ANNEX to the

ANNEX XV RESTRICTION REPORT

PROPOSAL FOR A RESTRICTION

SUBSTANCE NAME: LEAD

IUPAC NAME: LEAD

EC NUMBER(S): 231-100-4

CAS NUMBER(S): 7439-92-1

CONTACT DETAILS OF THE DOSSIER SUBMITTER:

EUROPEAN CHEMICALS AGENCY

P.O. BOX 400, FI-00121 HELSINKI, FINLAND

ECHA.EUROPA.EU

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Annex A: Manufacture and uses

A.1. Lead in ammunition

Detailed Exposure Scenarios for various uses of lead in ammunition are described in a supplementary risk assessment for the use of lead in ammunition (available on request from the Lead Registrant or the International Lead Association). Identifies a number of uses that are relevant for this report. These uses are detailed out further in section A.1.1 'Uses'

Lead is used by consumers and professionals in gunshot and other ammunition across a range of sporting, military and law enforcement uses. These uses are registered under REACH. The life-cycle of lead in ammunition is shown in Figure A.1-1.

The coloured boxes define the scope of this Appendix. It includes the manufacture and the downstream uses of lead in ammunition. The production of lead and lead nitrate and the downstream uses lead alloy production, battery recycling and formulation of primer are considered elsewhere. Each box potentially represents an identified use and therefore potentially an exposure scenario.

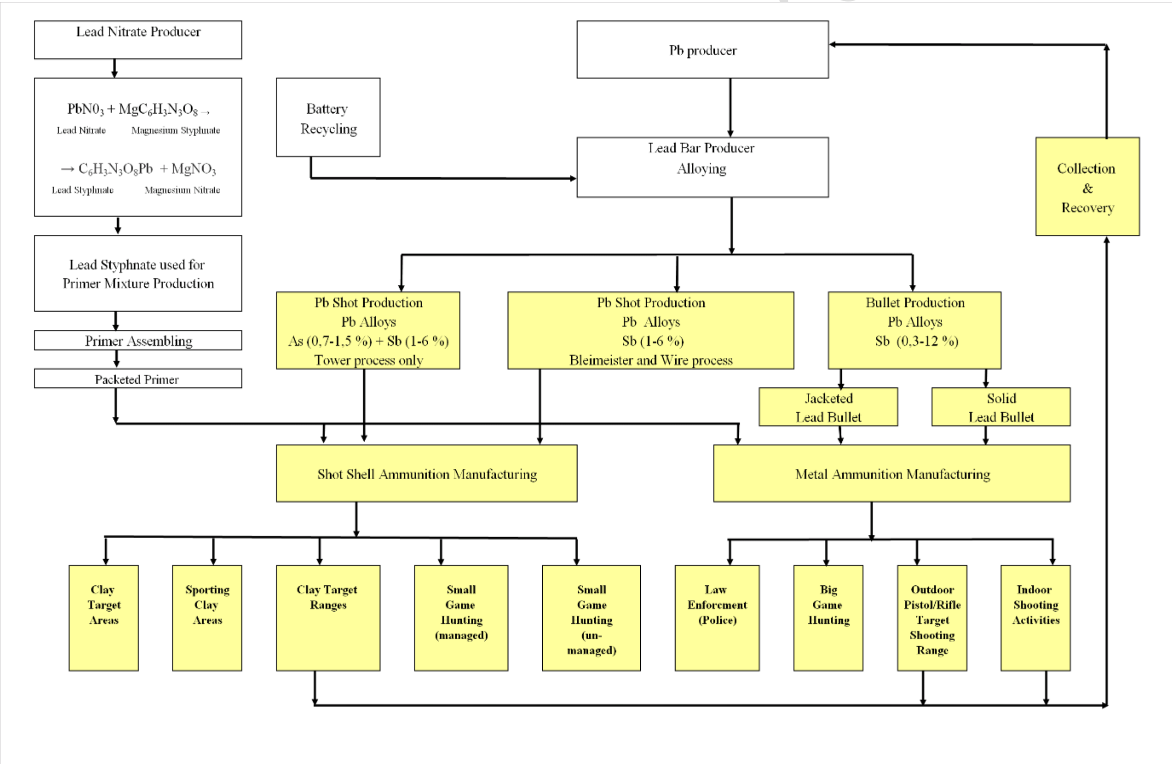


Figure A.1-1: Summary of the life cycle of lead in ammunition, including lead gunshot (reproduced from ILA-E, 2010)

A.1.1. Uses

The scope of the identified use hunting is pre-dominantly focused on hunting of terrestrial species.

Throughout Europe and in many other countries around the world, hunting is a leisure activity or sport and a tool for wildlife management. Hunting is the opportunity to capture and kill game in open spaces while keeping to a set of defined rules. These rules are progressively being modified through the gradual evolution of long-standing hunting traditions and the implementation of Community regulations. Over seven million Europeans take part in hunting activities, which are for most species restricted to a specific season. The hunters vary from 0.2 to 6%, as a percentage of population in the various EU countries, most of them in rural areas. Using the ratio of hunters to overall population of a country, it is possible to identify four areas (Pinet, 1995):

- The Scandinavian area, with the highest ratio (1:25 on average). Hunting is a spontaneous leisure pursuit.
- The Latin area, plus Ireland, with a lower ratio (1:40), forms the largest pool of hunters in the Union. Hunting is regularly practised here. They are primarily interested in small game, migratory or resident.
- There are still large numbers of hunters in the Anglo-Saxon area, but their ratio to population (1:60) is lower. Hunting traditions and disciplines are probably more closely linked to land ownership and there is a more "sporting" approach: good, stylish shooting is particularly appreciated. Pheasants and partridges are the most sought-after game species.
- The German (1:250) and Dutch (1:400) areas are influenced by long-standing aristocratic traditions and heavily urbanised territories. Big-game hunting is subject to complex, efficient codes of conduct. The game management aspect of hunting originated in this area.

Poland and Hungary are in a group of their own because of the deep political changes that have taken place there over recent history. Hunter population trends could become more consistent with their geographical neighbours (Austria, Slovenia) and its ratio (c. 1%)

Hunting can be divided essentially in two main types: small game (mainly use of shotgun cartridges) and large game (mainly use of rifle cartridges). Note that in several countries (e.g. Sweden, Denmark, Switzerland), Roe deer are shot with shotgun-pellets and rifle bullets are also used for bird hunting.

Pest and predator control is a vital part of hunting for land and wildlife management. It is also essential for agriculture, and may be undertaken for other specific reasons such as the protection of public health and air safety.

Most of the time, hunting rights are linked to land ownership (Pinet, 1995). Game physically lives in a particular area, a territory. Hunting means gaining legal access to this territory, mostly through payment to the owner of the land. However, this is not the main reason why hunters tend to stay in the same territory. It should not be forgotten that hunting is a sport practised over hundreds or even thousands of hectares. Game is scattered across this large territory and seldom concentrated at one single location. In order to have a reasonable chance of success, and therefore maintain interest, the hunter has to physically know their hunting territory. Hunting regularly in the same area

is due not only to traditional factors (home, family or friends) but also to a major development in modern European hunting: the management of the hunting territory. Growing knowledge of the ecological needs of game has led to the application of techniques aimed at improving living conditions for game and increasing the overall carrying capacity of the hunting territory. This work is often carried out by hunters themselves, hence their regular visits to certain preferred spots: they want to collect the fruits of patient work. Culling also ties hunters down to a given area. Although a minority, hunting tourism has developed in various countries of the Union, especially Ireland, Scotland, Spain and, to a lesser extent, Austria (Pinet, 1995). Enclosed territories, or game parks, are also hunting grounds (Pinet, 1995).

In Germany, the federal and state-owned hunting areas are managed by official forest organisations. Those areas are mostly large connected forest areas (> 1 000 ha). The foresters are responsible to manage the wood as well to hunt all the game in those areas – mostly large game with centre fire rifles - because the hunting areas consist mostly of forest areas. The smallest private owned hunting area must be larger than 75 ha. Most of the private hunting areas are founded by fusions of local farming - and wooded area owners. The fusion of landowners grant access to their properties to hunters who owns a hunting license. Those private owned hunting areas have an average area of 400 ha (estimation). The written lease contract is typically valid for min. 9 years. The fusion distributes the money to the land owners referring to their property area. The hunter, who is leasing the hunting area has the right to own the venison.

A.1.1.1. Small game hunting in managed areas – driven shooting

In some countries (e.g. Spain), hunting may take place over well-defined but reasonably large areas of land, e.g. in the case of managed hunting areas. This type of hunting can be referred to as "driven game shooting" or "driven shooting estates". There is an increasing trend towards encouraging wild birds. However, driven shooting could not continue in its present form without the rearing and release of large number of game birds.

Driven game shooting typically takes place on land that has been specifically managed to provide the best sport. In a classic 'pheasant drive' there are two woods, or coverts, on facing slides of a valley. One wood will contain the release pen, which the birds regard as home, the other wood is where they forage for food. The hunters are lined out in the valley bottom. The beaters disturb the birds in the areas where they are fed, so they naturally fly back to their home ground, over the line of waiting hunters. Behind the line pickers-up are stationed with gundogs to retrieve the shot game (see Figure A.1-2). The most common species are pheasant and partridges.

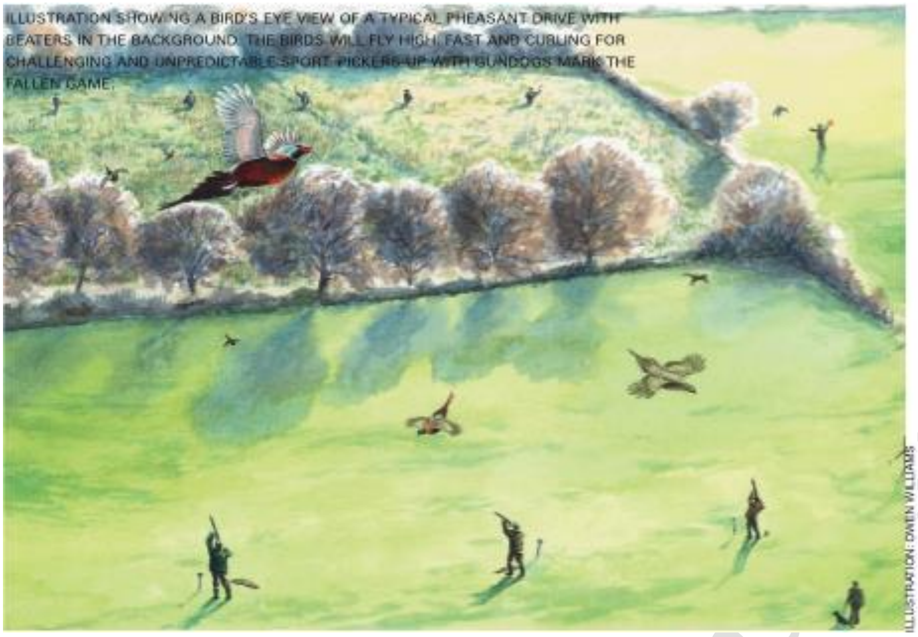


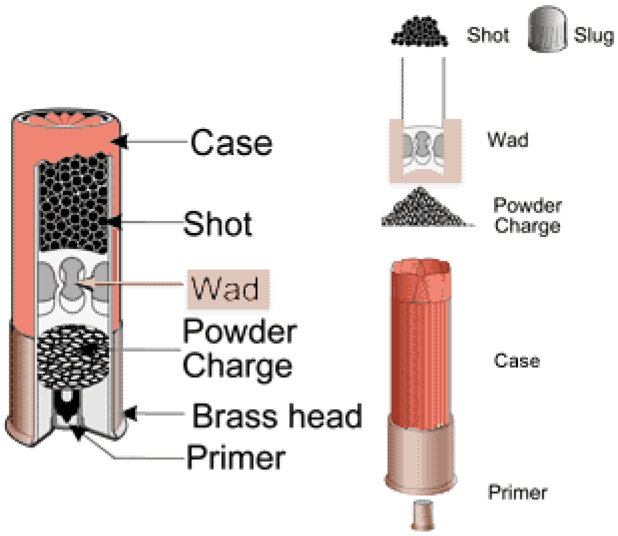
Figure A.1-2: Illustration showing a typical pheasant drive in UK with beaters in the background, the birds will fly high, fast and curling. Pickers up with gundogs mark the fallen game (From BASC, UK)

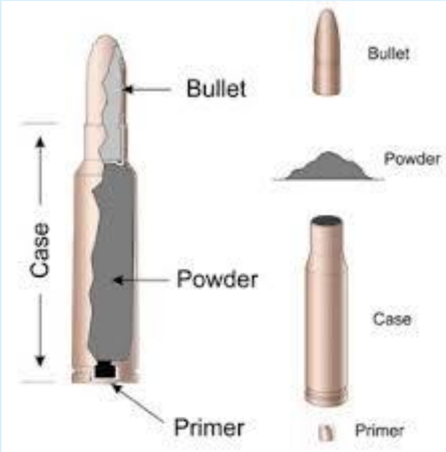
A.1.1.2. Large game hunting

Large game includes wild boar, red deer, fallow deer, chamois and sika. For these, mainly rifle cartridges are used.

A.1.1.3. Ammunition types

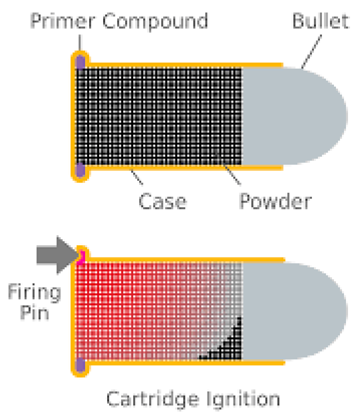
Table A.1-1: ammunition types in scope of this restriction

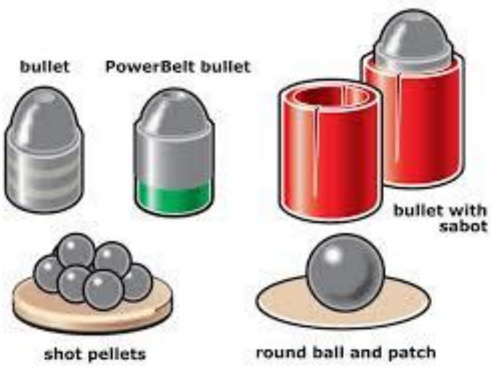
Use	Description of objects in scope of restriction
Hunting and sports shooting with shot	Shooting is carried out using shotgun cartridge of a case  *Source:* *http://theshotgunguide.blogspot.com/2013/06/the-anatomy-of-shotgun-ammo.html*

<table>
<tr><th>Use</th><th>Description of objects in scope of restriction</th></tr>
<tr><td>Hunting and sports shooting with bullets (centrefire)</td><td>

A centrefire cartridge is a firearm metallic cartridge whose primer is located at the centre of the base of its casing (i.e. "case head"). Unlike rimfire cartridges, the centrefire primer is typically a separate component seated into a recessed cavity (known as the primer pocket) in the case head, and is replaceable by reloading.

Source: Wikipedia</td></tr>
</table>

Use	Description of objects in scope of restriction
Hunting and sports shooting with bullets (Rimfire)	Rimfire ammunition is a type of firearm metallic cartridge whose primer is located within a protruding rim at the base of its casing. When fired, the gun's firing pin will strike and crush the rim against the edge of the barrel breech, sparking the primer compound within the rim, and in turn ignite the propellant within the case.  *Source: Wikipedia*

Use	Description of objects in scope of restriction
Air rifles	A pellet is a non-spherical projectile designed to be shot from an air gun, and an airgun that shoots such pellets is commonly known as a pellet gun. Air gun pellets differ from bullets and shot used in firearms in terms of the pressures encountered; airguns operate at pressures as low as 50 atmospheres while firearms operate at thousands of atmospheres. Airguns generally use a slightly undersized projectile that is designed to obturate upon shooting so as to seal the bore, and engage the rifling Low weight (6 gr) small calibre pellets (.177) of 4.5 - 5 mm in diameter metal pellets that are shot from an airgun  *Source: Wikipedia*
Muzzle loaders	Projectiles that are shot from Muzzle loading guns 

Use	Description of objects in scope of restriction
Slugs, sometimes referred to as Breneneke	A projectile that is shot from a shot gun, the projectile is placed in a casing simiar to the casing used in a shotgun cartridge. 

A.1.1.4. Uses advised against

After taking into account widespread existing restrictions through international laws (specifically the African-Eurasian Wildlife Agreement, AEWA: http://www.unep-aewa.org/map/parties.htm, see Annex 1) that oblige countries to phase out the use of lead shot for hunting in wetlands as soon as possible, such use will not be included as an identified use in the chemical safety report. There is a wealth of literature data on the effects of lead shot in wetlands, but it does not seem reasonable to perform a detailed risk assessment given the widespread restrictions already in place across the EU. Instead the use is advised against in the absence of an assessment demonstrating adequate control of risks, and in recognition of the widespread restrictions already in place.

A.1.2. Manufacturing, import and export

A.1.2.1. Lead shot production

The manufacture of lead alloys can be categorised into shot and bullet production. The shot production is further subdivided into a) tower process and b) Bleimeister and wire process. In the following sections, a schematic and detailed text description of the lead manufacturing process is provided.

Lead shot production: Tower process only

The tower lead production process is carried out in a tower of ranging from 40 to 70 m where the feeding of the ingots and the melting process in a temperature of 340-440°C takes place. Filling the molten alloy occurred in a large perforated pan which contains up to 2000 holes (which determine the pellet diameter). The molten alloy droplets fall approximately 42 m downwards into a water filled tank to avoid damage to shot. Thereafter the shot will be transferred out of the water tank into a heated drum for

drying (125°C). Shot are then raised to the 8th floor by an endless chain in order to start the production process for roundness selection and surface treating. Shot flow is transferred downward to the 7th floor, where the cleaning the shot from dust by screening process is carried out. Thereafter the shot flow is turned around into a rotating drum that will coat the shot with graphite. Shot flow down by gravity from 6th to the 4th floor in order to separate the misshapen and out of round shot pellets from the round ones. On the 3rd floor, the shot are polished and blended to size and pellet count takes place. Shot flow down to the 2nd floor into storage tanks. Shot will be transported down to the 1st floor, where they are packed into containers and transported to the shot shell loading plant.

Lead shot production: Bleimeister and wire process

Bleimeister production process:

The lead for the production of lead alloys comes from the recycling of batteries. Lead ingots contain Sb 1% to 6%. The ingots (2000 kg) are fed in a furnace and overflowed back into the main melting furnace, due to continuous agitation and pumping in a small pot. The molten alloy flows into orifice plates containing 200 holes. The size of the shot can be verified by changing the sizes of the holes. The molten alloy will be formed into droplets by vibration. The droplets will fall – 15 mm height - into a water tank. The water is recycled. The next steps are to cool down the shot and transport them with an elevator to the drying cylinder. Glass plate steps classifier and graphiting and then screen the cylinders for their size and packing conclude the Bleimeister process.

Wire production process:

The lead ingots from producer and the lead from the battery recycling are mixed and melted together with Sb 1 to 5%. After the wire is extruded it is flattened and the next operation is to shape the wire in strip and press to form rolls. The shot pellets are punched from the shaped strip while the strip scarp is feed back to remelting. Shot tumbling barrel, graphite coating and packing are the final processes that conclude the wire production process.

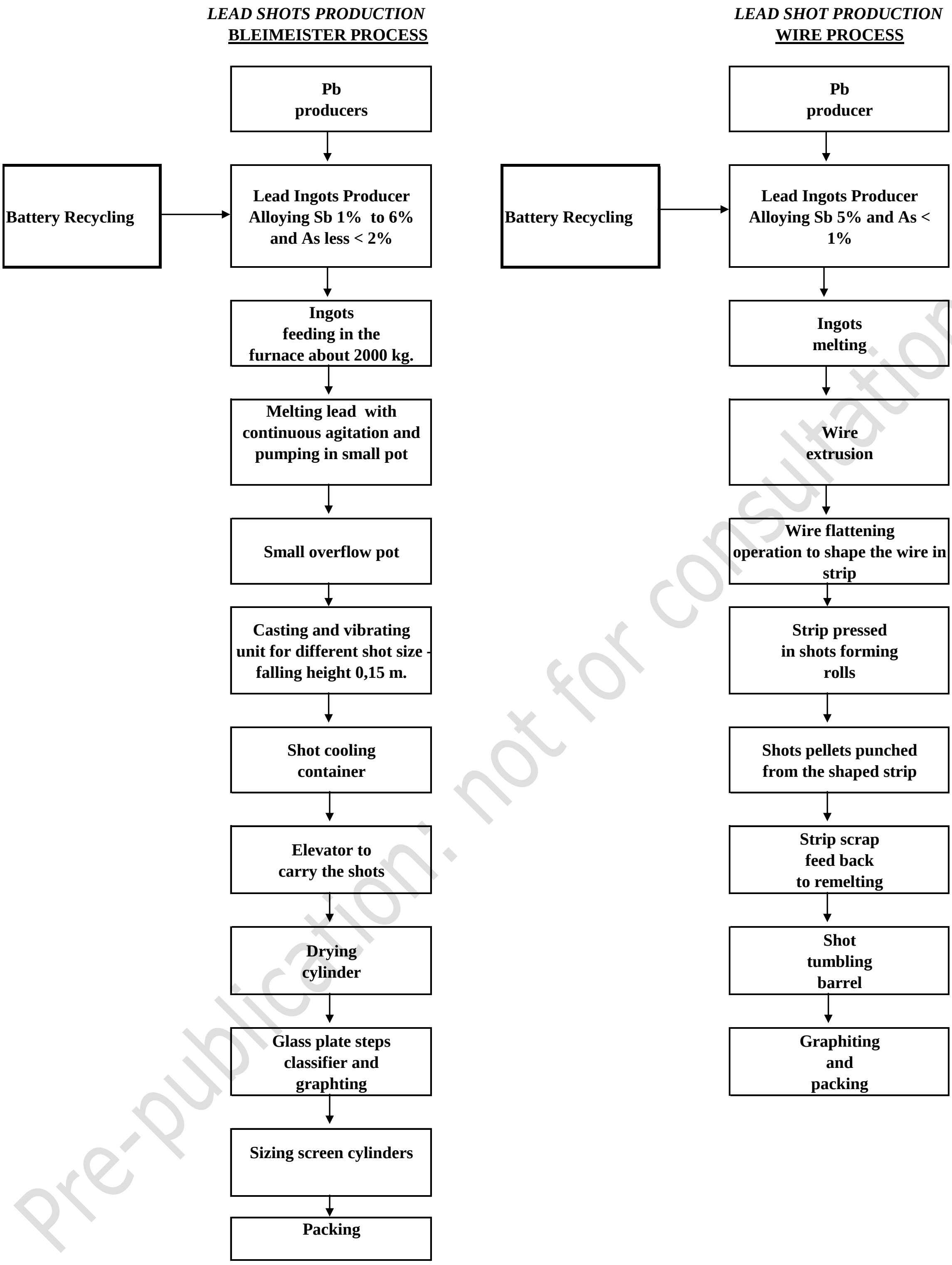


Figure A.1-3: Schematic description of the lead shot production by the Bleimeister and wire process.

A.1.2.2. Bullet production

Two types of bullets can be produced: a solid lead bullet and a jacketed bullet with lead core. The process descriptions are given below and are visualised in Figure A.1-4 and Figure A.1-5.

Solid lead bullet

The bullet production process consists in heating the lead ingots at a temperature of 340 to 440 °C. After the wire is extruded, it is flattened and the next operation is to shape the wire in strips and form rolls. The lead blanks are punched from the strip and pressed by a press in the exact shape of a solid lead bullet is produced.

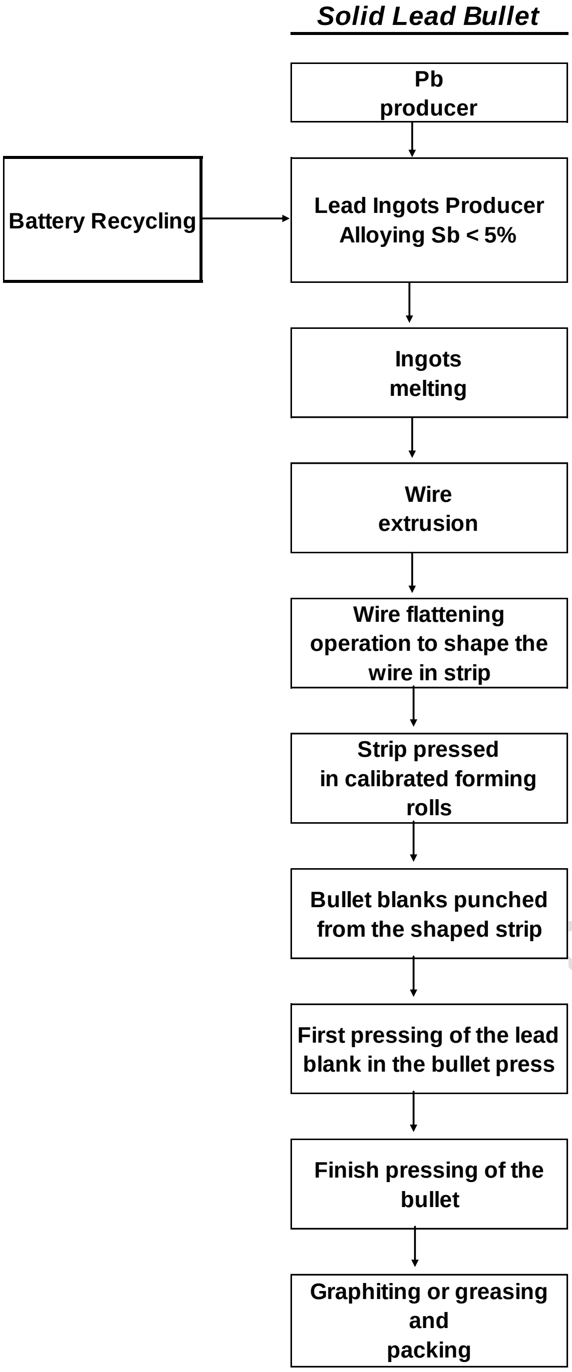


Figure A.1-4: Schematic description of the production of solid lead bullets

Jacketed bullet with lead core

The lead wire is pressed and dressed with a lead core layer. The lead core is inserted into the jacket and, due to the pressing process, the bullet obtains the right shape. The solid lead bullet is used mostly for target shooting and sporting activities, while jacketed bullets with lead core are used extensively by military and police and large game hunting, as well for outdoor and indoor pistol/rifle target shooting range activities.

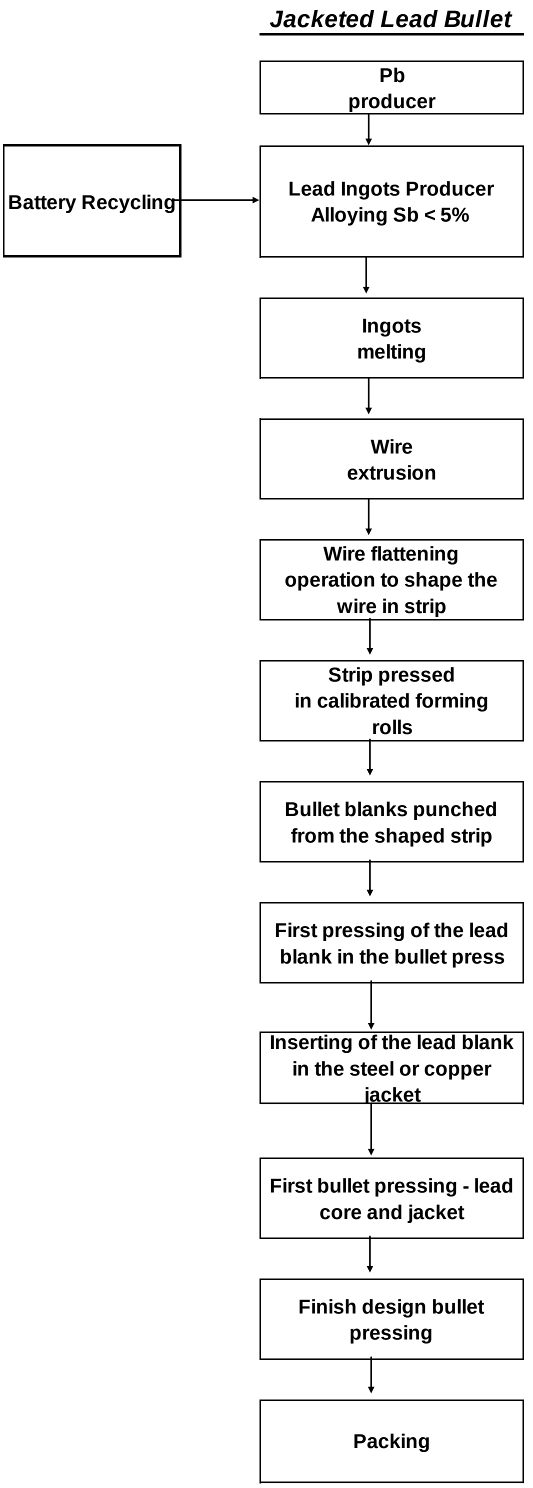


Figure A.1-5: Schematic description of the production of jacketed bullets with a lead core

Production of shot shell ammunition

The production of shot shell ammunition is mainly an assembling operation. Primed shot shell case is fed in a loading machine. The case is then "charged", or filled, with the correct amount of propellant. Next, the wad is fed into the shot shell case. Finally, the lead shot is loaded in the wad and the loaded shot shell case is crimped and prepared for shipment to the shooter. The whole process is summarised in Figure A.1-6.

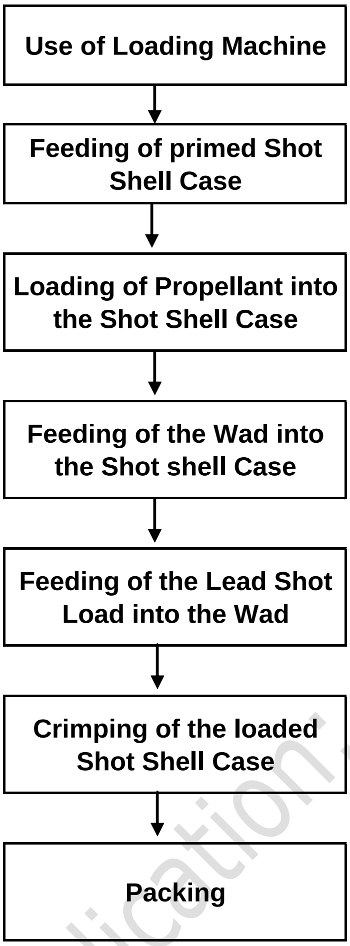


Figure A.1-6: Schematic description of production of shot shell ammunition

Production of metallic ammunition

The assembly process for the cartridge components begins with a thorough cleaning and polishing of the case by a vibratory finisher. The finisher works by vibrating a corn byproduct (dried and ground corncobs) with a polishing compound around the cases, creating a high lustre. Thus prepared, they are ready for final assembly. This is how a typical centre-fire metal cartridge is assembled: the cases are fed into a loading press which first sizes the case. This sizing forms the metal case to standard dimensions. The primer is then pressed into the case primer pocket. The case is "charged", or filled, with the correct amount of propellant. The bullet is firmly seated into the open end of the case. The bullet may have a coating of lubricant to prevent corrosion and assist in the assembly process. The bullet is then crimped into the case to give the correct overall length of the cartridge. The crimp reduces the diameter of the open end of the case and captures the bullet tightly, sealing the assembly together so moisture cannot invade the powder. In each stage of the process, special dies perform the important assembly function. After assembly, the finished cartridges are packaged, usually 50 to a box, and

prepared for shipping. The whole process is summarised in Figure A.1-7.

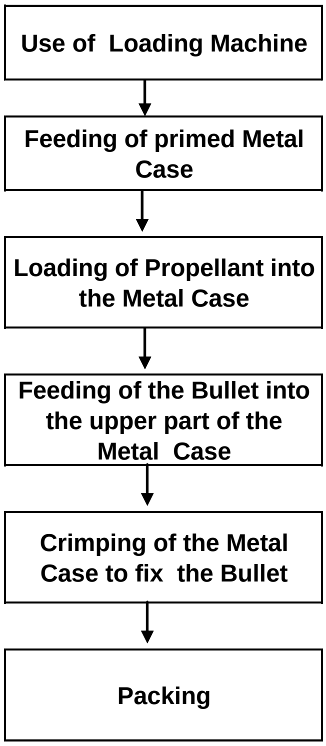


Figure A.1-7: Schematic description of production of metal ammunition

Reloading

Hunting enthusiasts and marksmen may elect to assemble (reload) their own rounds of ammunition. Preparation of ammunition rounds may be for purposes of achieving lower costs (reloading ammunition is less expensive than purchasing new ammunition) or for preparation of ammunition rounds with specific amounts or types of charge powder that enhance firing accuracy. Equipment for reloading (e.g. presses, powder dispensing devices), as well as the individual components of ammunition rounds, are available from specialty shops or on-line purchase and afford varying degrees of automation to the reloading process. Opportunities for exposure to lead exist during the cleaning of spent cartridges prior to reloading and in the handling of lead bullets or shotgun pellets during the reloading process.

Table A.1-2: Composition of Centrefire rifle and pistol ammunition (all calibres) (Brand: Federal Premium)

Substance	CAS	% (w/w)
Lead	7439-92-1	30-60
Copper	7440-50-8	25-41
Zinc	7440-66-6	1-16
Nitrocellulose	9004-70-0	0.5-12
Nitroglycerin	55-63-0	<7
Antimony	7440-36-0	<3
Nickel	7440-02-0	<1
Zinc oxide	1314-13-2	<0.25
Graphite	7782-42-5	<0.25

Source: SDS from Olin Winchester (synonyms: soft point bullets, full metal jacket bullets, power point bullets, jacketed hollow-point bullets) dated Feb 20, 2015: http://www.winchester.com/LEARNING-CENTER/SDS/Pages/Safety-Data-Sheets.aspx

Table A.1-3: Composition of Centrefire jacketed lead-core bullets (Manufacturer: Olin Winchester)

Substance	CAS	% (w/w)
Lead	7439-92-1	60-100
Copper/Zinc Alloy (brass)	Mixture	10-35

Source: SDS from Hornady dated October 1, 2014: http://www.hornady.com/support/downloads/msds

Table A.1-4: Composition of Rimfire rifle ammunition with lead projectile (Manufacturer: Hornady)

Substance	CAS	% (w/w)
Lead	7439-92-1	25-60
Copper	7440-50-8	25-43
Zinc	7440-66-6	5-14
Nitrocellulose	9004-70-0	6.5-13
Nitroglycerin	55-63-0	01-06
Antimony	7440-36-0	0-2
Zinc	7440-66-6	<0.25

Source: SDS for 'Varmint Express' rimfire cartridges loaded with 'NTX' bullets from Hornady: http://www.hornady.com/support/downloads/msds . Note that the small amount of lead (<1%) is associated with lead styphnate which is present in some primers

A.1.3. Import and export

A.1.3.1. Value of sold production, exports and imports by PRODCOM list (NACE Rev. 2)

Table A.1-5 provides an overview of the sold production, exports and imports of cartridges and other ammunition and projectiles and parts thereof, including shot and cartridge wads (Excluding for military purposes)

Even though the scope of the ammunition in Table A.1-5 is broader than just lead sinkers and lures, it gives an indication of the share of the imported ammunition placed on the market in Europe: this ratio in value is ca. 0.3 (import/production). Implying that about the major share of EU production is placed on the market in Europe itself.

In the following tables:

- PRODUCTION VALUE: this field gives the value of production in Euro.
- IMPORT VALUE: this field gives the value of imports in Euro, derived from the External Trade statistics.
- EXPORT VALUE: this field gives the value of exports in Euro, derived from the External Trade statistics.

Table A.1-5: Sold production, exports and import of cartridges and other ammunition and projectiles(2019, in €)

Member state	EXPVAL	IMPVAL	PRODVAL
Austria	7 659 020	8 518 010	(1)
Belgium	13 671 950	28 933 090	(1)
Bulgaria	0	0	329 185
Croatia	77 010	2 975 750	937 331
Cyprus	4 112 470	4 017 440	0
Czechia	51 464 340	10 243 350	(1)
Denmark	9 168 430	21 852 630	0
Estonia	1 271 560	2 916 770	0
Finland	25 056 130	10 301 350	30 223 580
France	46 045 190	57 942 220	92 893 875
Germany	133 553 700	92 505 960	196 652 770

Member state	EXPVAL	IMPVAL	PRODVAL
Greece	14 149 040	3 933 780	16 372 512
Hungary	0	0	(1)
Ireland	188 710	1 363 490	0
Italy	113 216 540	60 829 750	299 476 000
Latvia	762 010	12 889 780	(1)
Lithuania	6 226 290	6 918 580	(1)
Luxemburg	42 360	2 814 890	0
Malta	62 120	857 650	0
Netherlands	2 224 700	17 946 640	(1)
Poland	31 036 100	44 118 650	:
Portugal	92 070	8 829 880	1 140 093
Romania	185 690	653 650	(1)
Slovakia	37 106 660	13 346 550	(1)
Slovenia	3 771 170	3 711 800	(1)
Spain	108 225 640	32 411 080	105 009 342
Sweden	29 637 780	15 848 320	(1)
EU27_2020	323 772 370	155 435 970	964 849 962 (2)
United Kingdom	51 182 070	72 362 110	90 392 700

Table A.1-6 provides an overview of the sold production, exports and imports of cartridges and other ammunition and projectiles and parts thereof, including shot and cartridge wads (Excluding for military purposes) in tons per year.

It gives an indication of the share of the imported ammunition placed on the market in

Europe: this ratio in volume (tpa) is ca. 0.2 (import/production). Reconfirming that the major share of the European production is placed on the market within the EU itself.

Table A.1-6: Sold production, exports and imports of cartridges and other ammunition and projectiles (2019, in kg)

Member state	EXPQNT	IMPQNT	PRODQNT
Austria	628 100	1 515 000	(1)
Belgium	1 227 600	1 730 500	:
Bulgaria	0	0	(1)
Croatia	13 500	323 700	139 987
Cyprus	708 600	1 209 200	0
Czechia	3 984 400	1 516 700	(1)
Denmark	951 100	2 310 000	0
Estonia	124 800	206 700	0
Finland	663 800	1 183 300	(1)
France	8 153 200	10 179 300	6 472 265
Germany	6 504 300	9 000 800	:
Greece	5 076 600	910 600	8 605 782
Hungary	0	0	(1)
Ireland	41 600	257 500	0
Italy	25 333 500	10 521 100	38 486 979
Latvia	63 100	511 100	(1)
Lithuania	367 400	313 700	(1)
Luxemburg	400	106 900	0
Malta	500	139 300	0

Member state	EXPQNT	IMPQNT	PRODQNT
Netherlands	129 300	3 203 500	(1)
Poland	1 768 700	2 497 300	:
Portugal	2 000	1 606 500	5 577 772
Romania	0	0	(1)
Slovakia	2 323 700	2 671 400	(1)
Slovenia	0	0	(1)
Spain	17 272 900	9 245 100	19 867 157
Sweden	1 497 100	1 722 500	(1)
EU27_2020	37 220 400	20 287 600	97 963 097 (2)
United Kingdom	4 571 900	12 241 800	17 729 226

(1) Data for this item is confidential and has been suppressed
(2) At least one of the national figures in this EU aggregate is estimated

Information had been submitted as well from AFEMS on the production volumes of lead in the EU. The share of production that EU producers place on the EU market is about 70%

An Eu wide mass balance would then give (PRODQNT+IMPQNT-EXPQNT)= 80 kton of items per year consumed per year, which gives an indication that the use of lead in ammunition is high.

A.1.4. Market trends

The demand for ammunition in total however has seen a steady growth between 2007-2019

Table A.1-7: trend in export/import and production value

	Year	EXPVAL (€)	IMPVAL (€)	PRODVAL (€)	
EU27	2019	323 772 370	155 435 970	964 849 962	796 513 562
EU27	2015	410 843 110	163 178 420	879 575 304	631 910 614
EU27	2011	277 368 160	178 285 480	638 762 177	539 679 497
EU27	2007	277 457 270	99 277 620	847 861 521	669 681 871

Within net consumption in the EU between 2007 -2019 of 18%, suggesting an increased demand for hunting/sports shooting.

Although no Member state-wide legislation is already in place, there are various regional legislation in place that demand lead free hunting. These restrictions have an impact on hunter behaviour towards lead free ammunition, raise awareness on the lead issue and most importantly promote the use of non-lead ammunition.

A.1.5. EU legislation related to lead shot

Currently the Netherlands (since 1993) and Denmark (since 1996) are the only EU Member States with a total ban in place on the use of lead gunshot in all types of habitats. In the other Member States different types of legislation applied as summarised by Mateo and Kanstrup (2019), (Avery and Watson, 2009), Treu et al. (2020).

The European Commission requested ECHA to prepare an Annex XV restriction dossier proposing a harmonisation of the use of lead shot in/over wetlands in the EU. The restriction proposal (Annex XV dossier) was submitted in April 2017 and in August 2018, ECHA sent the opinion of its scientific committees on the proposal to the European Commission. It estimated that approximately one million wetland birds die in the EU from lead poisoning every year despite existing legislations in many Member States and an internationally binding agreement (AEWA) to protect waterbirds.

This restriction was recently added to Annex XVII of REACH, formalising the restriction of lead gunshot in wetlands into EU law[1]. The conditions of the restriction are available in entry 63 of Annex XVII to Regulation (EC) No 1907/2006.

Sports shooting at (non military) shooting ranges

In relation to the use of lead shot in sports shooting, legislations in place to regulate this specific use can be summarised as following:

- In Sweden, Norway and Denmark the use of lead shot in shooting ranges is banned in the entire territory (with some derogations in place; see below);

[1] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R0057&from=EN

- In the Netherlands the use of lead shot is banned for clay pigeon shooting.
- In Belgium, in the Flemish region, there is a regional ban for the entire territory.

According to the responses of Member State Competent authorities provided in the MS survey 2020, the following derogations have been granted:

- in Denmark derogations have been given to the Danish Shooting Union (DSU), for use of lead shot on their shooting ranges, as the International Shooting Sport Federation (ISSF) does not allow for the use of alternative gunshot materials in international competitions. DSU only applied for Compak sporting for derogation for hosting a competition and not for training, so no derogation was granted for training. The Danish athletes in this discipline are training with steel shot – but due to the international shooting organisations rules for competitions, they have to use lead shot for the competition.
- In Sweden: SFS 1998: 944 Shooting tests, hunting trail shooting, hunter's examination with approved test leaders; NFS 2002: 18 licensed shooters representing Sweden at international competitions in skeet, trap and double trap. This derogation applies to both training and competition.
- In Norway derogations have been granted to organisations for training to and participation in international competitions for which lead shot is the only allowed ammunition.
- in the Netherlands for professional athletes.
- In Belgium, in the Flemish region, derogations are granted only if the environmental permit allows this use, and this is only possible if extra measures are in place to collect fired shots.

A.1.6. Legislation in the EU related to lead bullets

In Europe the use of lead-based bullets is regulated in some regions, sites or National Parks only in a few countries (including Germany, Italy, Spain) in order to avoid contamination of game meat and/or to protect raptors from lead poisoning (Mateo and Kanstrup, 2019). Details on the regional provisions on the use of lead bullets in European member states are given in (Mateo and Kanstrup, 2019).

Germany

Several German states have required the use of non-lead rifle ammunition when hunting in state forests, and are examining the implementation of this transition (Gremse and Rieger, 2015).

Three of 16 German Federal States (Schleswig Holstein (LTSH 2014), Baden-Wuerttemberg (MLRV 2014) and Saarland (CdS Saarland 2014)) have regulated the use of lead bullets for hunting.

In Schleswig Holstein, the use of lead bullets and shotgun slugs for hunting has been banned since 1 April 2015. This action was based on the results of Gremse and Rieger (2012, 2014) (LTSH 2014).

In Baden-Württemberg, the use of lead bullets has been banned for hunting cloven-hoofed game since 2016.

At Saarland, state-wide restrictions of bullets containing lead have been in place, since 1 April 2014, with a grace period granted to phase out their use by 2017.

The Federal State of North Rhine Westphalia is in the process of passing hunting legislation, which will restrict the use of lead bullets and shotgun slugs in hunting

(MKULNV 2014).

Land in Germany is mostly owned by private, municipal, conventual, state and federal entities. 10 of the 16 forestry services of the Federal States, the Federal Forest Service and the 14 National Park Offices have rulings in place banning the use of lead rifle bullets on their land (DJV 2014).

The City of Rostock municipal forest (City of Rostock 2011), the German Federal Environmental Foundation (DBU 2011), the City of Greifswald (Greifswald 2011) and the City of Fuerstenwalde (City of Fuerstenwalde 2014), restricted the use of lead bullets in 2008, 2012 (both DBU and Greifswald) and 2013 respectively.

The Lead Ammunition Group reports that as well as policy developments, there have been changes in practice. Beginning in 2016, being mindful of lead-contaminated game potentially going into the human food chain, Forest Enterprise England (FE) required their staff to use non-lead ammunition for deer and boar culling. The decision was made following successful trials of selected non-lead bullets and was based on the evidence that lead from lead ammunition can contaminate carcasses and that FE’s marketing position could be seriously damaged if they continued to put lead-contaminated meat into the human food chain when there are proven alternatives available.

Austria

Although not yet regulated on national level, the Austrian professional hunters (OBS) committed themselves to a phase-out of lead free ammunition. Some voluntary initiatives are in place in some Austrian national parks[2]

Denmark

The Danish hunting association together with Danish Ministry of the environment have recently announced an initiative to phase out the use of lead in bullets for hunting as of 2023.

Switzerland

A number of cantons in Switzerland require lead fee ammunition for hunting. (Solothurn)

Netherlands

Several of the larger ground owners in the Netherlands demand lead free bullet ammunition (in addition to a legal ban on using lead shot) to be used on their domains. Most prominent among this is Staatsbosbheer who owns 220.306 ha of lands in the Netherlands and is the largest ground owner in the Netherlands.

USA

In their review, Treu et al. (2020) summarized the information as follows: California is currently the only country which has banned lead in rife bullets used for hunting (Mateo and Kanstrup, 2019), while Mauritania prohibits all forms of lead ammunition since 1975 for large game and sport hunting (Avery and Watson, 2009).

Effective from 1 July 2008, the California Fish and Game Commission prohibited the use of projectiles containing lead when hunting big game and non-game species in an area designated as the California condor range. This law must be fully implemented by 1 July

[2] https://www.nationalpark.at/de/service/presse/detail/nationalpark-startet-foerderung-fuer-bleifreie-jagd/

2019[3].

The California Department of Fish and Wildlife CDFW conducted extensive public outreach during 2014 and proposed regulations that phase-in the non-lead requirement. This outreach effort included question and answer sessions at sportsmen's shows, meetings with hunting organisations and a series of eight public workshops throughout the state. CDFW then presented draft regulations, as modified by public input from these workshops, to the Fish and Game Commission.

Sports shooting (at non military) shooting ranges

In relation to the use of lead bullets in sports shooting, no specific legislation apply in the EU. A legislation (not specific to address lead contamination related issues) identified by the Dossier Submitter is the following one:

- In Cyprus there is a national ban on the use of bullets at shooting ranges in the entire territory.

A.1.7. EU legislations related to game meat

In the following Table A.1-8 some EU legislations related to game meat are listed.

Table A.1-8 EU legislations related to game meat

Legislation	Title
Regulation (EC) 178/2002	laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety
Regulation (EC) 852/2004	On the hygiene of food stuff
Regulation (EC) 853/2004	laying down specific hygiene rules for on the hygiene of foodstuffs
Regulation (EC) 854/2004	laying down specific rules for the organisation of official controls on products of animal origin intended for human consumption
Council Directive 2002/99/EC	laying down the animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption

[3] In April 2015, the Fish and Game Commission adopted CDFW's proposed a regulation, to implement the non-lead requirement in the following three phases: Phase 1 – Effective 1 July 2015, non-lead ammunition will be required when taking Nelson bighorn sheep and all wildlife on CDFW wildlife areas and ecological reserves. Phase 2 – Effective 1 July 2016, non-lead shot will be required when taking upland game birds with a shotgun, except for dove, quail, snipe, and any game birds taken on licensed game bird clubs. In addition, non-lead shot will be required when using a shotgun to take resident small game mammals, furbearing mammals, non-game mammals, non-game birds, and any wildlife for depredation purposes. Phase 3 – Effective 1 July 2019, non-lead ammunition will be required when taking any wildlife with a firearm anywhere in California.

Legislation	Title
Council Directive 96/23/EC	On measures to monitor certain substances and residues thereof in live animals and animal products and repealing Directives 85/358/EEC and 86/469/EEC and Decisions 89/187/EEC and 91/664/EEC
Commission Decision 97/747/EC	fixing the levels and frequencies of sampling provided for by Council Directive 96/23/EC for the monitoring of certain substances and residues thereof in certain animal products
Commission Regulation (EC) 1881/2006	setting maximum levels for certain contaminants in foodstuffs such as 0.1 mg/kg wet weight for meat (excluding offal) of bovine animals, sheep, pig and poultry (game meat not mentioned)

Hunting for private domestic consumption

In case wild game is shot only for own private consumption or to give away to family and friends for private consumption on an occasional basis the hunter acts as a primary producer but not as a food business operator. Consequently, the EU Food Hygiene Regulations set out in Regulation (EC) 852/2004 and Regulation (EC) 853/2004 and its guidance do not apply. Such game has undergone no more than any necessary preparation that is part of normal hunting practice which is usually the evisceration of large wild game animals either carried out "in the field" or in a game larder (UK Food Standard Agency, 2015).

Direct supply of small quantities of in-fur/in-feather game carcass to the final consumer or local retailers

In case of individual hunting, hunting parties or hunting in shooting estates, that supply all the in-fur/in-feather wild game carcasses directly to the final consumer or to local retailers that directly supply the final consumer and not to approved game handling establishments, the hunter needs to be registered with the local authority as a food business under Regulation (EC) 852/2004 and to comply with its general hygiene requirements including temperature controls, food safety management procedures and hygienic transport. The requirements are adapted where private dwelling houses or temporary/moveable premises are being used. The supplier is responsible for supplying safe and traceable food under Regulation (EC) 178/2002 (UK Food Standard Agency, 2015).

Supply of in-fur/in-feather game carcasses to approved game handling establishments

In case in-fur/in-feather game is supplied to an approved game handling establishment, the supplier is required to register as a food business with the local authority and to comply with the general hygiene requirements for primary producers and associated operations (covering vehicle, game larders and collection centres) and the specific provisions of Regulation (EC) 853/2004 that apply to the initial handling of wild game intended for subsequent supply to an approved game handling establishment. According to this Regulation, "*(22) In order to ensure proper inspection of hunted wild game placed on the Community market, bodies of hunted animals and their viscera should be*

presented for official post-mortem inspection at a game-handling establishment. However, to preserve certain hunting traditions without prejudicing food safety, it is appropriate to provide for training for hunters who place wild game on the market for human consumption. This should enable hunters to undertake an initial examination of wild game on the spot. In these circumstances, it is not necessary to require trained hunters to deliver all viscera to the game-handling establishment for post-mortem examination, if they carry out this initial examination and identify no anomalies or hazards. However, Member States should be allowed to establish stricter rules within their territories to take account of specific risks".

As there are no maximum limits to the chemical elements in wild game, it is assumed that the criteria applied by EU Member States for reporting of a non-compliance in game meat is the same as the criteria for meat (muscle) and for the offal of cows, sheep, pigs and poultry (0.10 and 0.50 mg/kg wet weight respectively in the case of Pb).

A.1.8. Other non-EU legislation

n/a

A.2. Lead in fishing tackle

A.2.1. Uses

A.2.1.1. Recreational fishing

Definitions of recreational and subsistence fishing

The term recreational fishing usually designates fishing undertaken for enjoyment, recreation, or competition, where the catch fish or crustacean is not sold.

According to the FAO definition, recreational fishing is 'the fishing of aquatic animals that do not constitute the individual's primary resource to meet nutritional needs and are not generally sold or otherwise traded on export, domestic or black markets'. Globally, angling, which is a fishing technique with a rod, hook and line is by far the most common recreational fishing technique (Commission, 2008).

On the other hand subsistence fishing contributes substantially to meeting an individual's nutritional needs. In pure subsistence fisheries, fishing products are not traded on formal domestic or export markets but are consumed personally or within a close network of family and friends. Pure subsistence fishing sustains a basic level of livelihood.

While the demarcation between recreational and commercial fisheries is reasonably clear in Europe, the demarcation between subsistence and recreational fishing is absent (Hyder and J, 2017). Under the EU legislations on fisheries, any fishing where catches are sold is considered commercial. Conversely, where catches are not sold, this activity and its impact are generally monitored as recreational fishing. Hence in this report we will only talk about recreational and commercial fishing.

Fishing tackle description

Fishing tackle is the equipment used by fishers when fishing. Almost any equipment used for fishing can be called fishing tackle. For example, fishing tackle can be rods, reels, lines, hooks, sinkers (or weights), floats, swivels, lures (i.e. artificial baits), jigs, baits, harpoons, nets, gaffs, traps, waders, wire, etc.

'Fishing rig' usually designate a completed assembly of tackle ready for fishing. Sometimes ready to use assembly of line, hook, sinker(s) and float are available from retailers' shops or websites.

Source: based on (Marbouh, 2018)

Figure A.2-1: Example of fishing tackle

Among the fishing tackle, some are currently predominately made of lead. There are various types, shapes, dimensions and weights of lead fishing tackle. The description and characteristics of the lead fishing tackle depends essentially on the targeted fish species, the fishing equipment used and the environmental conditions (wind, currents, water bed) at the fishing site. Some fishing tackle consists solely of lead, for example sinkers and split shots (shots with a notch where the line is attached). In other fishing tackle, lead has been added to obtain certain functions: in lures for example, lead might be added to give the fishing tackle weight in the water. This is why the lead fishing tackle used by recreational fishers can be grouped into two main categories:

- Fishing sinkers (aka fishing weights) including wire
- Fishing lures (including jigs)

Few examples of lead fishing sinkers and lures is presented in Table A.2-1. This is only for illustration as many different shapes and sizes exist on the market. Fishing lures can range from relatively simple to increasingly complex and elaborately decorated/dressed jigs.

Table A.2-1: Examples of fishing sinkers and lures

Name	Description	Picture
Sinkers / weights	Used to pull line to require depth	
Bank sinker	Long and rounded with a small hole at the top where the line attaches. They are generally good options when using river rigs and when dropshotting.	
Bell sinker	Bell-shaped sinker generally attaches to the line via a ring at top of the bell. It is mainly used for fishing below the hook and dragging on the bottom.	
Bullet weight sinker	Shaped like bullets and have a hole through the middle where the line attaches. These sinkers are commonly used when worm fishing for bass and work well when positioned on the line in front of soft plastics.	
Cannonball/downrigger weight	For big fish - sea fishing. Can weight up to 5kg.	
Egg sinker	Shaped like an egg. These sinkers have a hole through the centre, this is where the line attaches. Compared to other shapes, these sinkers pass over rocks and rubble with less resistance and are commonly used for fishing in currents and deep water.	

Name	Description	Picture
Pencil	Elongated sinker.	
Pyramid sinker	The pyramid shape allows these sinkers to dig into soft surfaces such as sand or mud very well, allowing the bait to be held fairly still in a current, they also drop to the bottom very quickly.	
Split Shot	Small spherical piece of metal which is cut part way through the diameter and is used to add weight to the fishing line to set the float. The fishing line is placed into this sliced area and then the split shot is 'pinched' onto the line. The split shot's weights range from 0.01 g to 4.8g. The smallest split shots (≤0.06 g) are often referred as 'dust split shot'.	
Styl	Whereas split shot are generally round or egg-shaped, the styl is long and thin like a rod with a central split so they can be squeezed on to the line in the same way as a split shot.	
Trolling	Heavy weights are used for offshore fishing.	
Weighted hooks		

Name	Description	Picture
Wire		
Lures	**Used to attract fish**	
Jig or jig-head	A jig or jig-head consists of a sinker with a hook moulded into it and usually covered by a soft body to attract fish. Jigs are intended to create a jerky, vertical motion, as opposed to spinnerbaits which move through the water horizontally. Jig/jig-head might have various sizes, weights and colors.	 
Decorated/dressed jig-head	Elaborated version of the jig (cf. description below).	
Pirk	A type of fishing lure consisting of a metal bar with a triple hook attached.	
Plug	Lure with a hard body. Depending on the region, plug might have different names, e.g. crankbait, wobbler, minnow, shallow-diver, etc.	
Spinnerbait		

Name	Description	Picture
Sputnik	The name comes from its resembling a satellite with antennas. This bait is popular with surf fishermen as it digs into the sand and is not nearly as affected by wave action and tidal flow as other weights.	

Source: CfE #1034, ECHA market survey,(Canada, 2018)

Lead fishing tackle used for recreational sea fishing have usually a higher weight than the one used in fresh waters. Heavier weights are usually required in more stringent fishing conditions (e.g. deepness, courant etc). Some suppliers and manufacturers contacted by the Dossier Submitter during the ECHA market survey indicated that the average weight of marine lead fishing sinkers is ca. **140 g** and that marine fishers usually use fishing sinkers weighing between 20/40 g and 250 g. Heavy marine weights such as 700-800 g or 4-5 kg downrigger sinkers are seldom used in Europe. These statements are also confirmed by information received from VLIZ during the call for evidence (CfE #1034). Examples of marine fishing sinkers used by Belgium marine recreational fishers is summarised in Table A.2-2.

Table A.2-2: Example of fishing sinkers used in sea fishing in Belgium

Type of fishing	Sinkers
Static boat fishing with natural bait	Cannonball lead (115-370 g) Drifting lead (pear lead (60-350 g) Sliding lead (20-100 g)) Wrecking lead (100-400 g) Breakout lead (110-220 g) Grip lead (150-365 g) Spacers with ballast (6-30 g)
Active boat fishing with lures	Pilkers (60-250 g) Jigheads (10-250 g) Bottomships (60-300 g) Flounder spoons (30-150 g) Herring lead (50-90 g)
Beach angling	Cannonball lead (40-200 g) Long distance lead (beach bomb) (100-225 g) Lift lead (100-225 g) Breakout lead (100-225 g) Grip lead (100-225 g) Pyramid lead (40-225 g) Portuguese lead (100-225 g)

Source: CfE #1034

Statistics and key figures

The Dossier Submitter contacted various Fishers Associations, such as the European Angling Association (EAA), the International Sport Fishing Confederation (CIPS), the International Sea Fishing Federation (FIPS-M), the International Game Fish Association (IGFA), the European Federation of Sea Anglers (EFSA) and the European Anglers

Federation (EAF), in order to obtain information and statistics on fishers, fishing licences and fishing expenses. Via EAA, only the Finnish, Dutch, Slovenian and Spain national fishing associations responded to the Dossier Submitter questionnaire. The other information presented in this section was essentially gathered from literature and internet search.

Estimations of number of recreational fishers in Europe

The estimated number of recreational fishers (freshwater and marine) is presented in Table A.2-3 and is estimated to 23 Million fishers in EU27-2020. In addition, based on the marine recreational fishing participation rate established by Hyder et al., the number of marine recreational fishers in EU27-2020 is estimated to 6.2 Million (Hyder et al., 2018) as depicted in Table A.2-4.

As the definition of recreational fishing, but also the data collection, the reporting, the monitoring and the control systems differ among EU Member States, Table A.2-3 presents LOW and HIGH values that were gathered via literature research, fishing associations consultations and sometimes extrapolation. The sources of data per country are indicated below the table. The LOW and HIGH values were determined by using the smallest and highest estimates of recreational fishers found for every country (as recent and substantiated as possible). In some countries, the LOW values represent the number of fishing licences sold in the country rather than the number of fishers, as licences for fishing are not always compulsory for fishing (e.g. no licence needed for fishing in marine environment in some countries, or fishing not needed for certain age groups, etc).

The data presented in Table A.2-3 gives an overview of the recreational fishers estimates to our best knowledge, however, it might not reflect entirely the real numbers of recreational fishers in EU27-2020. For Malta, and Luxembourg no data could be retrieved, and an extrapolation was done. The freshwater fishing area in Malta is negligible (FAO 2020 Data collection report[4]), therefore, the participation rate of 5% of the total population for marine recreational fishing according to Hyder et al. (2018) was used. For Luxembourg, a low participation rate of 2.5% was assumed. This number was determined by calculating participation rates for each country, where available, and then comparing low participation rates among countries. The value of 2.5% represents an average.

Based on this (grey) literature search, it is assumed that there are between 12 and 23 Million recreational fishers in EU27-2020. As a comparison, EFTTA reports 25 to 30 Million recreational fishers in Europe which is comparable with the Dossier Submitter estimates considering that the UK, with roughly 4 Million recreational fishers, is included in the EFTTA estimate (EFTTA, 2017).

Arlinghaus et al. (2015) calculated a European average participation rate of 10.97% (Arlinghaus et al., 2015). With the current population of 447.7 Million (EUROSTAT EU27-2020), this would mean 49 Million people participating in recreational fishing in EU27. However, this estimate is considered as an overestimate for three reasons. First, the underlying literature used by Arlinghaus et al. (2015) goes back to 1998 up to 2007 and is considered outdated. Second, trends, in particular for those countries with comparably high participation rates, are decreasing (e.g. Finland, the Netherlands). Third, Norway,

[4] FAO – Data collection systems and methodologies for the inland fisheries of Europe (2020), available at http://www.fao.org/3/ca7993en/CA7993EN.pdf

Iceland, Ukraine and United Kingdom which demonstrate a high participation rates in recreational fishing among its population, were counted into the European average participation rate according to Arlinghaus et al. (2015).

Table A.2-3: Estimation of number of recreational fishers in EU27-2020

Country	Lower	Higher	Sources (Lower, Higher)
Austria	300 000	410 000	[1], [2]
Belgium	300 000	300 000	[3], [3]
Bulgaria	62 000[a]	180 000	[4], [1]
Croatia	117 000[b]	117 000[b]	[5]+[6], [5]+[6]
Cyprus	23 500[c]	23 500[c]	[7], [7]
Czech Republic	315 000	350 000	[6], [8]
Denmark	191 900[a]	616 000[d]	[9], [11]
Estonia	80 000	149 000	[9], [9]
Finland	1 500 000	1 500 000	[12]
France	1 528 500[ae]	2 500 000	[13], [14]
Germany	1 735 900[a]	3 400 000	[15], [16]
Greece	87 700[ac]	600 000[f]	[17], [19]
Hungary	324 000	450 000	[20], [22]
Ireland	218 000	406 000	[23], [24]
Italy	1 077 000[ac]	2 000 000	[25], [26]
Latvia	96 000[a]	200 000	[27], [28]
Lithuania	200 000	1 500 000	[29], [29]
Luxembourg	15 700[g]	15 700[g]	Extrapolation
Malta	14 000[h]	14 000[h]	Extrapolation

Country	Lower	Higher	Sources (Lower, Higher)
Netherlands	1 000 000	1 530 000	[30], [31]
Poland	630 000	2 000 000	[32], [33]
Portugal	187 900[ac]	600 000[i]	[34], [36]
Romania	200 000	248 400[j]	[37], [37]+[38]
Slovakia	120 000	120 000	[39], [39]
Slovenia	23 000	23 000	ECHA market survey
Spain	871 500[ac]	1 580 000	[40], [41]
Sweden	1 600 000	2 020 000	[42], [43]
SUM for EU27-2020	**12 000 000**	**23 000 000**	

Notes: (a): Number of licenses issued (represents usually an underestimate of recreational fishers as licenses might mandatory only for the age group of e.g. 16 – 65 y or licenses might not be mandatory for both marine and freshwater fishing).

(b): Estimates from separate sources (presenting freshwater or marine recreational fishing) were added.

(c) Number represents recreational fishing in marine water only.

(d): according to another FAO study from 2020 as well, the number of fishers would be 442 000 rather than 616 000

(e): Number represents recreational fishing in freshwater only.

(f): according to Hyder et al. (2018), the number of fishers would be 300 000 rather than 600 000

(g): Extrapolation where no data was available using low participation rate of 2.5% of total population.

(h) Extrapolation where no data was available, using participation rate accord. to Hyder et al. (2017) for marine recreational fishing when freshwater fishing is negligible.

(i): adding estimates from [34] and [35] would give and overall estimates of 440 000 fishers

(j): Regulation and licensing is done by different authorities in different areas. The number of issued licenses 2018 by DDBRA (Danube Delta) was added to the estimate of recreational fishers by ANPA.

Sources:

[1] EU intervention in inland fisheries. EU wide report – final version (2011) available at https://ec.europa.eu/fisheries/sites/fisheries/files/docs/publications/inland_fisheries_en.pdf

[2] (Arlinghaus et al., 2015) based on Kohl (2000)

[3] (Arlinghaus et al., 2015) based on Pintér and Wolos (1998)

[4] NAFA (National Agency for Fisheries and Aquaculture) (ИАРА – Изпълнителна агенция по рибарство и аквакултури). Monthly statistics of issued fishing licenses. In Bulgarian. http://iara.government.bg/?page_id=15986&lang=en

[5] (Soldo et al., 2018)

[6] FAO – Data collection systems and methodologies for the inland fisheries of Europe (2020) available at http://www.fao.org/3/ca7993en/CA7993EN.pdf

[7] (Michailidis et al., 2020)

[8] (Lyach and Čech, 2018)

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[10] FAO – Data collection systems and methodologies for the inland fisheries of Europe (2020) based on Sparrevohn and Paulsen (2012) - available at http://www.fao.org/3/ca7993en/CA7993EN.pdf

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[15] DFB–Binnenfischerei–Jahresbericht 2018

[16] (Arlinghaus, 2004)

[17] (Karachle et al., 2020)

[18] (Hyder et al., 2018)

[19] (Hurkens and Tisdell, 2004) based on Anagnopoulos et al. (1998)

[20] (Arlinghaus et al., 2015) based on Kovács and Füresz (1999)

[21] OECD.Stat (2013) on Recreational fisheries available at https://doi.org/10.1787/data-00226-en . The number reported in the table is from the 2013 column.

[22] Eurofish – Country Profile Hungary https://www.eurofish.dk/hungary

[23] (Arlinghaus et al., 2015) based on Williams and Ryan (2004)

[24] NSAD (National Strategy for Angling Development) – study from TDI (Tourism Development International) (2012) available at https://www.fisheriesireland.ie/media/tdistudyonrecreationalangling.pdf

[25] MiPAAF (Ministry of Agriculture and Forestry Policies) (2019) – study available at https://www.politicheagricole.it/flex/cm/pages/ServeAttachment.php/L/IT/D/8%252F7%252F2%252FD.2612281262da4f8f43af/P/BLOB%3AID%3D190/E/pdf

[26] FAO – Fishery and Aquaculture Country Profile (2015) – available at http://www.fao.org/fishery/facp/106/en

[27] Kurzemes Plānošanas regions - retrout (2019), ziņojums par makšķerēšanas tūrisma lomu ekonomikā projekta partnervalstīs: zviedrijā, somijā, polijā, lietuvā, igaunijā, Latvijā, available at https://www.kurzemesregions.lv/wp-content/uploads/2019/12/2.nodevums_RETROUT_zinojums_1.09.2019.pdf

[28] (Arlinghaus et al., 2015) based on EAA (2003)

[29] EAA (European Anglers Alliance). Socio economics – Lithuania, available at https://www.eaa-europe.org/topics/socio-economics/lithuania.html

[30] Sportvisserij Netherland (2020). Personal communication. Numbers from unpublished study from 2019 screening survey

[31] (Van der Hammen, 2019b)

[32] Instytut Rybactwa Śródlądowego (2018).Działalność podmiotów rybackich i wędkarskich w 2017 roku (in English: Activities of fishing and angling entities in 2017). p.100. based on Czerwiñski (2017) and Trella (2018)

[33] (Arlinghaus et al., 2015) based on Wolos (2003)

[34] DGRM (Directorate-General for Natural Resources, Safety and Maritime Services). Statistics issued licenses – available at https://www.dgrm.mm.gov.pt/pesca-ludica

[35] ICNF (Portuguese Institute for Nature Conservation and Forests). Stategic study,management of continental fisheries. Chapter 5 & Chapter 7 – available at

https://www.icnf.pt/pesca/estudos/pescascontinentais

[36] (Hurkens and Tisdell, 2004)

[37] MMSC and MADR (2014). Strategia Naţională a sectorului pescăresc 2014-2020 available at https://www.madr.ro/docs/fep/programare-2014-2020/Strategia-Nationala-a-Sectorului-Pescaresc-2014-2020-update-apr2014.pdf

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[39] OECD.Stat (2011) – available at https://doi.org/10.1787/data-00226-en.The number reported in the table is from the 2011 column.

[40] (Gordoa et al., 2019)

[41] EAA (European Anglers Alliance). Socio economics – Spain – available at https://www.eaa-europe.org/topics/socio-economics/spain.html

[42] Fritidsfiske i Sverige 2019 – Statistics on recreational fishing in Sweden 2019 available from: https://www.scb.se/publication/40460

[43] (Arlinghaus et al., 2015) based on Toivonen et al. (2000)

Table A.2-4: Estimation of number of marine recreational fishers in EU27-2020 based on Hyder et al. (2018) participation rate in marine recreational fishing

Country	EU population (Eurostat 2020)	Participation rate in marine recreational fishing	Recreation marine fishers
Austria	8 901 064	0.00%	-
Belgium	11 549 888	0.22%	25 000
Bulgaria	6 951 482	2.70%	188 000
Croatia	4 058 165	2.70%	110 000
Cyprus	888 005	2.70%	24 000
Czech Republic	10 693 939	0.00%	-
Denmark	5 822 763	6.90%	402 000
Estonia	1 328 976	1.48%	20 000
Finland	5 525 292	5.50%	304 000
France	67 098 824	2.06%	1 382 000
Germany	83 166 711	0.22%	183 000
Greece	10 709 739	2.70%	289 000
Hungary	9 769 526	0.00%	-

Country	EU population (Eurostat 2020)	Participation rate in marine recreational fishing	Recreation marine fishers
Ireland	4 963 839	2.13%	106 000
Italy	60 244 639	1.32%	795 000
Latvia	1 907 675	2.04%	39 000
Lithuania	2 794 090	2.04%	57 000
Luxembourg	626 108	0.00%	-
Malta	514 564	2.70%	14 000
Netherlands	17 407 585	3.20%	557 000
Poland	37 958 138	0.22%	84 000
Portugal	10 295 909	1.67%	172 000
Romania	19 317 984	2.70%	522 000
Slovakia	5 457 873	0.00%	-
Slovenia	2 095 861	1.32%	28 000
Spain	47 329 981	0.64%	303 000
Sweden	10 327 589	5.74%	593 000
SUM for EU27-2020	**447 706 209**		**6 195 000**

Source: based on participation rate in marine recreational fishing reported in (Hyder et al., 2018)

<u>Child participation in fishing activities</u>

Scattered information on child participation in fishing activities in some European countries is presented in Table A.2-5. This information is completed with additional statistics from non-EU countries as a matter of comparison. Only the most recent information found per country is presented.

Table A.2-5: Child participation in fishing activities

Country	Child participation	Source
Netherlands	In 2018, 20% of fishers were between 6 and 15 years old (225 000 young fishers)	[1]
Finland	In 2018, 13% of fishers were below 10 years old (estimated from annual survey)	[2]
France	In 2017, 14% of fishers were below 12 years old (based on fishing permit)	[3]
Slovenia	In 2020, 10% of the fishers in fresh water were below 12 years old (based on registered fishing permit). No data for the marine fishing.	[4]
Spain	Between 6 and 10% of fishers are below 14 years old	[5]
US	In 2017, 15% of fishers were between 6 and 12 years old 9% of fishers were between 13 and 17 years old	[6]

Sources :

[1] : https ://www.sportvisserijnederland.nl/over-ons/feiten-en-cijfers/visparticipatie-onder-jongeren.html

[2]: https://stat.luke.fi/en/recreational-fishing

[3]: https://www.federationpeche.fr/2313-chiffres-cles-2017-de-la-peche-en-france.htm

[4]: Communication from Ribiška zveza Slovenije (Fishing Association of Slovenia)

[5]: Communication from Alianza de Pesca Española Recreativa Sostenible (APERS)

[6]: https://www.scb.se/publication/40460, *https://outdoorindustry.org/wp-content/uploads/2015/03/2018-Special-Report-on-Fishing_FINAL.pdf*

Fishing effort and expenditure

Table A.2-6 presents the fishing effort and fishing expenditure in some EU27-2020 countries. As limited data exists on fishing effort and expenditure in EU27-2020, data from outside Europe were collated as well in Table A.2-6.

Table A.2-6: Recreational fishing effort and expenditure in various countries

Country	Fishing effort and expenditure	Source
Canada	15 fishing days/year/fishers (13 days in 2010 and 1995) Average expenditure per fisher: CA$ 730 (i.e. 471 €) Average expenditure per fisher related to lures, bait, line, tackle: CA$ 64.3 (i.e. 42 €) (study from 2015)	[1]
Finland	Average expenditure per fisher: 1 350 € (men) – 950 € (women) "Most significant expenses are the purchase of a boat".	[2]
Netherland	15 fishing days/year/fishers Average expenditure per fisher: 577 € per year (study from 2004)	[3]
Slovenia	10 fishing days/year/fishers No information on the average expenditure per fisher	[4]
Spain	40 fishing days/year/fishers Average expenditure per fisher: 1 500 € per year Average expenditure for sinkers, and lures: 100 – 150 € per year Average expenditure for nets, ropes and lines: 300 – 350 € per year	[5]
Sweden	8 fishing days/year/fishers Average expenditure per fisher: 647 € per year Total number of fishing days: 12.7 million (8.5 million days in lakes and rivers and 4.3 million days in the sea) (study from 2019)	[6]
US	18 fishing days/year/fishers Average expenditure per fisher: $ 1 392 par year (i.e. 1 180 € per year) Average expenditure for sinkers, and lures: ca. $40 (i.e 33 €)	[7]

Source: [1] https://www.dfo-mpo.gc.ca/stats/rec/canada-rec-eng.htm

[2]:Communication from Finish Federation of Recreational Fishing (FFRF) - Suomen Vapaa-ajankalastajien Keskusjärjestö

[3]: https://www.sportvisserijnederland.nl/over-ons/feiten-en-cijfers/economie-en-werkgelegenheid.html

[4]: Communication from Ribiška zveza Slovenije (Fishing Association of Slovenia)

[5]: Communication from Alianza de Pesca Española Recreativa Sostenible (APERS)

[6]: https://www.scb.se/publication/40460

[7]: https://outdoorindustry.org/wp-content/uploads/2015/03/2018-Special-Report-on-Fishing_FINAL.pdf and https://www.fishwildlife.org/application/files/6015/3719/7579/Southwick_Assoc_-_ASA_Sportfishing_Econ.pdf and https://www.fws.gov/wsfrprograms/Subpages/NationalSurvey/nat_survey2016.pdf

National licencing system for fishing

The Dossier Submitter contacted various Fishers Associations, such as the European Angling Association (EAA), the International Sport Fishing Confederation (CIPS), the International Sea Fishing Federation (FIPS-M), the International Game Fish Association (IGFA), the European Federation of Sea Anglers (EFSA) and the European Anglers Federation (EAF), in order to obtain information the national fishing licences systems. Via EAA, only the Finnish, Dutch, Slovenian and Spain national fishing associations responded to the Dossier Submitter questionnaire. The other information presented in this section was essentially gathered from literature and internet search.

There is no harmonised fishing licencing system in Europe. Every country has its own rules. Some countries like France require a fishing licence for fishing in freshwater only, while others, such as Spain, only require a licence for marine fishing. The age limit to get a licence varies also from one country to another, as well as the fishing tackle allowed per fishing licence. Some countries, such as Croatia, Poland, or some German Landers, request the successful passing of a 'fishing exam' in order to obtain a fishing licence. The fishing licence price is also not harmonised among the European countries. Although not complete, Table A.2-7 gives an overview of the different fishing licence in Europe.

Table A.2-7: Overview of recreational fishing licence in Europe

Country	Recreational fishing licence description	Licence for freshwater	Licence for marine water
Austria		?	N.A.
Belgium	Anyone wishing to fish in running waters in Belgium needs to hold a state licence or permit for this sport. In addition, to fish in non-navigable waters it is necessary to obtain permission (usually in the form of another permit) from the holder of the fishing rights in that area. <u>Freshwater fishing:</u> 2 types of licence (valid for the year in which it is purchased) - One licence allows fishing only from the bank - One entitles the holder to fish from the bank, in a rowing boat, from a pier or standing in the water Both can be obtained from Post Offices and from some Tourist Offices. Permits can be renewed online via some angling associations. An exception is made for children under 14 years of age, who may fish without a permit on Saturdays, Sundays, national holidays and during school holidays, as long as an adult with a valid permit accompanies them. One adult can accompany up to four children. <u>Marine fishing:</u> does not require a licence. Anglers may fish from a jetty, in the harbour basin or from the beach. During high season there are areas set aside on the beaches for anglers	YES	NO
Bulgaria	Recreational fishing in Bulgaria can only be carried with a permit. This type of fishing can be carried out in Black Sea and in inland waters (rivers, lakes, dams etc). Some specific provisions are in force in order to regulate the recreational fisheries, for example: 'recreational fishing shall be carried out only with fishing rods and with harpoons.	YES	YES

Country	Recreational fishing licence description	Licence for freshwater	Licence for marine water
Croatia	Anglers buy licenses valid for a particular fishing zone from the owners of the fishing rights. These licenses can be valid for a larger area (fishing zones of other nearby owners) if the owners sign reciprocity contracts. Fishing licenses are owned by the state and issued by the Ministry of Agriculture through owners of the fishing rights, with validation periods of one day (daily license) or one year (yearly license). Yearly license buyers must have a fishing exam certificate, and foreign citizens too must possess this certificate issued in their home country. If they don't have said certificate, foreign anglers have to pass the exam in Croatia. Daily licenses are sold without the need for a fishing exam certificate.	YES	YES
Cyprus	Freshwater fishing: it is necessary to have a licence to fish. Licences are personal - they are non-transferable - and are only issued to people over 12 years of age. A fee can either be paid to fish in a single reservoir, or a higher rate can be paid to access all reservoirs. All licences expire on the 31 December of the year in which they are issued. The fishing rules describes the authorised fishing methods (i.e single rod, line and hook per licence holder) Marine fishing: no licence is needed for sea angling, fishing with vertical lines and trolling. However, a licence is required for fishing with harpoons, fishing with long-lines and traps, or fishing at night with spear guns.	YES	NO

Country	Recreational fishing licence description	Licence for freshwater	Licence for marine water
Czech Republic	Each angler has to obtain a fishing license and a fishing permit before he or she can start practicing recreational fishing. A fishing licence allows anglers to practice fishing in the Czech Republic. A fishing permit allows anglers to practice fishing on individual fishing grounds To obtain a fishing license the first time applicants have to pass an exam to show certain qualifications, e.g.: 1. Basic knowledge of fish and aquatic organisms. 2. Basic knowledge of biology of fish and aquatic organisms. 3. Basic knowledge of fishing methods. 4. Basic knowledge of fisheries management in fishing grounds. 5. Basic knowledge of Act No. 99/2004 Coll., On fish farming, exercise of fishing rights, fishing guard, protection of marine fishery resources and on the amendment of certain acts "	YES	N.A.
Denmark	A fee-paid state licence is required for recreational fishing in Danish territorial waters, with some exemptions for private land owners fishing in their own waters and for fishing in put-and-take lakes. Anyone between 18– 65 years needs a licence for angling. Anyone under or over that age can fish for free.	YES	YES
Estonia	Fishing with one simple hand line is free of charge and open to everyone; for other tackle a licence is required. There is a limited number of licences for gillnets, longlines and other multi-catching gears.	YES	YES

Country	Recreational fishing licence description	Licence for freshwater	Licence for marine water
Finland	Freshwater fishing: all fishers aged 18–64 years have to pay a fishing management fee, except for angling with a hook and line, ice-fishing, and herring fishing with a rig, which are free of charge. For other fishing methods and for fishing with more than one rod, fishers need to pay the fishing management fee as well as have permission by the water owner. The fishing management fee is 45 euros for 1 year, 15 euros for 7 days and 6 euros for 1 day. Marine fishing: no permit required for recreational fishing in public waters in the sea.	YES	NO
France	Freshwater fishing: a fishing rod licence (carte de peche) or a permit (from the landowner in case of private fisheries water) for legal freshwater fishing is needed in France. Marine fishing: there is no licensing system or registry of marine recreational fishers	YES	NO
Germany	Both a federal fishing rod licence and a coastal fishing permit are required (except in Lower Saxony). German anglers have to pass a sport fishing exam to get a licence. In some federal states, notably both Baltic coastal States, domestic and foreign tourists can purchase a restricted tourist licence (valid 28 days) without passing an exam.	YES	YES
Greece	According to law (p.d. 99/2003 A' 94), the use of vessels for recreational fishing is not allowed and only the use of line gears is allowed, with the exception of longlines. For recreational and commercial inland fisheries, the number of licenses sold are collected. The responsible institution for providing these licences is the Ministry of Rural Development and Food (http://www.minagric.gr/index.php/en/)."""	?	YES

Country	Recreational fishing licence description	Licence for freshwater	Licence for marine water
Hungary	All recreational anglers or fishers, regardless of the type of water, must keep an official logbook where they immediately record all caught (and kept) fish. The logbook must be submitted to the angler's association (in Hungary all anglers must be members of an angling association) at the end of the year (and no later than 28 February of the subsequent year).	?	N.A.
Ireland		?	NO
Italy		?	NO
Latvia	For angling, there is a general fishing licence, as well as additional fishing permits for specific water bodies. Gear-specific limited licences are required for other recreational fisheries.	YES	YES
Lithuania	A fishing licence is needed for all recreational fishing and in some waters a special fishing permit is required as well. In order to fish for salmon, sea trout, whitefish and river lamprey, an amateur fishing permit is necessary.	YES	YES
Luxembourg		?	N.A.
Malta	No permits are required for recreational fishing. With a few exceptions, everyone is free to fish at any location at any time using: - hook and line - fish spear or grains - basket traps - small hand nets - other minor recognised implements	NO	NO
Netherlands		?	NO
Poland	Mandatory rod licence for everyone over 14 years, as well as an area-specific permit, for freshwater. Everyone has to pass an exam to get their rod licence. For the Baltic Sea, no licence but a sea fishing permit is required.	YES	NO

Country	Recreational fishing licence description	Licence for freshwater	Licence for marine water
Portugal	Anglers need to register to buy an annual licence for recreational fishing. The recreational fishing is essentially done on the coasts. With regard to regulation aspects, 92% of fishers had a valid fishing licence.	YES	YES
Romania		?	?
Slovakia		?	N.A.
Slovenia		YES	YES
Spain	In some areas, the licence does not have to be annual, but can valid up to four years, which means the number of licences issued annually do not coincide with the actual numbers in force. Also, there are some licences that authorize fishing in several Autonomous Communities so that fishers can make excursions to other Communities. Fishing from boats are issued for each boat in particular, but do not specify the number of authorized fishers In other cases, such as in Catalonia, fishing licenses serve both inland and marine waters.	YES	YES
Sweden		?	YES

Sources: National fishing association websites, FAO data collection 2020, Report on recreation fishing in the sea Baltic region available at https://ccb.se/wp-content/uploads/2018/02/ccb_recreational_fishing.pdf

A.2.1.2. Commercial fishing

Definition of commercial fishing

Commercial fishing designate fishing whose primary aim is to generate resources to meet nutritional (i.e. essential) human needs. Fish and other aquatic organisms caught from commercial fishing are sold on domestic and export markets. Commercial fishing includes fishing that supplies feed to the aquaculture and agriculture sectors and raw material to other industrial sectors (e.g. the biomedical sector) (Commission, 2008).

Commercial fishing gear description

Fishing tackle is more usually called 'fishing gear' in the context of commercial fishing, nevertheless as some fishing tackle, such as sinkers and lures, are used both in recreational and commercial fishing, we will use consistently, in this Annex XV report, the term 'fishing tackle' to designate the equipment used by fishers, both in recreational or commercial activities, when fishing.

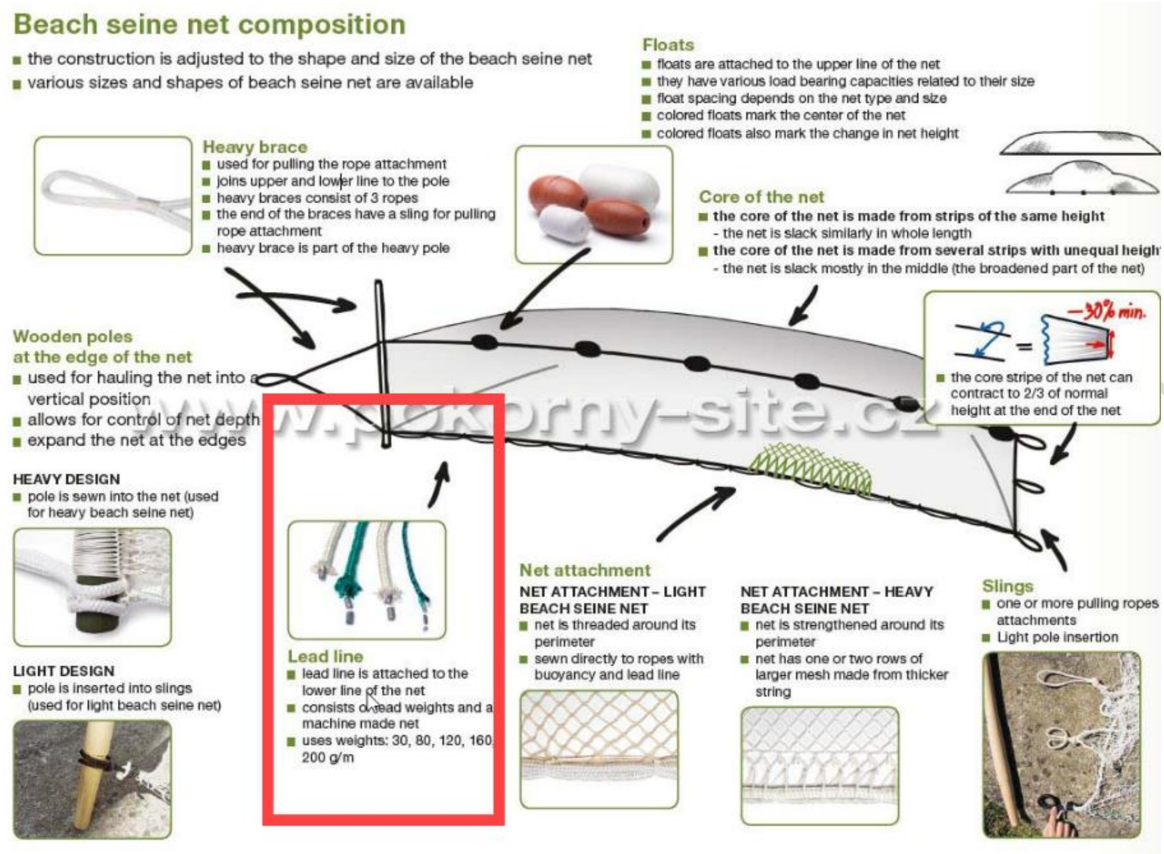
The fishing gears/tackle definition according to EUROSTAT is described in Table A.2-8. Lead is mainly present in nets, trawls and purse seine.

Lead is often encapsulated/enclosed in fishing nets in long ropes, head ropes, lead line, so that the net is kept vertical in the water.

In some trawling, lead is used to weigh the trawl down on the bottom. Lead weights/sinkers each of 110 g (in general) are threaded onto the line, and the total quantity on a trawl is 20-35 kilograms depending on the size of the trawl. A trawl can be used for about 10 years.

A purse seine is a long net with floats at the top and lead weights at the bottom. The lead is enclosed in a lead line[5] and there is a total of up to 1 200 kg lead in a purse seine. Purse seine have a 20-year long life (COWI, 2004, KEMI, 2007). Lead is also enclosed in a fishing line in seine nets as depicted in Figure A.2-2.

[5] In the Cowi report, it was indicated that lead is not enclosed in purse seine. This statement seems to not be valid anymore in 2020 for the purse seine nets.



Source: pokorny-site.cz

Figure A.2-2: Illustration of a seine net (beach type)

In some other applications, lead sinkers are added to the nets (for example ring sinkers). These sinkers are not embedded/enclosed in the nets. The size and design of the sinkers may differ considerably as shown below. Lead sinkers for fishing nets ranges from about 50 g to several kg per weight.

Source: (COWI, 2004).

Figure A.2-3: Example of sinkers added to fishing nets

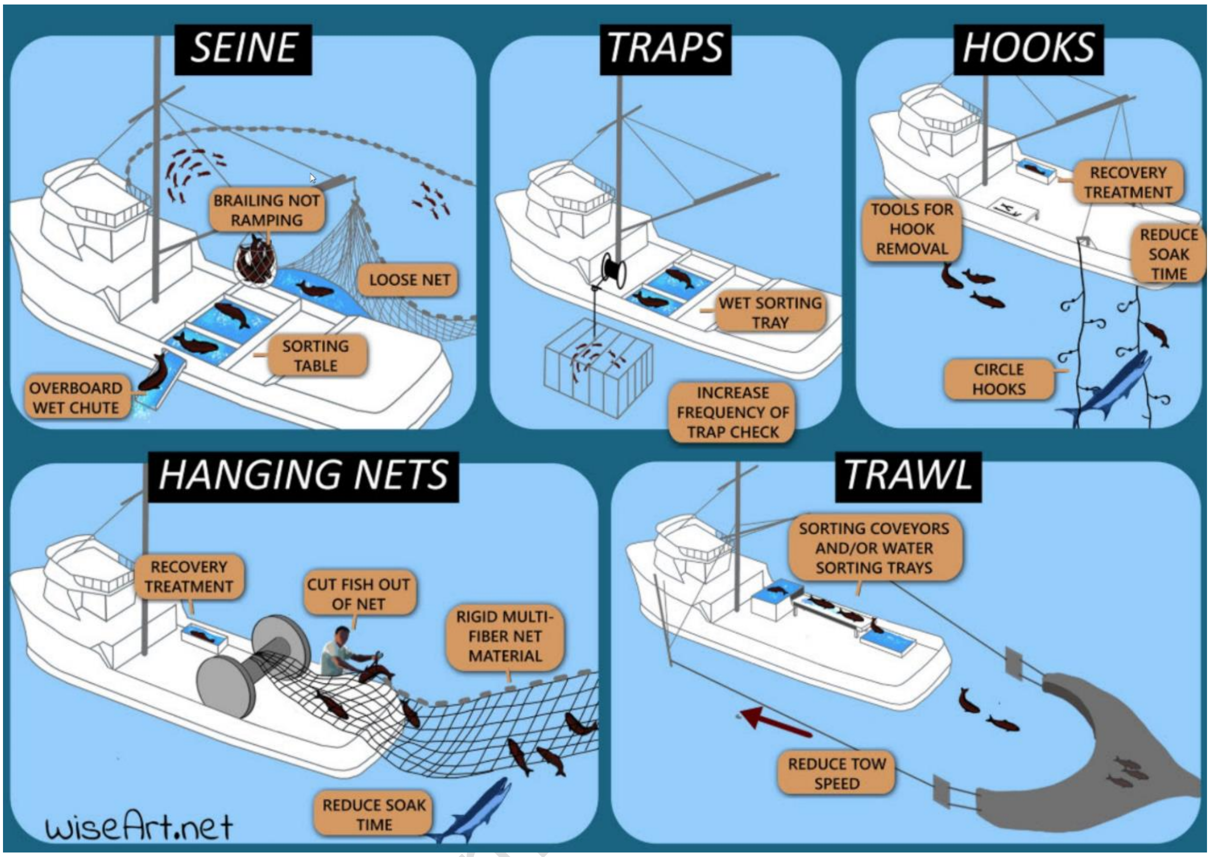
Table A.2-8: Gear types for commercial fishing – EUROSTAT definition

Fishing Gear Type	Includes	Lead inside?
Surrounding Nets Sun	Purse Seines Lampara Nets	YES – enclosed in lead line
Seine Nets	Beach Seines Danish Seines Scottish Seines Pair Seines	YES – enclosed in lead line
Trawls	Beam Trawls Bottom Otter Trawls Bottom Pair Trawls Midwater Otter Trawls Pelagic Pair Trawls Otter Twin Trawls	YES for Bottom trawl (essentially)
Dredges	Boat Dredges Hand Dredges Used On Board Of A Vessel Mechanised Dredges Including Suction Dredges	YES
Lift Nets	Boat-Operated Lift Nets Shore-Operated Stationary Lift Nets	YES
Gillnets And Entangling Nets	Set (Anchored) Gillnets Drift Gillnets Encircling Gillnets Trammel Nets Combined Trammel And Gillnets	Some yes. Some no (e.g. drift net)
Pots	Pots	Most probably not
Hooks And Lines	Handlines And Pole Lines (Hand-Operated) Handlines And Pole Lines (Mechanised) Set Longlines Drifting Longlines Trolling Lines	YES (sinkers and jigs similar to recreational fishing tackle)

Source: Eurostat (2017) Fishing fleet metadata (fish_fleet), consulted on 8/06/2020

On some small vessels the fishing gear is often set and lifted by hand. Medium and large fishing vessels are fitted with appropriate machinery and equipment: derrick, winches, net and line haulers, power blocks, net drums and other specialized gear.

Examples of various commercial fishing tackle are presented in Figure A.2-4.



Source: drawing made using wiseArt.net

Figure A.2-4: Illustration of various commercial fishing tackle

Statistics and key figures

In order to operate as a commercial fisher, fishers must register their vessels as fishing vessels with the national EU authorities. Fishing vessels can be divided into two groups, coaster vessels (vessels less than 12m), aka SFS for 'Small Scale Fishery', and trawler vessels (vessels at least 12m).

Table A.2-9 gives an overview of the number of vessels equipped with specific fishing gear. Commercial vessels equipped with hooks and lines, i.e. using among other fishing tackle, fishing sinkers and/or lures, counts for ca. 19% of the total commercial vessel fleet in EU-27 (2020) with 14 230 vessels registered for that type of equipment.

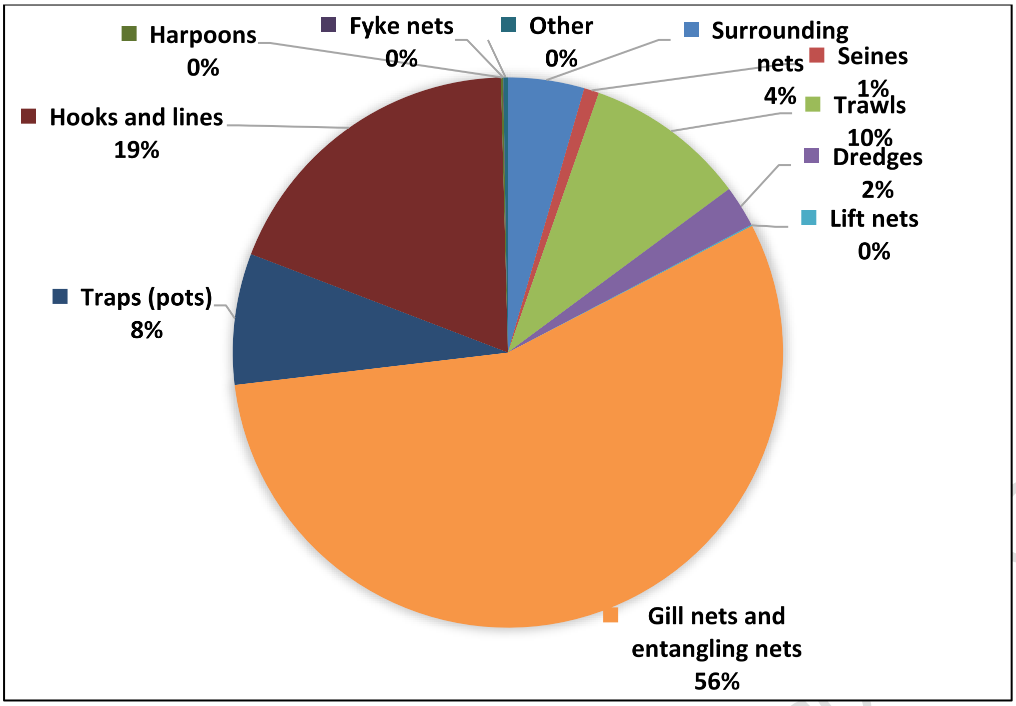
Despite an increase in 2013, when Croatia joined the EU, the number of commercial vessels equipped with lead fishing tackle and gears keeps on decreasing year after year.

Table A.2-9: Commercial fishing vessels overview in EU-27 (2020)

Fishing fleet type	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
All types of gears	77633	76914	75402	74014	80491	79644	77971	77382	76456	75814
Surrounding nets	3532	3474	3348	3264	3548	3519	3453	3473	3436	3398
Seines	707	702	597	509	734	714	693	678	679	668
Trawls	8661	8305	7922	7656	8112	7903	7665	7575	7475	7206
Dredges	1908	1923	1923	1931	1901	1860	1883	1868	1850	1854
Lift nets	37	39	43	45	49	47	51	51	52	54
Gill nets and entangling nets	40484	40378	39855	39194	44181	43878	43095	42822	42470	42256
Traps (pots)	6223	6270	6273	6434	6648	6617	6225	6178	5903	5839
Hooks and lines	16081	15823	15441	14981	15056	14844	14651	14473	14318	14230
Harpoons	0	0	0	0	85	83	83	86	91	94
Fyke nets	0	0	0	0	0	0	0	1	1	18
Other (miscellaneous, no gear, unknown)	0	0	0	0	177	179	172	177	181	197

Source: Eurostat, data extracted on 8/06/2020, last data updated on 24/02/2020 by Eurostat

Nets, ropes and lines potentially containing lead might be used on max. 92% of the of the total commercial vessel fleet in EU-27 (2020) as depicted in Figure A.2-5. Fishing sinkers and lures are used on max. 19% of the European fishing fleet.



Source: Eurostat, data extracted on 8/06/2020, last data updated on 24/02/2020 by Eurostat

Figure A.2-5: Repartition of fishing gear in the commercial fishing vessel fleet (year 2018)

A.2.1.3. Home-casting

Home-casting description

The following equipment is needed for home-casting sinkers and lures:

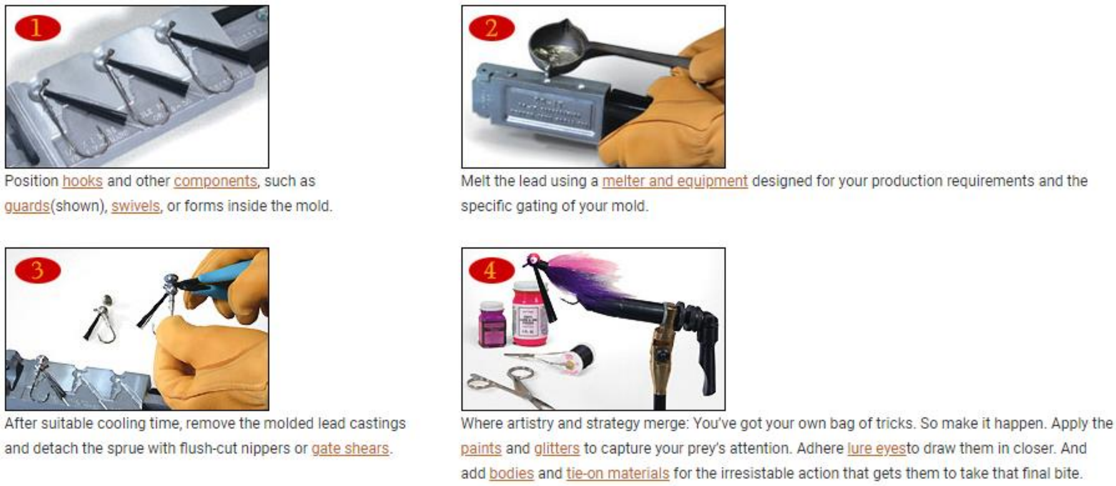
- A melting equipment
- Lead
- Moulds

In home-casting, the melting of lead is done usually in a very conventional cooking pot using a gas camping cooker. More elaborated, and dedicated melting equipment can also be purchased on the web.

The lead raw material can either be professional casting metal sold from specialised retailers in shops or on the web (e.g. http://www.naturabuy.fr/Plomb-fondre-cat-2580.html) or any object made of lead which is not used anymore (for example old car counterbalancing lead weight which can be acquired from car dealers, or old lead from roofers/thatches, etc… Lead can also be purchased from 'general retailing' website such as ebay (e.g. http://www.ebay-kleinanzeigen.de/s-bleibarren/k0).

The moulds can also be purchased from professional retailers in shops or on the web (e.g. http://www.midnightmoon.nl/) or from 'general retailing' website such as ebay (e.g. http://www.ebay.de/b/Angelsport-Bleigussform/161826/bn_52468110). Cooking-ware such as silicone moulds can also be used for home-casting. On internet, instructions and videos are also available for the fishers to construct their own mould in metal (aluminium, or steel), silicone or gypsum.

Instructions and videos for home-casting sinkers and lures are easily available on internet. The figure below is an example of instructions to home-cast jigs.



Source: picture and instruction from store.do-itmolds.com

Figure A.2-6: Step by step instructions to home-cast fishing lure

Source: brochure of a retailer producing also 'home-made' fishing sinkers

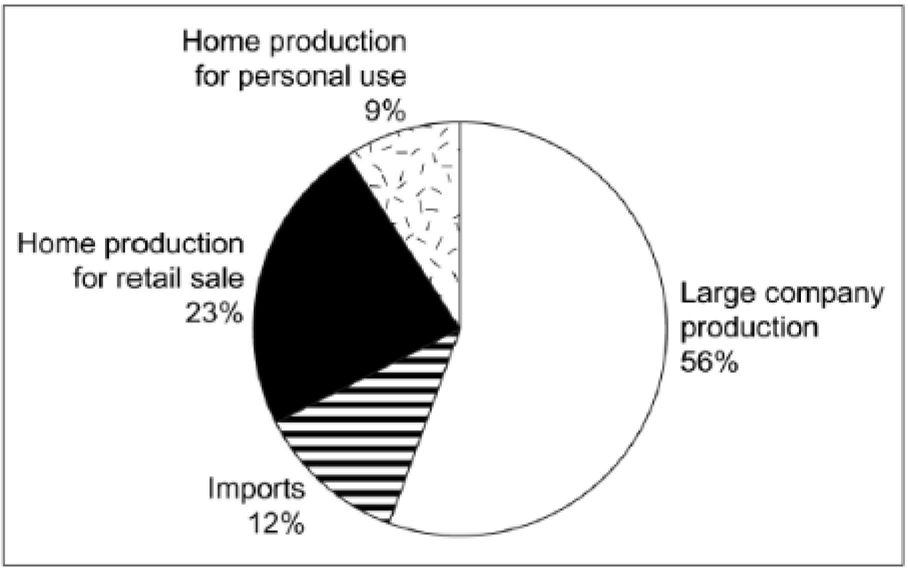
Figure A.2-7: Example of home-casting in non industrial, non OSH settings

Statistics and key figures

No EU-wide statistic could be found on the home-casting practice in Europe. Only limited information, often old, could be retrieved on home-casting statics.

For example, a survey carried out in 2019 in The Netherland (N=164) reported that 12% of the respondents were casting lead on average four times per year (CfE #1153). The Danish EPA reported also in 2000 prior the entry into force of the ban on lead fishing tackle (for recreational fishing), that about 25% of the fishers members of an angling association[6] used to perform home-casting of lead fishing sinkers (Lassen C, 2004).

According to the US EPA (US EPA, 1994) and a study carried out by Nussman in 1994, it was estimated that 2 500 – 2 600 tonnes of lead fishing sinkers were sold annually in 1994, in the United States. Do-it-yourself home-casting for retail and personal use together contributed for about 30% of this quantity (i.e. 875 tonnes) as depicted in Figure A.2-8 (Scheuhammer, 2003).



Source: (Scheuhammer, 2003)

Figure A.2-8 Sources of lead fishing tackle in the U.S based on 1994 estimates

[6] ca. half of the 60 000 Danish fishers were members of an angling association at that time.

A.2.2. Manufacturing, import and export

A.2.2.1. Value of sold production, exports and imports by PRODCOM list (NACE Rev. 2)

Table A.2-10 provides an overview of the sold production, exports and imports of fishing rods, other line fishing tackle; articles for hunting or fishing during the year 2018.

Even though the scope of the fishing equipment reported in the Table A.2-10 is broader than just lead sinkers and lures, it gives an indication of the share of the imported fishing tackle placed on the market in Europe: this ratio in value is ca. 2.6 (import/production).

In 2000, according to the information available in the COWI report (Table A5. 18) for the geographical scope EU15-2020, this ratio was only 1 (COWI, 2004), meaning that in 2018 fishing tackle placed on the market in Europe seems to come more frequently from abroad than before.

According to Table A.2-10, France is by far the biggest manufacturing country of fishing equipment in value in Europe, followed by Finland, Italy and Estonia.

In the following tables:

- PRODUCTION VALUE: this field gives the value of production in Euro.
- IMPORT VALUE: this field gives the value of imports in Euro, derived from the External Trade statistics.
- EXPORT VALUE: this field gives the value of exports in Euro, derived from the External Trade statistics.

Table A.2-10: Sold production, exports and imports of fishing rods, other line fishing tackle; articles for hunting or fishing n.e.c. (Jan-Dec 2018)

Country	Export value [€]	Import value [€]	Production value [€]	Note
Austria	5 548 070	15 427 460	0	
Belgium	35 543 650	31 593 420	0	
Bulgaria	2 366 660	3 429 560	1 501 687	
Croatia	2 330 170	7 135 860	2 119 067	
Cyprus	30 750	1 683 620	0	
Czechia	2 440 930	13 309 910	1 075 720	
Denmark	11 446 580	24 166 340	0	
Estonia	28 165 270	10 699 260	9 401 275	
Finland	14 312 240	18 563 670	20 356 086	

Country	Export value [€]	Import value [€]	Production value [€]	Note
France	63 197 340	91 199 180	28 846 622	
Germany	55 380 840	88 368 620	N.A.	(2)
Greece	421 430	7 380 660	0	
Hungary	4 630 570	12 223 380	1 254 614	
Ireland	533 540	5 411 920	0	
Italy	20 669 950	37 479 080	9 587 000	
Latvia	3 978 740	4 756 880	:	(2)
Lithuania	5 005 830	7 962 800	851 096	
Luxemburg	2 300	298 040	0	
Malta	13 730	475 780	0	
Netherlands	73 686 070	84 889 990	N.A.	(1)
Poland	54 389 280	49 442 750	1 326 927	
Portugal	2 906 690	8 255 400	817 519	
Romania	2 603 570	14 692 300	0	
Slovakia	3 734 920	7 455 290	0	
Slovenia	2 069 120	4 776 170	0	
Spain	38 116 100	53 504 310	1 204 057	
Sweden	22 743 350	30 143 450	N.A.	(2)
EU27_2020	115 874 390	405 737 350	88 094 671	(3)
United Kingdom	36 397 950	70 811 310	30 125 126	

Source: Eurostat, data extracted on 8/06/2020, last data updated on 14/02/2020 by Eurostat

PRCCODE:32301600 - Fishing rods, other line fishing tackle; articles for hunting or fishing n.e.c.

PERIOD:Jan.-Dec. 2018

Note: (1): Data for this item is estimated and has been suppressed, (2) Data for this item is confidential and has been suppressed, (3) EU27_2020 stands for the 27 countries part of the European Union in 2020 (i.e. AT, BE, BG, CY, CZ, DE, DK, EE, ES, FI, FR, GR, HR,HU, IE, IT, LT, LU, LV, MT, NL, PL, PT, RO, SE, SI, SK)

This table is equivalent to table A5-18 in COWI (2004).

Table A.2-11 provides an overview of the sold production, exports and imports of fishing nets during the year 2018. It gives an indication of the share of the imported fishing tackle placed on the market in Europe: this ratio in value is ca. 0.14 (import/production). In term of values, fishing nets seem to be essentially produced in Europe, and the import from outside Europe is marginal compared to the local production.

In 2000, and according to the information available in the COWI report (Tables A5. 25) for the geographical scope EU15-2000, this ratio was at least 0.3[7] (COWI, 2004). So it seems that the market of the fishing nets has remained stable during the period 2000-2020.

Table A.2-11: Sold production, exports and imports of fishing nets in value (Jan-Dec 2018)

Country	Export value [€]	Import value [€]	Production value [€]	Note
Austria	24 140	20 900	-	
Belgium	90 360	287 520	-	
Bulgaria	1 110	144 330	-	(1)
Croatia	1 350 600	212 050	3 427 248	
Cyprus	-	482 700	-	
Czechia	245 150	17 530	-	
Denmark	10 150 180	13 113 680	9 959 883	
Estonia	2 726 090	937 550	937 146	
Finland	159 860	1 209 270	-	
France	3 376 540	8 233 700	17 551 740	
Germany	2 653 850	3 012 520	-	
Greece	1 633 840	4 138 660	-	(1)

[7] The production value in the COWI Report was incomplete due to missing production information from a majority of the reporting country.

Country	Export value [€]	Import value [€]	Production value [€]	Note
Hungary	3 280	20 370	-	
Ireland	2 287 560	2 137 570	11 607 000	
Italy	8 043 530	2 267 880	17 466 000	
Latvia	1 977 630	2 228 420	-	
Lithuania	16 667 240	8 789 440	21 353 442	
Luxemburg	60	17 030	-	
Malta	44 780	305 230	-	
Netherlands	5 309 630	4 226 320	-	(1)
Poland	70 560	1 172 670	-	
Portugal	23 746 380	958 900	25 616 454	(1)
Romania	2 440	313 700	-	
Slovakia	2 955 430	43 650	-	(1)
Slovenia	105 940	74 580	-	
Spain	36 401 240	11 148 240	66 561 247	(1)
Sweden	35 120	667 960	-	
EU27_2020	67 543 890	28 868 850	192 561 396	(2)
United Kingdom	237 550	6 993 050	-	(1)

Source: Eurostat, data extracted on 19/08/2020, last data updated on 04/08/2020 by Eurostat

PRCCODE: 13941233 - Made-up fishing nets from twine, cordage or rope of man-made fibres (excluding fish landing nets)

And 13941235 - Made-up fishing nets from yarn of man-made fibres (excluding fish landing nets)

Note: (1): Some data for this item is confidential and has been suppressed, (2) EU27_2020 stands for the 27 countries part of the European Union in 2020 (i.e. AT, BE, BG, CY, CZ, DE, DK, EE, ES, FI, FR, GR, HR,HU, IE, IT, LT, LU, LV, MT, NL, PL, PT, RO, SE, SI, SK)

This table is equivalent to table A5-25-26 in COWI (2004).

Table A.2-12 provides an overview of the sold production, exports and imports of fishing nets during the year 2018 in quantity (tpa). It gives an indication of the share of the imported fishing tackle placed on the market in Europe: this ratio in volume (tpa) is ca. 0.3 (import/production). This confirms that fishing nets seem to be essentially produced in Europe, and the import from outside Europe is marginal compared to the local production.

In 2000, and according to the information available in the COWI report (Tables A5. 26) for the geographical scope EU15-2000, this ratio was at least 0.3[8] (COWI, 2004). So it seems that the market of the fishing nets has remained stable during the period 2000-2020.

According to Table A.2-11 and Table A.2-12, Spain is by far the biggest manufacturing country of fishing nets in Europe, followed by Portugal, Lithuania, Italy and Ireland.

Table A.2-12: Sold production, exports and imports of fishing nets in quantity (tpa) (Jan-Dec 2018)

Country	Export value [tpa]	Import value [tpa]	Production value [tpa]	Note
Austria	0.6	2.1	-	
Belgium	34.9	43.6	-	
Bulgaria	0.2	29.9	-	(1)
Croatia	165.1	24.1	261.7	
Cyprus	-	62.6	-	
Czechia	3.7	1.6	-	
Denmark	1 058.0	2 409.6	554.7	
Estonia	558.3	216.3	620.3	
Finland	6.8	110.9	-	
France	474.0	1 372.0	915.3	
Germany	510.0	591.0	-	
Greece	171.7	519.9	-	(1)

[8] The produced quantity in the COWI Report was incomplete due to missing production information from a majority of the reporting country.

Country	Export value [tpa]	Import value [tpa]	Production value [tpa]	Note
Hungary	0.2	5.6	-	
Ireland	204.3	310.8	1 589.0	
Italy	766.4	372.1	1 614.4	
Latvia	128.9	200.9	-	
Lithuania	2 042.4	5 171.7	2 571.7	
Luxemburg	-	3.6	-	
Malta	1.8	40.5	-	
Netherlands	634.0	751.2	-	(1)
Poland	2.0	307.3	-	
Portugal	4 306.0	143.8	5 561.0	(1)
Romania	0.2	34.8	-	
Slovakia	248.4	22.3	-	(1)
Slovenia	9.4	17.8	-	
Spain	6 065.4	3 179.0	13 089.7	(1)
Sweden	1.3	44.8	-	
EU27_2020	9 851.0	9 298.0	29 264.0	(2)
United Kingdom	123.4	1 182.2	-	(1)

Source: Eurostat, data extracted on 19/08/2020, last data updated on 04/08/2020 by Eurostat

PRCCODE: 13941233 - Made-up fishing nets from twine, cordage or rope of man-made fibres (excluding fish landing nets)

And 13941235 - Made-up fishing nets from yarn of man-made fibres (excluding fish landing nets)

Note: (1): Some dData for this item is confidential and has been suppressed, (2) EU27_2020 stands for the 27 countries part of the European Union in 2020 (i.e. AT, BE, BG, CY, CZ, DE, DK, EE, ES, FI, FR, GR, HR,HU, IE, IT, LT, LU, LV, MT, NL, PL, PT, RO, SE, SI, SK)

This table is equivalent to table A5-25-26 in COWI (2004).

A.2.2.2. Extra-EU trade information on fishing tackle in volume (tpa) and in value

Table A.2-13 and Table A.2-14 provide an overview of the trade balance (exports vs imports) of line fishing tackle and other equipment type in 2015 and 2019 in quantity and in value. Similar information was available in the COWI report (tables A5. 19 to A5.21).

PRODUCT: Line fishing tackle n.e.s[9]; fish landing nets, butterfly nets and similar nets; decoys and similar hunting or shooting requisites (excl. decoy calls of all kinds and stuffed birds of heading 9705) – Customs code: 95079000

Extra-EU[10] refers to transactions with all countries outside of the EU: the rest of the world except for the European Union (EU) Member States. The term is used in the context of external trade, balance of payments, foreign direct investment, migration, transport, tourism and similar statistical areas where goods, capital or people moving in and out of the EU are being measured and where the EU as a whole is considered in relationship to the rest of the world. Extra-EU transactions of the EU as a whole are the sum of the extra-EU transactions of the EU Member States.

Table A.2-13: Extra-EU trade information on fishing tackle per country (in volume)

	2015				2019				Average annual rate of change 2015-2019	
	IMPORT [tpa]	EXPORT [tpa]	Trade balance [tpa]	Cover ratio (export/import)	IMPORT [tpa]	EXPORT [tpa]	Trade balance [tpa]	Cover ratio	IMPORT [%]	EXPORT [%]
AUSTRIA	119	18	-101	0.15	108	2	-107	0.02	-2.35	-44.79
BELGIUM	472	369	-103	0.78	1255	244	-1011	0.19	27.72	-9.84
BULGARIA	55	5	-49	0.10	136	7	-129	0.05	25.63	7.46
CYPRUS	7	-	-7	-	12	0	-11	0.01	14.04	#DIV/0!

[9] n.e.s: stands for 'not elsewhere specified'

[10] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Intra-EU

	2015				2019				Average annual rate of change 2015-2019	
	IMPORT [tpa]	**EXPORT [tpa]**	**Trade balance [tpa]**	**Cover ratio** (export/import)	**IMPORT [tpa]**	**EXPORT [tpa]**	**Trade balance [tpa]**	**Cover ratio**	**IMPORT [%]**	**EXPORT [%]**
CZECHIA	135	5	-130	0.04	165	7	-158	0.04	5.17	8.20
GERMANY	1676	99	-1577	0.06	1712	36	-1676	0.02	0.54	-22.51
DENMARK	645	268	-378	0.41	478	187	-291	0.39	-7.21	-8.57
ESTONIA	37	293	256	7.90	66	274	208	4.14	15.62	-1.64
SPAIN	976	605	-371	0.62	1025	1129	104	1.10	1.24	16.86
FINLAND	388	123	-264	0.32	273	124	-149	0.45	-8.40	0.18
FRANCE	1762	336	-1425	0.19	1275	275	-1000	0.22	-7.77	-4.90
GREECE	153	13	-139	0.09	269	6	-264	0.02	15.23	-19.81
CROATIA	46	4	-43	0.08	42	14	-28	0.34	-2.53	41.67
HUNGARY	114	34	-81	0.29	279	20	-259	0.07	25.00	-11.95
IRELAND	349	23	-326	0.07	471	120	-351	0.26	7.77	51.10
ITALY	687	394	-293	0.57	647	240	-407	0.37	-1.46	-11.63
LITHUANIA	78	69	-9	0.89	79	59	-20	0.75	0.38	-3.91

	2015				2019				Average annual rate of change 2015-2019	
	IMPORT [tpa]	**EXPORT [tpa]**	**Trade balance [tpa]**	**Cover ratio (export/import)**	**IMPORT [tpa]**	**EXPORT [tpa]**	**Trade balance [tpa]**	**Cover ratio**	**IMPORT [%]**	**EXPORT [%]**
LUXEMBOURG	0		-0	-	0	-	-0	-	-15.91	-
LATVIA	61	20	-41	0.33	82	31	-51	0.38	7.81	11.66
MALTA	4	0	-4	0.02	7	-	-7	-	15.51	-100.00
NETHERLANDS	1290	67	-1223	0.05	2106	77	-2030	0.04	13.03	3.48
POLAND	522	88	-434	0.17	1065	348	-717	0.33	19.52	40.98
PORTUGAL	37	22	-15	0.59	65	14	-51	0.21	15.41	-10.96
ROMANIA	145	1	-144	0.00	333	-	-333	-	23.23	-100.00
SWEDEN	548	153	-396	0.28	505	137	-368	0.27	-2.01	-2.63
SLOVENIA	86	1	-85	0.01	54	4	-50	0.08	-10.89	40.61
SLOVAKIA	130	5	-125	0.04	122	26	-96	0.22	-1.56	53.80
EU27_2020	**10 520**	**3 015**	**-7 505**	**0.29**	**12 633**	**3 382**	**-9 251**	**0.27**	4.68	2.91

Source: Based on Eurostat, data extracted on 19/08/2020, last data updated on 14/08/2020 by Eurostat

Note: This table is equivalent to table A5-19-to 21 in COWI (2004).

Table A.2-14: Extra-EU Trade information on fishing tackle (in value)

	2015				2019				Average annual rate of change 2015-2019	
	IMPORT [million€]	EXPORT [million €]	Trade balance [million €]	Cover ratio (export/import)	IMPORT [million €]	EXPORT [million €]	Trade balance [million €]	Cover ratio	IMPORT [%]	EXPORT [%]
EU27_2020	152	69	-83	0.45	174	70	-104	0.40	3.44	0.36

Source: Based on Eurostat, data extracted on 19/08/2020, last data updated on 14/08/2020 by Eurostat

A.2.2.3. Extra-EU trade in sporting goods by product in value

Table A.2-15 provides an overview of the trade balance (exports vs imports) of Fishing rods, fish-hooks, fishing reels and other fishing equipment in 2013 and 2018 in value.

PROD_SP Fishing rods, fish-hooks, fishing reels and other fishing equipment

Extra-EU[11] refers to transactions with all countries outside of the EU: the rest of the world except for the European Union (EU) Member States. The term is used in the context of external trade, balance of payments, foreign direct investment, migration, transport, tourism and similar statistical areas where goods, capital or people moving in and out of the EU are being measured and where the EU as a whole is considered in relationship to the rest of the world. Extra-EU transactions of the EU as a whole are the sum of the extra-EU transactions of the EU Member States.

[11] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Intra-EU

Table A.2-15: Extra-EU trade information on sport (recreational) fishing equipment (in value)

	2013				2018				Average annual rate of change 2013-2018	
	IMPORT [million€]	EXPORT [million €]	Trade balance [million €]	Cover ratio (export/import)	IMPORT [million €]	EXPORT [million €]	Trade balance [million €]	Cover ratio	IMPORT [%]	EXPORT [%]
EU27_2020	306	122	-184	0.40	408	116	-292	0.28	5.9	-1.0

Source: Eurostat, data extracted on 8/06/2020 – last data updated on 24/02/2020, summary also available from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=International_trade_in_sporting_goods#Main_product_groups

Note: Extra-EU[12] refers to transactions with all countries outside of the EU: the rest of the world except for the European Union (EU) Member States. The term is used in the context of external trade, balance of payments, foreign direct investment, migration, transport, tourism and similar statistical areas where goods, capital or people moving in and out of the EU are being measured and where the EU as a whole is considered in relationship to the rest of the world. Extra-EU transactions of the EU as a whole are the sum of the extra-EU transactions of the EU Member States.

Intra-EU, on the other hand, refers to all transactions occurring within the EU. The term can have a different coverage, depending on the perspective taken: the EU as a whole, a Member State, a region or a city, a port or an airport

[12] https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Intra-EU

A.2.2.4. Manufacturing process description

Split shots below 4 mm

Split shots above 4 mm

Split shots above 4 mm are manufactured by pouring molten lead into moulds of various sizes.

Lead sinkers

Lead fishing sinkers are manufactured by pouring molten lead into moulds of various sizes and shapes.

Lure (e.g. jigs)

Spin casting is commonly used to cast lead onto fishhooks for small jig making: lead is melted and then poured into a lead jig mould.

Figure A.2-9 Spin casting mould to manufacture jigs or jig-heads.
Source: picture from https://www.tekcast.com/Fishing-Lure-Manufacturing-_c_120.html

Fishing nets, ropes and lines

The production of lead fishing nets, ropes and lines are linked to each other (COWI, 2004).

1) Manufacturing of lead wire by extrusion

The lead wire or lead string of beads also called lead rosary (small pieces of lead threaded on a plastic rope) are manufactured by few companies who then further supply the manufacturers of lead lines and seine ropes.

Lead rosary for internal ballasting of rope.

Figure A.2-10: example of lead rosary used to produce a fishing rope

2) Manufacturing of lead lines and seine ropes

During the production of lead lines, the lead strings and rosary are covered by a woven plastic stocking of polypropylene, polyester or other plastics. Lead lines are typically manufactured by the manufacturers of fishing nets who use the lines directly or sell the lines to other fishing nets manufacturers.

Lead lines are produced in different diameters and weight/meter.

3) Manufacturing of fishing nets

During the manufacturing of fishing nets, the lead- lines are sewn onto the netting. The netting is usually manufactured by other companies specialised on netting and ropes.

In fishing nets made of lead fishing lines, the lead is embedded in a woven plastic and not accessible by the fishers.

In some fishing nets, the lead lines are replaced by sinkers usually assembled by the fisher themselves.

Annex B: Information on hazard, releases, exposure and risk

B.1. Identity of the substance(s) and physical and chemical properties

B.1.1. Name and other identifiers of the substance(s)

See Annex XV report.

B.1.2. Composition of the substance(s)

See Annex XV report.

B.1.3. Physicochemical properties

See Annex XV report.

B.1.4. Justification for grouping

See Annex XV report.

B.2. Manufacture and uses (summary)

Manufacture and uses are outlined in Section A.

B.3. Classification and labelling

B.3.1. Classification and labelling in Annex VI of Regulation (EC) No 1272/2008 (CLP Regulation)

Lead powder (particle diameter <1 mm) or lead massive (particle diameter ≥ 1 mm) are classified for reproductive toxicity, Repr. 1A (H360FD) and lactation, Lact. (H362). In addition, a specific concentration limit for lead powder of 0.03 % applies; for lead massive a generic concentration limit of ≥ 0.3 % applies.[13]

A proposal for a harmonised classification for lead powder and lead massive was adopted by ECHA's Risk Assessment Committee on 30 November 2018. The proposal includes to retain the classifications for Repr. 1A (H360FD) and Lact. (H362) and to add Aquatic Acute 1 (H400) and Aquatic Chronic 1 (H410).[14] The updated harmonised C&L has been adopted for lead powder in the Commission Delegated Regulation (EU) 2020/1182 and applies from 1 March 2022 (ATP15[15]) (see also Table B.3-1). With regard to lead massive it is stated in this amendment to the Regulation that "*in view of the lower dissolution rate of the massive form, the malleable structure of lead, the specific intentional production of the powder and the different environmental classification between massive and powder forms for existing entries in Annex VI for other metals, further assessment needs to be done by RAC on whether to apply the same environmental classification to the massive as to the powder form of lead. In addition, new scientific data has been made available suggesting that the environmental classification for the massive form as*

[13] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32016R1179

[14] https://echa.europa.eu/registry-of-clh-intentions-until-outcome/-/dislist/details/0b0236e180db34ea

[15] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=uriserv:OJ.L_.2020.261.01.0002.01.ENG

recommended in the RAC opinion might not be appropriate Therefore, the environmental classification for the massive form will not be included in Annex VI to Regulation (EC) No 1272/2008 until RAC has had the opportunity to deliver a revised opinion."

Table B.3-1Harmonised classification for lead massive (particle size ≥ 1 mm) and lead compounds (Annex VI of CLP Regulation).

Index No	International Chemical Identification	EC / CAS No	Hazard class category	Hazard statement code(s)	Spec. Conc. Limits, M-factors, ATEs
082-013-00-1	Lead powder [particle diameter < 1 mm]	231-100-4 7439-92-1	Repr. 1A Lact. Aquatic Acute 1[1)] Aquatic Chronic 1[1)]	H360FD H362 H400 H410	Repr. 1A; H360D: C ≥ 0.03 % M = 1 M = 10
082-014-00-7	Lead massive [particle diameter ≥ 1 mm]	231-100-4 7439-92-1	Repr. 1A Lact.	H360FD H362	GCL ≥ 0.3 % applies

B.3.2. Classification and labelling in classification and labelling inventory/ Industry's self classification(s) and labelling

In addition to the harmonised classifications described in Section B.3.1 the REACH registration dossier for lead includes several additional human health and environmental classifications for the various grades of lead massive described in Section B.1.2.

B.3.2.1. Human health self-classification in the REACH registration

Table B.3-2Human health self-classification in REACH registration

Hazard class and category code	Hazard Statement
STOT RE 1	H372: Causes damage to organs; causes damage to central nervous system, blood and kidneys through prolonged or repeated exposure by inhalation or ingestion

B.3.2.2. Environmental self-classification in the REACH registration

Table B.3-3Environmental self-classification in REACH registration

Hazard class and category code	Hazard Statement
Aquatic Chronic 2	H411: Toxic to aquatic life with long-lasting effects – applicable to lead massive with arsenic grade only

B.4. Environmental fate properties

The information presented in this section includes data from the Voluntary Risk Assessment (VRAR) on lead and lead compounds (LDAI, 2008), the 2014 Danish Environmental Protection Agency (EPA, 2014) survey on lead and lead compounds, REACH registration dossiers as well as the report prepared by the US Sporting Arms and Ammunition Manufacturers' Institute (SAAMI, 1996).

Lead is naturally present in the environment (resulting in a background concentration of lead in all environmental compartments, including biota). Chemical processes affect the speciation of lead in the environment which, in turn, influences exposure and effects (LDAI, 2008).

B.4.1. Degradation

In general, (abiotic) degradation is not relevant for inorganic substances. The formation of different lead species (e.g. hydroxides) occurs under different environmental conditions However, the exposure and risk assessment in this restriction report will not differentiate between the properties of the various lead species (pooling of different speciation forms). This "elemental-based" assessment (pooling all speciation forms together) can be considered as a worst-case assumption.

The classic standard testing protocols on hydrolysis and photo-transformation are not applicable to lead and inorganic lead compounds. This was recognised in the Guidance to Regulation (EC) No 1272/2008 Classification, Labelling and Packaging, of substances and mixtures (metal annex):

"Environmental transformation of one species of a metal to another species of the same does not constitute degradation as applied to organic compounds and may increase or decrease the availability and bioavailability of the toxic species. However as a result of naturally occurring geochemical processes metal ions can partition from the water column. Data on water column residence time, the processes involved at the water – sediment interface (i.e. deposition and re-mobilisation) are fairly extensive, but have not been integrated into a meaningful database. Nevertheless, using the principles and assumptions discussed above in Section IV.1, it may be possible to incorporate this approach into classification."

B.4.2. Environmental distribution

B.4.2.1. Terrestrial compartment

Speciation is known to affect the environmental fate of metals. Speciation in soils is rather complex. Specifically the ionic and elemental compositions can be complex and it is influenced by soil sorption/precipitation reactions.

The sorption of metal species to soil depend on soil conditions. However, the soil conditions influence not only the sorption properties, but also speciation itself. Based on the principles of soil chemistry (e.g. Bohn et al, 2005) soil properties are known to have following effects:

- Soil minerals: In general, the electrostatic sorption capacity (i.e. cationic exchange capacity, CEC) is higher in clay soils with fine mineral texture and lower in coarse mineral soil. The sorption capacity for metal hydroxide cations and oxyanionic species increases with higher soil iron/aluminium (hydr)oxide content.

- Organic matter: soils rich in organic matter have a high sorption capacity towards cationic heavy metals species (high CEC, complex or chelate formation). On the other hand, the formation of soluble organic metal species enables the solubility of metals that would otherwise exist as precipitates.
- pH: soil pH dictates the chemical speciation of metals and their sorption tendency. In general, the solubility of metals usually increases in acidic conditions and decreases at higher pH (because at higher pH many metals tend to precipitate). However, it is noteworthy that, in highly alkaline soil conditions, some metals tend to dissolve or hydrolyse into anionic species (e.g. nickel, lead, manganese) that are poorly retained by soil. Adsorption to soil organic matter increases with increasing pH.
- Redox: soil redox conditions dictate the speciation of redox-sensitive metals and semimetals. Soil redox condition can also impact the soil sorption capacity.[16]

The range for pH in soil is generally considered to be approximately 4 to 9. In extreme conditions, i.e. in acidic sulphate soils, the pH can be very low (pH < 3) or in sodic soils it can be very high (pH > 10) (Husson, 2013). In soils, the redox range (Eh) can vary from -300 to +900 mV. Depending on redox conditions, soils can be classified as follows:

- aerated soils +400 mV (or 300 mV);
- moderately reduced 100-400 mV (or 300 mV);
- reduced 100 to -100 mV; and
- highly reduced soils -100 to -300 mV.

For example, at firing ranges the conditions in surface soil are considered oxic (without waterlogged conditions). Lead is reported to be more mobile in reduced soil conditions (Antić-Mladenović, 2017); these conditions are not expected in the terrestrial environment (e.g. at firing ranges).

The supplementary CSR for the use of lead ammunition developed for the REACH registration of lead (ILA-E, 2010) derived a worst-case corrosion (weathering) rate of lead in soil and sediment of 1% per year, based on reviews of the literature by Scheinost (2004) and others. Scheinost (2004), cited by ILA-E, (2010) concluded that fast initial weathering rates can be in the range 0.2 to 2 % per year, corresponding to first order rate constants of 0.002 to 0.02 per annum. Based on these assumptions, large amounts of shotgun pellets deposited on shooting ranges and hunting areas would be transformed every year into lead carbonates and sorbed species, and it would take between 50 and 500 years for lead shot to transform to other lead species. It should be noted that these factors would appear to be derived from data from both bullets and lead gunshot and the precise physico-chemical conditions associated with these factors are not reported in ILA-E (2010). The 1 % per year dissolution value used in the REACH registration for both soil and sediment was considered by the registrants to be a worst-case assumption because it assumes that the initial corrosion rate will remain constant over time, whilst in reality it decreases (Scheinost, 2004). For example, Linder (2004, cited by ILA-E, 2010) reports that the initial corrosion rate of lead will decrease by about 50% after 2-3 years. In a Swedish study, also cited in ILA-E (2010), an upper limit for lead corrosion of 1% per year is used (Anderberg et al., 1990, cited by ILA-E, 2010). The Dutch emission

[16] For example in reducing conditions Fe(III) can be reduced to Fe(II). The ferrous iron Fe(II) has a lower tendency to form precipitates (absorbent for metals like lead).

inventory (VROM, 2002, cited by ILA-E, 2010) also used a worst-case corrosion rate of 1% per year.

Lead dissolution, speciation and mobility

Lead ions have more than one oxidation state in the environment. The principal ionic form is Pb (II) (Pb^{2+}), which is more stable than Pb (IV) (Pb^{4+}). In all environmental compartments (water, sediment, soil), the binding affinities of Pb(II) with inorganic and organic matter are dependent on pH, the oxidation-reduction potential in the local environment, and the presence of competing metal ions and inorganic anions.

Lead in its metallic form (Pb°) needs to be transformed to its ionic forms to become available for uptake by biota. The rate and extent of the transformation/dissolution of lead in massive and various powder form have been assessed in standardised transformation/dissolution tests (in accordance to the OECD guidance, Annex 10 of the GHS).

Site-specific physico-chemistry should be considered when assessing lead dissolution, speciation and mobility. In general, site-specific hydrologic and geologic conditions can greatly influence lead mobility and also atmospheric conditions can weather metallic lead into more soluble and mobile forms (SAAMI, 1996).

The fate of lead is regulated by a number of physico-chemical processes (SAAMI, 1996), including:

- Oxidation[17]/reduction
- Precipitation/dissolution
- Adsorption/desorption
- Complexation/chelation

Lead can precipitate in a variety of forms including hydroxides, sulphates, sulphides, carbonates, and phosphates. Each of these precipitates are soluble, controlled by site-specific chemistry. The factors that directly control solubility[18] are pH, oxidation-reduction (redox) conditions, and the concentration of the components that determine solubility (the primary solubility controls). As these parameters are highly variable from one location to another, site-specific conditions determine how much lead can be solubilised.

In general, lead is much more soluble under acidic (low pH) conditions than at neutral or alkaline (high pH) conditions, but this can change under a variety of situations. Some precipitates, especially phosphates and sulphides, are particularly effective at controlling lead solubility, often resulting in very low lead concentrations in water. Factors controlling solubility can substantially reduce the bioavailability of lead in sediments and/or soils.

Lead can be adsorbed by a variety of materials including organic matter, iron and

[17] The rate of weathering and oxidation of lead is highly variable and site specific.

[18] (Ma et al., 2002) noted that important variables governing speciation and solubility are pH and oxidation-reduction potential. Metallic lead is stable in a very low redox potential condition, but typical soil conditions can have high level of redox potential, depending on composition In general, lead exhibits its greatest solubility in acidic (pH < 4) solutions. Under acidic conditions, elemental lead will oxidize, releasing a hydrated cation, Pb^{+2}. Under alkaline conditions, elemental lead will oxidize under most circumstances to form a lead hydroxide complex. This influences mobility.

manganese oxyhydroxides, clays, carbonates and sulphides. In general, neutral or slightly alkaline conditions are expected to give rise to low mobility conditions and only acidic conditions will result in substantial mobility. However, there are exceptions to this generality, as adsorption processes are highly dependent on site-specific conditions.

Complexation/chelation and transport of particulates that contain lead may increase physical movement of lead. Particulate transport mechanisms may be effective in altering the distribution of lead over time.

The prevalent species of lead (compared to other metals), iron, manganese, nickel and arsenic, and their potential leaching risk from soil to groundwater or surrounding watercourses is presented in the following table.

Table B.4-1 Potential leaching risk of Pb, Fe, Mn, Ni and As species from soil to water bodies. Potential leaching risk was estimated according to sorption tendency in respect to soil condition where species are found. *(Note that the toxicity of metals species is not assessed in the table, only their mobility).*

Element	Prevalent species	Soil conditions	Main sorption mechanisms	Leaching risk[1] (low/moderate/high)
Lead	Pb^{2+}	acidic or slightly acidic	electrostatic sorption or complex/chelate formation	Moderate (high in extremely acidic conditions)
	$Pb(OH)^{+}$	non-acid	Precipitation onto soil particles (as metal-OH^{+} species)	low
Iron	Fe^{3+}	oxic, extremely acid pH<2	electrostatic sorption or complex/chelate formation. In practice these acidic conditions cause dissolution of most metals in soil	high (in extremely acidic conditions)
	Fe^{2+}	reduced, slightly acidic	electrostatic sorption or complex/chelate formation	moderate/low (high in acidic conditions)
	$Fe(OH)_2^{+}$	oxic acidic, moderately reducing non-acidic	Precipitation onto soil particles (as metal-OH^{+} species)	low
	$Fe(OH)_3$	oxic and moderately reducing non-acidic	Precipitation as iron hydroxide	low

Element	Prevalent species	Soil conditions	Main sorption mechanisms	Leaching risk[1] (low/moderate/high)
Manganese	Mn^{2+}	reducing, moderately reducing, acid oxic	electrostatic sorption	moderate (high in extremely acid conditions)
	$Mn(IV)O_2$	oxic, non-acidic	Precipitation	low
Nickel	Ni^{2+}	reducing, moderately reducing, oxic, acidic, non-acidic	electrostatic sorption or complex/chelate formation	moderate (high in extremely acid conditions)
Arsenic	$HAsO_4^{2-}$	acidic or slightly acidic	sorption by ligand exchange	moderate
	$H_2AsO_2^-$	non-acid	sorption by ligand exchange	moderate

Footnotes

[1]low= forms precipitates in all soil types

moderate=retained by cation exchange or complex/chelate formation (sorption depends highly on soil clay and organic matter content)

high=poorly retained in the prevailing conditions

The potential leaching risk was assessed depending on the species sorption tendency to soil. The sorption behaviour of metal species relies on the basics of soil chemistry (e.g. Bohn et al, 2005), speciation modelling (Takeno, 2005) and literature references for soil (Lindsay and Schwab, 1982). Basically, all elements exist as species that are retained by most soils. Therefore, leaching risk is not estimated to be high for any of the species excluding Fe3+. For Fe3+ leaching risk is high because the environmental conditions where this species is found are extremely acidic, promoting dissolution of all metals in soil.

In typical soil conditions, iron is considered poorly soluble due to the formation of (hydr)oxide precipitates. The soil iron (hydr)oxides act as an important adsorbent for metal-OH+ cations and oxyanionic species. Soluble species mainly exist in rather reduced conditions, as soluble organic species or in highly acidic conditions not typical in most soils.

In acidic conditions, the environmental fate of dissolved Pb2+, Ni2+and Mn2+ depend on their sorption onto soil cation exchange sites and, in particular for lead, on their retention to organic complexes. In non-acidic conditions the mobility of lead is further reduced because of the adsorption of Pb(OH)+ species onto soil iron or aluminium (hydr)oxide surfaces. Also, precipitation of manganese occurs at higher pH. Nickel is more soluble than lead as it does not form hydroxide species, and has a lower tendency to be retained by organic matter.

Arsenic in soils exist as oxyanionic arsenate species. Oxyanionic species are adsorbed

onto soil iron- and aluminium (hydr)oxides surfaces by ligand exchange mechanism. The sorption tendency of these oxyanionic species tend to increase with lower soil pH – the opposite to iron, lead, nickel and manganese.

Site specific conditions at firing ranges

Lead ammunition can contaminate range soil as the result of projectiles fragmentation and leaching due to weathering[19]. Dinake et al. (2019) summarized in their recent review that the soil physical and chemical properties have a significant influence on the distribution, mobility, solubility, bioavailability, bio-accessibility and fate of Pb in shooting range soils.

Surface soils in particular are dynamic environments, as they are exposed to weathering process (rainfall, freezing, windscour, etc). Stable environmental conditions are not likely to occur in the field.

Years of shooting can cause lead to accumulate on soil surface. As the surface layer capacity is reached, lead will start to migrate towards the lower soil layers. The dynamic process of lead migration through these soil layers is driven by soil properties as stated in the overview section.

As reported by SAAMI, (1996), when bullets strike an impact berm they behave in a number of ways, including penetrating, agglomerating, fragmenting, smearing, and ricocheting. Most of the mass of lead in impact berms exists as intact bullets and relatively large fragments. But it is the very small particles of lead and the lead compounds resulting from the weathering of metallic lead that result in the most mobility. Furthermore, the continuous disturbance at some berms creates areas void of vegetation, resulting in erosion during rainstorms. The associated surface water runoff can then be transported to adjacent water bodies and under certain conditions can result in considerable transport of soil containing lead particles.

Lead shot particles are not typically subjected to such physical processes, but are exposed to atmospheric conditions that result in transformation of metallic lead into more soluble forms[20]. Lead that exists in the dissolved state can be sorbed to negatively charged clay particle surfaces. According to an Army Corp of Engineers report (Larson et al., 2007), erosion and surface water transport of contaminated clays can be a major source of lead mobility in the environment. This transport can be either attenuated or increased depending upon the mobility of the soil particles (Struck, 2011).

Turpeinen et al. (2000) examined the effects of pine (*Pinus sylvestris*) and liming (pH-change with $CaCO_3$) on the mobility and bioavailability of lead in boreal forest soil, previously used as a shooting range area, under laboratory conditions. Results showed that pine seedlings had a major role in the immobilization of lead in the contaminated soil. The presence of pine seedlings reduced the amount of water soluble lead by 0−56%

[19] As a result of the high lead loading of shooting range soils, both surface and underground water sources can be at potential risk of contamination.

[20] According to (Rooney, 2010), most of the lead at shooting ranges is present as intact lead shot: the corrosion products on the lead shot can be soluble; a large proportion (30-50%) of the lead associated with the soil is also soluble (for comparison, <5% of lead is soluble in uncontaminated soils); the corrosion products represent a large reservoir of potential soluble lead. (Jørgensen and Willems, 1987) estimated that all of the metallic lead pellets deposited in the soil in Denmark will be decomposed within 100 to 300 years . (Ma et al., 2002) stated that when lead pellets and bullets come into contact with soil, they may be exposed to oxidation, carbonation, and hydration reaction, and ultimately could be transformed into dissolved and particulate species and diffused into the environment at a decomposition rate of ~1% a year.

in humic rich surface soil and by 12−93% in mineral soil (5−20 cm) and also decreased by 40−57% the mobility of lead in the surface and mineral soil. Liming did not reduce the solubility, mobility or bioavailability of lead in the soil. Significant positive correlation was found between the concentration of total water soluble lead and the bioavailability of lead in the soils. The concentration of bioavailable lead was not, however, predictable from the concentration of total water soluble lead; bioavailable lead was only 4−6% of total water soluble lead in humic surface soil and 13−43% in mineral soil. In soil with low lead concentrations (15–30 mg/kg), only trace amounts of lead were taken up by plants, but the amount is usually increased with lead concentration in soil.

Lead shot with overlying steel shot[21]

Years of shooting can cause lead shot to accumulate on soil surface. As the surface layer capacity is reached, lead will start to migrate towards the lower soil layers. The dynamic process of lead migration through these soil layers is driven by soil properties as stated in section B.4.2.1. Theoretical modelling of predicted impacts from the addition of steel shot to lead shot-contaminated soils is presented in this section, in addition to a discussion of the potential for iron to increase soil acidification.

Steel shot in surface soil

The FITASC report (2020) states that the corrosion rate of steel shot will be faster than lead shot, stating that iron can be "five times to thirty times higher than that of lead." The lower figure is taken from an unreferenced "fact sheet" and could not be verified, and the higher figure is taken from a presentation by the International Shooting Sport Federation (ISSF), which references 10-year atmospheric corrosion studies in an urban environment (Uhlig and Revie, 1989), which may not be environmentally relevant to shooting ranges as it does not consider natural water and soil process which can be highly variable. While lead, on average, corrodes more slowly than does steel[22], in poorly aerated soils or soils high in organic acids, the corrosion rate may be four to six times higher than average rates (Uhlig and Revie, 2008). According to Uhlig and Revie (2008) the factors that control corrosivity of a given soil are porosity (aeration), electrical conductivity, dissolved salts, including depolarisers or inhibitors, moisture and pH. Unlike in air, the manufacturing process or composition of steel has little effect on corrosion rates in natural waters and soils. A possible exception to this may be in acidic environments, when steel containing manganese and small amounts of sulphur, exhibits decreased acid corrosion.

[21] The Dossier Submitter has assessed this scenario based on the statement made by FITASC (2020): "shooting steel shot on soils containing lead shot will acidify the soil at the site, accelerate lead corrosion and promote metal transport that will facilitate the migration of lead, antimony and other heavy metals from the contaminated site and deposit them in solution further downstream. Because they are more mobile, heavy metals will also migrate more easily to the water table"

[22] The lead oxide protective layer mechanism (FITASC, 2020) offers justification for the longevity of lead, but relies on stable environmental conditions being maintained. Indeed, a similar protective oxidation mechanism could occur for steel shot, but stable conditions are unlikely to be present in natural/semi-natural environments at shooting ranges. Surface soils in particular are dynamic environments, as they are exposed to weathering process (rainfall, freezing, windscour, etc) calling into question the stability required for "optimum" corrosion rates.

Modelled speciation

Some example soil types[23] (Tarvainen et al, 2011) are considered for the proposed modelling. Although shooting ranges are present across a high variability in soil types, such example soils studied represent two very different case, increasing the confidence of the analysis.

If the shooting range is situated in peatland, soluble lead will be somewhat retained within the peat, but a proportion of lead will exist in mobile soluble form, driven by the low pH (<4-5) found in such soils. Soluble mobile lead species can migrate through the peat into surface water bodies. If the shooting ground is situated in sandy soils, the humus layer may retain lead for decades if the soil surface remains undisturbed. However, when the capacity of the surface layer is filled, the surplus lead will migrate into lower layers of soil. The ability for lead to reach the groundwater in these soils is driven by factors such as pH, organic matter, cation exchange capacity (CEC) and oxide content that can vary considerably (Tarvainen et al, 2011).

The ionic speciation of soluble metals was assessed by using a simple VisualMinteq model in hypothetical "worst case" conditions at pH 4 and 7.

Input data were drawn from published literature. For lead, soil concentrations were represented by data collected from studies on shooting ranges conducted over 35 years (Dinake et al, 2019), which were used to predict a comparable concentration of replacement steel shot.

- Highest soil contamination by Pb 100 000 mg/kg (Dinake et al, 2019)
- Estimated steel deposits in soil 68,293 mg/kg, with total concentrations of:
  - Fe (98.8 % w/w) 67,473 mg/kg
  - Mn (1.2 %w/w) 820 mg/kg
  - Ni (1.2 %w/w) 820 mg/kg
- Estimation of the maximum solution concentration based on Kd-values
  - Pb 50 mg/l
  - Fe 34 mg/l
  - Mn 1.6 mg/l
  - Ni 1.5 mg/l
- DOC (dissolved organic carbon): 0 (no organic matter) and 50 mg/l (high organic matter content).

[23] Peatland with low pH and high organic matter; sandy moraine with neutral pH low organic matter.

CALCULATION AND JUSTIFICATION OF THE PARAMETERS IN VISUAL MINTEQ MODELLING

Conditions in VisualMinteq demonstrate maximum contamination for Pb reported in literature (Dinake et ak., 2019) and a subsequent deposition of steel shots relative to the amount of Pb contamination. Estimation for the amount of steel was calculated by using the mass ratio of steel and Pb in 2.4 mm pellets. In addition, the possible maximum amount of Mn and Ni impurities in steel were considered in the modelling. The contamination values demonstrate intensive use of firing ranges for over 35 years with Pb shots, followed by similar use with same time scale with steel shots. For Fe and Mn, soil background concentrations were added to their total concentrations. The possible impurities in Pb shots were not included. The soluble concentration of metals was calculated from the total concentrations with Kd-values.

Justification for the parameters

- pH: acidic soil= pH 4 and neutral soil= pH 7 (low pH was tested as it is known to enhance the predominance of soluble metal species).
- Steel shot composition, upper limit % w/w)

Element	Composition (% w/w)	
	Lower	Upper
Fe	98	99
C	0.85	1.2
Mn	0.6	1.2
Si	0.4	1.2
S	0	0.05
P	0	0.05

- DOC: the concentration in organic soils high in DOC can amount to 55.7-62 mg/l (Leroy et al, 2017)
- Fe range in soils 2000-550 000 mg/kg, 100 000 mg/kg for Kd background calculations (Bohn et al,2005)
- Mn range in soil 20-10 000 mg/kg, 2000 mg/kg for Kd (soil-water partitioning coefficient) background calculations (Bohn et al,2005)
- Kd-values: low Kd values were used to demonstrate maximum solubility. The Kd values were representative for sandy soil (Sheppard et al, 2009). Suitability of the Kd's were also by comparing them to theoretical values (Thibault et al 1990 and Carlon et al, 2004)

Calculations

Firing range surface soil contaminated with Pb 100 000 mg/kg (Dinake et al, 2019).

- steel shot composition: Fe 98.8 % and impurities Mn 1.2 % (values present ECHA upper limit % w/w) and Ni 1.2 % (hypothetical value based on assumption of nickel plated steel)
- with similar use and time scale (decades) the amount of steel with 2.4 mm pellets (FITASC 2020, table 3):
    - 100 000 mg Pb/kg x (0.056 g steel pellet /0.082 g Pb pellet)=68 293 mg steel/kg
        - 68 293 mg steel/kg x 98.8 % Fe=67 473 mg Fe/kg
        - 68 293 mg steel/kg x 1.2 % Mn=820 mg Mn/kg
        - 68 293 mg steel/kg x 1.2 % Ni=820 mg Mn/kg

Estimates for soil solution metal concentrations based on measured Kd (Kd=Csolid/Csolution) values for sandy soil:

- Pb
    - Csolution=100 000 mg Pb/kg /2000 L/kg=**50 mg Pb/l**
- Fe
    - Csolution=(68 293 + 100 000 background) mg Fe/kg/4900 L/kg=**34 mg Fe/l**
- Mn
    - Csolution=(820 mg + 2000 background) mg Mn/kg /1800 L/kg=**1.6 mg Mn/l**
- Ni
    - Csolution=820 mg Mn/kg /530 L/kg=**1.5 mg Ni/l**

Results and conclusions of the speciation modelling

Distribution of chemical species in the VisualMinteq model are shown in Table B.4-2 and Table B.4-3.

Table B.4-2 Distribution of soluble species (VisualMinteg model) in a hypothetical scenario of Pb contaminated soil with high soluble organic matter content, covered with high amount of steel shot

Organic species included		% of total concentration	
Component	Species name	pH 7	pH 4
Ni	Ni+2	**89,8**	**99,4**
	Ni DOM1	**10,1**	0,6
	NiOH+	0,1	
Pb	Pb+2	**9,8**	**67,9**
	Pb DOM1	**87,8**	**32,1**
	PbOH+	2,3	0,0
Mn	Mn+2	**100,0**	100,0
	MnOH+	0,0	
Fe	Fe+3		0,3
	Fe DOM1		**36,2**
	FeOH+2	0,1	**23,6**
	Fe(OH)2+	**99,3**	**39,7**
	Fe2(OH)2+4		0,1
	Fe3(OH)4+5		0,0
	Fe(OH)3 (aq)	0,5	
	Fe(OH)4-	0,1	

Table B.4-3 Distribution of soluble species (VisualMinteg model) in a hypothetical scenario of Pb contaminated soil with no organic matter content, covered with high amount of steel shot

No organic species		% of total concentration	
Component	Species name	pH 7	pH 4
Ni	Ni+2	**99,9**	**100,0**
	NiOH+	0,1	
Pb	Pb+2	**81,1**	**100,0**
	PbOH+	**18,6**	0,0
	Pb(OH)2 (aq)	0,1	
	Pb2OH+3	0,1	
	Pb3(OH)4+2	0,1	
	Pb4(OH)4+4	0,0	
Mn	Mn+2	**100,0**	**100,0**
	MnOH+	0,0	
Fe	Fe+3		0,5
	FeOH+2	0,1	**37,4**
	Fe(OH)2+	**99,3**	**61,7**
	Fe2(OH)2+4		0,3
	Fe3(OH)4+5		0,1
	Fe(OH)3 (aq)	0,5	
	Fe(OH)4-	0,1	

In summary, the metals that potentially dissolve from steel shots are not considered to enhance the mobility of lead. Instead, according to the speciation modelling, iron is likely to reduce the mobility of lead when iron exists as species that are easily precipitated into soil. The iron (hydr)oxides precipitates are known to have a high affinity towards lead sorption (e.g. Gustafsson et al, 2011), particularly at non-acidic conditions.

In acidic conditions (pH 4) with the presence of organic matter, a proportion of the iron exist as organic species. This indicates that iron and lead species could compete for the same organic sorption sites in acidic soils, which could potentially increase mobility of dissolved lead. However, even in acidic conditions, with high amounts of organic matter, most of the iron exists as inorganic species that have a high sorption capacity towards lead. So, as an overall impact, the iron from steel shot would still be expected to reduce the mobility of lead. Also, the affinity of lead to organic complex formation is greater than that of iron. Therefore, the amount soluble iron should be very high in respect to lead.

In the speciation model, practically all nickel and manganese existed as cationic species (Ni^{2+} and Mn^{2+}). In theory, dissolved Mn^{2+} or Ni^{2+} from steel could increase the soil solutions EC (conductivity). And with higher EC (resulting from metals lower in the galvanic series than lead) corrosion of lead shot could be enhanced. However, the literature relating to field soils and experimental studies does not provide evidence that this occurs at shooting ranges or that the amount potentially released from steel shot would have any significance at firing ranges. A summary of the speciation model results is provided below:

- No soluble species with the combination of Pb and Fe/Mn/Ni were detected with or without organic matter
    - metals from steel do not increase the Pb solubility by forming highly soluble multimetal Pb species
- At pH 7 the predominant soluble species is $Fe(OH)^{2+}$, which precipitates as (hydr)oxide in soil

- At pH 4 the predominant soluble species are $Fe(OH)^{2+}$ (24 %) and $Fe(OH)^{2+}$ (40 %) or organic species (36 %) Fe DOM1
  - inorganic species precipitate as (hydr)oxide in soil
  - organic species may remain soluble
- At pH 7 soluble Pb exists mainly as organic species (88 %) of (PbDOM1) and Pb^{2+} (10 %)
  - Pb has a high affinity towards retention by organic matter
  - organic species may remain soluble
- At pH 4 soluble Pb exists mainly as inorganic Pb^{2+} (68 %) or as soluble organic species (32 %) (PbDOM1)
- At pH 4 and 7 soluble Mn exists as inorganic species only; no soluble organic species.

Acidification mechanisms in soil

Soil acidity is known to promote steel corrosion. However, to the Dossier Submitter's knowledge, there is no indication that steel itself would promote soil acidification. In steel shot, iron exists in the metallic form. With respect to time scale, a proportion of iron oxidation in steel shot is expected.

In reduced soil conditions Fe^0 is oxidised to Fe^{2+}. In surface soil, where shots are deposited, the redox conditions are usually oxic: Fe^0 oxidises into ferric iron, Fe^{3+}. In steel, metallic iron exists in its elemental oxidation state (Fe^0). Because of corrosion the Fe in steel shots oxidises to form hydroxides through a series of reactions:

1. $4\ Fe^0 + 2\ O_2 + 8\ H^+ \rightarrow 4\ Fe^{2+} + 4\ H_2O$
2. $4\ Fe^{2+} + 8\ OH^- \rightarrow 4\ Fe(OH)_2$ in *reduced* conditions
3. $4\ Fe^{2+} + 4\ H^+ + O_2 \rightarrow 4\ Fe^{3+} + 2\ H_2O$
4. $4\ Fe^{3+} + 12\ OH^- \rightarrow 4\ Fe(OH)_3$

Overall reaction: $Fe^0 + 3\ O_2 + 6\ H_2O \rightarrow 4\ Fe(OH)_3$

According to these step-wise reactions:

- oxidation of Fe increases pH (reactions 1 and 3: consumption of acidifying H^+ in the reactions); and
- hydrolysis of Fe^{2+} or Fe^{3+} lowers pH (reactions 2 and 4: consumption of alkaline OH^- in the reactions)

The actual overall acidifying/alkalising impact depends on the degree of Fe hydrolysis:

  - no effect with hydrolysis of Fe^{2+} to $Fe(OH)_2$ or Fe^{3+} to $Fe(OH)_3$.
  - with lower degree of hydrolysis pH expected to *increase*: $Fe^0 + 3\ O_2 + 6\ H_2O \rightarrow 4\ Fe(OH)_2^+ + 4\ OH^-$

The degree of oxidation and hydrolysis depend on soil conditions, such as pH, redox state, temperature, and moisture content; however, based on the step-wise reactions of iron oxidation and hydrolysis, iron is not expected to have acidifying effects. Thus, the mobility of Pb is not expected to be enhanced due to the corrosion of Fe in steel shoots.

In the FITASC report (2020) the claim that iron released from steel shot contributes to

acidification of soils is based on a single consultancy report (not peer reviewed) by Hurley (2004). The author performed a leaching test with carbonated water (pH 6-6.5) and two shot types: steel and lead shots. The pH of the solution with both steel and lead shots was initially reported to increase, followed by a decrease. Low pH was linked to soluble iron. However, only the impact of hydrolysis was considered, not the oxidation reactions of iron.

The changes in pH in Hurley (2004) do not contradict the theoretical chemistry of the series of reactions for iron, as stated above. The overall endpoint of the reactions depends on the starting oxidation state of the iron, and should be used to determine the likely hazard of steel (iron) and lead shot in soils. The oxidation of iron in steel can initially increase pH, but this increase is subsequently lowered by the hydrolysis reactions of Fe^{2+} or Fe^{3+}. The final pH in water solution was reported to be 5.1 (0.2 to 0.7 units lower than initial pH). According to the chemical reactions of iron the reduction in pH does not originate from the overall reactions of Fe^0. However, if the iron in the steel shots used in the tests reported by FITASC had oxidised prior to the test, the acidifying impact in the aqueous solution may be possible, however at shooting ranges shots are fired before corrosion takes place. As for comparison to the reported acidic solution pH 5.1 by Hurley (2004), the pH of dissolved water in equilibrium with atmospheric CO_2 is 5.65. In soil, similar changes in the pH are not expected to occur because of soil buffering capacity. The buffering capacities vary in different soils, but this is not investigated in the Hurley (2004) report as to "*avoid possible complex interactions from clays and biomass sorption and soil-based electrolytes which would obscure the primary corrosion process.*"

In the FITASC report, it was contended that lead corrosion was considered elevated because of the presence of steel shot. The corrosion rate of metals can be higher in solutions with increased salt concentrations. In water solution, the Fe species dissolved from steel shot may have increased the solution's electric conductivity (EC). However, in most soil types, iron is poorly soluble and therefore EC is not expected to increase.

In summary, the conclusions made by FITASC (2020) regarding iron driven soil acidification and subsequent mobilisation of lead are underpinned by a single study in water (Hurley, 2004), in which conditions in the soil compartment were not explicitly considered. Given the pH buffering capacity of soils and their ability to precipitate metal ions, the Dossier Submitter considers the specific claim of acidification made by FITASC (2020) to be not scientifically grounded.

In the broader context of natural soil acidification (such as microbial acidification in peatlands or the influence of acid rain), iron driven acidification is of relatively low significance. The overall impact from oxidation and hydrolysis reactions of Fe^0, the main component of steel shot, is not considered acidifying. In order to observe acid production from steel shot, the iron deposited into soil should initially exist as oxidised species (Fe^{2+} or Fe^{3+}). According to Mann et al (1994) steel shots are oiled to prevent rusting and the initial oxidation of Fe is not expected to occur. In theory, acid production is possible if part of the iron in steel shot is oxidised before being fired to shooting range (due to the hydrolysis of Fe^{2+} or Fe^{3+}). The significance of this acid formation compared to natural biological processes or acid rain in soil is not possible to reliably estimate. In any case, the potential acid formation from hypothetical steel shot iron hydroxide coatings is not expected to significantly influence soil pH (because of soil buffering reactions) even if the proportion of oxidised Fe in steel shots could be determined.

B.4.2.2. Aquatic compartment

Lead enters the aquatic environment via municipal and industrial wastewater, runoff and leaching from natural and anthropogenically burdened soils, atmospheric deposition and corrosion and abrasion of lead containing materials (EPA-Denmark, 2014).

The amount of lead that is dissolved in surface waters depends on the pH of the water and the properties of specific lead salts. For example, solid lead dissolves relatively slowly (see section above), whereas the solubility of lead oxide is 107 mg/L at 25°C. At pH values at or below 6.5 most of dissolved lead is in the form of the free Pb^{2+} ion. In waters containing natural organic matter (NOM), organically bound lead also influences speciation and bioavailability, with increasing amounts of NOM generally reducing the concentration of the free Pb^{2+} ion. Sulphate ions limit the dissolved lead concentration through the formation of poorly soluble lead sulphate. At higher pH levels lead carbonates ($PbCO_3$ and $Pb_2(OH)_2CO_3$), determine the amount of lead in solution. The carbonate concentration is in turn dependent upon the partial pressure of carbon dioxide, pH, and temperature.

In most surface and ground waters, the concentration of dissolved lead is low because the lead will form complexes with anions in the water such as hydroxides, carbonates, sulphates, and phosphates that have low water solubility and these complexes will precipitate out of the water column. A significant fraction of lead in surface water is expected to be in an undissolved form, which can consist of colloidal particles or larger undissolved particles of lead carbonate, lead oxide, lead hydroxide, or other lead compounds incorporated in other components of surface particulate matters from runoff. Lead may also occur either as sorbed ions or surface coatings on sediment mineral particles, or it may be carried as a part of suspended organic matter in water. The ratio of lead in suspended solids to lead in dissolved form has been found to vary from 4:1 in rural streams to 27:1 in urban streams (LDAI, 2008).

An overview of the partitioning coefficients (Log K_D (L/kg)) for lead between freshwater and suspended particulate matter (SPM) (LDAI, 2008) is provided in Table B.4-4.

Table B.4-4 Reported log K_D, SPM values for lead in freshwaters in Europe (LDAI, 2008)

Location	Log K_D (L/kg)	Remarks	Reference
Four Dutch Lakes	6.0	average	Koelmans and Radovanovic, 1998
Calder River, UK	4.45 - 5.98	min-max range	Lofts and Tipping, 2000
Nidd River, UK	4.69 - 6.25	min-max range	
Swale River, UK	4.58 - 6.20	min-max range	
Trent River, UK	4.61 - 6.06	min-max range	
All rivers	5.41	observed mean	
All rivers	5.71	predicted mean	
Scheldt, Belgium	5.3	salinity of 1.5 ppm	Nolting et al., 1999
Po River, Italy	5.5	median value	Pettine et al., 1994
Dutch freshwater	5.81	mean	Stortelder et al., 1989; in Crommentuyn et al., 1997
Upland-influenced river water, UK	4.6	modelled value	Tipping et al., 1998
Low-salinity water, UK	5.5	modelled value	
7 freshwater locations in The Netherlands	5.93		Venema, 1994; in Crommentuyn et al., 1997
54 Czech rivers / 119 locations	5.44	median K_D	Veselý et al., 2001
	5.18	median K_A (1)	
RANGE	4.45 – 6.25		

K_A: based on the acid soluble concentration for the calculation of local and regional exposure concentrations the median log K_D, SPM value of 5.47 is selected. This value corresponds with a K_D, SPM of 295,121 l/kg. For freshwater sediments, the selected KD value was 153 848 L/kg (Log K_D: 5.19).

Dissolution, speciation and mobility of lead from ammunition and fishing tackles

Lead ions have more than one oxidation state in the environment. The principal ionic form is Pb (II) (Pb^{2+}), which is more stable than Pb (IV) (Pb^{4+}). In all environmental compartments (water, sediment, soil), the binding affinities of Pb(II) with inorganic and organic matter are dependent on pH, the oxidation-reduction potential in the local environment, and the presence of competing metal ions and inorganic anions.

Lead in its metallic form (Pb°) needs to be transformed to its ionic forms to become available for uptake by biota. The rate and extent of the transformation/dissolution of lead in massive and various powder form have been assessed in standardised transformation/dissolution tests (in accordance to the OECD guidance, Annex 10 of the GHS).

Lead massive deposited onto soils and aquatic sediments is not chemically inert. Lead can become bioavailable (Scheuhammer and Norris, 1995) although tens or hundreds of

years may be required (Scheuhammer and Norris, 1996).

Weathering and dissolution of elemental lead in spent ammunition is influenced by multiple factors (Eisler 1988; IPCS 1989; Scheuhammer and Norris 1995; EC, 2004 cited by Rattner et al., 2008; Scheuhammer and Norris, 1996; Swaine, 1986 cited by Bianchi et al., 2011; SAAMI, 1996), including:

- water chemistry;
- the extent of the mechanical disturbance of sediment (e.g., water flow rate);
- grain size of soils and sediments;
- gaseous aerobic conditions, acidity and alkalinity;
- rainfall, vegetation cover, and;
- the quantity of organic matter in sediment.

The dissolution rate of lead in aquatic environments increases with acidity, low water hardness (< 25 mg/L $CaCO_3$), and greater water velocity (Eisler, 1988; Scheuhammer and Norris, 1995; EC, 2004 cited by Rattner et al., 2008).

In aquatic environments with lower water velocities (e.g. lakes), lead particles and artefacts would become buried in bottom sediments, where they would move into the anoxic sediment layer and may be strongly adsorbed onto sediment and soil particles (EC, 2004).

The fate of spent lead in the environment depends on whether it remains exposed in water or buried in sediments or soils (Jacks et al. 2001 cited by Rattner et al., 2008).

Site-specific physico-chemistry should be considered when assessing lead dissolution, speciation and mobility[24]. In general, site-specific hydrologic and geologic conditions can greatly influence lead mobility and also atmospheric conditions can weather metallic lead into more soluble and mobile forms (SAAMI, 1996).

The fate of lead is regulated by a number of physico-chemical processes (SAAMI, 1996), including:

- Oxidation/reduction
- Precipitation/dissolution
- Adsorption/desorption
- Complexation/chelation

Lead can precipitate in a variety of forms including hydroxides, sulphates, sulphides, carbonates, and phosphates. Each of these precipitates are soluble, controlled by site-specific water chemistry. The factors that directly control solubility are pH, oxidation-reduction (redox) conditions, and the concentration of the components that determine solubility (the primary solubility controls). As these parameters are highly variable from one location to another, site-specific conditions determine how much lead can be

[24] In wetlands physico-chemical conditions are generally anoxic. However, chemical reactions in aqueous media are often characterised by pH and the redox potential together with the activity of dissolved chemical species (Scholz, 2016). Redox potential is the most common parameter used to measure degree of soils wetness or intensity of soil anaerobic conditions. The range of Eh (reduction/oxidation potential), values observed in wetland soils is from +700 to – 300 mV. Negative values represent high electron activity and intense anaerobic conditions typical of permanently waterlogged soils. Positive values represent low electron activity and aerobic to moderately anaerobic conditions typical of wetlands in transition zones (Inglett et al., 2016). Specific Potential diagrams for a lead-water system, showing stability of solids and dominant solute species as functions of pH and Eh, indicate which species are likely to exist at various Eh and pH at certain specific conditions.

solubilised.

In general, lead is much more soluble under acidic (low pH) conditions than at neutral or alkaline (high pH) conditions, but this can change under a variety of situations. Some precipitates, especially phosphates and sulphides, are particularly effective at controlling lead solubility, often resulting in very low lead concentrations in water. Factors controlling solubility can substantially reduce the bioavailability of lead in sediments and/or soils.

Lead can be adsorbed by a variety of materials including organic matter, iron and manganese oxyhydroxides, clays, carbonates and sulphides. In general, neutral or slightly alkaline conditions are expected to give rise to low mobility conditions and only acidic conditions will result in substantial mobility. However, there are exceptions to this generality, as adsorption processes are highly dependent on site-specific conditions.

Complexation/chelation and transport of particulates that contain lead may increase physical movement of lead. Particulate transport mechanisms may be effective in altering the distribution of lead over time.

The supplementary CSR for the use of lead ammunition developed for the REACH registration of lead (ILA-E, 2010) derived a worst-case corrosion (weathering) rate of lead in soil and sediment of 1% per year, based on reviews of the literature by Scheinost (2004) and others.

B.4.3. Bioaccumulation

B.4.3.1. Aquatic bioaccumulation

Bioconcentration (BCFs) and bioaccumulation factors (BAFs) for lead from water to aquatic invertebrates and fish are summarised in the Voluntary Risk Assessment for lead (LDAI, 2008) and the REACH registration for lead. A key consideration in these evaluations was whether steady-state tissue concentrations were achieved in studies and whether metal concentrations were measured throughout the exposure period. In that context, the lead concentration from biota sampled from natural environments are assumed to be at equilibrium. In addition, BCF data based on exposure concentrations that resulted in significant effects on the exposed organisms were not included.

BAF values are preferred to BCF values since the former include all possible exposure routes (i.e. water, food and soil/sediment) and are therefore considered to be more ecologically relevant.

Within a typical environmental concentration range (i.e. between 0.18 μg/L[25] (background concentration) and 15 μg/L (based on the 95th percentile of the PEC_{local} values), BAF values for fish range between 11 and 143 L/kg_{ww} (10 – 90th%) with a median value of 23 L/kg_{ww} while BAF values for molluscs range between 18 and 3 850 L/kg_{ww} (median value of 675 L/kg_{ww}) BAF values for insects range between 968 and 4 740 L/kg_{ww} (median value of 1 830 L/kg_{ww}) and for crustaceans between 1 583 and 11 260 L/kg_{ww} (median value of 3 440 L/kg_{ww}). The results are summarised in Table B.4-5.

[25] The measured aquatic lead concentrations below detection limit of 0.2 μg/L were considered as falling within the typical environmental concentration range.

Table B.4-5 Bioaccumulation factor estimates (BAF in L/kg$_{ww}$) for lead in freshwater organisms (LDAI, 2008)

Diet	Variable	10th percentile	50th percentile	90th percentile	n
Crustaceans	All exposures	1 187	3 159	10 570	8
	0.18-15 µg/L	1 583	3 440	11 260	7
Molluscs	All exposures	11	473	3 535	14
	0.18-15 µg/L	18	675	3 850	11
Annelids	All exposures	1 620	1 620	1 620	1
	0.18-15 µg/L	1 620	1 620	1 620	1
Acarides	All exposures	1 730	1 730	1 730	1
	0.18-15 µg/L	1 730	1 730	1 730	1
Insects	All exposures	968	1 830	4 740	7
	0.18-15 µg/L	968	1 830	4 740	7
Fish	All exposures	11	24	245	16
	0.18-15 µg/L	11	23	143	16

It is assumed that the diet of predators consists entirely of one realistic food type, i.e. fish (EC, 2003; TGD). However, it is recognised that ideally, for a more realistic assessment, refined data on the mixed diet food consumption of birds and mammals should be considered. Thus, a realistic mixed diet BAF value can be calculated using the following formula:

$$BAF_{mixed\ diet} = \sum_{i=1}^{n} f_i \times BAF_i$$

BAF_i corresponds to the representative bioaccumulation factor (10th, 50th or 90th percentile) for an individual prey species i (L/kg); n: the number of prey species considered in the mixed diet of the predator; fi: the proportion of the different food types in the mixed diet (value between 0 and 1).

To reflect such mixed diet scenario it is assumed (as no data are available on food type consumption and proportion of the different food types in the mixed diet) that birds/mammals consume equal proportion of the different food types, i.e. crustacean, mollusc, annelid, acaride, insect and fish.

However, based on an observation of relatively greater bioaccumulation for many metals in molluscs, BAF was also considered for a "mollusc food diet". The range of bioaccumulation factors (BAFs in L/kg$_{ww}$) for lead in the mixed and mollusc food diet is presented in Table B.4-6

Table B.4-6 The range of bioaccumulation factor (BAF in L/kg $_{ww}$) of lead in the mixed diet (LDAI, 2008)

Diet	Variable	10th percentile	50th percentile	90th percentile	n
Mixed food diet	All exposures	921	1 472	3 740	49
	0.18-15 µg/L	988	1 553	3 890	44
Mollusc food diet	All exposures	11	473	3 535	14
	0.18-15 µg/L	18	675	3 850	11

Table B.4-6 shows that the median of the mixed diet BAF for aquatic organisms is 1 553 L/kg (90th percentile: 3 890 L/kg) and that the mixed diet scenario is driven by the BAF values observed for invertebrates. The median BAF of the mollusc food diet is somewhat lower, i.e. 675 L/kg (90th percentile: 3 850 L/kg). The mollusc food diet results in lower overall BAF values for lead than the mixed diet.

B.4.3.2. Terrestrial bioaccumulation

A wealth of data are available on terrestrial bioconcentration factors or bioaccumulation factors. Therefore, only a selection of illustrative, representative, BAF data are reported. Data were considered reliable:

- if the data came from field studies or laboratory studies using soil and biota collected at the same field site. This is to ensure that biota lead burdens are in equilibrium with soil lead concentrations. Data from laboratory studies where lead was added to the soil as a lead salt are excluded;
- if lead concentrations were measured in soil and biota. The lead concentration in soil has to be expressed as “total” soil lead (e.g. lead measured after aqua regia destruction), extractable lead fractions (e.g. water-extractable lead) are not considered reliable;
- if guts from the biota were voided prior to analysis;
- if it was indicated how BAF values were expressed, i.e. on a dry or wet weight basis.

According to REACH Guidance (Chapter R16), the food-chain comprising soil, earthworms and earthworm eating predators was considered. Bioaccumulation factors (BAFs) for lead from to soil to earthworms are summarised in the Voluntary Risk Assessment for lead (LDAI, 2008).

The median BAF for earthworms on a dry weight basis is 0.39 kg_{dw}/kg_{ww} (median of 101 values) and 10-90th percentiles are 0.13-1.17. On a fresh tissue weight basis, BAF values are 0.10 kg_{dw}/kg_{ww} (median) and 0.03-0.27 (10-90th percentiles). The influence of soil properties on the BAF of earthworms *(A. calluginosa)* was studied in different soils and the equation describing the BAF as a function of pH reads, with BAF on a wet weight basis (kg_{dw}/kg_{ww}).

BAF=13.9*exp(-0.76*pH) (Ma, 1982). This equation predicts that the median BAF of the 101 data points above (BAF= 0.10 kg_{dw}/kg_{ww}) is found at pH=6.5. At pH 4.5, this BAF is 4-fold larger. There is no significant effect of total soil lead on the BAFs (LDAI, 2008).

Literature data are available for bioaccumulation of lead in isopods from soil or litter. Values range from 0.001-0.65 kg_{dw}/kg_{dw}. A median BAF for isopods on a dry weight basis

is 0.04 (median of 14 values).

From the literature overview, the following bioaccumulation/bioconcentration factors have been derived for lead:

- Aquatic compartment: Bioaccumulation/bioconcentration factors in freshwater: 1 553 L/kg (wet weight);
- Soil compartment: Bioaccumulation/bioconcentration factors in soil: 0.39 kg/kg (dry weight).

B.5. Human health hazard assessment

The following section on human health assessment specifically relates to hazards of lead metal with the context of shooting with lead ammunition and the use of leaded fishing gear.

B.5.1. Toxicokinetics (absorption, metabolism, distribution and elimination)

See Annex XV report.

B.5.2. Acute toxicity

See Annex XV report.

B.5.3. Irritation

Not relevant for this report.

B.5.4. Corrosivity

Not relevant for this report.

B.5.5. Sensitisation

Not relevant for this report.

B.5.6. Repeated dosed toxicity

B.5.6.1. Haematological effects

See Annex XV report.

B.5.6.2. Effect on blood pressure and cardiovascular effects

See Annex XV report

B.5.6.3. Kidney effects

See Annex XV report

B.5.6.4. Neurotoxicity and developmental effects

See Annex XV report

B.5.7. Mutagenicity

Not relevant for this report.

B.5.8. Carcinogenicity

Not relevant for this report.

B.5.9. Toxicity for reproduction

As presented in Section B.3, lead massive is classified under CLP in category 1A (H360DF) for reproductive toxicity.

The CLH report on lead (KEMI, 2012) highlights that strong evidence by studies in both humans and experimental animals have demonstrated negative impacts on male fertility (e.g. semen quality). Furthermore, Lead also causes neurodevelopmental effects. Pre- and perinatal lead exposure is toxic to the developing nervous system and IQ is one of the major parameters found to be negatively affected. The report concluded that lead clearly fulfils these criteria for reproductive toxicity and should therefore be classified as reprotoxic category 1A under CLP.

ECHA's Risk Assessment Committee, following the assessment of the KEMI CLH report (KEMI, 2012), has adopted a scientific opinion (ECHA, 2013) concluding that all physical forms of metallic lead should be classified as Repr. 1A; H360DF (Repr. Cat 1) (may damage fertility; may damage the unborn child) similar to the classification that applies for "lead and lead compounds").

The Background Document to the Opinion on the Annex XV dossier proposing restrictions on lead and its compounds in articles intended for consumer use (ECHA, 2018b), provided a good review of both animal and human studies on the reproductive toxicity of lead. An overview of these studies is given in the Appendix X of the restriction document on the Restriction on the use of lead shots over wetlands (ECHA, 2018a).

B.5.10. Derivation of DNEL(s)/DMEL(s)

See Annex XV report.

B.6. Human health hazard assessment of physicochemical properties

B.6.1. Explosivity

Not relevant for this Annex XV report.

B.6.2. Flammability

Not relevant for this Annex XV report.

B.6.3. Oxidising potential

Not relevant for this Annex XV report.

B.7. Environmental hazard assessment

B.7.1. Compartment specific hazard assessment

Lead and its compounds are hazardous for the environment. Extensive data on the effects of short and long-term lead exposure on a wide variety of aquatic and terrestrial organisms have been collated in REACH registration dossiers as well as previously in the EU voluntary risk assessment for lead and its compounds (LDAI, 2008).

In general, the toxicity of lead in the environment is dependent on the bioavailability of the specific lead substance or form (termed speciation) to which an organism is exposed. Relatively greater toxicity is usually associated with forms that have the greatest bioavailability in the environment, such as forms that are dissolved in aquatic systems, including the 'free-ion'.

Therefore, risk assessments undertaken for REACH registration, and in recent REACH restrictions for lead and its compounds have typically been underpinned by (read-across from) hazard data derived from ecotoxicity tests that used dissolved forms of lead rather than metallic lead.

Metallic lead (sometimes termed 'massive' lead) transforms/dissociates to liberate soluble/bioavailable species of lead relatively slowly in the environment. As such, metallic forms of lead are not usually considered to pose a significant ecotoxicological hazard in their own right, but rather act as source of other more mobile lead substances in the environment over time.

In the following section accumulation of lead in the aquatic and terrestrial compartments are considered.

B.7.1.1. Terrestrial compartment

In Europe, lead concentrations in top soils are geographically heterogeneous and vary from below 10 mg/kg up to >70 mg/kg. The median value was estimated by WHO (2007) to be 23 mg/kg. The lead content in uncontaminated top soils of remote areas is generally within the range of 10 to 30 mg Pb/kg (EFSA, 2010).

Data on the hazard of lead in the terrestrial compartment are presented in the CSR (2020). The generic PNEC for soil is reported as 212 mg Pb/kg dry soil.

There is currently no specific Community legislation on soil protection except for the Sewage Sludge Directive where limits for heavy metals and lead in agricultural soils (on which sewage sludge is applied) are defined. This directive sets a limit value for lead of **50 to 300 mg/kg of dry matter**. The allowed lead concentration in sludge for use in agriculture is 750 to 1 200 mg/kg. The limit value for lead which may be added annually to agricultural land, based on a 10-year average, is 15 kg lead/ha/year.

Within an EU project, metals in topsoil were analysed in all EU countries and evaluated. For lead, the threshold value that indicates the need for further assessment of the area was set at 60 mg/kg. The lower guidance value indicating a risk for human health has been set at 200 mg/kg and the higher guidance value indicating an ecotoxicological risk at 750 mg/kg (Tóth et al., 2016).

B.7.1.2. CSR

Data on effects of lead to the terrestrial compartment are presented in the CSR (2020). It is concluded that the available database and models allow for the derivation of an HC5-50 that is protective for the terrestrial environment. The application of an assessment factor of 1 is proposed on the HC5-50 derived with the statistical extrapolation method. According to the CSR This provides a robust and ecological relevant PNEC to be retained for the risk characterisation. The **generic aged PNEC** is **212 mg Pb/kg dry soil** (statistical extrapolation method with the log-normal distribution). Taking into account bioavailability of Pb in soil results in PNEC values between 170 and 440 mg Pb/kg soil for the 10th and 90th percentile of the eCEC in European arable soils.

B.7.1.3. Legislations regulating lead concentration in soil and plants

There is currently no specific Community legislation on soil protection.

DIRECTIVE of 12 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture (86/278/EEC) sets a limit value for lead of **50 to 300 mg/kg of dry matter**. The allowed lead concentration in sludge for use in agricultures is 750 to 1,200 mg/kg. The limit value for the amount of lead which may be added annually to agricultural land, based on a 10-year average, is 15 kg lead/ha/year.

COMMISSION REGULATION (EU) No 1275/2013 of 6 December 2013 amending Annex I to Directive 2002/32/EC of the European Parliament and of the Council as regards maximum levels for arsenic, cadmium, lead, nitrites, volatile mustard oil and harmful botanical impurities sets a maximum content of lead of 10 mg/kg (ppm) relative to a feed with a moisture content of 12 %[26].

REGULATION (EC) No 1881/2006of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs (Text with EEA relevance) sets maximum lead levels in vegetable of 0.1 to 0.3 mg/kg wet weight with the note that "*it is appropriate to take measures to reduce the presence of lead in food as much as possible*".[27]

National limits for lead concentration in soil are reported by (Carlon, 2007).

B.7.1.4. Aquatic compartment

Lead compounds and small lead particles are relatively mobile in the soil solution or runoff water. Therefore, close proximity to the surface water is considered a high risk factor for increasing the potential of lead mobility and transport from sites contaminated by lead shot. Lead shot erosion leading to elevated lead levels in water was reported by (Stansley et al., 1992) in an investigation of eight target shooting ranges in the United States that had surface waters (ponds, marshes, etc.) in their shotfall zones. They suggested that the suspension of pellets crust compounds containing lead, as described by (Jorgensen and Willems, 1987), might explain the high concentrations of waterborne lead observed at the ranges (4.3-838 µg/L vs 7.4 µg/L at control sites). At a trap and skeet range located in Westchester County, New York, surface water lead concentration ranged from 60 to 2,900 µg/L (USEPA 1994).

In in vitro leaching tests, short-term exposure (1 or 8 days) of lead shot under siliceous aerobic conditions resulted in lead concentrations of 1.77±0.36 µmol/L, under calcareous aerobic conditions of 0.32±0.15 µmol/L. Under anaerobic conditions no relevant leaching was observed. Under long-term exposure (15 or 22 days), leaching under siliceous aerobic conditions increased to 4.30±1.12 µmol/L but was slightly reduced to 0.20±0.09 µmol/L under calcareous aerobic conditions (Fäth et al., 2018), (Fäth and Göttlein, 2019).

Metallic lead (sometimes termed 'massive' lead) is currently not classified to be hazardous for the aquatic environment.

Lead powder[28] and lead compounds are classified as hazardous for the aquatic

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[26] http://extwprlegs1.fao.org/docs/pdf/eur129053.pdf

[27] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02006R1881-20150521&from=EN

[28] A proposal for a harmonised classification for lead was adopted by ECHA's Risk Assessment Committee

environment: Aquatic Acute 1 and Aquatic Chronic 1.

Data on effects of lead to the aquatic compartment are presented in the CSR (2020). The freshwater PNEC is reported as 2.4 µg dissolved lead/L.

B.7.1.5. CSR

Data on effects of lead to the terrestrial compartment are presented in the CSR (2020). It is concluded that due to the cautious approaches taken for the derivation of HC5,50% it is felt that the most appropriate AF for freshwater would be 2. Therefore, the reasonable worst-case **freshwater PNEC** (derived from the HC5,50% value of 4.7 µg dissolved Pb/L after bioavailability correction) is proposed to be **2.4 µg dissolved Pb/L**, which will be carried over to the risk characterisation. For comparison, the freshwater PNECs for the different EU-specific eco-region scenarios will be between 2.0 and 9.7 µg dissolved Pb/L (bioavailable HC5,50%: 4.0 - 19.4 µg Pb/L). However, it is important to note that in case potential risks would be noted for the freshwater environment it is then recommended to derive BLM normalised site-specific PNEC values using the physico-chemistry (pH, DOC, Hardness) prevailing at the site.

Legislations regulating lead concentration in water

DIRECTIVE 98/83/EC of 3 November 1998 on the quality of water intended for human consumption reduced the lead concentration from 25 to 10 µg/L.

WHO proposed a guideline value of 10 µg/L for lead in drinking water considering an allocation of 50% of the weekly tolerable intake (PTWI) to water (WHO, 2008). The weekly intake (PTWI) was considered more appropriate as peaks in exposure levels and daily-exposure variations are less relevant for lead due to its long half-life (WHO, 2003, 2008). The WHO proposal was integrated in the new EU Drinking Water Directive 98/83/EC (03.11.1998) where the limit of 10 µg/L was set for implementation on 25.12.2013. Based on the WHO guidelines, the USA decided to propose a limit value of 15 µg/L, taking into account the reduction of other sources of lead. EFSA concluded that the PTWI for lead is no more valid due to the absence of a demonstrable threshold for lead-induced effects.

In its letter of 18 March 2010, the Institut Européen pour la gestion raisonnée de l'environnement (IEGRE) questioned the rationale for this 10 µg/L limit and asked the Commission to raise the limit concentration of lead in drinking water to "maybe 15 or 20 µg/L". DG ENV sought SCHER's opinion on IEGRE's request, asking in particular whether, following the reduction of the use of lead in car fuels and in the food processing industry, relaxing the standard from 10 µg/L to 15 or 20 µg/L will not cause a potential risk for human health. In view of the available data, SCHER referred to EFSA concluding that when using a low concentration of lead in drinking water (2.1 µg/L), the dietary exposure of sensitive subgroups (infants and foetal exposures) to lead results in a Margin-of-Exposure value of less than 1 indicating that risks to young children regarding neurodevelopmental effects cannot be excluded. Therefore, effects may occur even at the proposed new drinking-water standard for lead (SCHER, 2011).

(RAC) on 30 November 2018. The proposal classification is for Repr. 1A (H360FD), Lact. (H362), Aquatic Acute 1 (H400) and Aquatic Chronic 1 (H410).

B.7.2. Non compartment specific effects

Massive forms of lead (as used in lead ammunition) are known to pose a significant hazard to any bird that ingests it. These hazards are closely associated with the ecology and physiology of particular bird species and the ecological niches (habitats) that they occupy.

Derived predicted no effect concentrations (PNECs) for key environmental compartments, collated from previous risk assessments for lead and its compounds, can be obtained in REACH registration dossiers or the voluntary risk assessment report (LDAI, 2008).

B.7.2.1. Toxicity to birds

Toxicokinetics

In general, the toxicokinetics of lead in birds are closely associated with the biochemical mechanisms and processes that regulate the absorption, distribution and metabolism of calcium. This is a result of the similarity of lead, in terms of atomic structure and mass, to calcium which leads to affinity to calcium uptake channels, enzymes and other biochemical processes that normally involve calcium (Simons, 1993) The lead ion is not metabolised or bio-transformed in birds, though it does form complexes with a variety of proteins and non-protein ligands. It is primarily absorbed, distributed and then the non-accumulated lead is excreted (WHO, 2003).

Absorption

Factors that influence the absorption of lead have been extensively investigated since the 1950s and reviewed by many authors including Pain and Green (2015). The uptake of lead pieces (shot, bullets, fishing tackles) by birds after ingestion is known to vary depending on several factors, including the individual digestive physiology of different bird species.

The main factors affecting the absorption of lead include: stomach characteristics, retention time of lead in the gastrointestinal tract (Schulz et al., 2006), diet and gender. These are outlined, below. However, the absorption of lead occurs in the intestine. Any lead ingested becomes more soluble in the stomach and after passing into the intestines, is absorbed as lead salts into the body of the bird (USFWS, 1986).

Stomach characteristics

Following ingestion, lead objects passes down the oesophagus, through the proventriculus (stomach), the primary function of which is gastric secretion, and enters the ventriculus, which is modified into a gizzard in birds. The gizzard is a muscular organ that often contains stones or 'grit' that is used, in the absence of teeth, to grind up food during digestion.

The characteristics of gizzards differ between species, e.g. the well-muscled gizzard of a geese can develop pressures of up to 275 mm Hg, which is significantly greater than the pressures of 180 and 125 mm Hg observed for ducks and hens, respectively (FAO, 1996).

According to Golden et al. (2016) citing Farner (1960), species such as waterfowl that feed on coarse objects like grain or plant material have muscular gizzards for grinding that are larger than birds whose diet is largely meat.

Grinding of ingested food material in the gizzard, whilst necessary for normal digestion, facilitates the erosion of any ingested lead particles, leading to greater absorption in the gastrointestinal tract than would occur if the lead remained as ingested according to Golden et al. (2016) when citing Jordan and Bellrose (1951). Thus, the particularity of avian digestive physiology is key factor in the lead poisoning observed in birds after the consumption of lead particles.

Different species of birds have different stomach pH. For example, the pH of a duck stomach ranges from 2.0 - 2.5, whilst that of an eagle is closer to 1.0 (USFWS, 1986).

In scavengers acidic gastric juices can promote rapid lead dissolution ((Fisher et al., 2006, Berny et al., 2015).

Retention time in the gastrointestinal tract

The anatomical characteristics of bird species differ and can influence the retention time and thus the absorption of ingested lead pieces (Franson and Pain, 2011) (Franson and Pain, 2011). Individual pieces of lead may either be rapidly regurgitated or, alternatively, passed through the gut resulting in limited absorption of lead. Other pieces may be retained within the gastrointestinal tract until completely dissolved and absorbed. Intermediate retention and absorption, between these two states, is also possible (Franson and Pain, 2011) (Franson and Pain, 2011).

In general terms, most lead ingested will either pass through the gastrointestinal tract or be completely eroded within 20 days of initial ingestion ((Franson, 1986, Sanderson et al., 1986) cited by cited by Pain and Green, 2015; LAG Appendix 4). However, if not ejected from the body within the first 24 hours, they becomes subjected to the grinding within the gizzard and dissolution within the stomach (USFWS, 1986).

Birds of prey typically regurgitate "pellets" comprising the indigestible portions of their food (e.g. bones, hair and feathers). Lead pieces present in prey can be regurgitated in these pellets.

Falconiformes, with an averaged pH of gastric contents being 1.6, regurgitate pellets with no bones in comparison to owls with pH of 2.35 regurgitating pellets with nearly all bones of their prey (Duke et al., 1975).

In addition, according to Duke (1997) cited by Golden et al. (2016) periodic reverse peristalsis moves the contents of the upper ileum and duodenum back into the stomach, an adaptation hypothesized to allow for greater digestion of nutrients without lengthening the gastrointestinal tract, which would be disadvantageous to flying due to added weight.

Diet

The diet of birds is one of the most important factors in determining the extent of lead absorption after ingestion. In general, because of the grinding that occurs in the gizzard, bird species that prefer whole or part-grain diets are more susceptible to lead poisoning than bird species that have a preference for 'grainless' diets (USFWS, 1986).

Rattner et al. (1989), considered diet to be the most important factor affecting lead-shot toxicity in waterfowl.

More recently, Ferrandis et al (2008) noted that supplying Red-Legged Partridge (*Alectoris rufa)* with large seeds (i.e., corn) may increase the risk of Pb shot ingestion.

The nutritional, chemical and physical characteristics of diet are known to affect lead absorption and subsequent deposition in tissues (Jordan and Bellrose, 1951; Longcore et al., 1974a; Sanderson and Irwin, 1976; Koranda et al., 1979, Sanderson and Bellrose, 1986;

Scheuhammer, 1996 all cited by Franson and Pain 2011). Differences in the toxicity observed in similarly conducted experimental studies are thought to be related to differences in the diets used in the experiments (Rodrıguez et al. 2010).

Diets high in protein and calcium are known to mitigate the effects of lead exposure (Koranda et al., 1979; Sanderson, 1992; Scheuhammer, 1996 all cited by Franson and Pain 2011). For example, calcareous grit consumption can reduce the rate of dissolution of ingested lead gunshot by reducing acidity within the gizzard (Martinez-Haro *et al*. 2009).

Other physiological factors

Taylor and Moore (1954 cited by USFWS, 1986), reported that the biochemical changes in female birds associated with active laying enhance the accumulation of lead in bones as does a calcium deficient diet. The medullary bones of birds (i.e. tibia, femur, sternum, ilium, ischium and pubis) supply up to 50 percent of the calcium used in egg production and this rapid turnover of calcium in the laying bird leads to an increased deposition of lead in these bones (USFWS, 1986). Finley and Dieter (1978 cited by Golden et al., 2016), reported that lead concentrations in femurs of laying mallards *(Anas platyrhynchos)* were four times higher than in non-laying females.

When calcium is mobilised for eggshell formation, intestinal absorption of calcium, and concurrently lead, can increase, resulting in greater bone lead concentrations in similarly exposed females than in male birds (Scheuhammer, 1996 cited in Golden et al., 2016). A diet deficient in calcium increases lead absorption in female birds (Scheuhammer and Norris, 1996).

Distribution

Absorbed lead is transported around the body in the bloodstream and deposited rapidly into soft tissues, primarily the liver, kidney, bone and also in growing feathers. The greatest lead concentrations are generally found in bone, followed by kidney and liver.

Intermediate concentrations are found in brain and blood whilst the lowest concentrations are found in muscle tissues (Longcore et al., 1974; Custer et al., 1984; Garcia Fernandez et al., 1995; cited by Pain and Green, 2015; LAG Appendix 4).

The concentration of lead in blood is a good indicator of recent exposure to lead and usually remains elevated for several weeks to several months following ingestion, in relation to the initial amount ingested and the time elapsed in since initial ingestion. Lead in bone is elatively immobile accumulating over an animal's lifetime, although it can be mobilised, particularly in birds, and especially in female birds (Pain and Green, 2015, LAG Appendix 4).

Metabolism

Lead competes with calcium ions, resulting in substitution for calcium in bone. It also mimics or inhibits many cellular actions of calcium and alters calcium flux across membranes (Simons, 1993; Flora et al., 2006).

Calcium plays two important physiological roles in birds. It provides the structural strength of the avian skeleton and plays a vital role in many of the biochemical reactions within the body via its concentration in the extracellular fluid (Dacke, 2000; Harrison and Lightfoot, 2006).

The control of calcium metabolism in birds has developed into a highly efficient homeostatic system, able to quickly respond to increased demands for calcium during egg production and during rapid growth rate when young (Bentley, 1998).

There are distinct differences between the mammalian and avian systemic regulations of calcium. The most dramatic difference between the two groups is in the rate of skeletal metabolism at times of demand. This is best demonstrated by an egg-laying bird where 10 %

of the total body calcium reserves can be required for egg production within a 24- hour period (Klasing, 1998). The calcium required for eggshell production is mainly obtained from increased intestinal absorption and a highly labile reservoir found in the medullary bone. The homeostatic control of the medullary bone involves oestrogen activity (Bentley, 1998).

Lead also binds to sulfhydryl groups in proteins and breaks disulphide bonds that are important for maintaining proper conformation for biological activity. In addition, it can alter many enzymes via its competing effects with other cations, such as ferrous iron and zinc (Speer, 2015).Effects on specific targets are described in the section describing sub-lethal effects.

Elimination

In general, some of the lead absorbed will be eliminated from the body in waste, but with continuous or repeated exposure some absorbed lead will continue to be retained and bone lead concentrations will increase (Pain and Green, 2015; LAG Appendix 4).

Summary on toxicokinetics

Birds readily ingest lead (shot, bullets and fishing tackles) through either primary or secondary ingestion. Avian physiology can facilitate the dissolution of lead pieces and absorption into tissue. Lead competes with calcium ions, resulting in substitution for calcium in bone. It also mimics or inhibits many cellular actions of calcium and alters calcium flux across membranes. Diet is one of the most important factors determining the severity of lead absorption. However, in addition to diet, there are a number of physiological factors influencing the uptake of lead, e.g. digestive physiology and gender differences (laying females are more susceptible to lead poisoning than male and non-laying females).

After absorption, lead will distribute into various tissue compartments such as blood, soft tissue, bone and feathers. Lead accumulation is greatest in liver and kidney but some accumulation can occasionally also be observed in muscle tissue. Lead in bone is relatively immobile (other than during breeding seasons for females as discussed) accumulating over an animal’s lifetime.

Lethal and sub-lethal effects

The toxic effects of lead are broadly similar in all vertebrates. These effects are well known from many experimental and field studies and have been the subject of many reviews (e.g. Eisler, 1988; Pattee and Pain 2003; Franson and Pain 2011; Ma, 2011; cited in Pain et al., 2015).

Many toxicological studies have been conducted using captive birds. These studies have involved species from various taxa, particularly wildfowl species but some studies have investigated effects on other species as predatory and scavenging species. These studies typically involve dosing of birds with lead gunshot and subsequent monitoring of blood lead concentrations and physiological and other clinical signs, such as altered behaviour (e.g. Hoffman et al. 1981, 1985, reviewed in Eisler 1988, Pattee and Pain 2003, Franson and Pain 2011 cited in Pain et al., 2015; Golden et al. 2016). Many authors have reported the signs of lead poisoning in birds and the dose of lead gunshot necessary to result in either lethal or sub-lethal effects (Locke and Thomas, 1996; Rattner et al., 2008; Franson and Pain, 2011; Franson and Russell, 2014, all cited in Golden et al., 2016; Rodrıguez et al., 2010).

Lethal effects (occurring after either acute or chronic exposure)

Lethal effects can result from either acute or chronic exposure to lead (as from the ingestion of ammunition, ammunition fragments, fishing tackles).

Acute lethal poisoning is usually associated with the death of a bird within a short period of time (Pain and Rattner, 1988). Mortality generally occurs rapidly after the ingestion without

the bird becoming noticeably intoxicated, typically within 1-3 days. Birds dying from acute lead poisoning are typically found to be in good to excellent condition with good to excellent deposits of fat.

Chronic lethal poisoning, as described in USFWS (1986), occurs as the result of a bird developing a progressive (non-reversible) illness that requires two to three weeks to eventually result in mortality (average time to death of approximately 20 days).

One of the first signs of chronic lethal poisoning is the occurrence of a diarrhoea characterised by brilliant, almost fluorescent, green staining of the faeces and the feathers around the vent. There is an increasing muscular weakness characterised at first by the abnormal positioning of the wings, followed by a progressive loss of flight. Lead-poisoned birds that are still able to fly do so weakly, often dropping to the ground after going only a short distance. As the condition worsens the bird becomes weaker, loses its ability to walk or fly and seeks refuge in dense cover. Untrained observers often mistakenly believe that lead poisoned birds are "cripples". Finally, the bird loses the ability even to walk, and if not caught and eaten by a predator, the bird becomes comatose and dies.

Affected birds may lose 30-40, sometimes 60 percent of their weight. Subcutaneous, abdominal

and coronary fat deposits are lost and the breast muscles undergo a marked atrophy (wasting away), resulting in the classical "hatchet-breast". These findings have often led untrained observers to believe the birds have died of starvation. The oesophagus is often packed throughout a major portion or its entire length with undigested food. This "impaction" may extend from the angle of the jaw, along the entire length of the neck, into the thoracic (chest) cavity and to the gizzard. Weakened and emaciated lead-poisoned birds, if picked up, will often die after a few brief struggles.

Birds affected by chronic lethal poisoning often exhibit marked myocardial damage (necrosis of the surface of the heart). Sileo et al.,1973, cited in USFWS, (1986), reported that lead-poisoned Canada geese exhibit electrocardiographic changes similar to those seen in humans suffering from myocardial infarction (i.e. a "heart attack"). Internally, necropsy reveals an emaciated carcass, often with liver atrophy, an enlarged gall bladder distended with thick, dark-green bile and, frequently, an impaction (congestion with food) of the oesophagus, proventriculus and/or gizzard (Locke and Thomas, 1996; Rattner et al., 2008; Franson and Pain, 2011; Franson and Russell, 2014 cited in Golden et al., 2016).

Schulz et al. (2006), administered 157 captive mourning doves 2–24 lead pellets, monitoring pellet retention and short-term survival, and measuring related physiological characteristics. During the 19- to 21-day posttreatment period, 104 doves that received lead pellets died and 53 survived; all 22 birds in a control group survived. Each additional administered lead pellet increased the hazard of death by 18.0% and 25.7% for males and females, respectively. The authors considered the results as supporting the hypothesis that free-ranging mourning doves (*Zenaida macroura*) may ingest spent lead pellets[29], succumb to lead toxicosis, and die in a relatively short time (i.e., an acute lead toxicosis hypothesis).

Vyas et al (2001) evaluated the toxicity of a single size 7.5 lead shot to passerines. No mortalities or signs of plumbism were observed in dosed cowbirds (*Molothrus ater*) fed a commercial diet, but when given a more natural diet, three of 10 dosed birds died within 1 day. For all survivors from which shot were recovered, all but one excreted the shot within 24 h of dosing, whereas, the dead birds retained their shot. Shot erosion was

[29] Based on data from 2 shot ingestion studies (Lewis and Legler 1968, Schulz et al. 2002), doves may frequently ingest multiple spent shotshell pellets.

greater when weathered shot were ingested compared to new shot, and the greatest erosion was observed in those birds that died (2.2-9.7%). Blood lead concentrations of birds dosed with new shot were not significantly different from those of birds exposed to weathered shot. Liver lead concentrations of birds that died ranged from 71 to 137 ppm, dry weight. The authors concluded that despite the short amount of time the shot was retained, birds may absorb sufficient lead to compromise their survival.

Pattee et al. (1981) dosed five captive bald eagles (Haliaeetus leucocephalus) with lead shot. Initial dosage consisted of 10 (n.4) lead shot. Additional groups of 10 shot were given if all of the previous 10 shot were regurgitated. Frequent radiographs were taken to confirm the presence or absence of shot prior to additional doses. Lead shot dosage and response of each eagle are summarised in Table B.7-1

Table B.7-1 Lead shot dosage and response of each dosed eagle (after Pattee et al., 1981)

Eagle	Total shot given	Days to death
A	10	20
B	30	10
C	20	12
D	156	125
E	80	133

Four birds died and the fifth became blind and was sacrificed after 133 days. Individual responses to lead-shot ingestion were very variable. The authors found that the interaction of factors such as the duration of shot retention, number of shot retained and amount of lead eroded appeared to affect the time to death. They concluded that while healthy eagles may regurgitate lead shot and survive occasional exposure, repeat exposure of birds would increase the likelihood of reaching a threshold where the eagle would stop eating, retain the ingested shot and die. This threshold may be related to lead erosion rates and shot retention, but the exact factors remain unclear.

Summary

Ingestion of lead objects (like from lead shot, ammunition fragments and fishing tackles) can cause mortality in birds. Ingestion of a single lead gunshot may be sufficient to cause the mortality of a small-sized duck (Guillemain et al., 2007),[30] or of a dove (Schulz et al. 2006).

The time to death after ingestion of lead gunshot in experimental studies varies between

species and dosage regime, with waterfowl generally succumbing within 2–4 weeks of exposure whilst some raptors survive for more than 15 weeks prior to death (Barrett and

[30] Although greater quantities are likely to be required to cause mortality in larger birds such as geese and swans.

Karstad, 1971; Pattee et al., 1981; Franson et al., 1986; Beyer et al., 1998; cited in Golden et al. 2016).

Conclusions of the previously mentioned studies using lead shot can be considered relevant for lead fishing tackle as well. As noted by Twiss and Thomas(1998) commonly used lead sinkers and jigs weigh between 0,5 and 15 g. Experiments with mallard ducks (Anas platyrhynchos) demonstrated that mortality was dose related in ducks given commercial lead shot; one #8 shot (0.073 g of lead) caused 35 percent mortality with higher amounts of lead causing 80 to 100 percent mortality (Finley and Dieter, 1978). More recently Brewer et al., (2003) reported a mortality of 90% for birds dosed with 0,2 g of lead shot. This suggests that even one lead sinker or jig of the minimum weight, can be lethal. Twiss and Thomas (1998) also noted that birds that have died following ingestion of a lead sinker issue are usually in good body condition (Pokras and Chafel, 1992), which implies acute toxicity, rather than a chronic condition.

Sub-lethal effects (occurring after both acute or chronic exposure)

Sub-lethal effects occur as a consequence of acute exposure and of chronic exposure to lead at a level that is not necessarily likely to result in immediate mortality; although death may eventually result from another cause. While some sub-lethal effects alter health directly, others may render birds more susceptible to causes of mortality such as predation, hunting mortality, collisions with objects, and illness or death from disease (Golden et al., 2016).

Lethal and sub-lethal endpoints

Mortality can result from either acute (short-term) or chronic (long-term) exposure to lead.

Acute lethal poisoning is usually associated with the death of a bird after it has ingested a large number of lead shot within a short period of time, although acute poisoning can occur after the ingestion of just one shot (Pain and Rattner, 1988; Guillemain et al., 2007, Schulz et al 2006). The sub-lethal effects associated with ingestion of lead items can arise after both acute (short-term) and chronic (long-term) exposure. These are elaborated further in Annex B, and include:

- **Haematology**: e.g. inhibition of enzymes, including delta-aminolevulinic acid dehydratase (ALAD), involved in haemoglobin synthesis; abnormal morphology of erythrocytes (leading to anaemia); hemosiderin accumulation is tissues leading to hemosiderosis. Suppression of daminolevulinic acid dehydratase (d-ALAD) activity, an enzyme involved in heme synthesis, is a highly sensitive biomarker of Pb toxicity. Such suppression also cause anemia in mammalian species, including humans. Recent studies have shown that d-ALAD activity is severely depressed following oral exposure to a single 45-mg Pb pellet in two terrestrial avian species: the Northern bobwhite quail and the Roller pigeon (Kerr et al. 2011; Holladay et al. 2012). Herring et al. 2020 found suppressed δ-ALAD activity (8% below reference) at blood concentrations as low as 0.03 μg/g in golden eagle nestlings. In blood lead levels equivalent to subclinical poisoning, griffon vultures exhibited 94% decrease in δALAD (Espin et al. 2015).
- **Cardiovascular system:** myocardial infarcts (dead portions of heart muscle); vascular damages de Francisco et al. (2016).
- **Ocular effects :** First evidence of ocular lesions due to sub-lethal blood lead levels in bald eagle was published by Eid et al. (2016). The rehabilitated bird was not released back to wild due to the level of vision loss.
- **Growth and body condition**: Newth et al. (2016) recently established a significant association between blood lead concentration and reduced winter body condition

above blood lead concentrations of 44 µg/dL. 10% of the wild whooper swans sampled in the study had blood concentrations above this level.

- **Behaviour and learning**: effects (observed in the laboratory and field) on locomotion, begging behaviour, individual recognition, balance, depth perception, thermoregulation (reviewed by Golden et al., 2016).
- **Immune function:** e.g. reduced spleen mass and circulating white blood cells (Rocke and Samuel, 1991); inhibition of antibody production (Trust et al., 1990); reduced immune system competence (Vallverdu-Coll et al., 2015a; 2015b; 2016a). (Vallverdu-Coll et al. 2015c) also investigated the influence of seasonal changes on Pb-induced immune changes in red-legged partridges and found that while Pb increased the T-cell PHA response in fall and spring, the T-cell independent humoral response was decreased in the autumn, indicating that both the cell-mediated and humoral immune responses are targets for Pb (Vallverdu-Coll et al. 2015c). The researchers showed that during the spring, oxidative stress was increased in both male and female birds; however, the response was sex-dependent. These data were replicated in mallard ducks from the Ebro Delta (Spain) by the same team of researchers that showed environmentally relevant concentrations of Pb caused sex-dependent changes in antioxidant ability and oxidative stress, particularly during mating season (Vallverdu-Coll et al. 2015b).
- **Reproduction and development:** e.g. disruption of the blood-brain barrier in immature animals (Locke and Thomas, 1996); reduced juvenile survival (Vallverdu-Coll et al., 2015b). (Vallverdu´-Coll et al. 2016) evaluated Pb influence on avian reproduction showing that red-legged partridge (Alectoris rufa) hens gavaged with three #6 Pb pellets (about 109 mg/pellet) had a reduction in hatching rate. Hatchability also was decreased in mourning doves (Zenaida macroura) when hens were exposed to a single #8 Pb pellet (about 70 mg) (Buerger et al. 1986). Results from these studies indicate that maternal transfer of Pb into the developing bird can significantly impact hatchability, growth, and survivability in multiple avian species.

A number of studies have developed tissue thresholds or reviewed existing thresholds for blood, liver, kidney and bone tissue in birds (Friend 1985; 1999; Franson, 1996; Pain, 1996; and Pattee and Pain, 2003, cited by Rattner et al., 2008; Buekers et al., 2008, Pain et al., 2009; Franson and Pain, 2011; Newth et al., 2016).

Table X shows the most common thresholds used as indicators of lead exposure (acute or chronic) that can lead to adverse effects in birds and other wildlife.

The thresholds can be also used for interpreting tissue concentrations for managing wildlife on contaminated areas. These indicative thresholds should only be interpreted as representative of the likelihood that certain clinical and sub-clinical effects in birds will occur and should not be considered to be equivalent to PNECs. Adverse effects in birds may occur at tissue concentrations below those reported.

Table B.7-2 Subclinical effects of lead poisoning in birds of prey and scavengers adjusted from review of Monclus et al. (2020). Matrix used (bl = blood; F = feathers; L = liver; E = eggs) and lead concentrations found associated with effects are shown.

Species	Effects	Association with lead levels	Details	n	Ref.
Biomarkers					
Griffon vulture	Oxidative stress (GPx, CAT, TBARS)	bl: ≥15 µg/dl	Spain 2014	66	Espín et al. (2014)
Eurasian eagle owl		bl: ≥2 µg/dl	Spain 2015	141	Espín et al. (2014)
Eurasian eagle owl	δ-ALAD inhibition	bl: ≥10 µg/dl	Spain 2011	218	Gómez-Ramírez et al. (2011)
Booted eagle; common buzzard; northern goshawk		bl: ≥5 µg/dl	Spain 2004	27; 4; 3	Martínez-López et al. (2005)
Eurasian eagle owl		bl: ≥5 µg/dl	Spain 2014	139	Espín et al. (2015)
Griffon vulture		≥8 µg/dl	Spain 2014	66	Espín et al. (2015)
Griffon vulture; Eurasian eagle owl		bl: ≥30 µg/dl	Spain 2014		Espín et al. (2015)
Black kites	DNA damage	No association bl: 3.88 (±4.3) µg/dl	Spain 2006	132	[Baos et al. (2006)
Golden eagles	Chronic stress (corticosterone)	No association F: <0.5 µg g−1	Switzerland 2018	24	Ganz et al. (2018)

Breeding parameters					
Bonelli's eagle	No. fledglings/breeding attempt	Decrease with ↑Pb F: 0.82 (±0.4) $\mu g\ g^{-1}$	Spain 2018	57	Gil-Sanchez et al. (2018)
Tengmalm's owl	Nestling mortality	No association L: 1.13 (±0.25)	Sweden 1996	13	Hornfeldt and Nyholm (1996)
Booted eagle	Fecundity	No association bl: 1.83 (±1.3) μg/dl	Spain 2017	8	Gil-Jiménez et al. (2017)
Spanish imperial eagle	Viability eggs	No association E: 0.82 (±0.4) $\mu g\ g^{-1}$ ww	Spain 1988	10	Gonzalez and Hiraldo (1988)
Marsh harrier	Shell thickness	No association E: 0.037 $\mu g\ g^{-1}$ ww	France 1999	13	Pain et al. (1999)

B.7.2.2. Secondary poisoning

The potential for secondary poisoning in birds and mammals was considered to be relevant in REACH Registration dossiers. PNECoral values for these two groups were derived deterministically from the lowest observed NOEC from a dataset of chronic (>21 day) studies investigating the effects of lead salts diet on ecologically relevant endpoints (e.g. growth and reproduction). The standard assessment factors for deriving these PNECs were reduced from 30 to 6 on the basis of an accompanying complimentary SSD analysis that demonstrated limited interspecies variability within the dataset. These PNECs are reported in Section B 7.3. However, as these $PNEC_{oral}$ values were derived on the basis of lead salts in diet they may only have limited relevance to an assessment of the secondary poisoning of predators or scavengers via the ingestion of lead gunshot in diet.

The methodology presented in the REACH registration dossier for the derivation of $PNEC_{oral}$ has been refined from the methodology originally proposed in the VRAR (LDIA, 2008). However, some of the concerns raised during the evaluation of the VRAR by TCNES (2008) and SCHER (2008) have yet to be addressed, specifically the relevance of neurotoxicity and the need for a dataset comprising greater biological diversity.

As such, a complimentary assessment of the risks of secondary poisoning of predators/scavengers via spent lead gunshot present in food is described in this Annex XV report, alongside the assessment of the risks posed to birds from the primary ingestion of spent lead gunshot.

The VRAR (LDIA, 2008) includes a study on secondary poisoning by Buekers et al. (2008) that focuses on the derivation of critical tissue concentrations for lead associated with adverse effects on growth, reproduction, physiology or haematology for use in wildlife monitoring. This study derived threshold (HC_5) values in blood of 71 µg/dL (95% confidence limits 26-116) for birds and 18 µg/dL (95% confidence interval of 10-25) for mammals. As these threshold were based on internal dose, rather than concentrations in food, they are largely independent on the form of lead to which wildlife are exposed and are therefore relevant to the assessment of primary and secondary poisoning of birds and mammals through the ingestion of spent lead gunshot. However, additional tissue thresholds for lead associated with adverse effects in birds after primary or secondary ingestion of lead gunshot have also been derived by other authors. These are described in the Annex XV report.

B.7.2.3. Toxicity to mammals

Poisoning by toxic chemicals can cause serious stock losses in domestic animals. Historically, lead and arsenic have been the most common causes of inorganic chemical poisoning in farm animals (New Zealand New South Wales Department of Industry, 2017).

Wijbenga et al (1992) examined the after-effects of a serious lead intoxication caused by contaminated feed. Calves and cows of two dairy farms in the Netherlands were examined. Clinical signs were observed and blood samples were taken. In addition, the blood lead levels were analysed. Cattle of one of the most afflicted farms showed severe effects of lead intoxication: blindness, muscle twitching and hyperirritability. Two animals died. Forty percent of the affected cows had to be slaughtered. The zinc-protoporphyrin level in blood seemed to coincide better with the clinical signs than the blood lead level. The ZPP levels in calves of this farm were still elevated after six months.

Wilkinson et al. (2003) investigated the accumulation of potentially toxic metals by grazing ruminants. The authors noted that main factors affecting the accumulation of potentially-toxic metals (PTM) by grazing animals are the presence of the metal, its concentration in herbage and at the soil surface, and the duration of exposure to the contaminated pasture and soil. In addition, the elapsed time between the contamination of the pasture and grazing, the quantity of soil ingested together with herbage, the mechanism of absorption of the metal into blood and the presence or absence of antagonistic metals can interact to influence the rate and extent of accumulation of heavy metals in edible body tissues.

Thornton and Abrahams (1983) estimated that 4000 km^2 of agricultural land in England and Wales has been contaminated in varying degrees by past mining and smelting

activities. Contaminants include one or more of the metals Cu, Pb, Zn, Cd and As. Studies conducted in southwest and central England conclude that only a small proportion of these metals are taken up into the leaf material of pasture plants and that plant uptake would not seem to constitute a major pathway to grazing animals. Using the titanium content of faeces as a stable indicator of soil ingestion, we found that grazing cattle involuntarily ingest from 1% to nearly 18% of their dry matter intake as soil; sheep may ingest up to 30%. Soil ingestion varies seasonally and with farm management. Calculations based on soil, plant and faecal analyses show that from 9% to 80% percent of the Pb and 34% to 90% of the As intake into cattle on contaminated land is due to ingested soil.

Toxicokinetics

Toxicokinetics related to ruminants is described in the Annex XV report.

Lethal and sub-lethal effects

In the CSR (2020) the PNEC oral for mammals was derived with 10.0 mg/kg food. The PNEC for soil for secondry poisoning to mammals was derived with 226 mg/kg soil d.w.

Cattle

Scheuhammer and Norris (1995) reviewed the environmental impact on lead from ammunition. The author noted that it was once believed that ingestion of metallic lead pellets did not pose a significant risk to domestic cattle, based on the failure of Allcroft (1951) to observe evidence of lead poisoning in calves fed metallic lead. Also, Bjørn et al. (1982) noted no elevation in blood lead concentrations of heifers grazing in pastures where upland bird hunting was common, and Clausen et al. (1981) reported that cattle retaining up to 100 lead pellets in the reticulum nevertheless had normal lead concentrations in liver and kidney tissue. Other studies, however, indicate that dairy cattle fed grass or corn silage contaminated by lead shot can suffer from lead poisoning [(Howard and Braum, 1980); (Frape and Pringle, 1984); (Rice et al., 1987)]. Rice et al. (1987) reported that in 14 steers fed chopped silage prepared from a field that had been used for clay target shooting, one animal died, a second demonstrated clinical signs of lead poisoning, and all animals had substantially inhibited ALAD enzyme activity. It was further noted that even when lead pellets were removed, samples of silage still contained an average Lead poisoning from shot ingestion has also been reported in ungulate mammals, in particular, cattle.

Wijbenga et al. (1992) examined the after-effects of a serious lead intoxication caused by contaminated feed. Calves and cows of two dairy farms in the Netherlands were examined. Clinical signs were observed and blood samples were taken. Blood parameters like zinc-protoporphyrin (ZPP), haemoglobin, haematocrit, etc. were analysed. In addition, the blood lead levels were analysed. Cattle of one of the most afflicted farms showed severe effects of lead intoxication: blindness, muscle twitching and hyperirritability. Two animals died. Forty percent of the affected cows had to be slaughtered. The ZPP levels in calves of this farm were still elevated after six months. The zinc-protoporphyrin level in blood seemed to coincide better with the clinical signs than the blood lead level.

There are further reports published indicating poisoning of cattle from the ingestion of lead from shots or bullets (see section 0).

Sheep

Johnsen et al. (2019) observed that the Norwegian Armed Forces' shooting ranges contain contamination by metals such as lead (Pb) and copper (Cu) and are often used as grazing pastures for livestock. To determine whether the sheep were at risk from grazing at a shooting range in Nord-Trøndelag (the Leksdalen shooting field), a study was conducted wherein the aim was to determine the amount of soil the sheep were eating, the accumulation of Cu and Pb in the livers of lambs grazing on the shooting ranges, and the accumulation of Pb and Cu in the grass. The grazing behaviour of the sheep was mapped using GPS tracking and wildlife cameras. Soil, grass, faeces, and liver samples were collected. All the samples were analysed for Pb, Cu and Molybdenum (Mo), and soil and faeces were also analysed for titanium (Ti). Mean concentrations in grass, soil, faeces, and liver was 41–7189, 1.3–29, 4–5, and 0.3 mg/kg Pb, respectively, and 42–580, 4.2–11.9, 19–23, and 273 mg/kg Cu, respectively. The soil ingestion rate was calculated using Ti in faeces and soil. From these results, the theoretical dose of Cu and Pb ingested by grazing sheep was calculated. The soil ingestion rate was found to be 0.1–0.4%, significantly lower than the soil ingestion rate of 5–30% usually used for sheep. Little or no accumulation of Cu and Pb in the grass was found. There was no difference between the metal concentrations in the washed and unwashed grass. According to the calculated dose, the sheep were at little or no risk of acute or chronic Pb and Cu poisoning from grazing on the Leksdalen shooting range. The analysis of liver samples showed that lambs grazing on the shooting range did not have higher levels of Cu or Pb than lambs grazing elsewhere. None of the lambs had concentrations of Cu or Pb in their livers indicating poisoning.

Johnsen and Aaneby (2019) investigated the intake of copper and lead by sheep and cattle grazing on shooting ranges. Three factors are important for the ingested dose of metals: soil ingestion rate, accumulation of the metals in plants and grazing behaviour. Up to 3700 mg Pb/kg dry weight (dw) and 1654 mg Cu/kg (dw) was found in soil and up to 52 mg Pb/kg (dw) and 35 mg Cu/kg (dw) was found in grass. The limit for sensitive land use set by the Norwegian Environment Agency is 60 mg Pb/kg and 100 mg Cu/kg, and the EU limit in fodder is 33.6 mg Pb/kg (dw). Soil ingestion was found by using titanium as a tracer, as titanium is abundant in soil, but not taken up in plants or animals. Low soil ingestion rates (b2%) were found in all investigated areas, including three shooting ranges and one cultivated pasture. There was no correlation between the copper concentration in soil and grass, such a correlation was found for lead. The risk of copper and lead poisoning by ruminants on shooting ranges was assessed based on the copper and lead concentration in the soil and grass, the soil ingestion rate and the grazing behaviour. The risk assessment concluded that the calculated dose of copper (chronic sheep: 0.07, cattle: 0.08, acute sheep: 0.7, cattle: 0.8, mg/kg, body weight (bw), day) and lead (chronic sheep: 0.12, cattle: 0.12, acute sheep: 1.2, cattle: 1.2, mg/kg, bw, day) ingested by ruminants was much lower than both the assumed chronic (Cu sheep: 0.26–0.35 cattle: 8, Pb sheep and cattle:6, mg/kg, bw, day) and acute toxic doses (Cu sheep: 20–100, Pb sheep and cattle: 600–800, mg/kg bw) for sheep and cattle

B.7.3. PNEC derivation and other hazard conclusions

B.7.3.1. PNEC derivation for environmental compartments

Compartment	LDAI (2008)	CSRs (2015)
$PNEC_{marine}$	**No PNEC value is provided** At TCNES II 07 it was agreed that due to the limited availability of marine toxicity data, further work was required before a robust PNEC could be set.	**PNEC: 3.5** (µg Pb dissolved/L) A reasonable worst case for freshwater PNEC derived from the HC5-50 value of 7 µg dissolved Pb/L and AF=2.
$PNEC_{sediment}$	**PNEC: 174** (mg Pb/kg dry wt) Species mean HC_5* (log normal distribution)= 522 mg/kg dw; AF**= 3	
$PNEC_{sediment\ bioavailable}$	**PNEC: 81.0** (mg Pb/kg dry wt) In the VRAL of lead (2008) the statistical distribution method has been used to derive a PNEC bioavailable of 81 mg/kg dry wt. (Species mean HC_5* (log normal distribution) of toxicity data expressed as bioavailable Pb = 244 mg/kg dw; AF**= 3)	**PNEC: 41** (mg Pb/kg dry wt) SCHER (2009) recommended the use of the classical AF factor approach applying a factor of 10 to the lowest unbounded bioavailable NOEC. In this case the lowest NOEC was 2.0 µmol excess Pb/g dry wt, resulting in a bioavailable PNEC of 0.2 µmol excess Pb/g dry wt or 41 mg Pb/kg dry wt.
$PNEC_{sewage\ treatment\ plant}$	PNEC: 100 (mg/L) According to the assessment performed in the VRAL (LDAI, 2008) an assessment factor of 10 was used for the derivation of PNEC for sewage treatment plant resulting in a PNEC of 0.1 mg/L. This value also recorded in the CSRs	
$PNEC_{micro-organisms}$	**PNEC: 100** (µg Pb dissolved/L) dissolved fraction only; AF**= 10	
$PNEC_{soil}$	**PNEC: 166** (mg Pb/kg dry wt). Species mean HC_5* (log normal distribution) = 333 mg/kg dw; AF**= 2	**PNEC: 212** (mg Pb/kg dry wt) The generic aged PNEC is 212 mg Pb/kg dry soil (statistical extrapolation method with the log-normal distribution). Taking into account bioavailability of Pb in soil results in PNEC values between 170 and 440 mg Pb/kg soil for the 10^{th} and 90^{th} percentile of the eCEC in European arable soils

Figure B.7-1 Overview of predicted -no effect-concentrations (PNEC values) for the European environmental compartments (Data compilation from by LDAI, 2008; CSRs 2015)

Lead is identified as a Priority Substance (PS) under the Water Framework Directive (WFD - 2000/60/EC)50. The annual average environmental quality standard (EQS) for lead in European freshwaters is currently 7.2 µg/L. A revised limit of 1.2 µg/L bioavailable lead in freshwaters was proposed in January 2012, as part of a wider package of revisions to WFD EQS.

B.7.3.2. PNECs for secondary poisoning in REACH Registration CSR

Compartment	Value	Reference
$PNEC_{oral}$ **(secondary poisoning)**	**$PNEC_{oral}$ = 10.9** mg/kg food (mammals) **$PNEC_{oral}$ = 16.9** mg/kg food (birds) Based on feeding studies with lead salts. Using a standard soil-earthworm bioaccumulation factor of 0.1 these $PNEC_{oral}$ values translate to critical soil lead limits for mammals of 10.9/0.1=**109 mg lead/kg soil** and for birds of 16.9/0.1=**169 mg lead/kg soil**.	REACH Registration Dossier

Figure B.7-2 PNECs for secondary poisoning.

B.7.3.3. Other thresholds for lead poisoning in birds and other wildlife

Tissue concentrations in wild birds provide a good indicator of exposure because they represent actual uptake based on environmental exposure. A number of studies have developed tissue thresholds or reviewed existing thresholds for blood, liver, kidney and bone tissue in birds (Friend 1985, 1999, Franson 1996, Pain 1996 and Pattee and Pain 2003 cited by Rattner et al., 2008; Buekers et al., 2008; Pain et al., 2009; Franson and Pain, 2011; Newth et al., 2016).

The most common thresholds used as indicators of lead exposure (acute or chronic) that can lead to adverse effects in birds and other wildlife are reported in the Annex XV report.

The thresholds can be also used for interpreting tissue concentrations for managing wildlife on contaminated areas[51], comparing lead concentrations in unexposed wild birds with the concentrations at which clinical effects and mortality may occur. However, they should not be considered to be equivalent to PNECs.

According to Franson and Pain (2011), lead concentrations in birds with no history of lead exposure are typically <0.2 ppm wet weight in blood, <2 ppm wet weight in liver and kidney and <10 ppm dry weight in bone.

Franson and Pain (2011) noted that birds exposed to relatively low lead levels on a sustained basis may suffer similar effects (but with lower soft tissue lead concentrations) than birds acutely exposed to higher levels of lead for a short period of time. In addition, the presence of lead shot in the digestive tract and tissue lead concentrations are not always associated in individual birds because of the varying retention time of shot in the gizzard and the uptake/retention dynamics of lead in tissues. However, in live birds sequential blood lead analyses from an individual give a much clearer picture of the significance of contamination as chronicity can be established. Haematological measurements can be used as indicators of biochemical damage, in addition to concentrations of lead in various tissues (such as in liver).

The chronicity of exposure to lead has an important influence upon the concentrations of lead in various tissues of birds. In cases of chronic exposure, the highest lead concentrations are generally found in bone, with lower concentrations in soft tissues such as liver, kidney, and blood (Custer et al., 1984; Pattee 1984, Mautino and Bell 1986, Mautino and Bell 1987; cited by Franson and Pain 2011). However, when birds die following acute exposure after the ingestion and absorption of large amounts of lead, concentrations in kidney and/or liver may exceed those in bone.

Bone lead concentration is generally considered the best indicator of lead exposure over the total lifetime of the bird, but the least useful indicator of recent lead exposure and absorption. The tissues usually chosen to evaluate recent exposure are blood, liver and occasionally kidney (Franson and Pain, 2011). However, as noted by Franson and Pain (2011), lead toxicity may depend upon factors other than simply the concentrations in tissues. These factors include the level and duration of lead exposure, previous history of exposure, species variability in response to exposure, the overall health of the bird, the extent of damage already done and the potential interactions between lead and other disease agents. These are in addition to the other factors that influence the concentration of lead in tissues, including: gender, breeding condition, age, stomach type and diet (discussed in the previous sections).

B.8. PBT and vPvB assessment

Not relevant for inorganic substances (with the exception of organo-metals). Therefore this section has not been elaborated for this assessment

B.9. Exposure assessment

In this section it is provided information to be considered as an integration to the data provided in the Annex XV report.

B.9.1. Environmental assessment

In this section it is provided information to be considered as an integration to the data provided in the Annex XV report.

B.9.1.1. Lead availability for primary and secondary ingestion (uses 1,2,3,7[31])

Concerning the availability of lead ammunition in the environment for primary ingestion (uses 1,3), the density of spent lead shot in the environment depends on shooting intensity and it is an important factor influencing the likelihood/frequency of ingestion from wildlife. For game shooting, the method and scale of the activity will determine the density of shot deposited in the local environment (Mateo, 2009, cited in UNEP 2014).

Each lead shotgun cartridge may contain several hundred pellets (depending on shot size) that are dispersed into the environment during hunting or sports shooting. Only a small proportion of the pellets (e.g. in the order of 1 % or fewer) are likely to hit the intended target as reported by (Cromie et al., 2010). The remainder is dispersed in the environment. Environmental persistence of shot (and bullet fragments) can be quite protracted, ranging from decades to hundreds of years (Jørgensen and Willems, 1987)[32].

The availability (for direct ingestion) of spent lead shot in a terrestrial setting can also be a function of the depth of fragments/shot in the soil (Rattner et al., 2008). The depth of lead fragments in soil can be influenced by land management practices, most notably cultivation (Fredrickson et al., 1977, Kendall et al., 1996). However, recently, Douglass et al. (2016) based on a field assessment done on five publicly managed mourning dove fields in North Carolina, reported that tillage does not reduce overall lead shot

[31] In commercial fishing (use 8) lead is enclosed/embedded/threaded in nets, ropes and lines (Danish EPA, CfE #1220), and lead from this type of fishing tackle is not considered to be available to enter the food chain.

[32] Shot deposited in the terrestrial environment can degrade over decades, decreasing in size.

concentrations[33].

For example, in the Brescia district of northern Italy, an area with more than 5 100 hunting posts, Andreotti and Borghesi (2012) estimated that 5-6 kg of lead pellets are dispersed annually around each post. One Spanish estate where red-legged partridge (*Alectoris rufa*) were being shot with up to 16 guns positioned at 40 m intervals, reported a shot density of 7.4 shot/m^2 within the top 1 cm of soil (shooting occurred over two days per year, for two years, with one shooting-free year in between), as reported by Ferrandis et al. (2008). However, the densities can be much higher in more intensively driven shooting estates, where shootings are conducted during the entire hunting season (Mateo, 2009).

As described by Kirby and Watkins (2015) there are some 29 000 hunting estates in Spain, occupying 36 million ha or 72 % of the Spanish land area. Of this area, approximately 2.7% of the hunting areas are enclosed, amounting to 1 million ha. For other EU countries, specific data on hunting estates and reserves are not readily available, nor is specific data on shot density. However, it can be assumed that based on the method and scale of the hunting activity, shot density in European hunting estates and reserves may locally reach similar levels as in US fields managed for dove hunting.

Haig et al. (2014) provided an overview of the amount of lead pellets deposited on several public fields managed for dove hunting in US, showing that in managed upland dove-hunting fields, shot densities may range from tens of thousands to hundreds of thousands of pellets per hectare. For example, on five public hunting areas managed for dove hunting in Missouri during 2005–2011, the average amount of lead ammunition deposited per year ranged between 2.5 and 8.9 kg ha^{-1} among areas. The estimated average number of no. 8 lead pellets (2.26 mm in diameter) ranged between 35 624 and 128 632 hectare (ha) per year among areas (Schulz et al. 2012). Shultz et al. (2006) reported that on 14 managed public hunting areas in Indiana, the mean density of lead shot post season was 27 515 pellets/ha; a 645 % increase from pre-season soil sampling estimates (Castrale, 1989). Using similar soil sampling protocols, posthunt shot densities in Missouri were 6 342 pellets/ha; a 1697 % increase from pre-season estimates (Schulz et al. 2002)[34].

Sports shooting (Clay target shooting) tends to result in greater density of deposited shot than mobile game shooting and in a very high local rate of pellet deposition. Reported lead accumulation rates on individual shooting ranges in the literature are between 1.4 metric tons/year (Craig et al. 2002) to greater than 15 metric tons/year (Tanskanen et al., 1991). Stakeholder's questionnaire (2020)[35] indicate that up to about 44 tons per range per year can be used[36]. This results in large concentrations of spent lead shot on relatively small parcels of land. Roscoe et al. (1989, cited by Scheuhammer and Norris, 1996), reported that within the shotfall zone of a trap and skeet club, in New Jersey, the top 7.5 cm of affected sediments contained over 87 million pellets per acre,

[33] The authors suggested that field managers could effectively reduce lead shot concentrations in the upper soil layers by limiting hunter access and/or requiring nontoxic shot on their fields.

[34] The major concern from hunting with shot ammunition is primary poisoning of birds. In areas with frequent bird hunting, an accumulation of lead in the soil might be expected. Ingestion route of lead via soil is also possible by birds but no specific data are available.

[35] See (Annex G) for additional information on stakeholder's questionnaire 2020 carried out by the Dossier Submitter.

[36] Cyprus Shooting Sport Federation (CSSF) reported 220 tons of lead used in 5 ranges per year.

which was over 4 000 times the shot density recorded near hunting blinds in the same area. Scheuhammer and Norris (1996) outlined that the shotfall areas of shooting ranges may include dryland fields, ravines, creeks, rivers, mudflats, marshes, ponds, and lakes. Spent shot generally remain within the upper 10 cm of soils, and are therefore available for ingestion by birds at these sites.

Concerning the availability of lead fishing tackle in the environment for primary ingestion (use 7), ingestion of fishing tackle may particularly occur in environments that have been heavily fished where there is a greater availability of lost or discarded lead fishing items. Lead in the form of fishing lures, sinkers, lead core fishing line, downrigger weights, and weights on a wide variety of fishing traps and nets can be introduced into the aquatic environment when recreational anglers lose fishing gear (Rattner et al., 2008).

Density of lead fishing tackle in many European waterbodies is not available. However, the amount of lead fishing tackle introduced into aquatic ecosystems varies greatly depending on the intensity of fishing pressure, the type of aquatic habitat (e.g., rocky or heavily vegetated that may increase gear breakage and loss) and angler's skill (Carpenter et al., 2003). In the United Kingdom, Cryer et al. (1987) estimated 24 to 190 sinkers/m^2 along the shoreline in South Wales, as cited by Rattner et al. (2008). In 2016, 300 kilos of lead from fishing sinkers was retrieved from Tornio river, boundary river between Finland and Sweden [37](unpublished data). In the US, Radomski et al. (2006), cited by Haig et al. (2014), estimated 16 tons of lead tackle released in five surveyed lakes over a 20-yr period.). Additional information (supporting the estimate of releases of fishing tackle) is available in Appendix D.

Concerning the availability of lead ammunition in the environment for secondary ingestion (use 1, 2) the following sources are implied:

- Available viscera and carcasses from large game hunting (containing fragments of lead bullets)
- Animals wounded/shot with lead ammunition (all types) but not found
- Animals shot for pest control with lead ammunition (all types) but not recovered
- Animals carrying ingested lead shot[38]

Several authors have studied the availability of lead (fragments from bullets) related to large game hunting. In 2013-2014 in Fennoscandia, the total amount of lead in gut piles, offal, and carcasses available to scavengers, associated to hunting 166 000 moose, was estimated to be 215 kg (Stokke et al., 2017). For deer (*Cervus elaphus* and *Capreolus capreolus*) studied in the UK and shot with lead bullets, the average total weight of metal fragments, likely to be mostly lead, was estimated to be 1.2 g per carcass and 0.2 g per viscera (Knott et al., 2010). Approximately 5-6 million gut piles are being discarded annually from deer and wild boars in the EU (FAO, 2018, Thomas et al., 2020). Stokke et al. (2017) estimated the loss of lead due to fragmentation to be 25 %, whereas Knott et al. (2010) recorded 17 %.

Modern firearms used for hunting discharge projectiles of various size and shapes, such

[37] News article in Finnish https://yle.fi/uutiset/3-9206047 (original title: Tornionjoen Matkakoskesta kerätty kesän aikana 300 kiloa lyijyä (2016) by Jarno Tiihonen)

[38] Predation risks are higher for injured and intoxicated individuals. Debilitated prey may form a large part of the diet of predators and scavengers (UNEP/CMS/COP11/Inf.34, 2014).

as rifle bullets and shotgun slugs. Bullets for hunting are designed to transfer energy from the projectile to the target to maximize power and kill game. Several studies have documented that lead-containing bullets fragment can radiate at a considerable distance in target animals upon impact. This makes bullet fragments easily ingested, difficult to be avoided (when consuming contaminated tissue) by raptors and scavengers. Fragmentation can also increase the surface area of the ingested material for digestion by stomach acids (Golden et al., 2016). Specifically, expanding lead core bullets fragment sending particles through the meat as the bullet penetrates, leaving bigger fragments and microscopic particles of lead widely distributed throughout the carcass (Arnemo et al., 2016, Knott et al., 2010)[39]. Expanding lead core bullets typically release thousands of fragments of varying size (including millions of nanoparticles) and the larger ones can be visualized using X-rays (Knott et al., 2010, Arnemo et al., 2016). In case of lethal shot and successful retrieval of the shot animal, the amount of lead available to scavenging is determined on the ratio of total lead deposited in the animal and the amount of that lead removed due trimming of the game meat and possibly left behind in the environment.

Lead contamination of carcasses is a serious threat to the health of scavenging birds (Johnson et al., 2013). Carcass remains and non lethally-shot animals provide important sources of food for predators and scavengers (Mateo-Tomas et al., 2015). Where hunting occurs, humans subsidise scavengers with remains of carcass, offering important resources for the survival of these species (Mateo et al., 2014, Gomo et al., 2017).

Hunting is thus essential for the survival of most scavengers in the world (Mateo-Tomás and Olea, 2010). Haig et al. (2014) explain that, in modern ecosystems, hunters are to be considered the top predator and the remnants of hunting are a more important wildlife food source now than at any other time in history. This suggests that to deal with lead poisoning for scavenging species, burying remnants of hunting containing lead particles, may not be a viable solution because it would critically reduce food availability for these species[40].

For lead shot, the availability for secondary ingestion is often related to cases of non-lethal shot or un-retrieved game. In general, birds having lead shot embedded in their flesh represent a source of lead for predatory or scavenging species. Studies on a variety of species/populations of live wildfowl have shown that >20 % of individuals (across 22 species) carry gunshot in their flesh (Pain et al., 2014). The percentage of waterfowl with embedded shot differ between species, areas with different hunting pressures and the age of birds (Mateo 2009).

In the French Pyrenees, lead poisoned birds of prey were detected during the hunting season in fall and winter, where the density of hunting of pigeons is high with some 170000 pigeons killed per season (Jean, 1996, Berny et al., 2015). It has been estimated that for every 100 shot 11.3 pigeons are killed and 6.4 pigeons are injured and never found (Sagot and Tanguy Le Gac, 1985). Similarly, the population of Egyptian vultures (*N. percnopterus*) on Canary Islands is sedentary and known to feed on rabbits shot with lead shot during the winter season (Donázar et al., 2002).

[39] As also reported by FACE: https://www.leadammunitionguidance.com/lead-ammunition-in-game-meat/

[40] In addition, scavenging species like vultures can provide an important ecosystem service by cleaning the environment of organic waste, which diminishes the spread of possible diseases (Markandya et al., 2008; Moleon et al., 2014).

Un-retrieved game can also be left in the environment purposefully if the motivation of hunting is damage-control (pest control). However, information on non-professional recreational or agricultural protection shooting is not readily available in the EU and is, hence, difficult to quantify. In general, rimfire ammunition (e.g. 0.22 LR) is often used for amateur farm shooting, resulting in many animals being shot multiple times (Hampton et al., 2015) and contributing to lead being deposited in carcasses.

In Europe, introduced and invasive Barbary ground squirrels (*Atlantoxerus getulus*) in the Canary Islands are also habitually shot and not retrieved (Gangoso et al., 2009) thereby posing a risk for local scavengers such as for the sedentary population of Egyptian vultures in the islands. As cited by Haig et al. (2014) it is not uncommon for individual recreational shooters (in the US) to shoot >170 squirrels in a single day (Pauli and Buskirk, 2007). Moreover, Pauli and Buskirk (2007) reported that in ground squirrels shot with expandable Pb-based bullets, ~70% of the fragments remaining in the carcass were small (<25 mg), with smaller fragments being more easily ingested than large ones[41]. Pauli and Buskirk (2007) also found that 47% of all prairie dogs shot with expandable Pb-based bullets had sufficient quantities of Pb in a single carcass to result in mortality of nestling raptors.

Finally, birds that have ingested lead shot as grit represent another available source of lead in environment for predatory or scavenging species (Pain et al., 2009). For example, two threatened wildfowl species in Spain, marbled teal and white-headed duck, suffer high mortality due to lead ammunition: ingested Pb shot was present in 32 % of shot stifftails (mainly white-headed ducks) and 70 and 43 % of dead or moribund stifftails and marbled teal, respectively (Mateo et al 2001).

Concerning the availability of lead fishing tackle in the environment for secondary ingestion (use 7) fishing tackle can be available in the following way:

- By consumption of preys having ingested split anglers' shot or other types of tackle. Raptor species that feed on waterbirds are at risk due to secondary ingestion of lead fishing tackle (Rattner et al. 2008, Ishii et al. 2017, cited by Garvin et al, 2020).
- While consuming fish with attached fishing tackle (as for loons and other piscivorous birds).

B.9.1.2. Secondary poisoning of birds from ammunition sources (use 1,2)

In this section it is provided information to be considered as an integration to the data provided in the Annex XV report. Data comprise evidence related to species with non-European distribution or additional details for species discussed in the Annex XV report.

Data of all confirmed or suggested ammunition related lead exposure in European birds of prey with respective tissue lead concentration info (n=19, including nocturnal species and obligate scavengers) is presented in table Table B.9-2, complementing and summarising the data in the report. The table is adjusted from Monclús et al. (2020).

Vultures

Of the 23 worldwide vulture species, in North and South America, species such as turkey vultures, California condors, American black vultures (*C. atratus*), and Andean condors

[41] Smaller fragments present relatively greater surface area, increasing the rate of Pb absorption into the bloodstream of the birds.

(*Vultur gryphus*) have been reported to be lead poisoned (Behmke et al., 2015, Finkelstein et al., 2012, Valladares et al., 2013, Wiemeyer et al., 2017). The California and the Andean condor are those most vulnerable in this geographical area, Californian condor being reintroduced to nature after extinction due ingestion and poisoning from ammunition derived lead (Finkelstein et al., 2012, Golden et al., 2016, Wiemeyer et al., 2017). Contamination in vultures in America is associated mainly with ammunition but also with mining activities, pollution and petrochemical industries (Plaza and Lambertucci, 2019, Behmke et al., 2015, Finkelstein et al., 2012, Valladares et al., 2013).

Native African species as White-backed vulture (*Gyps africanus*) have been found to have high concentrations of lead in blood and other tissues, where the BLL of studied individuals were associated with hunting activities (Garbett et al., 2018, Kenny et al., 2015, Van Wyk et al., 2001, Naidoo et al., 2017). For two other species occurring in Africa, blood lead values above the threshold in cape griffon (*G. coprotheres*) and lappet-faced vulture (*Torgos tracheliotos*) have been found (Naidoo et al., 2012, Van Wyk et al., 2001).

Facultative scavengers, raptor species

Altogether 14 species of facultative scavenging raptor species with non-European distribution was discovered via literature search. These results are summarised in Table B.9-1 with a highlighting example study of exposure. These studies are included in the basis of being reviewed as cases in ammunition related lead exposure (e.g. Pain et al. 2019).

Table B.9-1: Lead exposed facultative scavenging birds of prey with non-European distribution. Other reference = studies cited in distinguished reviews dedicated to map lead exposure from ammunition sources (e.g. Fisher et al. 2006; Pain et al. 2009; Pain et al. 2019)

Species	Country	Example of exposure	Other Reference
Bald Eagle (*Haliaeetus leucocephalus*)	USA, Canada	Lead recorded as the cause of mortality for 484 of 762 (63.5%) poisoned bald eagles submitted to the National Wildlife Health Center 1975–2013, and lead based ammunition suggested as the cause (Russell and Franson, 2014)	• Jacobson et al. (1977) • Craig et al. (1990)Langelier et al. 1991 • Elliott et al. 1992, • Nelson et al. (1989) • Gill and Langelier 1994, Scheuhammer and Norris 1996, • Wayland and Bollinger (1999) • Miller et al. (1998) • Miller et al. (2001) • Clark and Scheuhammer (2003) • Lindblom et al. (2017) • Russell and Franson (2014) • Warner et al. (2014) • Yaw et al. (2017)

Species	Country	Example of exposure	Other Reference
Wedge-tailed eagle (*Aquila audax*)	Australia	Moderately elevated lead concentrations in bone samples. The isotope ratio profile was similar to US-manufactured ammunition (Lohr et al., 2020). Also, subspecies Tasmanian wedge-tailed eagle (*Aquila audax fleayi*) was recently also discovered to suffer ammunition related lead exposure (Pay et al., 2020)	NA
Steller's Sea-eagle (*H. pelagicus*)	Japan	In carcasses found in the field or dead in the wild bird centres in Japan (June 2015–May 2018) Pb exposure was found to still be occurring and 9 of 34 (26.5%) of the recorded deaths of Steller's sea eagles were found to have been poisoned by Pb. Pb isotope ratio analysis showed that both Pb rifle bullets and Pb shot pellets cause Pb exposure in birds (Ishii et al., 2020)	• Kim et al. (1999) • Iwata et al. (2000) • Kurosawa (2000) • Ishii et al. (2017)
Eastern Marsh-harrier (*Circus spilonotus*)	Japan	296 pellets collected between January 2002 and February 2004. 18 contained a total of 24 pieces of lead shot. Among the prey species found in the pellets with lead shot, ducks accounted for 55.6%, and doves and crows 11.1 (HIRANO et al., 2004)	NA
Northern Harrier (*C. cyaneus*)	Canada, USA	Martin et al. (2003) present a case of ammunition related lead ingestion, reviewed e.g. in Pain et al. (2009)	• Martin and Barrett (2001)
Sharp-shinned Hawk (*A. striatus*)	Canada, USA	Martin and Barrett (2001) present a case of ammunition related lead ingestion, reviewed e.g. in Pain et al. (2009)	NA
Cooper's Hawk (*A. cooperii*)	Canada, USA	Martin and Barrett (2001) present a case of ammunition related lead ingestion, reviewed e.g. in Pain et al. (2009)	• Snyder et al. (1973)
Northern Goshawk (*A. gentilis*)	Canada, USA	Ishii et al. (2020) present a case of ammunition related lead ingestion, reviewed e.g. in Pain et al. (2009)	• Martin and Barrett (2001)

Species	Country	Example of exposure	Other Reference
Red-tailed Hawk *(Buteo jamaicensis*)	Canada, USA	Two lead poisoned individuals, suggested exposure to lead based ammunition from small game e.g. hares due to feeding behaviour (Clark and Scheuhammer, 2003)	• Martin et al. (2008)
Rough-legged Buzzard (*B. lagopus*)	USA	Lead poisoning with a suggested cause of ammunition related lead, reviewed e.g. in Pain et al. 2009	
Golden Eagle (*A. chrysaetos*)	USA	Out of 178 studied eagles, 10 % were clinically lead poisoned with BLL > 0.6 mg/L; and 4 % were lethally exposed with BLL > 1.2 mg/L. High lead in blood was correlated with feeding on carcass than those captured using live bait (Langner et al., 2015)	Russell and Franson (2014)
American Kestrel (*Falco sparverius*)	Canada, USA	Martin and Barrett (2001) present a case of ammunition related lead ingestion, reviewed Pain et al. (2009)	NA
White-tailed eagle (*Haliaeetus albicilla*)	Japan	12/50 birds were found with elevated liver lead concentrations (>2 ppm w.w.; max. 56.4 ppm) associated with poisoning. Isotope-ratio analysis suggest ammunition as source (Ishii et al., 2017)	NA
Great Horned Owl *(Bubo virginianus*)	Canada	Clark and Scheuhammer (2003)) suspected hares and upland game birds as the source of toxic Pb.	NA

In Canada and the US, an estimated 10–15% of documented mortality in bald and golden eagles was attributed to lead poisoning from ingestion of lead shot in waterfowl wounded or killed by lead ammunition (Scheuhammer and Norris, 1996, Clark and Scheuhammer, 2003). In a review on causes of mortality in 2980 bald eagles (*H. leucocephalus*) submitted to the National Wildlife Health Center (NWHC) from throughout the U.S. during 1975–2013, lead toxicosis was the most frequently diagnosed poisoning in both species, comprising 63.5% of all poisonings in bald eagles and 58.1% in golden eagles. Ingested lead ammunition fragments were found in 14.2% of bald eagles. In the Upper Mississippi River Valley in U.S, Lindblom et al. (2017) discovered that PbB in studied bald eagles was higher immediately following the hunting season and lower when the previous months' snowfall was high and the possible carcasses may be concealed.

In British Columbia, as cited in Fisher et al. (2006) 14% of 294 bald eagles found sick, injured or dead with significantly elevated lead exposure, the greatest number were found between in early spring when they were feeding mostly on wintering waterfowl (Elliot et al., 1992). The proportion of bald eagles with elevated lead exposure was found to be higher in areas of high waterfowl in comparison to areas with low hunting intensity (Wayland and Bollinger, 1999). According to Russell and Franson (2014) 4.7% of 1427 golden eagles submitted to the National Wildlife Health Center in Madison, Wisconsin, USA for diagnosis of their deaths died were from lead poisoning. 11.8% of golden eagles were found to have had ingested lead ammunition fragments (Russell and Franson, 2014). Golden eagles have suffered lead exposure in California in same areas as California condors. Kelly et al. (2011) discovered that lead exposure in golden eagles and turkey vultures declined significantly after a ban (in 2008) on the use of lead ammunition for most hunting activities in the range of the California condor in California.

Elevated liver lead concentrations (2 ppm w.w.) of Steller's Sea-eagle (*H. pelagicus*) was found in Hokkaido, Japan, where hunting of Sika deer is a popular activity. 43 dead eagles were collected after a ban on the use of lead bullets for hunting sika deer and the isotopic analysis was consistent with lead ammunition (Ishii et al., 2017). According to Ishii et al. (2017) and reviewed in Pain et al. (2019) one bird that died in 2013 had a lead bullet in the stomach and a liver lead of 36.3 ppm w.w.. Also Kurosawa (2000) and Saito (2009) have reported lead ammunition related poisonings of Steller's sea eagle in Japan. In the study by Ishii et al. (2017) 12 of 50 studied dead White-tailed sea eagles (H. albicilla) were found with elevated liver lead concentrations (>2 ppm w.w.; max. 56.4 ppm) associated with poisoning. According to an isotope analysis, the source of lead was likely lead ammunition (Ishii et al., 2017).

Third raptor species in Japan found to be exposed to ammunition related lead is eastern marsh harrier (*C. spilonotus*). 2002-2004, 18 of 296 regurgitated pellets by Eastern Marsh Harriers studied in Watarase Marsh, Tochigi Prefecture contained a total of 24 pieces of lead shot. Higher frequency of lead in pellets was found in two first months of the year during the hunting season for game birds (HIRANO et al., 2004).

Reviewed by Pain et al. (2009) stable lead isotope ratios to determine the source of lead exposure to wildlife on the north shore of Lake Eire, U.S., were found for most of the samples falling within the range of shot pellets for the following species by Martin and Barrett (2001): American Kestrel (*Falco sparverius*), Sharp-shinned Hawk (*A. striatus*) Cooper's Hawk (*A. cooperii*), Northern Goshawk (*A. gentilis*), Red-tailed Hawk (*Buteo jamaicensis*) and Northern Harrier (*Circus cyaneus*). However, none of the migrating birds sampled had lead levels indicating lead poisoning, but at least one individual of the tested species were found to have levels indicative of sub-lethal lead exposure (Martin et al., 2003).

One of the most recent new information on lead exposure in facultative scavengers comes from Australia. As a first assessment of wild species ammunition related lead exposure in the continent, Lohr et al. (2020) found moderately elevated lead concentrations in sampled wedge-tailed eagle (*Aquila audax*) bones. The species have been observed to consume shot wildlife species subjected to recreational hunting and the isotope ratio profile was similar to US-manufactured ammunition (Lohr et al., 2020). The authors point several limitations to the study and the results is considered preliminary, however also subspecies Tasmanian wedge-tailed eagle (*Aquila audax fleayi*) was recently also discovered to suffer ammunition related lead exposure (Pay et al., 2020). Among wedge-tailed eagles also black kites and whistling kites were suggested as those

Australian wildlife species most likely to be affected by harmful Pb concentrations through scavenging by Hampton et al. (2018), who assessed the risk of lead-based bullets to wildlife and concluded that the research had been non-existent so far.

Finally, one case of lead poisoning in nocturnal non-scavenging bird of prey, Great Horned Owl (*Bubo virginianus*) was reported by Brewer et al. (2003), who suspected hares and upland game birds as the source of toxic Pb.

Altogether 13 species of facultative scavengers with non-European distribution have been recorded to been exposed to lead. As many other species have been found together to scavenge in carcasses and gut piles left behind by hunters, it is very likely that the actual number of affected species is higher than known now.

Facultative scavengers, omnivores

Scientists tested blood lead levels in 302 ravens that scavenged on hunter-killed large ungulates and their offal in and around Grand Teton National Park, Wyoming in 2004 and 2005 (Craighead and Bedrosian, 2008). Blood-lead levels of ravens increased dramatically during hunting season, roughly five times higher than the rest of the year, likely due to ravens consuming lead bullet fragments left behind in gut piles of hunted elk, deer and moose. Blood samples were taken during a 15-month period spanning two hunting seasons, from mid-September 2004 to mid-December 2005. 47 %% of the ravens tested during the hunting season exhibited elevated blood lead levels (≥10μg/dL) compared to only 2% tested during the non-hunting. Offal is the primary food source of ravens during the time of exposure Craighead and Bedrosian (2008) also identified un-retrieved offal piles of hunter-killed game as a point source for lead contamination in the area. These substantial increases in blood-lead levels correspond almost exactly with the open and close of hunting season.

Just after the start of hunting season, blood-lead levels begin to rise. Shortly after the end of hunting season, they return to normal. Blood-lead levels show a spike again in the late spring, when melting snow uncovers gut piles left from the previous hunting season. All of the ravens at the study site feed on gut piles at some point throughout the hunting season and get exposed to lead.

Craighead and Bedrosian (2009) collected an additional 237 blood samples from ravens in the same study area spanning an additional two hunting seasons. The samples had a median blood lead level of 10.0 μg/dL with a range of 2.7–51.7 μg/dL. The median blood lead level of 84 additional samples collected during the non-hunting season was only 2.2 μg/dL with a range of 0.0–19.3 μg/dL. Fifty percent of the hunting season samples had blood lead levels >10μg/dL, while only 3% were greater than 10μg/dL during the nonhunting season.

Craighead and Bedrosian (2009) also documented that the blood lead levels of ravens around Grand Teton dropped corresponding with increased use of non-lead ammunition by hunters on the National Elk Refuge and in Grand Teton National Park. In fall of 2009 researchers distributed 194 boxes of copper bullets to hunters with permits for the park and the refuge, captured 46 ravens (which typically scavenge the discarded gut piles) during hunting season and tested their blood for lead. An estimated 24% of hunters in the area used copper bullets in 2009, and there was a 28% drop in blood lead levels in ravens compared with what would have been expected (Hatch 2010).

Legagneux et al. (2014) discovered the same pattern as Craighead and Bedrosian (2009) in eastern Quebec, Canada where the blood lead levels increased during the

moose hunting season. Furthermore, individuals with elevated blood lead levels had isotopic profile resembling that of ammunition (Legagneux et al., 2014).

Studies with evidence of ammunition related lead exposure recording lead tissue concentrations

Data of all confirmed or suggested ammunition related lead exposure in European birds of prey with respective tissue lead concentration info (n=19, including nocturnal species and obligate scavengers) is presented in Table B.9-2. The table is adjusted from Monclús et al. (2020), a comprehensive and recent review of 114 studies[42] of lead exposure in European birds of prey. Monclus et al. (2020) concluded vultures and facultative scavengers (golden eagle, common buzzard and white-tailed sea eagle) accumulated the highest lead concentrations and were the species most at risk of lead poisoning. The authors acknowledge from the review other sources of exposure, such as lead-based gasoline, mining activities and industry but note the importance on leaded ammunition as a main source affecting birds. 45 of the 114 studies reported lead ammunition as the known or suspected cause of exposure, 10 additional reported embedded shot in muscles of birds, suggesting a non-ingestion source of contamination but one that was still associated with hunting (Monclus et al., 2020).

Concentrations reported as exceeding subclinical threshold levels Monclús et al. (2020) applied the minimum lead concentrations that can cause subclinical symptoms or mortality as proposed by Franson and Pain (2011)[43]. Values in original studies were converted where relevant so that they were expressed as mg/kg dry weight (dw)[44] following Krone (2018) (Monclus et al., 2020).

Monclús et al. (2020) also assessed the effect of season (hunting, non-hunting, unknown and year-round) and blood lead concentrations were higher during the hunting season than in those sampled in the non-hunting season, year-round or at an unknown time (Monclús et al., 2020).

[42] All published data on lead in raptors (1983–2019), book chapters, technical reports and conference proceedings were excluded. Final 114 publications contained 10 reviews and 1 modelling study.

[43] Liver (Subclinical) > 6 mg/kg dw (2 mg/kg ww); kidney (Subclinical)> 8 mg/kg dw (2 mg/kg ww); blood (Subclinical) > 20 µg/dl; bone (Subclinical) > 10 mg/kg dw; liver (mortality) > 18 mg/kg dw (6 mg/kg ww); kidney (mortality)> 25 mg/kg dw (mg/kg ww); blood (mortality) > 50 µg/dl; bone (mortality) > 20 mg/kg dw. See also Annex XV report.

[44] 1 µg g^{-1} ww = 4.6 µg g^{-1} dw for blood, 3.1 µg g^{-1} dw for liver, 4.3 µg g^{-1} dw for kidney and 1.2 µg g^{-1} dw for bone.

Table B.9-2: Lead concentrations in European birds of prey adjusted from Monclús et al. (2020) in mean (range); *=median. Tissues: Bl=blood; B=bone; L=liver; K=kidney; PF=hand feathers (primaries); BF=body feathers; SF=arm feathers (secondaries); BlF=blood feathers (growing feathers with a blood-keel); TF=tail feathers (tertials); E=eggs; M=muscle; Lu=lungs; In=intestines; Br=brain; H=heart; S=stomach; F=faeces; AF=abdominal fat. Units: Blood µg dL-1; Bone, Liver, Kidney, Feathers µg g-1 dw; Eggs µg g-1 ww; rest of matrixes µg g-1 dw (except annotations). a = Values extracted from graphs.

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
Bearded vulture (*Gypaetus barbatus*) NT	France	2015	2005-2012	NA	L: 0.56* (0.16-16.11) n=8; K: 0.75* (0.10-2.76) n=8	L: % not specified	X	1 bird with embedded lead shot	Berny et al. (2015)
	Spain	2009	1990-2009	Flame-atomic absorption Spectrophotometer Zeeman-effect & Graphite Furnace Atomic Absorption Spectrophotometer	Bl: 4.25 (ND-52.0) n=101; B: 2.87 (0.43-40.5) n=43; L: 1.01 (0.15-22.0) n=43	Bl: 7% (7/101); B: 2% (1/43); L: 5 % (2/43)		Suggested ingestion of ammunition[45]	Hernández and Margalida (2009)

[45] According to expert judgement

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
Black kites (*Milvus migrans*) LC	Spain	2011	NA	Graphite Furnace Atomic Absorption Spectrophoto meter	B: 8.42 (2.79-39.70) n=9; PF: 0.79 (0.24-1.98) n=9	B: 44% (4/9)		Suggested ingestion of ammunition	Cardiel et al. (2011)
Cinereous vulture (*Aegypius monachus*) NT	Spain	2011	NA	Graphite Furnace Atomic Absorption Spectrophoto meter	B: 8.86 (2.46-25.40) n=3; PF: 0.52 (0.23-2.29) n=3	B: 66.7% (2/3)		Suggested ingestion of ammunition	Cardiel et al. (2011)
Common buzzard (*Buteo buteo*)	Poland	2008	2000-2007	Flame-Atomic Absorption Spectrophoto meter	B: 15.7* (7.6-17.9) n=6	B: % not specified		Suggested ingestion of ammunition	Komosa and Kitowski (2008)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
LC	Italy	2005	1998-1999	Graphite Furnace Atomic Absorption Spectrophotometer	B: 1.87* (0.28-42.0) n=18; L: 0.95* (0.2-47.7) n=18; K: 0.75* (0.2-10.8) n=18; BF: 1.48* (ND-8.87) n=18; M: <0.20* (ND-19.4) n=18	B: 6% (1/18); L: 11% (2/18); K: 6% (1/18)		3 birds with embedded lead shots	Battaglia et al. (2005)
	Spain	2003	1998-2001	Graphite Furnace Atomic Absorption Spectrophotometer	B: 0.58 (0.01-10.25) n=107	B: 0,9% (1/107)		Suggested ingestion of ammunition	Mateo et al. (2003)
	Netherlands	1996	1992	Graphite Furnace Atomic Absorption Spectrophotometer	B: 5.5 (ND-27.9) n=81; L: 3.3 (ND-24.4) n=80; K: 2.6 (ND-13.0) n=80	B; L; K: % not specified		3 birds with embedded lead shot	Jager et al. (1996)
	U.K.	1995	1980-1990	Inductively Coupled Plasma Mass Spectrometry	L: 1.34* (NA-909.1) n=56	L: 7% (4/56)		Suggested ingestion of ammunition	Pain et al. (1995)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	France	1993	1988-1990	Flame-Atomic Absorption Spectrophotometer	L: 0.71* (0.08-5.53) n=85; L-contaminated: 13,52* (7.6-19.6) n=5	L: 6% (5/90)		Suggested ingestion of ammunition	Pain and Amiardtriquet (1993)
	U.K.	1983	1979-1982	NA	L-poisoned: 175 n=1; K-poisoned: 66.7 n=1; L (non-poisoned): 2.3 n=1; K (non-poisoned): 2.4 n=1	L: 50% (1/2); K: 50% (1/2)		Lead pellets in stomach	MacDonald et al. (1983)
Egyptian vulture (*Neophron Percnopterus*)	Spain	2009	1999-2005	Longitudinal AC Zeeman Atomic Absorption Spectrophotometer with Transversely Heated Graphite Atomiser	Bl: 5.10 (0.25-12.3) n=137; B: 7.07 (4.27-8.91) n=39	Bl: 24% (14/169) ; B: 0,4 (1/169)		Suggested ingestion of ammunition	Gangoso et al. (2009)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	Spain	2002	1998-2001	Longitudinal AC Zeeman Atomic Absorption Spectrophotometer with Transversely Heated Graphite Atomiser	Bl: 14.6 (ND-178) n=26	Bl: 19% (5/26)		Lead in regurgitated pellets	Donázar et al. (2002)
Eurasian eagle owl (*Bubo bubo*)	Spain	2003	1998-2001	Graphite Furnace Atomic Absorption Spectrophotometer	B: 2.8 (0.33-185.23) n=42	B: 2,38% (1/42)		Suggested ingestion of ammunition	Mateo et al. (2003)
" Eurasian sparrowhawk (*Accipiter nisus*)	U.K.	1995	1980-1990	Inductively Coupled Plasma Mass Spectrometry	L: 0.55* (NA-12.33) n=150	L: 0,7 (1/150)		Suggested ingestion of ammunition	Pain et al. (1995)
Golden eagle (*Aquila chrysaetos*)	Sweden	2017	2014-2015	Inductively Coupled Plasma Mass Spectrometry	Bl: 18.86 (0.2-60) n=46; L: 1.18 n=111	Bl: 4,3% (2/46); L: 12,6% (14/111)		Suggested ingestion of ammunition	Ecke et al. (2017)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	Switzerland	2018	2006-2017	Inductively Coupled Plasma Mass Spectrometry	B: 16.06 (0.40-54.21) n=46; L: 4.89 (ND-80.44) n=55	B: 65% (30/46); L: 9% (5/55)	X	5 birds with embedded lead shot	Ganz et al. (2018)
	Sweden	2017	2014-2015	Inductively Coupled Plasma Mass Spectrometry	Bl: 18.86 (0.2-60) n=46	Bl: 4,3% (2/46)		Suggested ingestion of ammunition	Ecke et al. (2017)
	Switzerland	2015	2006-2013	Inductively Coupled Plasma Mass Spectrometry	Bl: 35.14 (3.66-108) n=6; B: 15.94 (1.22-38.40) n=17; L: 4.77 (0.2-77.35) n=26; K: 2.48 (0.18-30.88) n=25	Bl:34% (2/6); L: 4% (1/26); K: 4% (1/25)	X	Ingestion of ammunition (supported by the isotope analysis)	Madry et al. (2015)
	Switzerland	2015	2006-2013	Inductively Coupled Plasma Mass Spectrometry	Bl: 6.6* n=7; B: 12.45* n=17; BF: 0.38* n=11; PF: 0.22* n=21; K: 0.99* n=25; L: 1.16* n=26	Bl: 43% (3/7); B: 70,6% (12/17); L: 7,7% (2/26); K: 3,8 (1/26)	X	Ingestion of ammunition (supported by the isotope analysis)	Jenni et al. (2015)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	Austria, Germany, Switzerland	2007	2000-2001	Graphite Furnace Atomic Absorption Spectrophotometer	K: 13.29 (ND-54.95) n=5; L: 30.07 (0.47-184-42) n=7;	L: 29%; (2/7)		Suggested ingestion of ammunition	Kenntner et al. (2007)
Greater spotted eagle (*Aquila clanga/Clanga clanga*)	Poland	2008	2000-2007	Flame-Atomic Absorption Spectrophotometer	B: 44.8* (41.5-48.1) n=2	B: % not specified		Suggested ingestion of ammunition	Komosa and Kitowski (2008)
Griffon vulture (*Gyps fulvus*)	Portugal, Spain	2016	2011-2012	Inductively Coupled Plasma Mass Spectrometry	Bl: 1176.63 (968.82-1384.44) n=2; L: 564.87 (308.56-1077.38) n=3; K: 75.79 (34.59-100.46) n=3	Bl: 100% (2/2); L: 100% (3/3); K: 100% (3/3)		Lead pellets in stomach	Carneiro et al. (2016)
	Spain	2016	2008-2012	Graphite Furnace Atomic Absorption Spectrophotometer	Bl: 24.86 n=691	Bl: 44% (310/691)	X	Ingestion of ammunition (supported by the isotope analysis)	Mateo-Tomás et al. (2016)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	France	2015	2005-2012	NA	L: 3.04* (0.06-66.65) n=119; K: 3.7* (0.34-146.29) n=119	L: 2,5% (3/119); K: 2,5% (3/119)	X	8 birds with embedded lead shot	Berny et al. (2015)
	Spain	2014	2008; 2011	Atomic Absorption Spectrophotometer	Bl: 27.19 (9.31-362.13) n=66	Bl: 5% (3/66)		Suggested ingestion of ammunition	Espín et al. (2014)
	Spain	2011	NA	Graphite Furnace Atomic Absorption Spectrophotometer	B: 10.98 (3.62-137) n=20; PF: 1.91 (0.20-23.28) n=20	B: 50% (10/20)		Suggested ingestion of ammunition	Cardiel et al. (2011)
	Spain	2003	1998-2001	Graphite Furnace Atomic Absorption Spectrophotometer	B: 5.54 (2.59-10.31) n=4	B: 25% (1/4)		Suggested ingestion of ammunition	Mateo et al. (2003)
	Spain	1997	1994	Inductively Coupled Plasma Atomic Spectrophotometer	L: 52 n=1	L: 100% (1/1)		Lead fragments in the gizzard	Mateo et al. 1997

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
Honey buzzard (*Pernis apivorus*)	Netherlands	1985	NA	Atomic Absorption Spectrophotometer	Bl: 80* n=1	Bl: 100% (1/1)		Lead shot in the gizzard	Lumeij et al. (1985)
Laggar falcon (*Falco jugger*)	U.K.	1983	1979-1982	NA	L: 56.9 n=1; K: 193 n=1	L: 100%; K: 100%		Suggested ingestion of ammunition	MacDonald et al. (1983)
Northern goshawk (*Accipiter gentilis*)	Poland	2008	2000-2007	Flame-Atomic Absorption Spectrophotometer	B: 7* (ND-15) n=6	B: % not specified		Suggested ingestion of ammunition	Komosa and Kitowski (2008)
Peregrine falcon (*Falco peregrinus*)	Italy	2018	2015	Inductively Coupled Plasma Mass Spectrometry	Bl: 0.1 n=1; B: 4.06 n=1; L: 0.28 n=1; K: 0.86 n=1; AF: 0.14 n=1			Lead shot in the digestive tract	Andreotti et al. (2018)
	Spain	2003	1998-2001	Graphite Furnace Atomic Absorption Spectrophotometer	B: 2.66 (0.68-11.50) n=9	B: 11% (1/9)		Suggested ingestion of ammunition	Mateo et al. (2003)
	U.K.	1995	1980-1990	Inductively Coupled Plasma Mass Spectrometry	L: 0.48* (NA-22.03) n=26	L: 19% (5/26)		Suggested ingestion of ammunition	Pain et al. (1995)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	U.K.	1983	1979-1982	NA	L (poisoned): 64.3 n=1; K (poisoned): 34 n=1; L (non-poisoned): 5.3 n=1; K (non-poisoned): 2.7 n=1	L: 50% (1/2); K: 50% (1/2)		Suggested ingestion of ammunition	MacDonald et al. (1983)
Red kite (*Milvus milvus*)	U.K.	2017	1989-2007	NA	B: NA (30.3-187.5) n=11; L: > 15 n=6	B: 13% (11/86); L: 14% (6/44)		1 bird with lead shot in the oral cavity	Molenaar et al. (2017)
	France	2015	2005-2012	NA	L: 1.38* (0.02-159.03) n=34; K: 2.56* (0.09-189) n=34	L: 11.8% (4/34); K: 11.8% (4/34)	X	11 birds with embedded lead shot	Berny et al. (2015)
	Spain	2011	NA	Graphite Furnace Atomic Absorption Spectrophotometer	B: 2.97 (0.41-31.75) n=10; PF: 0.30 (ND-1.52) n=10	B: 20% (2/10)		Suggested ingestion of ammunition	Cardiel et al. (2011)
	U.K.	2007	1995-2003	Atomic Absorption Spectrophotometer	Bl: 24.07 (0.8-333.78) n=125; B: 18.28 (5-187.5) n=86; L: 6.26 (0.5-46.7) n=44	Bl: 37% (46/125); B: 13% (11/86); L: 3% (1/44)	X	Lead shot in regurgitated pellets	Pain et al. 2007

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	Spain	2003	1998-2001	Graphite Furnace Atomic Adsorption Spectrometry	B: 6.00 (1.44-38.34) n=12	B: 42% (5/12)		Suggested ingestion of ammunition	(Mateo et al., 2003)
Rough-legged buzzard (*Buteo lagopus*)	Poland	2008	2000-2007	Flame-Atomic Absorption Spectrophotometer	B: 15.4* (2.5-627.4) n=4	B: % not specified		Suggested ingestion of ammunition	Komosa and Kitowski (2008)
Spanish Imperial Eagle (*Aquila adalberti*)	Spain	2005	1980-1999	Graphite Furnace Atomic Absorption Spectrophotometer	B: 23.46 (ND-155.24) n=34; BF: 9.70 (ND-45) n=34	B: 12% (4/34)		Suggested ingestion of ammunition; 2 birds with embedded shot	Pain et al. 2005
Western marsh harrier (*Circus aeruginosus*)	Poland	2008	2000-2007	Flame-Atomic Absorption Spectrophotometer	B: 13* (2.5-38.9) n=5	B: % not specified		Suggested ingestion of ammunition	Komosa and Kitowski (2008)
	Spain	1999	1992-1995	Graphite Furnace Atomic Absorption Spectrophotometer	Bl: 21.35 (0.13-74.6) n=39; B: 14.12 (ND-18.51) n=7; L: 4.33 (2.02-8.75) n=3	Bl: 53% (20/39)		Lead shot in regurgitated pellets	Mateo et al. 1999 Mateo et al. (1999)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	France	1993	1990-1992	Graphite Furnace Atomic Absorption Spectrophotometer	Bl wild: 52,59 (5.3-284) n=94; Bl captive: 7.3 (5.3-10.8)	Bl: 45% (42/94); 30 µg/dl		Lead in regurgitated pellets and lead shot found in the crop	Pain et al. (1993)
White-tailed eagle (*Haliaeetus albicilla*)	Finland	2018	2000-2014	Inductively Coupled Plasma Mass Spectrometry	L: 18.45 (0.25-108.5) n=123	L: 31% (38/123); K:29% (36/123)		Lead shot in gizzard	Isomursu et al. (2018)
	Poland	2017	2009-2014	Inductively Coupled Plasma Optical Emission Spectrometry	L: 33.62 (0.1-188.6) n=22	L: 36% (8/22)		Suggested ingestion of ammunition	Kitowski et al. (2017)
	Sweden	2009	1981-2004	Inductively Coupled Plasma Mass Spectrometry	L: 10.6 (0.03-154) n=116; K: 6.4 (0.05-50.9) n=116	L: 15.5% (18/116); K: 21.6% (25/116)	X	Lead shots and fragments in the digestive tract	Helander et al. (2009)
	Germany	2009	2003-2004	NA	L: 48.36 n=1; K: 31.61 n=1	L: 100% (1/1); K: 100% (1/1)		Lead fragments in the oesophagus	Krone et al. (2009a)
	Poland	2008	2000-2007	Flame-Atomic Absorption Spectrophotometer	B: 9.8* (2.8-14.5) n=4	B: % not specified		Suggested ingestion of ammunition	Komosa and Kitowski (2008)

Species and Red List status	Country	Published	Study timing	Quantitative method for lead	Lead concentration in tissues	Above threshold*	Iso-topes	Lead source	Ref
	Germany	2007	1998-2006	NA	Bl: (39-572) n=29	Bl: 33,3% (29/87)		11 birds with lead fragments in the digestive tract	Müller et al. (2007)
	Finland	2006	1994-2001	NA	L: 14.27 (ND-66.66) n=9 K: 8.39 (ND-38.24) n=9	L: 33,3% (3/9) K: 22,2% (2/9)		1 bird with lead fragments in gizzard	Krone et al. (2006)
	Germany, Austria	2001	1993-2000	Graphite Furnace Atomic Absorption Spectrophotometer Zeeman-effect	L: 21.79 (0.04-192.12) n=57; K: 12.60 (0.04-73.67) n=57	L: 30% (17/57); K: 26% (15/57)		2 birds with lead fragments in stomach; 2 birds with embedded shot	Kenntner et al. (2001)

*As proposed by Franson and Pain (2011)

B.9.1.3. Sports shooting (all uses)

Shooting ranges vary in size and type, ranging from large shooting complexes which may also be intended to host international sport competitions (possibly with state of art environmental risk management measures in place) to small and mid-sized ranges used for recreational activities by members of private clubs (with basic or no environmental risk management measures in place). An example of a basic rifle and pistol range is presented in Figure B.9-1

Figure B.9-1 Example of a basic rifle shooting range, after Thomas Muntwyler's publication "Beweidung mit schweren Folgen" in UMWELT AARGAU bulletin for environmental information, Nr. 47, February 2010.

Environmental concern from sports shooting with shot shell ammunition is contamination of soil, mobilisation of lead from the soil into surface and/or ground water (which can be used as drinking water), contamination of plants growing on the contaminated soil, and the toxicity of lead for birds, other wildlife and livestock.

Environmental concern from sports shooting with lead bullets are similar to that for sports shooting with shot shell ammunition which are contamination of soil, mobilisation of lead from the soil into surface and/or ground water (which can be used as drinking water), contamination of plants growing on the contaminated soil, and the toxicity of lead for birds, other wildlife and livestock.

Based on the information gathered by the Dossier Submitter (MS survey, 2020[46]), it is possible in many EU countries to locate a shooting range on soil zoned for agricultural purposes.

Releases to the environment

There are thousands of active outdoor shooting ranges in the EU/ European Economic Area (EEA), including more than 16 000 non-military ranges (MS survey, 2020) distributed across 16 countries (14 being EU Member States)[47], as confirmed by national

[46] See description in the stakeholders consultation section.

[47] European Economic Area (EEA).

authorities. Germany hosts about half of the shooting ranges identified.

Table B.9-3 reports on the answers to the survey (MS survey, 2020) on the number of shooting ranges from 19 countries of the European Economic Area (EEA), including 17 Member States (EU27): Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, Germany, Iceland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Slovakia, Slovenia, Spain, Sweden. In addition, Switzerland replied to the survey as well.

Table B.9-3 Information on total number and type of shooting ranges gathered from: national authorities within the European Economic Area. Source: Member State (MS) Survey, 2020; FITASC and other sources, as specified.

Note: " no answer" indicates that the Dossier Submitter did not receive any reply to the survey from that MS; shooting range complex includes both shotgun and (air)rifle/pistol ranges; " na" indicates data not available.

Country	Column 1 Total number of shooting ranges (from national authorities)	Column 2 Total number of shooting ranges (values used by ECHA)	Column 3 Ranges using bullets (from national authorities)	Column 4 Ranges using shot (from national authorities)	Column 5 Number of shotgun ranges (data from FITASC)	Column 6 Additional info on number of ranges received by national sport shooting associations
Germany	7777	7777	more than 5000	500-1000	150	13 000-14 000 estimated ranges of which about 100 are shotgun ranges (German Shooting Sport & Archery Federation) [48]
Austria	no answer	-	no answer	no answer	63	
Belgium	na	-	na	na	13	

[48] The German Shooting Sport & Archery Federation has more than 14.000 clubs within its federation. They reported (ECHA survey 2020 for stakeholders) that most of these clubs have their own shooting range; some even have a separate shotgun and a rifle/pistol shooting range, others share a shooting range with a second club. Therefore they estimated a number of approx. 13.000-14.000 ranges of which about 100 are shotgun ranges. Concrete numbers are not available due to the fact that most ranges are managed/owned by the clubs which are not direct members of our federation but in the regional federations.

Country	Column 1 Total number of shooting ranges (from national authorities)	Column 2 Total number of shooting ranges (values used by ECHA)	Column 3 Ranges using bullets (from national authorities)	Column 4 Ranges using shot (from national authorities)	Column 5 Number of shotgun ranges (data from FITASC)	Column 6 Additional info on number of ranges received by national sport shooting associations
Cyprus	7	7	0	less than 500	9	5 shotgun ranges are part of Cyprus Shooting Sport Federation, CSSF
Croatia	no answer	-	no answer	no answer	-	
Denmark	612 (shooting complex)	612	404	253 use shot only, 55 (using shot and bullets)	20	250 outdoor shooting ranges are members of Skydebane foreningen (Skydebane foreningen)
Spain	na	-	na	na	200	
Estonia	43	43	less than 500	less than 500	38	
Finland	about 500	500	less than 500	less than 500	380	about 670 (shooting complex) rough estimate: 350 ranges using shot; 650 ranges using bullets (Finnish Shooting sport federation)
France	no answer	-	no answer	no answer	400	
Greece	no answer	-	no answer	no answer	26	

Country	**Column 1** Total number of shooting ranges (from national authorities)	**Column 2** Total number of shooting ranges (values used by ECHA)	**Column 3** Ranges using bullets (from national authorities)	**Column 4** Ranges using shot (from national authorities)	**Column 5** Number of shotgun ranges (data from FITASC)	**Column 6** Additional info on number of ranges received by national sport shooting associations
Hungary	no answer	-	no answer	no answer	200	
Ireland	no answer	-	no answer	no answer	35	
Italy	max 500 (estimated)	500	less than 500	less than 500	350	
Latvia	no more than 50	50	less than 500	less than 500	6	
Lithuania	142	142	less than 500	500-1000	18	
Malta	no answer	-	no answer	no answer	6	
Netherlands	about 40	40	less than 500	less than 500	23	650 sports shooting clubs are affiliated to the KNSA of which about an estimated 450 clubs with their own range, among which approximately 20 shotgun ranges. (KNSA: Royal Netherlands Shooting Sport Association)
Poland	na	-	na	na	5	
Portugal	no answer	-	no answer	no answer	56	
Romania	no answer	-	no answer	no answer	4	

Country	**Column 1** Total number of shooting ranges (from national authorities)	**Column 2** Total number of shooting ranges (values used by ECHA)	**Column 3** Ranges using bullets (from national authorities)	**Column 4** Ranges using shot (from national authorities)	**Column 5** Number of shotgun ranges (data from FITASC)	**Column 6** Additional info on number of ranges received by national sport shooting associations
Slovakia	between 250-316	250	less than 500	less than 500	120	
Slovenia	13 with licence and 350 without licence (hunting and shooting club)	363	less than 500	less than 500	9	

Country	**Column 1** Total number of shooting ranges (from national authorities)	**Column 2** Total number of shooting ranges (values used by ECHA)	**Column 3** Ranges using bullets (from national authorities)	**Column 4** Ranges using shot (from national authorities)	**Column 5** Number of shotgun ranges (data from FITASC)	**Column 6** Additional info on number of ranges received by national sport shooting associations
Sweden	about 4000 registered (2006)	4000			400	350-400 ranges estimated by Swedish Pistol Shooting Association (SPSF)[49]; 30 ranges registered with Swedish Metal Silhouette Association; approximately 3050 ranges, of which 500 shotgun ranges registered with Swedish Shooting Sport Federation; more than 1000 within Swedish Association for Hunting and Wildlife Management[50]; other[51]

[49] *SPSF* do not register shooting ranges. Almost all the clubs (a little less than 500) have access to an outdoor range, but a number of ranges are used by more than one club, especially in urban areas. An approximation is 350-400 ranges. None of those ranges are shotgun ranges.

[50] 1040 members of *Swedish Association for Hunting and Wildlife Management* are local shooting clubs with a shooting range. Typically, most of them are rifle ranges and some are shotgun ranges, but most of them have both rifle ranges and shotgun ranges. Approximately 65 % of the shooting ranges, i.e. approximately 676 have a shotgun range. Approximately 104, i.e. 10 %, are shotgun ranges exclusively.

[51] *Svenska Dynamiska Sportskytteförbundet*: all clubs associated to this organisation (114 clubs) have access to one or more outdoor ranges, ca 50 of them have access to a range approved for use with shotguns, against

Country	**Column 1** Total number of shooting ranges (from national authorities)	**Column 2** Total number of shooting ranges (values used by ECHA)	**Column 3** Ranges using bullets (from national authorities)	**Column 4** Ranges using shot (from national authorities)	**Column 5** Number of shotgun ranges (data from FITASC)	**Column 6** Additional info on number of ranges received by national sport shooting associations
Czech Rep	no answer	-	no answer	no answer	550	
Iceland	24	24	less than 500	less than 500	20	
Norway	about 1770	1770			351	
Bulgaria	81	81	less than 500	less than 500	not listed	
Luxembourg	12	12	less than 500	less than 500	not listed	
Total (for Columns 1 and 5 only)		**16 171 for 16 EEA countries;** **14 377 for 14 EU MS**			**3 217 for 26 EEA countries;** **2 846 for 24 EU MS (being 443 in countries with a ban on the use of lead shot)**	

Based on the data gathering carried out by the Dossier Submitter (summarised in Table B.9-3), the number of shooting ranges (all types) in the EU27-2020 can be expected to be larger than 14 000, for the following reasons mainly:

- Information from 13 EU Member States is not currently available.
- Some countries (among the ones that answered MS survey 2020) may not have information readily available for shooting ranges not needing a licence/permit (i.e. not needing to be registered) to operate, being private clubs for recreational

an impact berm; *Swedish Federation of black powder shooters* do not register ranges. In their association SSSF they we have approx. 120 gun clubs registered and many of the clubs are also shooting in other associations with modern guns on the same ranges. Small parts of the clubs have shotgun ranges; *Swedish Biathlon Federation* has 30 registered shooting ranges for biathlon, but also approximately 10 that are not in use the last years (not applied for prolongation) and we are working for 5 new ranges in a 5 years period. They also have ranges for air rifle shooting but since there is no license/registration needed for them it is difficult to state number of them (approx 30).

activities[52]. Several MS confirmed that information gathering on shooting ranges was particularly difficult. Nation-wide databases are often not in place, being data related to shooting ranges available at municipal level only.

To estimate the total number of shooting ranges in the EU 27 the Dossier Submitter has made several assumptions, as indicated in the following tables. It has to be noted that the Dossier Submitter, to facilitate the information gathering at MS level, requested information related to shooting ranges using "lead shot" and "lead bullets" without introducing additional specifications related to the uses identified in the Annex XV report (e.g. muzzle loading, etc.). Therefore, the estimates proposed below have to be considered as "total" values for all uses implying the use of lead shot or lead bullets. Furthermore, no EU estimate has been proposed for shooting areas due to limited data available.

Table B.9-4 Total number of estimated shooting ranges in EU 27 (rifle and pistol/shotgun ranges).

Total number of shooting ranges (estimate)	Total number of (air) rifle and pistol ranges (all types)	Total number of shotgun ranges (all types)
About 20 000 based on total number calculated for 14MS: 14 377 (as reported in column 2 Table B.9-3) and assuming 6 600 ranges for the 13 MS for which no specific data are available[53]	**About 16 000** estimated as total number minus total number of shotgun ranges	**About 4 000** being 2 846 FITASC ranges for 24 EU MS (443 in countries with a ban on the use of lead shot and specific derogations in place) and assuming for EU 27, other 1 000 to 1 500 non FITASC ranges (taking into account available data on column 4- 5 of Table B.9-3 for some MS)

Amount of lead ammunition used on an annual basis in the EU 27-2020

Based on information provided in the REACH registration Chemical Safety Report (CSR) for lead (2020) it can be assumed that on a typical outdoor pistol/rifle range and clay target range 5 000 kg/year and 10 000 kg/year of lead are used, respectively. A typical sporting clay target range (simulated game hunting) is assumed to use 10 000 kg/year of lead. On the contrary, a clay target area is assumed to use 390 kg/year[54].

[52] For example having the status of no-profit organisations. This may explain apparent divergence among different data sources.

[53] Assuming Germany being a unique case in the EU with a very high number of shooting ranges (rifle and pistol mainly), the Dossier submitter had made the following calculation to estimate the "expected value" for the 13 MS for which info was not available: 14 377 (total number from information available for 14MS) – 7 777 (total number of ranges in Germany from German authorities) =6 600. Therefore for EU 27 it has been assumed: 14 377 + 6 600 (for the 13 MS for which no info was available) = 20 977. The Dossier Submitter has approximated this value to about 20 000 ranges.

[54] In the CSR 2020, a clear distinction is made between shooting ranges and shooting areas.

A shooting range is defined as "an area designed and operated specifically for recreational shooting". The owner/operator of the site complies with environmental regulations. There is remediation upon closure plan in place. The range has a clearly defined boundary and it is assumed that lead ammunition is not allowed to be deposited outside the boundaries of the range.

Shooting areas are "areas not specifically designed and operated for shooting but where shooting activities can

Emission days per year related to lead ammunition uses in these types of ranges are assumed to be 200 days/year.

Based on the number of ranges identified (Table B.9-4) the following estimates for the amount of lead used in sport shooting in the EU 27 have been made, as described below.

Table B.9-5 Estimated amount of lead shot used in EU 27 in all types of shotgun ranges[55] per year. (No EU estimate has been proposed for shooting areas due to limited data available).

Range	Lead shot used in EU 27-2020 (tons/year) in sports shooting (clay target shooting)
Shotgun ranges members of FITASC	1) 28 460 (for 2 846 ranges in 24 EU MS, using CSR value: 10 000 kg/year) if all were using lead shot. However, assuming that in the countries with a ban in place and specific derogations, a few ranges are allowed to use lead shot (accounting for about 443 tonnes[56] of lead shot used), the overall amount can be expected to be: 28 460-3 987= 24 473 2) 22 760 + 11 384 +2 846 (for 2 846 ranges in 24 EU MS, if using CSR value: 10 000 kg/year for 80% or ranges, 40 tons per 10% of ranges and 1 tonne for 10% or ranges) =36 630 if all were using lead shot. However, assuming that in the countries with a ban in place and specific derogations, a few ranges are allowed to use lead shot (accounting for about 443 tons of lead shot used), the overall amount can be expected to be: 36 630-3 987=32 643 **28 558** (**average of scenario 1 and 2)** Note: some ranges may use up to more than 40 tons per year. Others may use less than 1 ton per year based on stakeholders' declarations[57]
Other shotgun ranges	3) 1 400 to 2 100 (for 1 000 to 1 500 ranges in EU 27): 1 750 average value**,** using rate of accumulation of 1.4 t/year per range, assuming all ranges being small size ranges (Craig et al., 2002) 4) 10 000 to 15 000 (for 1 000-1 500 ranges in EU 27): 12 500 average value, using CSR value: 10 000 kg/year **7 125 (average of scenario 3 and 4)**
Other shooting areas **(temporary)**	Not estimated due to lack of information
Total	**28 558 +7 125 =35 683, i.e. about 35 000**

take place". These areas do not necessarily comply with best practice guidelines and may not be subject to, or comply with, relevant environmental regulations

[55] Generally referred to as clay target shooting.

[56] About 10% of 4430 tons (being 4430 tons the amount of lead used by 443 ranges if all were using lead shot)

[57] Cyprus Shooting Sport Federation (CSSF) reported 220 tons of lead used in 5 ranges per year, i.e. 44 tons per range per year. Finnish Shooting sport federation estimated for about 350 ranges, 300 tons of lead used, i.e. ~1 kg per range per year.

Table B.9-6 Estimated amount of lead used in EU 27 in rifle and pistol ranges (all types) per year

Range	Lead ammunition used in EU 27-2020 (tons/year) in (air) rifle/ pistol ranges
Rifle and pistol ranges (all types)[58]	1) 80 000 (for 16 000 ranges, using CSR value: 5 000 kg/year) 2) 4 160 (for 16 000 ranges using lowest reported values: 0.26 tons per year (average from two countries, as reported by stakeholders)[59]
Other shooting areas (temporary)	Not estimated
Total	**42 080 (average of scenario 1 and 2) i.e. about 42 000**[60]

Amount of lead released on an annual basis in the EU 27-2020

Due the many uncertainties described in the previous paragraphs (related to the estimate of the number of shooting ranges and to the amount of lead used every year), the amount of lead released every year has been assumed to be equal to the estimated amount of lead ammunition used, with the aim to refine both data on uses and releases during the forthcoming consultation (2021).

Specifically it is noted that:

- The estimates on the numbers of shooting ranges provided by national sports shooting association do not necessarily overlap with the estimates provided by national authorities. For example, the German Shooting Sport & Archery Federation estimated 13 000 to 14 000 ranges in Germany compared to 7 777 ranges indicated by national authorities. The reasons for this type of divergence are not fully clear and may be related to the fact that the Dossier Submitter requested MS information on registered ranges mainly, whist some ranges may not need to be registered being private clubs. The Dossier Submitter has favoured a cautious approach to avoid overestimating the number of existing ranges and has generally selected the lower bound of the estimated number of ranges (among different sources and values), as in the case of Germany for rifle and pistol ranges.
- Based on the information provided in the REACH registration Chemical Safety Report (CSR) for lead (2020) it can be assumed that on a typical outdoor pistol/rifle range and clay target range 5 000 kg/year and 10 000 kg/year of lead are used, respectively. However, the Dossier Submitter has taken into account different scenarios (considering information gathered by stakeholders) and has used in some scenarios values significantly lower than the ones indicated in the CSR (2020), to

[58] The amount of lead actually used, is expected to be close to the average value resulting from these "extreme" scenarios.

[59] Finnish Shooting sport federation estimated for about 650 ranges, 144 tons, i.e. 0.2 tons per range per year. Swedish Shooting Sport Federation estimated for 2550 ranges, 750 tons used per year, i.e. 0.3 tons per range per year.

[60] Based on a survey performed by the International Biathlon Association (IBU), in EU-27 2020 there are 185 shooting ranges used for biathlon with an assumed annual consumption of 36828 kg lead.

avoid overestimating the amount of lead actually being used. See Table B.9-5 and Table B.9-6

- There is no complete information at the EU level (in many Member States) related to a potential annual recovery of lead in many shooting ranges. Available information on lead recovery do not indicate that annual recovery is currently a typical practice in the EU (MS survey, 2020). Therefore, it is difficult to estimate how much lead may not be released on a yearly basis in the environment due to the use of specific environmental risk management measures (RMM). No RMM is currently considered mandatory at the EU level (MS survey, 2020), including measures described in the CSR for lead (2020).
- The amount of lead released into temporary shooting areas at the EU level has not been estimated due to the lack of specific information.

Comparison with US data

As reported by Rattner et al., (2008), in the US, according to estimates of the US National Shooting Sports Foundation (NSSF), millions of Americans participate annually at about 9000 outdoor non-military shooting ranges in the United States (United States Environmental Protection Agency 2001, NSSF 2007,). The U.S. EPA (United States Environmental Protection Agency) estimates that about 72600 metric tons of lead shot and bullets are deposited in the U.S. environment every year at outdoor shooting ranges (U.S. EPA 2001).

Exposure pathways in shooting ranges using lead ammunition (basic scenario: no environmental RMM in place)

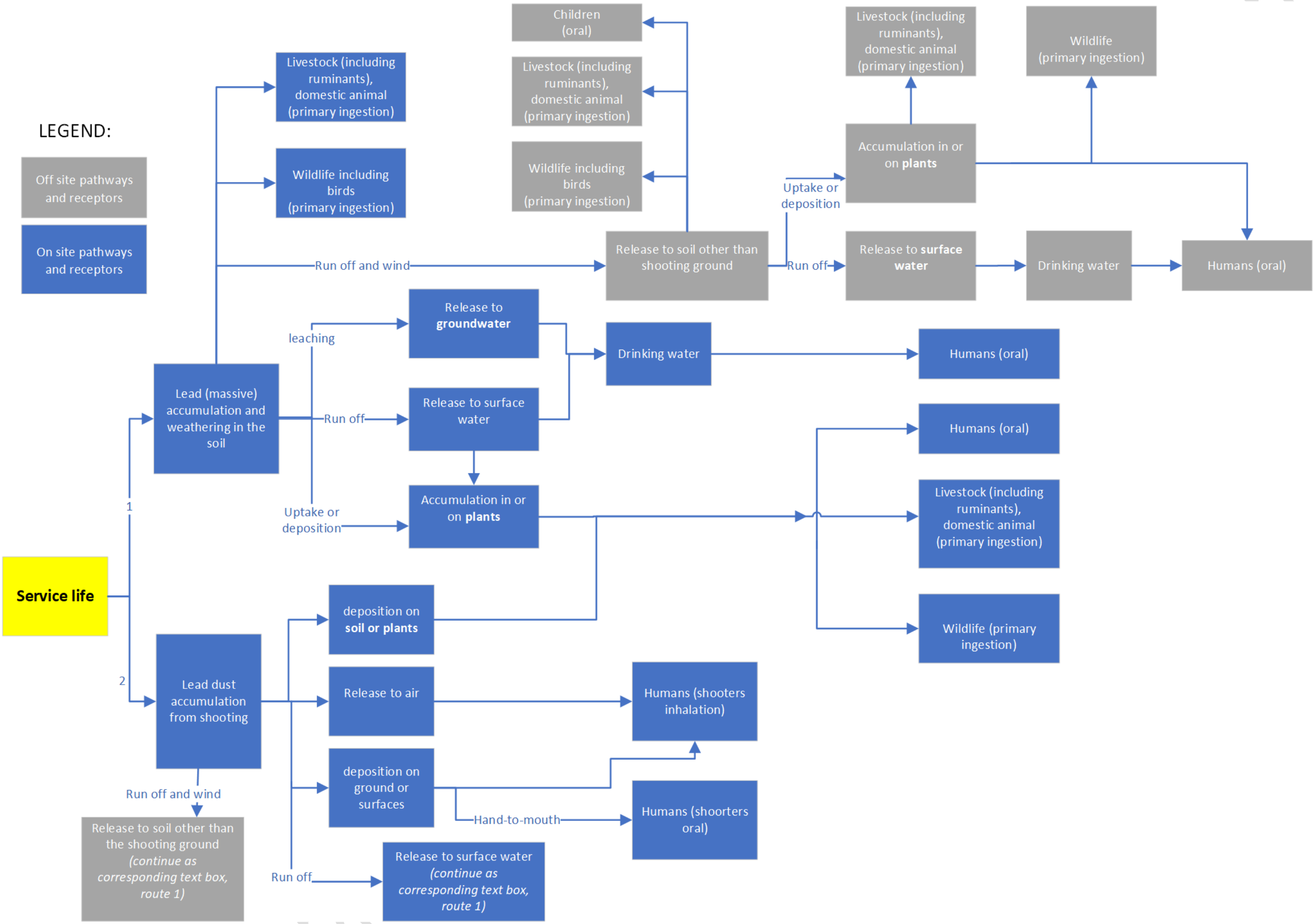

Figure B.9-2 Exposure pathways (on site and off site) in a range with no environmental RMM in place during service life.

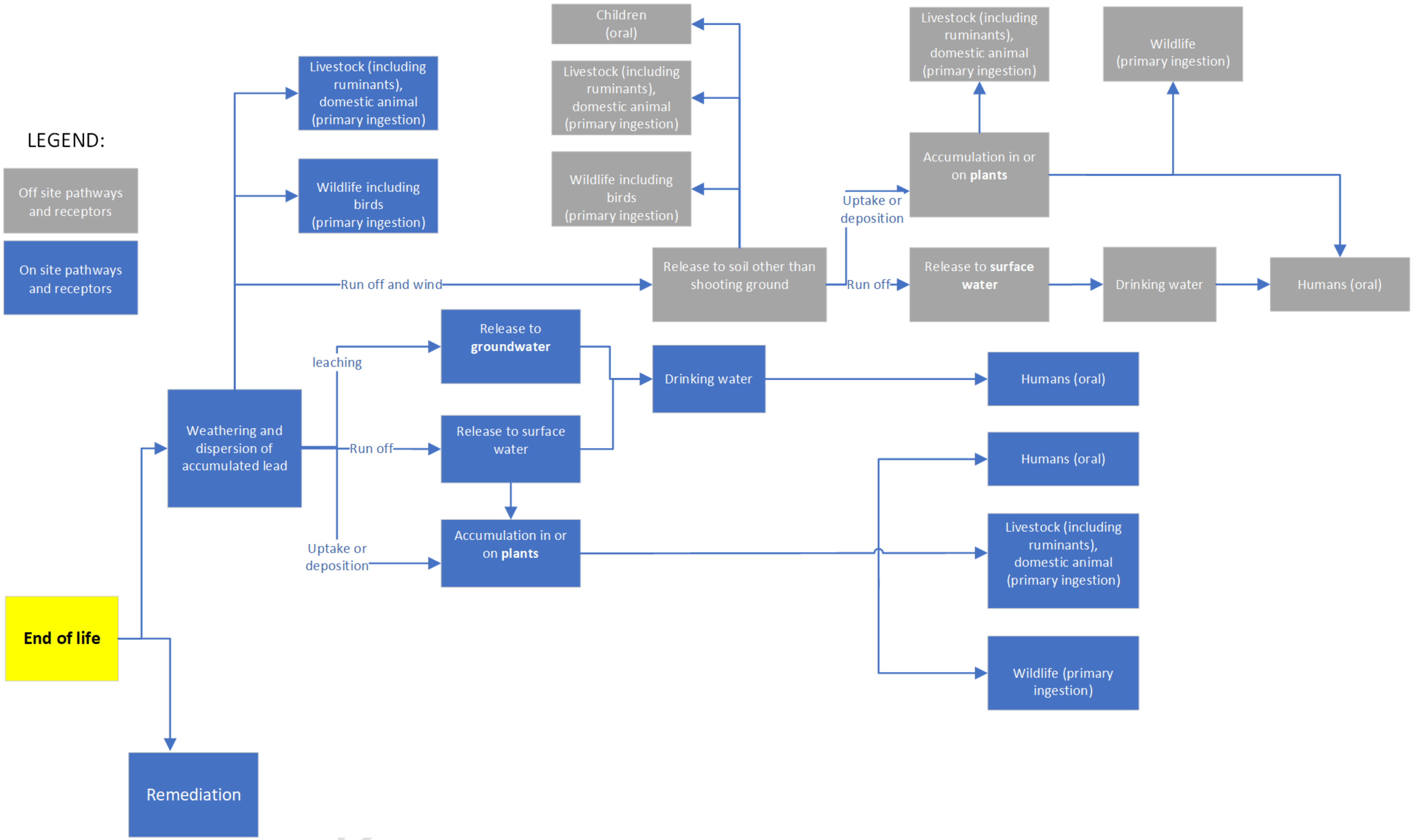

Figure B.9-3 Exposure pathways (on site and off site) in a range with no environmental RMM in place during end of life.

Soil

Concentration of lead in soil at shooting ranges (overview)

Reported lead concentration in shooting range soils vary depending on the amount of yearly shooting, years of operation of shooting ranges, as well as the grades of lead shot used at the range.

Dinake et al. (2019) reviewed literature from 1983 to 2018 to provide an overview on the pollution status of shooting range soils from lead (see Table B.9-7). Pb concentration as high as 97 600 mg/kg has been measured in a shooting range soil in the United States of America (South America), (Clausen and Korte, 2009), 66 972 mg/kg (Canada, North America) (Laporte-Saumure et al., 2012), 29 200 mg/kg (Japan, Asia) (Hashimoto et al., 2009), 38 386 mg/kg (Botswana, Africa) (Sehube et al., 2017), 300 000 mg/kg (Netherlands, Europe) and 206 600 mg/kg (New Zealand, Oceania). One of the first studies into assessment of Pb pollution of shooting ranges was carried out by Adsersen et al. (1983) some 35 years ago who found 200 000 to 300 000 mg of Pb per square metre of the studied site which had been in operation for 14 years. The accumulation of Pb into shooting range soils and nearby environment has seen drastic surge in recent years reaching highs of 200 000 (Rooney and McLaren, 2001) and 300 000 mg/kg in berm soils of a shooting range (Van Bon and Boersema, 1988).

It is noteworthy that due to the irregular distribution of lead shot at shooting ranges, different sampling strategies can cause a high variability in reported concentrations of lead and other metals (Craig et al, 2002).

Table B.9-7 Review of research studies (over 35 years) on contamination of shooting range soils from lead ammunition (Dinake et al., 2019)

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1] for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
Denmark (1983)	1	14	0.2–3 kg per m^2	–	–	Adsersen et al., 1983
Denmark (1987)	3	12–26	274–1000	0–5	7–12[2] (reference area)	Jorgensen and Willems, 1987
Netherlands (1988)	1	–	300–300 000	0–5	600 (critical value for soil sanitation)	VanBon and Boersema,1988
Netherlands (1989)	1	12	360–70 000	0–5	0.001–1.1 (control area)	Ma, 1989
Germany (1990)	1	–	5000	0–50	–	Fahrenhorst and Renger, 1990
Finland (1991)	1	–	10 500	0–70	–	Tanskanen et al., 1991

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1]for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
USA (1992)	8	–	838	0–7.5	–	Stansley et al., 1992
USA (1993)	1	78	11–345	0–800	5.0 mg/L (TCLP[3] Pb benchmark)	Pott et al., 1993
Finland (1993)	1	29	4700–54 000	0–40	240 (reference area)	Tanskanen, 1993
England (1994)	1	–	10 620	0–150	–	Mellor and McCartney, 1994
Sweden (1995)	–	–	52–3 400	0–20	–	Lin et al., 1995
USA (1995)	8	–	1000	–	–	Murray and Bazzi, 1995
USA (1995)	1		11–4675		5 mg/l (TCLP USEPA)	Basunia and Landsberger, 2001
Sweden (1996)	8	26	687–24 500	5–10	23–191 (reference soils)	Lin, 1996
USA (1996)	1	–	75 000	0–75	–	Stansley and Roscoe, 1996
Switzerland (1997)	1	–	29 550	–	50 (set tolerance level)	Braun et al., 1997
USA (1997)	1	–	2 256	5–15	25 (background soil)	Murray et al., 1997
New Zealand (1998)	3	60	4 000–8 300	0–75	300 (Australia and New Zealand set limit for soil)	Rooney et al., 19999
Denmark (1999)	1	30	60 000	0–40	5–15 (reference soils)	Astrup et al., 1999
USA (1999)	1	–	400	–	–	Bruell et al., 1999
New Zealand (2000)	3	7–51	15 370–206 600	1–7.5	300 (Australia and New Zealand set limit for soil)	Rooney and McLaren, 2000

Location and year of study	**Nr. of shooting ranges studied**	**Number of years in operation**	**Total Pb concen-tration (mg/kg)**	**Sampling Depth**	**MCL[1] for Pb referred to in the study (mg/kg)**	**Reference (see Dinake et al., 2019)**
USA (2000)	1	–	856.9	–	–	Peddicord and Lakind, 2000
Finland (2000)	1	–	9 804	5–20	–	Turpeinen et al., 2000
USA (2000)	1	–	110–27 000	0–3	–	Vyas et al., 2000
Switzerland (2001)	2	–	3 110–33 600	–	50 (Swiss official Pb tolerance level)	Mozafar et al., 2002
USA (2001)	1	14	875–4 448	0–10	400 (USEPA soil screening level)	Chen et al., 2001
USA (2001)	1	–	13 525–37 174	10–25	294 (adjacent areas)	Basunia and Landsberger, 2001
South Korea (2002)	1	45	78–165	0–10	53 (reference soil)	Lee et al., 2002,
USA (2002)	1	14	330–17 850	0–10	400 (USEPA soil screening level)	Chen and Daroub, 2002
USA (2002)	1	–	16 200	0–15	22.1–60.5 (background soil)	Hui, 2002
USA (2003)	2	3–16	12 710–48 400	0–10	400 (USEPA soil screening level)	Cao et al., 2003
Switzerland(2003)	1	38	80 900	0–10	23 (background soil)	Knechtenhofer et al., 2003
USA (2004)	2	0.25 (3 months)	193–1 142	0–15	–	Hardison et al., 2004
USA (2004)	1	–	385–12 400	3–20	0.3 (WHO[4] Pb limit in fish)	Labare et al., 2004
USA (2004)	2	–	134.9–144.6	–	14.7 (reference site)	Johnson et al., 2004
Italy (2004)	1	–	212–1 898	–	100 (Italian soil Pb threshold)	Migliorinia et al., 2004

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1]for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
Switzerland (2005)	1	90	1045–67 860	0–5	10–30 (background soil)	Vantelon et al., 2005
England (2005)	1	45	6410	–	296 (control site)	Reid and Watson, 2005
USA (2006)	4	–	1025–49 228	–	400 and 1000 (California and New Jersey Regulatory Pb screening levels)	Dermatas et al., 2006a
USA (2006)	2	–	3 196 and 10 542	–	400 and 1000 (California and New Jersey Regulatory Pb screening levels)	Dermatas et al., 2006
Finland (2006)	1	23	2500–49 700	0–5	75 (background soil)	Rantalainen et al., 2006
Canada (2007)	3	–	16 400–27 600	–	–	Bennett et al., 2007
Germany (2007)	1	–	16 760	–	–	Spuller et al., 2007
USA (2007)	2	–	406–22 333	–	64–85 (reference areas)	Johnson et al., 2007
Finland (2007)	1	16	28 700	0–6	–	Levonmaki and Hartikainen, 2007
USA (2007)	12	5–60	54.9–68 519	2–20	5mg/L (TCLP limit)	Isaacs, 2007
Finland (2007)	3	33–44	350–19 800	0–20	300 (Finish limit value)	Sorvari, 2007
USA (2007)	1	60	19.8–7 915	0–15.24	69 (background soil)	Duggan and Dhawan, 2007
Switzerland (2008)	1	–	100 000	2–10	530 (Dutch Intervention Value)	Robinson et al., 2008

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1]for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
USA (2008)	4	–	5040–60 600	0–30	400 (USEPA soil screening limit)	Cao and Dermatas, 2008
Finland (2009)	2	16–20	15 500–41 800	0–8	750 (upper guideline value for Pb)	Hartikainen and Kerko, 2009
USA (2009)	9	–	990–97 600	0–5	6–119 (background soils)	Clausen and Korte, 2009
USA (2009)	1	16	340	0–50	12 (background soil)	Scheetz and Rimstidt, 2009
Poland (2009)	2	–	640–4 600	0–10	400 (USEPA Pb critical level)	Rauckyte et al., 2009
USA (2009)	8	–	4 549–24 484	–	–	Bannon et al., 2009
Japan (2009)	1	10	29 200	0–10	–	Hashimoto et al., 2009
South Korea (2010)	1	–	3 529	0–30	400 (Korean limit)	Lee and Kim, 2010
Czech Republic (2010)	1	30	573–694	0–30	300 (critical limit for agricultural soils)[5]	Chrastny et al., 2010
Switzerland (2010)	2	–	500–620	0–30	200 (Swiss limt)	Conesa et al., 2010
USA (2010)	1	9	4 694–11 479	–	5mg/L (TCLP limit)	Yin et al., 2010b
USA (2010)	2	24	2 096–29 900	0–30	0.18–450 (background soils)	Yin et al., 2010
Canada (2010)	4	–	16 485–43 113	0–30	1 000 (MDDEP[6] level) 600 (CCME[7] level)	Laporte-Saumure et al., 2010
South Korea (2010)	1	–	8 684	–	100 (Korean warning standard)	Moon et al., 2010

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1]for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
Norway (2010)	1	–	22 000	–	1–50 (Background soil)	Heier et al., 2010
Switzerland (2011)	1	–	500	0–30	–	Conesa et al., 2011
Canada (2011)	4	–	14 400–27 100	0–30	1 000 (MDDEP commercial level) 600 (CCME industrial level)	Laporte-Saumure et al., 2011
USA (2011)	3	7–38	10 068–70 350	–	5 mg/L (TCLP limit)	Fayiga et al., 2011
Switzerland (2012)	2	–	466–644	0–40	40[8]	Evangelou et al., 2012
South Korea (2012)	1	–	4 626	–	700 (Korean hazard standard)	Ahmad et al., 2012
Finland (2012)	2	22–25	19 100–50 300	5–8	750 (ecological risk guideline value)	Selonen et al., 2012
Canada (2012)	1	–	423–66 972	0–90	1000 (MDDEP commercial level) 600 (CCME industrial level)	Laporte-Saumure et al., 2012
Australia (2012)	4	42–52	399–10 403	0–20	400 (USEPA critical level) 600 (EIL)[9] 600 (HIL)[10]	Sanderson et al., 2012
South Korea (2013)	1	–	7 996	0–30	200 (Korean warning standard)	Moon et al., 2013
Czech Republic (2013)	1	40	4 800	0–5	60 (guideline for agricultural soils)	Ash et al., 2013
Norway (2013)	5	–	2 000–30 000	–	60 (Norwegian soil quality guideline)	Okkenhaug et al., 2013
Canada (2013)	1	–	18 600–44 100	0–20	140 (criteria for residential soils) 600 (criteria for industrial soils)	Lafond et al., 2013

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1]for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
South Korea (2013)	1		11 885	0–30	–	Moon et al., 2013
South Korea (2013)	1	–	4 400–11 000	–	100 (Korea regulation level)	Kim et al., 2013
South Korea (2013)	1	–	11 900	0–30	100 (residential warning standard)	Moon et al., 2013
Australia (2013)	4	45–55	233–12 167	0–10	5 mg/l (TCLP regulatory limit)	Sanderson et al., 2014
USA (2014)	1	34	42 854	0–5	400 (USEPA soil contamination threshold)	Perroy et al., 2014
China (2014)	1	20	153.7–2 763	0–20	34.97 (background soil)	Liu et al., 2014
Argentina (2014)	1	–	80	0–5	–	Rubio et al., 2014
Netherlands (2014)	1	–	47–2 398	–	–	Luo et al., 2014b
Netherlands (2014)	1		355–2 153	0–20	–	Luo et al., 2014
China (2015)	3	–	2 019.75–9 160.25	0–10	-	Li et al., 2015
Australia (2015)	3	–	612–4 697	0–10	-	Sanderson et al., 2015b
Finland (2015)	2	22–28	19 000–28 000	1–6	-	Selonen and Setala, 2015
Netherlands (2015)	1	–	2 153–2 398	–		Luo et al., 2015
Norway (2016)	1	16	356–1 112	0–30	60 (Norwegian soil quality guideline)	Okkenhaug et al., 2016
Nigeria (2016)	1	60	17 500	0–15	400 (USEPA guideline)	Etim, 2016

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1]for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
South Korea (2016)	1	–	5 715.4	–	200 (Korean standard)	Yoo et al., 2016
South Korea (2016)	2	20–30	3 918–18 609	0–30	200 (Korean regulation value)	Islam et al., 2016
Australia (2016)	4	46–56	177–2 545	–	–	Sanderson et al., 2016
Spain (2016)	1	30	82.36–724.85	0–15	100 (generic reference level)	Rodriguez-Seijo et al., 2016
Spain (2016)	1	–	55–6 309	0–15	100 (generic reference Level) 400 (USEPA guideline)	Rodríguez-Seijo et al., 2016
South Korea (2017)	1	30	3 436	0–30	700 (Korean standard level)	Islam and Park, 2017
Norway (2017)	1	–	1 400	–	–	Okkenhaug et al., 2017
Norway (2017)	1	139	410–2 700	2–3	130 (reference soils)	Mariussen et al., 2017a
Norway (2017)	7	50–80	260–13 000	0–15	20 (background soil)	Mariussen et al., 2017a
Nigeria (2017)	1	–	2 333–16 976	0–15	–	Etim, 2017
Switzerland (2017)	2	–	500–620	0–30	–	Tandy et al., 2017
Spain (2017)	1	–	160–720	0–15	100 (Spanish GRL[11]) 400 (USEPA guideline)	Rodríguez-Seijo et al., 2017
Botswana (2017)	8	19–40	85–38 386	0–20	400 (USEPA guideline)	Sehube et al., 2017
Botswana (2017)	7	16–33	685–20 882	0–20	400 (USEPA guideline)	Kelebemang et al., 2017

Location and year of study	Nr. of shooting ranges studied	Number of years in operation	Total Pb concen-tration (mg/kg)	Sampling Depth	MCL[1]for Pb referred to in the study (mg/kg)	Reference (see Dinake et al., 2019)
Switzerland (2018)	1	–	471	0–30	40 (regulatory values for fodder plants)	Hockmann et al., 2018
Norway (2018)	1	–	450	0–10	300–700 (Norwegian soil quality criteria)	Pedersen et al., 2018a
Norway (2018)	4	–	580–33 000	–	0.17–3.6 (reference soil)	Mariussen et al., 2018
Norway (2018)	3	123	41–7 189	–	60 (soil quality guideline for sensitive land use)	Johnsen et al., 2018
Belgium (2018)	7	28	23.4–2 167	–	139 (control sample)	Vandebroek et al., 2018
Nigeria (2018)	1	53	14.85	0–15	4.99 (unpolluted site)	Magaji et al., 2018
Norway (2018)	2	–	450–3 200	0–10	300–2500 (Norwegian soil quality criteria)	Pedersen et al., 2018a

MCL[1]–Maximum contaminant limit.

9–12[2]–Where the units are not indicated in the table, they are in mg/kg.

TCLP[3]–Toxicity characteristic leaching procedure

WHO[4]–World Health Organization

Critical limit for agricultural soils by the EC Council Directive 86/278/EC (1986)[5]

MDDEP[6] – Ministere du Developpement Durable, de l'Environnement et des Parcs.

CCME[7] – Canadian Council of Ministers of the Environment

40[8] – maximum allowed trace element concentrations in fodder DW (dry weight)

EIL[9]–Ecological investigation level

The German Landesamt für Natur und Umwelt des Landes Schleswig-Holstein (LANU, 2005) investigated soil contamination in clay shooting ranges. Concentration of lead in the soil of a trap shooting range was 1500±42, 688, and 30±5.7 ppb (μg/kg) for depths of 0-10, 10-15, and 15-25 cm. Lead concentration of the control area was <5 ppb.

In addition, microparticles of lead from oxidation and other processes in the soil can become airborne and mobilize away from the fall zone at shooting ranges (Duggan and

Dhawan, 2007), thus representing a hazard for off-site receptors.

Distribution of lead contamination in the soil at skeet and trap ranges

The distance that shot can travel based on diameter is presented in **Table B.9-8**. This can be used to identify the perimeter of a shot fall zone (Australian EPA, 2019).

Table B.9-8 Distance shot can travel based on shot diameter

Shot diameter (mm)	Distance travelled (m)
2.8	220
2.5	200
2.4	195
2.3	185
2.2	175
2.0	160

However, wind can cause shot to spread over much greater area. Depending on the discipline, the shot fall zone can vary and is larger for a skeet range compared to a trap range. As shown in **Figure B.9-4**, the whole area of the shooting range is expected to be contaminated with lead above background level (Australian EPA, 2019).

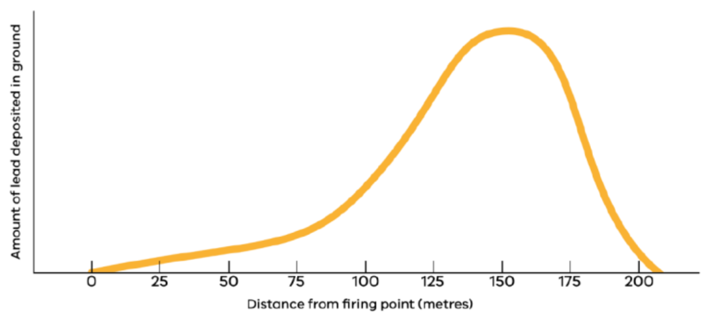

Figure B.9-4 Lead contamination at a skeet or trap range based on distance from the firing point (Australian EPA, 2019)

Concentration of lead in soil in areas adjacent to shotgun ranges

Shooting ranges can present an important source of lead contamination of agricultural soils located in their close vicinity.

In agricultural soils very close (10 m) to a shooting range, Chrastný et al. (2010) found that lead was mainly concentrated in the arable layer of the contaminated agricultural soils at total concentrations ranging from 573 to 694 mg/kg. Isotopic analyses ($^{206}Pb/^{207}Pb$) proved that Pb originated predominantly from the currently used pellets. Chemical fractionation analyses showed that Pb was mainly associated with the reducible fraction of the contaminated soil, which is in accordance with its predominant soil phases (PbO, $PbCO_3$). The 0.05 M EDTA extraction showed that up to 62% of total Pb from the

contaminated site is potentially mobilizable. Furthermore, Pb concentrations obtained from the synthetic precipitation leaching procedure extraction exceeded the regulatory limit set by the United States Environmental Protection Agency for drinking water. Ion exchange resin bags showed to be inefficient for determining the vertical distribution of free Pb^{2+} throughout the soil profile.

Table B.9-9 Lead concentration obtained from the SPLP extraction procedure and resin bag analyses (Chrastný et al., 2010)

Depth	SPLP (µg/L)		Resin bags (µg/L)[a]	
	Contaminated site	Control site	Contaminated site	Control site
0-5 cm	21.3±2.1	0.59±0.10	261±140	7.70±2.33
5-15 cm	22.8±3.3	0.26±0.04	213±57	9.85±0.23
15-10 cm	24.0±0.5	0.55±0.17	320±190	6.65±1.04
30-x cm	0.67±0.32	0.20±0.04	236±88	8.40±3.14

Data shown are means±SD (n=3)

[a]Lead concentrations determined in eluates

Distribution of lead contamination in the soil at rifle and pistol ranges

Ma et al. (2002) measured in soils of shooting ranges in Florida total lead concentrations in the berms of seven rifle ranges from 12,710 to 48,400 mg/kg and in berm of four pistol ranges from 22,400 to 38,984 mg/kg.

Oschwald et al. (2002) investigated lead contamination in two 300 m shooting ranges (range Zihlmatt and range B) which are part of the shooting area of Luzerner Allmend that started operation in 1935. In total 7,056,000 shots were fired, and 35.3 tons of lead deposited. The bullets were trapped in a berm next to a forest. The berm area overlapped with the deposition area of a clay target range. In the intermediate area II between the covered shooting stand and the berm, a small creek was running through and the gras was used to make hay. In the area in front of the shooting house sheep were grassing from spring to fall. Lead concentrations measured in the range are summarised in Table B.9-10. The lead concentrations in the area around the berm were above the Swiss threshold of 2,000 mg/kg that would trigger remediation.

Table B.9-10 Mean median lead concentration in soil (up to 25 cm) depending on the location of a shooting range (Oschwald et al., 2002)

Area, location	Pb concentration in soil (mg/kg)
Range Zihlmatt	
Close to the covered shooting stand	374
Intermediate area I (10 m from the shooting stand)	225
Intermediate area II (200 m from the shooting stand)	803
Intermediate area III (300 m from the shooting stand; in from of the berm)	8 752
Berm (316 m from the shooting stand)	247 797
Forrest I (up to ca. 10 m behind the berm)	4 297
Forrest II (up to ca. 20 m behind the berm)	1 098
Range B	
Berm	233 240

Cao et al. (2003) performed a study focussing on weathering of lead bullets and its effect on the environment at five outdoor shooting ranges in Florida, USA. The authors found that lead weathering occurs when Pb bullets come into contact with soil. The weathering products depend on soil properties at shooting ranges, among which soil pH is the most important. Lead carbonates were predominantly present in the weathering products and in the berm soils. In shooting range soils containing adequate amounts of phosphorus, insoluble lead phosphate (pyromorphite) can be formed. The weathering and transformation of lead in shooting ranges resulted in a significant elevation of lead concentration in soil, water, and vegetation. In alkaline soils containing high amounts of organic matter, lead is expected to migrate down the profile. High $CaCO_3$, Fe, Al, and P contents were favorable for immobilization of Pb in shooting ranges. Lead concentrations in most sampled soils exceeded the USEPA's critical level of 400 mg Pb/kg soil. Lead was not detected in subsurface soils in most ranges except for one, where elevated lead up to 522 mg/kg was observed in the subsurface, possibly due to enhanced solubilization of organic Pb complexes at alkaline soil pH. Elevated total Pb concentrations in bermudagrass [Cynodon dactylon (L.) Pers.] (up to 806 mg/kg in the aboveground parts) and in surface water (up to 289 µg/L) were observed in some ranges. Ranges with high P content or high cation exchange capacity showed lower Pb mobility. Our research clearly demonstrates the importance of properly managing shooting ranges to minimize adverse effects of Pb on the environment.

Hardison Jr et al. (2004) determined in a newly opened shooting range that 41 mg of Pb were abraded per bullet as it passed through the sand, which accounted for 1.5% of the bullet mass being physically removed. At a shooting range that had been open for 3 months, the highest Pb concentration from the pistol range berm soil was 193 mg/kg at 0.5 m height, and from the rifle range berm soil was 1142 mg/kg at 1.0 m height. Typically, Pb concentration in the rifle range was greater than that of the pistol range. Based on a laboratory weathering study, virtually all metallic Pb was converted to hydrocerussite ($Pb_3(C0_3)_2(OH)_2$), as well as to a lesser extent cerussite ($PbC0_3$) and massicot (PbO) within one week.

Xifra Olivé (2006) investigated in her thesis the mobility of lead and antimony in several Swiss shooting ranges to assess the potential risk of the substances leaching into the subsoil and ground water. Lead concentration in the topsoil of the berm were in one range >100,000 mg/kg, in the other ranges >10,000 mg/kg. Up 50 m distance from the target lead concentrations in topsoil were still ≥10,000 mg/kg, and up to 150 m still ≥1,000 mg/kg (see Table B.9-11). With increasing soil depth, the concentration of lead decreased strongly, especially in the Losone soil. Geogenic background concentrations in Losone soil were around 24 mg/kg Pb below ca. 35 cm depth. In the Zuchwil range geogenic concentrations were measured below 50 cm depth. The author concluded that the topsoil investigated present a direct risk to host organisms due to the high proportion of labile lead fraction.

Table B.9-11 Lead concentrations in the soil of shooting ranges in the berm and at different distances from the target (Xifra Olivé, 2006)

Range	Lead concentration in topsoil (mg/kg)				
	Target area	Berm area	≥ 25 m from the target	≥ 50 m from the target	>50 m from the target
Ober-Uzwil	>10 000	>100 000	>1 000	n.d.	n.d.
Monte Ceneri	n.d.	>10 000	n.d.	≈10 000	n.d.
Andermatt	n.d.	>10 000	n.d.	n.d.	n.d.
Losone	≈5 000	>10 000	>1 000 (meadow) ≈5 000 (wetland)	>10 000 (forest)	n.d.
Zuchwil	n.d.	n.d.	>10 000	n.d.	≈5 000 (120 m) >1 000 (150 m)

n.d. not determined

Dallinger (2007) reported lead concentrations up to 26 000 mg/kg in the berm soil of the Großwjer pistol range, up to 85 000 mg/kg in the 300 m range, up to 210 000 ppm in the Gämsen-Schießanlage, and up to 87 000 ppm in the Hasen-Schießanlage (Table B.9-12).

Table B.9-12 Lead concentrations in the soil of different shooting ranges in the area of Großwjer (Dallinger, 2007)

Area	Origin of sample	Lead concentration (mg/kg dry weight)	
		20.12.1995	02.04.1996
Pistol range (Großwjer)			
Area in front of berm	Soil (20 cm)	34	36-49
	Vegetation	12	19-34
Area of the berm	Soil (10 cm)		100
	Soil (20 cm)		26 000
	Vegatation		175-4 700
300 m range			
Area in front of the berm	Soil (20 cm)	40	
	Vegetation	15	
Area of the berm	Soil (5 cm)	38 800-85 000	
	Soil (20 cm)	188-11 370	
	Vegetation	37-835	
Gämsen-Schießanlage			
Area of the berm	Soil		178 000-210 000
Hasen-Schießanlage			
Area in front and aside of the berm	Soil (5 cm)	3,260	
Area of the berm	Soil (5 cm)	9,700-87,000	
	Soil (10 cm)		13 000-64 500
	Vegetation	580-715	

Bennett et al. (2007) reported that spent ammunition at outdoor rifle and pistol (RP) firing ranges creates a characteristic pattern of contamination, whereby small areas surrounding backstop berms exhibit extremely high soil lead concentrations (see Table B.9-13). The authors measured in vitro bioaccessibility and found that bioaccessibility on soil raged from about 100% in samples with low lead concentration to 13% in a sample with 21,900 mg Pb/kg.

Table B.9-13 Lead concentration in soil (0-5 cm) at the shooting ranges studied from (Bennett et al., 2007)

Range	Number of samples	Lead concentration (mg/kg)		
		Minimum	Mean (SE)	Maximum
A	80	<19	1 910 (569)	26 700
B	73	<10	1 260 (389)	16 400
C	23	12	6 170 (2 040)	27 600

Sehube et al. (2017) used information from eight military shooting ranges for this study. Soil samples were collected at each of the eight shooting ranges at the berm, target line, 50 and 100 m from berm. In all of the shooting ranges investigated the highest total lead (Pb) concentrations were found in the berm soils. Elevated Pb concentrations of 38 406.87 mg kg^{-1} were found in the berm soils of TAB shooting range. Most of the shooting range soils contained high levels of Pb in the range above 2000mgkg^{-1} far exceeding the United States Environmental Protection Agency (USEPA) critical value of 400 mg/kg. The predominant weathering products in these shooting ranges were cerussite ($PbCO_3$) and hydrocerussite ($Pb_3(CO_3)_2(OH)_2$). The Synthetic Precipitation Leaching Procedure (SPLP) Pb concentrations exceeded the USEPA 0.015 mg/kg critical level of hazardous waste indicating possible contamination of surface and groundwater.

Kelebemang et al. (2017) studied the mobility and bioavailability of lead (Pb) in seven military shooting range soils found in eastern and north eastern Botswana using sequential extraction procedure. Mobility of lead in the berm soils in all the seven shooting ranges was found to be over 90% implying high lead lability. The bioavailability index of lead was in the range 60–90%, an indication that most of the Pb can be available for plant uptake. Sequential extraction studies indicated that the partitioning of lead was mostly confined to the carbonate compartment in all the shooting ranges. All the seven shooting ranges failed the Synthetic Precipitation Leaching Procedure (SPLP) with SPLP Pb concentrations exceeding United States Environmental Protection Agency (USEPA) 0.015 mg/kg critical level of hazardous waste, posing a pollution threat to surface and groundwater.

Concentration of lead in soil from a shooting range converted in a public park

After the service life of a shooting range, the ground previously used for shooting, may be used for other purposes, assuming that the land will be zoned accordingly (e.g. for recreational and residential purposes) and undergo some kind of remediation.

Urrutia-Goyes et al. (2017) measured lead concentrations in the topsoil of an area used during Second World War as execution site, subsequently served the military, and later became a recreational shooting range in Greece. The area was then rehabilitated into a public park. However, lead concentrations measured with different methods were reported with 5 560, 2 043, and 7 160 mg/kg, demonstrating heavy contamination. The authors performed a human health risk assessment and concluded that that the main exposure pathway of concern, especially for children, is ingestion, followed by dermal contact and inhalation.

Plants

Lead concentrations in some shooting ranges have been reported to reduce plant dry weight, photosynthesis, water absorption and root growth (Koeppe, 1977).

Mellor and McCartney (1994) showed that concentrations of lead in oilseed rape (*Brassica napus* L.) plants were highest in the area of most intense lead shot deposition. Total lead concentrations in the soil commonly exceeded 5,000 mg/kg; these are considerably greater than threshold 'trigger' concentrations proposed by the Department of the Environment, above which soils are considered to be contaminated and warrant further investigation. Concentrations of lead in the oilseed rape plants themselves were also largest in the area of most intense lead shot deposition; in root samples the lead concentration exceeded 400 mg/kg. The authors also reported reduced crop density of plants grown within a shot-fall zone at soil lead concentrations 1,500 to 10,500 mg/kg.

Turpeinen et al. (2000) examined the effects of pine (*Pinus sylvestris*) and liming (pH-change with $CaCO_3$) on the mobility and bioavailability of lead in boreal forest soil, previously used as a shooting range area, under laboratory conditions. Solubility and mobility of lead were measured, and bioavailability of lead was assessed directly using a luminescent bacterial sensor for lead. Lead concentration in the soil (shot removed) was 9,804±1,599 mg/kg for topsoil (0-5 cm) and 325±96.5 mg/kg in mineral soil (5-20 cm). Control values are 32.7±5.7 and 17.6±6.3 mg/kg, respectively. Lead concentration in pine seedlings (n=3) were 2,720.9±471.9 mg/kg in roots, 76.6±62.6 mg/kg in stem, and 5.5±3.1 mg/kg in needles. The pine seedlings reduced lead concentrations of drainage water from 198±13 µg/L without pine seedlings to 101±10 µg/L with pine seedlings.

In agricultural soils very close (10 m) to a shooting range, Chrastný et al. (2010) measured increased lead concentrations in the biomass of spring barley (*Hordeum vulgare* L.) mainly in roots (138 versus 11 mg/mg) and leaves (16 versus 1 mg/kg) but also in stems (4.2 versus 1.6 mg/kg) and spikes (2.4 versus 1.2 mg/kg) (Table B.9-14). The authors identified two possible pathways of lead: (1) through passive diffusion-driven uptake by roots and (2) especially through atmospheric deposition.

Table B.9-14 Lead concentration (mg/kg) in barley and bryophyte samples (n=3) (Chrastný et al., 2010)

	Spring barley (mg/kg)				Bryophyte (mg/kg)
	roots	stems	leaves	spikes	
Contaminated site	138±9	4.24±0.32	16.4±0.4	2.37±0.10	250±20
Control site	11.0±0.4	1.61±0.10	1.09±0.07	1.23±0.22	6.33±0.59

Ma et al. (2002) and Cao et al. (2003) performed a study focussing on weathering of lead bullets and its effect on the environment at five outdoor shooting ranges in Florida, USA. The lead concentrations in bermudagrass along the central transect of Ranges 3 and 5 are shown in Table B.9-15. Generally, lead concentrations in grasses grown close to berms contained more lead, which is attributable to the fact that soils close to the berms contained more total lead and plant-available lead (Table B.9-15). Compared with the lead concentrations in the roots (up to 1342 mg/kg), lead concentrations in grass

shoots were lower (<806 mg/kg). However, there is still a considerable amount of Pb being transported into the aboveground biomass.

Table B.9-15 Lead concentration in soil and bermudagrass growing on shooting ranges (Cao et al., 2003)

Range	Distance (m)	Lead concentration (mg/kg dry weight)			
		Soil total	Plant-available	roots	shoots
3 (CWR)	1.5	354	12.1	512	324
	31.5	148	5.61	115	86.7
	61.5	464	73.2	1166	511
	91.5	6800	136	1342	806
5 (MHR)	1.5	1066	6.75	438	134
	31.5	562	46.3	769	500
	61.5	1018	28.2	698	518
	91.5	2715	68.2	952	500

Bennett et al. (2007) found a linear correlation between lead in soil and bioaccessible lead concentrations in vegetation (see Figure B.9-5) at rifle and pistol firing ranges. Ln [Pb] in unwashed plant samples analysed using the mammalian in vitro bioaccessibility method was also strongly correlated with ln [Pb] in soil samples (r2 =0.72, pb0.0001).

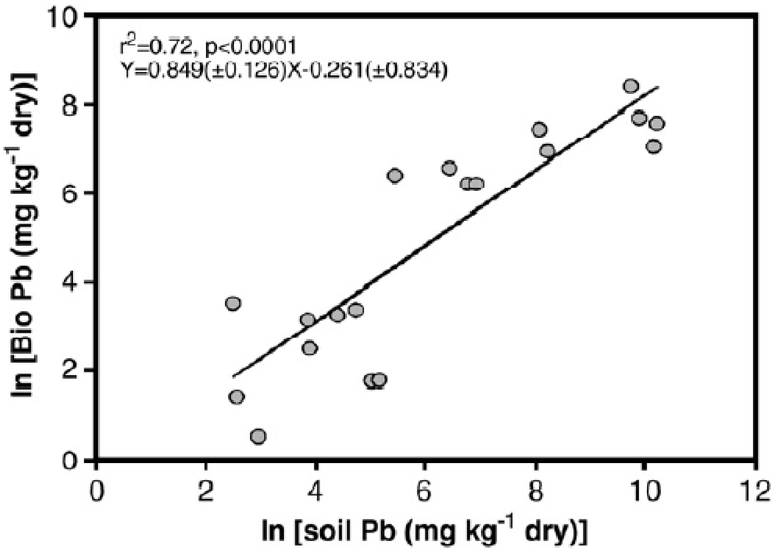

Figure B.9-5 Least squares regression of ln-transformed bioaccessible lead concentrations in vegetation versus soil lead concentrations (Bennett et al., 2007)

Dallinger (2007) reported the lead concentrations in samples from plants growing in front of berms with 19-34, 1.5-13, and 9.6-17 mg/kg and for plants growing on berms with 175-4,700, 37-835, and 580-715 mg/kg (see Table B.9-12). The type pf plants sampled is not mentioned.

Water

Stansley et al. (1992) in an investigation of eight target shooting ranges in the United States that had surface waters (ponds, marshes, etc.) in their shotfall zones. They suggested that the suspension of pellets crust compounds containing lead, as described by (Jørgensen and Willems, 1987) might explain the high concentrations of waterborne lead observed at the ranges (4.3-838 µg/L vs 7.4 µg/L at control sites). At a trap and skeet range located in Westchester County, New York, surface water lead concentration ranged from 60 to 2,900 µg/L (USEPA 1994).

Data collected on site at Prime Hook National Wildlife Refuge, Sussex County, Delaware (US), where a trap-shooting range operated, indicated that 37 years after shooting began (in the early 1960s), lead from a concentrated deposit of shotgun pellets was dissolved and infiltrated into the ground water. The study confirmed that many site-specific variables were relevant when assessing lead mobility in the environment. Water samples from wells located along the bank of the slough contained dissolved lead concentrations higher than 400 µg/L, and as high as 1000 µg/L. In contrast, a natural background concentration of lead from ground water in a well upgradient from the site is about 1 µg/L. One of the main outcome of the study is that soils or sediments containing little or no binding capacity, such as clean sands, can be quite efficient at transporting dissolved lead, especially in areas with acidic rain and low pH ground water (Soeder and Miller, 2003).

In a shooting range in Germany (Mainbullau) using lead shots for more than 40 years, lead concentrations for leaching water ("Sickerwasser") was determined in five different locations with 44.5; 1460; 198; 64.4, and 12.9 µg/L. The action levels for phase 1 (25 µg/L) requiring supervision was exceeded by 4/5 measurements and action levels for phase 2 (100 µg/L) requiring remediation, was exceeded by 2/5 measurements (German Wasserwirtschaftsamt Aschaffenburg, 2019).

The German Landesamt für Natur und Umwelt des Landes Schleswig-Holstein (LANU, 2005) investigated soil contamination in clay shooting ranges.

Ma et al. (2002) measured lead concentrations in the surface water of four shooting ranges in Florida, referred to as: CW, LC, TS, MH.

CW range dissolved Pb in the surface water is very close to total Pb, indicating soluble lead is predominantly in retention pond water, and perhaps, only soluble lead entered the pond with runoff water. For MH range, total Pb is over twice dissolved Pb in retention pond water. There is a large amount of nofilterable Pb (particulate Pb) suspended in water. It is possible that there is suspension of crust materials in the water column due to high water pH value. It was also possible that some lead particles were transported into the ponds via runoff water. However, no significant correlation existed between the total Pb concentration in the surface water and water pH as well as total soil Pb concentration. It implied that soil properties may play an important role in controlling the

mobility of Pb from soil to water. High levels of P and CEC in soil reflect low Pb mobility. So low Pb concentrations were found in the surface water from TR and MP ranges (Table 4-6). This again indicated that P application may be effective for properly managing shooting range to minimize Pb mobility (Ma et al., 2002).

Xifra Olivé (2006) measured averaged lead concentrations in pore water from the Losone topsoil (~5 cm depth) ranging from 181 to 17865 µg/L. In the Zuchwil topsoil (-10 cm depth), concentrations ranged from 123 to 787 ug/L. Pore water concentrations of Pb and Sb in Losone and of Pb in Zuchwil strongly decreased with depth. Averaged Pb concentrations in equilibrium with the Losone subsoil (-63 cm depth) and averaged Pb and Sb concentrations in equilibrium with the Zuchwil subsoil (-53 cm depth) exceeded the EU concentration guidelines for drinking water (The Council of the European Union, 1998) of 10 ug/L Pb. The author concluded that there is a risk for groundwater contamination at very long term if the soil is not remediated.

Ruminants

Giltner L. (1942) mentioned that lead shot or bullets are sometimes taken up by cattle grazing near shooting ranges; as few as 300 shot have proved fatal to a cow.

Ganguli and Chowhuri (1953) reported five of 25 poisoned dairy farm cattle that died within the course of a few days near Calcutta. The dairy farm was situated near a shooting range. In the agricultural, grazing and park sample, lead content ranged from 0.001 – 0.008 ppm in soil, from trace to 0.002 ppm in grass or herbage. In the shooting range samples, Pb values ranged from 0.22-0.88 ppm in soil, from 0.011-0.42 ppm in subsoil, and from 0.53-2.24 ppm in grass.

Braun et al. (1997) reported that five calves, seven to nine months of age, were put on pasture in the target area of a shooting range in early May. Acute lead poisoning occurred in one of the calves after five days of grazing, the remainder became ill one to three days later. The most important symptoms consisted of neurological disturbances and included maniacal movements, opisthotonos, drooling, rolling of the eyes, convulsions, licking, champing of the jaws, bruxism, bellowing and breaking through fences. All but one calf, which was euthanatized, died within several hours of the occurrence of the first symptoms. In one calf, the concentration of lead in samples of whole blood (940 micrograms/l), liver (38 mg/kg wet weight) and kidney (30 mg/kg wet weight) were markedly increased Post mortem examination of this calf revealed acute cardiac, renal and pulmonary haemorrhage, acute tubulonephrosis and acute severe pulmonary emphysema. The concentration of lead in the dry matter of a grass and a soil sample from the target zone of the shooting range were 29550 mg/kg and 3900 mg/kg, respectively. Further investigation revealed that this area had been used as a military shooting range for many years, and in the previous year, approximately 20000 bullets with lead contents of either 3.05 g or 8.55 g had been fired. The results of this study indicate that the target area of shooting ranges must not be used for pasture or for food production for animals or humans.

In New Zealand, Vermunt et al. (2002) reported lead poisoning in some dairy cows being part of a herd consisted of 140 spring-calving, Friesian dairy cows, that had consumed lead shot contaminated maize silage. An on-farm investigation identified the maize silage as the source of the lead poisoning. Large numbers of shot gun pellets were found mixed in with the silage. The silage being fed had been purchased from a nearby gun club,

which grew the crop beneath the target firing range. The lead concentration in the silage, following removal of any lead shot, was 32 mg/kg (on a dry matter basis). Properly made silage is very acidic (pH< 4.8), and in such an acid environment a proportion of the metallic lead is converted into a more soluble lead salt [(St. Clair and Zaslow, 1996); (Swain, 2002)].

In an environmental report from a Swiss area, Muntwyler (2010) reported mortality and acute intoxication of two cows that were grazing behind the berm of a shooting range. An investigation of the area retrieved that the fences were too close to the berm (2 and 5 m) instead of the required 10 m fenced area and an additional 20 m surrounding the fence for which grazing is banned.

In a New Zealand newspaper (Macnicol, 2014) it was reported that about 100 Southland dairy cows have died or been destroyed after contracting lead poisoning from grazing on a gun club property. The Ministry of Primary Industries confirmed this week it was alerted by a Southland veterinary practice on July 23 of dairy cattle dying from lead poisoning on a Southland farm. The cattle had been grazing fodder beet grown on leased land owned by the Nightcaps Clay Target Club at Wreys Bush. "Approximately 20 affected cattle, from a mob of about 100 cows, died or were euthanised at that time, the farmer subsequently chose to humanely slaughter the remaining cattle. Some of the cattle were pregnant," MPI said in a statement issued to the Fiordland Advocate. Environment Southland worked with the MPI and the farmer to offer advice on various disposal methods for the cows.

According to the Swiss expert system for risk assessment of contaminated soils (Swiss BUWAL, 2005), it must be assumed that cows grazing on such areas are or could be endangered if the contamination exceeds 1000 mg Pb/kg [dry matter]. Decontamination or removal of topsoil with more than 1000 mg Pb/kg [dry matter] is therefore necessary (Swiss BAFU, 2018).

B.9.1.4. Risks management measures to reduce lead exposure at shooting ranges

Many recent guidance have provided a description of RMM to control lead releases at shooting ranges, as described in the Annex XV report. The analysis of management practices to reduce lead exposure at shooting ranges published by Rooney (2002) is here summarised in relation to many RMM (Table B.9-16). Different practices were considered to have a different effectiveness.

In addition a recent analysis on the use of phosphate amendments by Scheckel et al. (2013) is also described in this section.

Table B.9-16 RMM according to Rooney (2002).

Alteration of soil Pb sorption capacity by organic matter addition, to reduce Pb mobility
• Increasing sorption capacity has the potential to reduce equilibrium solution Pb concentration, particularly at low soil pH.
• Organic matter has the potential to increase Pb mobility, which is undesirable.
Alteration of soil pH by lime addition to reduce Pb mobility
• Although the Pb concentration of leachate moving through the soil will be reduced, increasing soil pH is not sufficient to eliminate Pb mobility.
• Lime addition alone is insufficient to control Pb mobility, particularly in environments sensitive to Pb.
• Lime addition may have some benefit in areas with acid soil pH or rainwater acidity.
• Organic matter solubility increases proportional to pH, therefore the potential for SOC-facilitated Pb mobility will increase with lime addition.
• Transfer of Pb to the soil (soil Pb sorption) is increased by pH increase.
• Soil pH adjustment may be a requirement of phosphate immobilisation in order to optimise pyromorphite formation.
Periodic Pb recovery and recycling
• Rapid onset of corrosion and transfer of Pb to the fine earth fraction precludes even annual removal of Pb shot from limiting accumulation of potentially soluble Pb corrosion compounds.
• Soil solution Pb concentrations are likely to remain high after Pb shot recovery, and potential for Pb leaching may be maintained for decades, similar to that if Pb shot remains in the soil:
  o A large proportion of the fine earth Pb at clay target shooting (CTS) ranges is likely to be associated with potentially labile exchangeable and carbonate soil fractions;
  o Exfoliation of the existing corrosion crust is likely to occur during processing and remain in the soil.
• At active CTS ranges, this management technique would be negated by the continued use of Pb shot. Corrosion of newly deposited pellets will occur, but dissolution will be controlled by the existing equilibrium Pb concentration. Subsequent Pb recovery will again exfoliate corrosion crust material and add to the pool of potentially soluble Pb in the soil.
• Periodic removal is suggested in the U.S.A., and a 7-year recovery interval has been suggested by an Australian company in order to minimise environmental damage of Pb shot accumulation at ranges. These practices are unlikely to have significant impact on minimising the adverse effects of Pb shot.
Removal of Pb shot
Removal of Pb shot from the soil will remove contamination source
• Most beneficial at former ranges or at active ranges when shooters change to exclusive use of non-toxic shot.
• Given that elemental Pb as Pb shot makes up 70-95% of the total Pb burden at most clay CTS ranges, recovery of Pb shot would substantially reduce the

amount of Pb shot available for future transformation into potentially soluble Pb compounds.
- Highly soluble exfoliated crust material may be returned to the site in the soil.
- Soil washing, used after and in conjunction with Pb shot removal will substantially reduce the continued influence of exfoliated crust material and potentially labile fine earth Pb.

Cultivation

- Cultivation is likely to increase the total proportion Pb in the soil that is potentially soluble, by causing exfoliation of the existing corrosion crust. This is likely to induce further corrosion products to accumulate on the pellet surface.
- Recovery of Pb shot at any later date will be more difficult, as Pb shot will become spread throughout the depth of the plough-layer.
- Cultivation of the shot-fall zone is not recommended for New Zealand ranges

Sand traps

- A sand layer would make Pb shot recovery faster and easier (particularly by physical separation).
- Contact between Pb shot and sand would still initiate corrosion, and sand would provide minimal retention of solubilised corrosion crust material, possibly leading to greater potential for Pb mobility.
- Therefore, a sand layer would require hydraulic isolation from underlying soil, and runoff control and treatment would be necessary

Reducing shot-fall area by relocation of ranges

- Beneficial if the main consideration is the financial cost of processing a volume of soil to remove spent ammunition in the future.
- Higher loadings of Pb in the concentrated shot-fall zone have the potential to reduce the time required to achieve equilibrium solution Pb concentration and therefore accelerate rate of elevation of soil solution and fine earth Pb concentrations

Impermeable barriers and surface covers

Used to break hydraulic connection between the surface soil and underlying soil layers or groundwater, in order to eliminate adverse effects of Pb migration

- At existing ranges, contaminated soil could be removed and replaced on top of an impermeable barrier.
- At new ranges, a cover could be laid on the soil surface and protected from wind damage with a layer of sand.
- Potential lining materials could include compacted clay, high density polyethylene sheeting, such as that used for landfills (designed to last more than 50 years), geotextiles and asphalt.
- The design would need to incorporate a drainage and collection system for the management of Pb-contaminated drainage water generated within the contaminated soil mass, and to ensure no movement of Pb to surrounding permeable soil
- An impermeable barrier would be an appropriate management technique at ranges where phosphate immobilisation is determined to be unsuitable due to environmental sensitivity to P.

- An impermeable barrier covering soil containing Pb shot is likely to be ineffective, as percolation can still occur, and the soil chemistry may be adversely affected by the development of anaerobic soil conditions

Alteration of soil Pb sorption capacity by clay, to reduce Pb mobility

- Increasing sorption capacity has the potential to reduce equilibrium solution Pb concentration, particularly at low soil pH.
- Movement of Pb is possible regardless of the sorption capacity, due to continual presence of Pb in the soil solution

Runoff control

Recommendations include vegetative ground cover, mulches and compost, filter beds of crushed lime or other Pb-neutralising material, and retention ponds

- Runoff control is potentially useful at ranges where slope creates the potential for migration of Pb in surface runoff, and may have particular application to sporting clays ranges, where sloping terrain is desirable.
- Mulch and compost should be avoided due to the potential for Pb mobilisation by SOC.
- Filter beds constructed with phosphate compounds rather than lime would be expected have superior Pb-retention capabilities.
- Vegetative cover will also reduce the potential for wind erosion

Capture ponds

A pond of water constructed in the shot-fall zone to minimise deformation of Pb shot

to increase the potential for reuse after periodic recovery

- Effective in minimising adverse environmental effects of Pb shot corrosion, provided capture pond is hydraulically isolated from soil, groundwater, and other natural water bodies at a range.
- Potential risk of waterfowl using the pond and developing Pb toxicosis due to ingestion for grit.

Recommendations for general management practices

In addition to the best management practices discussed above, consideration of the following points would contribute to a comprehensive contamination management strategy:

- Land use and management, particularly the risks associated with agricultural and horticultural production on shot-fall areas;
- Location of all land that has received Pb shot deposition, including closed, abandoned, private and commercial ranges;
- Awareness and reduction of possible Pb shot deposition outside range perimeters;
- Record keeping at individual ranges, to document the number of rounds shot per meet and the type and size of shot used, including % antimony;
- Regular soil and groundwater analysis and reporting to monitor the rate of Pb transport from sites;
- Distribution of accurate environmental and technical information for shooters and local authorities;

- Arrange club environmental funds in order to accumulate some financial resources for site management and/or remediation;
- Comprehensive strategy for avoiding soil contamination at new CTS ranges;
- Elimination of further Pb contamination through introduction of truly non-toxic shot

Phosphate amendment

Scheckel et al. (2013) have recently reviewed the available information on the amendment of soil with phosphate. The authors summarised that phosphate amendments have been studied as a means to mitigate risks from exposure to Pb in soils. The rationale for amending soils with phosphate is that the addition of phosphate will promote formation of highly insoluble Pb species, such as pyromorphite. The formation of insoluble pyromorphite thereby reduces the risk of Pb leaching through soils into drinking waters and absorption by soil biota, and it remains inaccessible to physiological transport in the digestive system following incidental ingestion by humans. Based on this review US EPA (2015) identified research need for the use of phosphate amendments and summarised the available knowledge such as:

- If other metals, such as iron (Fe), aluminium (Al), and manganese (Mn), are present in soil, they may react with phosphate amendments. This may decrease the amount of phosphate available to react with Pb to form pyromorphite. The pH level of soil may influence the chemical form of Pb in soil. Certain forms of Pb do not easily react with phosphate to form pyromorphite. Water in soil is necessary to transport phosphate amendments through the soil and sustain the formation of pyromorphite. If phosphate amendments are applied to soils that have low water content, pyromorphite formation may be reduced. There is very little information about long-term stability of pyromorphite or the environmental conditions that could cause it to break down and release soluble Pb into soil.
- In many instances, Pb-contaminated soils also contain other co-contaminants of concern, such as antimony (Sb), arsenic (As), cadmium (Cd), vanadium (V), and zinc (Zn). Investigations of effects of phosphate amendments on co-contaminated soils are limited and studies have not examined the bioavailability of co-contaminants. Studies have shown that phosphate amendments may cause co-contaminants, such as As, to be released from soil and to enhance mobility of these contaminants within soil. Enhanced mobility may cause co-contaminants to migrate to ground or surface water or be more available for uptake into plants. High soil content of organic matter can reduce formation of pyromorphite. It is unknown if increased mobility of cocontaminant mobility results in an increase in co-contaminant bioavailability.
- Phosphate amendments may migrate to and contaminate areas off the application area. If applied in excess, phosphate amendments may run off the application area and contaminate ground or surface water.
- Formation of pyromorphite in soil from the site should be demonstrated. Results of in vitro and in vivo studies show that amending soils with phosphate reduced bioaccessibility and bioavailability of Pb from soil. However, these studies cannot be used to predict how well phosphate amendments will work at a specific site. Therefore, plans to amend soils with phosphate need to include assessment of site-specific efficacy to reduce Pb bioavailability. Phosphate amendments should be used in combination with other methods, such as revegetation, raised garden beds,

or gravel. The long-term effectiveness of the phosphate amendment should be established to determine if repeated applications are necessary to maintain reduced bioavailability

Chrysochoou et al. (2007) noted that phosphate leaching and eutrophication have been largely overlooked, along with other issues such as the enhanced leaching of oxyanionic contaminants, such as Se, As and W. The success and sustainability of applying phosphate in firing range soils therefore remain questionable.

B.9.1.5. Impacts on birds

The assessment makes use of the latest bird population size data reported to the European Commission. For the latest cycle, Member States submitted their info from 2013-2018 in mid-2019 by application of the format established in 2011 and updated in 2016. The results have been published in 2020 (Röschel et al., 2020, DG Environment, 2017). Member States are required to report to the European Commission on the sizes of and trends in populations of all wild bird species that are naturally present in the EU member states (Council Directive 2009/147/EC of April 1979, amended in 2009, on the conservation of wild birds "Birds Directive") every six years.

According to the Directorate-General for Environment, 2017, 'Reporting under Article 17 of the Habitats Directive: Explanatory notes and guidelines for the period 2013-2018' (DG Environment, 2017) Member states are required to report data for all regularly occurring breeding species, for wintering and passage Annex I taxa[61] and non-Annex I taxa triggering SPA designations (and in addition for Annex II species not occurring as breeders[62]) (DG Environment, 2017). One species can belong to several of these groups i.e. there is overlaps. The reported data includes parameters from, among others, population size, trends and distribution, along with information on the main pressures and threats, conservation measures, coverage by the Special Protection Area (SPA) network and details on relevant non-native species (DG Environment, 2017).

Member State data is used to create population status assessments by analysing the population sizes and trends reported. Bird biology, especially in terms of seasonality, is taken into account and therefore data distinguishing between breeding, wintering and passage is requested. Short and long term trend determination makes use of both breeding and wintering information but the population status assessments are only based on either the breeding or the wintering season, i.e. one unique value per taxa (for more information, see Röschel et al. (2020)).

In principle, the assessment of the EU population status is based primarily on species breeding-season data. Winter population data is only reported for a subset of taxa, called 'key wintering species' (DG Environment, 2017). Most of the species on the list are migratory species that either do not breed in the EU or are significantly more abundant here during winter, and species gathering in large flocks on a limited number of specific areas and are therefore easier to monitor. In general, birds can be much more mobile during the winter season due to weather and food availability, which could potentially complicate the aggregation of the Member States data. Therefore, the majority of the species for which winter data were requested, i.e. the key wintering species, are covered

[61] 197 species and sub-species are particularly threatened. Member States must designate Special Protection Areas (SPAs) for their survival and all migratory bird species.

[62] 86 huntable bird species, either in entire EU or in certain MS.

by coordinated international schemes, such as the African-Eurasian Waterbird Census (coordinated by Wetlands International), that take this into account. There are 86 species in the key wintering species list (DG Environment, 2017).

Reported breeding population data unit is generally breeding pairs, apart from low number of species with unusual or complex breeding biology or cryptic behaviour, for which other units, such as calling or lekking males, were used. The reporting unit for wintering birds is individuals. In some species, males may attract more than one female and the ratio in pairs can therefore be either 1:1 or 2:1.

Whilst waiting for the (2020) publication of bird population data from MSs compiled by the European Environmental Agency (EEA) from the latest 2013-2018 reporting round, the Dossier Submitter initially referred for the current assessment to the Euroredlist[63] containing 533 species. When the publication of bird population data from MSs compiled by the European Environmental Agency (EEA) from the latest 2013-2018 reporting round became available, (including 463 species[64]), the Dossier Submitter comfirmed which were the species occurring in the EU 27-2020 and tried to identify all relevant differences with the Euroredlist dataset (in addition to the different geographical scope).

The Dossier Submitter noted that for some of the species in the EEA data, the data was requested on a subspecies (ssp.) and biogeographic population level, lacking from the Euroredlist as Euroredlist lists the species on main species level only. Furthermore, Euroredlist uses different taxonomic names for multiple species compared to EEA requirements, e.g. multiple tit species previously classified under genus *Parus* but now under e.g. *Periparus*. Finally, species considered as invasive/introduced or holding limited migratory breeding populations only were not included in the Euroredlist, but some were reported to EEA[65]. These factors contributed to a list of so called "data gap" species, a list of bird species that were not consistent between these two lists of species (in addition to differences related to the different geographical scope). The main differences in terms of "format" between the two lists is summarised in Table B.9-17.

[63] The development of Red List species is supported by the EC financially since 2005. The regional Red List for Europe was produced during 2012–2014, as part of a Commission-funded project led by BirdLife International and involving a consortium including the European Bird Census Council, Wetlands International, IUCN, BTO, Sovon, RSPB, the Czech Society for Ornithology and BirdLife Europe. http://datazone.birdlife.org/info/euroredlist

[64] EU Overseas Countries and Territories (OCTs) and Outermost Regions (OR) are not covered by the nature directives except from two Portuguese autonomous regions (Madeira and the Azores) and one Spanish autonomous community (the Canary Islands). Both ORs were included in the EEA data and subsequently in ECHA's analysis also.

[65] The population status assessment is not performed for these species expect for the common pheasant.

Table B.9-17: (Format) differences between species lists used for the impact assessment

Dataset	Taxonomical level of information	Other differences
Euroredlist	Main species (e.g. Lagopus lagopus)	List contained outdated scientific names for some species.
EEA species list	Subspecies and other (e.g. Lagopus lagopus scoticus)	Data contained some invasive/introduced species not present in the Euroredlist

Euroredlist contains 533 species from geographical Europe (Leronymidou et al., 2015)[66].

Figure: Geographical Europe considered in Euroredlist species assessment (figure from (Leronymidou et al., 2015)).

[66] (Leronymidou et al., 2015) describes the methodology behind the European Red List of Birds 2015, being based for the first time on the data reported to EEA for the EU27 (in this context including UK, excluding Croatia as it was not a member until 2013 and therefore did not report). The contribution of the assessors for the Red List in terms of amending the EU27 data for 2015 Red List was to source the missing data in line with the information reported to EEA for all species in Greece and for non-Annex I species in the Czech Republic, as these were missing from what was reported to EEA. For the European assessment, (Leronymidou et al., 2015) similar data were sourced with the expertise and data holdings of national bird monitoring schemes and organisations across Europe. In short, the Euroredlist is therefore based on a combination of data reported by the Member States according to the requirements set in the Birds Directive, amended with info from Greece and the Czech Republic in order to cover the EU data (Leronymidou et al., 2015).

In addition to the population size of birds species in the EU 27-2020, the Dossier Submitter considered for each species taxonomical order, family and common name. IUCN red list category, CMS appendix, AEWA and key wintering species status were also considered.

When population size was indicated as a minimum or maximum value only in the EEA data, this was considered an omission and the value provided was used as both minimum and maximum when calculating the overall EU population size for the species. Average of the two values for all species was taken as arithmetic mean and for the species in the key wintering list, both wintering population and breeding population is considered as they are considered equally representative.

As the assessment looked into primary, secondary and exposure due to fishing tackle ingestion, it was relevant to consider existing bans in the use of lead in some of the Member States. These include a complete ban in the use of lead shot in Denmark and the Netherlands and a partial ban in Belgium. Therefore, when looking into lead shot exposure which primarily occurs in species ingesting lead shot as grit i.e. primary exposure, the Dossier Submitter excluded data from Member States with full ban and took into account 50% of each species populations in case of partial ban.

Once the Dossier Submitter had confirmed the species occurring in the EU27-2020 and gathered all the previously mentioned information, the level of potential risk for the EU species was elaborated based on the following key data:

1. Direct evidence of ingestion and/or poisoning from lead gathered from peer-reviewed literature; either reporting research done in the EU-27 (preferred) or outside the EU-27 (taking into account that risks to birds and other taxa within the EU can be expected to be similar to those elsewhere, due to conserved feeding ecology/habitat etc).
2. Indirect evidence of likelihood of exposure based on feeding ecology. Assuming that the same taxonomic family of birds have similar feeding behaviour. When assessing primary ingestion, evidence was also considered concerning the ingestion of grit and stones by bird species, within the same bird family.
3. The assessment by UNEP/CMS ad hoc Expert Group on the likelihood of ingestion by European bird species of lead ammunition in terrestrial environments and lead fishing weights[67]; especially in relation to EU species for which published literature was not available.

The result of the Dossier Submitter assessment is reported in the following table.

[67] During the development of this Annex XV report an *ad hoc* expert group (UNEP/CMS ad hoc Expert Group) of the UNEP-CMS provided specific information on the likelihood of ingestion of lead ammunition in terrestrial environments and lead fishing weights by European bird species, following the Dossier Submitter's request. UNEP/CMS ad hoc Expert Group also provided specific insights on the likelihood of exposure of EU species to lead from ammunition and fishing tackle, especially in species for which literature coverage is limited. The mandate for the CMS Secretariat to support the request from the Dossier Submitter is provided from UNEP-CMS Resolution 11.15(Rev COP13): *"6. Urges the Secretariat to consult regularly with relevant stakeholders, including government agencies, scientific bodies, non-governmental organizations and the agricultural, pharmaceutical, hunting and fishing sectors, in order to monitor the impacts of poisoning on migratory birds and to support the elaboration of national strategies and sector implementation plans as necessary to minimize detrimental impacts;"* The Dossier Submitter understands that further assessment will be submitted by UNEP/CMS ad hoc Expert Group in the consultation on this Annex XV report in 2021.

Table B.9-18 Number of bird individuals at risk of lead related ammunition or fishing tackle poisoning via primary or secondary routes across EU27 based on population numbers bird species (2013-2018) reported to EEA according to Birds Directive article 12 requirements.

Type of risk	Applied population estimate*	Number of individuals at risk across EU 27-2020**	Estimated mortality from direct ingestion only (not including mortality from sublethal poisoning)
Primary poisoning lead shot			
Primary poisoning (lead shot) breeding population***	Breeding	127 559 526	***0.5-2.0%*** ***(central value 1%)***
Primary poisoning (lead shot) wintering population for key wintering* species only	Wintering	7 869 678	***0.5-2.0%*** ***(central value 1%)***
Total for primary poisoning from lead shot		***135 429 204***	***1 354 292***
Secondary poisoning			
Secondary poisoning (lead bullet) breeding population	Breeding	14 391 990	Not defined
Secondary poisoning (lead bullet) wintering population for key wintering species only (n=1)	Wintering	227	Not defined
Total for secondary poisoning		***14 392 217***	
Primary poisoning fishing tackle			
Primary poisoning (fishing tackle) breeding population	Breeding	38 590	Not defined *(dataset not sufficient but additional to mortality due to ingestion of lead shot for AEWA listed species)*
Primary poisoning (fishing tackle) wintering population for key wintering species only	Wintering	7 375 347	Not defined *(dataset not sufficient but additional to mortality due to ingestion of lead shot for AEWA listed species)*
Total for primary poisoning from fishing tackle		***7 413 937***	

* As per EEA reporting requirements, population estimates are established according to breeding population sizes. For certain species, i.e. *key wintering -species*, the winter estimate is considered to be relevant.

** As 2020 data for Romania was unavailable, it was amended with data from the 10th Birds Directive Article 12 report (2008–2012).

*** Netherlands and Denmark population info excluded due to lead shot ban. Belgium 50% of the population across the species included due to partial lead shot ban.

UNEP-CMS ad hoc Expert Group assessment

UNEP-CMS ad hoc Expert Group referred to the Euroredlist (provided by the Dossier Submitter) when assigning different levels of risk of ingesting lead from spent ammunition (gunshot or bullets) and lead fishing tackle for species that occur regularly in the EU (excluding vagrants). Exposure risk from these sources was evaluated by the UNEP-CMS ad hoc Expert Group through (1) direct evidence of ingestion and/or poisoning published in the peer-reviewed literature, (2) for species in which lead exposure/poisoning has not been investigated, extrapolation at group level based on similarity in habitat use and feeding ecology to species with evidence of ingestion, (3) evidence concerning the ingestion of gastroliths (grit and stones) at species or group level.

UNEP-CMS ad hoc Expert Group reported that they were cautious when concluding on the potential for a species to be a risk and therefore further investigations could show some species that were identified as 'No Risk Identified' could be at risk. The risk scale used by them was 0 = no risk, 1 = very low, 2 = low, 3 = moderate and 4 = high risk.

UNEP-CMS ad hoc Expert Group noted that for the bird groups which they grouped in the High and Moderate risk categories considerable evidence was available for species listed or their congeners in the published literature. Other species falled into lower risk categories.

The conclusion on exposure risk for each species/group integrated both the likelihood and frequency of ingestion (exposure). Due to this, UNEP-CMS ad hoc Expert Group noted that some individuals in the 'Low' and 'Very Low' exposure risk categories were at risk from ingesting lead from shot or fishing tackle but far less frequently than for species in the 'Moderate' and 'High' risk categories.

The Dossier Submitter understands that further assessment will be submitted by UNEP/CMS ad hoc Expert Group in the consultation on this Annex XV report in 2021, likely including EU 27-2020 population data.

B.9.2. Exposure scenarios (human health assessment)

B.9.2.1. Hunting with shot shell ammunition

Exposure related to hunting activities

Hunting with lead-containing shot shell ammunition can lead to the uptake of lead fume and dust from the ammunition while shooting. However, no quantitative information is available to make an assumption of the lead concentration in the breathing air of the hunter and the inhaled lead per shot. Natural ventilation while hunting might reduce the uptake of lead via inhalation compared to conditions for sport shooters e.g. shooting from a covered stand.

Also the intake of lead dust (hand-to-mouth) following shooting and/or self-assembly of shotgun shell might be relevant. Hygiene measures are important to reduce the oral intake such as washing of hands, changing of clothes, avoiding smoking, drinking or eating while hunting.

Several studies are available measuring PbB levels in hunters. However, since the hunters are usually the highest consumers of game meat, the available data do not allow a separation between the contributions of lead from the hunting/shooting activities from that of game meat consumption. The data published by Fustinoni et al. (2017) indicate that hunting has a higher contribution to the PbB level compared to the consumption of game meat.

Fustinoni et al. (2017) measured PbB levels from 95 subjects in Italy (74 males and 21 females), of which 69 were hunters (hunting mammals and birds) and 26 non-hunters. According to the authors, most game meat eaters were also hunters who mostly hunted more than ten times per year. For non-hunting subjects, median PbB levels were 14 and 15 µg/L subjects with (n=8) and without (n=18) game meat consumption, respectively. The sex of those non-hunting subjects was not specified; most probably most of those subjects were females. For hunters, median PbB levels were 36 and 40 µg/L with (n=62) and without (n=7) game meat consumption, respectively. Also for the hunters the sex was not specified; most probably most of those subjects were males. A multiple linear regression analysis performed by the authors (containing the covariates sex, age, hunting, wine drinking, game meat consumption, tobacco smoking, shooting range, and occupational exposure) found an association with hunting (PbB levels almost double in hunters) and wine drinking (40% higher in drinkers) but not with consumption of game meat or other parameters. The author comment that whether the higher PbB level was due to inhalation of lead fumes while shooting with lead ammunition, to handling lead ammunition or both could not be ascertained. It is to be noted that this study has several shortcomings. Major shortcoming of this study is that the subjects that consumed game meat prior to the measurement of PbB levels were excluded and that blood samples were collected in spring-summer which is outside the official hunting season for Italy (which is September to February). Therefore, the measured PbB levels are not expected to reflect direct effects of game meat consumption or hunting activities on the PbB level, but more the chronic burden from hunting including game meat consumption.

Liberda et al. (2018) investigated participants from nine Cree First Nation communities located in the James and Hudson Bay region of Quebec, Canada. For lead shot shell users, the Relative Risk (RR) of elevated PbB level greater than 50 µg/L was 1.510 (C.I. 1.100–2.075, p = 0.007) compared to non-users; furthermore, ANOVA confirmed

significant increases in PbB levels for lead shot users (p = 0.001). Users of non-lead shot had no significant risk of having elevated PbB levels greater than 50 µg/L (RR = 1.048, C.I. 0.824–1.333, p = 0.702), and no significant differences in PbB levels between users and non-users of non-lead shot shell were found (p = 0.353).

Exposure related to consumption of meat of game hunted with lead shots

Impact of the ammunition on lead distribution in the game

The lead contamination in tissues of animals hunted with lead shots is complex forming multiple projectiles. Pellets most often hit the largest edible part, i.e. breast muscles. An accurate shot results in hitting this group of muscles with at least several lead balls (Figure B.9-6). Each single projectile follows the aforementioned laws of fluid mechanics. When a spherical projectile moves within a multi-phase medium in a turbulent manner, it generates a relatively high friction drag and pressure drag. As a pellet is made of lead, during its turbulent flow many lead chips may detach from its surface and generate a temporary cavity which enables lead transfer deep into muscles. Since the mass and energy of a single pellet projectile (in relation to a hunting bullet) are small, the mass of the detached lead chips and the size of the temporary cavity are also relatively small. However, one should compare the muscle mass of big game (wild boar, red deer or even roe deer) with the muscle mass of game birds. If the fact of several projectiles pitting the small breast muscles is added to these comparisons, the large diversification of lead levels in the muscles of game birds becomes clear. In addition, considering the destruction of tissues by hunting projectiles, including damage to the blood vessels, it should be remembered that lead chips may penetrate damaged veins and reach distant tissues via this route. This seems only possible with shots that do not kill an animal immediately (Felsmann et al., 2016).

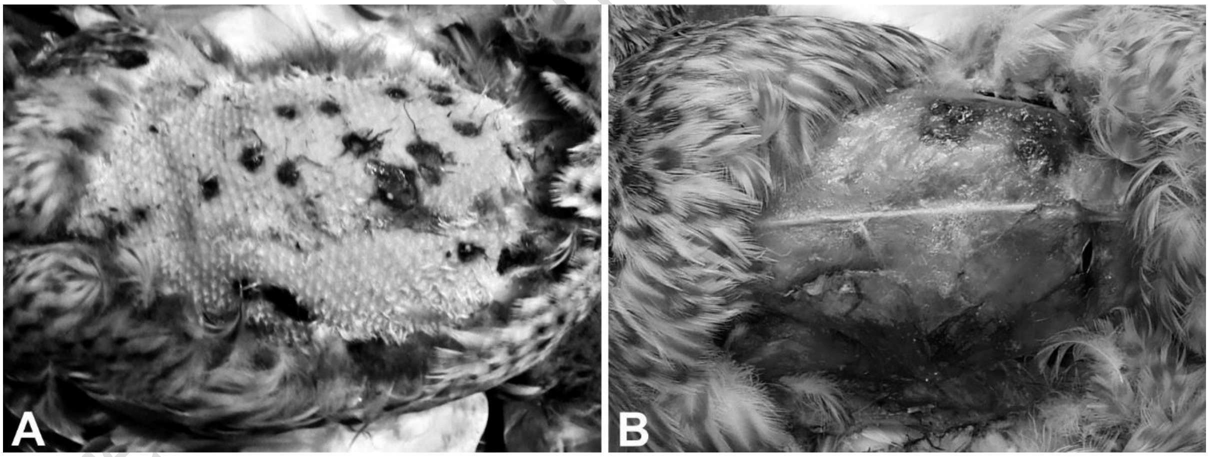

Figure B.9-6 Wounds inflicted by pellet gunshot in the skin and muscles of mallards. A. Several wounds of different sizes in the skin over the breast area. B. Wounds in the breast muscles (Felsmann et al., 2016)

As explained above, lead shot can ‘fragment’ after hitting quarry animals resulting in smaller particles of lead being distributed within the tissues of an animal. Some of these fragments may reside in tissues a considerable distance from the primary wound and remain there after butchery and food preparation (Green and Pain, 2014). According to the available evidence, it is not possible for consumers to successfully remove all embedded fragments of lead from the wound channels of shotgun shot game. Tiny lead particles would go unnoticed by consumers. In addition, removing lead pellets may not be a practical option for game meat retailers either. In the UK, the Food Standards Agency (FSA), referring to the sale of small game, in a risk assessment (FSA, 2012),

stated that:

> *"Regarding sale of small game, colleagues from the FSA Operations Group have indicated that the lead pellets are very small and it would be impractical to ensure they are removed during the dressing procedure: trying to remove them would be very time consuming and would cause damage to the birds which would likely make them unsellable."*

Pain et al. (2010) examined wild shot in gamebirds (mainly terrestrial birds) obtained in the UK to determine the potential hazard to human health from exposure to fragments of shot in the tissues. During X-ray analysis, the study found small fragments in 76 % of the 121 gamebirds examined. Most fragments were less than about a tenth of a shot in size. The fragments were sometimes clustered around bone, but sometimes appeared to be scattered throughout the bird. The authors noted that small fragments cannot be effectively removed because they are both too small to be detected by the human eye, and because their removal would require discarding a large proportion of the gamebird carcass. Usually when a gamebird is killed, several shot have penetrated it and the lead fragments and high tissue lead concentrations remain even when those shot pass through the bird, as sometimes happens.

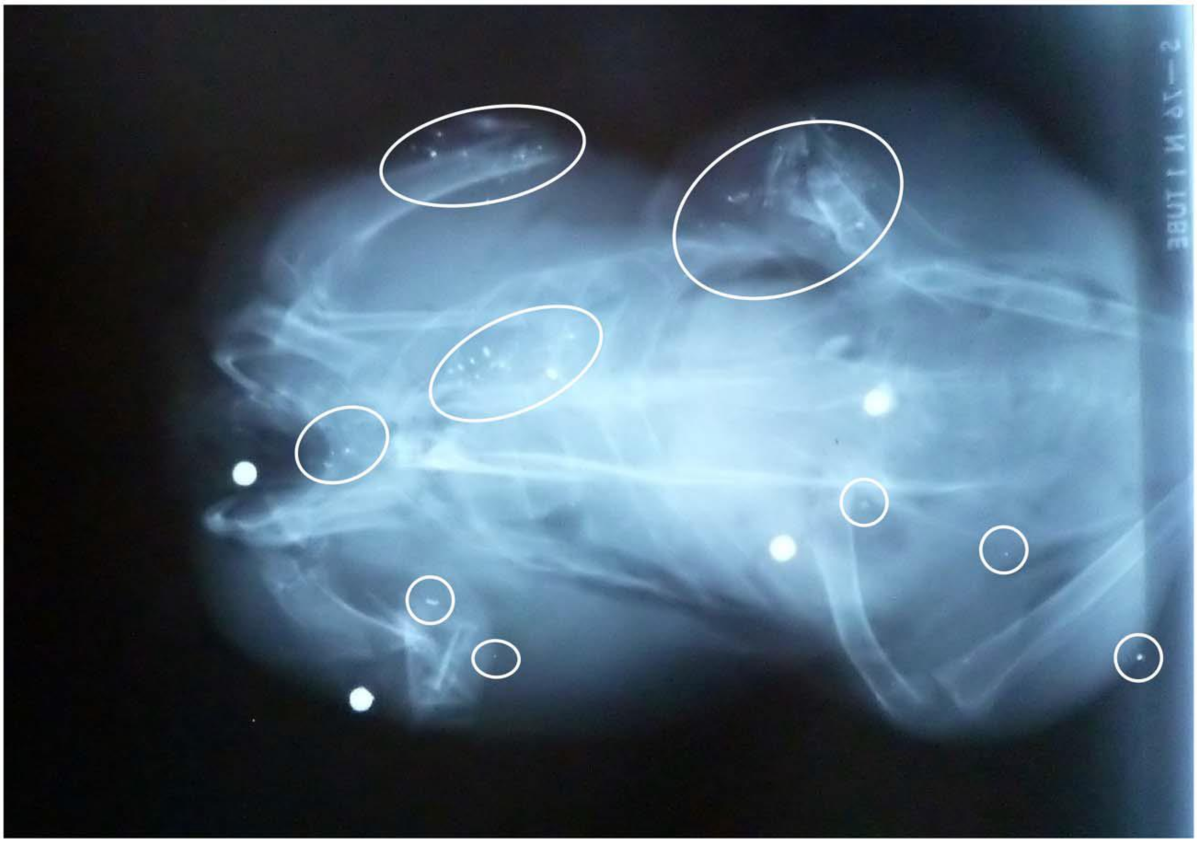

Figure B.9-7X-Ray of a woodpigeon illustrating four gunshot and numerous small radio-dense fragments. Radio-dense fragments may trace the passage of shot through the bird; some fragments are close to bone suggesting fragmentation on impact, others are not. doi:10.1371/journal.pone.0010315.g001 (Pain et al., 2010)

Birds may also carry embedded shot from previous exposures to shooting (Guillemain et al., 2007) which would not be targeted during butchery due to lack of visible recent tissue damage.

Roselli et al. (2016) measured samples from 14 wild birds obtained by Italian hunters. Mean (±SD) lead concentration was 16.9±32.4 mg/kg with a maximum of 98.55 mg/kg.

Andreotti et al. (2016) X-rayed 59 carcasses of woodcock shot by Italian hunters in Ukraine. To check the ammunition types and evaluate the mean weight of the embedded gunshot, the authors excised a sample of 62 whole pellets from 20 birds. Ammunition residues were found in 57 of the 59 woodcock (96.6%). Radiographs revealed 215 whole pellets and 125 fragmentation centres in 51 (mean = 3.64) and in 48 birds (mean = 2.14), respectively. Most fragmentation centres (75.7%) contained tiny particles (<1 mm). The overall estimated Pb load ranged from 45 to 52 mg/100 g wet weight, most of which (84.6%) in edible parts. The number of embedded pellets per unit of body mass (1.21/100 g of body weight) was higher in comparison with other bird species and also with woodcock shot in the UK, presumably owing to the hunting methods adopted by Italian hunters. The quantity and characteristics of ammunition residues we found suggest that game meat consumers are exposed to a relevant Pb assumption.

In quail gizzards (n=10) radiographic examination showed ingested pellets. In turtle doves (n=10), lead levels in the liver had higher values of 2.501 ± 1.404 mg/kg, compared to the maximum levels of <2 mg/kg. The content of lead in the humerus of partridges (n=10) showed a very high concentrations of 54.241 ± 36.731 mg/kg compared to the base level of 10 to <20 mg/kg. The high levels of lead in the tissues of the gamebirds, induced by lead shot exposure, are a significant risk to predators and scavengers (Stamberov et al., 2018).

Recommendations to handle game meat (birds)

The EU's rules on game meat should be followed[68].

The European Federation for Hunting and Conservation (FACE) provides the following Guidance on managing risks from game meat shot with lead ammunition[69]:

> All expanding lead core bullets fragment on impact and shed lead particles through the meat as the bullet penetrates. This is also true for lead shot. This gives rise to microscopic particles of lead widely distributed throughout the carcase. Expanding lead core bullets typically release thousands of fragments of varying size (including millions of nanoparticles) and the larger ones can be visualized using X-rays [Arnemo et al. (2016), Knott et al. (2010)].
>
> The lead levels are greatest immediately surrounding the wound channel, but may remain detectable up to 30 cm away depending on bullet type, bullet resistance during penetration and bullet velocity upon impact.
>
> Attempts to remove lead ammunition from game meat can be successful at significantly reducing the levels of lead contamination. Research in Sweden has

68 https://ec.europa.eu/food/animals/animalproducts/game_en

69 https://www.leadammunitionguidance.com/lead-ammunition-in-game-meat/

> shown that proper handling of game shot with lead ammunition can effectively eliminate the risk (Livsmedelsverket, 2014a). The Federal Institute for Risk Assessment, Germany (BfR, 2011) states that cutting out large sections of meat around the bullet hole is not always enough to guarantee removal of lead.
>
> Risk management options can include the application of appropriate game meat handling techniques, eating game shot with non-lead ammunition, or reducing their intake of game shot with lead ammunition.

European hunters generally follow the "best practice" as advised by several authorities. This basic game meat handling advice is often part of the hunting education prior to the compulsory hunting exam for new hunters. For example, it is frequently recommended to remove the meat around the gunshot wound any meat that is visibly affected by the bullet and an additional 10 cm of meat visibly unaffected by the bullet.

In order to place big game meat on the market, for example, hunters need to pass an assessment and the animals must be inspected by a person authorized (having passed a course) to approve that "best practice" is followed. The EU introduced Regulation (EC)853(2004) stipulates that hunters must be trained so that they are qualified to inspect game before it enters the food chain. Hence, Member States are obliged to put in place a trained hunter qualification process to meet this requirement. The purpose is to enforce traceability and hygienic practices in the production of wild game meat for public consumption. The Regulation applies to all game – fur and feather; large and small.

FACE[70] considers that, in order to avoid distortion of competition, as well as unjustified restrictions on standard hunting practices – in particular for small quantities of wild game and game meat, supplied directly to the final consumer or retailer – the European Commission (DG SANCO) should elaborate guidelines in order to harmonise these national rules.

The British Association for Shooting and Conservation & Countryside Alliance Clearly (BASC, 2014) conducted a joint survey of their members to gather information on game meat consumption. There were 2,317 respondents in total. The survey highlighted that those consumers that frequently eat game are more likely to take steps to minimise their own exposure to lead by removing lead fragments, areas of bruising and/or shot tracks (see Figure B.9-8). It was particularly clear that those who ate the most game were more likely to remove areas of bruising and shot or bullet fragments. It is not clear if this is due to education amongst frequent consumers, or simply due to greater access to game, meaning they can be more selective when preparing the carcase.

[70] https://www.face.eu/animal-welfare/game-meat/

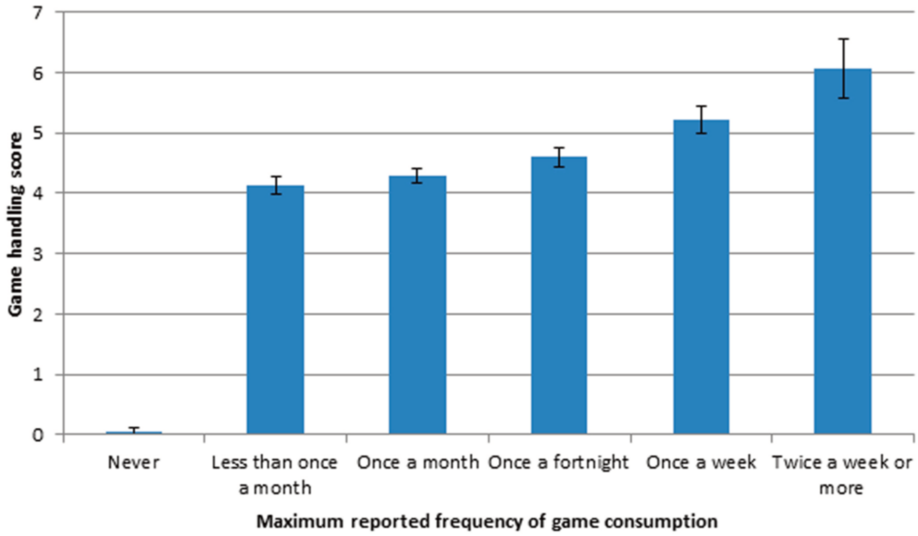

Figure B.9-8 The relationship between frequency of consumption and score for game handling techniques (BASC, 2014).

Concentration of lead in meat from game hunted with lead shot

Regulation EC No 1881/2006 sets maximum levels for certain contaminants in foodstuff. The maximum concentration for lead in meat are:

- Section 3.1.3. Meat (excluding offal) of bovine animals, sheep, pigs and poultry (0.10 mg/kg).
- Section 3.1.4. Offal of bovine animals, sheep, pigs and poultry (0.50 mg/kg)

No maximum concentration for game meat has been set. Thomas et al. (2020) are proposing to amend the specified sections of this Regulation with "wild game mammals and birds".

Guitart et al. (2002) investigated lead concentrations in the liver of 411 water birds (mainly Anatidae). Of these birds, 6.08% contained liver lead concentrations (wet weight) between 0.1 and 0.5 mg/kg, 27.25% were between 0.5 and 5 mg/kg and 13.14% were higher than 5 mg/kg. The liver lead concentrations varied from non-measurable levels (without toxicological significance) to 114.6 mg/kg (the latter from a shoveler duck). Thus 40.39% of the waterfowl livers contained lead levels above the EU lead threshold for poultry offal.

Johansen et al. (2004) found that concentration of lead in the meat of seabirds (murre and common eider; mean±SD) killed using lead shot was 6.1±13 mg/kg, which was 44 higher compared to drowned eider and eight times higher than in shot murres (mean±SD 0.73±2.9 mg/kg). Whole pellets and large pellet fractions were removed before analysis.

Pain et al. (2010) found that a high proportion of samples had lead concentrations exceeding 100 ppb w/w (0.1 mg/kg w/w). For example, 56 and 47% of fresh meat from partridge and pheasant, respectively, exceeded 0.1 mg Pb/kg, 21 and 18% exceeded 1.0 mg Pb/kg, and 5.7 and 2.4% exceeded 10 mg Pb/kg (see Table B.9-19). The percentage may increase further after cooking and especially after cooking under acidic conditions. Cooking methods may affect the bioavailability of lead in game meat.

Cooking small game meat (red-legged partridge breast) under acidic conditions (i.e. using vinegar) increases the final lead concentration in the meat as well as its

bioavailability. Lead particles in game meat can dissolve while cooking, producing soluble lead salts that then contaminate parts of the meat. These salts have greater bioavailability and may pose an increased risk compared to metallic lead particles (Mateo et al., 2007).

Table B.9-19 Percentages of samples of game and chicken that exceeded each of the three threshold values of lead concentration (0.1; 1.0; 10 mg/kg wet weight) (Pain et al., 2010)

Species	Cooking method	N	Percent of game meat samples exceeding		
			0.1 mg/kg	1.0 mg/kg	10 mg/kg
Chicken	Acid	14	0	0	0
	Non-acid	42	2.4	0	0
Red grouse	Acid	10	50	0	0
	Non-acid	10	40	20	0
Partridge	Acid	13	61.5	7.7	2.1
	Non-acid	13	69.2	23.1	3.8
	fresh	57	56.1	21.3	5.7
Pheasant	Acid	13	38.5	0	0
	Non-acid	10	60	10	1.6
	fresh	58	46.6	17.9	2.4
Wood-pigeon	Acid	11	27.2	9.1	0.1
	Non-acid	10	20	0	0
Woodcock	Acid	8	87.5	25	5.4
	Non-acid	8	37.5	12.5	0.3
Mallard	Acid	8	25	0	0
	Non-acid	8	37.5	25	0.3

Ertl et al. (2016) analysed concentrations of lead in muscle tissue from pheasants and five wild mammal species shot in Austria. Gunshot pellets and wound channel tissue were excluded from the samples taken for analysis. n 19 out of 61 meat samples lead concentrations were higher than 0.1 mg/kg, the maximum limit in meat as set by the European Commission (Regulation EC No 1881/2006). Animals killed using gunshot pellets (hares and pheasants) and chamois had particularly high lead concentrations. Mean lead concentrations (on wet mass) were 9.0 ± 26 mg/kg in meat from brown hares (n=9) and 125 ± 335 mg/kg in pheasants (n=10).

Carpenè et al. (2020) determined concentrations of essential and non-essential trace elements including lead in home-processed food obtained including three common species of game animals (woodcock, pheasant, and hare). Mean lead concentrations in processed meat were 0.943 mg/kg for woodcock, 0.137 mg/kg for pheasant and 3.395 mg/kg for hares, the highest value in hares was 17.3 mg/kg (see Table B.9-20).

Table B.9-20 Concentration of lead in processed meat from woodcock, pheasant and hare (Carpenè et al., 2020)

Species	n	Pb concentration (mg/kg wet weight)			
		Median	Mean	SD	Max
Woodcock	5	0.58	0.943	0.838	2.421
Pheasant	8	0.061	0.137	0.175	0.470
Hares	6	0.597	3.395	6.850	17.300

For the purpose of this restriction proposal, EFSA provided data on game meat bagged with lead shot in the EU. As reported in Table B.9-21, the grand average mean lead LB concentration in the samples analysed was 0.352 mg Pb/kg. Highest mean lead concentrations were found in hares (0.9 mg/kg) and pheasants (0.7 mg/kg). Highest reported maximum values are 104 and 113 mg/kg for hares and pheasants, respectively.

Table B.9-21 Concentration of lead in meat intended for consumption from game hunted with lead shots in the EU (EFSA data 20.06.2020)

Species	N	Samples below detection limit (%)	Pb concentration (mg/kg)			
			Median Ub	Mean Lb	Mean Ub	Max
Duck	1313	73	0.020	0.081	0.096	17.900
Game birds	48	24	0.040	0.207	0.214	1.979
Hare	341	60	0.020	0.889	0.903	104.000
Partridge	17	47	0.020	0.054	0.077	0.840
Pheasant	713	47	0.019	0.676	0.683	113.000
Quail	129	74	0.020	0.024	0.044	0.400
Rabbit	11	64	0.008	0.341	0.346	1.000
All	**2574**	**63**	**0.020**	**0.352**	**0.365**	**113.000**

Amount of meat consumption from game hunted with lead shots

Taylor et al. (2014) analysed data on game bird consumption in the sample population (National Diet and Nutrition Survey 2008–2010), in women of childbearing age (15–45 years old) and in children ≤ 6 years old. Of the 2126 participants (aged 1.5 to >65 years), fifty-eight (2.7%) reported eating game birds. The authors found that the prevalence of consumption of game birds by women of childbearing age and children ≤6 years old was relatively low and intakes were small (see Table B.9-22).

Table B.9-22 Portion size and proportion of total bird meat intake in 58/2126 persons of the general population in the UK consuming game birds (Taylor et al., 2014)

Age (years)	N	Game bird consumption (g/day) mean±SD; range	Game bird meat as proportion of total meat intake for game bird consumers mean±DS; range
≤ 6	3	6.8± 9.7; 1.3-23.2	0.08±0.11; 0.01-0.26
6-18	15	22.3±21.9; 3.75-92.9	0.19±0.19; 0.06-0.76
19-64	34	17.8±13.4; 2.0-46.9	0.18±0.16; 0.02-0.54
> 64	6	30.1±31.1; 1.8-79.0	0.28±0.29; 0.00-0.76

Ferri et al. (2017) investigated the consumption habits of 766 Italian shooters (96% males, 4% females). An average of 100–200 g game per serving (four servings per month) was consumed, with highest intakes of 3000 g per month; meat, liver, and heart were the preferred food items. Mammalian and feathered game was regularly consumed with friends and relatives in 83% and in 60% of cases, respectively. The authors reported mean (± SD) consumption of game meat per person and month of 126 ± 146 g for wild European woodcock meat, 157 ± 182 g for wild common pheasant meat and 169 ± 244 g for wild thrush meat. Calculating with 30.5 days per month, this would result in 4.14 ± 4.79 g/day for woodcock, 5.15±5.97 g/day for pheasant, and 5.54±8.00 g/day for thrush.

For the purpose of this restriction proposal EFSA provided recent data on the consumption of game meat in the EU. ECHA considers that the 95th percentile of chronic consumption of game meat is a good proxy of high frequency consumers such as hunter households. The daily consumption of game meat as provided by EFSA is reported in Table B.9-23, separated for different groups of high frequency consumers. Of specific importance for this report are infants and toddlers that are specifically sensitive to lead-related IQ loss.

Table B.9-23 Consumption of meat from game hunted with lead shots in the EU (EFSA data 20.06.2020)

Population	Game meat consumption (g/kg bw and day)		
	Min P95	Med P95	Max P95
Infants	0.450	0.658	4.261
Toddlers	0.153	1.131	4.922
Other children	1.181	2.632	6.154
Adolescents	0.474	1.646	3.902
Adults	0.172	1.606	3.664
Elderly	0.090	1.112	2.851
Very elderly	0.233	1.127	2.295
Pregnant women	0.127	0.887	2.241
Lactating women	1.228	1.228	1.228

PbB levels measured

Information on PbB levels related to the consumption of game hunted with lead shots is mainly available for people living in the circumpolar region with subsistence hunting of sea birds. This information is summarised in Table B.9-24.

Verbrugge et al. (2009) reviewed the information concerning human exposure to lead from ammunition in the circumpolar north. Circumpolar subsistence cultures use firearms, including shotguns and rifles, for hunting game for consumption. Lead shot is still used for waterfowl and seabird hunting in many subsistence areas (despite lead shot bans) because it is inexpensive, readily available, and more familiar than non-toxic or steel shot, which shoot differently. The results indicate that elevated lead exposure is associated with use of lead ammunition. Mechanisms of exposure include ingestion of lead dust, ammunition fragments, and shot pellets in harvested meat, and inhalation of lead dust during ammunition reloading. In Alaska, ammunition-related lead exposures have also been attributed to the use of certain indoor firing ranges, and the melting and casting of lead to make bullets. At the population level, the Dene/Métis and bird hunting Inuit in Canada averaged from 31 to 50 µg/L of lead in maternal blood, compared to 19 to 22 µg/L among Caucasians and other Inuit (Van Oostdam et al., 2003). However, 3.4% and 2.2% of the blood samples from the Inuit and Dene/Métis women, respectively, exceeded 100 µg/L. In Greenland, blood lead levels in Inuit mothers averaged 31 to 50 µg/L, similar to the Canadian Inuit and Dene/Métis (AMAP, 2003). In Siberia, indigenous women had average blood lead levels of 21 to 3.2 µg/L, while non-indigenous women, who presumably obtained a smaller proportion, if any, of their food from hunting, averaged 0.2 to 0.4 µg/L (AMAP 2003). In Nunavik (Arctic Quebec), adult Inuit blood lead levels were elevated and were related to age, smoking and, in particular, daily consumption of waterfowl (Dewailly et al., 2001). Blood lead, adjusted for age and sex, was associated with seabird consumption in Greenland (Bjerregaard et al., 2004). In that study, Greenlanders who reported consuming sea birds several times a week had a blood lead level > 50% higher than those who reported eating sea birds

only a few times a month or less. Lead isotopes were used to identify the source of lead. This method was used by Tsuji et al. (2008b) to definitively document lead from ammunition — both shot and bullets — as a source of lead in First Nations Cree in northern Ontario. Lévesque et al. (2003) used a similar approach to identify the source of lead in cord blood of Nunavik Inuit infants born from 1993 to 1996. Although mobilization of maternal bone lead resulted in less definite signatures than those documented by Tsuji et al. (2008a), there was still a strong suggestion that the source of elevated cord blood lead, found in approximately 7% of Inuit new-borns, was lead from ammunition. There were also signature differences between Inuit infants from Nunavik in northern Quebec, and Caucasian infants from southern Quebec. In Alaska, recent lead isotope data from blood of Alaska Natives from Bethel on the Yukon-Kuskokwim Delta and Barrow on the North Slope, regions where subsistence waterfowl hunts occur, showed signatures that overlapped with those of shot (Alaska Native Tribal Health Consortium, unpubl. data).

PbB levels in adults from Circumpolar groups of native population with subsistence hunting are summarized in Table B.9-24 below. Those data confirm that PbB levels in males are usually higher compared to females [Dewailly et al. (2001), Bjerregaard et al. (2004), Tsuji et al. (2008a)] and that for all those groups mean or median PbB levels were above 50 µg/L or even above 100 µg/L. PbB levels were shown to increase with increased consumption of game birds [Bjerregaard et al. (2004), Johansen et al. (2006)]. However, the relevant contribution of lead from hunting activities was not considered.

Table B.9-24 Blood lead (PbB) levels in populations with subsistence hunting of game

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
Dewailly et al. (2001), Canada	492 Inuit adults (Arctic Québec, Canada) with daily consumption of sea birds (Canada goose and ducks)		
	AM; GM; range		Females
	97.3; 78.7; 8.3-472.0		All females (n=283)
	64.2; 53.8; 8.3-171.8		18-24 years (n=67)
	95.2; 80.7; 16.6-428.6		25-44 years (n=131)
	126.3; 197.7; 24.8-472.0		45-75 years (n=85)
			Males
	111.8; 99.4; 16.6-345.8		All males (n=209)
	82.8; 76.6; 33.1-223.6		18-24 years (n=40)
	105.6; 95.2; 16.1-271.2		25-44 years (n=102)
	134.6; 124.2; 31.1-345.8		45-75 years (n=67)
	Results: Analyses of variance revealed that smoking, age, and consumption of sea birds were associated with lead concentrations (r^2 = .30, p < .001) Comment: Hunting activity not taken into account		
Bjerregaard et al. (2004),	Male (n=67) and female (n=94) persons from 4 villages in Greenland with sea bird consumption; data from 1993-1994		

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
Greenland	<u>mean±SD, range</u>		
	94.4±69.6; 7-351		All persons (n=161)
	88		Females (n=67)
	103		Males (n=94)
	<u>AM</u>	Ref.	<u>Frequency of sea bird consumption</u>:
	77.9		Rarely (n=12)
	79.2		Once a month (n=39)
	72.2		2-3 times per month (n=36)
	109.5	Δ 31.6	1-3 times per week (n=53)
	117.0	Δ 39.1	4-6 times per week (n=15)
	169.8	Δ 91.9	Daily (n=6)
	<u>Results</u>: Pb concentrations sign. increased with age, sign higher in males (103 µg/L) compared to female (88 µg/L) and sign correlated with sea bird consumption (PbB levels 50% higher in persons eating sea bird several times a week compared to persons eating only a few times per month) <u>Comment</u>: Hunting activity not taken into account		
Johansen et al. (2006), Greenland	50 adult males from Nuuk, Greenland, mean age 55 years (range 35-78 years), "some were hunters", seasonal hunting of birds (61% murre, 29% eider) with lead shots		
	<u>mean±SD; min-max</u>		Consumption of bird equivalents per month taking into account higher Pb concentration in eider comp. to murre
	17; 7-2[1)] (n=4)	Ref.	0
	62±48; 25-211 (n=73)	Δ 45 (mean)	0.1-5
	74±47; 12-221 (n=31)	Δ 59 (mean)	5.1-15
	82±45; 20-190 (n=42)	Δ 67 (mean)	15.1-30
	128±36; 87-154 (n=5)	Δ 113 (mean)	>30
	[1)] Value seems to be wrong		
	<u>Result</u>: sign correlation between PbB levels and consumption of bird meat (taking into account the time the blood sample was taken and intake of bird meat); <u>Comment</u>: Hunting activity not taken into account; the authors discuss as one possible reason for the relative high PbB levels for bird eaters compared to non-bird eaters the possibility of having lead pellets in the intestine or appendix; (Tsuji and Nieboer, 1997) found that 15% First Nation's people carried lead shot in the intestine		
Tsuji et al. (2008a), Canada	Two groups of native people with subsistence hunting, Northern Ontario, Canada (sub-arctic); hunting of migration birds, Pb from ammunition (lead shot shell pellets and bullets) was identified as source of Pb exposure (Tsuji et al., 2008b)		
	mean±SD; GM, min-max		
			<u>Hamilton</u> (highly industrialized city)
	29±21; 24, 12-110	Ref. F	Females non-native (n=27)
	25±16; 21, 9-68	Ref. M	Males, non-native (n=25)

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
			Fort Albany
	35, 44±32; 35, 5-137	Δ 6 (mean)	Females native (n=49)
	72±43; 60, 17-178	Δ 47 (mean)	Males, native (n=48)
			Kashechewan
	44±39; 33, 9-174	Δ 15 (mean)	Females native (n=48)
	78±45; 65, 9-166	Δ 53 (mean)	Males, native (n=51)
	Results: large proportion of native people with PbB levels > 100 µg/L: Fort Albany 8% females, 27% males; Kashechewan 6% females, 31% males; compared to non-native people from highly industrialised city: 4% females, 0% males; sign. positive relation between PbB and age for the sexes and location for the sexes Comments: Hunting activity not taken into account; no information on time and frequency of game consumption, hunting season and when blood was taken		

Ingestion of lead shots

Rozier and Liebelt (2019) present three cases of children ingesting lead shots with radiograph-documented lead pellet ingestion:

- A 2-year old child that ingested over 100 pellets in the abdomen and showed PbB level of 650 µg/L at the day of ingestion but no clinical signs.
- A 10-year old boy who had been chewing lead pellets for the past three days also showed a PbB level of 650 µg/L and at a repeated measurement 700 µg/L but no clinical signs.
- A 16-year old female swallowed about 12 lead pellets stored in the cheek while loading a shotgun. 5 days after ingestion she presented to an urgent care facility with complaints of abdominal pain. PbB levels were 530 µg/L.

Gustavsson and Gerhardsson (2005) presented a case report of a 45-year-old woman referred to the Department of Occupational and Environmental Health in January 2002 because of increased blood lead concentrations of unknown origin. She suffered from malaise, fatigue, and diffuse gastrointestinal symptoms. She had a blood lead level of 550 µg/L (normal range < 40 µg/L). The patient had not been occupationally exposed to lead, and no potential lead sources, such as food products or lead-glazed pottery, could be identified. Her food habits were normal, but she did consume game occasionally. Clinical examination, including standard neurologic examination, was normal. No anaemia was present. Laboratory tests showed an increased excretion of lead in the urine, but there were no signs of microproteinuria. An abdominal X ray in October 2002 revealed a 6-mm rounded metal object in the colon ascendens. Before the object could be further localized, the patient contracted winter vomiting disease (gastroenteritis) and the metal object was spontaneously released from the colon during a diarrhoea attack. The object was a lead shot pellet, possibly but not normally used in Sweden for hunting wild boar or roe deer. Blood lead levels slowly decreased. Nine months later the patient's blood lead levels were almost normal (~ 70 µg/L) and her symptoms had almost completely disappeared.

Indirect exposure of humans via the environment

Intake of lead from shot shell ammunition deposited in the environment can occur via water or plants and animals that have taken up lead derived from spent ammunition (see review of Green (2015).

Rooney et al. (2007) carried out an incubation experiment to assess the rate of oxidation of Pb shot and subsequent transfer of Pb to the soil under a range of soil pH conditions. Lead shot corrosion was rapid, so that soil solution and fine earth (<1 mm) Pb concentrations increased rapidly within a few months. Corrosion products, dominated by hydrocerussite ($Pb_3(CO_3)_2(OH)_2$), developed in crusts surrounding individual Pb pellets. However, irrespective of pH, Pb^{2+} activities in the soil solutions, modelled using WHAM 6, were much lower than would be the case if they were controlled by the solubility of the dominant Pb compounds present in the Pb shot crust material. In contrast, modelling of soil solide-solution phase distribution of Pb, again using WHAM 6, suggested that, at least during the 24 months of the study, soil solution Pb concentrations were more likely to be controlled by sorption of Pb by the soil solid phase. The authors found that in soils spiked with lead shot, the concentration of Pb in soil water reached values of approximately 0.5 and 2.0 mg/L at pH values of 6.9 and 5.7, respectively.

Schupp et al. (2020) established a mathematical model that considers input from fertilizer, ammunition, deposition from air, uptake of Pb by crops, and wash-out to simulate the resulting Pb concentrations in soil over extended periods. In a further step, human oral exposure by crop-based food was simulated and blood concentrations were derived to estimate the margin of exposure to Pb-induced toxic effects. Simulating current farming scenarios, a new equilibrium concentration of Pb in soil would be established after several centuries. Developmental neurotoxicity represents the most critical toxicological effect of Pb for humans. According to the model applied, a Pb concentration of ~ 5 mg/kg in agricultural soil leads to an intake of approximately 10 μg Pb per person per day by the consumption of agricultural products, the dose corresponding to the tolerable daily intake (TDI). Therefore, 5 mg Pb/kg represents a critical concentration in soil that should not be exceeded. Starting with a soil concentration of 0.1 mg/kg, the current control level for crop fields, the simulation predicts periods of ~ 50 and ~ 175 years for two Pb immission scenarios for mass of Pb per area and year [scenario 1: ~ 400 g Pb/(ha × a); scenario 2: ~ 175 g Pb/(ha × a)], until the critical concentration of ~ 5 mg/kg Pb in soil would be reached. The two scenarios, which differ in their Pb input via fertilizer, represent relatively high but not unrealistic Pb immissions. From these scenarios, the authors calculated that the annual deposition of Pb onto soil should remain below ~ 100 g/(ha × a) in order not to exceed the critical soil level of 5 mg/kg. The authors propose as efficient measures to reduce Pb input into agricultural soil to lower the Pb content of compost and to use alternatives to Pb ammunition for hunting.

B.9.2.2. Hunting with single projectile ammunition

There are several pathways by which consumers could be exposed to ammunition-derived lead bullets used for hunting such as:

(1) inhalation of lead containing fumes from propellant or lead dust when a hunter fire a gun (Green and Pain, 2015),
(2) hand-to-mouth contact following assembling of lead-containing bullets (hunter),
(3) ingestion of lead fragments by consumption of meat from wild game shot with lead ammunition (Green and Pain, 2019).

The endogenous exposure resulting from inhalation and oral uptake of lead is usually identified by measuring blood lead (PbB) levels. PbB levels reflect recent exposures but also lead that is mobilised from the bone, the main storage of lead.

Exposure related to hunting activities

Hunting with lead-containing bullets can lead to the uptake of lead fume and dust from the ammunition while shooting. However, no quantitative information is available to make an assumption of the lead concentration in the breathing air of the hunter and the inhaled lead per shot. Natural ventilation while hunting might reduce the uptake of lead via inhalation compared to conditions for sport shooters e.g. shooting from a covered stand.

Also the uptake of lead dust (hand-to-mouth) following self-assembly of ammunition seems to be a relevant source.

Iqbal et al. (2009) investigated PbB levels from 736 males and females from six cities in North Dakota, aged 2 to 92 years, 80.8 % of whom reported a history of wild game consumption (venison, other game such as moose, birds; waterfowl excluded) and 55.5 % lead-related hobbies car/boat repair, lead casting, target shooting. PbB levels for males (14.9 µg/L) were 6 µg/L higher compared to females (8.9 µg/L). For lead-relates hobbies such as casting bullets, hunting or target shooting the PbB level increment was 5 µg/L compared to persons with no lead-related hobbies (see also Table B.9-36). It has to be noted that blood samples were taken 4 to 5 months after the hunting season and that hunting activity as such was not analysed.

Fustinoni et al. (2017) measured PbB levels from 95 subjects in Italy (74 males and 21 females), of which 69 were hunters (hunting mammals and birds) and 26 non-hunters. According to the authors, hunters hunted more than ten times per year. For non-hunting subjects, median PbB levels were 14 and 15 µg/L subjects with (n=8) and without (n=18) game meat consumption, respectively. The sex of those non-hunting subjects was not specified; most probably most of those subjects were females. For hunters, median PbB levels were 36 and 40 µg/L with (n=62) and without (n=7) game meat consumption, respectively. Also for the hunters the sex was not specified; most probably most of those subjects were males. A multiple linear regression analysis performed by the authors (containing the covariates sex, age, hunting, wine drinking, game meat consumption, tobacco smoking, shooting range, and occupational exposure) found an association with hunting (PbB levels almost double in hunters) and wine drinking (40% higher in drinkers) but not with consumption of game meat or other parameters. The author comment that whether the higher PbB level was due to inhalation of lead fumes while shooting with lead ammunition, to handling lead ammunition or both could not be ascertained. It is to be noted that this study has several shortcomings. A shortcoming of this study is that hunters were mainly males and non-hunters mainly females; PbB levels of males are usually higher than PbB levels in females. Furthermore, blood samples were collected in spring-summer which is outside the official hunting season for Italy (which is September to February) and subjects that consumed game meat prior to the measurement of PbB levels were not included. Therefore, the measured PbB levels are not expected to reflect direct impact of hunting or game meat consumption on the PbB level.

The Norwegian Scientific Committee for Food Safety (VKM) (Knutsen et al., 2013) reported that PbB levels were significantly higher in participants who reported self-assembling of lead-containing bullets (median 31 vs 16 µg/L).

The Swedish National Food Agency (Livsmedelsverket, 2014b) analyzed the consumption of moose meat, the number of shots fired, tobacco smoking, gender and age and PbB levels in different categories were calculated. As a comparison group, data from adults (Riksmaten) who never ate game were used. Figure B.9-9 shows that both the intake of moose and the number of fired shots appear to be significant for the level of lead in blood. Adults from hunter families had PbB levels 5.3 µg/L higher than adults from Riksmaten. Furthermore, PbB level increased with the number of shots fired. Firing 1-50 shots during the last 6 month increased the PbB level by 4.7 µg/L, firing > 50 shots during the last 6 months by 8.2 µg/L.

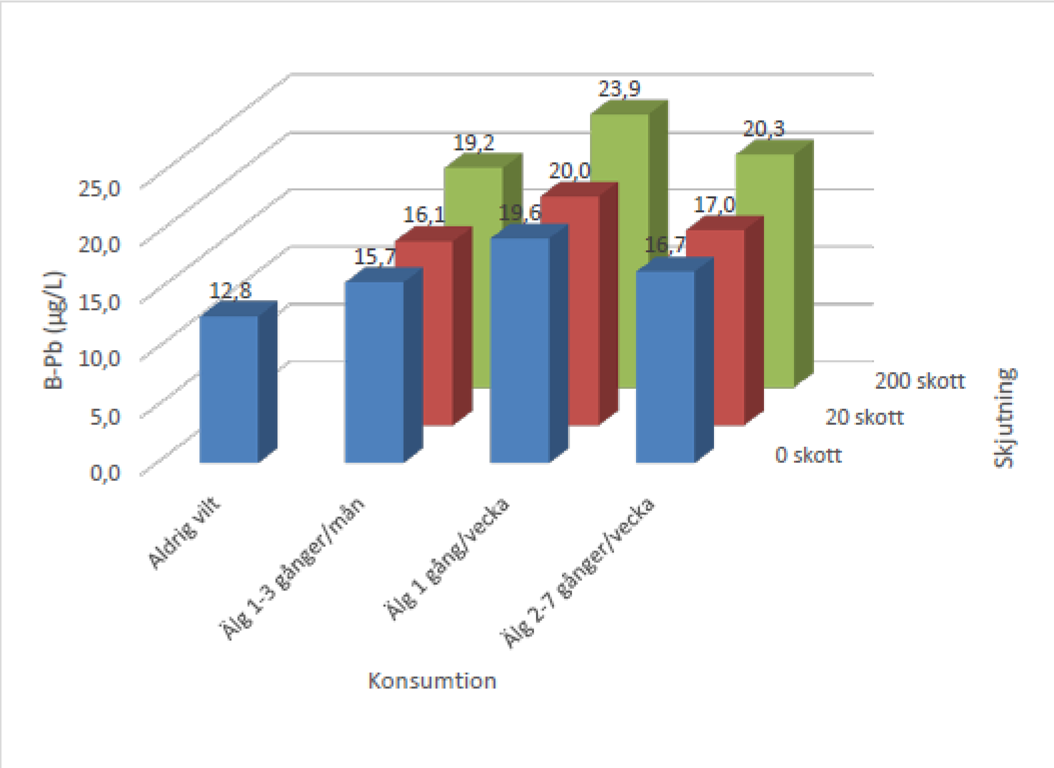

Figure B.9-9 Estimated blood lead levels in men, which takes into account the consumption of wild game meat (never wild meat among adults in Riksmaten 2010-11 and moose meat consumption last 3 months of hunting the study), the number of shots fired (values are adjusted for age and smoking habits). The number of males in the respective category consumption was 24, 13, 15 and 33 (Livsmedelsverket, 2014b)

Liberda et al. (2018) (see also 0) investigated participants from nine Cree First Nation communities located in the James and Hudson Bay region of Quebec, Canada. Users of any type of lead bullets had an increased RR of 1.406 for PbB level exceeding 50 µg/L (C.I. 1.044–1.894, p = 0.019). Significant differences were also confirmed between the PbB levels groups using ANOVA (p = 0.003). In comparison, the RR of elevated PbB level (> 50 µg/L) for lead shot shell users was 1.510 (C.I. 1.100–2.075, p = 0.007) (see also 0 above)

Exposure related to consumption of meat of game hunted with lead bullets

Impact of the ammunition on lead distribution in the game

Meat from the wound channel regularly contains hundreds of fragments. The analyses of the x-rays (e.g., Figure B.9-10) showed that occasional fragments sometimes appeared in piece details far from the wound channel, although there were no fragments in

samples from the area closer to the wound canal (Livsmedelsverket, 2014a).

Figure B.9-10X-Ray image of a wild boar book where a conventional, bonded bullet hit the upper arm bone and severely fragmented (Livsmedelsverket, 2014a)

Lead bullets, especially those of the disruptively-expanding or the expanding unbonded types, fragment on impact in accordance to their construction and might contaminate the edible meat of the hunted animal. Radiographic studies have shown that lead ammunition can cause a micronized "snow storm" of lead particles in the tissue centred around the wound channel. Wound ballistics, i.e. the characteristics of impact and tissue penetration, is dependent on abullet's kinetic energy. The mass of the bullet and especially the impact velocity together with its fragmentation and mushrooming qualities, determine the depth of penetration (VKM, 2013).

VKM (2013) summarizes the literature on the impact of bullet fragmentation in the game:

In a study by Trinogga and Krone (2008), fragments from a number of commonly used disruptively-expanding (RWS Kegelspitz®, Brennecke TUG®) and expanding (Norma Vulkan® (unbonded), RWS Evolution® (bonded) lead-containing bullets, as well as lead-free disruptively-expanding (RWS Bionic Yellow®, Möller KJG®) and expanding-nose bullets (Lapua Naturalis®, Barnes TSX®), were determined in roe deer, red deer, fallow deer, wild boar, and chamois (in total 315 animals) by taking latero-lateral and ventro-dorsal radiographs and data imaging analysis. The "lead cloud" of lead-containing bullets could be seen along the whole wound channel and also in adjacent tissues. The lead-containing bullets (disruptively-expanding, and expanding unbonded or bonded) always fragmented, even without hitting bones, and 90 to 280 fragments/bullet were counted in average. Fragment sizes varied between < 1mm and up to 10 mm. Additional

radiographs of game offal revealed hidden fragments and total counts of up to 600 fragments/bullet. The use of disruptively expanding lead-free bullets produced a few relatively large fragments in a range of 6 to 23 fragments/bullets in the animal carcasses. Lead-free expanding-nose ammunition did not produce any fragments.

Distances from fragments to the centre of the wound channel were measured at right angles and with an accuracy of ± 0.5 cm (Trinogga and Krone, 2008). The maximum distance determined was 22 cm. Ventro-dorsal mean distances were in the range of 5.6 to 11.4 cm for lead-containing bullets (disruptively-expanding, and expanding unbonded or bonded) and 1.3 to 6.6 cm for lead-free bullets (disruptively-expanding). Latero-lateral mean distances were in the range of 6.4 to 15.5 cm (lead-containing) and 3.2 to 7.8 cm (lead-free), respectively.

In a radiographic study examining fragment distribution in white-tailed deer shot in normal hunting practices with standard deer cartridges using several brands of expanding copper jacketed unbonded lead core bullets, in average >100 visible fragments were detected in the offal. In five whole carcasses 416 - 783 fragments were found. The lead-containing bullets included lead-top, plastic-top, and hollow-point designs. Additionally, a few expanding-nose copper bullets were used producing 0 - 2 fragments (Hunt et al., 2006). The lead fragments, mostly < 2 mm in size, were broadly distributed along the wound channel, and the fragments radiated as far as 15 cm (mean: 7 cm).

In a follow-up study, in average 136 visible lead fragments were found in eviscerated carcasses of 30 white-tailed deer killed with a single brand of a commonly used expanding unbonded lead-core copper-jacket bullets (9.72 g) (Hunt et al., 2009). The fragments were spread widely with a mean distance between fragment clusters of 24 cm and a maximal single fragment separation of 45 cm as revealed by two-dimensional radiography. When the edible deer meat was run through a meat processor, lead fragments were detected in the ground meat packages of 80% of the animals, and 32% of the packages per deer showed fragments.

Similar results had been observed before in an older study on fragmenting characteristics of disruptively-expanding (RWS Teilmantel-Rundkopf®, RWS Kegelspitz®, RWS H-Mantel®, Nosler Partition®, Brennecke Torpedo Ideal®) and expanding lead-containing (unbonded) (Hirtenberger ABC®) bullets (average weight: 10 g) shot into gelatine blocks or in pig legs and cow livers (Moreth and Hecht, 1981). Radiographic analysis showed that even if only muscle tissue was hit, bullet fragments were found at distances of up to 23 cm from the edge of the bullet path. Some fragments penetrated as far as 30 cm into the tissue, and fragments were found in sizes ranging from 25 µm up to several millimetres.

When in total ten red deer and two roe deer were harvested with a single shot to the thorax using 0.270 calibre Norma Lead-Top® 130 grain disruptively-expanding lead-core copper jacketed bullets, an average of 356 metal fragments were found by radiographic analysis in the carcass and of these were 180 fragments in the viscera (Knott et al., 2010). Differences in fragment counts in radiographs taken from the two sides of the same carcass suggested that considerable numbers of fragments were missed, possibly because they were too small, leading to an underestimation of total fragment numbers

A study examined the fragmentation patterns of disruptively-expanding (Remington Core Lokt®) or expanding unbonded (Nosler Ballistic Tip®) or bonded (Winchester XP3®, Hornady Interbond®) lead-containing bullets as well as one non-lead bullet (Barnes

TSX®) in 72 domestic sheep, previously euthanized and shot at a 50 m distance (Grund et al., 2010). Sheep carcasses were radiographed and tissue samples for lead analysis were collected along the abdominal cavity at perpendicular distances of 5, 25, and 45 cm from the exit wound. Additionally, eight white-tailed deer hunted with a .308 Winchester at a distance of about 110 m using expanding unbonded bullets (Nosler Ballistic Tip®) were similarly analysed. Bullet fragments were better visible in ventral-dorsal than in lateral radiographs and therefore further used. Approximately twice as many fragments were observed in sheep than in deer shot with the same expanding unbonded bullet type (Nosler ballistic tip). In the white-tailed deer, lead was not detected in samples at 25 cm, but in 12% of the samples at 5 cm (level of detection 1 mg/kg).

In sheep, the disruptively-expanding bullets produced in average more fragments (141) than the expanding lead-containing unbonded bullets (86) by ventral-dorsal view. Of the two expanding lead-containing bonded bullets, one (Hornady Interbond®) produced in average 82 fragments (ventral-dorsal view) and the other (Winchester XP3®) only nine. The lead-free bullets produced in average two fragments. Lead particles were most abundant around the exit wound. In sheep shot with disruptively-expanding and expanding lead-containing unbonded ammunition, lead concentration was above 1 mg/kg at a distance of 25 cm in 40 - 70% of the muscle samples. In sheep shot with bonded ammunition, 0 - 20% of the samples was above 1 mg/kg. Even at a distance of 45 cm, up to 10% of the samples still contained detectable lead concentrations, depending on the bullet type (Nosler ballistic tip®, Hornady Interbond®). Lead was not detected in any samples from sheep shot with the more stable bonded expanding lead containing bullet or with non-lead bullets. Water rinsing of the carcass spread the contamination to other areas. It was concluded that all meat from a deer hunted by lead containing bullet potentially contains some lead.

A study on white-tailed deer that were culled by sharpshooting to head or neck using disruptively-expanding soft point lead-containing bullets of three different calibres, and radiographed for analysis of fragment patterns, documented the importance of shot placement for lead contamination of the edible meat (Stewart and Veverka, 2011). In animals (n=30) shot in the head or the upper cervical spine from a distance of less than 100 m, none had lead fragments detected in the thoracic muscle, whereas eight of the ten animals shots to the lower neck region (shots that impacted any of the bottom three cervical vertebrae) had lead fragments in the thoracic muscle (all in extensor spinae muscle). The lead fragments travelled in average 21 cm from the entry wound into the thoracic cavity in deer shot in the lower neck region, and the maximum distance travelled was 40 cm.

In a more recent study, Felsmann et al. (2016) investigated the effect of a projectile on the game meat. The projectile that penetrates the animal body generates a temporary cavity and this phenomenon is accompanied by a change in the pressure within the funnel of a wound and in the adjacent tissues. This cavity is formed behind a projectile and may persist even after the projectile has left the target. Its size is difficult to predict and the momentary shape of the frontal part of a projectile seems to have a major impact on its formation and size (Felsmann et al., 2012). Due to the temporary cavity phenomenon, especially pressure fluctuations in the tissues where it is found, it may be assumed that this phenomenon is responsible for lead transfer deep into the tissues that surround the path of a wound. The highly variable results of studies on the content of lead at the same distance from the path of a wound in individual animals are unsurprising due to this physical phenomena (Dobrowolska and Melosik, 2008). The

increased lead levels in projectiles hitting bones, as reported by other authors, seem to confirm the presented explanation of lead transfer from projectiles to animal tissues. After hitting the bone, a projectile may be fragmented, the core may be exposed and secondary projectiles may be generated. Detached fragments of the projectile core most often move at a different velocity than the projectile (its core part), contaminating a larger area of tissues (Knott et al., 2010). These fragments increase the surface of lead elements that come in contact with the surrounding tissues. Detached projectile fragments and comminuted bone become secondary projectiles that generate a temporary cavity and, although an individual "secondary" temporary cavity may coalesce, it always expands the area of contaminated tissues (Felsmann et al., 2016).

Kollander et al. (2017) investigated whether game meat may contain nanoparticles of lead from ammunition. Lead nanoparticles in the range 40 to 750 nm were detected by ICP-MS in single particle mode in game shot with lead-containing bullets. The median diameter of the detected nanoparticles was around 60 nm. The particle mass concentration ranged from 290 to 340 ng/g meat and the particle number concentrations from 27 to 50 million particles/g meat. The size limit of detection strongly depended on the level of dissolved lead and was in the range of 40 to 80 nm. In game meat sampled more than 10 cm away from the wound channel, no lead particles with a diameter larger than 40 nm were detected. In addition to dissolved lead in meat that originated from particulates, the presence of lead nano-particles in game meat represents a hitherto unattended source of lead with a largely unknown toxicological impact to humans.

Menozzi et al. (2019) evaluated the content of lead in carcasses of wild boars shot with lead bullets, in comparison with that of copper caused by lead-free ammunitions. Radiographic images of hunted boars were obtained in order to assess the degree of bullet fragmentation in the carcasses. Samples of meat were collected from different body areas at increasing distance from bullet trajectory, to be analysed by ICP-MS for lead and copper levels. In wild boars shot with lead ammunitions, a massive dispersion of bullet fragments and very high lead levels were detected. By contrast, in wild boars killed with copper ammunitions no radiographic signs of bullet fragmentation were observed. The authors concluded that copper ammunitions seem therefore a safer alternative to standard lead-core ones, due to their minimal fragmentation and the relatively low toxicity of this metal.

In a risk assessment of lead exposure from cervid meat, Knutsen et al. (2019) concluded that the removal of meat around the wound channel reduces the lead exposure from cervid meat consumption. Lead fragmenting and distribution is dependent on several variables, and there are no available studies in moose. The available studies do not allow a firm conclusion on the amount of meat needed to be trimmed around the wound channel in order to remove lead originating from the ammunition. Other possible measures to reduce lead exposure from cervid meat would be to use lead based ammunition with low fragmentation or ammunition without lead.

Broadway et al. (2020) investigated fragmentation in deer shot with three different types of low velocity lead ammunition (rifled slugs, sabot slugs, and modern muzzle-loading bullets). All radiographed deer had evidence of fragmentation, with a geometric mean of 13.1 (95 % CI = 10.3, 16.8) fragments per deer. Most fragments (89 %) were < 5 mm from wound channels, and no fragment travelled beyond 205 mm from a wound channel. Fragments were often retained within the muscle tissue of deer with a geometric mean rate of 0.55 (95 % CI = 0.48, 0.65). Muzzleloader bullet fragments were larger than those generated by rifled and sabot slugs, and sabot slug fragments

had the shortest dispersal from wound channels. Shoulder-shot placement and bone contact for all ammunition resulted in a significantly larger number of fragments. Shoulder-shots also generated more small fragments and higher fragment retention in muscle tissue. The overall mean number of lead fragments detected across our ammunition treatments was less than in previous studies. The authors note that ammunition type and shot placement may be considerations for hunters wishing to limit their potential exposure to lead from harvested big game. Additionally, one has to bear in mind that, compared to high-velocity rifle bullets, significantly fewer lead fragments are made available to humans and wildlife that consume game shot with low-velocity ammunition types.

Recommendations to handle game meat (large game)

The EU's rules on game meat should be followed[71].

FACE Guidance on managing risks[72]:

> All expanding lead core bullets fragment on impact and shed lead particles through the meat as the bullet penetrates. This is also true for lead shot. This gives rise to microscopic particles of lead widely distributed throughout the carcase. Expanding lead core bullets typically release thousands of fragments of varying size (including millions of nanoparticles) and the larger ones can be visualized using X-rays (Arnemo *et al*., 2016; Knott *et al*., 2010).
>
> The lead levels are greatest immediately surrounding the wound channel, but may remain detectable up to 30 cm away depending on bullet type, bullet resistance during penetration and bullet velocity upon impact.
>
> Attempts to remove lead ammunition from game meat can be successful at significantly reducing the levels of lead contamination. Research in Sweden has shown that proper handling of game shot with lead ammunition can effectively eliminate the risk (Kollander et al., 2014). The Federal Institute for Risk Assessment, Germany (BfR, 2011) states that cutting out large sections of meat around the bullet hole is not always enough to guarantee removal of lead.
>
> Risk management options can include the application of appropriate game meat handling techniques, eating game shot with non-lead ammunition, or reducing their intake of game shot with lead ammunition.

European hunters generally follow the "best practice" as advised by several authorities. This basic game meat handling advice is often part of the hunting education prior to the compulsory hunting exam for new hunters. For example, it is frequently recommended to remove the meat around the gunshot wound any meat that is visibly affected by the bullet and an additional 10 cm of meat visibly unaffected by the bullet.

In order to place big game meat on the market, for example, hunters need to pass an assessment and the animals must be inspected by a person authorized (having passed a course) to approve that "best practice" is followed. The EU introduced Regulation (EC)

[71] https://ec.europa.eu/food/animals/animalproducts/game_en

[72] https://www.leadammunitionguidance.com/lead-ammunition-in-game-meat/

853/2004 stipulates that hunters must be trained so that they are qualified to inspect game before it enters the food chain. Hence, Member States are obliged to put in place a trained hunter qualification process to meet this requirement. The purpose is to enforce traceability and hygienic practices in the production of wild game meat for public consumption. The Regulation applies to all game – fur and feather; large and small.

Beginning in 2016, being mindful of lead-contaminated game potentially going into the human food chain, Forest Enterprise England (FE) required their staff to use non-lead ammunition for deer and boar culling. The decision was made following successful trials of selected lead-free bullets and was based on the evidence that lead from lead ammunition can contaminate carcasses and that FE's marketing position could be seriously damaged if they continued to put lead-contaminated meat into the human food chain when there are proven alternatives available.

FACE[73] considers that, in order to avoid distortion of competition, as well as unjustified restrictions on standard hunting practices – in particular for small quantities of wild game and game meat, supplied directly to the final consumer or retailer – the European Commission (DG SANCO) should elaborate guidelines in order to harmonise these national rules.

Concentration of lead in meat from game hunted with lead bullet

Bullet-derived lead concentrations were measured in tissues from wild boar and red deer hunted with unspecified different brands of expanding lead-based ammunition routinely used in hunting practices in Poland (Dobrowolska and Melosik, 2008). Samples from animals (meat and/or offal, depending on bullet path) were collected at the entry and exit wounds and along the wound channel at distances of about 5, 15, 25, and 30 cm. A control sample was taken as far from the bullet channel as possible. Maximum concentrations (wet weight) measured at the entry wounds were ca. 1100 mg/kg wet tissue (wild boar) and 480 mg/kg (red deer) and at exit wounds 740 mg/kg (wild boar) and 120 mg/kg (red deer). In all samples taken at 5 cm and 15 cm distance from the wound channel, the tissue concentrations exceeded 0.1 mg/kg. At 25 cm distance, nine of the 10 red deer and eight of the 10 wild boar samples were still over 0.1 mg lead/kg, and at 30 cm five (red deer) and eight (wild boar) of the 10 samples in each species were above (see Table B.9-25). All animals showed the highest levels of contamination in tissues around the maximum expansion of the wound channel, i.e. the mushrooming site. The length of the wound channel depended on the animal's age, weight, skin and tissue resistance, and bone hardness.

[73] https://www.face.eu/animal-welfare/game-meat/

Table B.9-25 Lead concentration in wild boar and red deer at different distance from the bullet pathway (Dobrowolska and Melosik, 2008)

Indiv. No.	Carcass weight	Pb concentration (mg/kg)						
		Wound		Distance from bullet pathway (cm)				
		entrance	exit	5	15	25	30	control
Wild boar								
1	86	1095.9	736.0	32.2	11.2	4.2	3.3	0.3
2	82	189.2	67.4	18.9	6.2	0.2	0.2	0.2
3	78	125.2	59.8	14.2	0.8	0.2	0.2	0.1
4	76	131.4	77.7	11.9	3.8	0.2	0.2	0.2
5	43	361.4	633.1	47.5	6.8	3.8	3.1	0.3
6	34	179.2	395.4	26.2	5.2	2.6	0.9	0.1
7	32	74.0	95.0	5.1	0.9	0.1	0.1	0.1
8	32	65.5	158.3	8.2	0.8	0.2	0.2	0.2
9	29	76.5	212.3	10.3	0.8	0.2	0.2	0.2
10	26	69.7	176.3	10.2	2.3	0.1	0.1	0.1
Red deer								
1	116	234.6	76.5	43.8	8.6	0.3	0.1	0.1
2	113	364.8	102.6	53.7	5.7	1.1	0.8	0.2
3	110	185.8	67.3	31.9	7.9	0.2	0.1	0.1
4	102	476.9	92.7	87.5	16.9	4.8	1.1	0.3
5	98	156.6	60.4	16.9	5.1	0.2	0.2	0.2
6	97	243.8	97.2	42.7	13.7	0.3	0.2	0.1
7	96	176.8	67.9	38.7	9.6	0.2	0.1	0.1
8	93	346.5	123.7	64.2	12.5	5.8	0.9	0.3
9	89	198.5	64.9	32.1	2.6	0.2	0.1	0.1
10	88	135.7	59.9	23.2	4.3	0.1	0.1	0.1

Livsmedelsverket (2014b), (Livsmedelsverket, 2014a) analysed 54 moose meat samples. Lead concentrations ranged from levels below detection limit 0.02 mg/kg up to 31 mg/kg. 54 Percent of the samples (29/54) showed lead concentrations above the detection limit, 33 % of the samples (18/54) exceeded the lead concentration of 0.1 mg/kg. The authors also analysed the lead concentration in wild boar meat around the wound channel (see Table B.9-26). Even if there was no visible impact of the shot on the meat, in a distance up to 15 cm from the wound channel the lead concentration still exceeded 0.1 mg/kg in 27% of the samples.

Table B.9-26 Lead concentration (mg/kg) in the meat of wild boar and deer in relation to the distance to the wound channel (Livsmedelsverket, 2014b, Livsmedelsverket, 2014a)

Sample in relation to wound channel	N	Pb concentration (mg/kg)			Samples >0.1 mg/kg[1)]
		Min	Median	Max	
Wild boar					
Wound channel	18	0.011	**146**	**1829**	94 %
0 to 5 cm	18	0.007	**9**	**1466**	89 %
5 to 10 cm	18	0.004	**0.11**	**18**	50 %
10 to 15 cm	15	0.004	0.04	**29**	27 %
Deer					
0 to 5	18	10.2	121	**439**	100 %
Shoulder	15	0	0.08	**235**	47%
Back	16		0.01		25%
Inner fillet	3		0.009		0%

1) Calculated from the individual data provide in the report

The research project "Safety of game meat obtained through hunting" (LEMISI) has been conducted in Germany, with the aims of determining the concentrations of lead (as well as of copper and zinc) brought into the edible parts of game meat (roe deer and wild boar) due to using either lead or non-lead hunting ammunition, whilst concurrently taking geogenic (i.e. 'background') levels of lead into account (Gerofke et al., 2018). A supplementary study was performed in red deer (Martin et al., 2019). All visibly damaged and tainted meat was removed by trained personal with a knife and shears. The carcass then was inspected visibly for marketability. Three samples of 100 g per animal were taken from marketable meat from the area close to the wound channel, the saddle and the haunch. Compared to non-lead ammunition, lead ammunition significantly increased lead concentrations in the game meat of red deer (see Table B.9-27) and roe deer and wild boar (Table B.9-28). The authors concluded that for the average consumer of game meat in Germany the additional uptake of lead only makes a minor contribution to the average alimentary lead exposure. However, for consumers from hunters' households the resulting uptake of lead - due to lead ammunition - can be several times higher than the average alimentary lead exposure.

Table B.9-27 Lead concentration (mg/kg) in marketable meat of red deer in Germany (Martin et al., 2019)

Sample origin	N	Mean (95% confidence interval)	Pb concentration (mg/kg)				
			Median	P75	P90	P95	Max
Haunch	64	0.0151 (0.0119; 0.0188)	0.010	0.020	0.030	0.0335*	0.09
Saddle	64	0.0535 (0.0192; 0.1009)	0.014	0.023	0.040	0.220***	1.140
Close to wound	64	58.2 (0.970; 168.6)	0.016	0.024	0.820*	48.04***	3442

* p<0.05; *** p<0.001

Table B.9-28 Lead concentration (mg/kg) in marketable meat of roe deer and wild boar in Germany (Gerofke et al., 2018)

Sample origin	N	Quantifiable (%)	Pb concentration (mg/kg)					
			Mean	Geometric mean (95% confidence interval)	Median	P95	P97	Max
Roe deer								
Haunch	745	296 (39.8)	0.169	0.0028*** (0.0016;0.0051)	**0.006**	**0.064**	0.1320	73.0
Saddle	745	336 (45.1)	0.968	0.0043*** (0.0022;0.0083)	**0.009**	**0.164**	0.6434	189
Close to wound	745	456 (61.2)	**13.958**	0.0138*** (0.0071;0.0265)	**0.025**	**2.237**	9.6761	4,728
Wild boar								
haunch	514	205 (39.9)	0.086	0.0040*** (0.0020; 0.0081)	**0.014**	**0.067**	0.1317	13.5
Saddle	514	259 (50.4)	**1.716**	0.0067*** (0.0028; 0.0159)	**0.021**	**0.691**	1.729	650
Close to wound	514	783 (50.8)	**5.367**	0.0109*** (0.0047; 0.075)	**0.025**	**1.446**	5.809	1582

*** p<0.001

For further calculations of the lead uptake from game meat in hunter families, Gerofke et al. (2018) used the mean (5.367 mg/kg), median (0.025 mg/kg) and 95 percentile (1.446 mg/kg) of lead concentration from marketable wild boar meat close to the wound.

ANSES (2018) collected information on lead concentration in muscle and liver of wild game, mainly wild boar and deer, in comparison to meat from farmed animals, which included quails, pigeons, pheasants and possibly deer. In wild game the median was 0.01 mg/kg, and 90 and 95 percentile far above 0.1 mg/kg (Table B.9-29). According to

Figure 15 of the report, lead concentrations in wild boar (n = 106) were higher than in wild deer (n = 75). In comparison to meat from butchers, the 95 percentile for wild boar muscle meat was 25.2 mg/kg. The authors conclude that the highest concentrations are found in muscles which can be explained by the presence of ammunition residues in the samples despite the recommendations available from the samplers for trimming the sampled meat and despite the preparation conditions of the samples for analysis. Residues may be too small to distinguish and eliminated before analysis.

Table B.9-29 Lead concentration (mg/kg) in muscle and liver of wild game (wild boar and deer mainly hunted with bullets) and farmed animals (ANSES, 2018)

Species	Sample origin	N	Pb concentration (mg/kg)			
			Mean	Median	P90	P95
Wild game (mainly wild boar and wild deer)	Muscle	203	**3.36**	**0.010**	**4.42**	**24.2**
	Liver	195	0.412	0.050	**0.320**	**0.868**
Farmed animals	Muscle	129	0.018	0.010	0.013	0.044
	liver	120	0.046	0.010	0.084	0.132

Table B.9-30 Lead concentration (mg/kg) in muscle and liver of wild boar and meat from a butcher (ANSES, 2018)

Species	Sample origin	N	Pb concentration (mg/kg)		
			Mean	Median	P95
Meat from wild boar	Muscle		3.273	0.029	**25.2**
	Liver		0.654	0.080	**4.34**
Meat from animals sold by butchers	Muscle		0.054	0.020	0.025
	liver		0.046	0.033	0.111

Lindboe et al. (2012) investigated the lead content of ground meat from moose (Alces alces) intended for human consumption in Norway. Fifty-two samples from different batches of ground meat from moose killed with lead-based bullets were randomly collected. In 81 % of the batches, lead levels were above the limit of quantification of 0.03 mg/kg, ranging up to 110 mg/kg. The mean lead concentration was 5.6 mg/kg, i.e. 56 times the European Commission limit for lead in meat.

In 2019, the Swedish National Food Administration (Livsmedelsverket, 2020) carried out a survey of the lead content in minced meat of game that has been handled in game handling facilities in Sweden. The purpose of the survey has been to accredit an analytical method for ammunition lead in game meat and also to follow up the advice given in 2014 and the control activities carried out to manage the risks of ammunition lead for consumers. A total of 100 samples of minced meat of elk and wild boar have been analyzed at the National Food Administration's own laboratory, which has also been able to ensure the quality of the entire analysis chain, including the preparation step, for analysis of ammunition lead. A total of 50 samples of minced meat of moose and 50 samples of minced meat of wild boar were analyzed. The samples were taken at 47

different game handling facilities, from Norrbotten to Skåne. The total proportion of samples with levels of lead that are likely to come from lead ammunition is 36 percent (36 samples out of 100). For wild boar, levels of lead with probable origin from lead ammunition were present in 42 percent of the samples (21 of 50 samples) and for moose in 30 percent of the samples (15 of 50 samples). The remaining 64 percent (64 out of 100 samples) is below the detection limit for the analysis (45 samples) or has a content that is within the measurement uncertainty (19 samples). The results show that 15 percent of these 100 samples have lead levels that are above the limit found in current EU legislation for, among other things, meat from domestic animals and poultry (0.10 mg / kg wet weight). For wild boar this limit is exceeded in 16 per cent of the samples (8 of 50 samples) and for moose in 14 per cent of the samples (7 of 50 samples). A further 21 percent of the samples (21 samples out of 100) have lead contents that are unlikely to originate in a background exposure (26 percent of the wild boar samples and 16 percent of the moose samples). The limit value of 0.10 mg / kg is the limit value for lead that applies to, among other things, meat from domestic animals and poultry within the EU. For game meat, there is currently no EU common or national limit value for lead. However, the National Food Administration considers that meat of game with lead contents exceeding this limit value should not be considered as safe food according to Article 14 of EU Regulation No. 178/2002. Exposure to lead can adversely affect public health. Especially fetuses and children in development, but also adults with high exposure for a long time, can be harmed. Therefore, it is justified to implement risk management measures.

Wilson et al. (2020) analysed ground venison packets from shotgun- and archery-harvested White-tailed Deer in Illinois in 2013 and 2014. The shotgun venison packets were either processed by three different commercial meat-processing plants (‘commercial’) or from a custom processor specialized in processing venison only (‘custom’). Radiographs indicated that 48 % of 27 ground venison packets from 10 shotgun-harvested deer contained metal fragments, while none of the 15 packets from three archery-harvested deer contained fragments. ICP-MS analysis verified that all metal fragments from seven of the venison samples from shotgun-harvested deer were composed of lead, with average concentrations from 1.04 to 8.42 mg/kg dry weight. Shotgun-harvested venison packets from a commercial processor were more likely ($z = 3.59$; $p < 0.001$) to have fragments and had significantly more ($W = 298.5$; $p = 0.004$) fragments than archery-harvested packets from a commercial processor (see Table B.9-31). The author calculated that a single serving of ground venison containing one of these metal fragments embedded in it would be predicted to have a lead concentration ranging from 6.4 to 51.8 mg/kg.

Table B.9-31 Data from ground venison packets from White-tailed Deer (Wilson et al., 2020)

Type of harvest	processor	Number of packets	% with fragments	Number of fragments per packet
Archery	Commercial	15	0.0±0.0	0.0±0.0
Shotgun	Commercial	21	57.1±10.8	0.86±0.19
Shotgun	Custom	6	16.7±29.8	0.16±0.15

Gbogbo et al. (2020) measured metals including lead in marketed game meat

(bushmeat) from the five most hunted species of animals in Ghana, Africa. Mean lead concentrations exceeded 1 mg/kg wet weight for all species measured; it ranged from 1.01 ± 1.0 mg/kg for cane rats to 3.05 ± 1.13 mg/kg for Maxwell's duiker. The type of ammunition used for hunting is not specified in the publication.

For the purpose of this restriction proposal, EFSA provided data on game meat bagged with lead bullets in the EU. As reported in Table B.9-32, the grand average lead concentration in the samples analysed was 2.5 mg Pb/kg. Mean (lower bond, Lb) lead concentrations were found in deer with 2.0 mg/kg, in wild boar with 2.8 mg/kg, and in doe deer with 10.9 mg/kg Highest reported maximum values are 5309 mg/kg for deer, 588 mg/kg for roe deer, and 3650 mg/kg for wild boar.

Table B.9-32 Concentration of lead in meat intended for consumption from game hunted with lead bullets in the EU (EFSA data 20.06.2020)

Species	N	Samples below detection limit (%)	Pb concentration (mg/kg)			
			Median Ub	Mean Lb	Mean Ub	Max
Chamois	15	87	0.010	0.002	0.010	0.021
Deer	5034	55	0.020	1.992	2.006	5309.000
Moose	330	48	0.010	0.026	0.035	2.720
Roe deer	314	48	0.029	10.893	10.903	588.620
Wild boar	4040	47	0.033	2.810	2.827	3650.000
All	**10334**	**52**	**0.020**	**2.501**	**2.515**	5309.000

Amount of meat consumption from game hunted with lead bullets

In Table B.9-33 calculated and estimated daily intake of game meat is summarised in high frequent consumers. For Italy and Spain, game consumption (with relevant part of bird meat) is reported with 23 g/day (AESAN, 2012), 30 g/day (Ferri et al., 2017), and 35 g/day (Ferri et al., 2017). For France (ANSES, 2018), Germany (Gerofke et al., 2018) and Switzerland (Haldimann et al., 2002), for which mainly meat from large game are consumed, the estimate is 50 g/day.

Table B.9-33 Game meat consumption (bagged with lead shots and bullets) in different groups of the population

Country	Reference	Group	Game	Meal size	Game meat consumption		
					average	median	high
France	(ANSES, 2018)	adults	Large game	200 g	3 meals/years (2 g/day)	2 meals/ month (15 g/day)	>1 meal per week (50 g/day)
		children		100 g	1 g/day	7.5 g/day	25 g/day
Germany	(Gerofke et al., 2018)	females	Deer, boar	200 g	1 meal/ years	5 meals/ year	up to 91 meals/ year (50 g/day)
		males		200 g	2 meals /year	10 meals/ year	
Italy	Ferri et al. (2017)	Hunters (n=766)	all	100-200 g			29.5±36.4 g/day (max. 100 g/day)
			boar				6.2±8.2 g/day
			hare				4.5±4.8 g/day
			roe deer				4.0±4.6 g/day
			wood-cock				4.14±4.79 g/day
			phea-sant				5.15±5.97 g/day
			thrush				5.54±8.00 g/day
Spain	(AESAN, 2012)	Non-hunters /hunters, Andalusia (n=199)				Non-hunters: 12 g/day (average) 31 g/day (P95)	Hunters: 23 g/day (average) 97 g/day (P95)
Spain	(Sevillano Morales et al., 2018)	hunters and relatives (n=377)	all				35 g/day
			Birds, small and large				8.57 kg/year 23.5 g/day
			deer, boar				4.2 kg/year 11.5 g/day
Switzerland	(Haldimann et al., 2002)						50 g/day

Ferri et al. (2017) reported among Italian shooters a mean ± SD consumption of game meat per person and month of 188 ± 249 g for boar meat, 137 ± 147 g for hare meat and 122 ± 141 g for roe deer meat. Calculating with 30.5 days per month, this would result in 6.16 ± 8.16 g/day for boar, 4.49±4.82 g/day for hare, and 4.00±4.62 g/day for roe deer.

For the purpose of this restriction proposal EFSA provided recent data on the consumption of game meat in the EU. ECHA considers that the 95th percentile of chronic consumption of game meat is a good proxy of high frequency consumers such as hunter households. The daily consumption of game meat as provided by EFSA is reported in Table B.9-34, separated for different groups of high frequency consumers. Of specific importance for this report are infants and toddlers that are specifically sensitive to lead-related IQ loss.

Table B.9-34 Consumption of meat from game hunted with lead bullets (EFSA data 10.06.2020)

Population	Game meat consumption (g/kg bw and day)		
	Min P95	Med P95	Max P95
Infants	0.891	1.667	2.147
Toddlers	0.114	2.219	5.245
Other children	0.710	2.630	11.920
Adolescents	0.334	1.149	2.454
Adults	0.252	1.560	6.597
Elderly	0.444	1.244	2.946
Very elderly	0.417	0.698	1.138
Pregnant women	1.566	1.566	1.566
Lactating women	4.635	4.635	4.635

Lead intake from game meat consumption and incremental PbB levels

Some information is available on daily lead intake for high game meat consumers (see also Table B.9-35).

Lindboe et al. (2012) investigated the lead content of ground meat from moose intended for human consumption in Norway. Fifty-two samples from different batches of ground meat from moose killed with lead-based bullets were randomly collected. In 81 % of the batches, lead levels were above the limit of quantification of 0.03 mg/kg, ranging up to 110 mg/kg. The mean lead concentration was 5.6 mg/kg, i.e. 56 times the European Commission limit for lead in meat. For consumers eating a moderate meat serving (2 g/kg bw), a single serving would give a lead intake of 11 µg/kg bw on average, with maximum of 220 µg/kg bw. Using Monte Carlo simulation, the median (and 97.5th percentile) predicted weekly intake of lead from moose meat was 12 µg/kg bw (27 µg/kg) bw) for one serving per week and 25 µg/kg bw (45 µg/kg bw) for two servings per week. From those data, ECHA calculated daily intake values for one meal per week of 1.7 (3.9) µg/kg bw/day and for two meals per week 3.5 (6.4) µg/kg bw/day.

Fachehoun et al. (2015) measured Pb concentrations in meat samples of white-tailed deer (*n* = 35) and moose (*n* = 37) shot with lead ammunition. Consumption of white tailed deer meat was 4.53 and 19.38 kg/year for mean and P95, respectively, and of moose meat 8.94 and 24.87 kg/year for mean and P95, respectively. Mean lead levels in white-tailed deer and moose were 0.28 and 0.17 mg/kg, respectively. P95 and maximum lead levels were 0.880 and 4.2 mg/kg for white-tailed deer and 1.40 and 2.0 mg/kg for moose, respectively. Following Monte Carlo simulations, the individual exposure dose for one game meal per week averaged 0.118 µg/kg bw/day with a 95th percentile of 0.305 µg/kg bw/day.

Gerofke et al. (2018) calculated daily lead intake for "extreme" consumers from hunter households. Assuming 91 game meals per year of 200 g/meal (50 g/day) with a mean lead concentration of 5.37 mg/kg meat, a mean daily Pb intake of 268.35 µg/day resulted. This would be 3.84 µg/kg bw and day for males (70 kg), 4.48 µg/kg bw and day for females (60 kg) and 16.61 µg/kg bw/day for children (16.15 kg).

ANSES (2018) assumed game meat consumption for heavy consumers with 50 g/day (200 g meat/meal; > 1 meal/week). For a mean lead concentration of 3.36 mg/kg meat a daily lead intake of 168 µg/day results. This would be 2.15 µg/kg bw and day for males (78 kg), 2.62 µg/kg bw and day for females (64 kg) and 4.41 µg/kg bw/day for children (19 kg).

Table B.9-35 Calculated lead intake in groups with high game meat consumption such as hunter families

Country Reference	Group (body weight)	Game meat consumption	Pb conc. in game meat (mg/kg = µg/g)	Daily Pb intake from game meat	
				(µg/day)	(µg/kg bw/day)
Sweden (Lindboe et al., 2012)		1 meal/week meal: 2 g/kg bw	5.6		1.7 (median) 3.9 (P97.5)
		2 meals/week meal: 2 g/kg bw	5.6		3.5 (median) 6.4 (P97.5)
Canada (Fachehoun et al., 2015)	Adults	1 meal/week	While-tailed deer: 0.28 (mean) Moose: 0.17 (mean)		**0.118 (mean)**
					0.007 (P50)
					0.305 (P95)
Germany (Gerofke et al., 2018)	Males (70 kg bw)	50 g/day (200 g/meal; 91 meals/years)	5.37 (mean)	268.35	**3.84 (mean)**
			0.02 (median)	1.00	0.01 (median)
			1.446 (P95)	72.30	1.03 (P95)
	Females (60 kg bw)	50 g/day (200 g/meal; 91 meals/years)	5.37 (mean)	268.50	**4.48 (mean)**
			0.02 (median)	1.00	0.02 (median)
			1.446 (P95)	72.30	1.21 (P95)
	Children (16.15 kg bw)	50 g/day (200 g/meal; 91 meals/years)	5.37 (mean)	268.35	**16.63 (mean)**
			0.02 (median)	1.00	0.06 (median)
			1.446 (P95)	72.30	4.8 (P95)

Country Reference	Group (body weight)	Game meat consumption	Pb conc. in game meat (mg/kg = µg/g)	Daily Pb intake from game meat	
				(µg/day)	(µg/kg bw/day)
France (ANSES, 2018)	Males (78 kg bw)	50 g/day (200 g/meal; >1 meal/week)	3.36 (mean)	168	**2.15 (mean)**
			0.010 (median)	0.50	0.006 (median)
			4.42 (P90)	221	2.83 (P99)
			24.2 (P95)	1210	15.5 (P95)
	Females (64 kg bw)	50 g/day (200 g/meal; >1 meal/week)	3.36 (mean)	168	**2.62 (mean)**
			0.010 (median)	0.50	0.008 (median)
			4.42 (P90)	221	3.45 (P90)
			24.2 (P95)	1210	18.9 (P95)
	Children (19 kg bw)	25 g/day (100 g/meal; >1 meal/week)	3.36 (mean)	84	**4.41 (mean)**
			0.010 (median)	0.25	0.013 (median)
			4.42 (P90)	110.5	5.82 (P90)
			24.2 (P95)	605	31.84 (P95)

PbB levels measured

Animals

Hunt et al. (2009) investigated the incidence and bioavailability of lead bullet fragments in hunter-killed venison. The authors radiographed 30 eviscerated carcasses of white-tailed deer shot by hunters with standard lead-core, copper-jacketed bullets under normal hunting conditions. All carcasses showed metal fragments (geometric mean = 136 fragments, range = 15–409) and widespread fragment dispersion. The authors took each carcass to a separate meat processor and fluoroscopically scanned the resulting meat packages; fluoroscopy revealed metal fragments in the ground meat packages of 24 (80%) of the 30 deer; 32% of 234 ground meat packages contained at least one fragment. Fragments were identified as lead by ICP in 93% of 27 samples. Isotope ratios of lead in meat matched the ratios of bullets, and differed from background lead in bone. Fragment-containing venison was fed to four pigs to test bioavailability; four controls received venison without fragments from the same deer. The total amount of lead fed to each pig was unknown, but quantitative analysis of similar packages from other deer in the study showed 0.2 to 168 mg (median 4.2 mg) of lead. Mean blood lead concentrations in pigs peaked at 22.9 µg/L (maximum 38 µg/L) 2 days following ingestion of fragment-containing venison, significantly higher than the 6.3 µg/L averaged by controls (see Figure B.9-11). The results indicate that after feeding in median 4.2 mg lead per pig, the PbB level increase was 17 µg/L. After 7 days the PbB levels returned to the baseline values.

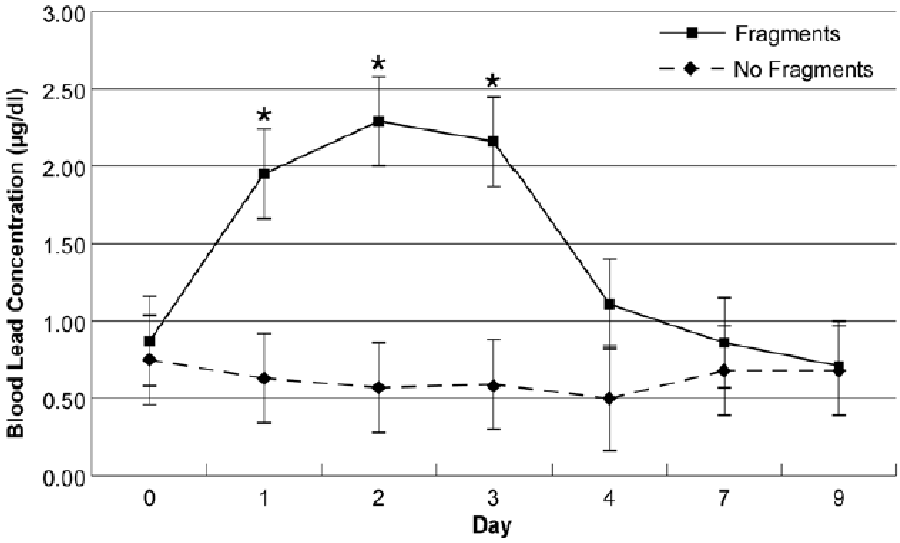

Figure B.9-11 Mean blood lead concentrations observed during swine feeding experiment. Mean (±SE) blood lead concentrations (µg/dL) in four pigs fed venison containing radiographically dense fragments (Fragments) compared with four control pigs fed venison without visible fragments (No Fragments) on days 0 and 1. Asterisks indicate days when means differed significantly between test and control groups. doi:10.1371/journal.pone.0005330.g002 (Hunt et al., 2009)

Humans

Adults

Studies reporting blood lead (PbB) levels in adults in relation to game meat consumption bagged with lead bullets are summarized in Table B.9-36.

It is to be noted that all studies have relevant shortcomings that limit their usefulness for assessment. As already stated, women usually have lower PbB levels compared to men and for hunters there is a significant contribution to the PbB level due to shooting activities and handling ammunition. Therefore, a reliable conclusion can only be drawn in case PbB levels for women and men are separated and between hunters and non-hunters (according to sex). Unfortunately, quite often PbB levels of males, which are usually the hunters, and of females, which are usually non-hunters, are available.

Haldimann et al. (2002) measured PbB levels from 25 male hunters and 6 female family members (incl. 2 female hunters) from the region of Bern, Switzerland. Compared to controls, PbB levels were lower for the female family member and slightly higher (increment 2 µg/L) for the hunters. However, no information on game meat consumption and hunting activities was provided for the controls, which consisted of samples from blood donors. Therefore, this study does not allow any conclusion related to PbB levels and game meat consumption or hunting activities.

Iqbal et al. (2009) investigated PbB levels from 736 males and females from six cities in North Dakota, aged 2-92 years, 80.8 % of whom reported a history of wild game consumption (venison, other game such as moose, birds; waterfowl excluded) and 55.5 % lead-related hobbies car/boat repair, lead casting, target shooting. PbB levels for males were 6 µg/L higher compared to females. For lead-relates hobbies such as casting bullets, hunting or target shooting the PbB level increment was 5 µg/L compared to persons with no lead-related hobbies as already mentioned above under the respective section. The consumption of game meat resulted increased the PbB level by 3 µg/L (GM;

95 % CI 1.6-4.4) which was adjusted for potential confounders. It has to be noted that blood samples were taken 4 to 5 months after the hunting season and that hunting activity as such was not analysed. The authors commented that recent consumption of wild game and the amount consumed per serving were also significant factors associated with higher PbB levels. For all game types, participants who reported consuming wild game within a month prior to the study had significantly higher PbB in comparison with those who did not consume wild game within that time frame. This could be explained by the fact that blood lead is an indicator of more recent exposure; in adults, the half-life of lead is approximately 30 days. Among participants who reported consuming other game such as elk or moose, an increase in PbB was also associated with a larger average serving size (>2 oz or 57 g).

Meltzer et al. (2013) performed a survey among hunters in Norway with regards to game meat (moose, deer) consumption ("The Norwegian Game and Lead Study" 2012). This study is also included in the opinion of the Panel on Contamination of the Norwegian Scientific Committee for Food Safety (Knutsen et al., 2013). The group consisted of 147 persons, 55 women and 92 men. Men showed mean measured PbB levels of 22.3 µg/L which were 7.3 µg/L higher compared to females with 14.7 µg/L. Persons consuming regular or often game meat (n=104) had PbB levels 7.7 µg/L higher compared to persons never consuming game meat (n=43). The result of an optimal multivariate linear regression analysis model for ln(blood lead) resulted in the following increase on PbB levels: 30 % higher for males compared to females, 18 % increase per 10 years of age, 9 % increase for wine consumption, 17 % increase for smokers, 31 % increase for regular/often cervid meat consumption, 52 % increase for making own bullets, 2 % increase for 100 shots per year, 4 % increase for purchased mined moose/deer meals per month, 2 % increase for own hunted minced moose/deer meals per months.

In "The Norwegian Fish and Game Study" (Meltzer et al., 2013) levels of different elements including lead were measured in adults with known high consumption of different environmental food-derived contaminants (n = 111) and random controls (n = 76). Complete data on biological measures were available for 179 individuals. Consumption of game and wine associated with small PbB increase. For high game meat consumers with up to 11 g/day (n = 59) PbB levels increased in median by 6.1 µg/L.

Bjermo et al. (2013) examined the body burden of lead, mercury, and cadmium in blood among Swedish adults and the association between blood levels, diet and other lifestyle factors. The frequency of game intake was associated with increase in PbB levels; after adjusting for age, gender, education, smoking, and plasma ferritin, PbB level increase for ≥1 game meat meal/month was about 3 µg/L.

The Swedish National Food Agency (Livsmedelsverket, 2014b) investigated persons from hunter families with mainly moose hunting and moose meat consumption. Data from adults in Riksmaten, who never ate game meat, were used as comparison. The study showed that adults from hunter families had PbB levels 5.3 µg/L higher than adults from Riksmaten. The difference was much higher for males (7.9 µg/L) compared to females (2.3 µg/L). An analysis showed that 35 adult women in hunter families who stated that they never shoot had 30 percent higher BPb levels compared to 33 women in Riksmaten who did not eat game. No significant trend was observed between PbB levels and increased consumption of game. However, PbB level increased with the number of shots fired. Firing 1-50 shots during the last 6 month increased the PbB level by 4.7 µg/L, firing > 50 shots during the last 6 months by 8.2 µg/L.

Fustinoni et al. (2017) (see also section 0 above) measured PbB levels from 95 subjects, 69 hunters and 26 non-hunters, 74 males and 21 females, recruited by local sections of the Italian recreational hunting association in different cities of North and Central Italy. Subjects who ate game meat in the week prior to blood sampling were not included to "*avoid the confounding effect of peak lead exposure that may follow such meals*". According to the authors, most game meat eaters were also hunters who mostly hunted more than ten times per year, and 20 of them also trained at the firing range, but only eight of them once or more each month. There was no preferred type of meat; meat from birds and mammals were consumed. It is not specified in the publication which mammals were hunted and which ammunition has been used. Median PbB levels were reported with 14 and 12 µg/L for female subjects with (n = 10) and without (n = 11) game meat consumption, respectively. For male subjects, median PbB levels were 36 and 23 µg/L with (n = 60) and without (n = 14) game meat consumption, respectively. For non-hunting subjects, median PbB levels were 14 and 15 µg/L subjects with (n = 8) and without (n = 18) game meat consumption, respectively. The sex of those non-hunting subjects was not specified; most probably most of those subjects were females. For hunters, median PbB levels were 36 and 40 µg/L with (n = 62) and without (n = 7) game meat consumption, respectively. Also for the hunters the sex was not specified; most probably most of those subjects were males. A multiple linear regression analysis performed by the authors (containing the covariates sex, age, hunting, wine drinking, game meat consumption, tobacco smoking, shooting range, and occupational exposure) found an association with hunting (PbB levels almost double in hunters) and wine drinking (40% higher in drinkers) but not with consumption of game meat or other parameters. The author comment that whether the higher PbB level was due to inhalation of lead fumes while shooting with lead ammunition, to handling lead ammunition or both could not be ascertained. It is to be noted that this study has several shortcomings. Major shortcomings are that the subjects that consumed game meat prior to the measurement of PbB levels were not included and that blood samples were collected in spring-summer which is outside the official hunting season for Italy (which is September to February). Therefore, the measured PbB levels do not reflect direct effects of game meat consumption or hunting activities on the PbB level.

Wennberg et al. (2017) measured concentrations of lead and cadmium in single whole blood samples from 619 men and 926 women participating in the Northern Sweden WHO MONICA Study on one occasion 1990–2014. Associations with smoking and dietary factors were investigated. Consumption of moose meat was asked for in 2014. In the adult population in northern Sweden, the median PbB in 2014 was 11.0 µg/L in young (25 – 35 years) men and 9.69 µg/L in young women. In an older age-group (50 – 60 years), the median PbB was 15.1 µg/L in men and 13.1 µg/L in women. PbB levels decreased from 1990 to 2009, after which time no further decrease was observed. PbB levels were higher in smokers than in non-smokers. In never-smokers, positive associations were found between PbB levels and consumption of wine and brewed coffee (women only). Higher PbB levels associated with consumption of moose meat was demonstrated in men, but not in women. PbB levels increased in men by 4.6, 5.6 and 17.2 µg/l for game meat consumption 1 time/week, 2 - 3 times/week, and 4-6 times/week, respectively, compared to males that never consumed gam meat. The trend observe was significant. However, hunting/shooting activities were not taken into account. For females PbB level was 3.3 µg/L higher for game meat consumption 2-3 times/week. Using multivariable linear regression adjusted for age, smoking and consumption of wine and spirits, an increase of 22% (95 % CI: 13 %, 31 %) in PbB for

weekly intake of minced meat or meat stew from moose was found in men, but no statistically significant association was found in women with 7 % increase (95 % CI: 2 %, 16 %) for weekly intake of minced meat or meat stew from moose.

Buenz and Parry (2018) reported the case of patient in New Zealand subsisting the previous 3 years solely on lead-shot meat. The patient used copper-jacketed lead bullets. He consumed 2 weighed meals per day of either 750 g ground meat (goat, red deer, or fallow deer) or one entire hare. Except for infrequent home-killed beef, he had no other food besides self-harvested meat. X-ray analysis of lead-shot meat provided by the patient revealed numerous metal fragments. PbB level of the patient was 747 µg/L. Conversion to lead-free ammunition was associated with a reduced blood lead level. Concomitant with his conversion to lead-free ammunition, a controlled experiment was performed using the patient's bullets to determine his daily lead intake from lead-shot meat. It was extrapolated that the patient was consuming 259.3 ± 235.6 µg of lead daily. The impact of lead from the hunting/shooting activity was not considered. Since the patient used copper-jacketed lead bullets, it might have been limited.

Caspersen et al. (2019) collected blood samples from 2982 women in gestational week 18 within The Norwegian Mother and Child Cohort study (MoBa) which were analyzed as part of the Norwegian Environmental Biobank. Women who reported to consume meat from game (n = 1368) had 0.5 µg/L higher median PbB levels (8.5 µg/L) compared to women who reported no consumption (n = 1614; 8.0 µg/L). It is to be noted that the amount of game meat consumption was not analysed and most likely reflects the consumption of game meat in the general population of Norway. The authors also reported that PbB levels increased with household income from 8.0 to 8.1 and 8.7 µg/L for low, medium and high income, respectively, increased when smoking during pregnancy from 8.1 to 9.4 µg/L, and increased with consumption of alcohol during pregnancy from 8.2 to 9.4 µg/L.

Vollset et al. (2019) analysed 300 breast milk samples from the Norwegian Human Milk Study. Median (min-max) PbB levels were < 0.67 (< 0.2 - 7.5) µg/kg breast milk. PbB levels were associated with intake of liver and kidneys from game. Compared to women never eating liver and kidneys from game (n = 190), its consumption (n = 102) was associated with an odds of having Pb breast milk concentrations above LOQ [OR = 2.03 (95 % CI: 1.19 – 3.49)] after adjustment for maternal age, maternal body mass index (BMI), education and number of siblings, and high seafood intake.

Table B.9-36 Blood lead (PbB) levels in adults following consumption of meat from game hunted predominantly with lead bullets

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
Haldimann et al. (2002), Switzerland	25 male hunters and 6 female family members (incl. 2 female hunters) from the region of Bern, Switzerland, game meat harvested with "lead shots", no information on species hunted or type of ammunition used; based on information from Kanton Bern 2018, hunted game consisted of roe deer, red deer and wild boar. Therefore, it is assumed that predominantly lead bullets were used for hunting.		
	AM±SD		
	43±19	Ref. F	Female blood donors (n=21; 23-64 years old)
	62±31	Ref. M	Male blood donors (n=21; 30-66 years old)
	41±6.4	Δ -2 (mean)	Female family members (n=6, 2/6 hunters; 21-60 years old)
	64±36	Δ +2 (mean)	Male hunters (n=25; 21-70 years old)
	Result: no increase in PbB levels in hunters or family members Comments: Result not reliable due to the following reasons: * No information on blood donors with regards to game meat intake or hunting; some individuals in the control group had blood lead levels that exceeded 100 µg/L * blood samples were taken outside hunting season hunting (February); authors indicated that game meat was consumed throughout the winter (frequency not specified); Sept. to Nov. with av. 2.2 (range 0.3-6) game meals/week (ca. 50 g per day); * Number of female family members very low * no correlation analysis (not possible due to missing information on controls) * for hunters regular indoor firearm training in "well-ventilated" indoor firing ranges * blood samples from voluntary donor blood of the same region (Bern, Swizerland) taken in August; not specified if game meat eaters or hunters or other hobbies		
Iqbal et al. (2009), USA	736 males and females from six cities in North Dakota, aged 2-92 year, 80.8% of whom reported a history of wild game consumption (venison, other game such as moose, birds; waterfowl excluded), 55.5% with lead-related hobbies car/boat repair, lead casting, target shooting etc.		
	GM; 95% CI		
	8.8; 6.6, 11.1		2-5 years of age (n=5)
	6.0; 4.1, 7.9		6-24 years of age (n=32)
	7.5; 6.5, 8.5		25-44 years of age (n=167)
	12.9; 12.3, 13.5		45-65 years of age (n=379)
	17.7; 16.9, 18.5		65 years of age or more (n=153)
	8.9; 8.1, 9.6	Ref.	Females
	14.9; 14.3, 15.4	Δ 6.0 (GM)	Males

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
	8.8; 8.1, 9.6	Ref.	No lead-related hobbies
	13.8; 13.2, 14.4	Δ 5.0 (GM)	Lead-related hobbies incl. casting bullets, hunting, target shooting
	8.4; 7.4, 9.4	Ref.	No consumption of game meat
	12.7; 12.2, 13.3	Δ 4.3 (GM)	Consumption of game meat
		Δ 3.0; 1.6–4.4 (GM; 95% CI)	Adjusted for potential confounders
	Results: Recent game consumption (<1 months) was associated with higher PbB levels; Increment of PbB 3.0 µg/L (1.6-4.4) from game meat consumption adjusted for potential confounders Comments ***** Blood samples taken 4-5 months after the hunting season ***** contribution by hunting not directly taken into account (only considered as lead related hobbies)		
Meltzer et al. (2013), Knutsen et al. (2013), Norway	"The Norwegian Game and Lead Study 2012": adult Norwegians in municipalities with typical cervid game consumption		
	mean±SD, median, min-max		
	19.4±10.5; 16.6, 6.0-69.3		Total group (n=147)
	14.7±7.0; 12.9, 6.2-35.4	Ref.	Women (n=55)
	22.3±11.2; 19.9, 6.0-69.3	**Δ 7.3 (mean)***	Men (n=92)
			Cervid consumption
	14.0±6.4; 12.5, 6.0-33.5	Ref.	Never (n=43)
	21.7±11.0; 20.1, 6.2-69.3	**Δ 7.7** (mean)*	Regularly/often (n=104)
			Self-assembled lead ammunition
	18.1±9.4; 15.6, 6.0-69.3	Ref.	No
	33.5±10.7; 31.4, 20-55.1	**Δ 15.4** (mean)*	yes
	Results: following multivariate regression analysis sign. PbB level increase for: * sex (men 30% higher PbB), age (18% higher PbB per 10 years age increase), wine consumption (9% higher PbB), smoking (17% higher PbB), regular/often cervid meat consumption (31% higher PbB), making own bullets (52% higher PbB), purchased minced meet (moose/deer; 4% higher PbB) compared to own minced meat (2% higher PbB)		
Meltzer et al. (2013), Norway	"The Norwegian Fish and Game Study": adults with known high consumption of different environmental food-derived contaminants (n=111) and random controls (n=76), complete data on biological measures were available for 179 individuals		
	median		
	21.3	Ref.	Female (n=98)
	28.3	**Δ 7.0 (median)**	Male (n=81)

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
			Consumption of game
	22.8	Ref.	1st tertile (0 g/day; n=58)
	22.2	-0.6 (Δ med.)	2nd tertile (up to 3 g/day; n=62)
	28.9	6.1 (Δ median)	3rd tertile (up to 11 g/d; n=59)
	Result: Consumption of game and wine associated with small PbB increase		
Bjermo et al. (2013), Sweden	273 adults in Riksmaten, Sweden, 2010-2011		
	median, 5-95 percentiles		
	12, 5.3-25	Ref.	Females (n=145)
	15, 7.0-29	Δ 3 (median)	Men (n=128)
	Estimated from Figure 3:		Game consumption, adjusted
	ca. 10 (mean)	Ref.	Never (n=51)
	ca. 11 (mean)	Δ 1 (mean)	<1 game meat meal/month (n=148)
	ca. 13 (mean)	Δ 3 (mean)	≥1 game meat meal/month (n=49)
	P_{trend}=0.01		
	Result: frequency of game intake was associated with increase in PbB levels; his was valid also after adjusting for age, gender, education, smoking, and plasma ferritin Comments: only few information in publication		
Livsmedelsverket (2014b), Livsmedelsverket (2014a), Sweden	Persons from hunter households in five areas of Sweden, 2012-2014; inclusion criteria such as men and women who regularly hunt; at least one person in the family eats game meat at least twice a month; mainly elk consumption		
	GM, 95% CI		Adults from Riksmaten
	11.0, 9.7-12.5	Ref. F+M	All adults (n=58)
	10.1, 8.5-11.9	Ref. F	Females (n=34)
	12.5,10.2-15.3	Ref. M	Males (n=24)
			Adults from hunter families hunting mutton, elk, deer, wild boar
	16.3, 14.8-18.0	Δ 5.3 (GM)	All adults (n=115)
	12.3, 10.7-14.2	Δ 2.3 (GM)	Females (n=51)
	20.4, 18.2-22.7	Δ 7.9 (GM)	Males (n=64)
	GM; 95% CI		PbB in relation to game meat consumption
	11.0, 9.7-12.5	Ref	Adults from Riksmaten not consuming game meat (n=58)
			Adults from hunter families
	20.0; 14.7-27.2	Δ 9.0 (GM)	1-3 times/month (n=6)
	15.9; 14.2-17.9	Δ 4.9 (GM)	1-3 times /week (n=85)
	17.3; 13.7-21.9	Δ 6.3 (GM)	≥4 times /week (n=22)

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
	GM; 95% CI		Adults from Riksmaten; PbB in relation to game meat consumption
	11.0; 9.7-12.5	Ref.	No game meat consumption (n=58)
	13.2; 12.3-14.2	Δ 2.2 (GM)	<1 times/month (n=152)
	16.6; 14.9-18.4	Δ 5.6 (GM)	≥1 times per month (n=63)
	GM; 95% CI		PbB levels relative to the number of shots fired last 6 months
	13.2; 12.6-14.0	Ref.	0 (n=46)
	17.9; 15.0-21.4	Δ 4.7 (GM)	1-50 (n=30)
	21.4; 18.4-24.8	Δ 8.2 (GM)	>50 (n=37)
	Results: Adults in hunter families had an average PbB of 16.3 µg/L, which is about 50% higher than the average content of randomly selected adults of the general Swedish population (11.0 µg/L). In hunter families no correlation between PbB and increasing game meat consumption but relationship between PbB levels and number of shots fired		
Fustinoni et al. (2017), Italy	95 subjects recruited by local section of the Italian recreational hunting association in different cities of North and Central Italy; there was no preferred type of meat (birds and mammals), no information if only lead shot was used or also lead bullets; subjects who ate game meat in the week prior to blood sampling were not included to "avoid the confounding effect of peak lead exposure that may follow such meals".		
	Median; 5^{th}, 95^{th} percentiles		
			No game meat consumption
	12; 7, 25	Ref. F	Females (n=11)
	23; 11, 59	Ref. M	Males (n=14)
			Game meat consumption
	14; 6, 74	Δ 2 (median)	Females (n=10)
	36; 12, 61	Δ 13 (median)	Males (n=60)
			Game meat consumption
	17; 10, 53	Ref.	None
	15; 6, 39		<5 game meat meals per year
	39; 3, 116	Δ 22 (median)	6-10 game meat meals per year
	35; 13 61	Δ 18 (median)	>10 game meat meals per year
			No hunting
	15; 7, 30	Ref.	No game meat consumption
	14; 6, 74	Δ -1 (median)	Game meat consumption (same values as for females consuming game meat)

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
			Hunting / no game meat consumption
	15; 7, 30	Ref.	No hunting(n=18)
	17; -	Δ 2 (median)	<5 hunts/year (n=1)
	42; 25, 59	**Δ 27 (median)**	>10 hunts/years (n=6)
			Hunting / game meat consumption
	14; 6, 74	Ref.	No hunting (n=8)
	13; --	-	<5 hunts/year (n=1)
	37; 15, 61	**Δ 23 (median)**	>10 hunts/years (n=61)
	Result: A multiple linear regression analysis (containing the covariates sex, age, hunting, wine drinking, game meat consumption, tobacco smoking, shooting range, and occupational exposure) found a significant association with hunting Comments: No appropriate separation of the data presented in the publication with regard to sexes. Results do not reflect direct effect of game meat consumption or hunting activities on the PbB levels because subjects with game meat consumption prior to measurement were not included and the measurement (spring-summer) was outside the hunting season		
Wennberg et al. (2017), Sweden	Adults in northern Sweden, 2014, consumption of minced meat or stew from moose		
	Median; min-max		
			Men: Consumption of moose meat
	12.4; 4.10-27.4	Ref.	Never (n=21)
	11.0; 6.74-88.2	-	Several times/year (n=78)
	12.3; 5.45-34.8	-	1-3 times/month (n=33)
	17.0; 5.92-39.2	Δ 4.6 (median)	1 time /week (n=16)
	18.1; 10.9-64	Δ 5.6 (median)	2-3 times/week (n=14)
	29.6; 15.0-102	Δ 17.2 (median)	4-6 times/week (n=4)
	Trend sign. p<0.001		
			Women: Consumption of moose meat
	9.30; 4.11-27.4	Ref.	Never (n=25)
	10.8; 3.64-47.0	Δ 1.5 (median)	Several times/year (n=74)
	12.1; 6.13-24.2	Δ 2.8 (median)	1-3 times/month (n=30)
	11.0; 5.77-33.0	Δ 1.2 (median)	1 time /week (n=18)
	12.6; 6.44-27.6	Δ 3.3 (median)	2-3 times/week (n=16)
	9.10	-	4-6 times/week (n=1)
	Trend not sign. p=0.177		

Reference	PbB (µg/L)	PbB (µg/L) calculated increment	Specification
	Result: * Higher PbB with consumption of moose meat was demonstrated in men, but not in women (Jonckheere-Terpstra test for trend) * Consumption of game meat 2-3 times/week increased PbB levels 45% in males and 35% in females * Using multivariable linear regression adjusted for age, smoking and consumption of wine and spirits, an increase of **22%** (95% CI 13%, 31%) in B-Pb for weekly intake of minced meat or meat stew from moose was found in **men**, but no statistically significant association was found in **women** [**7%** increase (95% CI − 2%, 16%) for weekly intake of minced meat or meat stew from moose]. * Authors also found positive associations between B-Pb and smoking and between B-Pb and consumption of wine and brewed coffee. Comments: * contribution of potential hunting/shooting activities not taken into account * amount of consumption not considered (potentially higher in men than in women)		
Buenz and Parry (2018), New Zealand	Case report of chronic lead intoxication from a patient subsisting solely on lead-shot meat shot with copper jacketed lead bullets; while eating lead-shot meat, the patient was consuming 259.3 ± 235.6 µg of lead daily		
	747 µg/L		PbB while subsisting solely on lead-shot meat
	Result: * Subsisting solely on lead-shot meat resulted in high (toxic) PbB levels * Conversion to non-lead ammunition was associated with a reduced blood lead level Comment: lead exposure from hunting was not considered. Therefore, it is not possible to conclude that the lead body burden was solely due to consumption of game meat.		
Caspersen et al. (2019), Norway	2982 women in gestational week 18, Norway (The Norwegian Mother and Child Cohort study) recruited 1999-2008, game meat consumption (reindeer, grouse, moose)		
	Median		Game meat consumption of women
	8.0	Ref.	no (n=1614; 54%)
	8.5*	Δ 0.5	yes (n=1368; 46%)
	Result: * Women who reported game meat consumption had significant higher median Pb concentrations (Kruskal-Wallis/Wilcoxon rank-sum test)) Comment: * No frequency and amount of game meat consumption reported For Comparison: * household income low and medium PbB 8.0 and 8.1 µg/L, household income high 8.7 µg/L * Smoking during pregnancy increased from 8.1 to 9.4 µg/L * Alcohol during pregnancy increased from 8.2 to 9.4 µg/L		

Children

Swedish Livsmedelsverket (2014b) investigated PbB levels in hunter families in relation to lifestyle factors and dietary habits. The participating families consisted of men and women (18 - 65 years), where at least one parent regularly pursues hunting, as well as their home children (3 - 17 years). An additional criterion for participation was that of at least one person in the family consumed game meat at least twice a month. More detail of such study are reported above under "Adults". No correlation was observed in children for PbB levels and the frequency of game meat consumption. The authors discuss that such a missing correlation must be interpreted with caution taking into account "measurement errors". For example, it means that the lack of association between PbB levels and intake of game (moose) in children should not be interpreted as showing that there is no uptake of lead through the consumption of game (moose). Among participating children, the distribution in the consumption of game was small, which hampered the possibility of demonstrating a possible association between intake of game and BPb levels in children.

Bressler et al. (2019) summarised the surveillance data on PbB levels of children in Alaska 2011 to 2015. The prevalence of elevated PbB levels (≥ 50 μg/L) was low among children tested (1.0 to 2.3 %). Several possible sources of exposure were identified among children with elevated PbB levels such as parental occupation (n = 40; 54%), game meat hunted with lead ammunition (n = 37; 50%), fishing weights (n = 10; 14%), lead ammunition or firearms (n = 9; 12%).

Kosnett (2009) estimated PbB levels in children associated with regular consumption of 100 g game meat per meal containing 1 ppm (1 mg/kg) lead due to contamination from lead ammunition (background level plus game meat increment). The authors derived the estimates from use of LeadSpread Verion 7 (DTSC, 2007), assuming geometric standard distribution of 1.6; ingestion constant (μg/dL/μg/day) of 0.16 for child (aged 3 to 5 years). The authors calculated relative bioavailability of 0.2 and 1.0 in relation to bioavailability of lead acetate. The estimated PbB levels represent Pb level increments attributed to game meta consumption added to 50th percentile PbB lead of 15 μg/L for child 1 - 5 years of age.

Table B.9-37 Estimated PbB levels in children from game meat consumption (Kosnett, 2009)

Game meat meals per week	Bioavailability relative to lead acetate	PbB levels (μg/L)		
		50th percentiles	Δ (increment to 50th percentile)	95th percentile
none	-	15	Ref.	
2	0.2	24	**Δ 9**	35
5	0.2	38	**Δ 23**	64
2	1.0	61	**Δ 46**	114
5	1.0	125	**Δ 115**	265

EFSA (2010) PbB calculated PbB levels using IEUBKwin version 1.1. resulting from the combined food, soil and dust, air and smoking exposure. Exposure of hunter families was not investigated specifically. For dietary lead exposure of average and high consumer PbB levels were calculated. The resulting PbB increment of high consumers were calculated with 2 µg/L for Infants 3 months breast milk, 2-5 µg/L for Infants 3 months infant formulae, 10-29 for Children 1 to 3 years, and 9-31 µg/L for Children 4 to 7 years (see Table B.9-38).

Table B.9-38 Calculated PbB levels in children for average and high consumers of lead in diet (EFSA, 2010)

Group	Calculated PbB levels (µg/L)		
	Average consumer	High consumer	Δ (increment average to high consumer)
Infants 3 months breast milk	3	5	**Δ 2**
Infants 3 months infant formulae	4-9	6-14	**Δ 2-5**
Children 1 to 3 years	18-48	28-77	**Δ 10-29**
Children 4 to 7 years	15-46	24-77	**Δ 9-31**

Qvarfort and Holmgren (2012) performed a risk assessment simulation using the Integrated Exposure Uptake Biokinetic Model (or IEUBK Model), developed by the US Environmental Protection Agency (US EPA) which showed that minced moose meat with a total lead metal content of 0.9 mg/kg ww, [The National Food Agency, Sweden 2012] and presuming bioaccessible part of metallic lead is only 2%, and assuming an uptake of 50%, (children) will cause a temporary increase of the blood lead level in a child to only 3.0 µg/L.

B.9.2.3. Sports shooting with shot shell ammunition

Chun et al. (2018) investigated the exposure to lead and other metals in 9 male and 5 female Korean clay shooting athletes in a covered outdoor shooting range. Exposure was 292 µg Pb/m^3 air measured with personal air samplers and 18.7 µg Pb/m^3 with group samplers. Mean PbB level and standard deviation was 45.2 ± 16.0 µg/L for both sexes combined. The differences in PbB levels were significant between the sexes with 36 ± 7.7 µg/L for females and 51 ± 16.4 µg/L for males. According to the authors, the PbB levels were higher than the upper limit of normal (data not provided). Mean PbB levels in the general population of Korea (2010 to 2011) were reported with 18.3 ± 7.9 µg/L for females and 22.2 ± 10.4 µg/L for males (Eom et al., 2017). The differences in PbB levels between the general population of Korea and the clay shooters were 18 and 29 µg/L for females and males, respectively. Chun et al. (2018) reported that PbB levels increased with increasing training frequency: 29 µg/L for 4 times/week (n = 1); 36.4±5.5 for 5 times/week (n = 7), and 58.2±15.5 for 6 times/week (n = 6). However, due to the marked sex-related differences in PbB levels, such a separation

according to training frequency would have to be performed according to sex. Without such a separation the presented data might be interpreted in a way that females trained less frequently compared to males.

B.9.2.4. Sports shooting with single projectile ammunition

The review by Laidlaw et al. (2017) provides information on the sources of potential lead exposure from shooting guns and firing ranges, mostly indoor shooting ranges. The authors note that most bullet projectiles are made from lead, and a large amount of lead may also present in the primer, composed of approximately 35% lead styphnate and lead peroxide (and also contains barium and antimony compounds), that ignites in a firearm barrel to provide the propulsion for the projectile (Tripathi and Llewellyn, 1990, Hawa et al., 2010, Basu, 1982, Meng and Caddy, 1997, Romolo and Margot, 2001). A portion of the lead bullet disintegrates into fine fragments while passing through the gun due to misalignments of the gun barrel (Tripathi and Llewellyn, 1990).

Lead particles, along with dust and fumes originating from the lead primer and the bullet fragments are ejected at high pressures (18,000–20,000 psi; 124–128 mpa) from the gun barrel, a large proportion of which occurs at right angles to the direction of fire in close proximity to the shooter (Tripathi and Llewellyn, 1990).

Figure B.9-12 shows a schematic outline of an outdoor and an indoor shooting range. In this case, the outdoor shooting range has a “roofed area” covering the shooter. Major differences are the larger dimension of an outdoor range compared to an indoor range and usually natural ventilation in the outdoor range and artificial ventilation in the indoor range.

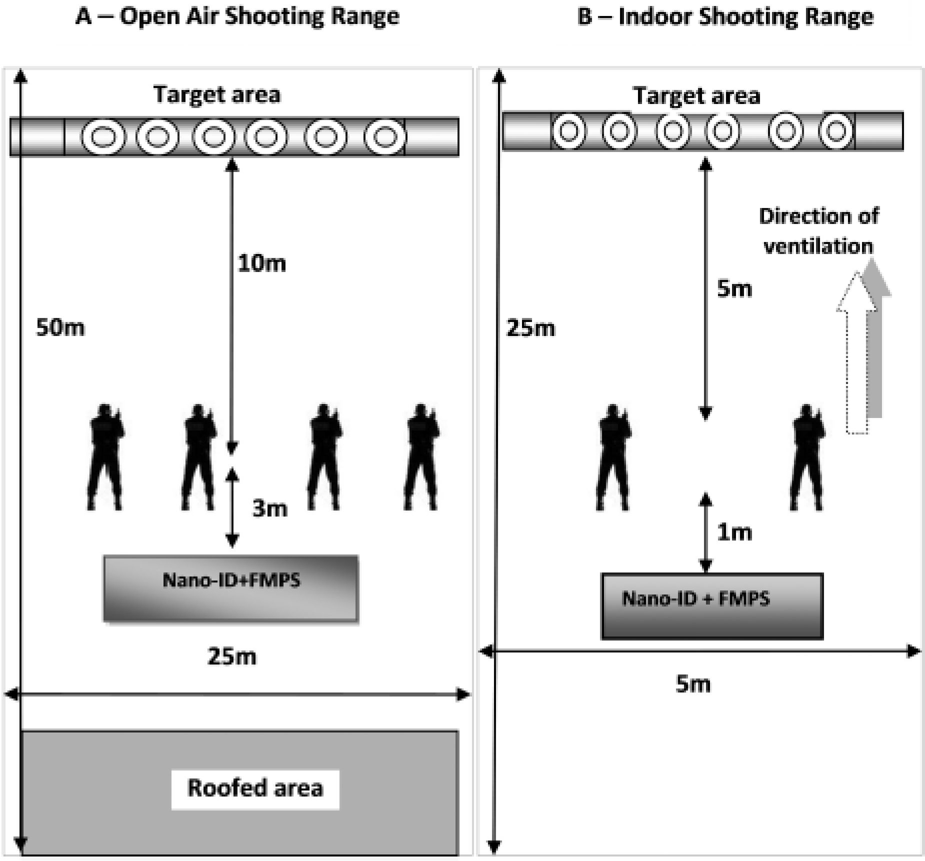

Figure B.9-12 Schematic outline of the situation on outdoor [panel A] and indoor [panel B] shooting ranges (Lach et al., 2015)

The shooter can inhale fine Pb particulates (mainly from the primer) which constitutes the primary exposure pathway. Fine and coarse particulates from both the primer and bullet fragments also attach to the shooter's hands, clothing, and other surfaces, and can be inadvertently ingested, providing a secondary lead exposure pathway (Dalby et al., 2010, Mathee et al., 2017). Deposition of lead-containing gunshot residues on hands, followed by hand-to-mouth activity, could contribute to elevated PbB levels (Bonanno et al., 2002). Finally, shooters may be exposed to lead that has accumulated in soil dust when changing targets at outdoor firing ranges.

Lead dust can adhere to shooter's clothes and potentially contaminate vehicles and homes. The CDC (1996) measured carpet dust lead concentrations in FBI student dormitory rooms and in 14 non–student dormitory rooms at a firing range and training facility. They observed that student dormitory rooms had significantly higher lead levels than non–student dormitory rooms, suggesting that the FBI students were contaminating their living quarters with lead. 'Take home lead' has been described mostly for occupational settings but given the fine particle nature and lead concentrations of dust associated with shooting, the 'take home lead' pathway of exposure from shooting must be recognised and curtailed (Laidlaw et al., 2017).

The practice to keep lead bullets in the mouth for shooting was reported for 17% of shooters investigated in South Africa with an average PbB increase of 82 µg/L (Mathee

et al., 2017).

The type of firearm, calibre and the facility where it is used also influence the potential magnitude of exposure. Generally, the potential for exposure decreases as follows: high-calibre handgun shooters > small-calibre (.22 calibre) handgun shooters > high-calibre rifle shooters > small-calibre (.22 calibre) rifle shooters > shotgun shooters > air gun shooters.

With respect to firing ranges, exposure potential would be highest at indoor facilities, lower at covered outdoor facilities and lowest at uncovered outdoor facilities. Ventilation controls can be employed to limit exposures, but success in exposure reduction varies as a function of system design. Whereas Prince and Horstman (1993) found that ventilation controls appeared to be only moderately successful in reducing air lead and blood lead levels, Crouch et al. (1991), Addy (1996), Halverson (1996) and Klien (2000) determined that the design, configuration and proper maintenance of the ventilation system in indoor ranges was critical, and could significantly reduce lead exposure.

Indoor shooting ranges

Indoor shooting ranges are not intended to be within the scope of this restriction

However, the information from indoor shooting ranges provide some useful information that would need to be adapted to the conditions of outdoor shooting ranges.

Lead concentration in air

Dams et al. (1988) measured lead concentrations in indoor shooting range from the use of Hirtenberger bullets. Stationary sampling at three locations in the range did not reveal large concentration gradients. Large concentration variations were observed by sampling before, during and after shooting. Lead concentrations peaked at 5 060 µg/m^3.

Svensson et al. (1992) measured higher air lead levels (time-weighted average 660 µg/m^3, range 112–2238 µg/m^3) in shooting ranges where powder charges were employed compared to ranges where air guns were used (4.6 µg/m^3, range 1.8–7.2 µg/m^3). Levels in the latter were in turn higher than those in ranges used for archery (0.11 µg/m^3, range 0.10–0.13 µg/m^3).

Following 64 min shooting with large calibre weapons (440 GK) in an indoor shooting range with an air flow of 0.05 m/s, Mühle (2010) measured the following lead concentrations:

- 4 500 µg/m^3 30 cm next to a shooter at head level,
- 2 240 µg/m^3 1.50 m behind the shooter, at the subject's head level without FFP-2 filter, and
- 10 µg/m^3 1.50 m behind the shooter, at the subject's head level provided with FFP-2 filter

Mean lead percentage in the dust of the shooting range was 59.9±7.7 %. Figure B.9-13 shows the concentration of the particle fractions while four shooters were using large-calibre short arms for one hour. The highest air dust concentrations were reached approximately 15 minutes after the start of shooting. The lead concentration dropped quickly to initial values after the end of the shooting session. The authors concluded that during full occupation of the shooting, ventilation capacity was not sufficient to sufficiently reduce the air dust concentration (Mühle, 2010).

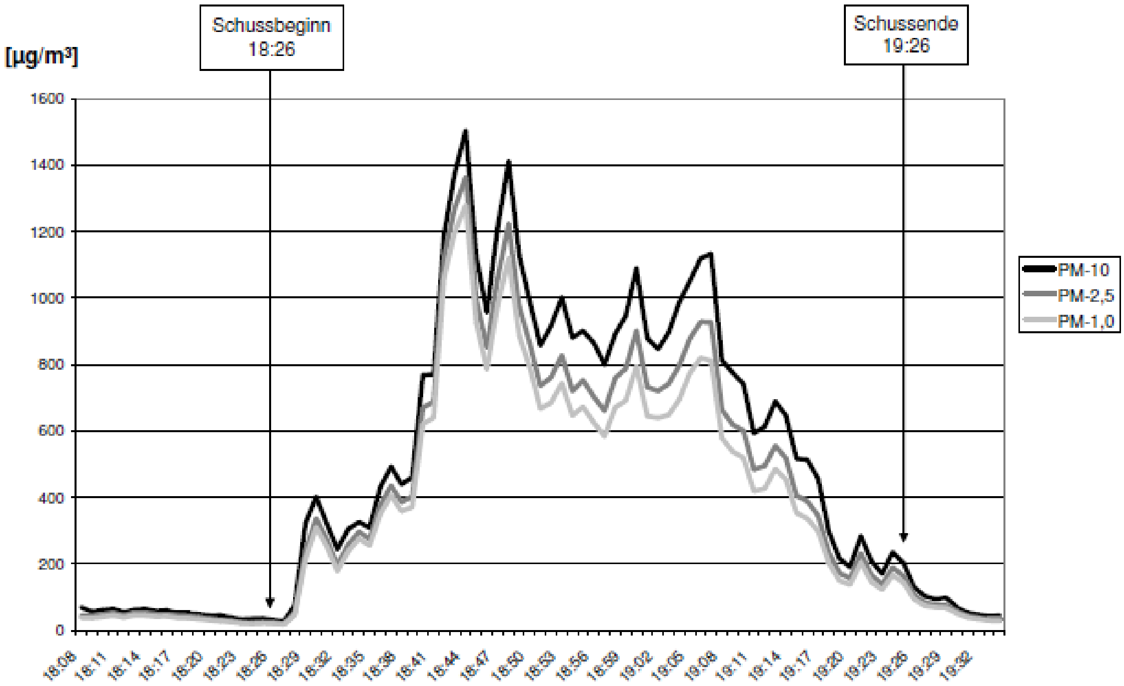

Figure B.9-13 Time course of lead concentrations in the air in an indoor shooting range with four sports shooters firing large calibre handguns (Mühle, 2010)

During the evaluation of the measurements of a publicly accessible indoor shooting range, an average lead concentration of 50 µg/m^3 was measured in the breathing zone of shooters (LGL, 2016). In the middle of the room and in the target area the concentrations were 890 and 750 µg/m^3, respectively. These concentrations were determined with the ventilation system switched on. The continuous measurements of the dust fractions determined concentration peaks of up to approx. 100 µg/m^3 in the breathing area of the shooters. Only at a time when a series of 20 shots was fired, a peak value of approx. 350 µg dust/m^3 was reached. The corresponding measured values in the middle area of the stand were significantly higher at around 700 µg/m^3 and 1 300 µg/m^3 respectively. Averaged over the sampling period, approx. 21 µg/m^3 dust was calculated as an alveolar fraction and approx. 26 µg/m^3 as a respirable fraction in the breathing area of the contactors. In contrast, the concentration of the alveolar dust in the middle of the plant was approx. 200 µg/m^3 and that of the inhalable fraction approx. 250 µg/m^3.

Lead in recovery rooms of shooting ranges

Mirkin and Williams (1998) implemented standard sampling protocols to evaluate lead contamination present in the bullet recovery room of the South Carolina State Law Enforcement Division's Firearms Department. Air sampling, skin wipes, and surface swabs were used to test for lead concentrations in the atmosphere, on the skin of personnel discharging weapons, and on walls and other surfaces present in the room, respectively. All samples were analysed by standard National Institute for Occupational Safety and Health methods using an inductively coupled plasma mass spectrophotometer. The atmospheric lead concentration, 4.1 ± 0.016 µg/m^3, was well below the threshold limit value, but was higher than expected considering the presence of a dedicated exhaust system in the bullet recovery tank. Furthermore, high skin contamination levels were reported for personnel whose only exposure to the room was

incidental contact with the walls. A survey of the room surfaces found mean lead concentrations to be 42.2 ± 0.42 mg/m^2. This study indicated that the concentration of lead present on the surfaces of the bullet recovery room presented a potential health hazard to personnel, and a thorough cleaning of the room using surfactant solution was recommended.

PbB levels

Svensson et al. (1992) found in 22 shooter who used powder charges significantly increased PbB levels during the indoor shooting season (before: median 106 µg/L, range 32–176 µg/L; after: 138 µg/L; range 69–288 µg/L), while 21 subjects who mainly used air guns displayed no significant increase (before: median 91 µg/L, range 47–179 µg/l; after: 84 µg/L; range 20–222 µg/l). Thirteen archers had significantly lower levels than the pistol shooters before the season, and showed a significant decrease during the season (before: median 61 µg/L, range 27–92 µg/L; after: 56 µg/L; range 31–87 µg/L). At the end of the indoor season, there was a significant association between weekly pistol shooting time and blood lead levels.

Demmeler et al. (2009) observed that the larger the calibre of the weapon, the higher the PbB levels of indoor-shooters. The following median PbB levels were reported in 131 sport shooters (9 females, 182 males) from 11 clubs with indoor shooting ranges in relation to the weapon used:

- airguns (n = 20): 33 µg/L (range 18 – 127 µg/L);
- airguns and 0.22 calibre weapons (n = 15): 87 µg/L (range 14 – 172 µg/L);
- 0.22 calibre and large calibre handguns (9 mm or larger) (n = 51): 107 µg/L (range 27 – 375 µg/L)
- large calibre handguns (n = 32): 100 µg/L (range 28 – 326 µg/L)
- only use of large calibre handguns (n = 11; International Practical Shooting Confederation shooters): 192 µg/L (range 32 - 521 µg/L).

The authors did not measure PbB levels in non-shooting persons but discussed that PbB levels for the German population were 33 µg/L in 1998 and further decreased since that time. They reported a clear difference between the uptake of lead from shooters using lead-containing cartridges and airgun users. The former group (n = 110) had a median of 105 µg/l (range 14 – 521 µg/l) whereas the latter (n = 20) had median PbB levels of 33 µg/l. PbB levels of the first group also depended on the training time or rather on the time of exposure within the period of 1 month. The Spearman's rank correlation coefficient of 0.395 ($P < 0.001$) showed an upward trend of PbB levels with the time spent on the range per month. PbB levels did not only depend on the factors mentioned above, but also on the rounds shot each month which were examined by analyses of quartiles. 27 marksmen shooting less than 200 rounds per month (1^{st} quartile) had a median of 87 µg/L (range 28 – 314 µg/L). 28 marksmen shooting between 200 and 399 rounds per month (2^{nd} quartile) had a median of 90 µg/L (range 27 – 315 µg/l). Shooters (n = 29) of the 3^{rd} quartile group which included 400–680 rounds per month had 118 µg/l (range 29 – 375 µg/L) whereas shooters (n = 23) of the 4^{th} quartile group (more than 680 rounds per month) had indeed 138 µg/l (range 37 – 521 µg/L).

Mühle (2010) reported in his thesis a high correlation between number of shots per months and increased PbB levels (even though the sample was fairly small).

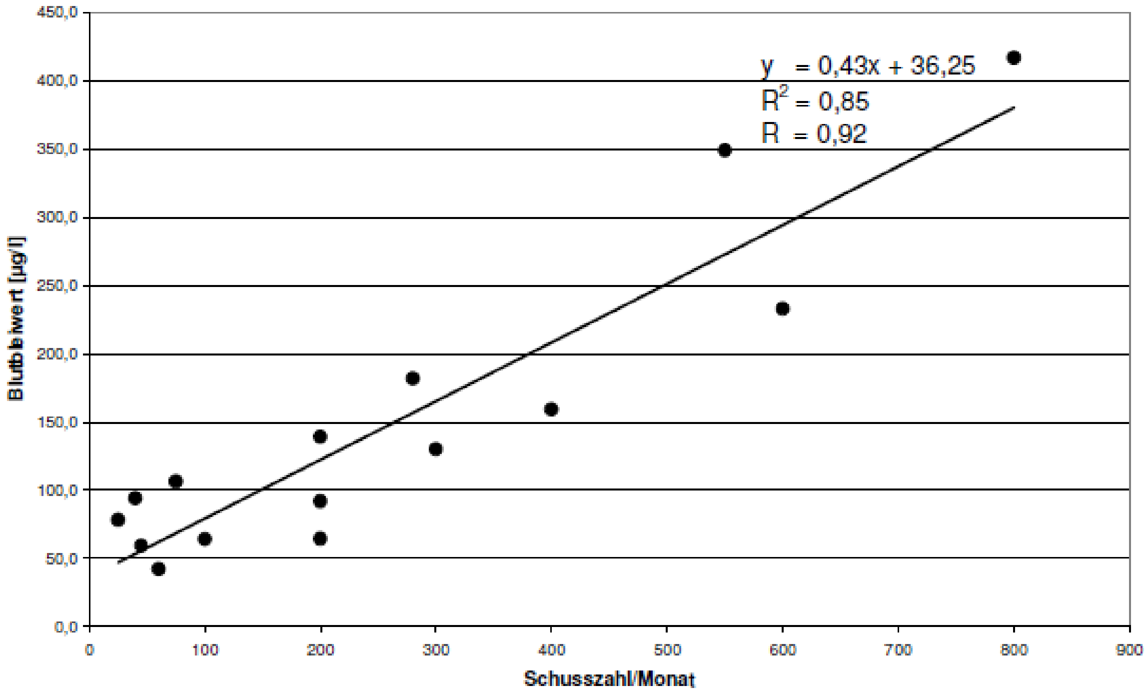

Figure B.9-14 Correlation of number of shots per month (Schusszahl/Monat) with PbB levels (Blutbleiwert) in indoor sports shooters (Mühle, 2010)

A recent review by Laidlaw et al. (2017), compiled existing literature from a broad range of recent studies of firing range users, employees, and their families, including indoor but mainly outdoor ranges, in an attempt to document and clarify risks by firing range use, setting, and shooting behaviour. The study focused on the use of lead primers and lead bullets. The study does not cover shooting ranges where lead shot is used although the concerns might be similar. The authors reviewed 36 articles that included blood lead levels (PbB levels) from shooters at firing ranges. In 31 studies, PbB levels > 100 µg/L were reported in some shooters, 18 studies reported PbB levels > 200 µg/L, 17 studies > 300 µg/L, and 15 studies PbB levels > 400 µg/L.

For indoor shooting ranges the quality of the ventilation system is important to limit exposure. Laidlaw et al. (2017) noted that there is a "lack of evidence" gap in the literature demonstrating that ventilation systems can maintain air lead levels at indoor ranges below the US OSHA (50 µg/m^3)[74] or California (0.5–2.2 µg/m^3) guideline.

Outdoor shooting ranges

Lead concentration in air

Significant overexposures to airborne lead were identified in a covered, outdoor firing range among seven cadets during firing of conventional, non-jacketed, lead bullets. The mean lead concentrations in general area air samples and personal-breathing-zone air samples were 68.36 µg/m^3 and 128.46 µg/m^3, respectively, calculated as an 8h, time-weighted average (TWA). Eight (44%) of 18 area air samples, taken as far as 50 yards from the firing line, and 10 (67 %) of 15 personal breathing zone air samples exceeded the current Occupational Safety and Health Administration (OSHA) standard for

[74] https://www.osha.gov/laws-regs/regulations/standardnumber/1910/1910.1025

occupational exposure to airborne lead (50µg/m³). Blood lead levels (using a *t*-test) were found to increase significantly in all cadets after day 2 ($p < 0.0001$) and day 5 ($p < 0.0007$) of firing conventional, non-jacketed, lead bullets. None of the blood level values exceeded the OSHA standard of 400 µg/L. A strong positive correlation ($r = 0.92$; $p < 0.000001$) existed between personal-breathing-zone air lead levels and the number of rounds fired by the cadets. A positive correlation also existed between blood lead levels and cumulative personal breathing zone air lead levels ($r = 0.85$; $p < 0.02$), as well as the total number of rounds fired ($r = 0.84$; $p < 0.02$). Based on environmental and medical data, it was concluded that a potential health hazard may exist due to inorganic lead exposure to cadets at this covered outdoor range during firing exercises (Tripathi et al., 1989).

Lead concentrations were measured in the breathing air near chest and face of two instructors in a covered outdoor shooting range while cadets were firing non-jacketed and jacketed lead ammunition with police revolvers. For the non-jacketed bullets mean lead concentrations were 67.1 µg/m³ (range 36.7-95.6 µg/m³) and 211.1 µg/m³ (range 49.1-431.5 µg/m³) for the two instructors, respectively. Using copper-jacketed bullets, lead concentrations in the air were reduced by more than 90% to 5.4 and 8.7 µg/m³ (Tripathi et al., 1991).

Table B.9-39 Lead concentrations in the air related to outdoor shooting activities

Reference	Pb air (µg/m³) Measured	Pb air (µg/m³) increment	Specification
Tripathi et al. (1991)	PbB levels in breathing zone air and blood were measured in two instructors not involved in shooting; cadets were using 38 calibre police revolvers firing a total of 950, 1 539, 3 000 non-jacketed, and 2 160 jacketed lead bullets on 4 different days		
	Mean; range, 8-h TWA		Non-jacketed lead bullets
	0.8; 0.3-1.2	Ref	Background
	87; 3.8-299	Δ 86.2	General area air sampled during firing
	67.1; 36.7-95.6 (n=3)	Δ 66.3	Instructor 1 (breathing zone sampling)
	211.1; 49.1-431.5 (n=3)	Δ 210.3	Instructor 2 (breathing zone sampling)
	Individual measurements, 8-h TWA		Jacketed lead bullets
	0.5	Ref	Background
	9.5	Δ 9.0	General area air sampled during firing
	5.4 (n=1)	Δ 4.9	Instructor 1 (breathing zone sampling)
	8.7 (n=1)	Δ 8.2	Instructor 2 (breathing zone sampling)
	Results: * All personal breathing zone lead level samples were above the OSHA standard of 50 µg/m³ when using non-jacketed bullets * Use of copper-jacketed ammunition resulted in an 89 percent reduction in lead levels in general area air samples		

Bonanno et al. (2002) performed an initial investigation into lead exposure to target shooters using an outdoor covered pistol range. Lead concentration in air was measure in the breathing zone (collar) of the shooters. Airborne lead and lead dust levels were

also examined on horizontal surfaces and shooters hand. The effects of ammunition calibre, ammunition type and shooting season on airborne lead levels were investigated. During summer season, the front wall of firing lanes was removed in order to improve ventilation. In two competitions (one in summer 8/29 and one in winter season 11/7) each participant fired 120 rounds, 60 rounds with 22 calibre and 60 rounds with centre-fire (45 calibre) total firing time was about 1 hour. In the third competition (during winter time 11/20) 60 rounds with centre-fire using a specific low lead 45 calibre ammunition (WinClean™). The use of larger calibre resulted in higher lead concentration in the air and of lead dust on the hand of the shooter. The use of lead-reduced 45 centre fire ammunition resulted in a 99 % reduction of lead in the breathing air.

Table B.9-40 Lead in air and on the hand of short shooters in a covered outdoor shooting range (Bonanno et al., 2002)

Date	Front wall	Active ventilation	Type of ammunition	Number shooters/ shooters sampled	22 calibre		45 centre fire	
					Pb air µg/m³	Pb on hand µg	Pb air µg/m³	Pb on hand µg
8/29/99	Off	Not present	Un-controlled	9/8	286	233	579	324
11/7/99	On	Present – running	Uncontrolled	14/9	235	50	1558	353
11/20/99	On	Present - off	Low-lead	6/6	—	—	ca. 15 (99% reduction)	—

Lach et al. (2015) studied aerosols formed during shooting events in indoor and outdoor shooting ranges. Conventional (TOX) and so called 'green' ammunition (NON-TOX) was used, where the composition of primers does not contain lead, barium, or antimony. Lead concentrations were not measured by personal sampling but **stationary** with devices placed one and three meters behind the shooter for the indoor and the outdoor range, respectively. The total measured lead mass aerosol concentration ranged from 2.2 µg/m³ for indoor shooting with NON-TOX ammunition (primer without Pb), to 10 µg/m³ for outdoor shooting with TOX ammunition (primer with Pb) and to 72 µg/m³ (for indoor shooting with TOX ammunition). The proportion of the total mass of airborne particles deposited in the respiratory tract varied from 34 to 70%, with a median of 55.9% as calculated using the ICRP lung deposition model.

Wang et al. (2017) measured from one shooter the task-based personal exposure to total fume, lead, and acidic gasses during two-hour shooting sessions at indoor and outdoor shooting ranges. Both pistols with a short barrel (Sig Sauer P226, Newington, NH) and rifles rifle with a long barrel (Rock River Arms AR15, Colona, IL) were used. The pistol used 9 x 19 mm Parabellum (also known as Luger) ammunition (Winchester, Alton, IL), while the rifle fed .223 Remington ammunition (Remington, Madison, NC). Both types of ammunition had full-metal-jacketed bullets with brass casings. The pistol ammunition contains typically a loading of 0.5 to 0.6 g propellant, whereas the rifle ammunition 2.3 g propellant. The shooter wore three different personal samplers to his collar at the same time. Each sampling lasted for two hours, during which the shooter

fired about 180 ± 3 rounds of ammunition. The sampling was repeated for at least five times per combination of types of firearms and ranges (total n = 23). The 2-hour sampling period ensured a sufficient amount of mass collected for the analytical instrument and represented a reasonable time a casual shooter would spend at a shooting range per day. Only one type of firearms was used during each sampling period. The results indicated that significant amount of aerosol mass was in the respirable fraction (400–2800 μg/m^3) and inhalable fraction (600–3500 μg/m^3). The respirable airborne lead concentration during two-hour shooting sessions was between 200 and 1700 μg/m^3 (see Figure B.9-15), although not directly comparable, were exceeding the Occupational Safety and Health Administration 8-h time-weighted-average permissible exposure limit (PEL) of 50 μg/m^3. **Indoor ventilation effectively removed gaseous pollutants, but was unable to reduce the particulate fume and lead exposure to acceptable levels.** Outdoor ventilation relied more upon natural weather and had a larger deviation. The authors discuss the high fume and lead concentrations for outdoor rife shooting with the calm weather condition resulting in little natural dilution.

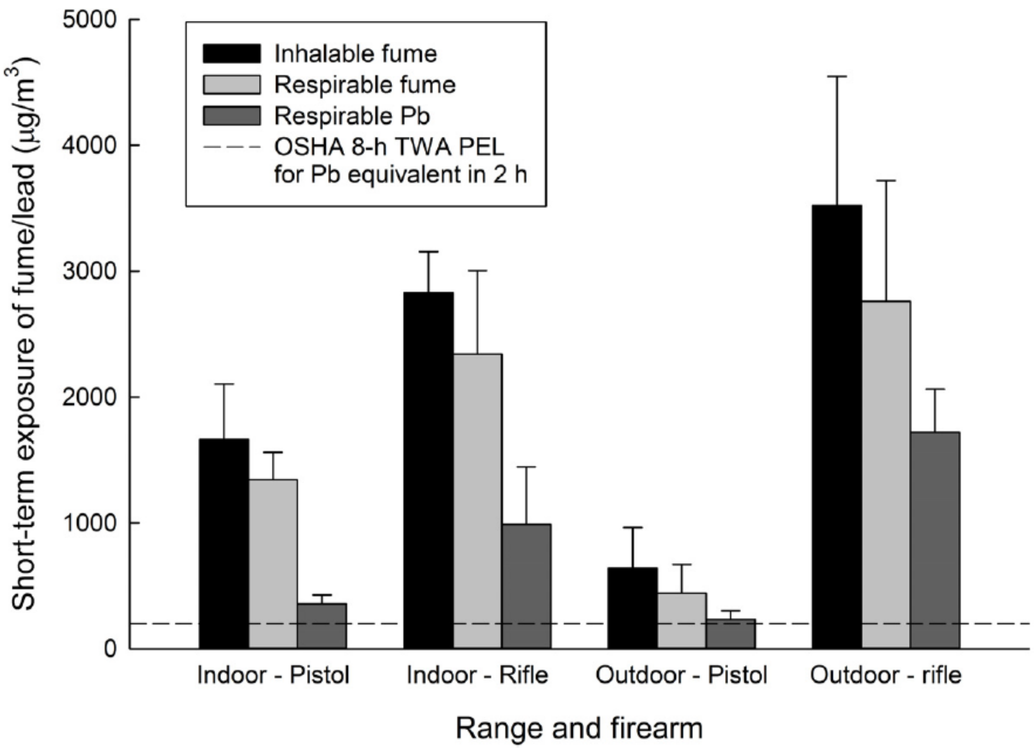

Figure B.9-15 Shooter's short-term exposure to inhalable, respirable fume, and respirable lead with different firearms at indoor and outdoor ranges. The dashed line represents the OSHA 8-h TWA PEL converted to 2-h equivalent (200 mg/m^3) (Wang et al., 2017)

PbB levels

The City of Los Angeles assessed exposure of its full-time shooting instructors at uncovered outdoor ranges via air monitoring and blood lead-level measurements because excessive lead exposure in shooting instructors at indoor firing ranges and covered outdoor firing ranges has been documented. PbB levels in seven firing range instructors (outdoor shooting ranges) were 410 ± 100 μg/L (range 280-660 μg/L) before a training event, 450 ± 100 μg/L (range 280-700 μg/L) after the training event and

310 ± 50 µg/L (range 280-380 µg/L) 6 months after the training event (Goldberg et al., 1991).

Tripathi et al. (1991) investigated two instructor not involved in firing. Cadets fired a total of 950, 1,539, 3,000 nonjacketed, and 2,160 jacketed bullets on June 18, 19, July 7, and September 4, 1987, respectively. The total number of cadets involved in firing were seven, seven, six, and six on June 18, 19, July 7, and September 4, 1987, respectively. Thirty-eight caliber police revolvers and conventional, nonjacketed lead bullets (.38 special caliber, manufactured by 3D Inv, Inc., Doniphan, NE) were used, as well as totally copper-jacketed lead bullets (.38 caliber special ammunition, Omark Industries, Lewiston, IA). After the use of nonjacketed bullets PbB levels were 60 and 41 µg/L higher than the first measurement for instructor 1 and 24 µg/L higher than the first measurement (see Table B.9-41). However, since the PbB values for pre-exposure baseline (June 17) and the PbB values measured on June 18 are identical numbers, there is some uncertainty with those reported data not allowing a quantitative conclusion.

Table B.9-41 Blood lead levels related to sports shooting activities (Tripathi et al., 1991)

Pb air (mg/m^3) personal sampling	PbB blood	PbB (µg/L) increment	Specification
Instructor 1			
			Jacketed bullets
0.8	*1)*		Before shooting June 17
36.7	209 µg/L (1.01 µmol/L)	*2)*	After shooting June 18
95.6	269 µg/L (1.30 µmol/L)	*2)*	After shooting June 19
69.0	250 µg/L (1.21 µmol/L)	*2)*	After shooting July 7
			Non-jacketed bullets
5.4 (92% red.)	220 (1.06 µmol/L)	*3)*	After shooting September 4
Instructor 2			
			Jacketed bullets
0.5	*1)*		Before shooting June 17
49.1	99 µg/L (0.48 µmol/L)	*2)*	After shooting June 18
431.5	123 µg/L (0.77 µmol/L)	*2)*	After shooting June 19
152.6	123 µg/L (0.77 µmol/L)	*2)*	After shooting July 7
			Non-jacketed bullets
8.7 (96% red.)	130 (0.63 µmol/L)	*3)*	After shooting September 4

1) for background PbB levels the same values as measured for June 18 were provided which does not seem correct
2) Not possible to calculate the PbB increment due to obviously wrong background PbB values
3) Not possible to calculate the PbB increment due to missing background PbB values

Löfstedt et al. (1999) reported that measured PbB levels in male officers (n=575) was 0.24mmol/L (50 µg/L); range 0.05–0.88 mmol/L (10–182 µg/L), and in female officers

(n=53) it was even lower (0.18mmol/L; 37 µg/L). Occupational shooting mostly involved handguns whereas rifles dominated during recreational shooting. The type of ammunition was not specified. There was no systematic information about the relative frequency of indoor vs. outdoor shooting. Apart from shooting exercises, five officers reported lead exposure from various previous or ongoing occupational (car mechanic, metal worker, petrol contacts) or recreational (tin solder and bullet casting, respectively) activities. For both sexes combined, a positive correlation of PbB levels with the number of bullets annually fired both on and off duty was observed, and this finding remained in a multiple regression analysis including age, smoking habits, and latency from last shooting exercise.

Gulson et al. (2002) measured the concentration and isotopic composition of lead in blood over a 15-month period for a subject who undertook recreational shooting in outdoor and indoor firing ranges on an irregular basis with use of dominantly cast lead bullets in the outdoor range. The authors have also measured the isotopic composition in cast lead, Cu-jacketed and Teflon-coated bullets, propellant and primer from which he assembled the cartridges. The first PbB level measurement with 32 µg/L was taken after 4 month without shooting but one week after outdoor shooting of 80 rounds with cast lead 9 mm ammunition (silver shadow). Therefore, this PbB level is not expected to be the true background (baseline) value for this subject. The PbB level increased to 67 µg/L following 4 visits in an outdoor shooting range during 4 months. 1st visit with 130 shooting rounds and the use of a mix of casted lead bullets and copper bullets, 2nd visit with 130 rounds and the use of copper jacketed bullets, 3rd and 4th visits with 80 rounds and the use of cast lead bullets. PbB level was measured (31 Aug 1999) 13 days after the last shooting. Next PbB level of 66 µg/L was measured (6 Dec 1999) about 2 months after another outdoor shooting round session (80 rounds, cast lead bullets). Three indoor shooting sessions followed with 200, 80 and 80 rounds (21 Dec 1999, 5 Jan, 6 Jan 2000) using copper jacketed – mix speer bullets. PbB level measured about one month later (1 Feb 2000) was 54 µg/L and dropped to 38 µg/L after 2 month without shooting (10 April 2000). It has to be noted that it is not recorded when casting of the lead bullets took place, which is also a relevant source of lead exposure.

Gelberg and DePersis (2009) reviewed the New York State Heavy Metals Registry for information on individuals who had lead exposure from target shooting. This registry received reports on all New Yorkers tested for lead. Overall, 598 individuals have been reported with exposures from target shooting. Over one half (n = 384) had non-occupational exposures. These individuals were reported more frequently with elevated blood lead levels (over 400 µg/L) than those with occupational exposures. Hobby target shooters were reported to be at significant risk of having elevated blood lead levels.

In a pilot project, which is published only as an abstract, Turmel et al. (2010) measured blood lead levels and pulmonary function in 12 biathletes using a gun powder cartridge containing a lead bullet of 2.6 grams. 12 cross-country skiers of similar for age, sex, anthropometric status, number of training hours per week and prevalence of atopy were used as controls. Lung function did not differ between the groups but mean PbB levels in biathletes (0.087 ± 0.015 µmol/L; 18 ± 3.1 µg/L) was slight but significantly higher compared to the cross-country skiers (< 0.04 ± 0.0 µmol/L; < 8.3 µg/L). The type of ammunition used was not specified. The difference in PbB levels between biathletes and cross-country skiers was ≥10 µg/L.

Tagne-Fotso et al. (2016) investigated two thousand inhabitants of northern France (general polulation), aged between 20 and 59 years. The geometric mean of the PbB

level was 18.8 µg/L (95% confidence interval [CI]: 18.3 – 19.3). Occupational factors affected PbB Levels only in men and represented 14% of total explained variance of PbB levels. External occupational factors significantly increasing mean PbB levels were tobacco, consumption of some beverages (wine, coffee, tea, and/or tap water), raw vegetables, housing characteristics (built prior to 1948, Pb piping in the home) and do-it-yourself or leisure activities (paint stripping or rifle shooting). Rifle shooting during the previous two days was related with a significant elevation in mean PbB levels and also risk of having a PbB level higher than the 90th percentile; however, this activity only concerned a small number of people (6 people). Consumption habits accounted together for 25% and 18% of the total explained variance, respectively, in men and women. Industrial environment did not significantly contribute to PbB level variations.

Mathee et al. (2017) investigated in South Africa 87 shooters (80 males, 7 females) from one outdoor and three indoor shooting ranges and as controls 31 archers (23 males, 8 females) from three archery ranges. Eight gun shooters also worked at a range. The mean experience in shooting was 22 years. 92 % of the shooters used non-jacketed lead bullets and 54 % of the shooters were also hunters. Shooters had significantly higher PbB levels compared to archers (see Table B.9-42). The twelve shooters from the outdoor shooting range had on average a 43 µg/L higher PbB level (70 ± 42 µg/L) compared to 20 archers (27 ± 14 µg/L) (of which 19 did not perform gun shooting). PbB levels for shooters training in three indoor shooting ranges were in mean 78, 134 and 165 µg/L higher (105 ± 70 µg/L, 161 ± 98 µg/L, 192 ± 163 µg/L) compared to the 20 archers (27 ± 14 µg/L). Considering all gun shooters, irrespective of indoor or outdoor training, PbB levels were 42 µg/L lower for females compared to males. Shooters with higher shooting frequency (more than monthly) showed higher PbB levels compared to shooters shooting less frequently (less than monthly). Casting of own bullets increased the PbB levels by 22 µg/L, hunting by 34 µg/L and placing bullets in the mouth by 82 µg/L.

Table B.9-42 Blood lead levels related to sports shooting activities (Mathee et al., 2017)

PbB (µg/L) **Measured or calculated**	**PbB (µg/L)** **increment**	**Specification**
Mean±SD; median; range		**All shooters (arch and gun)**
		Type of range (all shooters)
27±14; 20, 20-61	**Ref.**	Archery 1 (n=20; 5% gun shooters)
37±25; 20; 20-104		Archery 2 (n=14; 50% gun shooters)
44±22; 39; 20-82		Archery 3 (n=11; 55% gun shooters)
70±42.6; 73; 20-172	**Δ 43 µg/L**	**Outdoor range (n=12)**
105±70; 91; 20-377	Δ 78 µg/L	Indoor range 1 (n=30)
161±98; 139; 61-428	Δ 134 µg/L	Indoor range 2 (n=17)
192±163; 161; 20-600	Δ 165 µg/L	Indoor range 3 (n=14)
Mean±SD; GM (CI)		**Gun shooters only**
		Sex
78±71; 53 (26-108)	Ref.	Female (10%)
120±104; 89 (75-106)	Δ 42 µg/L	Male (90%)
P 0.065		

PbB (µg/L) Measured or calculated	PbB (µg/L) increment	Specification
 84±55; 66 (48-91) 118±87; 86 (64-117) 143±152; 101 (71-144) *P 0.001* 125±97; 98 (49-197)	 Ref. Δ 34 µg/L Δ 59 µg/L Δ 41 µg/	Frequency of shooting Less than monthly (27%) > monthly, but less than weekly (41%) > weekly, but <3 per week (24%) >3 times per week (8%)
 120±75; 99 (81-121) 111±125; 71 (53-95) *P 0.056*	 Ref. --	Usual duration of shooting < 1 h (51%) > 1 h (49%)
 115±81; 91 (76-109) 137±159; 86 (54-138) *P 0.81*	 Ref. Δ 22 µg/L	Casting of own bullets No (78%) Yes (22%)
 107±23; 84 (70-100) 185±175; 125 (76-205) *P 0.080*	 Ref. Δ 82 µg/L	Place/keep bullets in mouth No (83%) Yes (17%)
 98±78; 75 (58-96) 132±118; 95 (75-122) *P 0.162*	 Ref. Δ 34 µg/L	Hunts No (46%) Yes (54%)

Vandebroek et al. (2019) investigated, among others, police officers (n=10) having shooting training only a few times a year. The police officers indicated that they used only 9 mm ammunition. The provided 9 mm ammunition consisted of a lead bullet totally covered by copper and a NON-TOX primer (not containing antimony, barium, or lead). PbB levels increased from mean 14.1 µg/L before shooting training to a mean of 14.7 µg/L after the training.

B.9.2.5. Shooting with air rifle

Svensson et al. (1992) reported in air gun ranges lead concentrations in the air of 4.6 µg/m^3 (time-weighted average) and a range of 1.8–7.2 µg/m^3. In 21 individuals who primarily used air rifles no significant increase in PbB levels was observed. Before shooting season the median was 91 µg/L (range 47–179 µg/l), after the season 84 µg/L (range 20–222 µg/L). However, no information is available on the PbB levels directly after a shooting session.

Demmeler et al. (2009) reported for 20 air gun shooters PbB levels of 33 µg/L (range 18–127 µg/L). The authors did not measure PbB levels in non-shooting persons but discussed that PbB levels for the German population were 33 µg/L in 1998 and further

decreased since that time. Due to missing control persons, the data cannot be used for a quantitative conclusion.

A case report of a male 78-year adult was published that showed elevated PbB levels (initial two measurements 130 and 176 µg/L). The patient did not apply hygiene measures (hand washing, using gloves or mask, changing clothes), the ventilation in the shooting are was insufficient and he used inappropriate techniques for cleaning. After advice on appropriate personal hygiene measures, the PbB levels did not changed in a follow up (172 µg/L). The patient reported that he had cleaned his shooting area from significant dust on the reloading bench with without wearing a face mask. In a further follow up the PbB level even increased (240 µg/L); the patient reported to perform indoor target shooting (three to five lead pellets from an air pistol per evening) and that he had vacuum cleaned the bullet trap where the lead pellets disintegrated (Johnson-Arbor et al., 2020). This case report shows high PbB levels following indoor shooting and inappropriate hygienic measures to clean the bullet trap.

There have been numerous reports of lead poisoning resulting from the ingestion of foreign bodies. A case involving the ingestion of spent air rifle pellets is described. No clinical symptoms were observed, despite the fact that the young child exhibited elevated blood lead levels as high as 2.7 µmol/L (560 µg/L). X-rays of the child's abdomen confirmed the ingestion of the pellets. The patient was treated with laxatives, and the pellets were successfully passed over the course of the next few days. Prior to release from the hospital, the child's blood lead level had dropped to 1.7 µmol/L (350 µg/L) (Treble and Thompson, 2002).

B.9.2.6. Lead in fishing sinkers and lures

Handling fishing tackle

Sahmel et al. (2015) found that simply handling fishing sinkers resulted in deposition of lead on the skin and that an average of 24% of this lead could be transferred from the hands to the mouth.

Home-casting of fishing tackle

Several reports or studies have been published describing toxicity symptoms in persons melting lead or in children living in the vicinity of lead melting activities. As an extreme example, an Alaskan adult male patient suffered from lead poisoning as a result of inhaling lead dust and fumes from melting and casting lead for several years. This patient was anaemic and showed a high level of neutrophils. The PbB level was 1330 µg/L, the highest PbB level ever recorded in Alaska (State of Alaska Epidemiology, 2001).

Brown et al. (2005) assessed children's and their caregivers' PbB levels and risk factors for lead exposure in Chuuk State, Federated States of Micronesia. Children aged 2-6 years were randomly selected within 20 randomly selected villages. Mean PbB levels were 39 µg/L for children and 16 µg/L for caregivers. Children with PbB levels ≥ 100 µg/L (elevated) were 22.9 (95% CI: 4.5-116.0) times more likely to have a caregiver with elevated PbB levels, 6.2 (95% CI: 1.4-27.3) times more likely to live on an outer island, and 3.4 (95 % CI: 1.7-6.9) times more likely to have a family member who made lead fishing weights than did other children even after controlling for age and sex. For children, 61% of elevated PbB levels could be attributed to making fishing weights. Caregivers with elevated PbB levels were 5.9 (95 % CI: 1.5-23.7) times more likely to live in a household that melted batteries than other caregivers even after controlling for

age and education. For caregivers, 37% of the elevated PbB levels could be attributed to melting batteries.

During June–August 2004, blood lead (PbB) levels and various haematological parameters were evaluated in children aged 5–9 years old at ten primary schools located in eight neighbourhoods in Cartagena, Colombia. The schools selected for this study are attended mainly by children from families of low income. A total of 189 subjects participated in the survey. The arithmetic mean ± standard error BPb level was 54.9 ± 02.3 µg/L (range < 10–210 µg/L). The geometric mean was 47.4 µg/L (95% CI: 42.9–51.8). A proportion of the children (7.4%) had PbB levels above the US Centers for Disease Control and Prevention's threshold of concern (100 µg Pb/L). BPb levels were correlated weakly, but significantly and positively, with red blood cell count (RBC), and negatively with child body size, age, mean corpuscular volume (MCV), and mean corpuscular haemoglobin (MCH). BPb levels did not differ significantly between boys and girls but significant differences were observed between neighbourhoods ($P < 0.001$). Activities such as metal melting-related processes and fishing net sinker production are the main sources of Pb exposure in Cartagena (Olivero-Verbel et al., 2007).

Cross-sectional, analytical studies were undertaken among 160 young school children in subsisting fishing villages in South Africa. PbB levels ranged from 22 to 224 µg/L, with a mean PbB level of 74 µg/L. Around 74 % of these children had PbB levels ≥ 50 µg/L and 16 % had PbB levels ≥ 100 µg/L. Both socio-economic factors and lead melting practices were strongly associated with elevated PbB levels (Mathee et al., 2013).

Among 311 children (151 girls and 160 boys), aged 3 to 7 years, living in coastal fishing communities in southern Thailand, the mean (standard error of mean, SE) values for age adjusted PbB were 62.2 (5.0) µg/L in boys and 67.2 (4.9) µg/L in girls of parents with an occupation in making fishing nets with lead weights. These mean PbB values were respectively 2.3 and 2.5 times higher than those of similarly aged boys (27.04 µg/L) and girls (26.88 µg/L) of parents with other occupations (Yimthiang et al., 2019). Based on these data the absolute increase in PbB level for boys and girls are 36.16 µg/L and 40.32 µg/L, respectively.

Bressler et al. (2019) summarised the surveillance data on PbB levels of children in Alaska 2011 to 2015. The prevalence of elevated PbB levels (≥ 50 µg/L) was low among children tested (1.0 to 2.3%). Several possible sources of exposure were identified among children with elevated PbB levels including domestically produced fishing weights (n = 10; 14%).

Biting lead split

The practice to bite lead split shot to secure onto the fishing line has frequently been reported (Grade et al., 2019). Carrier et al. (2012) report a 21-year-old man who presented with colicky abdominal pain. Abdominal plain radiograph showed multiple intracolonic metallic bodies. Markedly elevated PbB levels of 1 410 µg/L and zinc protoporphyrin serum levels confirmed the diagnosis of lead poisoning. The patient reported that he commonly chewed fishing lead sinker and may sometimes swallow them during the preparation of the fishing rod.

Swallowing of lead fragments

Grade et al. (2019) reported that poison control centres are commonly consulted on cases of ingestion of lead and previous studies had noted that some of these are fishing weights (Cole et al., 2010). In 2016, 2 412 of the poisoning cases reported to poison

control centres in the US were due to single exposures to lead, typically due to the ingestion of small lead items (Gummin et al., 2017). In many cases the lead item ingested was not defined. However, in 38 cases reported to US poison control centres in 2016 the item ingested was specifically recorded as lead fishing tackle and most of these (28 cases) were due to ingestion by children under 6 years of age (Gummin et al., 2017).

Grade et al. (2019) noted that not all ingestions of lead sinkers will result in reports to poison control centres and the toxic impacts of the exposure may not be immediately evident. It is likely that the poison control centre numbers underestimate the total number of children exposed to lead via this route.

Retention of lead fishing sinkers in the stomach and intestines of children following ingestion has been demonstrated and can result in long-term elevation of lead levels (Mowad et al., 1998). Significantly elevated blood lead levels have been documented in children ingesting lead fragments. For example, measured PbB levels in a 4-year old child were found to exceed 650 µg/L the day following the ingestion of a single fishing sinker (Cole et al., 2010).

Significantly elevated blood lead levels have been documented in children ingesting lead fragments. For example,

- a PbB level of 530 µg/L was reported in an 8 year old boy who ingested 20 to 25 fishing sinkers showed (Mowad et al., 1998)
- a PbB levels of 550 µg/L was measured in a boy after ingestion of 8 fishing sinkers (St. Clair and Benjamin, 2008)
- PbB levels exceed 650 µg/L in a 4-year old child following the ingestion of a single fishing sinker (Cole et al., 2010);
- PbB levels of 450 to 690 µg/L were reported in 3 and 5 year old children after ingestion of fishing sinker (McCloskey et al., 2014)

B.10. Risk characterisation

B.10.1.1. Environment

The estimates of emissions in this report are directly linked to the amount of ammunition and type of ammunition used and based on data/data interpretations from COWI (2004), AFEMS, AMEC (2012)[75] and ECHA (2017).

Rimfire cartridges are, according to (COWI, 2004), only used for sporting purposes[76] and mainly cover ammunition for calibre .22 (5.6 mm) guns. According to International Sports Shooting Federation ((SSF) rules, rimfire calibre .22 ammunition is used within the disciplines of rapid fire pistol, 25 m pistol and standard pistol, 50 m pistol and 50 m rifle (including running target).

A survey of European manufacturers indicates that the weight of the bullet of a calibre .22 cartridge generally ranges between 30 and 40 grains. AFEMS estimates [AFEMS 2004a] the lead content of an average rimfire cartridge to be 2.4 grams.

Centre fire rifle cartridges for sports shooting are used in the ISSF-discipline of 300 m rifle (calibres of up to 8 mm).

AFEMS estimates [AFEMS 2004a] the average lead content of a cartridge in this category to be 7 grams (125-185 grains) and this is based on weight distributions of 6.5 mm, 7.65 mm and WIN 308 rifle cartridges. A similar estimate is made for centre fire cartridges used for hunting.

There is no updated information on the production of lead ammunition or consumption by hunters in the EU. COWI (COWI, 2004) estimated the combined total emission of lead in 2005 for the EU15, Hungary, Lithuania and Poland to be 150 tonnes per year for hunting using centre firing ammunition. Further work would warrant updated figures on the types and tonnages of lead ammunition used.

B.10.2. Use 1: Hunting with shot shell ammunition

Risks related to hunting/shooting

The database is insufficient to conclude on the potential risk related to hunting with leaded shot shell ammunition.

Risks related to the consumption of game meat/shots

In Table B.10-1 ECHA calculated the daily intake of lead from the consumption of game meat, the resulting incremental PbB levels, and the corresponding RCRs based on the following considerations:

- To calculate the daily intake of lead from game meat, ECHA has used the information from EFSA on the minimum, median and maximum daily consumption of game meat in young children (infants and toddlers) and adults of hunter families as presented in Table B.9-23 and the mean concentration of lead in game meat hunted with lead shots (0.352 µg Pb/kg meat; see also Table B.9-21).

[75] Available here: https://echa.europa.eu/documents/10162/13580/abatement+costs_report_2013_en.pdf/6e85760e-ec6d-4c8a-8fcf-e86a7ffd037d.

[76] All tough they are actually also used for some small game hunting (source:personal communication with David Scallan (FACE)_

- For the calculation of PbB levels resulting from daily lead intake via game meat, ECHA has adapted the dietary intake values in µg/kg bw that correspond to the BMDLs reported in EFSA (2010) to the bioavailability of metallic lead. The following assumptions were made.

For developmental neurotoxicity in children aged ≤ 7 (infants and toddlers), EFSA (2010) concluded that the $BMDL_{01}$ of 12 µg Pb/L blood corresponded to a dietary intake of 0.5 µg Pb/kg bw/day. Assuming 50% bioavailability of metallic lead compared to lead ions for children results in the following relationship:

12 µg Pb/L blood ≙ 1 µg/kg bw/day.

For CKD in other children, adolescents, adults, elderly, very elderly, pregnant women and lactating women, EFSA (2010) concluded that the $BMDL_{10}$ of 15 µg Pb/L blood corresponded to a dietary intake of 0.63 µg Pb/kg bw/day. Assuming 10% bioavailability of metallic lead instead compared to lead ions for adults:

15 µg Pb/L blood ≙ 6.3 µg Pb/kg bw/day or
2.4 µg Pb/L blood ≙ 1 µg/kg bw/day.

Accordingly, $BMDL_{01}$ of 12 µg/L (IQ loss) and $BMDL_{10}$ of 15 µg/L (CKD) are used to calculate the health impacts reported for children and adults, respectively.

Table B.10-1 Calculated daily intake, incremental PbB levels and health impacts from the consumption of meat from game hunted with lead shot in the EU based on data from EFSA (20.06.2020)

Popu-lation	Type of ammu-nition	Game meat consumption (g/kg bw and day; P95)[77]		Pb conc. in game meat (µg/g meat; Mean Ub)[78]	Daily intake of lead (µg/kg bw/d)	PbB level increment (µg/L)	IQ point loss in children	Incr. preval. of CKD (%) in adults	Incr. in SBP (mmHg) in adults
Infants	Shot	Min	0.450	0.366	0.165	1.974	0.16	–	–
		Med	0.658	0.366	**0.241**	**2.887**	**0.24**	–	–
		Max	4.261	0.366	1.558	18.693	1.56	–	–
Toddlers	Shot	Min	0.153	0.366	0.056	0.671	0.06	–	–
		Med	1.131	0.366	**0.413**	**4.962**	**0.41**	–	–
		Max	4.922	0.366	1.799	21.593	1.80	–	–
Adults	Shot	Min	0.172	0.366	0.063	0.151	–	0.1	< 0.01
		Med	1.606	0.366	**0.587**	**1.409**	–	**0.9**	**0.47**
		Max	3.664	0.366	1.339	3.215	–	2.1	0.11

[77] See **Error! Reference source not found.**.

[78] See **Error! Reference source not found.** and **Error! Reference source not found.**.

Number of people eating meat from game hunted with shots

In the UK it was estimated that 27,000 to 62,000, roughly 0.1%, of the adult population are consuming game at, or in excess, of the limits of the FSA advice (at least one 100 g portion weekly) (BASC, 2014).

Green and Pain (2019) considered that main consumers of game are hunters and their families and associates, and that a few percent of the population may be frequent (a few times per month) or high (once per week or more) consumers of game in most countries. While the authors have only been able to find any kind of estimate or assumed consumption levels for six countries, these countries hold more than two-thirds (67%) of all EU hunters (FACE 2010) and include the five countries with the most hunters, i.e. France, Spain, UK, Italy and Germany. Consequently they are likely to be broadly representative of the EU and illustrate that the number of people at potential risk of health effects from lead in game is non negligible across the EU. Taking the consumption of at least one meal of game meat per week, averaged across the whole year, as the definition of a high-level game consumer, and assuming that 1% of the total population of the EU countries are high-level consumers, gives a rough estimate of about 5 million high-level consumers in the EU.

Based on national statistics on the number of hunters, ECHA calculated for EU-27 6.0 million hunters and, with an average household size of 2.3 according to EUROSTAT, 13.9 million of persons living in hunter household. For EU-28, including the UK, the numbers are 6.9 million hunters and 15.9 million persons living in a hunter house hold.

Recommendations on the consumption of game meat

Children, especially small children up to 7 years and pregnant women are of specific vulnerability. Lead is mobilised from the bones during pregnancy; therefore, lead exposure of girls and females in fertile age should be as low as possible. During pregnancy even a single uptake of food with high lead content may damage the foetus during sensitive phase of development. Pregnant women show 17% higher uptake of lead from food compared to the general population. For children up to the age of 7 years the margin of exposure is <1 for neurodevelopmental effects (BfR, 2011).

Consequently, there are several national recommendations to minimize the consumption of game shot with lead ammunition for (small) children, pregnant women and in general for women in child bearing age such as from Germany (BfR, 2011), Italy (ISPRA, 2012), Spain (AESAN, 2012), UK (FSA, 2012).

Several authorities in the EU have issued warnings on the consumption of game meat pointing out the possible contamination of it with lead as a source of concern (**Table B.10-2**):

Table B.10-2: Advise given on game meat consumption by several food safety agencies

Authority, Date, Link	Scope of advice
France March 2018 https://www.anses.fr/en/content/consumption-wild-game-action-needed-reduce-exposure-chemical-contaminants-and-lead	Because the expert appraisal highlighted a health concern related to lead, the Agency is proposing various levers for action to reduce consumer exposure (substitution of lead ammunition, trimming of meat, frequency of consumption). Pending additional data and given the level of lead contamination in large wild game (deer and wild boar), the Agency recommends that women of childbearing age and children avoid all consumption of large wild game, while other consumers should limit themselves to occasional consumption, around three times a year.
Germany December 2014 http://www.bfr.bund.de/cm/349/research-project-safety-of-game-meat-obtained-through-hunting-lemisi.pdf	In an exposure estimate, the BfR concluded that, with consumption of two meals of game meat per year (normal consumers) and also of five meals a year (high consumers) with the eating habits that are customary in Germany, the additional lead uptake from the game meat is of no toxicological significance for adults. This statement does not apply to children and pregnant women. As the developing nervous system of foetuses and children shows a particularly sensitive reaction to lead, every additional uptake of lead should be avoided by these population groups.
Norway June 2013 http://www.vkm.no/dav/cbfe3b0544.pdf	At the individual level, the risk for adverse effect is likely to be small. At present lead levels, adults with normal blood pressure will most likely not experience any clinical symptoms by a small increase, although it may add to the burden of those individuals who are at risk of experiencing cardiovascular disease. A small reduction in the intelligence of children will not be notable at the individual level, but at the population level it can, for instance, increase the proportion not able to graduate from school. Lead exposure was declining in the population on which the reference value for increased prevalence of chronic kidney disease was based. EFSA noted that this reference value (15 µg/L) is likely to be numerically lower than necessary. The implications of having a concurrent blood lead concentration above the reference value cannot fully be interpreted, since it is not known when and at which level of lead exposure the kidney disease was initiated. However, an eventual increased risk of chronic kidney disease would be higher among those who consume cervid meat regularly or more often than those who rarely consume such meat. For these reasons, continued effort is needed to reduce lead exposure in the population.

Authority, Date, Link	Scope of advice
Spain February 2012 http://www.aecosan.msssi.gob.es/AECOSAN/docs/documentos/seguridad_alimentaria/evaluacion_riesgos/informes_cc_ingles/LEAD_GAME.pdf	Although the information available in Spain regarding the lead content in wild game meat and its consumption is incomplete, following the analysis of data available in Spain, it has been shown that the average lead content in pieces of large and small game exceeds the European Union general limits for meat and offal (there are no specific limits for this food) and these contents are similar to those found throughout Europe and other countries. It has been proved that wild game meat is consumed in Spain, although it is more common for hunters and their families. It is not restricted to the hunting season, and its consumption of products that come from it, such as cured sausage or pâté, by the general public in restaurants is not negligible.
Sweden October 2014 https://www.livsmedelsverket.se/globalassets/rapporter/2014/bly-i-viltkott---del-4-riskhantering.pdf	Need not be discarded from a risk perspective, but consumption should be limited up to once per month. Pregnant women planning pregnancy and children under seven years, however, should continue to avoid consumption.
UK Food Safety Agency October 2016 https://www.food.gov.uk/science/advice-to-frequent-eaters-of-game-shot-with-lead	To minimise the risk of lead intake, people who frequently eat lead-shot game, particularly small game, should cut down their consumption. This is especially important for vulnerable groups such as toddlers and children, pregnant women and women trying for a baby, as exposure to lead can harm the developing brain and nervous system.

Indirect exposure of humans via the environment

Relevant pathways for human exposure include drinking water and food, indoor / outdoor air (including swallowing household dust or dirt containing lead) and soil. For the general population, food and water are considered to be the most important sources of exposure to lead (EFSA, 2013). Consumption of game meat can potentially contribute disproportionately to overall dietary exposure (EFSA, 2013).

B.10.2.1. Human health

Consumers

Risks related to hunting/shooting

The database is insufficient to conclude on the potential risk related to hunting with leaded bullet ammunition.

The Norwegian Scientific Committee for Food Safety (VKM) (Knutsen et al., 2013) reported that PbB levels were significantly higher (15 µg/L) in participants who reported self-assembling of lead-containing bullets (median 31 vs 16 µg/L).

The Swedish National Food Agency (Livsmedelsverket, 2014b) analysed the consumption of moose and / or stews from moose, the number of fires fired, tobacco smoking, gender and age. Based on this model, PbB levels in different categories were calculated. As a

comparison group, participants are included in Riksmaten - adults 2010-11 who never ate game. Figure B.9-9 shows that both the intake of moose and the number of fired shots appear to be significant for the level of lead in blood. Compared to the PbB level of adults from Riksmaten who never consumed wild game (12.8 µg/L), the consumption of moose meat resulted in increased PbB levels (15.7, 19.6 and 16.7 µg/L, for 1-3 times/month, 1 times/week and 2-7 times/weeks). In addition, PbB levels increased further by 10 percent for every hundred shots fired.

Lead intake from game meat consumption and related risks

ECHA calculated the daily intake of lead from the consumption of game meat, the resulting incremental PbB levels, and the corresponding risks based on the following considerations:

- To calculate the daily intake of lead from game meat, ECHA has used the information from EFSA on the minimum, median and maximum daily consumption of game meat in young children (infants and toddlers) and adults of hunter families as presented in Table B.9-34 and the mean concentration of lead in game meat hunted with lead bullets (2.5 µg Pb/kg meat; see also Table B.9-32).
- For the calculation of PbB levels resulting from daily lead intake via game meat, ECHA has adapted the dietary intake values in µg/kg bw that correspond to the BMDLs reported in EFSA (2010) to the bioavailability of metallic lead. The following assumptions were made.
- For **developmental neurotoxicity in children** aged ≤ 7 (reduction on IQ scale), EFSA (2010) concluded on a $BMDL_{01}$ (decrease in IQ by 1 point on the full scale IQ) of 12 µg Pb/L blood (1 µg/L = 0.083 IQ points). According to EFSA; 12 µg/L corresponds to a lead intake from diet containing soluble lead of 0.5 µg Pb/kg bw/day. Assuming 50 % bioavailability of metallic lead compared to lead ions for children results in the following relationship:
    - **12 µg Pb/L blood ≙ 1 µg/kg bw/day**.
- For the increase of prevalence of **CKD in adults**, EFSA (2010) concluded on a $BMDL_{10}$ (10 % increase in the prevalence of CKD) of 15 µg Pb/L blood (1 µg/L = 0.667 % increase in the prevalence of CKD). According to EFSA, 15 µg/L corresponds to a lead intake from diet containing soluble lead of 0.63 µg Pb/kg bw/day. Assuming 10 % bioavailability of metallic lead compared to lead ions for adults:
    - 15 µg Pb/L blood ≙ 6.3 µg Pb/kg bw/day ↔ **2.4 µg Pb/L blood ≙ 1 µg/kg bw/day.**
- For the increase in **systolic blood pressure in adults**, EFSA (2010) concluded on a $BMDL_{01}$ (1 % change in SBP corresponding to an increase of 1.2 mmHg from the baseline value of 120 mmHg in a normotensive adult) of 36 µg Pb/L blood (1 µg/L = 0.033 mmHg). According to EFSA, 36 µg/L corresponds to an intake of diet containing soluble lead of 1.5 µg/kg bw/day. Assuming 10 bioavailability of metallic lead compared to lead ions for adults:
    - 36 µg Pb/L blood ≙ 15 µg Pb/kg bw/day ↔ **2.4 µg Pb/L blood ≙ 1 µg/kg bw/day.**
- In EFSA (2010) calculated daily intake of game meat, incremental PbB levels and Accordingly, $BMDL_{01}$ of 12 µg/L (IQ loss) and $BMDL_{10}$ of 15 µg/L (CKD) are used to calculate the health impacts for children and adults, respectively.

Table B.10-3 Calculated daily intake, incremental PbB levels and health impacts from the consumption of meat from game hunted with lead bullets in the EU based on data from EFSA (20.06.2020)

Population	Type of ammunition	Game meat consumption (g/kg bw and day; P95)[79]		Pb conc. in game meat (µg/g meat; Mean Ub)[80]	Daily intake of lead (µg/kg bw/d)	PbB level increment (µg/L)	IQ point loss in children	Incr. preval.of CKD (%) in adults	Incr. in SBP (mmHg) in adults
Infants	Bullet	Min	0.891	2.516	2.242	26.898	2.24	—	—
		Med	1.667	2.516	**4.194**	**50.325**	**4.19**	—	—
		Max	2.147	2.516	5.401	64.816	5.40	—	—
Toddlers	Bullet	Min	0.114	2.516	0.287	3.442	0.29	—	—
		Med	2.219	2.516	**5.582**	**66.989**	**5.58**	—	—
		Max	5.245	2.516	13.195	158.341	13.20	—	—
Adults	Bullet	Min	0.252	2.516	0.634	1.522	—	1.0	0.05
		Med	1.560	2.516	**3.925**	**9.419**	—	**6.3**	**0.31**
		Max	6.597	2.516	16.596	39.831	—	26.6	1.32

Number of people eating meat from game hunted with lead bullets

Green and Pain (2019) considered that main consumers of game are hunters and their families and associates, and that a few percent of the population may be frequent (a few times per month) or high (once per week or more) consumers of game in most countries. While we have only been able to find any kind of estimate or assumed consumption levels for six countries, these countries hold more than two-thirds (67%) of all EU hunters (FACE 2010) and include the five countries with the most hunters, i.e. France, Spain, UK, Italy and Germany. Consequently they are likely to be broadly representative of the EU and illustrate that the number of people at potential risk of health effects from lead in game is non negligible across the EU. Taking the consumption of at least one meal of game meat per week, averaged across the whole year, as the definition of a high-level game consumer, and assuming that 1% of the total population of the EU countries are high-level consumers, gives a rough estimate of about 5 million high-level consumers in the EU.

Recommendations on game meat consumption

Several authorities in the EU have issued warnings on the consumption of game meat pointing out the possible contamination of it with lead as a source of concern (see **Table B.10-2**).

[79] See **Error! Reference source not found.**.

[80] See **Error! Reference source not found.** and **Error! Reference source not found.**.

B.10.3. Use 3: Sports shooting with shot shell ammunition

Consumers

Hazard conclusion

Lead is recognised as a non-threshold substance for children (effects on IQ). For adults (general population) the sub-clinical effects on kidney and blood pressure are also considered as non-threshold. BMDL values were calculated by (EFSA, 2010, updated 2013). Those BMDLs are used as DNELs.

Endpoint	**Popu-lation**	**BMD definition**	**BMDL (µg Pb/L blood)**	**Corresponding alimentary Pb exposure**	
				µg/kg bw/d	**µg/person and day**
Developmental neurotoxicity	children	1% reduction on IQ-scale	**12**	0.5	10
Cardiovascular effects	adults	1% increase systolic blood pressure	**36**	1.50	90.0
Kidney toxicity/ nephrotoxicity	adults	10% increased prevalence CKD	**15**	0.63	37.5

The $BMDL_{10}$ of 15 µg/L is used as DNEL for adults and the $BMDL_1$ of 12 µg/L as DNEL for children.

Exposure conclusion

In one study that investigated 9 male and 5 female Korean clay shooting athletes training in a covered outdoor shooting range, the difference in PbB levels between the general population of Korea (Eom et al., 2017) and the clay shooters (Chun et al., 2018) was 18 and 29 µg/L for females and males, respectively.

Risk

Taking into account the $BMDL_{10}$ for CKD of 15 µg/L (EFSA, 2010), the resulting RCRs from the study by (Chun et al., 2018) are 1.2 and 1.9 for females and males, respectively.

However, due to the limitations of the study (small number of shooters, missing controls) and missing further studies, the database is insufficient to conclude on the potential risk related to sports shooting with leaded shot shell ammunition.

B.10.4. Use 4: Sports shooting with single projectile ammunition

Consumers

Hazard conclusion

Lead is recognised as a non-threshold substance for children (effects on IQ). For adults (general population) the sub-clinical effects on kidney and blood pressure are also considered as non-threshold. BMDL values were calculated by (EFSA, 2010, updated 2013). Those BMDLs are used as DNELs.

Endpoint	Popu-lation	BMD definition	BMDL (µg Pb/L blood)	Corresponding alimentary Pb exposure	
				µg/kg bw/d	µg/person and day
Developmental neurotoxicity	children	1% reduction on IQ-scale	**12**	0.5	10
Cardiovascular effects	adults	1% increase systolic blood pressure	**36**	1.50	90.0
Kidney toxicity/ nephrotoxicity	adults	10% increased prevalence CKD	**15**	0.63	37.5

The $BMDL_{10}$ of 15 µg/L is used as DNEL for adults and the $BMDL_{01}$ of 12 µg/L as DNEL for children.

Exposure conclusion

Most information on PbB levels is available from shooters' training in indoor shooting ranges, with PbB levels often > 200 µg/L or even > 400 µg/L, leading to RCRs > 10 or even > 20 (Laidlaw et al., 2017).

Based on the information from Demmeler et al. (2009), Laidlaw et al. (2017), Mathee et al. (2017), and Mühle (2010) the risks for elevated PbB levels are:

- higher for user of fire weapons (using lead-containing primer) compared to users of air weapons;
- increasing with increasing calibre of the weapon used;
- increasing with increased shooting frequency;
- Risk increases with reduced ventilation
- Risk increases with low hygiene measures

With regards to out-door shooting, only very limited information is available.

In 12 biathletes, PbB levels of 0.087 ± 0.015 µmol/L (18 ± 3.1 µg/L) were ≥10 µg/L higher compared to the cross-country skiers with < 0.04 ± 0.0 µmol/L (< 8.3 µg/L) (Turmel et al., 2010). In twelve shooters from an outdoor shooting range in South Africe, PbB levels were 43 µg/L higher (70 ± 42 µg/L) compared to 20 archers (27 ± 14 µg/L). For shooters casting own bullets the PbB increase was 22 µg/L (Mathee et al., 2017).

Risk

Taking into account the BMDL$_{10}$ for CKD of 15 µg/L (EFSA, 2010), the resulting RCRs are either <1 (Turmel et al., 2010) or 2.9 for out-door shooting and 1.5 for casting own bullets (Mathee et al., 2017).

However, due to the limitations of the studies (e.g., small number of shooters) and missing further studies, the database is insufficient to conclude on the potential risk related to sports shooting with leaded bullets. Use 5: Shooting with air rifle

B.10.4.1. Human health

Workers

Add text

Consumers

Hazard conclusion

Lead is recognised as a non-threshold substance for children (effects on IQ). For adults (general population) the sub-clinical effects on kidney and blood pressure are also considered as non-threshold. BMDL values were calculated by (EFSA, 2010, updated 2013). Those BMDLs are used as DNELs.

Endpoint	Population	BMD definition	BMDL (µg Pb/L blood)	Corresponding alimentary Pb exposure	
				µg/kg bw/d	µg/person and day
Developmental neurotoxicity	children	1% reduction on IQ-scale	**12**	0.5	10
Cardiovascular effects	adults	1% increase systolic blood pressure	**36**	1.50	90.0
Kidney toxicity/ nephrotoxicity	adults	10% increased prevalence CKD	**15**	0.63	37.5

The BMDL$_{10}$ of 15 µg/L is used as DNEL for adults and the BMDL$_1$ of 12 µg/L as DNEL for children.

Exposure conclusion

Inhalation exposure

Due to the limitations of the available studies ((Svensson et al., 1992), (Demmeler, 2009), (Johnson-Arbor et al., 2020)), the database is insufficient to conclude on the potential risk related to sports shooting with air rifle.

Oral exposure

A case report demonstrated high PbB levels in a child (560 µg/L) following the ingestion of spent air rifle pellets (Treble and Thompson, 2002).

Risk

due to the limitations of the studies (e.g., small number of shooters) and missing further

studies, the database is insufficient to conclude on the potential risk related to sports shooting with air rifle pellets.

B.10.5. Use 7: Lead in fishing sinkers and lures

Consumers

Hazard conclusion

Lead is recognised as a non-threshold substance for children (effects on IQ). For adults (general population) the sub-clinical effects on kidney and blood pressure are also considered as non-threshold. BMDL values were calculated by (EFSA, 2010, updated 2013). Those BMDLs are used as DNELs.

Endpoint	Popu-lation	BMD definition	BMDL (µg Pb/L blood)	Corresponding alimentary Pb exposure	
				µg/kg bw/d	µg/person and day
Developmental neurotoxicity	children	1% reduction on IQ-scale	**12**	0.5	10
Cardiovascular effects	adults	1% increase systolic blood pressure	**36**	1.50	90.0
Kidney toxicity/ nephrotoxicity	adults	10% increased prevalence CKD	**15**	0.63	37.5

The $BMDL_{10}$ of 15 µg/L is used as DNEL for adults and the $BMDL_1$ of 12 µg/L as DNEL for children.

Exposure conclusion

Home-casting of fishing tackle

Lead intoxication with a PbB level of 1330 µg/L (RCR 88.7) was reported for one man melting and casting lead for several years (State of Alaska Epidemiology, 2001).

For children living in the vicinity of persons melting lead to cast fishing tackle or bullets, increases of PbB levels ranged from 36 µg/L (RCR 3.0) to ≥ 100 µg/L (RCR ≥ 5.0) [(Brown et al., 2005), (Mathee et al., 2013), (Yimthiang et al., 2019)].

Biting lead split

In one person who commonly chewed fishing lead sinkers and sometimes swallowed them had extremely high PbB level of 1 410 µg/L.

Swallowing of lead fragments

Grade et al. (2019) reported that poison control centres are commonly consulted on cases of ingestion of lead and previous studies had noted that some of these are fishing weights (Cole et al., 2010). Several case reports are available demonstrating high PbB levels > 500 µg/L in children following the ingestion of lead fishing sinkers (e.g., showed (Mowad et al., 1998), (St. Clair and Benjamin, 2008), (Cole et al., 2010), (McCloskey et al., 2014).

Risk

Very high risks (RCR >40) are reported for home-casting of fishing tackle, biting lead split and swallowing fishing tackle. Lead is recognised as a non-threshold substance for children.

Annex C: Alternatives – generic information

This appendix holds generic information on **alternative substances** to lead in ammunition (shot and bullet) and fishing tackle.

Starting from the list of substances that could fulfil the same technical function as lead, the Dossier Submitter assessed their risk reduction potential compared to lead (section C.3) as well as the availability of the raw material (section C.2).

C.1. Identification of potential alternative substances and techniques fulfilling the function

C.1.1. Alternative shot substances

C.1.1.1. Hunting

Lead, coated

Coated lead shot has been put in in the market in various forms, plating of shot has been done with nickel or with copper. The main idea behind plating is that that it overcomes the deforming of lead pellets by providing an extra hard layer around shot. Coating is performed by placing lead shot in a bath of an ionic solution and the plating material.

The application of the copper coating to the lead pellets protects the charge in its passage through the barrel to eliminate deformed pellets and ensure that pellets retain their perfect roundness. Today, the wide array of chokes and improvements in forcing cones employed in modern 'over-under' shotguns, with many users adopting full choke to increase pattern density to kill high birds, has meant that the shot charge and the pattern it throws is critical. This is where copper-coated shot plays a vital role. With less shot deformed there are more pellets in the pattern, ensuring clean kills of high birds

Non-lead alternatives

Alternatives for shot have been widely assed in the restriction proposal for lead in shot over wetlands. The main alternatives for lead in shot are based on the use of different metals with bismuth, tungsten and steel as the most commonly used.

In recent years, several companies have created non-toxic shot from bismuth, tungsten, or other elements or alloys with a density similar to or greater than lead, and with a shot softness that results in ballistic properties that are comparable to lead. These shells provide more consistent patterns than steel shot and provide greater range than steel shot. They are also generally safe to use in older shotguns with barrels and chokes not rated for use with steel shot e.g. bismuth and tungsten-polymer (although not tungsten-iron) shot. All non-lead shot other than steel is far more expensive than lead, which has reduced its acceptance by hunters.

Bismuth and its alloys

The ballistics or performance is generally good, provided the shot size is increased to allow for density lower than lead. Bismuth is suitable in all guns. Bismuth can be used as a drop in alternative to lead without concerns over compatibility with guns.

Bismuth is alloyed with 3–6 % tin to reduce the frangibility of the bismuth when used as shot. Shot made from bismuth-tin alloy is fully approved in the US as non-toxic (Thomas, 2019).

Copper and its alloys

Include technical suitability of

- Pure copper
- Brass
- Bronze

The technical suitability of copper shot is discussed in the approval of this type of shot by the US Fish and Wildlife Service[81] the shot is described as

Corrosion-inhibited copper shot (CIC shot) consists of commercially pure copper that has been surface-treated with benzotriazole (BTA) to obtain insoluble, hydrophobic films of BTA-copper complexes (CDA 2009). These films are very stable; are highly protective against copper corrosion in both salt water and fresh water; and are used extensively to protect copper, even in potable water systems. Other high-volume applications include deicers for aircraft and dishwasher detergent additives, effluents of which may be directly introduced into municipal sewer systems, indicative of the exceptionally low environmental impact of BTA.

The idea behind using copper shot is similar to the copper coating (discussed above) to overcome the softness and deformation of lead by using a harder material that will provide more pellets in the shot pattern to take high birds. This shot type is usually considered to a be an alternative for the upper part of the market.

Steel (soft iron)

Steel was one of the first widely used lead alternatives that the ammunition industry turned to. But steel is one hundred times harder than lead, with only two-thirds its density, resulting rather different ballistic properties when compared to lead.

Therefore, rather than steel, "soft iron" is used for shots, which is manufactured by annealing iron containing approximately 1 % or less carbon (Thomas, 2019).

Steel shot does have the potential to cause some choke expansion ("bulging") particularly with heavy loads in older, traditional lightweight guns. Care is also needed when shooting steel shot as it can ricochet more than lead. However, an unsafe shot with steel would also be an unsafe shot with lead. As a result of its hardness, steel shot has traditionally been contained in robust plastic wads (BASC) [82]

Steel shot may be coated with a thin layer of copper or zinc to inhibit rusting which is permitted under US regulations (USFWS, 1997).

Tin

The low-density (7.31 g/cm^3 vs. 11.3 g/cm^3 for lead) does not predispose it for use as gunshot (Thomas, 2019).

Tungsten and its alloys

The density of tungsten shot is favourable for good ballistics and performance, so the percentage of tungsten in shot material is important. It is suitable for use in appropriately proved guns and widely available.

[81] https://www.federalregister.gov/documents/2017/08/15/2017-17175/migratory-bird-hunting-approval-of-corrosion-inhibited-copper-shot-as-nontoxic-for-waterfowl-hunting

Tungsten can be made into shot either as a mixture of powdered metal mixed with a high-density polymer (95 %W + 5 % polymer), or as a composite mixed (sintered or alloyed) with other metals (Thomas, 2019).

For the use of tungsten matrix shot, the British Association for Shooting and Conservation (BASC)[83] recommends the following: *Tungsten varieties come in many forms. It tends to be as dense or denser than lead so you may not need to change the shot size or you might even reduce the size of the load.*

Powdered bronze can be sintered with tungsten powder to make a hard, high-density tungsten-bronze gunshot (Thomas, 2019).

Zinc and its alloys

Zinc is used most often as an alloying metal (Thomas, 2019).

C.1.1.2. Sports shooting

The evidence provided in the call for evidence concerning the use of alternative shot in clay target shooting is less clear than for hunting.

ISSF and FITASC rules requires the use of lead shot with a gauge not greater than 12 mm (usually 12 mm is used). Shotguns must be smooth bored. They are invariably 12-gauge, single-triggered and over-under type — one barrel is placed above the other. They fire cartridges loaded with lead pellets: the weight of the pellet load must not exceed 24.5 grams per cartridge; the diameter of each pellet must not exceed 2.6 millimetres. Guns and cartridges are subject to official checks during the shooting programme.

Based on the demand from hunters and sports shooters, soft iron shots have also been developed for competition purposes (Figure C.1-1).

Rottweil Competition Line shotgun cartridges: since soft iron shot requires more volume for the same weight, the cup of the Steel Trap is correspondingly higher than that of the Special Trap. (© ROTTWEIL)

Figure C.1-1 Rottweil Competition Line shotgun cartridges with lead shots (left) and soft iron shots (right)

[83] https://basc.org.uk/lead/guide-to-using-non-lead-shot.

C.1.2. Alternative substances for bullets

C.1.2.1. Hunting

Lead as well as non-lead bullets used for hunting might either be monolithic, semi-jacketed or jacketed with other metals to facilitate the gliding of the bullets through the barrel. Further, non-lead bullets may contain traces of lead.

Lead, coated

Lead bullets are usually semi-jacketed bullets which consist of a hard lead alloy core and a jacket partly surrounding this core. The percentage of further metals (mainly antimony, arsenic and zinc) determines the degree of hardness of the alloy. The semi-jacket of most bullets consists of tombac, a copper-zinc alloy with a copper content of >80 %. Tombac additionally always contains arsenic which determines the hardness of the material. In addition, there are semi-jacketed lead containing bullets with a semi-jacket consisting of steel for hunting (Gerofke et al., 2018).

Non-lead alternatives

Based on an analysis of the information submitted in the call for evidence it is clear that for most larger game a wide variety of non-lead bullets already exist, the challenges in substitution are within the smaller calibres that are used for hunting smaller game and pests.

The main non-lead alternatives on the market are bullets made of copper or a copper alloy. Copper bullets expand rapidly, providing the hydrostatic shock necessary for quick kills. Unlike lead bullets, copper bullets don't break apart and release dusts that lead-based bullets do. Non-lead bullets are able to travel farther through the target, thus increasing stopping power because the bullet can more easily penetrate tissue and bone. In addition, non-lead bullets usually pass completely through the animal, leaving an exit wound. This may offer a benefit for hunters, as the resulting increased blood loss may leave a better trail for hunters should quarry escape after the initial shot.

Most of the non-lead bullets developed to replace lead are made from pure copper or copper-zinc alloy (brass), with or without other metal jacket coatings (Paulsen et al. 2015; Thomas et al. 2016).

Pure copper

Non-lead monolithic bullets consist of almost pure copper (density 8.96 g/cm^3) or 100 %-electrolyte copper. Such monolithic bullets are used as bullets for as slugs fired from shotguns.

Brass

Copper can also be alloyed with approximately 5 % (less than 40 %) zinc **brass** to make similar non-lead bullets (Thomas, 2019). Monolithic bullets made from brass, an alloy from copper and zinc with a percentage of zinc of less than 40 %.

Brass is also used for ammunition cartridges.

Bronze

Bronze is an alloy of approximately 90 % copper and 10 % tin which is potentially suitable for the use of bullets. However, metal hardness may be problematic (Thomas, 2019).

Tombac

Tombac or Tombak is a copper-zinc (brass) alloy with a higher zinc content (5 to 20 %). In tombac there is additionally always arsenic present which determines the hardness of the material. The semi-jacket of most bullets consists of tombac (Gerofke et al., 2018).

Polymers

There are different application of polymers. Polymers can for example be used as polymer shell to encase the lead projectile, as nose of the bullet or as a major component of the bullet.

Polymer coated bullets are hard cast bullets with a tough polymer shell which encases the lead projectile. They are similar in concept to copper plated bullets, except the plating is made out of polymer instead of copper or copper alloy.

Polymer-tipped bullets are a type of hollow-point bullet tipped with a polymer nose cone. Most tips are made of polyoxymethylene, although some manufacturers have used polyester urethane-methylenebis(phenylisocyanate) copolymers

In metal-polymer composites the polymer is a major component of the bullet. Such bullets are generally lighter and have higher velocities than pure metal bullets of the same dimensions. They permit unusual designs that are difficult with conventional casting or lathing. For example, a polycase bullet could consist of powdered copper and a nylon-like polymer matrix. Another example is a tungsten/polymer composite comprising of tungsten powder, another metal powder having a high packing density, and organic binder have high density, good processability and good malleability.

Advantages of polymer coated bullets are less friction between the bullet and the bore, less smoke, less debris left in the barrel, no toxic off-gassing and can be used for indoor shooting where lead bullets are restricted.

Tin

Due to the low-density of tin (7.31 g/cm^3 vs. 11.3 g/cm^3 for lead) it does not predispose it to use as bullets; however, it could be used as an alloying material (Thomas, 2019).

Tungsten

Tungsten can be used at any %W, when used as a densifier with other approved material (Thomas, 2019).

C.1.2.2. Sports shooting

The general feedback in the call for evidence was that here are no viable alternatives for the bullet calibres used in sports shooting.

The bullet calibres used (air and firearms) are .22LR, .30-.38 and 0.177 Air. These are the basic calibres used in many of the ISSF and IBU events, which are *de facto* standard as well for all sports shooting activities leading to these events.

The ISSF 10m Air Rifle target has a white central dot which is the 10 ring, with a radius 0.25mm. The surrounding 9 ring has a 2.75mm radius.

Very limited quantities of 0.22LR ammunition loaded with copper projectiles are available. Independent testing with this copper ammunition shows the enclosing circle diameters for only 5 shots at 45.7m (50 yards) to on average 35.6mm. This would not be considered acceptable for even entry level target shooting.

C.1.3. Alternative substances for fishing tackle

The following alternatives to lead were identified by the Dossier Submitter via literature review of recently published articles (Canada, 2018, Thomas, 2019), the ECHA market survey (cf Appendix D), and information provided via the ECHA call for evidence (CfE #909 from Sportvisserij Nederland, CfE #1034 from VLIZ and CfE #1078).

The technical feasibility of alternative both for the fishers, and for the manufacturers of fishing tackle is discussed in details in Appendix D.4.2.1 (Technical feasibility of alternatives).

C.1.3.1. Lead, coated

The comment CfE #1034 from the call for evidence is referring to lead with 'plastic' coating marketed as an 'alternative to lead'.

C.1.3.2. Non-lead alternatives

Bismuth

Bismuth has successfully been used as an alternative to lead for some fishing sinker applications (e.g. nail sinker type), and seems suitable as sinkers and lures according to (Thomas, 2019).

Fishing sinkers in bismuth are available on the European market, and a manufacturer of bismuth fishing tackles has been identified in the US via the ECHA market survey.

Fishing tackle in bismuth can be of similar size to lead fishing tackle.

According to Thomas et al., bismuth is not used pure as an alternative to lead in fishing tackle, it is alloyed with 3–6 % tin to reduce the frangibility of the bismuth (Thomas, 2019).

Ceramic/Glass

Ceramic/Glass is used as a replacement for lead for some fishing sinker applications. Ceramic is less dense than lead and therefore ceramic fishing tackle is larger than lead ones. The larger size of ceramic sinkers could be a disadvantage in some applications but on Fisher internet blogs[84], larger size and lower density of ceramic sinkers are presented as a good alternative to decrease snags and the likelihood of getting caught on rocks. The colour and noise created when using ceramic sinkers is also said to attract fish. Ceramic sinkers are currently produced by at least one manufacturer in the US, but ceramic sinkers were not found available at some of the major online fishing equipment retailers in Europe.

Ceramic sinkers are likely to cost more than equivalent lead sinkers.

Copper and its alloys (Brass and Bronze)

Brass is an alloy of 95 % copper and 5 % zinc. Copper lowers the mobility of zinc in the freshwater environment where many discarded sinkers remain. Brass may contain lead as impurity, or it may be added intentionally in order to make brass more corrosion resistant.

Copper can be also be alloyed with tin (ca. 12 %) to make bronze which also lowers the mobility of copper in acid aqueous media. Bronze is considered suitable for sinkers and

[84] E.g. https://www.greatlakesscuttlebutt.com/news/press-room/the-ceramic-sinker/

jigs (Thomas, 2019).

A limited number of pure copper and brass fishing sinkers seems available on the European Market, but none were identified in bronze on the European Market.

Concrete

Similar to stones, concrete can be used as an alternative to lead for carp fishing on soft/muddy bottoms (CfE #909). European manufacturers of concrete fishing sinker are for example UFO.

High density polymer

High density polymer formulation (thermoplastic-based with metallic fillers and resins) are marketed as 'lead-free' and as an alternative to lead. Depending on the type, and amount of fillers added to the polymer, the density of such formulation can be 'customised' and may reach 11 g/cm^3, very close to the lead one. Tungsten, for example, may be used as a filler.

Various trade names of such types of polymer exist, and different types of objects can be produced from this polymer, using thermoforming. It includes fishing sinkers and lead-free ammunition. While commercial applications already exist for bullets, no application in fishing could be identified or confirmed during the ECHA market survey.

Iron

In the presence of water and oxygen, iron is forming iron oxide (rust). Given sufficient time, any iron mass, in the presence of water and oxygen, could eventually convert entirely to rust. Iron is abundant in the earth's crust and occurs naturally in the aquatic environment.

Rebar (for reinforcing bar)

Rebar is steel reinforcement bars which are used to improve the tensile strength of the concrete. Rebar as an alternative to lead was mentioned by some respondants in the call for evidence. No specific use of rebar in fishing tackle was identified during the ECHA market survey.

(Stainless) Steel

Steel has successfully been used as a replacement for lead for some fishing sinker applications. Steel is less dense than lead and therefore steel weights are larger than lead weights. In order to prevent corrosion, the steel weights must be coated or be made from a stainless steel. Stainless Steel fishing tackle is available on the European Market and some fishing tackle (e.g. back lead for carp fishing) is produced in Europe.

Stones or pebbles

According to a survey carried out in November 2019 during Hengelexpo, the most commonly used alternative by Belgian fishers is stone (36 % of the 65 respondents). Stones seems to be a popular alternative among the carp fishers (CfE #909) especially in soft or muddy bottoms. The general properties of stone were judged to be by far the best to replace lead in fishing tackles (VLIZ - CfE #1034). Stones also offer by nature the best camouflage for the fish. Stone fishing tackle can be made by the fishers themselves, or purchased from retailers that are specialised in this type of alternatives. e.g. https://fishstone.de/en/ is proposing 'straps, in which the user can insert their own stones or Pallatrax Stonze which is a sold ready to use with a swivel/hook inserted to place the stone on the fishing line (cf. Figure C.1-2)

Figure C.1-2: example of stone (alternative to lead)

Source: Fishstone.de and Pallatrax.co.uk

Tin

Tin is widely used as an alternative for lead split shot fishing sinkers because its softness and ductility/malleability meets the requirements of this application (i.e it can be pinch repeatedly on and off fishing lines). At 7.3 g/cm3, tin is not as dense as lead and therefore the tin weights would be larger but it is not clear that this is either an advantage or disadvantage. Tin fishing sinkers are produced in the U.S., Canada, China and UK. Tin split shot sinkers are in general 3 times the price of the equivalent lead sinkers, depending on size and quantity (ECHA Market survey).

Tungsten

Tungsten has successfully been used as a replacement for lead for some fishing tackle applications. Tungsten fishing tackle have the advantage of being smaller and harder than lead ones and therefore are less likely to get stuck on rocks. Some fishers also claim that fish are attracted to the noise created by tungsten sinkers. One of the main drawback of tungsten is its price (ca. 10 times more expensive than lead).

Powdered tungsten can be mixed with a soft polymer putty that can be squeezed around fishing lines, and then be removed and re-used later. Such putty could be used to replace lead split shot for example.

Tungsten powder can also be mixed with hard plastic polymers and shaped into many forms designed for use as fishing sinkers using thermoforming technology. The Dossier Submitter contacted some suppliers of this high density polymers (cf. section on 'High density polymer').

Zamac or Zamak™

Zamac is a family of alloys with a base metal of zinc and alloying elements of aluminium, magnesium, and copper. Zamac alloys are part of the zinc aluminum alloy family; they are distinguished from the other zink-aluminium alloys because of their constant 4 % aluminium composition.

Zamac 3 and Zamac 5 are the most frequent Zamac used to manufacture fishing tackles. Alternative in Zamac has been found in the European market. Some production is done in Europe.

Zink

During the ECHA market survey, zinc has been identified in various sinkers, lures and jigs applications.

Nevertheless, due to the toxicity of zinc to mammal, avian species and aquatic organisms zinc should be used only as an alloying metal (Thomas, 2019), for example in

zamac.

C.1.4. Alternatives identified by Thomas (2019)

Table C.1-1: Compositional criteria for metals used as lead alternative in gunshot, rifle bullets, and fishing sinkers as proposed by (Thomas, 2019); amended

Metal/metal alloy	Shotgun shot	Rifle bullets or shotgun slugs	Fishing sinkers
Bismuth-tin alloy, Bi-Sn	**Suitable and fully approved in USA and Canada**	Not suitable, due to frangibility concerns at high-velocity impacts	**Suitable as weights and jigs**
Brass, copper-Zn (95 %-5 %)	Not suitable, Fäth et al. (2018) for aquatic environmental concerns	**Highly suitable**	**Suitable (corrosion resistant)**
Bronze, copper-tin alloy, Cu-Sn	**Suitable, especially when used in conjunction with denser tungsten**	**Potentially suitable, but metal hardness may be problematic**	**Suitable as weights and jigs**
Copper, Cu	Not suitable, Fäth et al. (2018) for aquatic environmental concerns	**Highly suitable**	Not suitable, Fäth et al. (2018) for aquatic environmental concerns
Iron, Fe	**≥ 99 % Fe**	Not suitable	**Suitable as corrosion-resistant "stainless" steel for weights and jigs**
Lead, Pb	Less than 0.1 % by mass	Less than 0.1 % by mass	Less than 0.1 % by mass
Nickel, Ni	Less than 1 % by mass	Allowed as a bullet jacket coat	Less than 1 % by mass
Tin, Sn	While demonstrated to be nontoxic, and unconditionally approved in Canada, the low-density limits use as gunshot	Not suited when used alone, but can be used in conjunction with other approved materials	**Suitable for use as split shot, weights, or jigs**
Tungsten, W	**95 % W, with polymer**	**Any %W, when used as a densifier with other approved material**	**Any %W, when mixed with polymers, glass, or other approved material**
Zinc, Zn	Less than 1 % by mass	Allowed only as an alloying metal	Allowed only as an alloying metal

Iron in stainless steel is unacceptable, ballistically, because of its greater hardness than annealed iron shot. This would increase pressures beyond safe limits, and be also more expensive to produce

C.2. Availability and price of alternative substances

Table C.2-1: Price and availability of the alternative substances

Substance	Source	Price in US$/tonne	Price indexed	Critical supply?
Lead	Recycled lead essentially	1 965	1.00	Not critical. Recyclable
Bismuth	China (84 %)			Critical Raw Material. Limited abundance.
Brass	-	4 000	2.03	Not critical. Recyclable
Bronze	-	1 350	0.69	Not critical. Recyclable
Ceramic/glass	-			Not critical. Recyclable
Concrete	-			Not critical.
Copper	Chile (29 %) Peru (12 %)	7 800	3.97	Not critical. Numerous competing uses.
High density polymer	-			Not critical.
Iron		100	0.05	Not critical. Numerous competing uses.
Nickel	Australia, Indonesia, South Africa, Russia and Canada	17 355	8.83	Not critical. Recyclable
Rebar	-	441.5	0.22	Not critical. Recyclable
Stainless steel	China (44 %) Europe (4 %)	2 345	1.19	Not critical. Recyclable

Stones	-			Not critical.
Tin	China and Indonesia	17 660	8.99	Not critical. Relatively abundant
Tungsten	China (85 %) Russia (50 %) Portugal (17 %) Spain (15 %) Austria (8 %)	30 300	15.42	Relatively abundant; included within EU Critical Raw Materials;
Zamac	-	3 250	1.65	Not critical. Recyclable
Zinc	China (39 %), Australia (11 %) Peru (10 %)	2 450	1.25	Not critical. Relatively abundant

Source: https://www.lme.com/, https://www.metalary.com/, http://www.experience-zamak.fr/indice-zamak/, https://worldsteelprices.com/european-steel-prices/ consulted on 24 August, (Wood E & IS GmbH, 2020)

C.3. Risk reduction potential of alternative substances

C.3.1. CLP classification

Table C.3-1 Classifications according to the CLP criteria

Material EC/List No	Harmonised classifications (Annex VI to CLP)	Additional classifications in the registration dossier
Lead (Pb) 231-100-4	*Lead massive [particle diameter ≥ 1 mm]:* • Repr. 1A, H360DF • Lact., H362 *Lead powder [particle diameter < 1 mm]:* • Repr. 1A, H360DF • Lact., H362 • Aquatic Acute 1, H400 • Aquatic Chronic 1, H410	*Lead massive and powder:* • STOT RE 1, H372 (oral, inhal)
Aluminium (Al) 231-072-3	*Al powder, pyrophoric:* • Pyr. Sol. 1, H250 • Water-react. 2, H261 *Al powder, stabilised:* • Flam. Sol. 1, H228 • Water-react. 2, H261	*Al metal and granular:* • Not classified
Antimony (Sb) 231-146-5	—	*Antimony massive:* • Not classified *Antimony powder:* • Carc 2, H351 (Inhal.) • STOT RE 2, H373 (Inhal.)
Bismuth (Bi) 231-177-4	—	Not classified
Brass 603-111-8	—	Not registered
Bronze 603-110-2	—	Not registered
Ceramic materials and wares, chemicals **266-340-9**	—	Eye damage 1, H318 Eye irrit. 2, H319

Copper (Cu) 231-159-6	*Copper granulated [particle length: from 0,9 mm to 6,0 mm; particle width: from 0,494 to 0,949 mm]:* • Aquatic Chronic 2, H411 (15th ATP[85])	*Copper massive:* • Not classified *Copper powder:* • Aquatic Acute 1, H400 • Aquatic Chronic 1, H410 *Copper flakes:* • Acute Tox. 4, H302 • Acute Tox 3, H331 • Eye Irrit. 2, H319 • Aquatic Acute 1, H400 • Aquatic Chronic 1, H410
Concrete 924-212-6	–	Not registered
Glass 920-837-3	–	Not registered
High density polymer	–	Not registered
Iron (Fe) 231-096-4	–	*Elemental iron in alloys or iron powder:* • Not classified *Carbonyl iron powder:* • Flam. Sol. 1, H228 • Self-heat. 1, H251
Nickel (Ni) 231-111-4	*Ni powder [particle diameter < 1 mm]:* • Skin Sens. 1, H317 • Carc. 2, H351 (Inhal.) • STOT RE 1, H372 (Inhal.) • Aquatic Chronic 3, H412 *Nickel:* • Skin Sens. 1, H317 • Carc. 2, H351 (Inhal.) • STOT RE 1, H372 (Inhal.)	
Steel 603-109-7	–	–
Stainless steel 912-499-0	–	–

[85] The updated harmonised C&L has been adopted for copper granulated in the Commission Delegated Regulation (EU) 2020/1182 and shall apply from 1 March 2022: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv%3AOJ.L_.2020.261.01.0002.01.ENG&toc=OJ%3AL%3A2020 %3A261 %3ATOC

Tin (Sn) 231-141-8	—	Not classified
Tungsten (W) 231-143-9	—	*Tungsten metal:* • Flam. Sol. 1, H228 • Self-heat 2, H252
Zamac	No information	No information
Zinc (Zn) 231-175-3	*Zinc powder, zinc dust (pyrophoric):* • Pyr. Sol. 1, H250 • Water-react. 1, H260 • Aquatic Acute 1, H400 • Aquatic Chronic 1, H410 *Zinc powder, stabilised:* • Aquatic Acute 1, H400 • Aquatic Chronic 1, H410	*Zinc metal (massive):* • Not classified

C.3.2. Existing regulatory activities

For the alternative substances investigated in this report no regulatory activities are currently ongoing except for copper:

- Copper:
  - ED under assessment as Endocrine Disruptor
  - CLH: copper granulated: Aquatic Chronic 2 (15^{th} ATP) shall apply from 1 March 2022

C.3.3. Alternative materials to lead approved by the U.S. Fish and Wildlife Service

The following table lists the approved formulation of shots for hunting waterfowls in the US. The formulations listed have been assessed as non-toxic for wild-life by the US Fish and Wildlife Service(USFWS, 1997).

Table C.3-2: List of shot formulations unconditionally approved for hunting waterfowl and coots by US Fish and Wildlife Service (USFWS, 1997) according to Thomas (2019)

Type	Composition by weight
Bismuth-tin	97 % bismuth and 3 % tin
Iron (steel)	Iron and carbon
Iron-tungsten	Any proportion of tungsten and C 1 % iron
Iron-tungsten-nickel	≥ 1 % iron, any proportion of tungsten, up to 40 % nickel
Tungsten-bronze	51.1 % tungsten, 44.4 % copper, 3.9 % tin, and 0.6 % iron and 60 % tungsten, 35.1 % copper, 3.9 % tin, and 1 % iron
Tungsten-iron-copper-nickel	40–76 % tungsten, 10–37 % iron, 9–16 % copper, and 5–7 % nickel
Tungsten-matrix	95.9 % tungsten and 4.1 % polymer
Tungsten-polymer	95.5 % tungsten and 4.5 % Nylon 6 or 11
Tungsten-tin-iron	Any proportions of tungsten and tin and ≥1 % iron
Tungsten-tin-bismuth	Any proportions of tungsten, tin, and bismuth
Tungsten-tin-iron-nickel	65 % tungsten, 21.8 % tin, 10.4 % iron, and 2.8 % nickel

Source: https://www.fws.gov/birds/bird-enthusiasts/hunting/nontoxic.php

Even though these substances have been assessed as non-toxic alternatives to lead gunshots, the same materials can be used for fishing tackle and other types of ammunition.

Other materials which have not undergone any evaluation could also be considered as safe for the environment.

C.3.4. Human health risks related to alternatives

Potential human health risks could be related with the **inhalation** exposure to particles or fumes from coated or jacketed lead or from alternative substances. Potential health effects of alternative metals include respiratory tract irritation (e.g., copper), metal fume fever (mainly zinc) and risk for carcinogenic effects in the respiratory tract (e.g., nickel).

For most alternative substances, its **skin contact** within hunting, sports shooting and fishing is not expected to pose a risk. However, for nickel, which has skin sensitising properties, skin contact may pose a risk depending on the concentration of nickel in the material.

If game meat hygiene measures have been properly applied there does not seem to be a risk from the **consumption of meat from game** bagged with non-lead ammunition containing copper and zinc.

The issues are addressed in more detail in the following sections.

C.3.4.1. Risks from inhalation exposure to metal dusts and fumes

Lead, coated or jacketed

Airborne lead exposure and related risks can be significantly reduced (97–99 %) by using a non-lead primer and bullets jacketed with nylon, brass or copper for shooting [(Valway et al., 1989), (Tripathi et al., 1990), (Tripathi et al., 1991), (Goldberg et al., 1991), (Löfstedt et al., 1999), (Bonanno et al., 2002)].

For example, Tripathi et al. (1991) investigated lead concentrations in the air and in the blood of two instructors firing either with non-jacketed lead bullets or with copper jacketed lead bullets. For the non-jacketed bullets mean lead concentrations were 67.1 $\mu g/m^3$ (range 36.7-95.6 $\mu g/m^3$) and 211.1 $\mu g/m^3$ (range 49.1-431.5 $\mu g/m^3$) for the two instructors, respectively. Using copper-jacketed bullets, lead concentrations in the air were reduced by more than 90 % to 5.4 and 8.7 $\mu g/m^3$ (Tripathi et al., 1991).

Non-lead alternatives

The type of metal particles that are emitted from the projectile is related to the composition of the projectile. A metal jacket composed of brass will lead to emission of copper and zinc particles.

The emission from home-casting bullets or fishing tackle are depending on the substances used for casting. Based on the melting points the following metals could be considered to be potentially used for home-casting of bullets and/or fishing tackle: bismuth (271°C), tin (232°C), zinc (420°C), and zamac (380-390°C). Antimony (630°C), aluminium (660°C), copper (1085°C) and its alloys such as brass (900-940°C) or bronze (950°C) would require specific equipment for home-casting.

Inhalation of metal fumes, especially of zinc oxide (Cooper, 2008), but also of copper (Nemery, 1990) or other metals may lead to **metal fume fever**. Metal fume fever commonly occurs in industrial plants where metals are heated to near boiling points, forming oxide fumes and is especially common after exposure to zinc oxide fumes. Metal fume fever is an influenza-like or malaria-like reaction that is accompanied by an acute, self-limited neutrophil alveolitis (Graeme and Pollack Jr, 1998, Cooper, 2008).

For the evaluation of lung toxicity of metals following inhalation, it is important to differentiate between substances (metals) with effects on the lung which are secondary to lung overload (acting more like inert dusts) from substance with substance-specific hazards leading to higher toxicity and risks. Effects on the lung secondary to lung overload may be observed with metals such as aluminium, bismuth, iron, tin or tungsten. Avoiding exposures leading to lung overload is expected to also avoid adverse effects on the lungs. Metals with substance-specific hazards are for example lead (e.g., neurotoxicity), nickel (genotoxic respiratory carcinogen), copper or zinc (metal fume fever as explained above).

To evaluate the risk from shooting for hunters and sports shooters, which represent a part of the general population, often no DNELs or other threshold for inhalation have been derived. However, as a proxy, the OEL or DNELs derived for workers following long-term inhalation exposure could be used, taking into account that usually children, pregnant women or other sensitive persons are less likely to be hunters or sports shooters.

In the following, thresholds (usually for workers) are provided for alternative substances above which a risk has to be assumed. For several particulate substances thresholds for inhalable and respirable fraction are presented, if available. Inhalable particulate fraction is that fraction of a dust cloud that can be breathed into the nose or mouth. Respirable particulate fraction is that fraction of inhaled airborne particles that can penetrate beyond the terminal bronchioles into the gas-exchange region of the lungs. It has to be noted that measured exposure concentrations in the air without specification are considered to reflect the inhalable fraction.

Aluminium

The leading effects of aluminium on the lung is lung inflammation due to dust overload. OELs of 4.0 mg/m^3 (inhalable) and 1.5 mg/m^3 (respirable) have been proposed by DFG (2018)[86]. In the registration dossier the respective DNEL for workers is 3.72 mg/m^3. For the general population no hazard was identified.

Antimony

Antimony powder is self-classified for carcinogenicity (Carc. 2) and STOT RE 2 following inhalation exposure. In the registration dossier a respirable DNEL for workers of 0.052 mg/m^3 was derived which would be comparable to an inhalable measurement of 0.263 mg/m^3.

Bismuth

For bismuth it is reported in the registration dossier that there are indications from animal experiments with intratracheal instillation (Sano et al., 2005) that lung effects are secondary due to lung overload. Based on an oral study, the DNEL inhalation long-term for workers was derived with 13.1 mg/m^3. For the general population no inhalation DNEL was derived.

Copper and its alloys

SCOEL (2014) proposed an OEL of 0.01 mg/m^3 for the respirable fraction; however, data base was insufficient at that time to derive an OEL related to the inhalable fraction. The leading effect identified was lung inflammation.

In the registration dossier the long-term inhalation DNEL was derived with 1.0 mg/m^3; signs of inflammation in the bronchioalveolar lavage of the test animals still observed at 0.2 mg/m^3 were considered as not adverse by the registrant.

There seems to be a need for an evaluation if an OEL for the respirable fraction can be derived.

[86] https://onlinelibrary.wiley.com/doi/pdf/10.1002/9783527818402.ch2

Iron/steel (Fe)

Iron is leading to lung inflammation secondary due to lung overload. In the registration dossier the DNEL for long-term inhalation for workers was derived with 3.0 mg/m^3.

Nickel (Ni)

Nickel has a harmonised classification for Skin Sens 1 and for Carc 2 and STOT RE 1 related to inhalation. RAC has proposed in 2018 and OEL of 0.005 mg/m^3 for respirable dust and of 0.03 mg/m^3 for inhalable dust[87].

Tin (Sn)

The EU-OEL for tin[88] is 2.0 mg/m^3. In the registration dossier a long-term inhalation DNEL of 71 mg/m^3 was derived. However, since tin is a metal of low water solubility with potential lung effects (assumed secondary to overload), extrapolation from an oral study is not appropriate.

Tungsten (W)

For tungsten the data with regards to inhalation toxicology is very limited. In the registration dossier a long-term inhalation DNEL of 5.8 mg/m^3 was derived.

Zinc (Zn)

Metal fume fever is the leading effects of zinc following inhalation exposure. DFG (2018) derived OELs of 2.0 mg/m^3 (inhalable) and 0.1 mg/m^3 (respirable). In the registration dossier a DNEL of 5.0 mg/m^3 was used.

Hunting and sports shooting

No reliable information is available on the concentration of metals in the air following controlled shooting with defined alternative shots and/or bullets compared to lead shots or bullets. Therefore, it is not possible to assess the risk from shooting/hunting depending on the type of ammunition used. Stakeholders holding such information are invited to submit those to ECHA.

For metals presumably leading to lung effects only secondary to overload such as aluminium, bismuth, iron, tin and tungsten, the risks could be controlled by limiting the exposures to avoid overload of the lungs.

For other metals leading to substance-specific effects such as acute metal fume fever (mainly zinc but also copper), irritation (copper), or which are even potential carcinogens (antimony, nickel), exposure from shooting activities and the consequent health risks need considered for specifically.

For hunting and shooting with soft iron shots, no specific health risk is to be expected when avoiding lung overload by metal dusts.

For hunting with alternative non-lead bullets, bullets or shots made copper or containing zinc require specific evaluation.

One series of publications showed a risk for health effects from exposure to copper and possibly zinc in volunteers from controlled shooting with alternative

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[87] https://echa.europa.eu/documents/10162/9e050da5-b45c-c8e5-9e5e-a1a2ce908335

[88] https://echa.europa.eu/substance-information/-/substanceinfo/100.028.310

bullets. Since the exposure scenario reflects a military use, the results are most probably less relevant for hunting or sports shooting activities.

However, in the absence of reliable data on exposure following hunting and shooting activities, it provides information that may be considered as "worst case" for the general population (hunter or sports shooter).

After introduction of non-lead ammunition, Norwegian Armed Forces received reports of acute respiratory symptoms in soldiers exposed to fumes from firing the standard weapon, HK416 rifle (Heckler & Koch rifle 5.56x45mm NATO caliber). Consequently, a series of volunteer studies were performed in which 54 to 55 healthy men per study were shooting in a semi-airtight tent for 60 min with either leaded (SS109, RUAG), non-lead (NM229, NAMMO), or modified non-lead ammunition (n= 19; NM255, NAMMO). The concentrations of total dust, as well as particles of copper (Cu), zinc (Zn), bismuth (Bi), lead (Pb) and tin (Sn) were significantly different between the groups. Shooting with non-lead ammunition resulted in Cu concentrations twice as high as with leaded ammunition (6.4 versus 3.7 mg/m^3), three times higher Zn concentrations (1.6 versus 0.5 mg/m^3) and nine times higher Bi concentrations (0.9 versus 0.1 mg/m^3) (see Table C.3-3). The measured Cu concentrations exceed the DNEL of 1 mg/m^3 derived in the registration dossier.

Table C.3-3 Exposure measurements during firing of military small arms (Voie et al., 2014)

Parameter	Ammunition						Proposed workers OEL/DNEL
	Leaded	n	Non-lead	n	Modified non-lead	n	
Rounds fired	17±11	17	13±9	19	14±7	19	
Dust (mg/m^3)	10.8±3.7[a, b]	14	17.3±2.4[c]	17	17.0±5.6[c]	17	
Pb (mg/m^3)	0.7±0.3[a, b]	15	--	18	0.1±0.3[c]	17	
Bi (mg/m^3)	0.1±0.1[a, b]	15	0.9±0.5[b, c]	18	1.7±0.7[a, c]	17	13.1 mg/m^3 (DNEL)
Cu (mg/m^3)	3.7±1.4[a, b]	15	6.4±1.4[c]	18	5.7±2.2[c]	17	1.0 mg/m^3 (DNEL)
Sn (mg/m^3)	0.2±0.1	15	--	18	0.0	17	2.0 mg/m^3 (EU OEL)
Zn (mg/m^3)	0.5±0.2[a]	15	1.6±0.4[b, c]	18	0.9±0.5[a]	17	2.0 mg/m^3 (inhal), 0.1 mg/m^3 (respir), OEL, DFG

[a]Differs significantly from non-lead ammunition

[b]Differs significantly from modified non-lead ammunition

[c]Differs significantly from leaded ammunition

In 42 of the 54 volunteers, general symptoms such as chills, headache and/or malaise appeared 3–12 h after shooting. More symptoms (see Table C.3-4) were reported when non-lead ammunition was used compared with leaded and modified non-lead ammunition (Voie et al., 2014). Shooting with all three types of ammunition lead to a significant declines in lung function such as mean FEV_1, FEV_1/FVC, FEF_{25-75} and DLCO which lasted 24 hours, and in a few cases even longer. Bronchial responsiveness (BR) expressed as individual DRS values increased for the whole study group. No significant

differences in lung function were observed between the three types of ammunition (Borander et al., 2017). Markers for systemic and airway inflammation were significantly increased 24 hours after shooting with leaded or non-lead ammunition. Statistically significant between lead and non-lead ammunition was an increase in the number of blood neutrophils, which was higher with non-lead ammunition (2.9 to 8.3 x 10^6 cells/ml; n=37) compared to leaded ammunition (2.4 to 5.0 x 10^6 cells/ml; n=17) (Sikkeland et al., 2018).

Table C.3-4 Number and percentage of subjects that reported symptoms within 24 h after firing (Voie et al., 2014)

Symptom	Ammunition							
	Leaded (n=17)		Non-lead (n=19)		Modified non-lead (n=19)		Total (n=55)	
	n	%	n	%	n	%	n	%
Headache	6[a]	**35**	14[b]	**74**	9	47	29	53
Fever	3/11	27	8/17	47	5/15	33	16/43	37
Chills	9	**53**	14[c]	**74**	8[a]	42	31	56
Myalgia	6	35	6	32	5	26	17	31
Malaise	8	47	9	47	10	53	27	49
Nausea	0	0	2	11	2	11	4	7
Thirst	0	0	3	16	2	11	5	9
Metallic taste	5	29	8	42	4	21	17	31
Discomfort mouth/ throat/ chest	11	65	13	68	12	63	36	66
Coughing	12	71	17	90	14	74	43	78
Shortness of breath	2	12	5	26	7	37	14	26
Total score of symptoms	62[a]	34	99[b,c]	48	78[a]	38	239	40

[a]Differs significantly from non-lead ammunition

[b]Differs significantly from leaded ammunition

[c]Differs significantly from modified non-lead ammunition

Home-casting

No information could be retrieved on the metal concentration in the air while home-casting bullets or fishing tackle. Stakeholders holding such information are invited to submit those to ECHA. Nevertheless the generic information on the risk from inhalation exposure described in section 0 and 0 remains valid.

C.3.4.2. Risks from handling alternative ammunition or fishing tackle

Lead, coated

The handling of ammunition or fishing tackle made of lead that is coated is considered to be of no relevant risk.

Non-lead alternatives

The handling of alternative ammunition or fishing tackle containing iron (steel), copper, bismuth, tin, tungsten is considered to be of no relevant risk.

The handling of ammunition containing nickel is of potential risk with regards to skin sensitisation. Alloys containing nickel are classified for skin sensitisation when the release rate of 0.5 µg Ni/cm^2/week, as measured by the European Standard reference test method EN 1811, is exceeded.

C.3.4.3. Risks from meat consumption from game hunted with alternative ammunition

Lead, coated

Most lead bullets used for hunting are usually semi-jacketed. Therefore, it can be assumed that the lead concentration measured in game meat results from hunting with semi-jacketed lead bullets. Therefore, the coating of the lead bullet does not prevent contamination of the game meat with lead.

Non-lead alternatives

Bismuth

Bismuth did not show a health hazard in a sub-chronic toxicity study in rats even when a water soluble salt was administered. Consequently, no human health risk is expected for the consumption of meat from game hunted with bismuth.

Copper and zinc

Reliable data on the metal concentration in game meat following the use of alternative shots or bullets are only available for game bagged with copper and zinc bullets.

Paulsen et al. (2015) simulated the release of different metals from non-lead rifle bullet fragments in game meat during storage and ingestion. The release of copper and zinc from meat posed no toxic risk post-ingestion by humans, but the authors advised that the aluminium, nickel, and lead content of bullets be kept deliberately low.

Irschik et al. (2013) indicated that the release of copper from shot game would not contribute much released metal to humans, concluding that the daily recommended daily intake of copper would not be exceeded, especially if bullet fragments around the entry site were removed. However, solid copper bullets do not fragment to the same extent as bonded and unbonded lead-core bullets [(Hunt et al., 2009), (Irschik et al., 2013), (Stokke et al., 2017)].

Schlichting et al. (2017) examined the contamination of **copper** and **zinc** in game meat from roe deer, wild boar and red deer hunted either with lead bullets (surrounded by a tombac jacket with a high copper and zinc content) or non-lead ammunition (bullets). Within the scope of the study, samples of 1254 roe deer, 854 wild boar and 90 red deer from different regions within Germany with known lead-contamination of the soil were examined. For each animal killed, the hunters had to fill in a sample data sheet in which detailed information on the animals (species, age and gender) and how they had been shot (including bullet material, i.e. lead vs non-lead), bullet type used, information on the entry and exit of the bullet, shooting distance and if a bone was hit were recorded.

The hunted game was brought to game traders who had also been specifically trained for this project and who collected the samples according to uniform standards. Three samples were taken from each animal after completion of the regular process of skinning and cleaning the carcass according to hygiene standards for game meat. The samples were taken from marketable meat of the saddle and haunch and from the area close to the wound channel, which had been widely cut out. The sample amount was 100 g for each of the three subsamples. The samples were analysed by accredited laboratories. For red deer, no difference was observed in copper and zinc content when using lead or non-lead ammunition. It should be kept in mind though that the sample size was significantly lower than that for the other two species. The outcome of this study shows that the usage of both lead-based ammunition and alternative non-lead ammunition results in the entry of copper (see Table C.3-5) and zinc (see Table C.3-6) into the edible parts of the game. However, the levels of copper and zinc in game meat measured in this study are in the range found in previous studies of game (see Table C.**3-7**). The content of copper and zinc in game meat is also comparable to those regularly detected in meat and its products from livestock (pig, cattle, sheep); copper compounds are used as a feed additive in the fattening of pigs and poultry. The consumption of game meat contributes to copper and zinc intake. If the mean or median values are considered then the intake of copper is between 0.2 and 0.5 mg and the intake of zinc is between 5.2 and 7.5 mg per day for average consumption. According to the authors a health risk for the consumer due to an average consumption of game meat with the reported content of copper or zinc is unlikely. The authors consider that since the general population on average eats more meat and/or products of farm animals, the intake of copper through the consumption of these products is much higher than it is through the consumption of hunted game meat, irrespective of whether lead or non-lead ammunition was used for hunting. This only applies, of course, if game meat hygiene measures have been properly applied, i.e. the meat close to the wound channel has been widely cut out and areas with hematomas have also been widely removed.

Table C.3-5 Copper content in hunted roe deer, wild boar and red deer (mg/kg) Schlichting et al. (2017)

Sample	Bullet	N	Copper concentration in game meat (mg/kg)				P
			Mean[a]	Median	95th[b]	Maximum	
Roe deer, haunch	Lead	745	1.614	1.564	2.196	6.451	0.359
	Non-lead	509	1.695	1.577	2.702	9.048	
Roe deer, saddle	Lead	745	1.810	1.759	2.769	4.034	0.576
	Non-lead	509	2.017	1.730	3.672	37.537	
Roe deer, around wound channel	Lead	745	1.464	1.400	2.063	3.946	<0.0001
	Non-lead	509	1.635	1.500	2.444	9.701	
Wild boar, haunch	Lead	514	1.437	1.375	2.136	4.300	0.432
	Non-lead	340	1.456	1.368	2.363	8.050	
Wild boar, saddle	Lead	514	1.506	1.200	1.986	110.000	0.005
	Non-lead	340	1.404	1.270	2.420	5.238	
	Lead	514	1.426	1.322	2.286	9.616	0.005

Sample	Bullet	N	Copper concentration in game meat (mg/kg)				P
			Mean[a]	Median	95th[b]	Maximum	
Wild boar, around wound channel	Non-lead	340	1.627	1.419	2.728	18.886	
Red deer, haunch	Lead	64	1.891	1.857	2.648	2.969	0.954
	Non-lead	26	1.896	1.874	2.478	2.902	
Red deer, saddle	Lead	64	1.794	1.746	2.462	4.787	0.789
	Non-lead	26	1.759	1.760	2.280	2.390	
Red deer, around wound channel	Lead	64	1.701	1.743	2.165	2.553	0.712
	Non-lead	26	1.755	1.650	2.363	2.721	

[a] Arithmetical mean

[b] 95th percentile

Table C.3-6 Zinc content in hunted roe deer, wild boar and red deer (mg/kg) Schlichting et al. (2017)

Sample	Bullet	N	Zinc concentration in game meat (mg/kg)				P
			Mean[a]	Median	95th[b]	Maximum	
Roe deer, haunch	Lead	745	30.574	31.660	44.640	65.000	0.089
	Non-lead	509	31.946	32.000	48.000	64.000	
Roe deer, saddle	Lead	745	28.842	31.324	50.000	63.000	0.006
	Non-lead	509	31.348	31.770	55.800	131.584	
Roe deer, around wound channel	Lead	745	30.532	29.719	48.000	72.296	<0.0001
	Non-lead	509	33.649	32.870	53.624	138.000	
Wild boar, haunch	Lead	514	31.700	32.029	45.700	56.000	0.397
	Non-lead	340	31.358	31.000	49.407	70.073	
Wild boar, saddle	Lead	514	28.266	29.000	45.000	98.521	0.049
	Non-lead	340	27.646	25.975	52.168	95.202	
Wild boar, around wound channel	Lead	514	30.406	28.410	52.000	88.232	0.027
	Non-lead	340	32.360	30.919	55.955	78.036	
Red deer, haunch	Lead	64	33.965	35.216	43.225	52.642	0.302
	Non-lead	26	35.850	36.373	52.410	57.510	
Red deer, saddle	Lead	64	35.371	37.486	53.010	58.990	0.689
	Non-lead	26	35.134	31.569	63.580	74.640	
Red deer, around wound channel	Lead	64	32.992	31.450	48.030	70.457	0.715
	Non-lead	26	34.110	32.575	48.417	67.933	

[a] Arithmetical mean

[b] 95th percentile

Table C.3-7 European studies on copper and zinc content in game meat (mg/kg wet mass). Data according to Ertl et al. (2016), complemented by additional references by Schlichting et al. (2017)

Species	Reference	Country	Copper				Zinc			
			n	mean	median	max	n	mean	median	max
Roe deer	(Dannenberger et al., 2013)	Germany	118	2.8		4.2	118	23.5		39.3
	(Falandysz, 1994)	Poland	145	1.8		8.1	145	30		60
		Poland	84	1.7		6.0	84	36		56
	(García et al., 2011)	Spain					75	1.56		8.0
Wild boar	(Amici et al., 2012)	Italy	75	12.20	11.80	25.17	57	53.21	53.14	80.10
	(Bilandžić et al., 2012)	Croatia	31	3.12	1.68	15.3				
	(Dannenberger et al., 2013)	Germany	85	1.7		2.3	85	24.0		31.9
	(Falandysz, 1994)	Poland	149	1.7		5.8	149	32		93
		Poland	118	1.5		5.7	118	37		72
	(Gasparik et al., 2012)	Slovakia	120	1.61			120	13.48		
	(Roslewska et al., 2016)	Poland	8	6.15		6.8	8	61.28		80.60
		Poland	8	7.5		9.2	8	68.21		106.1
	(Sager, 2005)	Austria	14	1.17	1.19	1.48	14	37.3	34.4	60.6
	(Strmisková and Strmiska, 1992)	Slovakia	10	1.3			10	41.0		
Red deer	(Falandysz et al., 2005)	Poland	82	3.3		6.4	82	39		64
	(Jarzyńska and Falandysz, 2011)	Poland	20	3.63	3.3	7.26	20	49.5	46.2	95.7
	(Gasparik et al., 2004)	Slovakia	22	2.49		5.34	22	54.76		109.12
	(Lazarus et al., 2008)	Croatia	48	3.48	3.02		48	43.4	43.8	67.4
	(Sager, 2005)	Austria	21	1.56	1.62	2.25	21	48.5	53.2	63.8

The maximum residue level (MRL) for copper permitted in food of animal origin from pigs, cattle, sheep, goats, horses, poultry and other farm animals is 5 mg/kg (fresh weight) according to regulation (EC) No 149/2008 and the amending regulation (EC) No 396/2005. For wild game meat (i.e. the meat after removal of trimmable fat) the

permitted residue level so far has been 0.01 mg/kg, which corresponds with the lower level of detection. This is because since spring 2013 "game meat" has been listed under "other terrestrial animal products" in Annex I to regulation (EC) No 212/2013 and the amending regulation (EC) No 396/2005 and no residue value has been derived based on natural content up to now. In order to account for the natural background levels of copper in game meat (as a result of environmental uptake mainly through feeding), Germany in its role as "evaluating member state" proposed a residue level for copper in game meat of 4 mg/kg. EFSA found that the contribution of the proposed MRL to total consumer exposure to copper was negligible. It amounts up to 0.7 % of the Acceptable Daily Intake (ADI) of an adult (Schlichting et al., 2017).

Iron/steel

The main constituent of steel, **iron**, has a lower oral toxicity compared to lead, copper or zinc. Therefore, a potential health risk from the consumption of meat from game hunted with steel ammunition is not expected to be higher than that for zinc or copper in case appropriate meat hygiene is applied.

Tungsten showed adverse effects on kidneys in a sub-chronic toxicity study in rats when a water-soluble salt was administered. Due to missing information on tungsten concentrations in game meat, no conclusion on human health risk can be drawn.

C.3.5. Environment risks related to alternatives

Major potential environmental risks related to the use of shots, bullets or fishing tackle made of alternative substances are aquatic toxicity and the toxicity of wildlife feeding on wounded or dead birds in which it was embedded or in the viscera of game left in the field.

C.3.5.1. Aquatic toxicity

Lead, coated

A galvanic tin-coated lead core prototype shot was shown not to leach tin in aquatic environment (Fäth et al., 2018).

Non-lead alternatives

The leaching behaviour of metals and their toxicity to *Daphnia magna* (EC_{50} value for 48 h immobilisation) of commonly available gunshot pellets was investigated under standardised medium for daphnids (Fäth et al., 2018) and under different water conditions (geology/redox conditions) (Fäth and Göttlein, 2019). The result of those studies are summarised in the following Table C.3-8 and addressed in the text below under the respective heading. The conditions of the experimental aquatic environments are also outlined in Figure C.3-1. The grey shading represents those values that exceeded the EC_{50} for *Daphnia magna* according to Khangarot and Ray (1989). Spring water originating from siliceous bedrock showed the highest concentrations of nearly all leached metals (Pb, Zn, Ni, Cu) under aerobic conditions. The authors concluded that according to the conducted leaching tests, Cu- and Zn-based as well as Zn-coated gunshot should be avoided by reason of the high risks they pose to the aquatic environment.

Table C.3-8 Metal concentrations (in µmol/L) for different shot types during short- and long-term exposure leaching tests as provided by (Fäth and Göttlein, 2019) including data from (Fäth et al., 2018)

Shot type (main component)	Leached element	Metal concentration (µmol/L), mean±standard error				
		ADaM	Siliceous (pH 6.5) aerobic	Calcareous (pH 7.6) aerobic	Siliceous (pH 6.5) anaerobic	Calcareous (pH 7.6) anaerobic
Short term period (1 day; 8 days)						
PL (Pb)	Pb	**1.81±0.26**	**1.77±0.36**	0.32±0.15	<LOQ	<LOQ[a]
	Sn	<LOD[b]	<LOQ	**0.39±0.06**	<LOQ	**0.31±0.08**
Blind Side (Fe)	Zn	**13.39±3.35**	**11.82±3.91**	2.47±0.26	0.21±0.01	<LOD
Hubertus (Zn)	Zn	**33.79±4.56**	**29.99±9.02**	3.96±0.81	1.33±0.19	<LOQ
Silver (Pb)	Ni	0.59±0.08	**0.68±0.09**	0.55±0.06	**1.56±0.47**	**0.65±0.10**
Sweet Copper (Cu)	Cu	**1.91±0.51**	**3.53±1.06**	**2.63±1.12**	0.14±0.01	<LOQ
Ultimate (W)	Sn	<LOD	<LOD	<LOD	0.89±0.29	0.89±0.44
Long-term period (15 days; 22 days)						
PL (Pb)	Pb	0.60±0.25	**4.30±1.12**	0.20±0.09	<LOQ	<LOQa
	Sb	<LOQ	<LOQ	**0.75±0.05**	<LOQ	0.59±0.05
Blind Side (Fe)	Cr	<LOQ	<LOQ	<LOQ	0.10±0.01	<LOQ
	Zn	**34.70±0.92**	24.82±1.29	3.78±0.16	0.49±0.11	<LOD[b]
Hubertus (Zn)	Zn	30.48±1.79	**55.71±3.75**	4.83±0.15	0.69±0.10	<LOQ
Silver (Pb)	Ni	**1.34±0.19**	0.52±0.02	0.31±0.04	**1.20±0.23**	<LOQ
Sweet Copper (Cu)	Cu	4.11±0.37	**5.92±0.27**	**6.35±0.10**	<LOQ	<LOQ
Ultimate (W)	Sn	<LOQ	<LOD	<LOD	**1.23±0.07**	0.65±0.08

ADaM: standardized medium termed "Aachener Daphnien Medium; LOQ: Limit of quantification; LOD: limit of detection; bold values indicate homogeneous subsets with the significant highest concentrations among the tested environments determined by ANOVA. Grey shading represents those values that exceeded the EC50 for *Daphnia magna* according to (Khangarot and Ray, 1989)

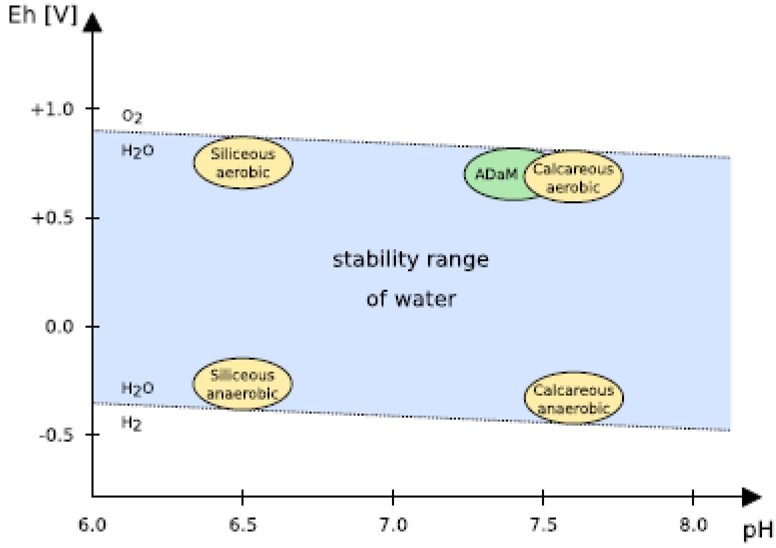

Figure C.3-1 Schematic placement of the four investigated environments (yellow) as well as the ADaM solution (green) used by Fäth et al. (2018) in the stability range of water defined by the redox potential and the pH value at 298.15 K and 105 Pa in an Eh/pH chart (Fäth and Göttlein, 2019)

Bismuth

Bismuth does not have any harmonised or self-classification.

When testing the leaching rate for a commercial bismuth shot (Eley Bismuth Alphamax) no detectable leaching rate of bismuth or other metals (tin, nickel, iron, lead) was identified (see also Table C.3-8) and consequently also no impact on immobilisation of Daphnia magna (Fäth et al., 2018).

Brass

For brass chemical fate studies demonstrated that the brass dissociated to its ionic components of copper and zinc quickly at pH 2.0. At pH 5.0 and 6.5, the dissociation occurred too slowly to account for the observed toxicity. The data suggested that the toxicity is due to filtration by the daphnids and subsequent ingestion. EC50 determinations for the brass particles are nearly identical with published EC50 values for copper salts (Johnson et al., 1986).

Pb (or Bi) is present in brasses as small “islands” of metal, whereas Cu and Zn are mixed in a solid solution. With time, Zn in the brasses was preferentially lost relative to Cu. Pb releases from the brass faucets in 6 hour stagnation runs increased rather than decreased with time. This behaviour is inconsistent with formation of passivating scale layers, but is consistent with progressive dezincification producing a porous surface layer through which Pb can diffuse more rapidly, or from which Pb particulates can be detached more readily with time (Maynard et al., 2008).

Copper

Copper massive does not have a harmonised classification for aquatic toxicity, whereas copper granulated has a harmonised classification for Aquatic Chronic 2 which shall apply from 1 March 2022. Copper powder and copper flakes are self-classified in the registration dossier for Aquatic Acute 1 and Aquatic Chronic 1.

The continental threshold for copper was reported to be 1.1 µg/L (Peters et al., 2019).

When testing the leaching rate of a commercial copper shot (FOB Sweet Copper) high leaching rates were demonstrated with 0.79, 3.03, 4.22 and 4.0 µmol/L after 1, 8, 18 and 22 days, respectively. The authors identified the EC_{50} value for 48 h immobilisation of *Daphnia magna* with 1.46 µmol Cu/L (Fäth et al., 2018). Even higher concentrations leached under siliceous and calcareous aerobic conditions as demonstrated that pose a risk to aquatic organisms (Fäth and Göttlein, 2019).

Thomas et al. (2007) measured the release of copper from pure copper shots, sintered tungsten-bronze shots and glass beads in a buffered, moderately hard, synthetic water of pH 5.5, 6.6, and 7.8 over a 28-day period. The dissolution of copper from the copper shot was affected significantly by the pH of the water and the duration of dissolution (see Figure C.3-2). The resulting Expected Environmental Concentrations (EECs) were not presented in the publication.

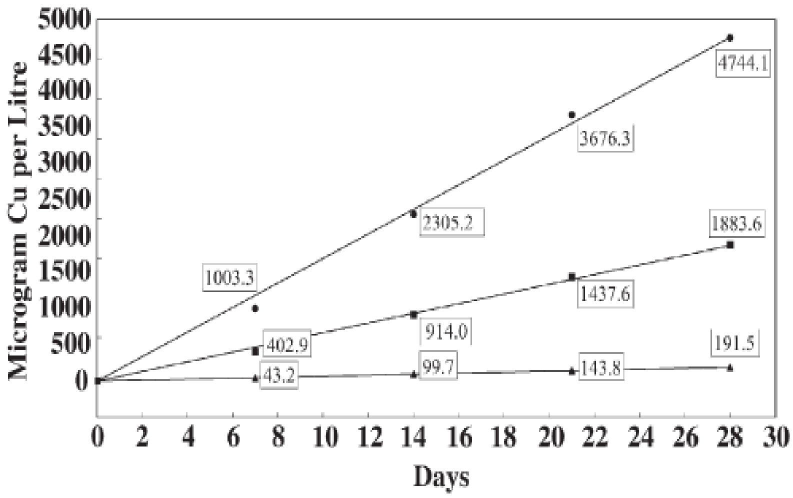

Figure C.3-2 Dissolution of copper from copper shot in moderately hard water at 15°C under three different pH levels during a 28-day period. Regression equation for pH 5.6 (●), y=169.67x (R2=0.9965). Regression equation for pH 6.6 (▪), y=67.038x (R2=0.9974). Regression equation for pH 7.9 (▴), y=6.8573x (R2=0.9981). Values accompanying each datum point are untransformed means (Thomas et al., 2007).

High-density polymer

Fishing sinkers made of polymer could fall under the definition of the recently adopted restriction proposal of microplastic.

Nickel

Nickel powder, but not nickel metal, has a harmonised classification for Aquatic Chronic 3.

Metal bioavailability and toxicity to aquatic organisms is dependent on the physico-chemical composition of the surrounding medium. No information could be retrieved on the leaching of nickel from metal to aquatic environment.

Stainless steel

Stainless steel can be used to manufacture fishing sinkers and lures. It has been noted that stainless steel sinkers can leach cadmium, and other elements, under acidic conditions however the pH required are unlikely to be encountered during most fishing

uses (Katz and Jelinski, 1999)

Steel

The median iron concentration in rivers has been reported to be 0.7 mg/L. In anaerobic groundwater where iron is in the form of iron(II), concentrations will usually be 0.5–10 mg/L, but concentrations up to 50 mg/L can sometimes be found. Concentrations of iron in drinking-water are normally less than 0.3 mg/L but may be higher in countries where various iron salts are used as coagulating agents in water-treatment plants and where cast iron, steel, and galvanized iron pipes are used for water distribution (WHO, 2003).

Elemental iron or iron powder does not have any harmonised or self-classification.

Iron is an abundant element in the earth's crust and can be an environmental pollutant in waters near coal and hard rock mines. In the US the current water quality criterion is 1.0 mg/L. Based on more recent investigations the authors are proposing to reduce it to 0.49 mg/L (Cadmus et al., 2018).

When testing the leaching rate of two commercial steel shots (Rottweil Steel Game, Winchester Blind Side) the leaching of iron itself was not reported (Fäth and Göttlein, 2019).

The available data do not indicate a risk of iron for the aquatic environment.

Tin

Tin does not have a harmonised classification and is not self-classified for any endpoint.

In the registration dossier the following is concluded "*Aquatic ecotoxicity data on tin is available for algae, invertebrates and fish. The test data on studies that are that based truly soluble tin indicate no adverse effects are expected at the range of concentrations of tin permitted by its very low solubility. The solubility of tin is very low due to its tendency to precipitate out of solution. The potential adverse effects of the precipitate were also studied in a chronic chironomid sediment and respiration inhibition tests and no significant adverse effects were seen. Therefore, an environmental classification is not proposed.*"

When testing the leaching rate of a commercial tungsten shot (Ultimate) no leaching of tungsten was observed (see also Table C.3-8). However, leaching of **tin** occurred under anaerobic conditions; for the long-term period under siliceous conditions the leaching tin reached concentrations that pose a risk to aquatic organisms (Fäth and Göttlein, 2019).

The available data indicate no aquatic toxicity of tin in shots under aerobic conditions; the reported risk of aquatic toxicity of tin under anaerobic condition (Fäth and Göttlein, 2019) would require further investigations.

Tungsten (W)

Tungsten is not classified for environmental hazards.

In the registration dossier the following is summarised: "*No definitive results were available from tests performed with tungsten metal. Therefore, the most reliable studies identified for sodium tungstate were used in for read-across in the PNEC derivations. This approach is considered to be appropriate since sodium tungstate has been shown to undergo more dissolution in water solutions mimicking natural water conditions than tungsten metal. Hence, sodium tungstate is likely to be more bioavailable than tungsten metal and adequately protective for estimating potential toxicity. Furthermore, neither*

tungsten metal or sodium tungstate are classified for aquatic toxicity and their PBT profile is the same"

When testing the leaching rate of a commercial tungsten shot (Ultimate) no leaching of tungsten (see also Table C.3-8) was observed (Fäth and Göttlein, 2019).

Thomas et al. (2007) measured the release of copper from pure copper shots, sintered tungsten-bronze shots and glass beads in a buffered, moderately hard, synthetic water of pH 5.5, 6.6, and 7.8 over a 28-day period. The dissolution of copper from the control copper shot affected significantly by the pH of the water and the duration of dissolution (see Figure C.3-3). The rate of copper release from tungsten bronze shot was 30 to 50 times lower than that from the copper shot, depending on pH. The observed expected environmental concentration of copper released from tungsten–bronze shot after 28 days was 0.02 µg/L at pH 7.8, and 0.4 µg/L at pH 5.6, using a loading and exposure scenario specific in a U.S. Fish and Wildlife Service protocol. Ratio Quotient values derived from the highest EEC observed in this study (0.4 µg/L), and the copper toxic effect levels for all aquatic species listed in the U.S. Environmental Protection Agency ambient water quality criteria database, were all far less than the criterion value (0.1 µg/L).

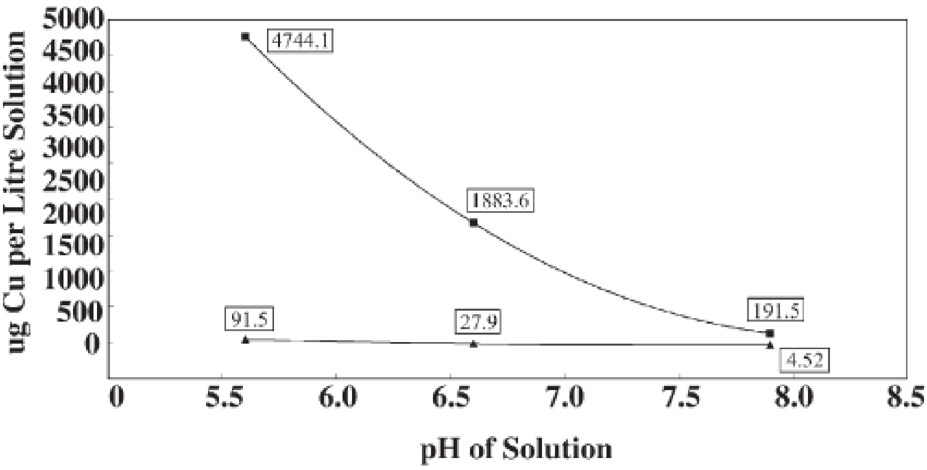

Figure C.3-3 The effect of pH on the dissolution rate of copper from copper shot and tungsten–bronze shot when immersed in a moderately hard water at 15 °C for 28 days. Values accompanying each datum point are the untransformed means from day 28. Regression equation for copper shot (▪), $y=677.79x^2-11130x+45814$ ($R^2=1.0$). Regression equation for tungsten–bronze shot (▴), $y=19.69x^2-303.53x+1173.8$ ($R^2=1.0$) (Thomas et al., 2007).

In the call for evidence (CfE #1034), VLIZ mentioned recent studies which highlight movement and detection of tungsten in soil and drinking water sources (Emond et al., 2015, Inouye et al., 2006, Tuna et al., 2012, Wasel and Freeman, 2018). Movement and detectability of a substance are usual behaviour and would not be a problem in case of a non-toxic substance such as tungsten. VLIZ mentioned also that Inouye et al. (2006) even 'showed that the sub-lethal toxicity of tungsten appears to be higher than that of lead'. The authors of this study tested a soluble tungsten salt and a soluble lead salt. Since tungsten metal is insoluble, such a statement is not correct for tungsten metal.

Based on the available data there are no indications for aquatic toxicity, or other environmental hazard of tungsten used in shots, and fishing tackle.

Zinc

Zinc powder - but not zinc massive - has a harmonised classification for Aquatic Acute 1 and Aquatic Chronic 1.

In the registration dossier, zinc massive is not self-classified for aquatic toxicity. It is noted that the potential ecotoxicity of metals in massive form is determined by their capacity to release ions in aqueous media. This capacity was assessed in transformation/dissolution (T/D) testing at pH 6, at which release of zinc ions from metal was found to be maximal. It was noted that the diameter of a zinc metal sphere of 1 mg should be ≤ 0.082 mm, in order to reach the reference value for acute aquatic effects. This particle size is much smaller than the default particle size distinguishing massive metal from powder/dust (1mm). The critical diameter of a spherical metal particle, resulting in sufficient surface loading to reach the reference value for chronic aquatic effects at 1mg/l loading of the substance was set at 2.1 mm. Accordingly, the critical diameters of a sphere, resulting in reaching the reference value for chronic aquatic effect at mass loading criteria of 0.1mg/l and 0.01mg/l are determined to be 0.21 mm and 0.021 mm, respectively.

When investigating the leaching behaviour of metals from alternative shots in different environmental conditions, high leaching of zinc (up to 55.7 µmol/L; see also Table C.3-8) has been observed that pose a risk to aquatic organisms under aerobic conditions (Fäth and Göttlein, 2019).

Based on the experimental results (Fäth and Göttlein, 2019), aquatic toxicity of zinc leaching from zinc containing shots containing under certain environmental conditions has to be assumed.

C.3.5.2. Toxicity to wildlife

Lead, coated

Attempts to cover lead shot to prevent lead toxicity with a protective coating of non-toxic metals or other materials to prevent the degradation and uptake of lead while in the gizzard/stomach of birds have all failed (USFWS, 1986), (Scheuhammer and Norris,1995), (Friend et al., 2009), Thomas (2019). The coatings (if used for shot or fishing tackle) will wear off or will be dissolved in the highly acidic environment of the avian gizzard and stomach, exposing lead core to the digestive actions of the gut.

Different species of birds have different stomach pH. For example, the pH of a duck stomach ranges from 2.0 - 2.5, whilst that of an eagle is closer to 1.0 (USFWS, 1986). Due to the highly acidic environment of the raptors and scavengers stomach, jacketed lead bullets (fragments) can be equally expected to wear off or be dissolved in the birds stomach.

In addition to the toxicity for wildlife, comment CfE #1034 is also highlighting the issue of secondary microplastics creation from the abrasion of the polymer-based coating.

Non-lead alternatives

In the USA 11 distinct shot types have been given approval for hunting fowl (USFWS, 1997) (see also Table C.3-2) largely based on experimental data with game-farmed ducks. Alternative shots are either made of steel, bismuth or tungsten.

Bismuth and its alloys

Shot made from bismuth-tin alloy is also fully approved as non-toxic (Thomas, 2019). Sanderson et al. (1997) demonstrated that ingested bismuth-tin shot or implanting bismuth-tin alloy into the breast muscle of ducks did not have any toxic impact on the birds and did not affect their reproduction.

Brass

Zinc can be alloyed with copper to make brass, which lowers the mobility of zinc in solution. Brass might also contain lead as an impurity or additive to limit copper corrosion. Therefore, brass exhibits less potential toxicity than zinc and lead alone to animals which might ingest them (Thomas, 2019).

Copper

Franson et al. (2012) reported that American kestrels (Falco sparverius) that were dosed experimentally with copper shot exhibited no signs of toxicity.

Feeding of shots made from copper to 24 mallards resulted in 4 % mortality which was below the mortality of control birds fed plastic (20 %) (Irby et al., 1967).

Feeding of 6 copper or **brass** shots to 10 ducks did not results in relevant body weight loss during a 4 week retention period (Krone et al., 2009b).

Iron/Steel

Feeding of shots made from pure iron, zinc-coated iron, or molybdenum-coated iron to 23 or 24 mallards resulted in mortality of some animals (12 % for iron, 4 % for zinc-coated iron) was below the mortality of control birds fed plastic (20 %) (Irby et al., 1967).

Twenty mallards (*Anas platyrhynchos*) of both sexes were dosed by oral gavage with steel shot. All pellets were fired from a shotgun into an absorbent material, retrieved, and weighed prior to introduction into the ducks. Birds were fed whole kernel corn and grit and observed for signs of toxicity for 30 days following dosing. Steel shot pellets lost 57 % of their mass in the birds' gizzards. No mortality was observed, mean bird weight change was not different, and there were no significant morphologic or histopathologic abnormalities of the liver and kidney (Brewer et al., 2003).

Steel shot may be coated with a thin layer of copper or zinc to inhibit rusting and is permitted under US regulations (USFWS, 1997). The level of uptake of copper and zinc from the dissolution of these metals in the gut of birds from such a thin layer would be defined as non-toxic under the USFWS (1997) regulations (Thomas, 2019).

Tin

After force-feeding of pure tin shots, mallards did not show a significant body weight loss and did not die within 30 days (Grandy IV et al., 1968).

Tungsten

Twenty mallards (*Anas platyrhynchos*) of both sexes were dosed by oral gavage with No. 4 Heavi-Shoty (H-S), a commercially available shot that contains a mixture of tungsten (W), nickel (Ni), and iron (Fe). All pellets were fired from a shotgun into an absorbent material, retrieved, and weighed prior to introduction into the ducks. Birds were fed whole kernel corn and grit and observed for signs of toxicity for 30 days following dosing. Hevi- Shot pellets lost an average of 6.2 % of their mass in the birds' gizzards. No mortality was observed and mean bird weight change was not different. There were no significant morphologic or histopathologic abnormalities of the liver and kidney.

Results indicated that mallards dosed orally with eight No. 4 H-S pellets were not adversely affected over a 30-day period, and that H-S provides another environmentally safe nontoxic shot for use in fowl hunting (Brewer et al., 2003).

Failure to distinguish between elemental tungsten and tungsten alloys has caused confusion, especially about their relative toxicity in shotgun ammunition. Controlled experiments indicate that the carcinogenicity of embedded tungsten–nickel–cobalt alloys derives from their nickel and cobalt content, and not the tungsten. The carcinogenicity of metallic nickel and cobalt implants in animal tissues is well-established. Studies in which pure tungsten metal is embedded in animal and human tissues indicate that there is no toxicity or carcinogenicity developed locally or systemically. The exposed tungsten corrodes slowly in the tissue fluids and is excreted from the body. Chronic studies in which pure tungsten-based shot are placed, continuously, in the foregut of ducks over 150 days indicate that there are no adverse physiological effects, nor disruption of ducks' reproduction and development of their progeny (Thomas, 2016).

When shot made of bismuth-tin alloy was implanted into mice intra-peritoneally for extended periods of time no toxic effects were reported (Pamphlett et al. 2000; Stoltenberg et al. 2003). Although mobilization of bismuth from the shot occurred over months, no detrimental effects on weight gain, movements, and appetite were observed.

Zinc

Because of the demonstrated acute toxicity of ingested **zinc** shot to birds, fishing weights and gunshot should never be made of this pure metal (Thomas, 2019).

For example, ingested zinc shot has been demonstrated to be acutely toxic to mallards (Levengood et al., 1999), (Levengood et al., 2000), (Grandy IV et al., 1968).

Feeding of 6 zinc shots to 10 ducks did not results in mortality but in 80 % body weight loss during a 4 week retention period (Krone et al., 2009b).

C.3.6. Summary of risk reduction potential of the alternative substances

C.3.6.1. Lead, coated or jacketed

The use of jacketed lead bullets is significantly reducing lead exposure of the shooter or hunter. However, coating of lead bullets does not prevent lead contamination of game meat bagged with jacketed lead bullets.

The use of coated leaded shots or lead fishing tackle is expected to reduce lead exposure from handling via the hand-to-mouth route.

Attempts to cover lead shot to prevent lead toxicity with a protective coating of non-toxic metals or other materials to prevent the degradation and uptake of lead while in the gizzard/stomach of birds have all failed (USFWS, 1986), (Scheuhammer and Norris,1995), (Friend et al., 2009), Thomas (2019). The coatings (if used for shot or fishing tackle[89]) will wear off or will be dissolved in the highly acidic environment of the avian gizzard and stomach, exposing lead core to the digestive actions of the gut.

[89] Whether the shot is picked up from a marsh or ground, or from the bodies of wounded or dead birds in which it may be embedded, is not relevant for the overall toxicity.

Different species of birds have different stomach pH. For example, the pH of a duck stomach ranges from 2.0 - 2.5, whilst that of an eagle is closer to 1.0 (USFWS, 1986). Due to the highly acidic environment of the raptors and scavengers stomach, jacketed lead bullets (fragments) can be equally expected to wear off or be dissolved in the birds stomach.

C.3.6.2. Non-lead alternatives

The dossier submitter considers that potential human health risks related with the use of alternative shot substances are mainly a consequence of inhalation of fumes/dusts from shooting, home-casting and the consumption of game bagged with such alternative substances.

Potential environmental risks are mainly related to aquatic toxicity of the used shot material and toxicity to wildlife picking up the shots from a marsh or ground, or from the bodies of wounded or dead birds in which it was embedded.

The dossier submitter considers that – in contrast to shots – aquatic toxicity of alternative bullets is less relevant because bullets might either remain in the carcass of the bagged animal or in the soil.

However, the risk of spent alternative bullets and their fragments being ingested by scavengers from discarded gut piles, non-retrieved killed or wounded animals has to be assessed.

C.3.6.3. Summary table of risk reduction potential

Table C.3-9: Toxicity of the alternative substances compared to lead

Alternative material	Human health inhalation (mg/m^3; inhalable)	Human health Game meat (game meat)	Aquatic toxicity	Wild life toxicity (ingestion)
Lead	**Yes**, risk increases with calibre, frequency, low ventilation	**Yes**	Depending on Pb release from shots: Pb metal not classified; Pb powder Aquatic Acute/Chronic 1	**Yes**
Alternative shots for hunting				
Lead, coated	Risk seems low	**Yes**	Depending on release of and risk of coating material and release of Pb over time	**Yes**

Bismuth-tin (3-6 %) alloy	>13 (Bi)	No	No: Bi not classified	No
Brass (copper-zinc alloy)	>1 (Cu) >2 (Zn)	No	Depending on Cu, Zn (and Pb) release from shots	
Bronze (copper-tin alloy)	>1 (Cu) >2 (Sn)	No		
Copper (Cu)	>1 (Cu)	No (based on data generated with Cu bullets)	Depending on Cu release from shots: Cu metal not classified; Cu granulated Aqua Chronic 2; Cu powder self-class. Aqua Acute/Chronic 1	No
Nickel (Ni) (alloying metal)	**>0.03; carc (Ni)**	**>4 µg/kg**	Depending on Ni release from shots: Ni metal not classified; Ni powder Aquatic Chronic 3; Ni release from shots	**Yes**
Steel (soft iron >99 % Fe)	>3 (Fe)	No oral	No: Fe not classified	No
Tin (Sn)	>2 (Sn)	No hazard identified	No: Sn not classified, Sn release from W shots under anaerobic conditions	
Tungsten (W)	>5 (W)		No: W not classified; no W release from shots	No

Tungsten -bronze	>5 (W) >1 (Cu)		No: Cu release 30-50-times lower than from Cu shots	
Zinc (Zn)	>2 (Zn); zinc fever		Depending on Zn release from shots: Zn metal not classified Zn powder Aquatic Acute/Chronic 1	**Yes**
Alternative bullets for hunting				
Lead, coated	Low	**Yes (based on Pb data)**	n/a	**YES**
Copper, pure	>1 (Cu)	No (based on data)	n/a	No
Brass (copper-zinc <40 %)	>1 (Cu) >2 (Zn)	No (assumed based on Cu and Zn data)	n/a	
Bronze (copper-tin 10 %)	>1 (Cu) >2 (Sn)		n/a	
Tombac (copper-zinc up to 20 %)	>1 (Cu) >2 (Zn)	No	n/a	
Tungsten (often used as alloying metal)	>5 (W)	>0.48 mg/kg bw (DNEL oral)	n/a	
Zinc	>2 (Zn); zinc fever	No (based on data)	n/a	**YES**
Alternative fishing tackle				
Lead, coated		n/a	Depending on releases of coating material and Pb over time	**YES**

Bismuth	>13 (Bi)	n/a	Bi not classified	
Brass	Home-casting less likely	n/a	Cu, Zn (and Pb) release under certain conditions	
Ceramic/Glass		n/a		
Copper	Home-casting less likely	n/a	Cu metal not classified; Cu granulated Aqua Chronic 2; Cu powder self-class. Aqua Acute/Chronic 1; Cu release from shots under certain conditions	No
Concrete		n/a		
High density polymer	Home-casting not likely	n/a	Might fall under the microplastics definition	Might fall under the microplastics definition
Iron	Home-casting less likely	n/a	Fe release but Fe not classified	
Rebar (for reinforcing bar)	Home-casting not likely	n/a		
Stainless Steel (e.g., 11 % Cr, 8 % Ni)	Home-casting not likely	n/a	Corrosion resistant: no releases of Fe, Cr or Ni	
Steel (Fe, <2 % carbon; 1 % Mn)	Home-casting not likely	n/a	Not corrosion resistant: releases of Fe (not classified) and Mn (Mn self-classified Aquatic Chronic 2 or 3)	

Stones and pebbles				
Tin	>2 (Sn)	n/a	Sn not classified, Sn release from W shots under anaerobic condition	
Tungsten	Home-casting not likely	n/a	W not classified; no W release from shots	No
Zamac or Zamak™	>2 (Zn);	n/a		
Zink	>2 (Zn) zinc fever;	n/a		**YES**

C.4. Environmental footprint of alternative material

C.4.1. Methodology, uncertainties and limitations

C.4.1.1. Methodology

The assessment of the environmental footprint of the alternatives is outside of the remit of the restriction process. Nevertheless, having in mind the future EU Chemicals strategy, and the EU Green Deal policy developed at the European level, this aspect should not be neglected when looking at the alternatives, and in particular at the overall environmental risk reduction of the alternatives. Using a simplistic qualitative approach, the Dossier Submitter described and compared lead and its alternatives against the following criteria to understand the global environmental footprint of the alternatives, and compare it to the one of lead:

- Toxicity and risk for the human health (covered in section C.3.4)
- Toxicity and risk for the environment (both aquatic and wildlife ingestion) (covered in section C.3.5)
- Sourcing of the raw material to manufacture fishing tackle and ammunitions (extraction vs recycling)
- Resource depletion associated to the sourcing/production of the raw material, and the manufacturing of fishing tackle and ammunitions (at the end of the supply chain)
- Impact on climate change and in particular emission of Greenhouse gases from the sourcing/production of the raw material, and the manufacturing process of fishing tackle and ammunitions

For each of the global environmental foot print criteria listed above, lead was used as the baseline.

C.4.1.2. Uncertainties and limitations

The analysis in these sections do not intend to be exhaustive and specific to the fishing tackle and ammunitions, but rather indicative. It is based essentially on a report prepared by Wood at the request of the Dossier Submitter (Wood E & IS GmbH, 2020), and on information extracted from the Granta CES Material Database (Ichlokmanian; Bert, 2017).

The Wood report and the additional work performed by the Dossier Submitter to assess the global environmental footprint of lead and its alternatives are intended as a rapid assessment of available evidence from public sources. The source data has not been peered reviewed. In that context:

- Analysis relies on publicly available data sources and relevant datasets (no additional market analysis and related data has been purchased).
- Full life cycle analysis (LCA) is not completed in the current study. Data collated provides an indicative impact assessment only.
- Sourcing of raw material indicates in general the sourcing of the raw material to manufacture objects made of lead and its alternative and is not specific to the fishing tackle and ammunition sector unless specified.
- Resource depletion data identifies headline impact areas (rather than providing a formalised and detailed LCA assessment).
- Net CO_{2e} emissions are assessed by looking at available data within processing steps from raw materials to products at high level (no third-party formally verified LCA calculations have been carried out).

C.4.1.3. Main public references used to establish the scoring

The following public references were used by Wood (Wood E & IS GmbH, 2020) to establish the scoring of the raw material against the different environmental footprint criteria:

- http://minerals4eu.brgm-rec.fr/m4eu-yearbook/ . [Accessed December 2020].
- https://www.ilzsg.org/static/enduses.aspx?from=1 . [Accessed December 2020].
- https://www.resourcepanel.org/sites/default/files/documents/document/media/e-book_metals_report2_recycling_130920.pdf . [Accessed December 2020].
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- https://www.lowtechmagazine.com/what-is-the-embodied-energy-of-materials.html . [Accessed December 2020].
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C.4.2. Sourcing of the raw material

As the EU chemical strategy, and the European Green Deal policy, intend to focus on reusing recycled material rather than new/extracted natural resources, the Sourcing criteria is looking at the impact on the natural resources. Raw material that are essentially coming from primary sourcing (e.g. extraction of natural sources) have a high impact on the environment footprint, while raw material coming from recycling sources (also called secondary sourcing) have a low impact on the environment footprint. The scoring criterion is therefore based on the proportion of raw material coming from recycled source and is summarised in the table below.

Table C.4-1: Scoring criteria to assess the sourcing impact on the environmental footprint

Criterion	Low Impact (Score =3)	Moderate Impact (Score =2)	High Impact (Score =1)
Estimated Secondary / Recycled sourcing	>50 % of the total sourcing of the raw material	31 % - 50 %	30 % or lower

Source: based on (Wood E & IS GmbH, 2020)

For each raw material considered, data has been gathered on the scale of primary (i.e. extraction of natural resources) and secondary sourcing (i.e. use of recycled material as sourcing) used for further processing of the raw material, i.e. it looked at what is the source of the raw material used in the value chain to produce objects made of the raw material.

The information gathered indicates the sourcing of each raw material to manufacture objects in general and is not specific to the fishing tackle and ammunition sector unless specified otherwise. Nevertheless, it provides raw material specific figures that are broadly applicable for all subsequent manufacturing processes and, importantly, offers clear details of where significant use of secondary of recycled material is feasible. It therefore gives an indication of the natural resources used to produce fishing tackle and ammunition, and it gives an indication of the impact of the sourcing of the raw material on the global environmental footprint.

Table C.4-2: Impact of the raw material sourcing on the global environmental footprint

Material	Estimated Primary sourcing[1]	Estimated Secondary / Recycled sourcing[1]	Impact (scoring)
Lead	21 %	79 % (100 % for fishing tackle[2])	Low (3)
Alternative metals			
Bismuth	>99 %	<1 %	High (1)
Copper	65 %	35 %	Moderate (2)

Iron	50 %	50 %	Moderate (2)
Nickel	45 %	55 %	Low (3)
Tin	25 %	75 %	Low (3)
Tungsten	65 %	35 %	Moderate (2)
Zinc	75 %	25 %	High (1)
Alternative alloys			
Brass (copper-zinc alloy)	30 %	70 %	Low (3)
Bronze (copper-tin alloy)	30 %	70 %	Low (3)
Zamak™ or Zamac (zinc-aluminium alloy)	30 %	70 %	Low (3)
Alternative steels			
Rebar (for reinforcing bar)	30 %	70 %	Low (3)
Stainless Steel (e.g., 11 % Cr, 8 % Ni)	44 %	56 %	Low (3)
Steel (Fe, <2 % carbon; 1 % Mn)	44 %	56 %	Low (3)
Other Inorganic			
Ceramic/Glass	90 %	10 %	High (1)
Concrete	95 %	5 %	High (1)
Stones and pebbles	5 %	95 %	Low (3)
Other Organic			
High density polymer	50 %	50 %	Moderate (2)

Note: [1]: % of Total annual sourcing of the raw material ; [2]: based on the ECHA Market survey

Source: based on (Wood E & IS GmbH, 2020)

C.4.3. Resource depletion

Another important element to assess the global environmental footprint of an object, is to look at the resources' depletion associated to its production. This means to look at how much other resources such as energy, water or chemicals are needed in order to produce an object.

Four elements are used to evaluate the relative impact of alternatives in term of resource depletion:

- Energy requirements – net energy requirements for the sourcing/production of raw material/manufacturing of object/transport.
- Water requirements – water usage during the sourcing/production of raw material/manufacturing of object (where data is available)
- Chemical requirements – scale of chemical use in the sourcing/production of raw material (over and above base feedstock)
- Raw material scarcity – measure of relative abundance of resource available to process (extent of competition for resource from other applications)

The scoring criteria are summarised below.

Table C.4-3: Scoring criteria to assess the resource depletion on the environmental footprint

Criterion	Low Impact (Score =3)	Moderate Impact (Score =2)	High Impact (Score =1)
Energy requirements	Lower than lead (per tonne of production)	Similar to lead (per tonne of production)	Higher than lead (per tonne of production)
Water requirements	Lower than lead (per tonne of production)	Similar to lead (per tonne of production)	Higher than lead (per tonne of production)
Chemical requirements	Lower than lead (per tonne of production)	Similar to lead (per tonne of production)	Higher than lead (per tonne of production)
Raw material scarcity	Lower than lead (known resources and competing uses)	Similar to lead (known resources and competing uses)	Higher than lead (known resources and competing uses)

Source: based on (Wood E & IS GmbH, 2020)

The information gathered on resource depletion is two folds:

- Resources depletion associated to the sourcing/production of the raw material: i.e. how much energy, water, chemicals are needed to extract and transform the raw material, or to recycle the raw material, so it can be used for further processing in the supply chain, and in particular in the manufacturing of fishing tackle and ammunition.
- Resources depletion associated to the manufacturing of the fishing tackle and ammunition: i.e. how much energy, and water, are needed to melt, and cast or process the raw material into fishing tackle and ammunition. This information is populated only when available, and has not been peered reviewed.

Even if not 100 % accurate, as it does not cover the entire supply chain (e.g. resource

depletion associated to the transport between the different actors in the supply chain), and is not totally specific to our case, the information gathered gives an indication of the relative resources depletion used to produce fishing tackle and ammunition, and it gives an indication of the impact of resources depletion on the global environmental footprint.

According to Wood (Wood E & IS GmbH, 2020), the scale of the resource depletion from the sourcing/production of the raw material is the most significant proportion of the overall lifecycle impacts. On this basis the data on resource depletion associated to the sourcing/production of individual raw materials is a suitable proxy to compare the overall life-cycle impacts of the raw material between each other.

The Table C.4-4 below gives an overview of impact on the resources depletion associated to the sourcing/production of the raw material, to the manufacturing of fishing tackle and ammunition, as well as the overall impact.

Table C.4-4: Impact of the raw material resources depletion on environmental footprint

	Resource depletion associated to the sourcing[1]				Resource depletion associated to the manufacturing[2]		
Material	Energy Requirements	Water requirements	Chemical requirements	Resource Scarcity	Casting energy requirement	Casting water requirement	Overall Impact (scoring)[3]
Lead	2	2	2	3	2	2	Moderate (2)
Alternative metals							
Bismuth	1	2	1	1	2	2	High (1)
Copper	1	2	2	3	-	-	Moderate (2)
Iron	1	2	2	3	1	1	Moderate (2)
Nickel	1	3	1	2	1	1	High (1)
Tin	2	2	2	2	2	2	Moderate (2)
Tungsten	1	2	2	3	1	1	Moderate (2)
Zinc	1	3	3	2	-	-	Moderate (2)
Alternative alloys							

Brass (copper-zinc alloy)	2	2	2	3	1	1	Moderate (2)
Bronze (copper-tin alloy)	2	3	2	3	1	1	Moderate (2)
Zamak™ or Zamac (zinc-aluminium alloy)	2	2	2	2	1	-	Moderate (2)
Alternative steels							
Rebar (for reinforcing bar)	1	2	2	3	1	-	Moderate (2)
Stainless Steel (e.g., 11 % Cr, 8 % Ni)	1	2	2	3	1	-	Moderate (2)
Steel (Fe, <2 % carbon; 1 % Mn)	2	2	2	3	1	-	Moderate (2)
Other Inorganic							
Ceramic/Glass	2	3	2	2	-	-	Moderate (2)
Concrete	1	1	1	3	-	-	High (1)

Stones and pebbles	3	3	3	3	1	-	Low (3)
Other Organic							
High density polymer	2	3	1	2	-	-	Moderate (2)

Source: based on [1] (Wood E & IS GmbH, 2020) and [2] (Ichlokmanian; Bert, 2017) and Table D.4-12

Note: [3]: data on resource depletion associated to the sourcing/production of individual raw materials used as a suitable proxy to estimate the overall life-cycle impact of the raw material

C.4.4. Greenhouse gases emissions (GHG)

Greenhouse gases emissions are measured in 'carbon dioxide-equivalents' (CO_{2e}). The more greenhouse gases emitted, the more important the environmental footprint.

The information gathered on resource depletion is two folds:

- GHG emissions associated to the sourcing/production of the raw material: i.e. how much CO_{2e} is emitted during the sourcing/production of the raw material. Whenever possible a distinction between the CO_{2e} emission from primary sourcing (i.e. extraction/transformation) and secondary sourcing (i.e. recycling) is made.
- GHG emissions associated to the manufacturing of the fishing tackle and ammunition. This information is populated only when available.

The scoring criterion is summarised below.

Table C.4-5: Scoring criteria to assess the sourcing impact on the environmental footprint

Criterion	Low Impact (Score =3)	Moderate Impact (Score =2)	High Impact (Score =1)
GHG (CO_{2e}) emissions	Lower than lead (per tonne of production)	Similar to lead (per tonne of production)	Higher than lead (per tonne of production)

Source: based on (Wood E & IS GmbH, 2020)

Even if not 100 % accurate, as it does not cover the entire supply chain, and is not totally specific to our case, the information gathered gives an indication of the relative GHG (CO2e) emissions to produce fishing tackle and ammunition, and it gives an indication of the impact of GHG (CO2e) emissions on the global environmental footprint.

The GHG emissions associated to the sourcing/production of individual raw materials is therefore a suitable proxy to compare the overall life-cycle impacts of the raw material between each other.

Table C.4-6: Impact of the raw material GHG (CO2e) emissions on the global environmental footprint

Material	Primary sourcing CO_{2e} [1]	Secondary / Recycled sourcing CO_{2e} [1]	Casting only CO_{2e} [2]	Impact (scoring) [3]
Lead	2	2	2	Moderate (2)
Alternative metals				
Bismuth	1	1	2	High (1)
Copper	1	1	-	High (1)
Iron	2	2	1	Moderate (2)

Nickel	1	3	1	Moderate (2)
Tin	1	1	2	High (1)
Tungsten	1	1	1	High (1)
Zinc	1	2	-	Moderate (2)
Alternative alloys				
Brass (copper-zinc alloy)	1	3	1	Moderate (2)
Bronze (copper-tin alloy)	1	1	1	High (1)
Zamak™ or Zamac (zinc-aluminium alloy)	1	3	-	Moderate (2)
Alternative steels				
Rebar (for reinforcing bar)	2	2	-	Moderate (2)
Stainless Steel (e.g., 11 % Cr, 8 % Ni)	2	2	-	Moderate (2)
Steel (Fe, <2 % carbon; 1 % Mn)	2	2	-	Moderate (2)
Other Inorganic				
Ceramic/Glass	2	2	-	Moderate (2)
Concrete	3	3	-	Low (3)
Stones and pebbles	3	3	-	Low (3)
Other Organic				
High density polymer	1	1	-	High (1)

Source: based on [1] (Wood E & IS GmbH, 2020) and [2] (Ichlokmanian; Bert, 2017)

Note: [3]: data on GHG emissions associated to the sourcing/production of individual raw materials used as a suitable proxy to estimate the overall life-cycle impact of the raw material

C.4.5. Summary of the global environmental footprint of the alternatives

The following criteria are used to compare the global environmental footprint of lead and its alternatives:

- Toxicity and risk for the human health (covered in section C.3.4)
- Toxicity and risk for the environment (both aquatic and wildlife ingestion) (covered in section C.3.5)
- Sourcing of the raw material (extraction vs recycling)
- Resource depletion (water, energy, chemical)
- Emission of Greenhouse gases

The Table C.4-7 is the outcome of the qualitative (relative) assessment of the five above-mentioned criteria.

Table C.4-7: Summary of the global environmental footprint of lead and its alternatives

Material	HH toxicity	Env toxicity (aqu.+wildlife)	Sourcing	Resources depletion	CO_{2e} emissions
Lead	High (1)	High (1)	Low (3)	Moderate (2)	Moderate (2)
Alternative metals					
Bismuth	-	-	High (1)	High (1)	High (1)
Copper	Moderate (2)	Moderate (2)	Moderate (2)	Moderate (2)	High (1)
Iron	-	-	Moderate (2)	Moderate (2)	Moderate (2)
Nickel	High (1)	Moderate (2)	Low (3)	High (1)	Moderate (2)
Tin	-	-	Low (3)	Moderate (2)	High (1)
Tungsten	-	-	Moderate (2)	Moderate (2)	High (1)
Zinc	Moderate (2)	High (1)	High (1)	Moderate (2)	Moderate (2)
Alternative alloys					
Brass (copper-zinc alloy)	-	-	Low (3)	Moderate (2)	Moderate (2)
Bronze (copper-tin alloy)	-	-	Low (3)	Moderate (2)	High (1)
Zamac (zinc-aluminium alloy)	-	-	Low (3)	Moderate (2)	Moderate (2)
Alternative steels					

Rebar	-	-	Low (3)	Moderate (2)	Moderate (2)
Stainless Steel (e.g., 11 % Cr, 8 % Ni)	-	-	Low (3)	Moderate (2)	Moderate (2)
Steel (Fe, <2 % carbon; 1 % Mn)	-	-	Low (3)	Moderate (2)	Moderate (2)
Other Inorganic					
Ceramic / glass	-	-	High (1)	Moderate (2)	Moderate (2)
Concrete	-	-	High (1)	High (1)	Low (3)
Stones / pebbles	-	-	Low (3)	Low (3)	Low (3)
Other Organic					
High density polymer	-	High (1)	Moderate (2)	Moderate (2)	High (1)

Source: based on section C.3, (Wood E & IS GmbH, 2020),and (Ichlokmanian; Bert, 2017)

Annex D: Impact assessment

D.1. Lead in Hunting

D.1.1. Baseline

D.1.1.1. Lead in shot

Following the estimations of wetlands dossier, ECHA estimates that around 16 000 tonnes of lead shot per years is dispersed into the terrestrial environment in the EU.

The best estimate currently available for the annual tonnage of lead released to the EU-27 environment is that reported in the AMEC study for the European Chemicals Agency (Abatement costs of certain hazardous chemicals, lead in shot, final Report 2012). This study reported the following estimates for EU-27 region:

These estimates were confirmed by AFEMS[90] in the ECHA call for evidence (2016) held as part of the preparations of the report on wetlands. According to AFEMS, the annual consumption of shot cartridges in Europe is estimated to be between 600 and 700 million units. This corresponds to a total amount of lead released to the environment of 18 000-21 000 tonnes annually. This estimate is in line with that reported by AMEC (2012) (same data was used).

The proposed restriction on the use of wetlands was anticipated to reduce lead emissions to EU wetlands by about 1 4500 to 7 700 tonnes per year, depending on how many hunters would be affected. In the central case analysed in in the corresponding dossier it is estimated that around 4 700 tonnes of lead per year would no longer be dispersed into the wetlands.

The estimates from the wetland dossier can then be used to derive the estimate for the releases of lead in terrains other than wetlands. This estimate is reported in Table D.1-1

Table D.1-1: remaining release outside of wetlands

Total releases = 21 216 tonnes per year	low	Medium	High
Addressed in wetlands	1432	4740	8 091
Still to address outside of wetlands	19784	16475	13 125

On the basis of this the dossier submitter estimates that around 16 500 tonnes of lead are released by using lead shot outside of wetlands.

[90] Association of European Manufacturers of Sporting Ammunition.

D.1.1.2. Lead in bullets

AFEMS estimated the total volume of production according to Table D.1-2

Table D.1-2: volume of production of bullets

Ammunition type	Estimate of total units of ammunition (millions per year in the EU)	Estimation of total units of non-lead ammunition (millions)	Edtimted amount of lead (in tonnes)
Bullets for hunting (rimfire)	0-20	0	300-400
Bullets for hunting (centerfire)	30-60	0.2	2000 - 2500

This would correspond to an annual amount of about 2700 tonnes per year, of which a fair share will be exported to markets outside of Europe. According to the AFEMS, about 70 % of production is for use outside of Europe.

The consumption in the EU alone is difficult to estimate, no precise figures were submitted in the call for evidence. Except for the Finnish hunting association who made detailed assessment of the amount of lead used in hunting with bullets, with specification as per species and the type of bullet used in hunting these species.

In order to make an EU wide estimate, national hunting statistics per Member State were used to estimate the consumption of lead for hunting with bullets. Using this method ECHA estimates that around 135 -170 tonnes of lead are used for hunting with bullets.

This method was applied by the dossier submitter following submission of the Finnish hunting association in the call for evidence as well following examples in other impact assessment of the use of lead (Such as from the Environment Canada).

Step 1: Hunting statistics

Although the wildlife agencies in member states provide hunting statistics, the statistics are not necessarily comparable or published in comparable formats. The dossier submitter has therefore compiled a European hunting bag based on a compilation of national hunting bags, summarising the overlaps and adding unique species in Member states.

The Dossier Submitter undertook an internet search on hunting statistics in order to compile the European game bag. Table D.1-3 gives an overview of the sources found

Table D.1-3 Hunting statistics: sources found

Country	Availability	Animal type	Source	Info
Austria	Yes	Birds and Mammals	http://www.statistik.at/web_en/statistics/Economy/agriculture_and_forestry/livestock_animal_production/hunting/index.html	
Belgium	No	NA	https://www.inbo.be/nl/thema/maatschappij/jacht/afschotstatistieken	
Bulgaria	Yes	Birds and Mammals	http://www.slrb.org/lovna-statistika/	up to 2013/2014
croatia	yes	Birds and Mammals	https://www.dzs.hr/Hrv_Eng/publication/2019/01-02-01_01_2019.htm	
Cypres	No	NA		
Czech Rebublic	Yes	Birds and Mammals	http://www.myslivost.cz/omsjihlava/Myslivost/Vysledky-mysliveckeho-hospodareni-v-CR.aspx	up to 2009/2010
Denmark	Yes	Birds and Mammals	http://fauna.au.dk/jagt-og-vildtforvaltning/vildtudbytte/	
Estonia	Yes	Birds and Mammals	https://www.keskkonnaagentuur.ee/et/kuttimine	

Finland	Yes	Birds and Mammals	https://stat.luke.fi/en/tilasto/4482/julkistukset	
France	Yes	Mammals	http://www.oncfs.gouv.fr/Tableaux-de-chasse-ru248	
Germany	Yes	Birds and Mammals	https://www.jagdverband.de/node/3304	
Greece	Yes	Birds and Mammals	http://www.ksellas.gr/index.php?option=com_content&view=article&id=161&Itemid=204&lang=en	Only hare, woodcock and wildboar, until 2012)
Hungary	Yes	Birds and Mammals	http://www.vmi.szie.hu/adattar/vgstat.html	
Ireland	No	NA	NA	
Italy (Friuli Venezia Giulia)	Yes	Birds and Mammals	http://www.regione.fvg.it/rafvg/cms/RAFVG/ambiente-territorio/tutela-ambiente-gestione-risorse-naturali/gestione-venatoria/FOGLIA9/	
Italy (South Tyrol Region)	Yes	Birds and Mammals	https://jagdverband.it/jagd-in-zahlen/	

Latvia	Yes	Mammals	https://data1.csb.gov.lv/pxweb/en/vide/vide__geogr__ikgad/GZG110.px	
Lithuania	Yes	Birds and Mammals	http://www.lmzd.lt/lt/medziokle/medziojamoji-fauna/statistika/	Until 2014
Luxembourg	No	NA	NA	
Malta	Yes	Birds and Mammals	https://msdec.gov.mt/en/Pages/WBRU/Reports-and-Statistics.aspx	
The Netherlands	No	NA	NA	
Poland	Yes	Birds and Mammals	https://www.pzlow.pl/index.php/statystyki-lowieckie	
Portugal	No	NA	NA	
Romania	Yes	Birds and Mammals	http://www.insse.ro/cms/ro/content/fondul-cinegetic-date-anuale	2006-2008 only
Slovakia	Yes	Birds and Mammals	http://www.mpsr.sk/en/index.php?start&lang=en&navID=30	

Slovenia	Yes	Birds and Mammals	https://pxweb.stat.si/SiStatDb/pxweb/sl/30_Okolje/30_Okolje__16_gozdarstvo_lov__03_16731_gozd_splosno/1673150S.px/	
Spain	Yes	Birds and Mammals	https://www.fecaza.com/caza/estudios-economicos-y-tecnicos	Documents per 10 years
Sweden	Yes	Birds and Mammals	https://rapport.viltdata.se/statistik/	
United Kingdom	Yes	Birds	https://www.gwct.org.uk/research/long-term-monitoring/national-gamebag-census/bird-bags-summary-trends/	
United Kingdom	Yes	Mammals	https://www.gwct.org.uk/research/long-term-monitoring/national-gamebag-census/mammal-bags-comprehensive-overviews/	

Step 2: compilation of statistics

Since not all species are reported in the same Member State (due to different granularity of reporting statistics) and not all hunting statistics for member states could be found, assumptions had to be made on how to deal with missing values. To this end we followed the method described by Thomas (Thomas et al., 2020) and assumed similar number of mammals are killed per hunter by the remaining in case of any unreported value, i.e. extrapolations were made for certain species and consequently summarized over the EU. This method was only applied to species of which there was reasonable certainty to believe that these species were hunted, this was cross checked with other sources such as websites of national hunting associations.

For species for which there was no reasonable certainty that they would eb hunted throughout the EU, such as chamois, ibex, (alpine) marmots, bear, wolf, etc it was opted to sum only the national statistics and not make any extrapolations. As the result of statistics are inevitably uncertain

Step 3

Based on information submitted in the call for evidence we assigned bullets weights to certain species, this was done based on the assessment of the Finnish hunting association.

When shooting game with bullets, hunters can choose between various calibres but also the specific weights that can be used in the bullet's hunter choose. Variation of bullet weight per calibre are marketed in pre-loaded cartridges. The choice of bullet weight is not only a matter of choice, but also a matter of regulation, sometimes a specific bullet wight is prescribed to, *de juro or de facto*, to ascertain an amount of energy to eb transferred to the animal that would guarantee a swift ethical kill.

The specific bullets weight per species given in the comments from the Finnish hunting association were evaluated and applied in this assessment.

These three steps combined gave the amount of lead used in hunting with lead bullets as also shown in Table D.1-4

Table D.1-4: compiled hunting statistics

species	# of species harvested	minus 10 %	plus 10 %	shot gun	rifle	small calibre	centerfire	bullet weight	shots	Lead use (min)	Lead used (max)
Weasel	396 997	357297	436697	100						0	0
Squirrel	5 100	4590	5610	100				0.032	0	0	0
American mink	578 016	520215	635818	100						0	0
Polecat	186 760	168084	205436	100						0	0
Ferret	83 816	75435	92198	100						0	0
Muskrat	401 624	361461	441786	100						0	0
Stoat	28 034	25230	30837	100						0	0
Pine marten / stone marten	650 132	585119	715145	100						0	0
Marmots	7 566	6809	8323	100						0	0
Rabbit	8 016 884	7215196	8818572	100				0.032		0	0
Arctic hare	86 168	77551	94785	100				0.032		0	0

European hare	2 039 436	1835492	2243380	100				0.032		0	0
Raccoon dog	2 453 841	2208457	2699225	10	40 %			0.005	2	8833.827	10796.899
Red fox	2 829 236	2546313	3112160	50	50 %			0.005	2	12731.564	15560.800
Badger	639 369	575433	703306	5	95 %		x	0.005	2	5466.609	6681.411
jackal	36 857	33171	40543		100 %		x	0.005	2	315.127	385.156
Beavers	86 574	77917	95231	25	75 %		x	0.005	2	555.156	678.524
Otter	978	880	1075		100 %			0.005	2	8.798	10.753
Roe deer	2 294 324	2064892	2523756	15 %	85 %		x	0.008	2	26678.399	32606.933
Lynx	430	387	473		100 %		x	0.005	2	3.677	4.494

sika deer	32 161	28945	35377		100 %		x	0.008	2	439.961	537.731
chamoix	43 453	39108	47798		100 %		x	0.008	2	594.437	726.534
ibex	607	546	668		100 %		x	0.008	2	8.304	10.149
Mouflon	118 177	106359	129994		100 %		x	0.0026	2	525.413	642.171
Wolf	2 008	1807	2209		100 %		x	0.011	2	37.770	46.164
Fallow deer	156 032	140429	171635		100 %		x	0.008	2	2134.518	2608.855
White-tailed deer	1 574 985	1417486	1732483		100 %		x	0.008	2.5	26932.243	32917.186
Wild boar	2 218 687	1996818	2440556		100 %		x	0.011	2	41733.502	51007.614
Wild forest reindeer	18	16	20		100 %		x	0.008	2	0.246	0.301

red deer	480 464	432418	528510		100 %		x	0.008	2	6572.748	8033.358
Brown bear	1 045	941	1150		100 %		x	0.032	2	57.182	69.890
Grey seal	1 204	1084	1324		100 %		x	0.008	2	16.471	20.131
Moose	157 868	142081	173655		100 %		x	0.011	2.5	3711.871	4536.732
bison	0	0	0				x	0.011	2.5	0.000	0.000
SUM										**137 ton**	**168 ton**

Small game / large game

Small game is defined is defined differently in various Member states. The dossier submitter has performed an analysis (See also the following section) on what is generally regarded as small, medium and large game throughout the EU. To this end various legislation have been analysed as well as various recommendations from manufacturers of hunting ammunition on suitability of ammunition for hunting certain game.

From the test performed on non-lead ammunition the smallest calibre type that was successfully used is 5.6 mm centrefire. When reviewing the legislation of the Netherlands[91], Belgium[92], Luxemburg[93], Italy[94], Estonia[95] this seems to coincide with the minimum calibre required for hunting deer (roe deer) species and other large game, see Table D.1-5: a selection of rules for hunting ungulates .

Table D.1-5: a selection of rules for hunting ungulates

Member State	Rules	comments
Netherlands	Big game may only be shot with rifles with the following ammunition : red deer, fallow deer, wild boar and moufflon: bullets of a calibre not smaller than 6,5 mm of which the impact energy at 100 meters of the barrel end (E100) is at least 2.200 joules Roe deer: bullets of which the impact energy at 100 meters of the barrel end (E100) is at least 980 joules.	The rules for roe deer are generally met only be centrefire ammunition
Belgium	Roe deer: 980 J op 100 m afstand van de loopmond bedraagt; For other large game: wild (deer, boar, mouflon, fallow deer): bullets not smaller then dan 6,5 mm, with E(100) is 2200 J	The rules for roe deer are generally met only be centrefire ammunition

[91] https://www.jagersvereniging.nl/vragen/welke-geweren-en-munitietypen-mogen-gebruikt-worden-om-te-jagen/

[92] https://www.wapenunie.be/portaal/jagers/wapens-toegestaan-voor-jacht-in-vlaanderen

[93] https://www.fshcl.lu/resources/documents/_includes/GrossherzoglicheVerordnungen/A-N-262-armes-et-munitions-moyens-autoris-s-et-chiens-de-chasse.pdf

[94] http://www.earmi.it/diritto/faq/calibro22.htm

[95] https://www.riigiteataja.ee/en/eli/ee/Riigikogu/act/511012019006/consolide

Germany	for Roe deer: minimum impact energy more than 1000 J at 100 m. For other ungulates: minimum calibre 6,5 mm, minimum impact energy more than 2000 J at 100 m.	The rules for roe deer are generally met only be centrefire ammunition
Luxembourg	roe deer: bullet cartridges for rifled barrels developing on impact an energy of at least 980 J at 100 m from the muzzle; - deer, wild boar, mouflon and fallow deer: bullet cartridges with a caliber of at least 6.5 mm for rifled guns and developing at impact an energy of at least 2,200 J at 100 m from the muzzle.	
Italy	Rifled bore guns, firing a bullet with a diameter more than 5.6mm or a case longer than 40mm, overall length more than 60 cm and a barrel length more than 30 cm.	The rules for roe deer are generally met only be centrefire ammunition Rimfire ammunition not allowed for hunting
Estonia	Large game defines as: moose; red deer; roe deer; wild boar; brown bear; wolf; lynx; grey seal.	

D.1.1.3. Lead in other hunting ammunition

Despite shot in shot gun and bullets in rifle ammunition, lead can also be used in air guns and in muzzle loaders. Although technically these are projectiles and could be discussed under 'bullets'; air rifle hunting and muzzle loading hunting have unique characteristics and deserve to be discussed separately.

Air rifles

Table D.1-6: Volume of lead in air pellets

Ammunition type	Estimate of total units of ammunition (millions per year in the EU)	Estimation of total units of non-lead ammunition (millions)	
Air rifles	No values		

In their submission, AFEMS indicated that the use of air rifles for hunting is practically zero, although some use is authorised for pest control the possibilities to hunt with air rifles are rather limited. An overview of the known regulations in Europe is given in table.

The table is compiled based on the information the Dossier Submitter collected on hunting laws in Europe and or on various internet searches. In most cases the minimum energy requirements for hunting are not met by air guns, unless the hunting law spells out that different specific requirements for air guns.

Table D.1-7: legal status of using air rifles for hunting per MS

Legal status of air rifle hunting in the EU	
Legal	Illegal
Sweden (energy limit) (rodents, birds, etc) pest control	Sweden, Estonia, Latvia, Lithuania, Poland Germany, The Netherlands, Belgium, Luxembourg, Austria, Czech Republic, Slovenia, Slovakia, Romania, Bulgaria, Greece, Finland, France, Italy, Poland, Portugal
Denmark (pest control)	
Hungary	

Pellets are used extensively in sports shooting where the accuracy and precision of the shot is dependent on the interplay between the pistol/rifle used in terms of rifling and the pellet shape, size, weight, plasticity. When used for hunting, it is used for hunting vermin. Pellets are available in different calibres each with a variety of configurations (e.g. flat-nose, round-nose, pointed, hollow-point). Each calibre may also be available in different weights.

Muzzle loaders and historic firearms

Table D.1-8: Volume of lead in Muzzle loaders

Ammunition type	Estimate of total units of ammunition (millions per year in the EU)	Estimation of total units of non-lead ammunition (millions)
Muzzle loaders	No values	No values

A muzzle-loading rifle is a muzzle-loaded small arm or artillery piece that has a rifled barrel rather than a smoothbore. A muzzle loading weapon is loaded through the muzzle, or front of the barrel (or "tube" in artillery terms). This is the opposite of a breech-loading weapon or rifled breechloader (RBL), which is loaded from the breech-end of the barrel. In artillery and small arms a switch from muzzle loading to breach loading took place during the 19the century.

The sport of muzzle-loading includes use both of original and reproduction arms. Muzzle-loading shotguns are used for hunting live quarry and for clay pigeon shooting.

There are an unknown number of vintage and historic rifles, shotguns and pistols in the EU including both muzzle loading guns and historic breechloading guns.

These may be possessed by museums or collectors and fired occasionally, while some are used occassioanlly for hunting or target shooting.

Hunting with muzzle loading, historic arms can be grouped under the 'black powder hunting 'category. Although authorised in some countries, it is not considered to be legal in other countries. An overview of the legality of use for hunting is given in Table D.1-9

Table D.1-9: legal status of black powder hunting in the EU

Legal status of black powder hunting in the EU	
Legal	Illegal
United Kingdom	Sweden
Finland	Estonia
France	Latvia
Spain	Lithuania
Italy	Poland
Denmark	Germany
	The Netherlands
	Belgium

Hungary	Luxembourg Austria Czech Republic Slovenia Slovakia Romania Bulgaria Greece Italy

D.1.2. Alternatives

D.1.2.1. Lead in gunshot

Function of lead in shot

The focus of this restriction proposal are shotgun cartridges that are loaded with spherical lead 'shots'. The spherical shots are propelled during the use of the cartridge to reach a target. The spherical shots should penetrate (and may pass through) the target, causing the death or wounding of the target, where it is an animal.

Lead has historically been used as gunshot in cartridges (TemaNord, 1995) because of its:

- softness and lubricating features (resulting in low abrasion of the shotgun barrel);
- low melting point (making it easily transformed into shot);
- high density (yielding high momentum after firing).
- relatively low price and high abundance (resulting in low cost of cartridges)

Based on these properties, lead is often considered to be an ideal material for use in ammunition. Other materials often have somewhat different ballistic behaviour to lead but this does not necessarily result in a conclusion that they are technically or economically inferior to lead gunshot. The technical and economic feasibility of the use of alternative to lead in gunshot is outlined in the sections below.

Suitability of lead-free shot

Non-lead shot cartridges are widely available in Member States with existing regulations on the use of lead gunshot. The call for evidence organised by ECHA to support the development of this restriction proposal confirmed that alternatives (e.g. steel, tungsten or bismuth) are already commonly used in wetlands.

In the EU, Denmark has been a testing ground for the introduction and evaluation of alternative gunshot, following the initial regulation for hunting in wetlands in 1985 and the total phase out of lead shot in 1996. Many products have been designed specifically for the Danish market and users (Kanstrup, 2006). There is no indication that a lack of suitable alternative shot types, shot sizes, or other potential drawbacks of the shift from lead to non-lead shot in Denmark has changed the cost of hunting, the number of

hunters, or their harvest (Kanstrup, 2015).

Although the risks from the dispersal of lead gunshot in the environment have been known since the late 1800s, the first alternative gunshot materials were only marketed in North America in the 1970s. The availability of alternatives to lead gunshot has increased steadily since this time, corresponding with the introduction of bans on the use of lead gunshot in countries within and outside the EU. Steel gunshot (soft iron) is by far the most used alternative to lead gunshot.

In response to Danish and US regulatory requirements, additional metals were introduced in the early 1990s as alternative to lead shot: specifically, bismuth and tungsten. Originally, bismuth was used in shot in an almost pure form; more recently it has been alloyed with tin (6 %) to reduce the tendency of pellets to fragment. Tungsten shot is often based on metal powder embedded in a plastic polymer (Tungsten Matrix) and has ballistic properties very similar to lead shot (Scheuhammer, 1995).

In the US, the environmental safety of alternatives to lead shot is evaluated before they are allowed to be placed on the market. Table D.1-10 gives an overview of the currently allowed shot types in the US. Following extensive testing on captive waterfowl in the US and Canada, zinc gunshot considered to be toxic, and it is not permitted to be placed on the market in either country (Scheuhammer 1995; Putz, 2012).

Table D.1-10: Approved 'non-toxic' shot in the US (USFWS[96])

Alternative	Composition
Bismuth-tin	97 % bismuth, and 3 tin%
Iron (steel)	iron and carbon
Iron-tungsten	any proportion of tungsten, and ≥1 iron
Iron-tungsten-nickel	≥1 % iron, any proportion of tungsten, and up to 40 % nickel
Copper-clad iron	84 to 56.59 % iron core, with copper cladding up to 44.1 % of the shot mass
Tungsten-bronze	51.1 % tungsten, 44.4 %copper, 3.9 % tin, and 0.6 % iron, or 60 % tungsten, 35.1 % copper, 3.9 % tin, and 1 % iron
Tungsten-iron-copper-nickel	40–76 % tungsten, 10–37 % iron, 9–16 % copper, and 5–7 % nickel
Tungsten-matrix	95.9 % tungsten, 4.1 % polymer
Tungsten-polymer	95.5 % tungsten, 4.5 % Nylon 6 or 11
Tungsten-tin-iron	any proportion of tungsten and tin, and ≥1 iron

[96] https://www.fws.gov/birds/bird-enthusiasts/hunting/nontoxic.php, accessed 25 January 2017.

Tungsten-tin-bismuth	any proportion of tungsten, tin, and bismuth
Tungsten-tin-iron-nickel	65 % tungsten, 21.8 % tin, 10.4 % iron, and 2.8 % nickel
Tungsten-iron-polymer	41.5–95.2 % tungsten, 1.5–52.0 % iron, and 3.5–8.0 % fluoropolymer

Steel

This alternative is widely available, but due to its comparatively greater hardness (relative to lead) it requires use in compatible guns. The Dossier Submitter considers that 100 % of new guns currently on the market are compatible with steel gunshot and that a maximum of 15 % of existing (old) guns. This issue is further discussed in the Suitability of guns section.

Steel gunshot is widely seen to provide equivalent performance to lead or other materials, (Scheuhammer, 1995; Pierce, 2014) without major concerns caused by ricochet (DEVA, 2013). However, some adaptation to the different ballistic properties of steel may be required by hunters to achieve equivalent performance e.g. typically used shot size would need to be increased to account for the lower density of steel.

According to the '**Permanent International Commission** for the Proof of small arms' (CIP), which sets standards for firearms and ammunition in the EU, "standard" steel gunshot cartridges are suitable for use in the majority of standard 'nitro-proved' shotguns[97]. "High performance" steel cartridges, which generate greater pressures when fired, are only to be used in 'steel shot' proved guns. The difference between standard steel and high-performance steel is further explained in the Suitability of guns section.

Steel shot is the most commonly used alternative due to its price, which is in the same range or even below that of lead shot, making it the cheapest of the known alternatives (ignoring the cost of any gun modification such as modifying choke, barrel change etc).

Bismuth

The ballistics or performance is generally good, provided the shot size is increased to allow for density lower than lead. Bismuth is suitable in all guns. Bismuth can be used as a drop in alternative to lead without concerns over compatibility with guns. Bismuth shot is available in most gauges and with a wide variety of loadings. The shot is available for home loading, including for large-bore guns. Bismuth is an alternative that can be used in all guns and is often used in forests where owners limit the possibilities to use steel[98]

Tungsten

The density of tungsten shot is favourable for good ballistics and performance, so the percentage of tungsten in shot material is important. It is suitable for use in appropriately proved guns and widely available. Tungsten-based shots have been approved as nontoxic by the US Fish and Wildlife Service. However, it is relatively more expensive than lead and steel gunshot, which has restricted its use as an alternative.

The term 'suitability' refers to whether the alternative can be used to the same effect. In

[97] Standard steel not suitable in certain specific 'standard proofed' shotguns, such as Damascus barrelled shotguns.

[98] Personal communication, Finnish hunting association.

the context of hunting this means that alternatives can be used with the same level of performance in killing game in the fastest and least painful way possible.

The suitability of alternatives for lead shot has already been established in the ECHA dossier on the use of lead in/over wetlands (ECHA, 2018b), and have been evaluated by ECHA's Committees for Risk assessment (RAC) and Socio-Economic Analysis (SEAC)[99]. The conclusion of SEAC on alternative ammunition was that steel gunshot, according to the Dossier Submitter the alternative most likely to replace lead shot, has a comparable performance once shooters have adjusted to its ballistic properties, e.g. in terms of patterning. For hunting larger fowl, high performance steel gunshot may have to be used, which requires the use of a shotgun that has been proofed accordingly (see below).

The main difference between hunting in and over wetlands and hunting outside of wetlands (upland game shooting/hunting) is in the species involved. Whereas wetland species are mainly birds such a duck and geese. The species hunted outside of wetlands with shot are pheasants and grouse but also small mammals such as rabbit, hare but even roedeer.

Table D.1-11: A list of nontoxic shot cartridges available for hunting upland game species of birds and mammals. A + indicates that the type of nontoxic shot is appropriate for that species (source: (Thomas, 2009)

species	steel shot in gauges 10,12,16, 20	bismuth tin shot in gauges 10,12,16,20, 29, .410	tugsten based shot e.g. tungsten-matrix, tungsten-iron or Hevi Shot. IN gauges 12,16,20
Geese species	+	+	+
Large-bodied ducks	+	+	+
Small-bodied ducks *	+	+	+
Ring-necked pheasant Phasianus colchicus	+	+	+
Partridge species	+	+	+
Wood Pigeon Columba palumbus	+	+	+

[99] https://echa.europa.eu/documents/10162/07e05943-ee0a-20e1-2946-9c656499c8f8

Woodcock Scolopax rusticola	+	+	+
Snipe Gallinago gallinago	+	+	+
Red Grouse Lagopus lagopus scotica	+	+	+
Ptarmigan Lagopus muta	+	+	+
Golden plover Pluvialis apricaria	+	+	+
Rabbit Oryctolagus cuniculus	+	+	+
European hare Lepus europaeus	+	+	+
Mountain hare Lepus tímidos	+	+	+

Furthermore, several field studies examine the suitability of non-toxic shot for hunting purposes. Comparative studies on the efficiency of lead versus non-lead shot are abundant in the literature. Nicklaus (1976) reported no difference in crippling loss when using lead or steel. Cochrane (1976) reported that the best lead shot shells available outperformed the best steel shot shells in that they produced fewer cripples at "normal" shooting ranges. Hartmann (1982) concluded that steel shot is suitable for water bird hunting within normal shooting distances (max. 35 m). Kanstrup (1987) reported no difference in the "killing impact" of lead and steel shot in Eider Duck (*Somateria mollissima*) hunting. Morehouse (1992) reported a slight increase in fowl crippling loss rates in the US during the early steel shot phase-in over the period 1986-1989, but also that crippling loss for both ducks and geese declined in 1991 towards levels observed during the early 1980s. Strandgaard (1993) concluding that steel shot is just as effective as lead shot when used to kill roe deer and is a valid alternative.

In a more recent study, Gundersen et al. (2006) find that an appropriate combination of shot type and size resulted lead and non-lead ammunition with similar "killing impact". Likewise, a large-scale European study on the effectiveness of steel gunshot ammunition in hunting fowl (Mondain-Monval et al., 2015) indicates performance levels of steel

gunshot very similar to lead shot. The study also suggests that hunter behaviour and judgement, the abundance of birds and strong wind conditions are significant determinants of a hunter's ability to bag birds.

In a recent, large-scale comparative study of the effectiveness of steel and lead shot in shooting mourning doves (*Zenaida macroura*) (Pierce et al., 2014), hunters using lead shot (cal. 12, with 32 g of US #71/2 shot) and steel shot (cal. 12, with 28 g of US#6 and US#7 shot) produced the same results in terms of birds killed per shot, wounded per shot, wounded per hit, and bagged per shot. Hunters in this double-blind study wounded 14 % of targeted birds with lead shot, and 15.5 % and 13.9 % with #7 and #6 steel shot, respectively. Hunters missed birds at a rate of 65 % with lead shot, and 60.5 % and 63.6 % with #7 and #6 steel shot, respectively. Pierce et al. (2014) conclude that "[shot] pattern density becomes the primary factor influencing ammunition performance", and that this factor is controlled by the shooter.

Comments from the call for evidence (Gun Trade Association, British Sports shooting Council) highlighted that Non-lead shotgun ammunition has been found to perform effectively in the field. However, CIP recognizes that in order to achieve equivalent lethality to lead in 'standard' hunting ammunition loaded with steel shot, current limits on momentum for 'standard' loads would have to be increased.

Suitability of guns

<u>Standard steel can be used</u>

The suitability of steel for using in gunshots has already been widely discussed in the dossier on wetlands, and indeed many of the findings on (shot) gun suitability are applicable to the use of steel shot outside of wetlands as well.

In the dossier the possibilities to use steel are discussed in depth.

Proofing of guns is accompanied by proof marks that are stamped into the metal of the gun barrel (typically in the parts underneath the chamber). In a European context the most reliable system of proof marking is that used by the CIP. The CIP system uses a "Standard Mark", a "Superior Mark" and a "Steel Mark". These terms apply to the performance (pressure) of the cartridges that can be used in a gun. A general observation is that the marking can be interpreted equally for lead shot and alternative shot types, including steel, bismuth and tungsten (matrix types).

Standard or superior/magnum-proved guns can fire 'standard' steel and other alternative shot cartridges. To fire 'high performance' steel cartridges, the gun is recommended (by the CIP) to be subject to the "Steel Shot" proof, which is a more rigorous test of the gun's ability to handle the pressures and shot hardness of steel/steel-like shot cartridges. A gun successfully passing "Steel Shot" proof will be stamped with a Fleur de Lys on its barrel, see Figure D.1-1 Proof marks used by CIP. (right).

CIP Standard Mark	CIP Superior Mark	CIP Steel Mark
CIP N	CIP S	CIP

Figure D.1-1 Proof marks used by CIP.

Practical guidance for hunters on how to be sure that steel shot can be used in the shotgun they currently own can be found on the websites of the BASC (UK) and the website of the Victoria Game Authority (AUS):

On the use of steel shot in guns the BASC notes the following[100]:

For steel-like shot the CIP imposes limits on velocity, momentum (weight of load x velocity), and pellet size. For pellets BB and larger it also limits choke, to maximum half choke.

Currently the regulations cover 10 bore, 12 bore, 16 bore and 20 bore guns/ cartridges.

There are two types of steel shot cartridges: Standard and High Performance.

- *Standard steel shot cartridges, meeting defined limits of cartridge size, and shot velocity and momentum, can be fired through standard and magnum-proved guns.*
- *High Performance steel cartridges, with their own, higher, size, velocity and momentum limits, are to be fired only through guns which have passed special steel shot proof.*

Some hard tungsten-based shot types are now treated as steel, and are to be used accordingly.

Most tungsten-based shot types, though, including ITM, TMX, Hevi-shot II (but not Hevi-shot I) and others, are made to a similar softness to lead and are treated by CIP as lead.

This is stated again on the website of the Victorian game authority[101]

It does not mean that an existing gun, without this proof stamp, is inherently unsafe to use steel loads which generate lower chamber pressures, comparable to existing lead shot loads. If in doubt about your gun – see a competent gunsmith.

[100] https://basc.org.uk/wp-content/plugins/download-monitor/download.php?id=722

[101] http://www.gma.vic.gov.au/education/fact-sheets/non-toxic-shot/steel-shot-standards-pressures-and-proofing

Practical guidance is also available for hunters in Germany[102,103,104], France[105106], Austria (Putz, 2012) and France (Baron, 2001) and is all of a similar nature, explaining to hunter which sort of cartridges can be used in guns with different proof marks (Summarised in Table D.1-12).

Table D.1-12 Operating pressure, cartridge size and proofing[107]

cartridge type	cartridge size	max operational presure (bar)	max velocity (2.5 m after muzzle) m/s	max impuls (NS)	max shot size	gun proofing
standard	12/65 - 12/70	760	400	12	3.25	normal
high performance	12/70	1050	430	15	no limit	steel proof
high performance	12/76 and above	1050	430		no limit	steel proof

This advice is in line with the CIP specification on the use of steel shot. It must be noted that if any of the limits for the standard proof are exceeded, then the cartridges must be treated as high performance cartridges and can only be used from a steel proofed gun (with fleur de lys).

Using steel gunshot cartridges therefore becomes a matter of carefully selecting cartridges based on the specification of the shotgun that a hunter owns. The CIP specification for standard and high-performance steel cartridges, and the BASC's explanation of these specifications, clearly outline the types of steel gunshot cartridges that can be used in different shotguns[108]. Not complying with these rules can result in 'ring bulging', overload and increased wear and tear in guns.

Wear of the gun barrel derives primarily from the friction of the shot load passing through the barrel. The load consists of two elements: The load of shot pellets (in normal cal. 12 loads 30-34 gram) and the wad that provide a seal that prevents gas from blowing through the shot rather than propelling it. Originally, wads were made from felt or paper, but more recently, plastic has become the most used material. At the same time the wad has been developed not only to provide a seal between the powder and shot but also to prevent direct contact between the gunshot pellets (the load) and the inner wall of the barrel, which is achieved by constructing the wad like a cup that contains the load.

This applies for most shot types, including also many lead shot cartridges. For soft materials like lead the primary reason for preventing contact between shot and barrel is to minimise deformation of shot and thereby optimising the pattern of the shot cloud.

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102 http://www.flintenschuetze.de/cms/front_content.php?idcat=119

103 http://www.jagd-bayern.de/fileadmin/_BJV/Jagd_In_Bayern/jib_2006_07/JiB_7_06_Alternativ_Schrote.pdf

104 https://www.beschussamt-ulm.de/beschussamt/Interne_Dokumente/Dokumente/VF_504_M_Info-Verwendung-Bleifreie-Schrote.pdf?m=1488869144

105 http://www.fdc54.com/fichiers/munitions_sans_plomb.pdf

106 http://www.syndicatdelachasse.com/actu04/dec/acier.pdf

107 http://www.flintenschuetze.de/cms/front_content.php?idcat=119

108 http://www.chircuprodimpex.ro/produse/alice-non-toxice-de-vanatoare/cip-regulations-on-steel-shot-ammunition.pdf

For hard materials like steel the reason to use a plastic wad is mainly to prevent the hard pellets damaging the barrels of softer and not hardened steel qualities. Due to the use of modern plastic wads the use of hard pellets does not impose an increased risk of wear in the barrel bore. The only point along the barrel where some wear might arise is when hard shot passes through the choke (the narrowed portion at the mouth of the gun barrel).

The chokes used in shotguns produced by different manufactures are not consistent, uniform manner. Concerns relating to the use of steel gunshot pertain to abruptly-developed, as opposed to progressively-developed, chokes[109].

It is possible that large hard shot (larger than US #4 steel, 3.5 mm diameter) passing through an abruptly developed, tightly-choked barrel, could cause a small ring bulge to appear around the choke conus, simply because the hard shot do not deform when passing through the constriction. This does not occur if the barrels are more openly choked, such as "modified" or "improved cylinder". This is the essence of the concerns about wear from hard non lead shot types, such as steel. Ring bulges are also known to occur in shotgun barrels when large lead shot pellets are fired through tight chokes. A gun barrel with a ring bulge can continue to fire any shot type. It is a cosmetic change, and not related to safety or the risk of exploding barrels (Thomas et al. 2015). This might however decrease the value of the gun.

In addition, wear of gun is also caused by the physical impact released by the recoil from heavy loads, which may cause stress to the gun lock and stock Recoil is a function of, powder type, load weight and velocity and, in principle, independent of shot material.

However, as non-lead shot is normally accelerated to a higher velocity there is a general tendency that alternative gunshot may cause a more pronounced recoil, though lighter loads and improved powder composition can compensate for this. Danish gunsmiths have experienced that guns more regularly need maintenance and lock repair when firing large numbers of rounds of high velocity (>420 m/s) cartridges with steel shot. This applies only to standard guns that are not constructed to deal with heavy recoil[110], but would equally apply to heavy load lead shot cartridges.

The Victoria game authority mentions that the effect of steel shot on the barrels of a selection of 10 English and European manufactured firearms was undertaken by the Royal Military College of Sciences in the UK in 1996 (Report no longer publicly available). The types of firearms used included a Browning U/O, Beretta U/O, Miroku U/O, Purdy SxS, Holland and Holland SxS. All guns used were full choke models, some with integral chokes and some with screw in chokes. After over 9 000 standard steel shot cartridges had been fired through the ten different guns, no measurable damage had occurred to any of the guns. The standard cartridges used recorded muzzle velocities in the range of 377 m/s to 392m/s with shot weights between 24 and 32 grams. These were regarded as being fairly light for game loads. Three of the guns were then tested with cartridges loaded to produce much higher muzzle velocities (438m/s, 28 gram) and in each case deformation of the chokes resulted after approximately 50 cartridges were fired.

[109] In firearms, a choke is a tapered constriction of a shotgun barrel's bore at the muzzle end. Chokes are almost always used with modern hunting and target shotguns, to improve performance. Its purpose is to shape the spread of the shot in order to gain better range and accuracy. Chokes are implemented as either screw-in chokes, selected for particular applications, or as fixed, permanent chokes, integral to the shotgun barrel.

[110] Nystrøm & Krabbe, gun and ammunition retailer.

Coburn (1991) reported, from the Winchester perspective, that ring bulging has not been a significant issue over the twenty or so years since steel shot was introduced, although it has occurred, usually in full choked barrels, either as integral chokes or screw-in chokes. Where this has been known to occur, the actual deformation was in the range of three to five one-thousandths of an inch (0.003 to 0.005 inch), which is barely discernible to the naked eye. In the early days for some screw-in chokes, the threading expanded and chokes were difficult to remove, however, today, manufacturers have overcome this problem through redesign.

The third impact factor is temperature, i.e. the heating of the shotgun barrel and lock after firing multiple rounds of ammunition over a short period of time. This is only discussed briefly here but is known particularly from the hunting of game species occurring in large numbers, for instance during driven shoots or excessive pigeon and dove hunting.

Heating derives from the burning of the powder, the pressure and the friction of the shot and wad against the barrel wall. There is very little information about the affect of different shot types and cartridge constructions on temperate. Temperature and heating *per se* is not a significant concern, apart from certain gun types, e.g. semi-automatics where excessive heating may cause increased wear on sliding mechanisms due to reduced effectiveness of greasing. However, in the context of water bird hunting in a Europe context the number and frequency of shots taken is regarded, broadly, to be limited, and the concern of heating of guns seems to be of very low importance. There is no indication that non-lead ammunition should impose a greater impact than leaded ammunition in this regard.

Possibilities for non-steel proofed guns

The advice offered by manufacturers to customers asking if their gun are suitable for use with steel gunshot have been compiled from a selection of manufacturers' websites (Table D.1-13).

Table D.1-13 Advice from shotgun manufacturers on the use of steel shot in shotguns (non-exhaustive list)

Manufacturer	Advice given (direct quotes from websites)
Remington	We do not recommend the use of steel shot through any barrel manufactured before 1963 or through any barrel having a fixed Full choke. Anything larger would not perform well out of a fixed full choke and could open up your muzzle over time. If you have barrels manufactured after 1963, with fixed Modified or Improved Cylinder chokes, you may shoot up to size #2 steel shot. The use of steel shot larger than size #2 is only recommended in modern barrels with the Rem Choke system. If you have the Rem Choke system, you may shoot any size steel through the Improved Cylinder and Modified choke tubes. The Full choke tube must state "For Steel or Lead" to be capable of handling steel shot. Source: https://support.remington.com/General_Information/Can_I_use_steel_shot_in_my_shotgun_barrel%3F
Winchester	Generally speaking, any shotgun designed for smokeless powder is able to withstand the pressures generated by today's steel shot loads, within the appropriate chambering. As steel shot does not compress like lead, we do not suggest using steel shot through firearms with a full-choke. We do not suggest the use of steel shot in the Winchester Model 59 with a fibre glass barrel. Source: http://www.winchester.com/learning-center/faqs/firearms-guns/Pages/Firearms-and-Guns-Question02.aspx

Browning	1. WILL ACCEPT ALL CURRENT FACTORY STEEL SHOT LOADS: All Browning shotguns with the Standard Invector, Invector-Plus or DS choke tube systems, However, we do not recommend the use of Invector full or extra full chokes with steel shot. They pattern too tightly, and sometimes result in a "blown" pattern. 2. WILL ACCEPT ALL CURRENT FACTORY STEEL SHOT LOADS EXCEPT THOSE WITH T, F, BB AND BBB SIZE SHOT: The B-2000 and B-80 shotguns with conventional chokes (Non-Invector) 3. DO NO USE ANY STEEL SHOT LOADS: The Belgian-made A-5, Superposed, Leige, and other Belgian Over/Under models, Double Automatic, American-made A-5 and all other models not listed in category 1 or 2. Note: Belgian Auto-5 barrels are interchangeable with the new Invector barrels which are made in Japan. With this new Invector barrel installed on the Belgian-made Auto-5 receiver, steel shot loads can be used. Source: http://www.browning.com/support/frequently-asked-questions/can-i-shoot-steel-shot-in-my-browning-shotgun.html
Beretta	The manual (available at : http://stevespages.com/pdf/beretta_shotguns.pdf[111]) explains how to change the choke so as to be able to safely use steel shot in Beretta shot guns
Bernelli	The manual (available at : http://www.benelliusa.com/sites/default/files/originals/product-manuals/ethos_2013.pdf) explains how to change the choke so as to be able to safely use of steel shot in Bernelli shot guns

[111] The original manual can be purchased at: http://estore.beretta.com/en-eu/beretta-overandunders/side-by-sides-owner-manual-ita-fr-eng-/

The conclusion of this assessment is that if a gun has no steel proof mark then this does not mean that it cannot be used with steel shot on the condition that the right cartridges are used. The shotgun can still be used if attention is payed to selecting the right cartridge type that is compatible with shotgun that is used, especially chamber length, and pressure of the cartridge (Putz, 2012).

As explained by the BASC and the Victorian game Authority, the actual risk depends on the selection of cartridges and ensuring that cartridges are used that match with the proof level of the shotgun.

Putz (2012) argues on the basis of an analysis of the characteristics of the non-lead cartridges provided by one German manufacturer (Rottweil) that hunting ducks and fowl can still continue with steel cartridges of which the maximum diameter of the pellet is not bigger than 3.25 mm. In line with the guidance given as well as the German website and advices that were consulted as well as the findings of Ronholt (1991) that steel shot exhibited somewhat different ballistic properties compared with lead. However, it could be used effectively within normal hunting ranges and Hartmann (1982), concluding that steel shot are suitable for water bird hunting within normal shooting distances (max. 35 m).

For those hunting geese, hare, foxes bigger shot sizes are needed and consequently, following CIP rules, steel proofed guns would be required (Putz, 2012).However, this is subject to debate as many hunters use 'magnum proof' shotguns which are capable of withstanding higher pressures than those generated with standard lead shot. Hence, with suitable cartridges adaptations can be made.

However, the considerations surrounding the proofing of guns may leave a concern that many modern guns may be proofed only to a standard level and owners therefore may hesitate to use them with the most available non lead ammunition, i.e. steel shot in the range of standard and high performance types. This concern is more related to the question of availability of non-lead ammunition suited for their gun, particularly on the local scale. To evaluate this quantitatively the distribution of different gun types among European hunters is needed. Unfortunately, no such statistics are generally available, neither of the types and constructions of guns owned by hunters, nor of the distribution of guns used in different types of hunting, including hunting in wetlands.

In a recent announcement to voluntarily phase out the use of lead shot in the UK, the Gun trade association issued guidance on the of us steel shot[112] which reinforces the conclusion made in the wetlands dossier on the possibilities to use steel shot.

This guidance states that all tough steel shot lacks the density of lead and is almost as hard as the barrels, the manufacturers have got around those issues. First, steel shot cartridges use cup wads to prevent the shot from touching the barrel walls. These have traditionally been made from hard plastics but now environmentally friendly fibre or water-soluble cups available. Secondly, to make up for the lower density, size and velocity can be changed.

For live quarry shooting the advice is to choose a size two larger than your old lead size e.g. If you were shooting size 6 lead shot, you should choose 4s in steel.

'Standard steel' cartridges have been designed by manufacturers in association with

[112] https://www.gwct.org.uk/media/1094678/GTA_factsheet_shootingnonlead_ver102.pdf

proof authorities[113] that can be fired through any nitro-proved gun[114]. They must have a cup wad to protect the barrel; they have a maximum shot size of 4; and they have to conform to the normal pressure limits of nitro proved guns.

Trials in 1991[115] using standard steel cartridges with light loads (24 grams) demonstrated that even light walled game guns of contemporary manufacture with ¾ chokes showed no damage after firing 1000 rounds.

Standard steel loads can be fired safely through light walled guns but there is a risk that in some circumstances a slight bulging at the choke neck can occur. The likelihood of such bulging is increased by heavy loads, large diameter shot and steep, tight chokes. Old guns may be more vulnerable. The British Proof Authority recommend less than half choke (0.5mm). Such a bulge would not be an immediate safety issue but would inevitably have an impact on its proof status and value. Having a gunsmith widen the chokes would reduce this risk. Further trials to quantify this risk are planned.

Increased velocity can also be achieved by changing the propellant and generating more pressure. Such cartridges are known as 'high performance' steel. They should only be fired in guns proved for steel. This is indicated by a 'fleur-de-lis' mark on the gun and the words STEEL SHOT.

The gun trade association provides further guidance on what to pay attention to in the use of steel shot, in terms of safety and gun compatibility.

Need to replace guns

There are very few data available on the number of 'old guns' in the EU that may need to be replaced as a result of the proposed restriction. This is because in many Member States shotguns are not registered, especially old guns. Therefore, estimations of the share of old non-suitable guns among hunters could be very biased. It is not known to what extent old guns are used in the field.

Some guns may not be suitable for use with certain types of non-lead shot types, particularly hard shots such as steel. Hence, some hunters may choose to replace their shotgun, and a regulation of lead shot ammunition on the European level would impose an extra cost to such hunters.

Shotguns may be purchased either as new guns or second-hand. The cost of a gun is not linked to its utility but mostly to other features, e.g. brand, stock quality and cosmetics (engraving and other decorations). Furthermore, the prices vary between countries.

However, judged from a sample of online stores in five different EU Member States, prices for shotguns suited for the use of non-lead shot, including high performance steel shot cartridges, range from approximately €500 (for instance a Frankonia Magnum 12/76, over/under, in Slovenia at €490, second-hand) to several thousand Euros. Typical prices for a suitable new or well-maintained second-hand gun are approximately €1 000 Euros (for instance a new Beretta A300 Outlander 12/76, semi-automatic in Finland at €890, or a new Bok FAIR Premier, over/under, in Poland at €1,000). To many hunters such a cost may not be regarded as negligible. However, as the typical service life of a

[113] Rules of Proof 2006. http://www.gunproof.com/Proof_Memoranda/RULESOFP.PDF

[114] Steel shot should not be fired through Damascus steel barrels.

[115] The Assessment of the Tolerance of Shotgun Chokes to Steel Shot – An Initial Study, Allsop, RMCS, May 1991.

shotgun is likely to exceed 15 years it is likely to be affordable given the average annual hunting budget of a European hunter, which is estimated to be €2 400 (Kenward et al., 2009).

Hunters who are in doubt of the suitability their gun(s) can get advice from a gunsmith, or submit a gun for 'proof testing' (also termed 'pressure testing' or 'proofing'. A typical price for a pressure test is around 70 Euros. The price level for a modification of the choke, if recommended, is also around 70 Euros per barrel[116].

Guns that can fire standard lead shot cartridges safely can also fire standard non-lead shot cartridges safely, if they are the same length, and of an equivalent load weight (Thomas et al. 2015). Thus lead-like shot types like tungsten matrix shot or bismuth-tin can be used confidently in any standard-proofed European gun with any choke constriction.

Also, standard steel gunshot cartridges can be used in any modern gun (most guns built after 1961) typically used to fire lead gunshot cartridges. The only possible concern about the use of steel gunshot and other 'hard' gunshot in standard guns pertains to the 'choke region' of the barrel (near the muzzle), where large shot (typically considered to be larger than 3.5 mm diameter) passing through an abruptly developed, tightly-choked, barrel could cause a small ring bulge to appear around the choke conus. However, this is considered a cosmetic, rather than a safety, concern.

As to the use of 'robust guns', be that side-by-side, over-and-under, semi-automatic or pump-action guns, designed and proofed for high performance cartridges with lead or non-lead shot, there seems to be no limitations in the use of non-lead shot, and steel shot cartridges of either standard or high performance quality is regarded to be the most suited for water bird hunting depending on quarry size, hunting conditions, shooting distances.

Waterbird hunting in Europe is generally performed with robust guns. This is driven by two main factors: 1. That waterbird hunting due to the size of quarry and rather rough environment calls for robust equipment, and 2. That many European countries already have established regulations prohibiting the use of lead gunshot, hence this has motivated hunters to already adopt non-lead hunting, which in terms of waterbird hunting is generally regarded to be using with steel gunshot cartridges.

Some hunters may, for different reasons, need to have their gun(s) proofed, modified or, eventually replaced. Based on the Dossier submitter's analysis the cost of such actions is rather limited compared to the general budget of average European hunters.

Thus, the gun making industry has pro-actively responded in addressing the present and future needs, as major gun manufacturers export a large proportion of their guns to countries that already have non-lead shot regulations in place (e.g., the US and Canada), their guns are already now able to firing standard and high performance non-lead shot.

In conclusion, many guns manufactured after 1961 can fire standard steel shot. Guns manufactured before this date would need to be proofed (if not already done) at a one-off cost of 70 euro and a modification cost of 70 euro for a new choke. All guns manufactured after 1954 will be stamped with the relevant proofing mark. Furthermore, for guns not proofed for steel, using standard cartridges remains a viable option for fowl

[116] Mr. Thorkild Voigt, Korsholm Skjern. http://www.korsholm.dk/

hunting.

Face recognises this on their website[117] where th ey explain that shotguns can be categorised as follows:

- Suitable: Shotguns capable for use with non-lead shot without testing/modification;
- Limited suitability: Shotguns capable for use with a limited range of non-lead shot cartridges without testing/modification (e.g. standard pressure, limited range of shot sizes);
- Unsuitable: Shotguns that are currently unsuitable for steel shot, which require modification (e.g. to choke or chamber), or replacement and/or testing to ensure they support the pressures of alternatives.

However exact figures on the share of guns falling in limited suitability of unsuitable are not known.

Comments from the call for evidence on gun replacement.

In the call for evidence the Gun trade association (UK) and the Finnish hunting association had submitted information on the number guns. Other organisations had submitted comments that indicated that indeed there may be issues with older guns, but these comments were not supported by evidence on the extent of the issue. As such the dossier submitter decided to use the most factual evidence to see if there's a need to change any of the assumptions used in the proposal on lead ins hot over wetlands.

The Gun trade association argued that, based on figures, of the 1,375,556 licenced shotguns in England & Wales (estimated 1.5 million in the UK), 491,564 (estimated 540,000 in the UK) are traditional 'side-by-side' shotguns. It is further estimated that of these, approximately 60 % (324,000) are older shotguns with 2.5 inch (65mm) chambers which are not suited to currently produced steel shot cartridges. Taking this example and knowing that this estimate were made as well in the light of total phase out of the use of lead in the UK, it can be argued that 324 000 / 1 375 556 shotgun are not suitable for standard steel, equivalent to about 21 %.

Furthermore, shotgun barrels that are heavily choked may not be suitable for use with steel shot. The modification or replacement cost of shotguns for those shooters required to use steel shot instead of lead shot could thus be considerable.

Barrels comprise three regions: the chamber, the barrel bore, and the terminal choke. The only point along the barrel where some risk might arise is when the steel shot passes through the choke. However, the shooting of steel shot smaller than #4 does not cause concern when fired through tight chokes. It is possible that large steel shot (larger than #4 steel) passing through an abruptly developed, tightly-choked (full and extra-full), barrel could cause a small ring bulge to appear, simply because the steel shot does not deform when passing through the constriction.

This does not occur if the barrels are more openly choked, such as "modified" or "improved cylinder". This damage is cosmetic and is not considered to be dangerous. However, for shooters with gun barrels having concerns about "fixed" chokes, the choke, if necessary, can be relieved readily by a gunsmith to a more open choke. If a gun is particularly old, has thin walls, or Damascus barrels, it should be checked by a gunsmith,

[117] https://www.face.eu/2020/12/what-does-the-new-regulation-on-banning-lead-shot-over-wetlands-mean-for-europes-hunters/

but experience from Denmark, where lead has been banned for 25 years and most shooters use steel, suggests that the risks are very minimal.

CIP approval exists for 'standard' steel shot cartridges in calibre 12 (70mm chamber length only) and also for calibres 10, 16 and 20. No CIP approval currently exists for 'standard' steel shot cartridges in calibres 28 and .410. While the large majority of the shotguns used in the UK are in calibre 12 (1,185,978 shotguns in England & Wales), around 14 % are in calibres 28 and .410, for which no standard steel shot approval currently exists (15,092 shotguns in calibre 28 and 171,288 shotguns in calibre .410).

Adding these figures together would imply that around 35 % of shotguns would not be suitable for the use with steel. An internet[118] search however would suggest that the calibre exists in a lead-free version, thus it can be anticipated that with regulation demand would increase and consequently availability would increase.

Another issue that is problematic is the number of steel-proofed shotguns. In Finland, there are only 50,000-80,000 hunters with a steel-proofed shotgun (The number is based on data obtained from the Finnish Customs since 1996). In Finland this is anticipated to change with the wetland's restriction entering into force.

In the dossier on wetlands it was estimated that 21 % of all hunters will already be impacted by that restriction. Face reports there is a wide variety of non-lead shot available for 10, 12, and 20 gauge, but few options for 16, 28 bore and .410. which would imply that most hunters can obtain lead free shot without needing to change guns.

For the size 16[119], 28 and .410[120] bismuth cartridges are available and can be used.

All in all, the Dossier submitter argues that given the above information in the worst case no shotguns will need to be replaced and most adaptation will already follow from the wetland's restriction. In the rest of the analyses the dossier submitter assumes that 15 % of guns owners will move to bismuth solutions but will not replace guns. A conservative value of a 10% replacement rate will be used in the impact assessment.

Animal welfare

One of the key concerns relates to the potential for an increase in "crippling loss" of birds. This term refers to birds that have been shot, but are un-retrieved, either because they have not been killed outright (wounded birds), or because they have been killed but the carcass cannot be found (Thomas et al., 2015).

The crippling loss for some birds has been reported to be in the range of 10-50 % (Haas, 1977; Nieman et al., 1987). In this case the crippling loss describes the number of wounded birds that survive with pellets in the body (so-called "pellet carriers") plus the number of deadly wounded but non-retrieved birds over the number of all birds hunted.

This range is independent of the shot types used. Noer et al. (1996) found in Denmark in a population of Pink-footed Goose (*Anser brachyrynchus*) a prevalence rate of 36 % of lead shot carriers, and for eider suck (*Somateria mollissima*) a prevalence rate of 34 %. For both species accurate data on population dynamics were available. Based on annual survival rates and the frequency of shot carriers it was estimated that per bagged bird,

[118] https://www.munitionsexpress.com/shotgun-ammo/lead-free/410-bore/ or

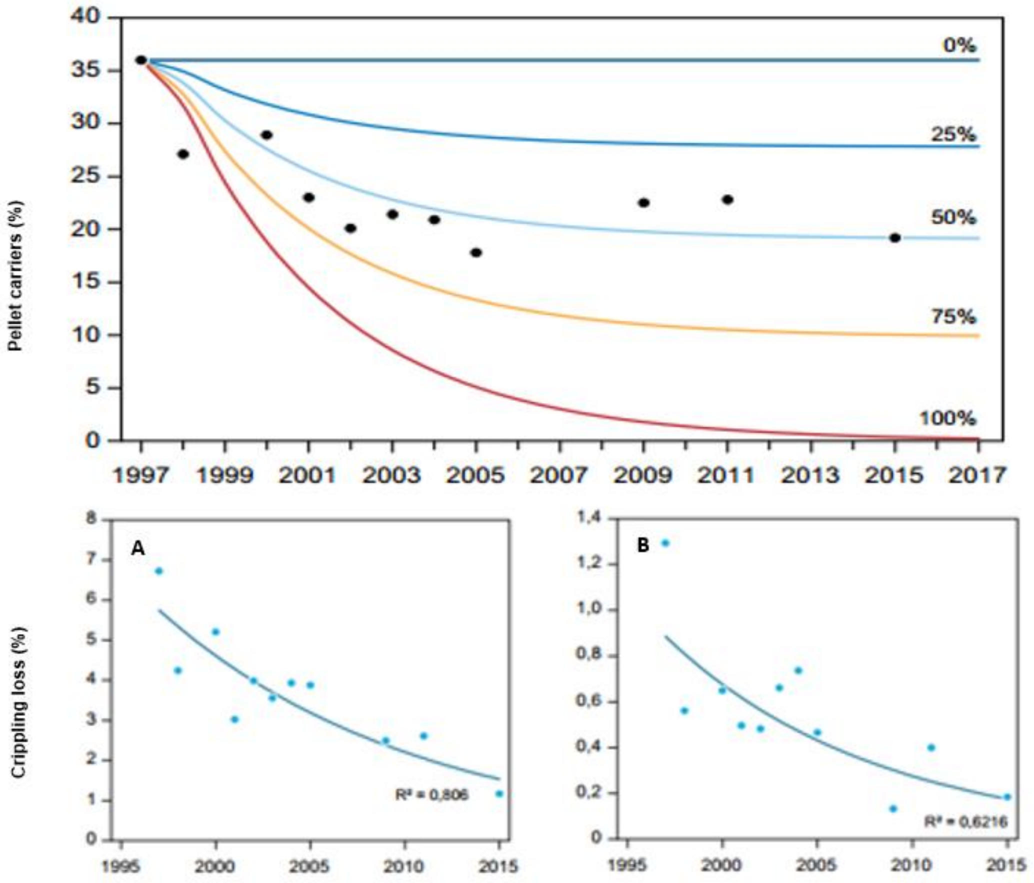
[119] See https://www.eleyhawkltd.com/products/game-cartridges/vip-bismuth

[120] https://www.riocartridges.com/en/rio_ammunition/products/hunting_loads

another bird was wounded (and survived). Moreover, there was an unknown number of mortally wounded but non-retrieved birds. Hence, the estimated crippling loss was well beyond 50 %. Notably, most of the examined birds had been wounded before the Danish ban on lead shot in wetlands (in 1993), and the carried shot was mostly lead shot.

Cartridge consumption per bagged bird varies considerably depending on the skill of the shooter, the shooting distance, the quarry size and many other factors. Haas (1977) found that dove hunters fired an average of 8.6 (lead) shots per bagged bird. Noer et al. (1996) found between 1.5 and 10.50 shots per bagged bird among 14 duck hunters, with an average of 3.3 (steel) shots. These large numbers of shot fired without creating a kill represent a risk not only for missing the target, but for wounding it. Noer et al. (2001) also found a clear correlation between cartridge consumption and the prevailing crippling loss ratio. Here, an ideal situation would be a 1:1 ratio – one bagged bird per shot. Whilst this is not achievable in practical terms, the setting of goals for reducing cartridge consumption has proven to be an effective tool to control crippling. As a result of a Danish campaign (in 1997) a code of maximum three shot per bagged bird was established. In addition, the shooting distance was found to be crucial for both cartridge consumption and wounding risk. Hence, the recommended shooting distances in the same set of hunting codes were reduced accordingly.

The latest evaluation of the impact of the campaign is presented by Holm et al. (2015). The results are summarised in Figure D.1-2. The top panel shows the development in frequency of pellet carriers from 1997 to 2015 for pink-footed goose. The bottom panels show for old (A) and young specimens (B), the corresponding development in crippling loss (i.e. % wounded birds / % bagged birds), based on the frequency of pellet carriers and data on the total annual bag.



Notes: Top: The frequency (%) of old (>1 year) with embedded pellets. The curves show the predicted development, if the level of wounding was un-changed (0 %) or declined with, resp. 25 %, 50 %, 75 % and 100 %. The dots show the actual trend. Bottom: Crippling loss (% wounded / % bagged birds). A: Old birds (>1 year); B: Young birds (1 year)

Figure D.1-2. Development of wounding of pink-footed goose in Denmark over the period 1997-2015. After Holm et al. (2015).

Holm et al. (2015) detect a clear and significant reduction in wounding rates over time. The authors attribute this to better organisation and planning of hunting, combined with a better education of hunters. shows the harvest of pink-footed geese in Denmark and Norway since 1990 (Madsen et al. 2015).

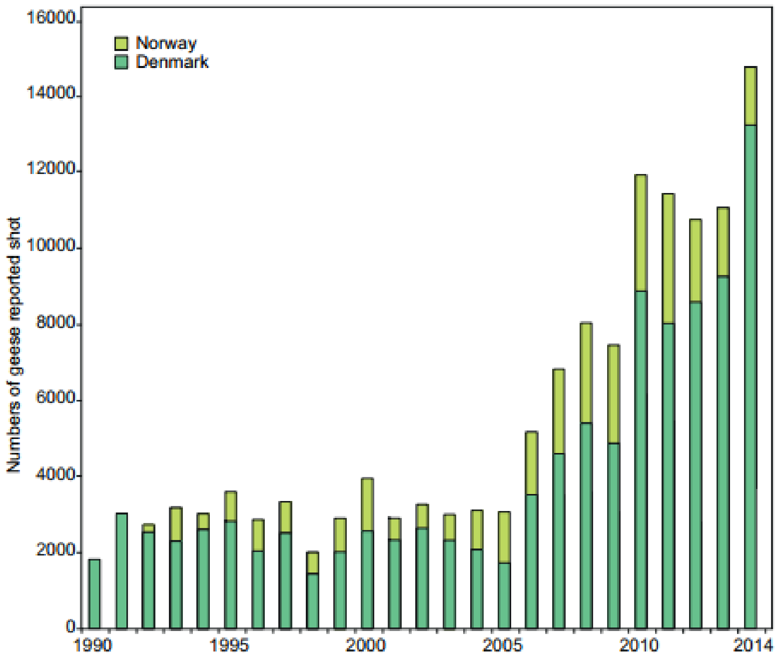


Figure D.1-3 Harvest of pink-footed geese in Denmark and Norway from 1990-2014. After Madsen et al. (2015).

Comments in the call for evidence from the Finnish Hunters' Association conducted a field test to test for non-lead shotgun cartridges and their penetrating in ballistic gelatin. On the basis of the test, it can be said that the most efficient High Performance -steel cartridges already outperform the average lead cartridges. On the other hand, Standard Steel -cartridges for older shotguns are significantly weaker in penetration and are at high risk of increasing the number of clipped animals if used in the same way as lead, highlighting the need to adapt hunting techniques to the shot material that is used.

Evidence that was submitted in the call for evidence from the USA where Non-toxic alternatives to lead shot are being used efficiently and are effective, as demonstrated by low crippling rates in the USA where use of lead shot in wetlands was banned 30 years ago. United States Fish and Wildlife Services Waterfowl Harvest Survey data show that crippling rates for both ducks and geese were slightly higher in the phase-in period of five years (1987 - 1991) immediately after the ban on lead shot was introduced. However, after the phase-in period (1992 – 2001) crippling rates of both ducks and geese were much lower than when lead shot was the predominant ammunition used (1952 – 1986) and showed a long-term continuing decline during the period reported. Average post-phase-in crippling rates with non-toxic shot (predominantly steel) were 18 % lower than pre-ban crippling rates (predominantly lead) for ducks and 15 % lower for geese. The small short-lived increase in crippling during the phase-in period probably occurred while hunters switched from lead to steel and got used to the differences in ballistics between ammunition types. Once they had done so, the period with non-toxic ammunition was associated with less crippling.

Ricochet

All types of shot can ricochet (i.e. deflect) from a hard surface such as water, rocks, or the surface of tree trunks if they hit the surface at an acute angle. Shot made from soft lead, tungsten and bismuth-tin may flatten and even break up on direct contact with

rocks. However, steel shot will bounce off hard surfaces, and is not so prone to deformation or fracture, but whether this difference is sufficient to increase the likelihood of injury is not supported by the available evidence.

Ricochet can, roughly, be divided into two components: 1. Ricochet angles and 2. Energy of ricocheting shot. DEVA[121] studies show that ricochet angles do not differ significantly between different types of shot (DEVA, 2013). The same studies show that some types of lead-free shot have greater ricochet energy due to mass stability and that steel and other hard shot has a higher tendency to direct rebound from hard surfaces.

This last element was mentioned particularly by the UK Lead Ammunition Group (LAG, 2015). This was evidenced as the result of pattern testing early steel shot loads at a special pattern testing facility at Holland & Holland's shooting grounds in North London. The Group concluded that in such circumstances precautions need to be taken when firing steel shot at a resilient pattern plate, as steel will rebound to a greater extent than lead. However, for all practical purposes when shooting in the field the group concluded: "An unsafe shot with steel is an unsafe shot with lead".

Under the practical circumstances of hunting the risk of ricochet depends on the physical environment, i.e. the risk of hitting rocky surfaces and obstructions like bush and trees. Water bird hunting in wetlands has a high prevalence of shots in open space with "the sky as background", hence with a low risk of hitting obstructions. Birds (e.g. wounded birds) may be shot/dispatched at the water. Shot of any type will ricochet from water surfaces given that the hitting angle is small (< 5°), but with no difference between shot types.

Danish experience

Ricochet was a central part of the Danish debate during the transition from lead to non-lead gunshot in the 1990s. Many actors were concerned that particularly steel shot, which was then the only available alternative, would create an increase in ricochet accidents. For this reason, various measures were introduced. Codes of safe hunting were adapted, including that recommended safety angles were increased from 25° to 40°, and hunters were recommended to wear safety glasses when hunting in groups. In addition, a safety campaign was launched under the motto "better red than dead" – meaning that hunters were recommended to wear red caps or hat ribbons to be visible to fellow hunters. The campaign was inspired by the switch from lead to non-lead shot.

Today, two decades later, there is no evidence, that the change from lead to non-lead shot has caused any change in risk of injury. Research from DEVA (DEVA, 2013) concluded that ricochet from lead and steel is comparable. Furthermore, the Danish Hunting Insurance[122] company registers reports on shooting accidents including accidents caused by ricocheting gunshot. However, the records from period after the phase-out of lead shot do not indicate any increase in frequency of such accidents. This may be a product of the precautionary steps that were taken in the 1990s, and also that hunters have used lead-like gunshot (bismuth-tin) particularly for forest hunting where the risk of ricochets (e.g. from tree trunks) is larger than in open habitats. Furthermore, hunters are educated to take safety angles into consideration. This is a mandatory part of education and testing of hunters in Denmark and has been so since 1967.

[121] http://www.deva-institut.de/home.php

[122] http://www.danskjagtforsikring.dk/

Since 1985 the use of lead shot for training and competition shooting (clay pigeon) has gradually been phased out in Denmark. Today, lead shot is allowed on a few specially approved shooting grounds. Steel shot has become the only realistic alternative and was from the beginning foreseen to generate an increased risk of accidents caused by shot ricocheting from clay pigeons' installations, ground (running target), etc. However, after 20 years and millions of rounds later there has been no detectable change in accidents caused by ricocheting shot[123]. So, this initial concern proved groundless. Shooters are recommended to wear safety glasses (in some disciplines this is mandatory). This precaution is mainly introduced to prevent eye injuries from clay pigeon splinters, but will in addition protect against shot – either direct or ricocheting shot. This applies equally to steel and lead shot.

Based on research and experiences there is no indication that a change from lead shot for hunting to other types including steel shot would cause any increased danger due to ricocheting shot.

The Finnish hunting association had submitted information in the call for evidence that particularly steel and some tungsten-based shot, can Ricochet more and are more likely to bounce-back. Hunters and their dogs can be at greater risk when shooting around hard surfaces and water.

Danish experiences from hunting accidents do not indicate an increased risk of ricochet caused by non-lead shot, including steel shot. Neither do Danish experiences from clay pigeon shooting indicate a higher danger/risk of ricochets with use of non-lead shot (steel) than with lead shot. In general, there is no evidence from shooting in countries where steel shot has been used for many years of an increase in reported accidents or insurance claims.

A study from DEVA (DEVA, 2013) demonstrated that ricochet occurs both in steel and in lead shot, a conclusion also reached by the Game and wildlife conservation[124]

Impact of forest industry

A concern often raised within the context of substitution lead with steel is the possible damage steel shot in timber on sawmills.

There is no documented evidence of any problem with the use of steel ammunition in forestry in the Nordic countries (Denmark in particular). Concern that steel shot might damage standing timber was raised when lead was to be prohibited in the 1990s in Denmark, and the forestry authorities had recommended against the use of steel. There is still concern among some woodland owners. Experience from Scandinavian countries suggests however that it has not been a significant problem; except possibly in woodlands managed for veneer timber, though even in this instance it has not been a major issue in practice

The items was original discussed in a study from the Nordic council, reference was made to a study of the Danish institute of forest technology which carried out a series of shooting test to establish penetration capacity of steel shot in in various species of wood, Norwegian spruce, oak and old and young beech. The shots were fired at distances of 20 and 30 metres. The test showed a maximum penetration of 7.5 mm and no significant difference in depth of penetration for lead shot and steel shot. The density of shot in raw

[123] Danish Wing Shooting Association, personal communication

[124] https://www.gwct.org.uk/media/1094670/Moving-away-from-lead-shot-QA.PDF

material was analysed. On average, one shot for each 29 cm^3 beech was found.

This would mean that at normal shooting distances that the shot would remain in the bark of the trees (which in most case for timber production is removed.

Shot embedded in the xylem system will remain the same distance to the centre of the tree as the tree grows. It is assumed that steel shot will corrode over time, more quickly in species heavy in tannin. The corrosion will cause the wood the discolour and will this reduce it quality. Discoloration will also often occur simply because of the access the oxygen provided by the penetration of a shot. The last cause is seen to be common for both steel and lead shot.

In an online publication[125] on timber quality control, UPM (one of Finland's larger) states that timber is systematically scanned for foreign objects which scan for objects with an iron contamination from a size of eight millimetres must be detected as reliable and trouble-free.

Many sawmills these days are equipped with metal detectors[126] for reason other than just steel shot. Advertisements for metal detectors suitable for the timber industry are numerous ranging from handheld devices to full blown automatic sorting system that disregard timber with a large metal objects, select them out and put this timber to other uses.

During the Public consultation on the wetlands proposal, concerns were raised on the impact of steel shot on machineries used in the forestry industry. Evidence received in the SEAC consultation however (based on experiences in DK and FI), suggested that there is no impact on forestry industry to be expected at the EU level. ECHA followed up on this aspect with the Finnish forestry authorities, who investigated the issue with their clients who reported that hard shot (such as steel) poses no problem in their machinery. Consequently, the Finnish Forest Authorities will lift the existing ban on the use of steel shot in Finnish forests in autumn 2018[127].

ECHA learned[128] from Metsahallitus that they have asked all their clients to see what the problem is, all the sawmill companies replied that here is no problem and that hard shot (such as steel) can be used. There has been no feedback from private landowners that the trees have been damaged by the shots. In a reaction to this and to prepare for a future without lead shot Metsahallitus lifted the ban.

Availability of lead-free shot

Kanstrup and Thomas (Kanstrup and Thomas, 2019) identified 22 European manufactures of non-lead shot cartridges distributed among the following 7 Member States: Italy (6), , France (4), Spain (4), Sweden (1), Germany (1), Poland (1), and Czech Rep. (1). All companies had a steel shot line, some with a wide selection of gauges and loads. Bismuth shot cartridges were produced by two, copper by two, and zinc by one company (Table 1). In addition, six North American and four UK manufacturers produced non-lead cartridges. One (Kent Cartridge) had specialized in

[125] https://d-nb.info/102516010X/34

[126] https://sahateollisuuskirja.fi/en/sahatavaran-valmistus/sahatavaran-laadutusjarjestelmat-konenakosovellukset/

[127] https://www.eraluvat.fi/ajankohtaista/ajankohtaiset-aiheet/uutiset/korvaavien-haulien-kielto-poistuu

[128] Personal communication, Antti Otsamo

this type of non-lead cartridge and was directly affiliated with a British company (Gamebore). The 28 manufacturers, including the six North American companies, had agencies in most European countries; hence, their products, including non-lead ammunition, were available, or could easily become available in any region or country, subject to demand. The result of this survey are in Table D.1-14: Availability of lead free shotFigure D.1-6

Table D.1-14: Availability of lead free shot

Country	Regulation of lead shot for hunting[a]	Number of non-lead cartridge manufacturers identified	Number of non-lead cartridge brands identified	Non-lead shot types available
Austria	x		1	S
Belgium	x		1	S, B
Bulgaria	x		1	S
Czech Rep.	x	1	1	S
Croatia	x		0	–
Denmark	xx		16	S, B, T
Estonia	x		1	S
Finland	x		8	S, B, C
France	x	4	3	S
Germany	x	1	4	S, B
Greece	–		2	S
Hungary	x		1	S
Iceland	–		1	S
Ireland	–		0	–
Italy	x	6	1	S
Latvia	x		2	S

Lithuania	x		2	S
Luxemburg	x		2	S
Malta	x		1	S
Norway	x		2	S, B
Poland	–	1	0	–
Portugal	x		1	S, B, T
Romania	–		0	–
Slovakia	x		0	–
Slovenia	x		0	–
Spain	x	4	0	–
Sweden	x	1	1	S, B
The Netherlands	xx		4	S

1. [a]No regulation, x = ban of lead shot in wetlands/waterbird hunting, xx = total ban of lead shot

2. *S* steel shot, *B* bismuth shot, *T* tungsten shot, *C* copper shot, – none

Alternative shot is expected to be readily available. Many European manufacturers of lead gunshot have production lines of steel gunshot and other non-lead alternatives. There are also non-EU manufacturers selling different types of non-lead ammunition on the EU market. Some local retailers might currently not hold stocks of non-lead gunshot though or have limited quantities on stock.

From the wetland dossier the Dossier Submitter had learned that availability of steel gunshot in Europe. This was done through an online search of the product catalogues of ammunition manufacturers that are members of AFEMS[129] as well as other companies. Ten manufactures were identified in the following countries: Italy (2), UK (2), Spain (1),

[129] http://www.afems.org/

Sweden (1), Germany (1), Poland (1), Czech Republic (1), and Greece (1). All of these companies have a line of non-lead shotgun hunting cartridges. All have a steel gunshot production line with a rather varied selection of calibres and loads. Bismuth shot cartridges are also produced by two manufacturers, copper by two, and zinc by one. The manufacturers have agencies in most European countries, hence their products, including non-lead ammunition, are available or can easily become available in any Member State, once the demand is there. In addition, several North American manufacturers produce and export non-lead ammunition to Europe. These companies have a long tradition for production of non-lead hunting cartridges. One (Kent) has specialised in this type (i.e. steel shot) and is directly affiliated with a British company (Gamebore). It has, at present, a significant share in the Danish market of shot cartridges.

ECHA organised a call for evidence (from 4 October 2019 to 21 December 2019, to test to what extent the SEAC conclusion on the use of lead shot in wetlands are applicable to the use of lead shot outside of wetlands. In this call for evidence comments on this issue were received from:

- British association of Shooting and Conservation (BASC)
- British sports shooting council (BSSC)
- Norges Jeger- og Fiskerforbund (NJFF)
- Federation for Hunting and Conservation - Malta (FKNK)
- Finnish hunting association
- Finnish ministry of Agriculture.

In their submission to the call for evidence the *British Association for Shooting and Conservation(BASC)* reported the result of a study by (Ellis, 2019) on availability of lead free shot. (Ellis, 2019) finds that there is a general trend for a greater variety of non-lead brands available for the popular shotgun gauges and chambers.

These comments covered the availability of lead-free shot, the following issues were raised

- A research of five major European ammunition manufacturers indicates that while lead-shot alternative products for 12-gauge is available for all five, only two manufacturers produce 16 and 20 gauge lead-shot alternatives. None seems to produce non-lead shot cartridges for the 28 or 36 gauge (.410 calibre) firearms. The 36 gauge (.410 calibre) has increasingly become popular, especially in the Mediterranean basin, with more and more firearms being made available by the trade in this calibre.
- CIP approval exists for ‘standard’ steel shot cartridges in calibre 12 (70mm chamber length only) and also for calibres 10, 16 and 20. No CIP approval currently exists for ‘standard’ steel shot cartridges in calibres 28 and .410. While the large majority of the shotguns used in the UK are in calibre 12 (1,185,978 shotguns in England & Wales), around 14 % are in calibres 28 and .410, for which no standard steel shot approval currently exists (15,092 shotguns in calibre 28 and 171,288 shotguns in calibre .410).

Non-lead shotgun cartridges are available in most Member States from retail shops with online service. However, the screening showed that the product range of non-lead ammunition is significantly restricted compared to lead shot brands. This is supported by research undertaken by the UK Lead Ammunition Group (2015) who concluded that “the

available variety of non-lead shotgun and rifle ammunition is more restricted than currently available for lead, so optimum loads may not yet exist for all circumstances". This may very well be the situation in other EU Member States with no or partial bans on the use of lead gunshot. Stocks of non-lead ammunition held in local retail shops may be very limited in quantity, specification and brand. Hence, a small-scale local purchaser may not initially be able to buy the most appropriate cartridge for their shotgun or hunting purpose. However, this should not be considered to mean that an appropriate cartridge is not available.

The availability of non-lead ammunition is first and foremost limited by the demand at the national, regional, and local level (Thomas, 2013). Manufacturers provide non-lead ammunition and their products are available, or can easily become available in any Member State, regionally and locally, once the demand is there. Another example of this, is in Italy where a partial ban has been put in place Recent industry information suggests that the market share of alternatives for lead was estimated to be up to 50 %[130]

In Denmark, ammunition dealers at retail level will offer a very broad selection of non-lead cartridge types. One example is Korsholm[131], who offer 15 different brands of non-lead shot cartridges (mostly steel) in different calibres each with a selection of 3-5 different shot sizes. In contracts, our screening identifed that no non-lead gunshot was available online in Poland where a restriction on the use of lead gunshot has yet to be introduced. This is despite the fact that Polish company FAM produces steel gunshot hunting cartridges.

The impact of demand on the availability of non-lead gunshot was discussed in by UK LAG (2015). It was concluded that, based on the development of non–toxic markets in Denmark, the Netherlands and in North-America that "the variety and performance of non-lead ammunition will, if demand exists, improve to meet demand". Also, Thomas (2014) finds that manufacturers in Europe make and distribute cartridges according to hunter demands, which, in turn, is driven by regulations.

As already highlighted in the section on gun replacement, in the shot sizes mentioned, alternatives are available in bismuth and can be used without the need to change guns.

ECHA conducted market study of its own to investigated the availability of non-lead shot in various member states, the results (see Table D.1-15Table D.1-15) highlight that lead free shot is widely available throughout the EU.

[130] Personal Communciatin AFEMS 2017.

[131] http://www.korsholm.dk/dk/jagt-produkter/ammunition/halgpatroner.html?m-layered=1

Table D.1-15: Result of market study: availability of lead shot

Gauge	Number of brands found				
	Lead	Steel	Copper	Bismuth	Tungsten
12/70	13	17	2	2	10
	• Remington Express Extra Long Range • Hornady Varmint Express • Baschieri & Pellagri Baby Magnum • Baschieri & Pellagri MG2 Mythos HV • Baschieri & Pellagri F2-4 Trap • Baschieri & Pellagri F2 Long Range • MB Dispersante • Sellier & Bellot Buck Shot • Forest Favorit Forest Crowbuster • Forest Ammo Blitz hunting shotshell, HV • RWS Game Edition pigeon • Sellier & Bellot Long Range	• Remington Nitro Steel • Rottweil Steel Game • Sellier & Bellot SB Steel Shot • FIOCHI FSteel • SAGA Heavy Steel • Sellier & Bellot Jagd Steel • RWS Game Edition Ente • Sellier & Bellot B+P 3 Valle Steel HV • Sellier & Bellot Eco-Game Steel • Tunet Steel Shot Line • Armusa Steel • Sellier & Bellot Steel Shot • WINCHESTER ZZ Canard Steel • Wincheste	• Rottweil Copper Unlimited • B&P 4 Dual Shock	• ELEY VIP Bismuth • Gamebore	• Gyttorp Silver • Saga Maximum Tungsten • AmmoX Premium • Baschieri & Pellagri MG2 Tungsten • TUNET SPHERO TUNGSTEN • UnA-Tungsten • Clever Mirage Tungshot • KENT Impact tungsten • Fob Sphero Tungsten • MARY-ARM XTREM Tungsten

	• RWS Game Edition Crow	r X2 Steel • Mirage T4 Waterfowl Steel Shot • Remington Steel shot • Winchester Buckshot			
16/70	5	2	-	2	-
	• Sellier & Bellot Red/Black • Sellier & Bellot Vega plastic • BRENNEKE Camou • Brenneke classic • WINCHESTER Super Speed 2nd Generation	• Rottweil Steel • Mirage Soft Steel T3	-	• ELEY VIP Bismuth • Rio Bismuth	-
20/70	6	2	1	3	2
	• WINCHESTER Super Speed 2. Generation • B&P Mythos Valle Semi-magnum • Mirage T3 • Rottweil Exact • Rottweil Waidmannsheil • RC Italy SIPE T3	• Fiocchi Steel Shot 20 • Rottweil Steel Game	• FOB Sweet Copper	• Eley Bismuth • Eley Field Special Bismuth • Gamebore Bismuth	• Kent Impact Tungsten Matrix • B&P MG2 Tungsten Cal.20

Economic feasibility of alternatives

Alternative ammunition used to be more expensive than lead. However, recent data on the market price of gunshot cartridges indicate that on average there may be no significant difference in price between lead and steel gunshot. Moreover, the long-term economic impact on shooters due to different prices of alternative shot is difficult to

reliably predict because several factors affect the retail price of gunshot including raw material price, production processes, market demand for different cartridge gauges and taxes, e.g. VAT, in different Member States.

(Kanstrup and Thomas, 2019) conducted an internet study to evaluate the prices of lead shot and non-toxic shot in various European countries, Tungsten shot was by far the most expensive type of non-lead shot. Steel shot cartridges are available at much lower prices, approximately the same as equivalent, high-quality lead shot cartridges, which correspond with the findings of (Thomas, 2014), (Kanstrup and Thomas, 2019)see table Table D.1-16: Average prices of shot types in retail sale identified in the Internet search in 29 European countries (Thomas, 2014),

Table D.1-16: Average prices of shot types in retail sale identified in the Internet search in 29 European countries (Thomas, 2014), (Kanstrup and Thomas, 2019)

Type	*N* [a]	Price in Euro/25 pcs	
		Average	**Range[b]**
Steel	36	11.9	7.50–25.25
Bismuth	8	57.81	42.25–60.00
Tungsten	2	85	79.25–90.00
Copper	3	37.28	21.50–41.25
Lead	25	10.45	6.50–18.25

Within the framework of ECHA’s call for evidence, many commenters stated that the prices of steel shot where prohibitive of regulating the use of lead further, outside of wetlands. Some commenters however had submitted actual quantitative evidence and data.

One of such commenters, the British Association for Shooting and Conservation had submitted a market study on the availability and process of steel shot and other alternative to steel shot. This study covered both the use of shot as well as rifle ammunition.

Comments from the call for evidence (BSSC, gun trade association) reported that a total of 730 shotgun cartridge brands were found for sale on the websites of the 15 largest ammunition retailers in the UK. Of these, 87 % were lead cartridges at an average cost of £0.32/cartridge. The remaining 13 % of cartridge brands were predominantly steel (10 %) at an average cost of £0.38, followed by bismuth (3 %, £1.30/cartridge) and tungsten (0.2 %, £2.53/cartridge). 76 % of the non-lead shotgun cartridges were for 12 bore shotguns, and 15 % for 20 bore. There were four non-lead cartridges available for

28 bore, two each for 10 bore and 16 bore and only one for .410.

Wholesale and retail prices of cartridges will basically depend on production prices, but will also—and to a very high degree—be influenced by volume, transport cost and other basic vectors. Particularly, the profits generated along the value chain from production to retail, taxes, VAT etc. influence the retail prices to be paid by the hunters. To exemplify this, the price per cartridge for ELEY VIP Bismuth calibre 12/70 (shot size 3.2 mm) was €1.4 on the webpage of a UK-based supplier[132], but €2.7 at a Danish store[133]. This illustrates that the retail price of two identical cartridges may differ by a factor of two depending on market factors.

There is significant variation in price per cartridge even within a single gauge and chamber combination for a single shot type. This is due to variation in the intended use and specification of the load. For example, sporting loads tend to be cheaper than high performance goose loads whether the shot material is steel or lead.

Table D.1-17[134]: The average for lead and steel cartridges for all of the gauge and chamber length combinations found for sale on Guntrader. (Ellis, 2019)

Gauge	Chamber length (mm)	Steel price per cartridge	
		Average lead	Average steel
.410	50	0.35 €	-
.410	65	0.42 €	2.19 €
.410	70	-	0.55 €
.410	76	0.49 €	1.46 €
10	89	2.15 €	1.06 €
12	65	0.43 €	0.21 €
12	70	0.43 €	0.53 €
12	76	0.81 €	0.80 €
12	89	1.34 €	0.88 €

[132] http://www.sportingsupplies.co.uk/contents/en-uk/d194.html

[133] http://www.iversen-import.dk/bismuth-forrest-vip-32-gr-skovpatron-405-m-sek.html

[134] Prices converted to euro with conversion rate of 1:1.13 (pound to euro)

16	65	0.46 €	0.26 €
16	70	0.58 €	0.69 €
20	65	0.42 €	0.36 €
20	70	0.45 €	0.47 €
20	76	0.85 €	0.68 €
28	65	0.40 €	2.19 €
28	70	0.51 €	0.87 €

Note: Range is not given where only a single brand was found. The cheapest choice for each combination is given in bold

In the dossier concerning wetlands this was already highlighted by the dossier submitter, in which was found that the retail prices of lead and various non-lead shot cartridges based on the information from different European countries reported in Table E.5. Lead shot cartridge prices vary from €0.29-0.65 (mean = €0.45), while steel shot cartridges vary between €0.23-0.99 (mean = €0.46). Bismuth (and tungsten cartridges) are significantly more costly with prices between approximately €1.7-2.5 per cartridge (with a central price estimate of €2.0), see also Table D.1-18: Comparative prices for of lead and non-lead shotgun cartridges in the EU in cal. 12 (32 gram load)..These prices are taken forward in the impact assessment.

Table D.1-18: Comparative prices for of lead and non-lead shotgun cartridges in the EU in cal. 12 (32 gram load).

Shot material	Summary statistic	Price (€)
Lead (n=48)	Mean	0.45
	Min	0.29
	Max	0.65
	Median	0.47
Steel (n=23)	Mean	0.46
	Min	0.23
	Max	0.99
	Median	0.38
Bismuth (n=3)	Mean	1.96
	Min	1.68
	Max	2.50
	Median	1.71

These data support the general finding that prices of lead and steel shot are currently comparable while bismuth (and tungsten), which are produced, sold and used in lower volumes, are likely to remain more expensive than lead (even though the price of bismuth shot may reduce slightly).

D.1.2.2. Lead in bullets

Function of lead in bullets

Rifle ammunition cartridges contain a single projectile (bullet). The mass of the bullet is described in grains in the US but and in grams in the EU. – there are 437.5 grains in an ounce. And on grain is approximately 0.06 gr.

"Calibre" is the measure of a bullet's diameter; the higher the calibre, the bigger the bullet and, when used for hunting – it generally follows that the larger the bullet the larger the game it can be used to hunt. The calibre of the ammunition must match the calibre of the rifle/gun being used (the calibre is usually stamped on the barrel or receiver of the rifle). For example, .22 calibre 55-60 grain bullets can be used in a .22 calibre rifle (a 55 grain bullet has a mass of 3.6 g), a 150 grain bullet has a mass of 9.7 g, and a 220 grain bullet has a mass of 14.3 g. Bullets of different size (grains) are selected based on the species being hunted e.g. a 150 grain bullet can be used to hunt white-tailed deer, a 220 grain bullet to hunt bear.

Calibre can also refer to the complete set of dimensions (length, calibre, etc) of a bullet. As such the word bullet in that case refers to a specific type of bullet.

(Stroud and Hunt, 2009) reviewed basic bullet materials available to bullet manufacturers, which include lead alloys, lead with external copper wash, lead core with copper jacket, pure copper, and bismuth. Lead and bismuth are highly frangible, whereas pure copper bullets tend to remain intact after impact. Bullet fragmentation increases the degree of lead contamination in tissue ingested by scavengers feeding on hunter-killed animal remains. Modern bullet design, velocity, composition, and bone impact are significant factors in the character and distribution of lead particles in carcasses, gut piles, and wound tissue left in the field by hunters. Prior to the 1900s, bullets were made entirely of lead. Their velocity was relatively slow (<2,000 feet per second), and their tendency to fragment was accordingly lower than that of modern ammunition. Development of smokeless powder in the 1890s increased bullet speeds above 2,000 feet (610 m) per second, causing lead bullets to melt in the barrels and produce fouling which reduced accuracy. Copper jacketed lead-core bullets were therefore developed, which permitted velocities that may exceed 3,000 or even 4,000 ft/sec in modern firearms. Standard hunting bullets now typically travel at 2,600 to 3,100 ft/sec, speeds highly conducive to fragmentation.

One of the advantages of these types of non-lead bullets is that they do not fragment like lead bullets (see Figure D.1-4 Bullet Fragmentation: Lead vs 100 % copper or gilding metal construction (typically 90 % copper) Source: IWS)

Fragmentation in modern centrefire lead rifle bullets is a direct result of their design to be a controlled-expansion projectile. They are specifically designed so that the frontal portion of the bullet consistently and reliably expands to almost twice their original diameter.

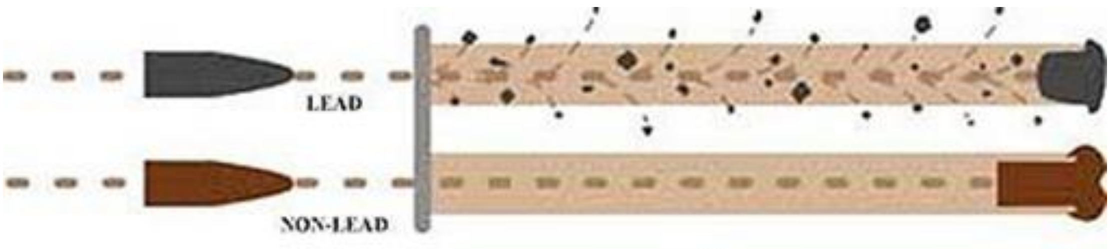


Figure D.1-4 Bullet Fragmentation: Lead vs 100 % copper or gilding metal construction (typically 90 % copper) Source: IWS

This design ensures a quick and humane kill:

1. It delivers a hydrostatic shock wave that travels out from the bullet's path and into the animal's body that has received the bullet, causing significant damage to internal organs and bones.
2. It ensures that when the bullet passes through the body, the increased diameter and sharp edges of the expanded bullet causes more internal physical damage to the animal.

However, one other consequence of a rapidly expanding lead bullet traveling at high velocities is that some of the soft metal itself erodes away from the frontal section of the bullet as it strikes and travels through the animal. The fragmenting characteristic of lead bullets is cause for concern for wildlife and humans who eat any portion of an animal shot with this type of bullet. While efforts have been made to retain the expanding characteristic of lead bullets but eliminate the fragmenting aspect (e.g. special bonding of the jacket to the bullet core), none have been entirely successful in this regard. IWS also notes that lead rim fire ammunition (e.g. .22 calibre bullets) which can be used to hunt smaller game animals, also fragment extensively despite travelling at lower velocities. Hunt and X-rayed rifled-killed deer hunted with lead bullets and found all contained lead fragments, with 74 % containing >100 lead fragments. These lead fragments were then shown to be bioavailable and could result in elevated blood lead levels following ingestion.

Suitability of non-lead or non-toxic rifle ammunition

Non-lead ammunition has the advantage that it fragments less (Figure D.1-4), the bullets are of monolithical design and retain their weight upon impact with a target.

The Institute of Wildlife Studies (IWS)[135] states that non-lead bullets are extremely effective and notes that bullets made from 100 % copper were initially developed by Barnes Bullets in the mid 1980's as a premium bullet for big-game hunting in Africa. They were found to have excellent performance properties including extremely consistent and rapid expansion, combined with excellent weight retention and associated deep penetration. In addition, they gained a reputation as being very accurate. Continued advancements have resulted in more manufacturers producing numerous calibres and bullet weights using either 100 % copper or gilding metal construction (typically 90 % copper). Non-lead bullets are available in factory loaded ammunition from all major manufacturers including Federal, Hornady, Winchester, and Remington,

[135] The US-based Institute of Wildlife Studies (IWS) is a non-profit group of hunters and wildlife biologists that is dedicated to promoting hunting and wildlife conservation through the use of non-lead ammunition.[103] This group provides extensive information on the advantages and disadvantages of lead and non-lead hunting ammunition.

as well as for reloaders.

IWS has shown that non-lead bullets compare very favourably with lead bullets in terms of ballistics. In this test two popular non-lead bullets (100 % copper and copper-zinc alloy containing 90 % copper) and one lead bullet used for hunting were fired into the same block of standard ballistic gelatin to compare expansion, penetration, and hydrostatic shock. The two non-lead (copper) bullets compared very favourably to the lead bullet in terms of performance

In a technical note to support the transition to lead free bullets, (Kanstrup and Haugaard, 2020a) notes that a change from lead to copper will change the projectile's weight / volume ratio. In general, the shift from lead to other materials (Such as copper) will imply a shift to material with a lower density. This has several consequences:

1. to preserve the volume, a change from lead to copper will result in a weight reduction. If you want to maintain the weight, the volume will increase. Within a given calibre (projectile diameter) to maintain the weight, constant volume is achieved only by increasing the length of the projectile.
2. the project length must be increased by a factor corresponding to the ratio between the density of the lead-containing and lead-free projectile. Increasing project length affects the projectile's passage of the rifle barrel, as this increases contact and thus i.a. greater friction. This can increase the pressure during firing.
3. In addition, the increase in the rifle range is adapted to a specific project weight and thus-Length in a given calibre. For many rifles, this point in classic lead-based projectiles. Changes in project length can cause that the projectile is not stabilized properly, thereby affecting the external ballistics and the projectile becomes inaccurate.
4. In some calibres, increased projectile weight may have the consequence that the total cartridge length becomes too large and that the cartridge cannot be placed in the magazine of the weapon or in its chamber. Rounding of the projectile tip so that it becomes more round-nosed, affecting its ballistic properties.

The contact surface between the projectile and the rifle barrel can also be reduced by the projectile is provided with a number (1-3) of radial cuttings which also counteracts material deposits in the rifle barrel. This too causes a weight loss that can only be offset by changing length and shape.

Non-lead monolithic bullets (e.g. 100 % copper hunting bullets) are longer than lead core bullets of the same weight. Longer bullets may react differently, depending on the twist rate the gun barrel.

As a consequence of increasing project length, manufacturers of lead-free projectiles in the individual calibers reduced the projectile weight and, in some cases, changed their shape. Reduced weight gives - all other things being equal - less energy at all shooting distances. This can in principle be compensated for by increasing the speed by adjusting gunpowder type and quantity. However, the speed has great importance for the stabilization of the projectile in the rifle barrel and thus for the precision and change of combustion and speed also have safety (pressure) and wear aspects. Copper bullets tend to perform better when they are faster, which provides additional energy to expand the projectile. This is usually achieved by using a lighter projectile (for example a 130-grain copper bullet instead of 150 grain lead bullet).

The smaller the caliber, the more pronounced this is. As volume and weight of a projectile (a cylinder) is related to the square of the caliber (diameter), maintaining a given ball weight will result in an increase in length, which are relatively larger for small calibers than for large ones (Figure D.1-5).

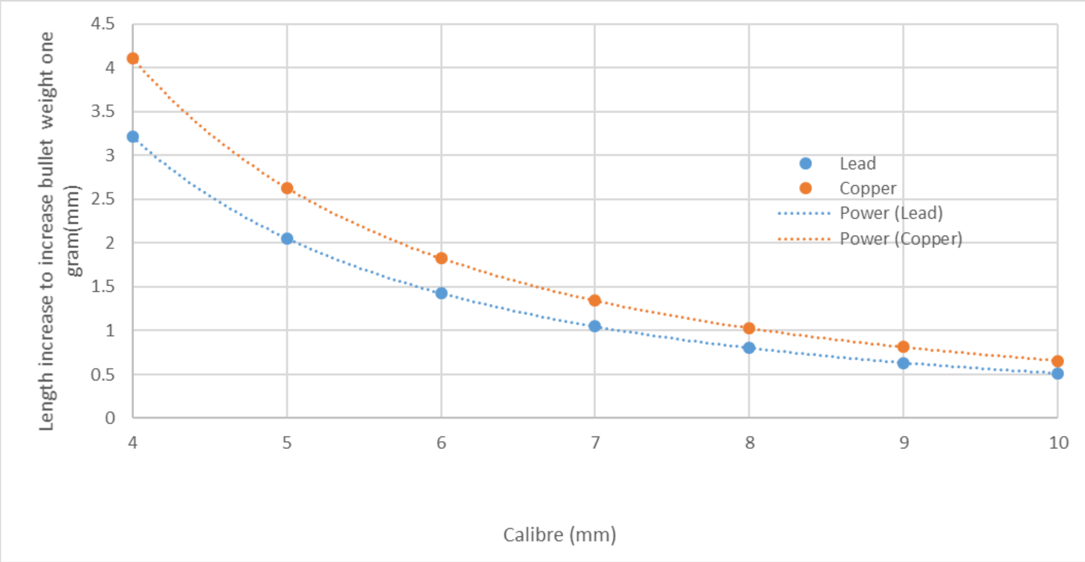


Figure D.1-5: The need to increase the length of the projectile to achieve a gram weight increase as a function of caliber for resp. lead and copper projectiles.

It is recommended to choose a lighter non-lead option to result in a similar length and performance to the lead bullets that the hunter is familiar with.

The overall result has been shown to be that lead-free projectiles in most calibers produced in a lighter version bullet weight and thus basically also energy compared to the equivalent lead projectiles.

This has been of limited importance for the larger calibers as these are already available with spherical weights and impact energy lying significantly above the legal requirements for rifle hunting in Denmark. But for some of the smaller calibers this implies that the shift from lead ammunition to unleaded ammunition, that the legal requirements for bullet weight and / or energy cannot be complied with.

Hunting legislations where the use of non-lead ammunition is allowed recognise this and permit non-lead bullets of lower weight

Kantrup (Kanstrup and Haugaard, 2020a) notes further that in combination with a limited supply the energy requirements of the Danish hunting legislation can all be met with lead free alternatives for the highest classes of game, for lower classes (class 3 and 4) the energy requirements are not met and availability of lead free ammunition is low.

Comments from the call for evidence (Gun Trade Association, BSSC) highlighted that the limited availability of non-lead rifle bullets poses potential risks to animal welfare. Currently gun shops tend to stock like-for-like copper bullets and so it is not possible to buy lighter/faster non-lead bullets.

The effectiveness and lethality of non-lead rifle bullets made of copper or gilding metal have been demonstrated by field shooting on UK species of deer (Knott et al. 2009) and on German species of deer and wild boar (Sus scrofa) by Spicher (2008). These results have been supported by the experimental shooting of euthanised sheep and wild white-tailed deer Odocoileus virginianus by Grund et al. (2010) at distances of 80-175 m.

Further evidence of the effectiveness of non-lead rifle bullets is provided by detailed, controlled, ballistic experiments of Trinogga et al. (2013) and Gremse et al. (2014). Both studies concluded that non-lead bullets were equally as effective as lead-core counterparts in expanding, creating destructive wound channels, and retaining their initial mass after penetration. It is possible that some tiny copper bullet fragments could be ingested by scavengers (e.g. golden eagles Aquila chrysaetos) and humans. However, Franson et al. (2013) reported that American kestrels Falco sparverius experimentally-dosed with copper pellets did not exhibit any signs of toxicity.' [extract from Thomas, 2015]

From the available studies, it appears that two main factors determine the technical feasibility of alternatives; bullets are compared usually in calibre size (i.e. does the bullet fit in the gun), and on hunting efficiency (will the bullet not cause unnecessary harm to the animal). The suitability of non-lead bullets in hunting is discussed by Kanstrup (Kanstrup et al., 2016), who found that non-lead and lead-core rifle bullets were equally effective in producing rapid, one shot, kills of red deer and roe deer in Europe and concludes that for hunting purposes there is no consistent and significant difference between lead containing and non-lead bullet for hunting roe and red deer under normal circumstances. These results are similar to other studies mentioned by Kanstrup (Spicher, 2008; Knutt et al., 2012; Gremse and Rieger, 2012). Further studies by Gremse (Gremse, 2014a) and (Gremse, 2014b) indicate that abandoning of lead as a bullet material for hunting bullets is possible.

A more recent study (Martin et al., 2017) is more definitive. It sets the length of the escape lead and lead compounds distance as an indicator for adequate bullet effectiveness for human killings of game animals in hunting. Based on 2 059 shooting records (Martin et al., 2017) concluded that there is no indication that non-lead ammunition results in longer escape distances of dear or wild boar. The length of the escape factor depends more on other factors such as shot placement, shooting distance, hunting method or the age of the animals. Caudell (Caudell et al., 2012) conclude that for most typical hunting equipment, the level of performance is good enough with standard alternative ammunition but there might be certain scenarios (outside of typical hunting) where higher performance non-lead bullets are desired. These scenarios include most notably professional wildlife management where the penetration and consecutive continued flight of the bullet after hitting the animal may pose additional risks (e.g. wildlife management at airports).

Although some doubts have also been raised ((Hoffmann, 2013) or and (Bahr, 2013) have for instance noted longer flight distances for shot animals. The more recent studies rebuke these findings by pointing put that the comparison made in the study of Hoffman and that from Bahr compared lead free and lead containing bullets in different calibres which rendered the test non-conclusive.

Although some doubts have also been raised (Hoffmann, 2013, Bahr, 2013) have for instance noted longer flight distances for shot animals. More recent studies rebuke these findings by pointing out that the test performed by Hoffmann was carried out by comparing lead and non-lead from different calibres.

From the available studies it appears that the suitability of centrefire ammunition from 5.6 mm and up (smallest calibre tested) is well established. This would imply that, based on the hunting legislation in e.g. Netherlands and Italy that set the minimum calibre at 5.6 mm centrefire that for hunting species of roe deer and heavier game species,

suitable alternatives exist.

For small game bullets, these bullets have only been recently introduced (they were restricted in California only as per mid-2019) and the Dossier Submitter has not found substantive testing of these calibres in literature. The most popular calibre in the small rimfire cartridges (.22LR) has been tested by both (Hampton et al., 2020) and by (McTee et al., 2017), the test were performed on the same brand an model (CCI .22 LR), there were McTee tested the bullet positively, Hamilton expressed doubts but also recognised the limitations of the test. Other products in the same calibres (RWS and Norma) have not been found by the Dossier Submitter, although one grey literature test found the Norma lead free .22LR performing [136] well. Other grey literature test in Denmark[137], showed that some combinations of .22LR and guns demonstrated high accuracy whereas other combinations did not.

An overview of the tests to which references are made in the text above describing the main outcomes as well as the calibres used is described in Table D.1-19: overview of tests of lead and non-lead bullets

[136] https://midwestoutdoors.com/greatoutdoors/norma-ammunition-22-long-rifle-performance-review/

[137] https://www.projektkort.dk/wp-content/uploads/2017/03/22lr-Ammo-Comparison-Test-within-AccurateShooter.com_.pdf

Summary of relevant field studies

Table D.1-19: overview of tests of lead and non-lead bullets

source	Year	Cartridges used	Game	conclusion
OBS praxis test	2014	Barnes TSX 5,4 g .270 Win. Kupfer Deformation BlaserCDC 9,4 g 7mm BlaserMag. Kupfer Deformation RWS Evolution Green8,8 g .300 Win. Mag..30-06.308 Win.Zinn Teilzerleger IBEX6,3 g 6.5x576.5x57 RKupfer Teilzerleger IBEX7,8 g .270 Win. Kupfer Teilzerleger Jaguar Classic 3,1 g 5,6x50R Kupfer Teilzerleger Jaguar Classic 4,7 g .243Win.6x62 FreresKupfer Teilzerleger NORMA Kalahari 7,8 g .270 Win Kupfer Teilzerleger NORMAKalahari 8,1 g 7mm Rem.Mag. Kupfer Teilzerleger	Roe deer, red deer, chamois, wild boar, mouflon, marmots	Non-lead bullets are available to hunt in an animal-welfare-friendly manner, to enable a possible search and to achieve high venison quality. There is no such thing as the perfect non-lead bullet! (as with leaded bullets). Rather, everyone has to find the right ammunition for their weapon and the respective game species. Deformation bullets with stable mass are preferred where possible, as they do not leave any splinters in the game
(Grund et al., 2010)	2009			

(Knott et al., 2009)	2009	Norma, 130 grain (n=34) Barnes Federal Vital Shok, 130 grain (n=59), Nosler BT, 95 grain (n=17); Norma, 130 grain (n=3) Barnes Federal TSX (n=32, Calibres: .270 /.243 . 308 . 270	red deer and roe deer Capreolus capreolus sika deer Cervus nippon	When all shots were combined across sites, the mean accuracy score was 1.04 for lead bullets and 1.04 for copper bullets, while the mean outcome score was 1.22 for lead bullets and 1.38 for copper bullets. However, when 'heart and lung' shots at the southern English site were excluded (as these are not the normal practice at the site), the mean outcome score across sites improved to 1.22 for copper bullets and 1.13 for lead bullets (Fig. 2). Mean accuracy was not affected by excluding these shots. The mean comparison score was 1.05, indicating a high degree of satisfaction with the copper bullets' performance compared to that of traditional lead bullets. Discussion: The results of this trial suggest that there is no difference in the accuracy of copper and lead bullets. Furthermore, it suggests that differences in killing power between the two are small, especially when normal practice is followed. Using newly available copper bullets designed to expand to a greater degree than the bullets used in our trial may further erode this difference. These conclusions should be treated as indicative rather than definitive. The number of stalkers involved was small and some desirable aspects of experimental design, such as blinding of the stalkers to the type of ammunition, were not practical.

(Caudell et al., 2012)	2012			
(Trinogga et al., 2013)	2013	**Barnes XLC or TSX** – **Non-lead deforming bul** Lapua Naturalis – Non-lead deforming bullet RWS Bionic Yellow – Non-lead partially fragmen bullet Moeller KJG – Non-lead partially fragmen bullet Reichenberg HDBoH – Non-lead partially fragmen bullet Norma Vulkan – Bullet with one or two leac core(s) RWS Evolution – Bullet with one or two leac core(s) RWS UNI classic – Bullet with one or two leac core(s)	34 carcasses — 15 wild boar (*Sus scrofa*), 13 roe deer (*Capreolus capreolus*), four chamois (*Rupicapra rupicapra*), one red deer (*Cervus elaphus*) and one fallow deer (*Cervus dama*	Bullet material did not exert a significant influence on wound dimensions under real life hunting conditions, this study clearly demonstrates the equality of non-lead bullets to conventional hunting bullets in terms of killing effectiveness. Non-lead hunting rifle bullets thus meet the welfare requirements of killing wildlife without superfluous pain as good as do conventional bullets. The present study evaluated real life hunting conditions, accepting that not all details of the actual shots can be known with certainty. Our results show that in those situations that hunters judge as appropriate for shooting, non-lead hunting rifle bullets function as well as conventional bullets

		Semi-jacketed	Bullet with one or two lead-core(s)	
(Hoffmann, 2013)	2013	Schützen mit 9,3x62 und Magnum-Patronen nutzen verstärkt bleifreie Munition, Jäger mit Waffen in den Kalibern 7x64 oder 7x65R eher Bleimunitio		
(Bahr, 2013)	2013			
(Hackländer et al., 2015)	2015			226 protocols on hunting events by professional hunters covering 55 variables on hunter, rifle, ammunition, shot conditions, hit point, behavior of game (roe deer, red deer, sika deer, fallow deer, chamois, mouflon, wild boar and marmot) and game meat evaluation. The protocols compile the use of 15 expandable bullet types in 14 calibers. Apart from three established lead bullet types, 12 non-lead bullet types were used. The statistical analysis with the help of regression trees revealed that the bullet material (lead vs. non-lead) did not affect killing efficacy, blood trails, or evaluation of game meat quality. Instead, other factors such as hit point, exit wound size, caliber etc. were important. These results are in line with various studies and underline the general option to switch from lead to non-lead rifle

				ammunition.
(Kanstrup et al., 2016)	2016	Accubond 7 WSM Barnes TSX 270 Barnes TSX 223 Barnes TSX 30-06 Barnes TSX 308 Barnes TTSX 308 Barnes TTSX 6,5x55 Barnes TXS 30-06 Barnes TXS 6,5x55 Barnes X 222 Barnes X 270 Barnes X-tsx 270 Hornady 222 Hornady 30-06 Hornady GMX 30-06 Kobber30-06 Lapua 222 Lapua Mega 30-06 Lapua Mega 308 Lapua Mega 6,5x55	657 hoofed animals, most red deer (Cervus elaphus) and roe deer (Capreolus capreolus)	The efficiency of copper versus lead bullets was tested using flight distance after being hit as the primary response parameter. For red deer, we were not able to show any statistical significant difference between performance of non-lead and lead bullet. For roe deer, we found a small, statistically significant, relation between flight distances and shooting distance for roe deer struck with non-lead bullets but not with lead bullets. However, this difference was not of such magnitude as to have any practical significance under hunting conditions. We conclude that in terms of lethality and animal welfare, non-lead ammunition within the tested range of bullet calibres can be recommended as an effective alternative to lead-core bullets.

Lapua Naturalis 30-06

Lapua Naturalis 308

Lapua Naturalis 6,5x55

Naturalis 30-06

Norma Oryx 6,5x55

Nosler 7 RM

Nosler Accubond 7 RM

Nosler Bal Tip 270

Nosler Partition 6,5x55

Nosler E-tip 6,5x55

RWS Evolution 7 RM

RWS Evolution Green 7 RM

RWS Kegles 30-06

Teilmantel spitz 223

Unknown 222

unknown 308

Vulcan 7 RM

(McCann et al., 2016)	2016	Rifl e caliberCategorical0.257, 0.277, 0.284, 0.308, and 0.338 Velocity rankCategoricalStandard or magnum judged ad hoc by belting and case capacityBullet typeCategoricalBarnes (TXS, TTSX), Hornady (GMX), and Nosler (ETIP	983 elk (*Cervus elaphus*)	Among 921 elk removals evaluated, mean shot distance was 182 meters, and the median and mode of distance travelled were 46 m and 0 m, respectively. Multivariate analyses revealed that shots to the head and neck were most effective, followed by those striking the shoulder and chest. Heavier bullets should be used whenever practical. Mean group size for non-lead ammunition fi red through NPS fi rearms was 50 mm at 91 m, with minimum and maximum group sizes of 18.8 and 98.6 mm, respectively. We found that non-lead ammunition provided the necessary precision for accurate shot placement in spot and stalk hunting conditions and that these bullets typically accomplished instantaneous or near-instantaneous incapacitation of elk whenever vital areas of the body were impacted. We conclude that non-lead bullets are effective for wildlife management and hunting scenarios.

(Martin et al., 2017)	2017	Hornady GMX non-lead; gilding metal; plastic tip Sako Hammerhead single lead core with tombac jacket; non-bonded RWS H-Mantel double lead cores with tombac jacket; copper tip; non-bonded RWS ID Classic double lead cores with nickel - plated steel jacket Hornady Interlock single lead core with tombac jacket; non-bonded Möller KJG non-lead; copper; plastic tip RWS KS single lead core with tombac jacket; non-bonded Lapua MEGA single lead core with tombac jacket; non-bonded Lapua Naturalis LR non-lead; copper; plastic tip Norma Oryx single lead core with tombac jacket; bonded Nosler Partition double lead cores with tombac jacket; non-bonded Wiinchester Silvertip single lead core with tombac jacket; aluminium tip; non bonded Brenneke TAG non-lead; copper;	1,254 roe deer (*Capreolus capreolus*) and 854 wild boar (*Sus scrofa*) from different regions within Germany	escape distances of roe deer and wild boar were compared in order to analyse whether lead or non-lead ammunition showed a significantly different killing efficiency. There was no difference based on bullet material between the percentage of the two wildlife species that had no or only a very short escape distance (<10 m). Moreover, neither was there any significant difference in the average length of the escape distance (10 m or more) between animals shot using lead ammunition and those shot with non-lead bullets. Our research does not suggest that non-lead ammunition leads to an unreliable killing effect

coated; aluminum tip

Brenneke TIG double lead cores with nickel - plated steel jacket

Brenneke TIG Nature non-lead; double tin cores with nickel - plated steel jacket

Generic TM single lead core with tombac jacket; non-bonded

Brenneke TOG single lead core with copper-nickel-plated tombac jacket; bonded

Barnes TSX non-lead; copper

Barnes TTSX non-lead; copper; plastic tip

Brenneke TUG double lead cores with nickel - plated steel jacket

Brenneke TUG Nature non-lead; double tin cores with nickel - plated steel jacket

Brenneke Uni Classic double lead cores with nickel - plated steel jacket

Norma Vulkan single lead core with tombac jacket; non-bonded

Sellier & Bellot XRG non-lead copper; aluminum tip

<table>
<tr>
<td>(McTee et al., 2017)</td>
<td>2017</td>
<td>.17 HMR (Hornady Magnum Rimfire), .22 LR (long rifle), and .223 Rem (Remington) rifles with expanding and nonexpanding lead and nonlead bullets
<table>
<tr><td>17 HMR</td><td>Lead</td><td>Expanding</td><td>Hornady</td><td>Hornady Vma</td></tr>
<tr><td></td><td>Lead</td><td>Nonexpanding</td><td>CCI</td><td>Full Metal Jacket</td></tr>
<tr><td></td><td>Copper</td><td>Expanding</td><td>CCI</td><td>CCI TNT Green</td></tr>
<tr><td>.22 LR</td><td>Lead</td><td>Expanding</td><td>Eley</td><td>Subson c</td></tr>
<tr><td></td><td>Lead</td><td>Nonexpanding</td><td>Federal Premium</td><td>Champ on</td></tr>
<tr><td></td><td>Lead</td><td>Nonexpandingb</td><td>Remington</td><td>Golden Bullet</td></tr>
<tr><td>.223 Rem</td><td>Lead</td><td>Expanding</td><td>American Eagle</td><td>Tipped Varmin</td></tr>
</table>
</td>
<td>Columbian ground squirrel</td>
<td>All types of lead bullets left lead in at least one-third of the Columbian ground squirrels. Unexpectedly, estimated concentrations of lead in carcasses did not differ between expanding and nonexpanding bullets within the .17 HMR and .22 LR calibers, partially because of the high variability in fragmentation. The greatest estimated concentrations of lead were in Columbian ground squirrels shot with expanding ammunition in .17 HMR and .223 Rem, which had an average of 23.6 mg and 91.2 mg Pb/carcass, respectively. Nonlead bullets incapacitated similar to lead bullets. Our results indicate that nonlead bullets eliminate the risk of additional lead exposure to scavengers while maintaining the lethality of lead bullets.</td>
</tr>
</table>

			Coppe r–tin	Expanding	Black Hills	Barnes Varmin Grenad e	
(Hampton et al., 2020)		lead-based expanding Winchester® Power-Point 40-grain (gr) hollow-point ammunition (Winchester Australia Ltd., Moolap, VIC, Australia), as per Hampton et al. (2016), and 2) lead-free CCI® Copper 21-gr hollow-point ammunition (CCI Ammunition, Lewiston, ID, USA; Fig. 1a). The lead-free bullets were of sintered copper construction, meaning they were made from compressed powdered metal (Caudell et al. 2012). The lead-free bullets were advertised by the manufacturer as being for small game (CCI Ammunition).				The only commercially available lead-free .22 LR ammunition available for shooting European rabbits in Australia at the time of our study produced lower precision, poorer animal welfare outcomes, poorer terminal ballistics, and were more expensive than commonly used lead-based ammunition We do not suggest that results of our study are indicative of all lead-free ammunition performance. The specific lead-free product we tested could be an anomaly. Our study had several limitations, including small sample size, shooting at a single species, using a single rifle, using a single type of lead-based and lead-free ammunition, and observing a single shooter. McTee et al. (2017) demonstrated that different lead-based .22 LR bullets have vastly different abilities to instantly incapacitate. Had we used a lead-based bullet with poor terminal ballistics, the conclusions of our study may have been different.

(Stokke et al., 2019)	2019			We found no appreciable difference in killing efficiency between copper and lead-based bullets in our study, which was based on data collected by hunters under normal hunting conditions in Fennoscandia. We evaluated the efficiency of copper versus lead-based ammunition in relation to a quantifiable animal welfare standard. We did not detect any significant difference between reported animal flight distances between copper and lead-based ammunition relative to our standardized predicted animal flight distances based on body mass. Copper ammunition exhibited a larger, more reliable and stable expansion compared to lead-based ammunition. This characteristic seems to offset the advantage lead-based ammunition has in terms of killing efficiency due to fragmentation effects

GUNLEX	2019	Hornady Superformance International (monolithic copper alloy bullet with plastic tip) Hornady Custom International (monolithic copper alloy bullet with uncovered expansion tip) Sellier&Bellot XRG (monolithic copper alloy bullet with aluminium tip) Sellier&Bellot TXRG (monolithic copper alloy bullet with plastic tip) Sako Racehead HPBT (lead core / full metal jacketed bullet) (control group)	Target shooting	According to testing shooter, these values of disperse are sufficient for hunting purposes and for short-to-medium distance sport shooting where precision is not critical (for example, disciplines like dynamic rifle or shooting metal silhouettes). It is insufficient for any precision-based shooting disciplines.
GUNLEX	2019	COPPER-22 ammunition with bullet weighing 1,05 g	Taregt shooting	According to testing shooter, this disperse is insufficient not only for target shooting, but (considering additional disperse caused by average shooter and firearm) even for recreational shooting or small game hunting.

Impact on guns

Every copper-jacketed bullet fired from a barrel leaves some copper residue (fouling) on the rifling of the barrel. It builds up with every bullet fired and, if not removed, may interfere with bullet placement accuracy and pressure. This applies also to non-lead bullets, and some shooters report greater copper fouling with these bullets than with similar lead-core bullets, thus requiring more frequent barrel cleaning.

Copper fouling is already recognized by different makers of non-lead bullets who have created shallow rings in the mid-posterior section of the bullet into which copper is displaced during its contact with the rifling. In this way, copper build-up is theoretically reduced. This is a feature of the non-lead bullets made by Barnes Bullets, Hornady, RWS, Cutting Edge Bullets, and others. The last-named company actually reduces the length of the bullet's region that engages the rifling, both to increase velocity and to reduce the amount of copper fouling in barrels. The nature of the material used to make the non-lead bullet may vary among companies. Thus, "pure copper", "annealed copper", "gilding metal", and "brass" are listed as choice materials to enhance ballistic performance. Annealing copper softens the metal made hard by shaping in die-made (swaged) bullets. Perhaps the greater extent of fouling (if real) can be attributed to the different metal types used. By way of comparison, the composition of non-lead bullets should be compared to the material used for jackets of lead-core bullets, for which metal fouling affecting accuracy does not appear to be a concern. In theory, the pure copper surface of non-lead bullets and that of copper-jacketed lead-core bullets should leave the same amount of fouling in a given barrel. The same consideration applies to bullets made from copper-zinc alloys (gilding metals).

Repeated firing with non-lead bullets during range practice can be expected to produce copper residue in the barrel bore, and it is customary to remove it after such practice. Under typical European hunting conditions in which a hunter uses a sighted-in rifle with a cleaned bore, many cartridges are not expected to be fired during a day's hunt, so the issue of extensive barrel fouling and reduced accuracy may not arise. This may be a simple issue of raising awareness and instructing hunters in proper gun maintenance. In the German field studies (Gremse and Rieger 2012), the average bag per person per year was between 3.2 and 11.2 animals. Regular gun care during the hunting seasons and a thorough cleaning twice a year have become the norm during these 6-year-field trials with over 1300 participants. These practices have shown themselves suited to ensure rifle accuracy.

The California impact assessment assumes that 10 % of the guns (or gun-owners) need to replace guns due to the gun's age, and their dependency on rare calibres for which it is likely that alternatives will not be developed. Discussions with industry[138] on this subject indeed suggest that there is little need to replace guns but that for some calibres, alternatives are not yet readily available (or never will be) and hunters may need to purchase new guns.

Guidance on the website of the German hunting association states that:

(translated from German:

Only with pure copper bullets does it have to be cleaned more frequently than before. After about 40 to 60 shots have been fired, barrel cleaning with chemical barrel cleaners

[138] Personal communication with Nammo Lapua Oy

(e.g. Robla Solo, Hoppes Benchrest or the ammonia-free Bore-Blitz or M-Pro 7) is recommended.

The biggest danger for the barrel, however, is the powder smoke that reacts with the air and can attack the barrel steel. It is therefore advisable to neutralize the powder smoke with an oil or CLP after every shooting or after strong temperature changes (condensation) and to wipe the barrel so dry that the point of impact is prevented by the so-called oil shot. In principle, every weapon should be thoroughly cleaned at the end of the hunting season.

The sighting should always be carried out on the shooting range in compliance with the minimum precision requirement (scatter circle at 100 m not larger than 4 cm to 5 cm). Especially after thorough chemical cleaning, it can take a few shots when moving until enough of the bullet material has spread in the barrel to ensure consistent precision and point of impact.

Ricochet

In 2008 reservations arose as to the allegedly unpredictable behaviour of ricocheting non-lead bullets. A study evaluated by Kneubuehl ((Kneubuehl, 2011) did not confirm these findings. On the same issue the lead ammunition group (Lead Ammuntion Group, 2015) concludes[139]:

In other circumstances of deflection as opposed to rebound, such as is more normal in the field, heightened risk is restricted to the vicinity of the strike as kinetic energy is lost on impact though perhaps to a greater extent with lead than steel. For all practical purposes, an unsafe shot with steel shot is an unsafe shot with lead. There is no evidence from shooting in countries, where steel shot has been in use for many years, of an increase of reported accidents. Bill Harriman, BASC's Director of Firearms, reviewed the risk in 2010 and his report "Ricochet characteristics of rifle bullets" concluded:

- Any bullet of any type or construction will ricochet if the circumstances are correct.
- Ricochets from high velocity rifle bullets are rare.
- Copper alloy rifle bullets do not appear to be any more likely to ricochet than conventional jacketed bullets.
- Ricochets are only likely to be dangerous in the immediate vicinity of the impact i.e. in a situation that would be an inherently unsafe shot.
- Ricochets are not an issue if a shot is taken with the target animal in front of a safe backstop.

Further studies have been published in Germany by the Federal Ministry for Food and Agriculture in a project on "Deflection of projectiles in hunting ammunition 2009 –2011". The project concluded that there are no significant differences evident in deflection characteristics between ammunition using bullets containing lead, and without it respectively (Heider 2014).

[139] http://www.leadammunitiongroup.org.uk/reports/(Lead Ammuntion Group, 2015)

Situations where replacement poses challenges

Further to that, ECHA received information in the call for evince on situations where the use of non-lead ammunition would pose further difficulties due to specific shooting or hunting conditions, these are summarised in table

Table D.1-20: comments from CfE on hunting situations where lead substitution would pose problems

Type of hunting	Calibres	what blocks
hunting game birds shotgun distances <35 metres rifle distance 40-300 metres	222Rem, 223 Rem, 243 Win, 6,5x55, 7,62x39, 308 win, 7,62x53R, 30-06	• the shooting range is often long (150-250 m) and the target small. • Full metal jacket bullets (copper shell + lead core) pass through the bird intact, no lead fragments in impact = no human health risk, no risk to scavengers or raptors, bullets can be recovered from the shooting range with bullet catchers and those do not lead to lead dust (the copper shell contains lead).
Practice shooting		• Shooting practice is carried out with cheaper full metal jacket bullets (could be hundreds of bullets/year) and just test accuracy of actual hunting bullets (expanding lead or copper) compared to training bullets. 50 cartridges of full metal jacket bullet cost less than 50€, 20 cartridges of Naturalis costs 60€. • Army and police buys their training bullets (FMJ) also from same market and same production lines affecting cartridge availability for military if civilians and voluntary national defence personnel cannot buy FMJ cartridges from home market or EU –market. 70-90 % of cartridges are used by civilians.
Game target competitions		
Racoon, mink and badger hunting in caves	22LR	There is also no alternative to a 22LR rifle because of the bullet design of the cartridge. 22LR is also used in Lapland for willow grouse short distances less than 50 meters. 22LR is used in pistols to kill raccoon dogs, minks and badgers in caves and it could dangerous to a hunter and a hunting dog to

		shoot copper bullet in small cave because of ricochet. Raccoon dog is included on EU list of Invasive Alien Species of Union Concern and is hunted in Finland only hunt them 170 000-200 000/year. It could also be very bad signal ban lead bullets in calibre LR22 if same time we struggle with damages raccoon dogs cause to our wildlife. There is no risk to scavengers or raptors if you don't leave animal killed with 22LR lead bullet behind. That could be instructed by Finnish Wildlife Agency or we can prepare special legislation inside hunting degree.
Seal hunting		• Seal hunting (grey seal and ringed seal) requires the use WMAX –bullets for safety reasons. Impact causes dramatic fragmentation of the core and jacket. It is very dangerous to shoot full metal jacket or full copper bullet in archipelago because if you miss bullet can travel several kilometres when it ricochets from water or wave. • The accuracy that is required is high, as good as shooting game birds (shooting range 100-200 metres, shoot seals to the head (very small target). If full copper bullet hits any other part of animal than head, you lose the animal as it dives. Exploding bullet is safer to humans because it explodes also in water impact and if it hits kill is instant. • Bullet to the seals head doesn't ruin the meat. Typical calibres for seal hunting are 243, 308, 30-06. Seal hunting is traditional hunting in Finland for meat, oil and fur but seals are hunted also because they cause damage to fisheries.

- Roe deer can be hunted with shot as well, e.g. in Sweden for roe-deer hunting shotguns are allowed only between 1 October and 31 January[140]

Alternatives and forest fires

In some of the comments (AFEMS) it was highlighted that that alternatives to lead could play rile n fatser ingnition of forest fire,ECHA examined the source of this claim (Finney et al., 2013) and found that In some of the comments (AFEMS) it was highlighted that that alternatives to lead could play rile n faster ignition of forest fire ,ECHA examined the source of this claim (Finney et al., 2013) and found that:

As with all fire behaviour and ignition research, moisture content of the organic material will be an important factor in ignition. Peat moisture contents of 3-5 %, air temperatures of 34-49 °C (98-120 °F), and relative humidity of 7 to 16 % were necessary to reliably observe ignitions in the experiments. Peat moisture contents above this (perhaps 8 %) did not produce ignitions. Field conditions matching the experimental range would imply summer-time temperatures, as well as solar heating of the ground surface and organic matter to produce a drier and warmer microclimate where bullet fragments are deposited.

Is highly unlikely that wen the European hunting season opens these conditions will be met regularly.

[140] https://jagareforbundet.se/jakt/hunting-in-sweden/permitted-firearms-and-ammunition/

Product availability of non-lead rifle ammunition

For all but the smallest calibre bullets (those used for varmint hunting and hunting smaller animals), non-lead ammunition is widely available. Currently available alternatives are either made completely of non-lead materials, such as copper; or designed such that a lead interior is "jacketed" by copper and theoretically protected from exposure upon impact. Other designs have been proposed and it is expected that the increase in demand will result in greater options of non-lead ammunition. Non-lead bullets generally have equivalent, if not superior, performance when compared to their lead counterparts. Copper bullets were originally designed for the "premium" market not because of concerns over lead poisoning but rather for their enhanced ballistic capabilities.

(Epps, 2014) stresses that it is important to recognize that equally effective non-lead options do *not* yet exist for all types of firearms used in hunting, including one of the most common cartridges used in the United States: the rimfire .22, used for small game hunting. While non-lead .22 ammunition using bullets made of tin is available, many shooters report that it does not function well (or at all) in some common types of .22 firearms, especially semi-automatic firearms that require pressure from heavier bullets to self-load. Other firearms for which non-lead options are very limited or unavailable include: 1) traditional muzzleloading firearms (designs dating to before circa 1865, loaded with loose black powder and a separate bullet rather than a self-contained cartridge), 2) firearms from the black powder cartridge era (designed before circa 1900) which are widely used in the highly popular "Cowboy Action" shooting competitions and by many hunters, especially in states where use is permitted in primitive weapons deer seasons, and 3) some modern hunting rifles chambered for less common cartridges.

The analysis of Thomas (Thomas, 2012) suggests that alternatives for the most popular cartridges are available on both the EU and US market. The 37 leading ammunition manufacturers produce a wide range of 35 non-lead bullet calibres that in theory cover a wide variety of hunting types. An analysis for the European market is made by Thomas (Thomas et al., 2016) in which the authors conclude that product availability (i.e. that which is made) of non-lead rifle ammunition in a wide range of calibres is large in Europe and is suited for all European hunting situations. At least 13 major European companies make non-lead bullets for traditional, rare, and novel rifle calibres. Local retail availability is now a function of consumer demand, which relates, directly, to legal requirements for use.

Thomas et al. (2016) found the efficacy of non-lead bullets equal to that of traditional lead-core bullets. Comments submitted in the call for evidence would suggest that there are in general good alternatives for hunting big game (roe deer*, white-tail deer, sika deer, wild boar, brown bear and moose, elk) at shooting distances 50-100 meters, with the use of calibres like 243 Win, 6,5x55, 7,62x39, 308 win, 7,62x53R, 30-06.

Information from FACE[141] would suggest that for certain calibres there is a problem securing non-lead ammunition for .22LR (a very popular round for pest control) and the .243 WIN (a popular multipurpose deer/fox). A non-lead .243 round that was heavy enough to be legal for large deer would have to be longer than current barrels are able to stabilise, so there would need to be a shift to larger calibres or many hunters would need new barrels. There are several other calibres below .6mm where alternatives are

[141] Personal communication from David Scallan, FACE.

poorly available including air rifles and pistols used for target shooting. Indeed, these calibres in lead containing form (or similar calibres) are scheduled to be phased out with a longer transition period under the Californian regulation regarding the use of lead ammunition for hunting (Duncan, 2014) . Since the introduction of the Californian regulation, alternatives in that same calibre have been developed (Winchester .22).

Both rifle bullets and .22 calibre rimfire bullets are currently marketed with non-lead alternatives. Non-lead ammunition in .22 rimfire was made available only after California required the use of "nontoxic" .22 ammunition in the range of California condors. Prior to that time, expert testimony was presented to the California Fish and Game Commission claiming that non-lead .22 caliber rimfire was impossible to produce. However, commercially available non-lead .22 caliber ammunition was available four months after the Commission decision to ban lead .22 ammunition (Miller, 2012).

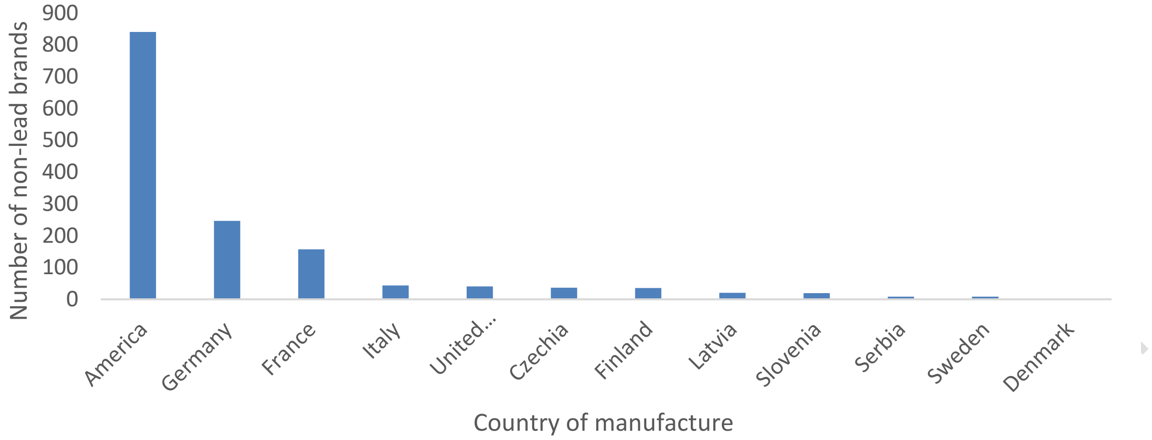
The .22 calibre rimfire cartridge is, by far, the most popular ammunition made and used in North America. It is used for everything from target shooting and competition to the control of nuisance wildlife and hunting. Tradition .22 cartridges have a pure lead bullet that fragments very easily, leaving behind many toxic shards. New, alloy and pure copper bullets, coated with a lubricating polymer, are now available. While the weight of the bullets is less than traditional lead projectiles, the new non-lead .22 cartridges produce extremely high velocity, increasing accuracy and efficacy on impact.

Thomas (Thomas et al., 2016) presents a list of lead free ammunition that is available in Europe wherein data is presented on lead free bullet availability from the principal 13 European rifle ammunition makers that have already developed their own brands. Thomas argues that is this is in response to the ongoing demand for and evaluation of non-lead rifle ammunition in Germany (Gremse and Rieger, 2014) , and possibly, for export into the growing North American market.

Thomas (Thomas et al., 2016) concludes that the major companies, Blaser, Brenneke, Fiocchi, Geco, Lapua, Norma, Rottweil, RWS, Sako, Sellier & Bellot, Sax, Sauvestre, Schnetz, and Hornady International, list calibres suitable for hunting every European game species and for every commonly used rifle and conclude from this that the product availability (i.e. that which is manufactured, as opposed to what is commonly available at the retail level) of non-lead rifle ammunition is not a limiting factor in Europe in the further growth in the use of non-lead bullets.

Comments submitted in the call for evince (from BASC) showed that out of 94 manufacturers, 58 produced at least one non-lead ammunition brand. In total almost 1,500 brands of non-lead ammunition were found, with roughly 60 % from America and the remaining from Europe, particularly France and Germany.

Figure D.1-6:The number of non-lead brands produced per country (Ellis, 2019)



Generally speaking, the more popular a calibre is, the greater the available choice of ammunition (Figure D.1-6). However there are important exceptions to this as shown by the orange box in Figure D.1-7 which represents those calibres where there is at least one gun for sale on Guntrader.uk, but there are fewer than 5 non-lead alternatives available (sometimes none).

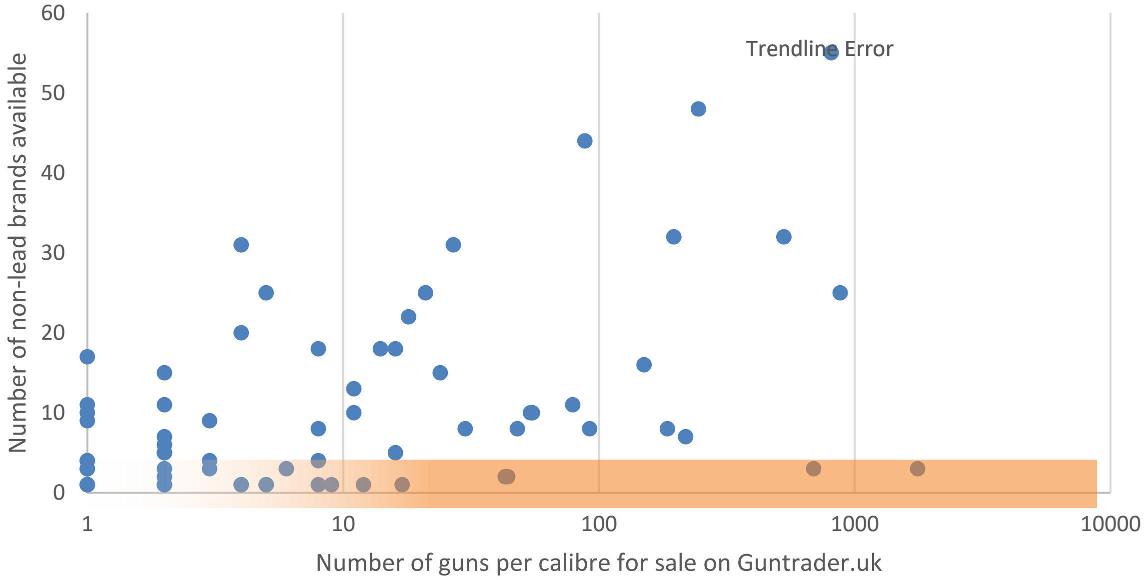


Figure D.1-7: The relationship between the number of guns for sale on Guntrader.uk and the number of non-lead ammunition brands for that calibre. The number of guns axis is log transformed to aid presentation. The orange box highlights those calibres were there are few non-lead alternatives available.

Amongst the top ten most commonly sold calibres there is generally a good selection of non-lead brands available (Table D.1-21). However, for the rimfire calibres there are only three options each, with limited availability also for .22-250Rem and 6.5x55SE.

Table D.1-21: The number of non-lead ammunition brands available for the ten most commonly advertised rifle calibres on Guntrader.uk

Calibre	Number of guns for sale on GunTrader	Number of non-lead brands available
.22 LR	1763	3
.243 Win	877	25
.308 Win	810	55
.17 HMR	690	3
.223 Rem	528	32
.30-06 Springfield	245	48
.22-250 Rem	218	7
.270 Win	196	32
6.5 x 55 SE	185	8
6.5 Creedmoor	150	16

The most commonly sold calibres with poor choices of non-lead ammunition are shown in Table D.1-22. These are the calibres that would be most affected by a phase-out of lead ammunition.

Table D.1-22: The ten most common calibres for sale on Guntrader.uk with five or fewer non-lead brands available

Calibre	Number of guns for sale on GunTrader	Number of non-lead brands available
.22 LR	1763	3
.17 HMR	690	3
.204 Ruger	44	2
.22 WMR	43	2
7.62 x 54 R	17	1
.260 Rem	16	5
.22 Hornet	12	1
6.5 x 47 Lapua	9	1
.17 Hornet	8	1
.45 Colt	8	4

ECHA carried out an independent investigation into the availability of non-lead alternatives for some of the common calibre types used in the European Union (Table D.1-23). Of all the examined calibres only two - .222 REM and 17 HMR – were found to have fewer than five non-lead alternative brands available, whereas the remaining calibres had non-lead alternatives available in excess of five, or sometimes even ten, different brands. Some of the non-lead brands were available for most of the calibre types. Of these KJG-SR (Sax Munitions GmbH), Evolution Green (RWS), ZERO (GECO), TUG Nature+ (Brenneke), Naturalis (Lapua), Ecostrike (Norma), HIT (RWS), and GMX (Hornady) were some of the most commonly encountered brands. Much akin to their lead-based counterparts, non-lead alternatives are available in a multitude of grains for hunters to choose from, depending on their specific hunting needs and preferences.

Table D.1-23: results of ECHA market Study: availability

Calibre	Available grains	Lead		Non-lead alternatives		Recommended for
		Manufacturer	**Brand**	**Manufacturer**	**Brand**	
9.3 x 62	155 (1) 184 (2) 196 (3) 220 (4) 225 (5) 232 (6) 250 (7) 255 (8) 258 (9) 285 (10) 286 (11) 291 (12) 293 (13)	RWS	Cineshot (3)	Sax Munitions GmbH	KJG-SR (1)	Large and medium sized game (e.g. wild boar, moose, red deer, bear)
		RWS	DK (5)	RWS	Evolution Green (2)	
		Geco	Softpoint (8)	GECO	ZERO (2)	
		RWS	Speed Tip Pro (9)	Brenneke	TUG nature + (4)	
		Remington	PSP (10)	Brenneke	TAG (5)	
		Lapua	Mega (10)	Norma	Ecostrike (6)	
		Winchester	Power Point (11)	Lapua	Naturalis (7;10)	
		Hornady	InterLock® SP-RP (11)	Hornady	GMX (7)	
		RWS	Evolution (12)	RWS	Hit (7)	
		RWS	UNI CLASSIC (13)	RWS	HIT Short Rifle (7)	
.30-06 Spr.	124 (1) 136 (2)	Winchester	Ballistic silvertip (7)	Sax	KJG-SR (1)	Light to Medium game (e.g.

	147 (3) 150 (4) 155 (5)	Winchester	Ballistic silvertip (9)	RWS	Evolution Green (2)	wild boar, wild goat, deer, moose).
	165 (6) 168 (7)	Hornady	Interlock SP (9)	Geco	Zero (2)	
	170 (8) 180 (9) 184 (10)	RWS	Uni Classic (10)	Brenneke	TUG nature + (3)	
	185 (11)	RWS	Evolution (10)	Hornady	GMX (4)	
		Lapua	Mega (11)	Norma	Ecostrike (4)	
		Brenneke	Basic (11)	Brenneke	TAG (5)	
		RWS	SPEED TIP PRO (6)	Hornady	GMX (6)	
				RWS	Hit (6)	
				RWS	HIT Short Rifle (6)	
				Lapua	Naturalis (8)	
				Barnes	TTSX Euroline (4;7;9)	
				Nosler	E-Tip (4;7;9)	
.308 Win.	124 (1) 136 (2)	RWS	Cineshot (3)	Sax	KJG-SR (1)	Medium to heavy game
	147 (3) 150 (4)	Remington	Core-Lokt PSP (4)	RWS	Evolution Green (2)	(e.g. antelope, deer,

	155 (5) 165 (6) 170 (7) 180 (8) 184 (9) 185 (10)	RWS	Speed Tip pro (6)	GECO	ZERO (2)	pronghorn, elk, moose and bear)
		Geco	Express (6)	Brenneke	TUG nature + (3)	
		Geco	Softpoint (7)	Norma	Ecostrike (4)	
		RWS	Uni Classic (8)	RWS	HIT Short Rifle (4)	
		RWS	HMK (8)	Brenneke	TAG (5)	
		RWS	Evolution (9)	RWS	Hit (6)	
		RWS	Speed Tip (9)	Lapua	Naturalis (7)	
		Winchester	Power Point Subsonic (10)	Barnes	TTSX Euroline (4)[142]	
		Lapua	Mega (10)	Hornady	GMX (4;6)	
		Brenneke	Basic (10)			
8x57	127 (1) 139 (2) 150 (3) 160 (4) 170 (5) 175 (6)	Federal	Power-shok (5)	SAX	KJG-SR (1)	Medium to large-sized game (e.g. moose, chamois, badger, red deer, wild boar, bear
		GECO	Softpoint (8)	RWS	Evolution Green (2)	
		RWS	Cineshot (9)	GECO	Zero (2)	

[142] Also available in 130 and 168 grains.

	180 (7) 185 (8) 187 (9) 195 (10) 198 (11) 201 (12)	RWS	JS HMK (9)	Brenneke	TUG nature + (3)	
		WINCHESTER	JRS (10)	Barnes	TTSX Euroline (4)	
		RWS	JS Classic (11)	RWS	HIT (4)	
		RWS	JS Evolution (12)	RWS	HIT Short Rifle (4)	
				Norma	Ecostrike (4)	
				Brenneke	TAG (6)	
				Hornady	GMX (7)	
				Lapua	Naturalis (7)	
7x64	104 (1) 127 (2) 128 (3) 139 (4) 140 (5) 145 (6) 150 (7) 159 (8) 160 (9) 162 (10) 165 (11) 178 (12)	RWS	Cineshot (4)	Sax	KJG-SR (1)	Medium to heavy game (Best for wild boar, red deer and similar)
		Brenneke	Teilmantel ™ (6)	Geco	Zero (2)	
		RWS	Speed Tip (7)	Brenneke	TUG nature + (3)	
		RWS	Speed Tip PRO (7)	Hornady	GMX (5)	
		RWS	Evolution (8)	Barnes	TTSX (5)	
		RWS	ID Classic (10;12)	RWS	Hit (5)	

		RWS	KS (10)	RWS	Evolution Green (9)	
		Geco	Softpoint (11)			
.300 Win.Mag	124 (1) 136 (2) 147 (3) 150 (4) 155 (5) 165 (6) 170 (7) 180 (8) 184 (9)	RWS	Cineshot (3)	Sax	KJG-SR (1;4)	Medium to heavy game (**Especially** recommended for: red deer, wild boar, moose, bear).
		RWS	SPEED TIP (4)	RWS	Evolution Green (2)	
		Federal	Power Shok (4)	GECO	ZERO (2)	
		RWS	KS (6)	Brenneke	TUG nature + (3)	
		Geco	Express (6)	Brenneke	TAG (5)	
		GECO	Teilmantel (7)	Hornady	GMX (6)	
		Geco	Plus (7)	RWS	Hit (6)	
		RWS	Uni Classic (8)	RWS	HIT Short Rifle (6)	
		Federal	Power Shok (8)			
		RWS	Evolution (9)			
.243 Win	58 (1) 75 (2) 76 (3) 77 (4) 80 (5)	Winchester	SUPER X SOFT POINT (5)	Hornady	Superformance® (1;2;5)	For small and varmint-sized game (Alternative for medium sized game,
		RWS	WIN TMS	Norma	Tipstrike Varmint (3)	

	90 (6) 95 (7) 96 (8) 100 (9) 105 (10)	Winchester	SUPREME BALLISTIC SILVERTIP (7)	Sax	KJG-HSR (4)	such as deer)
		Winchester	WSSM (9)	Barnes	Vor-TX (5)	
		Lapua	SoftPoint (9)	Nosler	E-Tip (6)	
		Federal	Power Shok (9)	Lapua	Naturalis (6)	
		Geco	Teilmantel (10)	Brenneke	Win TOG (8)	
				Norma	Tipstrike Oryx (9)	
6.5x55	92 (1) 93 (2) 106 (3) 120 (4) 123 (5) 130 (6) 140 (7) 156 (8)	RWS	Target Elite Plus (6)	SAX	KJG-SR (1)	Mostly recommended for deer-sized or smaller game.
		GECO	Softpoint (8)	RWS	EVOLUTION GREEN (2;3)	
		RWS	Evolution (8)	Lapua	Scenar (4;5;7)	
				Lapua	Naturalis (7)	
				Hornady	SST Superformance (7)	
				RWS	Doppelkern (7)	
17 HMR	239 (1)	Norma	V-Max (3)	Hornady	NTX (1)	

	247 (2) 262 (3) 309 (4)	Winchester	V-MAX (3)	CCI	TNT Green (2)	Varmint and small-game hunting.
		Federal	V-Shok TNT HP (3)			
		Winchester	JHP (4)			
		Hornady	XTP (4)			
		Hornady	V-Max (4)			
.222 REM	40 (1) 50 (2) 55 (3)	Norma	V-Max (1)	Lapua	Naturalis (2)	Small to medium game hunting such as roe deer, small antelopes, fox, and birds.
		Sako	Gamehead (2;3)	Sako	Powerhead II (2)	
		Sako	Range FMJ (2)			
		Sako	Speedhead			
		Hornady	V-Max (2)			
		Lapua	FMJ (3)			
		Norma	Jackmatch (3)			

Economic feasibility of non-lead rifle ammunition

A comparison of prices for lead-core and non-lead rifle ammunition was presented in(Thomas, 2013)). That study compared the retail prices of nine commonly used calibres (from .223 to .416) of assembled rifle ammunition in different weights, types, and brands available across the USA. It found that prices for the two types of ammunition were generally comparable, and where the non-lead products cost more, the relatively small increase was not enough to deny purchase and use. The same result applies to bulk lead and non- lead compounds, 57 purchase of bullets for ammunition hand-loaders: lead-core and non-lead bullets cost about the same at the retail level. An economy of scale effect is likely to lower the price of non-lead ammunition further, as

more hunters adopt this ammunition. A regulated use of non-lead rifle ammunition in hunting would increase an economy of scale effect across the most widely used bullet calibres. Kanstrup (Kanstrup et al., 2016) concluded that non-lead rifle ammunition is largely available in all normal calibres (particularly 6.5×55, 308 Win. and 30–06) in Danish hunting stores at prices comparable to equivalent lead products. The lowest range of availability was found in the small calibres (<6 mm). In Germany,(Gremse and Rieger, 2014)) found non-lead rifle ammunition in adequate supply across the range of hunting calibres typically used, with ammunition for small calibres (≤6 mm) being offered mostly by specialty manufacturers. Pricing comparisons in Germany mirror the conclusions of (Thomas, 2013)

Figure D.1-8 shows that as the number of non-lead brands for each calibre increases, the price drops rapidly. This is especially true where there are fewer than 5 brands for a given calibre. Once there are more than 5 brands available the price falls more slowly and stabilises at around £2.50 per cartridge.

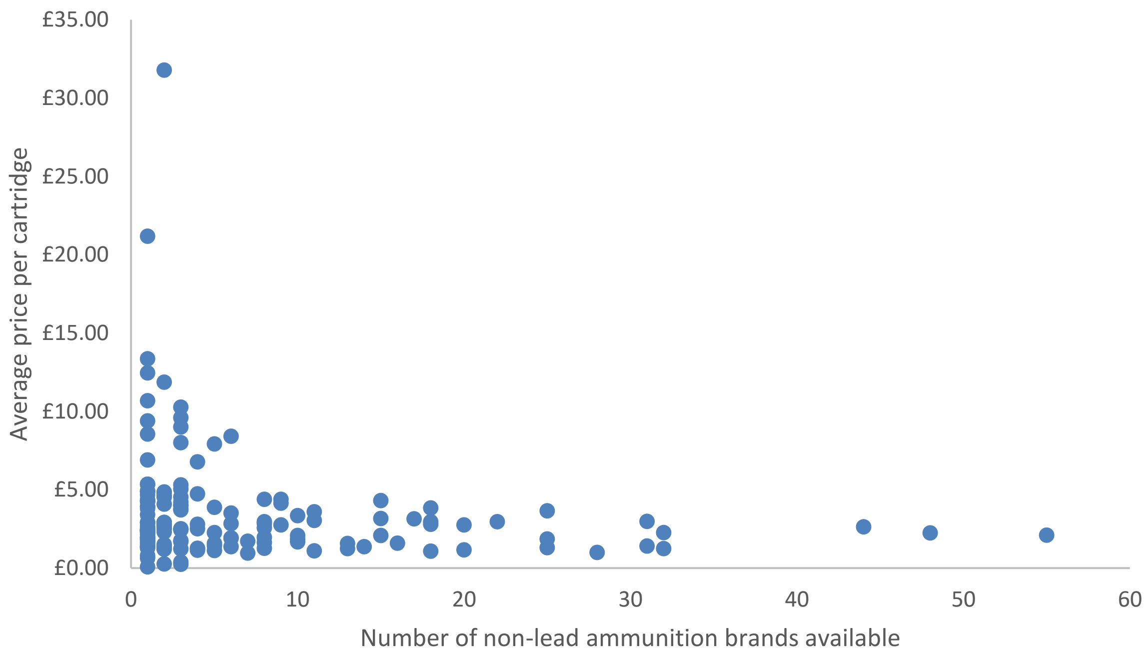


Figure D.1-8: The impact of availability of non-lead ammunition per calibre on average prices (Ellis, 2019)

An average cost of £2.50 per cartridge seems high for relatively common calibres such as .308 Win. However, this is an average that includes speciality ammunition, as well as normal hunting ammunition. Figure D.1-9 shows that the average cost per cartridge for lead and non-lead cartridges is broadly similar for the ten most commonly sold rifle calibres.

Figure D.1-9: The average cost (and range) for the ten most commonly sold calibres on Guntrader. The cheapest option for each calibre is given in bold (Ellis, 2019)

Calibre	Lead price per cartridge	Non-Lead price per cartridge
	Average	Average
.17 HMR	0.59 €	0.43 €
.22-250 Rem	2.43 €	1.93 €
.223 Rem	1.53 €	1.40 €
.22LR	0.22 €	0.26 €
.243 Win	2.67 €	2.08 €
.270 Win	2.99 €	2.54 €
.30-06 Spring	3.02 €	2.53 €
.308 Win	2.90 €	2.37 €
6.5mm Creedmoor	2.60 €	1.79 €
6.5x55SE	2.73 €	3.21 €

ECHA undertook a market analysis of its own to validate some of the comments submitted in the call for evidence as well as to validate arguments brought forward to support and or object to substitution. The independent market analysis centred on assessing the market availability and pricing of non-lead alternatives for some of the most popular calibre sizes in the European Union. To this end, ECHA surveyed more than 120 online retail stores located in the EU. In the course of performing online searches, ECHA collected information on prices for both lead-based ammunition and non-lead alternatives. Table D.1-24: results of ECHA market studydisplays minimum, average and maximum prices for lead-based ammunition and non-lead alternatives. The non-lead alternatives are further broken down in the following five categories on the basis of the material relied upon in the manufacture of the bullet:

- Copper
- Copper and zinc (brass)
- Copper with steel casing
- Copper and nickel alloy

- Tin

Furthermore, for each calibre size the total number of surveyed online stores and countries is indicated. On the whole, the greater the popularity of the calibre size, the higher the number of online stores and countries in which these ammunitions are sold. For instance, two of the most popular centrefire rifle calibres used for hunting big game- .308 WIN and .300 WIN MAG – were encountered in 70 and 75 online stores respectively, each representing 20 countries.

Table D.1-24: results of ECHA market study: price difference between lead and non-lead

Calibre	Online stores		Countries	Price for lead €			Price for non-lead																	
							Non-lead (all) €			Copper €			Copper and zinc (Brass) €			Copper with steel casing €			Copper and nickel alloy €			Tin €		
				MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX	MIN	AVG	MAX
9.3 x 62	40		19	38	73	114	50	92	129	50	90	126	68	94	122	88	100	105	-	-	-	72	92	129
.30-06 Spr.	47		17	30	60	80	30	65	89	50	67	88	54	62	65	30	52	75	60	74	89	39	65	82
.308 Win.	70		20	30	57	80	40	72	133	52	74	133	54	62	69	70	74	81	-	-	-	40	66	83
8x57	58		17	30	64	103	51	78	102	58	76	102	66	75	88	70	85	101	70	81	89	51	70	85
7x64	56		17	32	63	101	32	71	100	58	79	100	52	65	84	-	-	-	-	-	-	32	70	93

.300 Win. Mag	75		20	27	74	121	57	86	111	77	96	111	58	68	89	81	93	102	-	-	-	57	86	111
.243 Win	28		16	26	47	63	30	57	80	42	55	80	55	58	61	-	-	-	-	-	-	30	54	79
6.5x 55	18		10	28	51	75	60	86	109	60	77	86	-	-	-	-	-	-	-	-	-	86	95	109
17 HMR	10		3	19	27	35	21	86	35	21	27	35	-	-	-	-	-	-	-	-	-	-	-	-
.222 REM	4		2	16	33	45	42	50	59	42	50	59	-	-	-	-	-	-	-	-	-	-	-	-

For all the calibre sizes, with the unique exception of 17 HMR, average price of the non-lead alternatives lumped together was found to be higher compared with their lead-based counterparts (Table D.1-24: results of ECHA market study: price difference between lead and non-lead). In few instances, namely for .222 REM and 6.5x55, the average price of non-lead alternatives was more than 50 % higher in comparison with the corresponding lead-based ammunition. In most cases, the average price difference was less than 25 %, and in some it went down as low as 7 % (e.g. .30-06 Spr.). However, lumping all the non-lead alternatives together, without accounting for the specific material used, provides a potentially skewed and misleading view of the magnitude and nature of the price differences. Given the versatility of the materials used in the manufacture of rifle cartridges and the great variance in the material costs, it is reasonable to suggest that 'non-lead alternatives' should be differentiated on the basis of the specific material used. Furthermore, it has been observed that the more popular the calibre is, the more brands are usually available in non-lead versions, which in turn drives down the prices. For this very reason, the price differences between lead-based cartridges and non-lead alternatives for popular calibre sizes is significantly less accentuated than between those for less popular calibres (e.g. 6.5x55).

Table D.1-25 illustrates price differences between lead-based ammunition and non-lead alternatives, whilst also providing a breakdown of the latter in terms of material used, which provides a more nuanced view of the price-level differences. For instance, for .30-06 Spr., the average price of all the non-lead alternatives lumped together irrespective of the material differences was 7 % higher than that of the lead-based version. However, the material-specific focus enables us to better unravel the pricing intricacies. The average price of non-lead alternative to .30-06 Spr., based purely on brass would be only 3 % higher than the price of the same calibre bullet based on lead, whereas the average price of an alternative containing copper with steel casing would cost 13 % less. Similarly, for another popular calibre size - .300 Win.Mag – the average price of all the analysed non-lead alternatives was about 16 % higher than that of the lead-based versions, however, the material-specific focus provides a more detailed and informative picture, namely that a brass-based alternative would cost on average 8 % less than the lead-based ammunition of the same calibre. Therefore, it is important that the price differences are viewed in the context of the material-specific breakdown.

Table D.1-25: price differences with break down on material uses

Calibre	AVG price of lead ammo per 1 case (€)	% difference with lead					
		Non-lead ammo	Copper	Brass	Copper with steel casing	Copper and nickel alloy	Tin
9.3 x 62	73	26 %	23 %	29 %	37 %	-	26 %
.30-06 Spr.	60	7 %	12 %	3 %	-13 %	23 %	8 %
.308 Win.	57	21 %	30 %	9 %	30 %	-	16 %
8x57	64	21 %	19 %	17 %	33 %	27 %	9 %
7x64	63	13 %	25 %	3 %	-	-	11 %
.300 Win.Mag	74	16 %	30 %	-8 %	26 %	-	16 %
.243 Win	47	18 %	17 %	23 %	-	-	15 %
6.5x55	51	69 %	51 %	-	-	-	86 %
17 HMR	27	0 %	0 %	-	-	-	-

.222 REM	33	52 %	52 %	-	-	-	-

Other factors that may influence substitution

Besides prices and product availability, other factors could influence substitution from lead in bullets. These are described in this section.

Adaptation of hunting laws

All tough not extensively analysed throughout this dossier, hunting laws in several EU Member States define minimum weight and momentum bullets must have in order to achieve efficient and humane taking of game.

Transition away from lead to non-lead bullets would imply to allow lighter bullets to be used. The need for these changes is recognized in publication like (Kanstrup and Haugaard, 2020b) data strongly suggest, that for the tested types of ammunition in caliber 6,5x55 SE the use of bullet mass and minimum impact energy values as currently specified under § 14 NFS 2002:18 are excluding from use in hunting for all game (Klass 1) readily available bullets and ammunition, that in standardized, repeatable, terminal ballistic testing show the closely similar terminal ballistic performance to those deemed fit by this legislation for the same use.

In view of the results presented (Table D.1-19) for the German studies this strongly suggests equal field performance for the known quantity leaded constructions and the tested lead free alternatives. A change in legislation reflecting the state of knowledge in science that bases projectile and ammunition selection on measured terminal ballistic performance should generally be considered. This approach would likewise aid decision-making processes in regard of reducing lead introduction in game meat.

Recently the Finnish government hunting laws have been adapted in order to accommodate better the use of non-lead ammunition[143] [144]:

The is likely to be a factor of influence in setting the transition period.

D.1.2.3. Lead in other hunting ammunition

Air rifles

Lead is used as the pellet material due to its combination of properties (density, plasticity, low melting temperature) meaning that it grips the rifling and deforms into the barrel dimensions and has enough weight for continued momentum. There is no other material that has the same range of properties plasticity and low melting temperature. Non-lead pellets are commercially available in low quantities and are generally made of tin-zinc alloys. The market share is extremely small as the ballistic performance is not sufficient for target shooting.

[143] https://www.finlex.fi/en/laki/kaannokset/1993/en19930666_20140412.pdf

[144] https://valtioneuvosto.fi/paatokset/paatos?decisionId=0900908f806821d5

https://riista.fi/mmm-lyijyttomiin-luoteihin-siirtymista-helpotetaan/

Common pellet calibres: .177, .22, .25

As one of the most accurate calibres from long distances, the .177 calibre pellet is by far the most popular on the market today. As the smallest pellet of the available calibres, the .177 can be fired at the highest velocities means greater accuracy from longer distances. The .22 calibre pellet is larger in weight and size compared to .177 calibre pellets. .25 calibre is the largest of the common calibres.

When used for hunting, lead pellets are used for pest control. As vermin are not considered "game", there is no risk to humans from ingesting lead fragments in game meat

Lead-free airgun pellets are usually made from zinc alloy. Though harder than lead, this material is still malleable and shouldn't cause any harm to the barrel of your air rifle.

Unlike for hunting bullets, there are no known studies or peer reviewed comparative test comparing the performance of lead and non- lead (often tin) based air rifle pellets

Product reviews on hunting for a, online purchasing fora would suggest that the accuracy of air rifles for hobby shooting (which would cover a fair share of their use) is adequate. However these tests and or reviews are not conclusive enough to come to a firm decision on product suitability.

Muzzle loaders

In the call for evidence comments were submitted from

- MLAIC - Muzzle Loaders Associations International Federation
- Historical Breechloading Smallarms Association
- The British Shooting Sports Council
- Association of Manufacturers of Hunting and Sport Weapons and Ammunition (JSM)
- British Association for Shooting and Conservation
- Deutscher Schützenbund e.V.
- Classic Old Western Society of Finland ry
- ANPAM - Associazione Nazionale di Produttori di Armi e Munizioni civili e sportive
- Svenska Pistolskytteförbundet
- The Gun Trade Association
- The Finnish Shooting Sport Federation
- Federation of European Societies of Arms Collectors (FESAC).

Many of these firearms are muzzle loading, or early breech loading, which can only be loaded with pure lead balls or bullets. The principle, dating to the 1840s, depends on the bullet expanding in the barrel, to engage the rifling. Only pure lead can achieve this. Many of the later rifles have a rifling twist that is designed for lead-filled, jacketed bullets, of a certain density range. They will not be accurate when firing bullets under this density range. There are consequently no practical alternatives to pure lead, or jacketed lead, for use in these vintage firearms

These types of guns can only support lead, as there was no other type of ammunition available when they were designed. Many muzzle loading and black powder rifles depend

on the expansion of soft lead ammunition during shooting for accuracy. More abrasive metals would cause excessive wear to the barrels and a dangerous loss of accuracy, which could result in bullets flying wide of the bullet catcher.

The abrasive nature of steel shot quickly destroys the barrels of these modern guns, so they are designed for easy barrel replacement, which eliminates the cost of replacing the entire shotgun. This is obviously not the case with antique and vintage shotguns, which have a far higher value than some modern shotguns, due to their rarity. Their continued existence is due to the care with which they are looked after by their owners, who wish to preserve them for future generations, as they are part of our national heritage. This care includes the use of suitable ammunition, which is traditionally lead.

Due to the expense of black powder shotgun cartridges, few people hunt with them, using them mostly for specific, historic clay target competitions.

D.1.3. Approach to impact assessment

D.1.3.1. Capital vs operational cost

Cost analysis

Substitution costs

The substitution cost induced by the current restriction proposal is comprised of a stock cost (for testing existing guns and prematurely replacing non-standard proofed shotguns) and a flow cost (related to the incremental cost from switching over to non-lead gunshot). In order to make these two cost components commensurable one needs to i) bring forward the replacement of non-standard proofed guns, and ii) convert the stock cost into a constant annuity, which can then be compared to the incremental cost from using steel and bismuth shot. Both steps are explained below (following Sydsæter et al., 2005), the actual results of the substitution cost assessment are reported in Section 5.5 of the main report.

Forwarding the replacement of shotguns

As explained in the main report, the central case scenario and the worst case scenario both presume that a certain number of non-standard proofed shotguns would need to be prematurely be replaced. Under the worst-case scenario it is assumed that these guns would not have been replaced over the 50 years following the entering into force of the restriction; under the central case scenario it is assumed that 95 % of the shotguns that would need to be prematurely replaced, would have been replaced (in equal annual proportions) over the 20 years following the entering into force of the restriction, whereas 5 % would not have replaced over the 50 years following the entering into force of the restriction.

It is useful to introduce the following notation for modelling the forwarding of the investment into new shotguns. Let:

- N denote the total number of non-standard proofed shotguns to be replaced;
- $n = N/(T - \delta)$ be the constant annual fraction of shotguns to be replaced over the relevant period T (taking into account a transitional period to comply of δ years);
- P be the average retail price of a new shotgun; and
- r denote the social discount rate.

Then, the present cost (PC) of forwarding the purchase of those shotguns that would not

have been replaced otherwise can be modelled as:

$PC(not\ replaced\ otherwise) = N * P * (e^{-r\delta} - e^{-rT})$,

whilst the PC of forwarding the purchase of those shotguns that would have been replaced (in equal annual proportions, i.e. entailing a constant stream of replacement cost) over the next 20 years can be modelled as:

$PC(replaced\ otherwise) = \int_{\delta}^{T} n * P * e^{-rt} dt = n * P * (\, e^{-r\delta} - e^{-rT})/r$.

In the calculations presented in Table 5.5 of the main report a transitional period of $\delta = 3$ years and a social discount rate of 4 % (in accordance with the SEA guidance on restrictions) are assumed.

Annuitisation of the stock cost

The obtained PC of replacing the stock of non-standard proofed shotguns needs to be converted into a constant annuity to make it commensurable with the annual flow cost (i.e. the incremental cost of using alternative shot ammunition). This can be achieved by annuitising the PC estimates as derived in E.5.1.1 using the standard formula:

$PC = A\frac{1-(1+r)^{-T}}{r} \leftrightarrow A = PC\frac{r}{1-(1+r)^{-T}}$.

This results in a constant annuity A, which, when paid each year over the next T years and assuming a constant social discount rate r, corresponds to the PC.

Private vs social cost of the restriction

There is obviously a difference between the private cost of the restriction to be borne by the individual hunter and the social cost of the restriction. The private cost as calculated in Section 5.5 of the main report contains the VAT, which is a simple transfer from hunters to governments and should therefore be disregarded when calculating the social cost. One may turn to a stylised micro-economic model to think about the welfare impacts of the restriction.

It is important to think about the net impact in terms of the elements that it would entail. The restriction is made to address an externality, namely the lead poisoning of waterbirds, the internalisation of which is denoted by ΔE; it will impose a consumer surplus loss ΔCS as hunters will have to pay more for each cartridge they consume; it will entail a producer surplus change ΔPS (possibly a gain), as producers will sell steel and other non-lead cartridges instead of lead cartridges on which they may earn more (at least that is what the evidence reported in Annex B.3 suggests). The total welfare impact is simply the sum over the three elements: $\Delta W = \Delta E + \Delta PS + \Delta CS$; notably, these elements will have different signs.

As a convention, the social cost will be defined as $\Delta PS + \Delta CS$, while the social benefit equals the externality addressed by the regulation. To better understand the social cost, consider a simple world with one buyer (i.e. the hunters) and one seller (i.e. the gun industry) and abstract form any taxes. Let the indirect utility function of the buyer before (denoted by v_0) and after (denoted by v_1) the regulation be given by:

$v_0 = y - p_L q$ and $v_1 = y - p_S q$,

where y denotes disposable income; p_L and p_S are the per unit prices (excl. VAT) of lead and steel shot, respectively; q is the number of cartridges consumed per year (assumed to be unaffected by the restriction for the quantification of impacts on hunters). The impact of the regulation on the buyer can thus be summarised as:

$\Delta v = v_1 - v_0 = -q(p_S - p_L) = -q\Delta p$,

i.e. the buyer suffers a consumer surplus loss that equals the aggregated price differential he is facing due to the restriction.

Next, consider the seller's profit function before (denoted by Π_0) and after (denoted by Π_1) the regulation enters into force:

$\Pi_0 = p_L q - c_L q - f_L$ and $\Pi_1 = p_S q - c_S q - f_S$,

where c_L and c_S are the per unit production costs for lead and steel shot, respectively; f_L and f_S are costs unrelated to the production (incl. shipping, stocking, selling, etc.). The impact of the regulation on the seller can be summarised as:

$\Delta\Pi = \Pi_1 - \Pi_0 = (p_S q - c_S q - f_S) - (p_L q - c_L q - f_L) = q(\pi_S - \pi_L) - \Delta f = q\Delta\pi - \Delta f$,

where $\pi_S = p_S - c_S$ and $\pi_L = p_L - c_L$ are the per unit profits made from selling steel and lead shot, respectively. The sign of the producer surplus change $\Delta\Pi$ depends on both the change in the per unit profit $\Delta\pi$ and the change in other costs Δf.

One may now conclude on the net social cost of the restriction in this model economy:

$\Delta CS + \Delta PS = \Delta v + \Delta\Pi = -q(\Delta p - \Delta\pi) - \Delta f = -q\Delta c - \Delta f$,

which just equals the extra resource cost (in terms of material, energy, and labour) implied by the restriction.

D.1.3.2. Main assumptions used in cost calculations

Gunshot

The main driver for required changes in order to comply with regulations on the use of lead shot outside of wetlands, is the legislation that is already in place.

The main legislations in place concern the legislation in Member States with full bans and the legislation concerning the use of lead in wetlands.

Best - low impact

Under this scenario it is assumed that with the Ramsar definition and the wording of the restriction in its current form, many hunters in countries with more than 20 % of the area covered in wetlands will already adapt to this restriction and start using steel shot. This would imply that in countries like Finland, Ireland, Lithuania, Latvia, Estonia, Sweden, due to the abundance of wetlands in these countries as well as the inclusion of a 100 meter buffer zone, hunters will opt to use steel more frequently than in other countries.

In Member states that before the wetlands restriction already had a wide area ban, hunters are not expected to be significantly impacted by the wetland's restriction.

This would in the following member states; France, Cyprus, Greece.

In sum it is assumed that about 40 % of all hunters are already impacted by the wetland or by existing legislation covering the use of lead in terrestrial areas. 60 % of hunters are impacted by this restriction. This scenario is expected to be realistic but would depend on hunters reacting precautious to the wetland restriction.

Middle - middle impact

The middle scenarios assumed that the wideness of the wetlands restriction will impact most hunters and a significant number of terrestrial hunters are already impacted by the

wetland restriction. However, the additional impacts expected for member states with more than 20 % of their territory covered by wetlands would not occur, it is assumed that here are still areas where hunters would be able to use lead.

In Member States that before the wetlands restriction already had a wide area ban, hunters are not expected to be significantly impacted by the wetland's restriction.

This would in the following member states; Sweden, France, Cyprus, Greece.

In sum, this scenario assumed that 35 % of all hunters are already impacted by the wetland's restriction or existing legislation and that 65 % of the hunters will be impacted by this restriction. This scenario is expected to be the most realistic

Worst – high impact

The worst scenario assumes that the impact of the wetland restriction are low not many hunters would be impacted by the impacted by a restriction on the use of lead shot in wetland and consequently many hunters would still be impacted by a restriction of using lead in hunting in terrestrial areas. The percentage of hunters that would yet be covered by the wetland scenario is thought to be arodun30 % with 70 % of the hunters outside of wetland not being impacted by the wetlands restriction just yet. This scenario is expected to less realistic

In Member States that before the wetlands restriction already had a wide area ban, hunters are not expected to be significantly impacted by the wetland's restriction.

This would in the following member states; Sweden, France, Cyprus, Greece.

Shot

Table D.1-26: Main assumptions used in impact assessment of shot

Scenario	Best case	Central	Worst case
one-off costs			
Number of hunters impacted by proposal Total hunters = 5 862 770	Number of hunters impacted by wetland restriction Assuming that practically a full ban will be in place in countries with more then 20 % of wetland surface (SE, LV, EE, LI, IE, SI and FI) Minor impact expected in Member states with a wide restriction on 2 2 76 990	Number of hunters impacted by wetland restriction Countries wide ban on wetlands hunting prior to EU wide restriction, broad definition of wetland will lead to most water bird hunting impacted (10 %) as well as 53 % of all terrestrial shooting 1 593 134	Number of hunters impacted by wetland restriction Smallest possible implementation of wetland ban, number wetland hunters impacted 905 235
	3 585 780 (61.2 % of all hunters)	4 269 636 (72.8 % of all hunters)	4 957 535 (84.6 % of all hunters)
Average purchase price of a new shotgun[i]	€750	€1 000	€1 500
Counterfactual replacement of existing shotguns that are not standard proofed.	No need to replace shot guns	95 % of shotguns to be replaced over the next 20 years[j]; 5 % of shotguns not to be replaced within the next 50 years.	No shotguns would be replaced within the next 50 years
Percent of gun owners that re-proof	0 %	5 %	5 %

Cost of proofing test per barrel	€70		
Shotguns prematurely replaced[k]	0 %	5 %	10 %
Amortisation period (years)[h]	10 years	20 years	50 years
Operational costs			
Number of lead cartridges consumed in EU-27 g	663 million		
Retail price of lead shot	€0.45 per cartridge	€0.45 per cartridge	€0.465per cartridge
Retail price of alternative shot	(100 % of the price for a lead shot); Bismuth/Tungsten: not relevant €0.45	(102 % of the price for a lead shot); Bismuth/Tungsten: €2 per cartridge (400 % of the price for a lead shot) € 0. 46	Steel: €0.61 per cartridge (104 % of the price for a lead shot); Bismuth/Tungsten: €3 per cartridge (430 % of the price for a lead shot) € 0.47
Percentage steel	100 %	85 %	85 %
Percentage Bismuth/Tungsten	0 %	15 %	15 %
Emission reduction (t)	Hunters affected/total hunters * 21 216 tonnes (which is equal to number of cartridges * 0.032 kg of lead per cartridge)		

Notes: a – based on Amec (2013); b - Hirschfeld and Heyd (2005); c - Based on market assumptions for steel cartridgesf – Source, BASC/Niels Kanstrup; g – based on Amec (2013); h – to be

consistent with assumptions on the 'lifetime' of shotgun used in the scenario; i – Sweden also excluded as they have a ban on the use of lead gunshot for hunting birds; j - Source: Waarde van de jacht, tijd en geld besteed door jagers aan maatschappelijke diensten, CLM Onderzoek en Advies 2014; k – 25 % based on personal communication from stakeholders (BASC & John Swift), 10 % based on the fact that the average hunter own 2.6 shotguns (25/2.6 is 10 (rounded) (Amec, 2013) l source: Amec 2013

Bullets

Table D.1-27: Main assumptions used in impact assessment for bullets

Scenario	Best case	Central	Worst case
one-off costs			
Share of hunting performed with lead free bullets	5 % I.e. 5% of all game captured in the EU is currently taken with lead free ammunition. The share in the low scenario sis based on stakeholder feedback	10 % I.e. 10% of all game captured in the EU is currently taken with lead free ammunition The share in the low scenario sis based on stakeholder feedback, AFEMS suggested that the share 0f use would not be higher than 10%	15 % I.e. 15% of all game captured in the EU is currently taken with lead free ammunition The share in the low scenario sis based on stakeholder feedback suggesting the share of non-lead use can be as high as 20% in Finland (Stokke et al) or even 20% in Germany (Gremse, personal communication).The dossier submitter lowered this to 15% to be on the conservative side.
Average purchase price of a new shotgun[l]	Not relevant for larger calibres, existing non-lead can be used without adaptation For small calibres adaptation is foreseen for the barrel (Caudell et al., 2012)	Not relevant for larger calibres, existing non-lead can be used without adaptation For small calibres adaptation is foreseen for the entire gun (Caudell et al., 2012)	Not relevant for larger calibres, existing non-lead can be used without adaptation For small calibres adaptation is foreseen for the entire gun (Caudell et al., 2012)
Counterfactual replacement of existing shotguns that are not standard proofed.	95 % of rifles to be replaced over the next 10 years[j]; 0 % of rifles not to be replaced within the next 10 years.	90 % of rifles to be replaced over the next 20 years[j]; 5 % of rifles not to be replaced within the next 20 years.	95 % rifles to be replaced over the next 20 years[j]; 5 % of rifles not to be replaced within the next 50 years.

Percent of gun owners that re-place	10 %	10 %	10 %
Number of hunters that prematurely replace their gun	403 628	605 442	1 210 884
Amortisation period (years)[h]	10 years	20 years	50 years
Operational costs			
Prices were taken as averages per group of cartridges that were suitable for a specific group of animals, prices without VAT			
Price difference vis-à-vis lead shot.	Small calibres: € 2.36 Large calibres: € 0.65	Small calibres: €2.68 Large calibres: € 1.74	Small calibres: € 2.68 Large calibres: € 1.75
Bag of small game per hunter With small game defined as per the hunting statistics in section on baseline (small animals, all animals smaller then roe deer)	5	10	15

D.1.4. Other assessed options

D.1.4.1. Shot

Table D.1-28 Restriction options for hunting with lead gunshot

	Scenario	Comment
R01	Ban on placing on the market and use of lead gunshot	Effective, practicable, monitorable, consistent with restriction over wetland
R02	Require specific shot design when lead is used	Not effective (does not prevent secondary poisoning)
RO3	Ban on the placing on the market of game meat collected with lead shots or maximum levels of lead in game meat	A ban on the placing on the market of game meat that contains lead (RO4) would in theory be possible under EC1881/2006 which would then be amended to incorporate a Maximum level of lead for game meat. However, it would not prevent hunters to use lead shot for hunting game for individual consumption.
R04	Advice on handling and disposal of game and meat bagged with lead shot	Not practical to remove all fragments
R05	Compulsory information to consumers (hunters) about the risk of lead in hunting education and labelling of risks of lead on the package at points of sale	Many hunting courses are organised by hunting associations, and do not necessarily address the lead problem specifically (although these courses do address hygiene in game meat handling) Awareness raising could be achieved during training and by information on the package of lead containing bullets.

RO1: Ban of lead shot for hunting

Effectiveness

This risk option is effective because it results in a 100 % reduction of lead release for hunting with shot, it reduces the risks from lead for humans and the environment with risks from alternative(s) being much lower.

It further has the highest cost benefit (steel shot is almost the same price as lead shot).

Full bans are already in place in the Netherlands and in Denmark and with significant reduction of lead emission[145] (Kanstrup and Balsby, 2019) as a result, showcasing that such bans are implementable, practical and enforceable with derogations allowing athletes to use lead shot for international competitions. Other jurisdictions are discussing a voluntary phase out such as the major wildfowl shooting organisations in the UK where

[145] http://www.emissieregistratie.nl/erpubliek/erpub/weergave/grafiek.aspx

the British Association for Shooting and Conservation (BASC), British Game Alliance (BGA), Countryside Alliance (CA), Country Land and Business Association (CLA), Game and Wildlife Conservation Trust (GWCT), The National Gamekeepers' Organisation (NGO), The Moorland Association (MA), Scottish Land & Estates (SLE) and The Scottish Association for Country Sports (SACS) say significant recent advances in technology have enabled the transition to take place[146].

Possibilities to substitute lead shot are available and technically and economically feasible also for uses outside of wetlands, see section 2.4.1.

Monitorability

The risk option is implementable, easy to enforce and monitorable.

RO2: specific design/construction of lead shot

Effectiveness

Options exist to cover lead shot with a thin layer of another metal to reduce lead exposure.

These designs are effective in reducing the lead exposure of the shooter and may reduce lead exposure to the environment but are not effective to prevent primary intoxication of wildlife as the coated material gets destroyed in bird gizzards resulting in lead uptake and consequent toxicity. These designs are also not effective in reducing lead contamination of game meat.

Practicality and Monitorability

Since this risk option is not effective, practicability and monitorability are not further addressed.

RO3: Ban on placing on the market of game meat collected with lead shot or a maximum level of lead in game meat

EC Regulation 1881/2006 does not set maximum levels (ML) of lead in game meat (EC n2006). This may have been because the committees setting these levels assumed (1) that lead projectiles would remain intact, and therefore present little risk to consumers who would remove projectiles from food at the table and/or (2) that relatively few people eat wild game frequently. Recent research has shown that neither of these assumptions is incorrect.

Firstly, because lead bullets and gunshot pellets often fragment on impact leaving behind tiny lead particles, their removal is not practical in small game animals like gamebirds (Green and Pain 2019). In large game animals like deer, shot with bullets, removal of contaminated tissue results in considerable meat wastage. After removal of large visible lead fragments in gamebirds prior to cooking, lead levels in the meat were still on average, more than an order of magnitude above the EU MLs set for the muscle of domestic livestock and poultry (Pain et al. 2010). Even meals made from gamebirds with no visible lead pellets or large fragments in the carcass often had lead concentrations considerably higher than the MLs set for other meats. Secondly, food standards generally aim to protect specific consumer groups as well as the general public. Many who frequently consume wild game are likely to be sport and subsistence hunters and

[146] https://basc.org.uk/shooting-and-rural-organisations-take-responsibility-of-move-away-from-lead-ammunition/

their families and friends. In some countries, such as the UK and Denmark, game animals, especially gamebirds, are often given to employees of game shoots and consumed by them and their families. This represents a form of occupational exposure to lead, which, while strictly regulated in other contexts, is not in the case of game shooting. Some people may consume game for health reasons and it is widely promoted as such in the UK. Although many recipes for game are given in websites and literature promoting the consumption of game, most do not include information on removing lead-contaminated tissues. Green and Pain (2019) suggested that the numbers of people who frequently consume wild game are higher than previously assumed, perhaps about 1 % of the population of the EU (c. 5 million people). Those choosing to eat game for ethical or health reasons could purchase it from retailers where a lead ML could be applied

It might be thought that testing game meat for lead would be difficult because lead from ammunition is unevenly distributed across the tissues of wild-shot animals, so that multiple samples would need to be analysed for comparison with the ML. Additionally, if large lead fragments were present, the lead levels would b is leadingly high. However, protocols are readily avail- able in which large particles of ammunition are removed prior to analysis to simulate culinary practices (Pain et al. 2010).

The relevant MLs of lead of concern in European Commission Regulation (EC) 1881/2006, Setting Maximum Levels of Certain Contaminants in Foodstuffs,

Annex, Section 3, Metals, Lead, are as follows:

- Section 3.1.3. Meat (excluding offal) of bovine animals, sheep, pigs and poultry (0.10 mg/kg).
- Section 3.1.4. Offal of bovine animals, sheep, pigs and poultry (0.50 mg/kg) (EC 2006).

We consider below the effects of amending these Sections to:

Section 3.1.3. Meat (excluding offal) of bovine animals, sheep, pigs, poultry and wild game mammals and birds (0.10 mg/kg).

Section 3.1.4. Offal of bovine animals, sheep, pigs, poultry and wild game mammals and birds (0.50 mg/kg).

Effectiveness

This amendment would harmonise the regulations across all domestically reared and wild game animals within the EU. It would, if passed, apply to all EU nations and other countries across which wild game meat and meat products are traded commercially.

Establishing an EC ML for lead in traded game meat would require means to both monitor and enforce the regulation. We propose that the same monitoring and lead testing procedures used for domestically reared meat could be applied to wild game. The consumers of game meat obtained from retail outlets, such as restaurants, shops and supermarkets, would be affected by the lead content of the portions served or bought, rather than the lead content of the entire carcass.

This would have implications for the scale of monitoring and testing of the meat from large game animals, but for gamebirds, the lead content of the whole animal bought or served is usually the issue.

The solution as such would address the risk only partially, hunters that do not market their game would not be covered by such a regulation and they could continue to use

lead. Furthermore, it would not protect the hunter families that may consume game meat with high frequency acquired outside of common markets, i.e. they hunt themselves.

Practicality

The solution is practical and can be implemented, existing regulations for meat form other animals already measure for lead and these same methods and procedures could be applied to game meat as well.

Enforceability

In principal this option is enforceable, as controls in slaughterhouses for lead content can be done and can be traced back to any hunter. The consequences for such a hunter would then be that he can no longer sell his meat through that slaughterhouse.

Monitorability

The same monitoring and lead testing procedures used for domestically reared meat could be applied to commercial wild game.

RO4: Cut away more meat

For small animals such as gamebirds collected with lead shot the lead particles may be distributed all over the animal.

Effectiveness

Advice on the handling of game meat is already available and are an integral part of the education of hunters but does not prevent the consumption of game meat containing relevant lead concentrations >0.1 mg/kg. Therefore, this risk option is not effective.

Practicality

Removal of lead shot is impractical in small game animals (Green and Pain 2019).

Monitorability

For meat that is placed on the market, the monitoring would be done as per Risk option 3. Any meat that would be used for home consumption or is placed on the market outside of the regular markets would not be monitored. This makes the overall monitorability of such a measure low.

RO5: Compulsory Information

The role of information in addressing the risks involved in the use of lead has been extensively discussed in a number of fora. A recent paper by (Newth et al., 2019) explained how different attitudes toward the problem and the solution being proposed (restriction and regulation). Views on non-lead alternatives notably differed between the two perspectives. Those in 'Open to change' were more likely to be happy to use non-lead options, felt that they were fit for purpose and therefore saw little need for further research to develop a viable alternative. They believed that the availability of further information on non-lead ammunition would reduce concerns. (Newth et al., 2019) reports that previous survey found that 41 % of British shooters felt that more guidance about the non-lead options would help improve compliance with current restrictions.

However, those in *Status quo* were generally not happy to use non-lead ammunition, did not feel that the alternatives were fit for purpose and strongly believed that lead shot was better than steel at killing and not wounding an animal. A dislike of the alternatives

was also a key reason that British shooters gave for not complying with the current regulations in England (Cromie et al., 2010) and concerns about the effectiveness of non-lead shot relative to lead have been reported in shooting communities elsewhere (Kanstrup, 2006, 2015, 2019). There was a strong belief among those in *Status quo* that more research should be done to develop a viable alternative. It seems logical that those who were more content with the non-lead alternatives, reflecting the perspective of 'Open to change,' are more likely to support the replacement of lead shot with these alternatives while those who were not, are less likely to support this suggested solution.

Practicality

This option is in principal practical, most hunter have to pass an exam in order to obtain a hunting license and in the context of that exam a module scan be envisaged that explains the consequences of the use of lead. If such a message comes from within the hunting community then the effectiveness can eb high ((Newth et al., 2019)

Current modules in hunting exam already address issues such as ecology, and wildlife hygiene, so a module on eco toxicity with an emphasis on lead could play a role in alleviating some of the

Effectiveness

The effectiveness can be high, but the practice has shown that information alone will not help. If the message gets passed on from within the hunting community this can be seen as a more stronger media then just scientific and academic advice as such media are often regarded as covert attacks on hunting. This is not the case, these media aim at enhancing the sustainability of hunting (see).

Monitorability / Enforceability

The exams and hunting study books can be examined for their content.

As per risk option 3, the effects of such a measure (reduction in prevalence in lead poisoning) can be measured in the long term only by the same means as lead poisoning is measured and observed now: field studies of carcasses and blood lead levels in humans.

D.1.4.2. Bullets

Table D.1-29 Restriction options for hunting with lead bullets

RO1a	Ban on the use of small calibre (<5.6 mm centrefire and rimfire in general) lead bullets for hunting	No alternatives approved
RO1b	Ban on the use of large calibre (≥5.6 mm centrefire) lead bullets for hunting	Alternative available and approved, effective, practicable, and monitorable
R02	Require specific shot design when lead is used	Not effective (does not prevent contamination of game meat)
RO3	Ban on the placing on the market of game meat collected with lead bullets or maximum levels of lead in game meat	A ban on the placing on the market of game meat that contains lead (RO4) would in theory be possible under EC1881/2006 which would then be amended to incorporate a Maximum level of lead for game meat. However, it would not prevent hunters to use lead shot for hunting game for individual consumption
R04	Advice on handling and disposal of game and meat bagged with lead bullets	The price of an alternative is lower than the value of extra meat that would need to be cut away
R05	Compulsory information to consumers (hunters) about the risk of lead in hunting education and labelling of risks of lead on the package at points of sale	Many hunting courses are organised by hunting associations, and do not necessarily address the lead problem specifically (although these courses do address hygiene in game meat handling) Awareness raising could be achieved during training and by information on the package of lead containing bullets.

RO1a: Ban of small calibre lead bullets for hunting

This risk option addresses a ban on the use of small calibre (<5.6 mm centrefire and rimfire in general) lead bullets for hunting.

Effectiveness

This risk option would be effective in reducing the risks from lead bullets for small calibres.

Practicality

Manufacturers have found it difficult to develop lead-free bullets in small calibres (e.g. .22 LR, .17 HMR and .22 Winchester magnum) as alternatives pose problems in terms of stabilisation of bullets in flight, which in turn negatively affects bullet accuracy. Newer

products in this category have become available recently (Norma, RWS, CIC) but, contrary to larger sized bullets on which a wealth of information on performance exist, those have not been widely tested.

Monitorability

Since alternatives are currently not widely available, monitorability of this risk option is not further addressed.

RO1b: Ban of large calibre lead bullets for hunting

This risk option is a ban on the use of large calibre (≥5.6 mm centrefire) lead bullets for hunting.

Effectiveness

This risk option would be effective in reducing the risks from lead bullets for large calibres.

Practicality

Non-lead bullets for large game are widely available; most manufactures have developed non-lead production lines (see section 0). Field studies have shown that non-lead ammunition for large calibres can be used as effectively as their lead-based counterparts.

Monitorability

As the bullet still contains lead, measures to detect lead cannot be performed without coming to full conclusion: the detection method would detect lead but it would not give an indications as to whether that lead is bounded or not. The monitorability of such measures as therefore low.

RO2: Different bullet construction

Rifle bullets can be separated into two general types: jacketed or solid. Jacketed bullets are constructed of a metal jacket (aka sleeve) and a core. The most common metals used for jackets are gilding metal (i.e., copper alloy) or copper-plated soft steel. A lead core is most often pressed into the jacket. Some military bullets feature a soft steel core. A subset of jacketed bullets is the bonded bullet. These have the lead core bonded to the jacket.

1. Lead core bullet
2. Lead bounded bullets
3. Full metal jacket
4. Solid bullet

Table D.1-30 Bullet types and construction characteristics

Bullet type		Characteristics
Jacketed bullet	 	There are a number of different jacketed bullet types. There are full metal jacket (FMJ), hollowpoint (HP), soft point (SP) and partition. Within most of these types, there are features that improve performance such as polymer (aka ballistic) tips and boattails. The FMJ bullet design was one of the first jacketed-bullet designs, developed in the late 1800s as a nonexpanding bullet to satisfy military treaties. Commonly found commercial FMJ bullets are usually .22 or .30 calibre and mimic a military bullet design. Commercial FMJ bullets are usually accurate, but not quite to the level of offering a better hunting or match bullet. Military manufactured FMJ bullets usually leave a lot to be desired in terms of accuracy. Sporting applications for FMJ bullets are when expansion is not desired such as for pelt hunting or small-game hunting as well as plinking.
Lead bounded bullets		Bonding is usually a heat process where the lead core is bonded to the jacket. The jacket and core cannot separate, but react and expand as one. This results in tough bullets that have high weight retention, typically better than 90 percent. They also frequently produce very deep penetration, but not to the extent that solids do. Because the bonding process often uses heat, bonded bullets will usually have thick jackets. The heat used in the bonding process anneals the jacket back to a relatively soft condition, and the jacket has to be made thicker to achieve the required strength.

Solid bullet		Solid bullets are usually a solid piece of a copper alloy. They can be made by turning them on a lathe or by a forming process on a traditional bullet press. Solids can range from one that's completely solid to another that has a cavity formed in the nose similar to a hollowpoint. Such a cavity may be used to house a polymer tip in the nose. These latter solids, developed in 2003 by Randy Brooks of Barnes Bullets, are designed to be controlled--expansion projectiles for hunting. Solids meant for hunting include the Barnes triple-shock expanding (TSX) bullet and the tipped, triple-shock expanding (TTSX) bullet, Federal Premium's Trophy Copper, Hornady's gilded metal expanding (GMX) bullet, Nosler's expanding-tip (E-Tip) and Winchester extreme point (XP) copper. These have all earned reputations as efficient hunting bullets with nearly 100 percent retained weight and effective penetration.

Full metal jacket are usually not used in hunting, their use is usually strictly regulated as these bullets are non -expanding bullets and are in general not used for hunting. By design, fully jacketed projectiles have less capacity to expand after contact with the target than a hollow-point projectile. While this can be an advantage when engaging targets behind cover, it can also be a disadvantage as an FMJ bullet may pierce completely through a target, leading to less severe wounding, and possibly failing to disable the target. Furthermore, a projectile that goes completely through a target can cause unintentional, collateral damage downrange of the target.

The only Member State where the use of full metal jacket bullet is allowed explicitly by law is Finland where the type of bullet is used in specific hunting situations in Finland. T bullet is used to shoot at birds

Different bullet designs have different implication for the metal deposition of lead.

In a study comparing copper and lead-core bullets, show that considerable differences exist between lead-free bullets with respect to the energy-to-volume conversion, the number of fragments, and the cavity shape. Interestingly, the lead-free TSX bullet is remarkably similar to the lead-containing NVU bullet in all parameters quantified and of relevance for assessing bullet performance, except for the number of fragments.

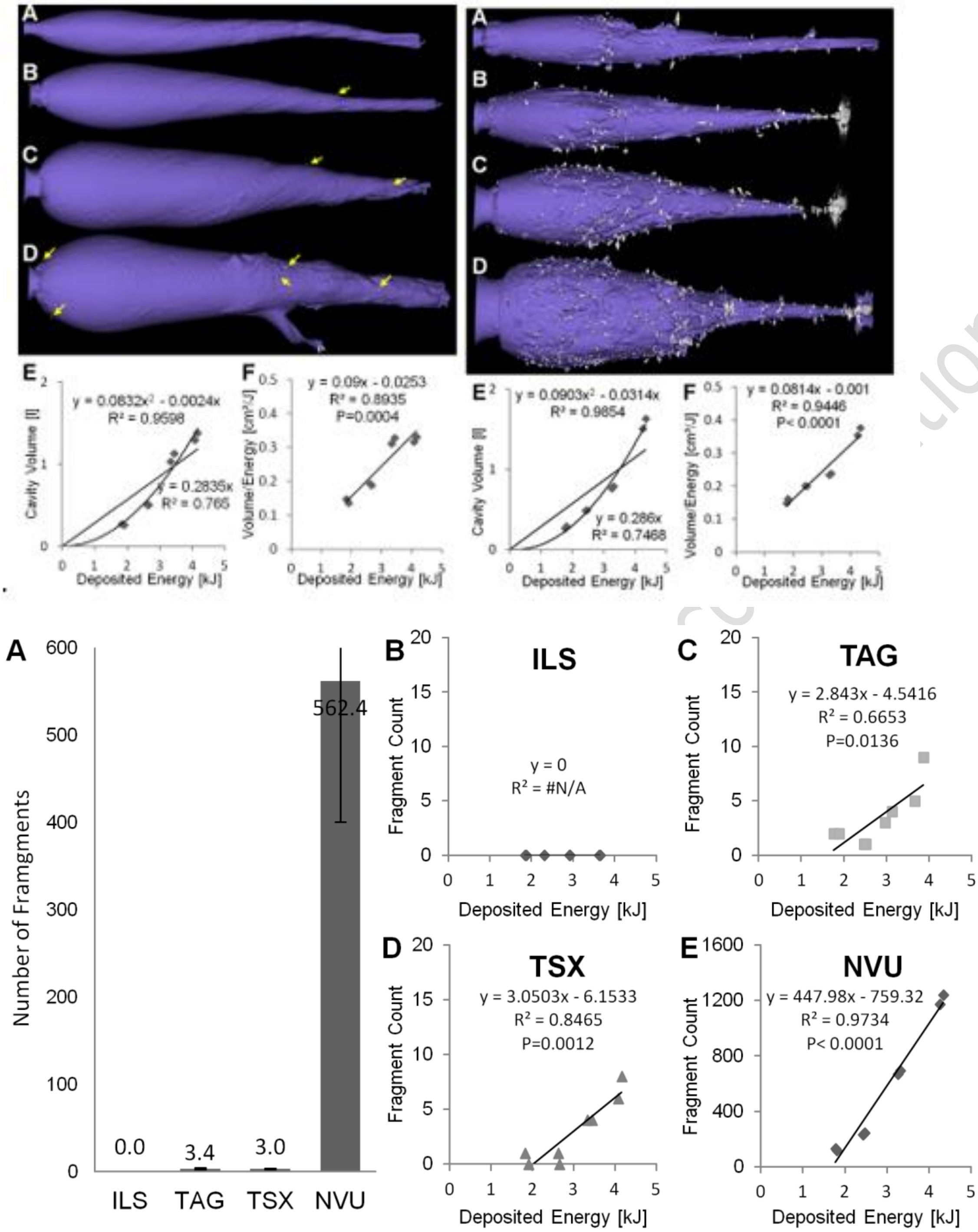


Figure D.1-10: Non-lead copper expanding bullet TSX (left) and Lead core Bullet Norma Vulkan (right) in ballistic simulant media. A 600 m/s, B 700 m/s, C 800 m/s, D 900 m/s impact velocity. Metal deposits analysed using computer tomography. Gremse et al. 2014

Of interest is that the use of solid bullets made of brass (with about 3-4 % of lead) did not result in a significant deposition of fragments.

In a paper investigating metal deposition of different bullet types (Stokke et al., 2017) corroborated that the average metal loss differed per bullet type, see table and gave a quantification of mass loss.

Table D.1-31: metal loss per bullet type

Bullet type	Mass lost	Mass loss (percentage)
Lead core bullets	3.00 +/- 0.17 g	18–27 %
Bonded lead core bullets	2.65 +/- 0.15	10–24 %
Copper bullets	copper bullets 0.54 +/- 0.18 g	0–15 %

One main reason for bonding the lead core to the jacket is to provide improved resistance to mantel separation, which is a serious functional failure. Another intended advantage is greater retention mass. Surprisingly, the study of (Stokke et al., 2017, Knott et al., 2010) shows that mantel separation occurred as frequently for bonded lead-core bullets as for lead-core bullets.

The concern on lead loss in lead-core bullets are corroborated by the study of to Knott et al. (2010), who estimated that 6.85-mm-caliber, 8.39-g (130 grains) lead-core bullets deposited 17 % of their weight as fragments into carcasses of red deer and roe deer. (Knott et al., 2010)presumed that they might have lost smaller fragments as a result of low resolution of the radiographs. Their concern seems to be relevant because the concerns raised by (Stokke et al., 2017) indicate about 25 % lead loss due to fragmentation.

Due to the lower density these bullets are often longer or lighter, and in the latter case need to be faster to transport the same amount of kinetic energy, designs have been tried with copper bullets where extra weight was added. To improve down range performance Barnes experimented with the MRX-Bullet until 2012.

Figure D.1-11 Barnes Maximum Range X Bullet (MRX) sold until 2012 exemplifying the possibility of a rear core in an expanding solid copper bullet. Picture Barnes Bullets LLC

The MRX used the profile, ogive, bearing surface detents, polymer tip and nose cavity of the popular Barnes TTSX (lead free) bullet. In addition, a tungsten rear core was added – for raising bullet mass while retaining length.

Figure D.1-12: Barnes TSX, TTSX, MRX expanded. Picture Federal Cartridge Co.
Upon impact such bullet performs identical to the TTSX. Only copper surfaces contact surrounding media (i.e.. Meat)

Since copper is a material that is harder than lead, the bullets need to be manufactured differently to expand and release the energy within the target, e.g. by a drilled hole in the tip Furthermore, adjustments in bullet design are required to avoid damaging of the barrel due to the harder material It is noted that such construction such as the barnes msx would add additional cost to the production of bullets. Such an addition may bring benefits but a series of studies both in the ballistic soaps as well as in the field prove demonstrate that lead free bullets can be used in practice.

Effectiveness

Bullets with lead core, fragment and dispose lead in the target (game). Designs have been made to limit this deposition of lead (lead core) but studies have shown that this does not lead to sufficient reduction in metal depositions in order to mitigate the risk of lead completely by design only. Solid bullets made of brass or copper do. One of the shortcoming (weight) of solid bullets can be compensated by adding weight to the bullet, but there’s sufficient evidence of effectiveness in hunting of solid copper without that additional weight.

Practicality

This risk option would be practical.

Monitorability

As the bullet still contains lead, measures to detect lead cannot be performed without coming to full conclusion: the detection method would detect lead but it would not give an indications as to whether that lead is bounded or not. The monitorability of such measures as therefore low.

RO3: Ban on placing on the market of game meat collected with lead shot or a maximum level of lead in game meat

See section 0.

RO4: Cut away more meat

Lead concentration in the wound channel can be very high. Dobrowolska and Melosik (2008) reported for 16/20 meat samples from the wound channel of wild boar and red deer lead concentrations >100 mg/kg wet weight, 1/20 even exceeding 1000 mg/kg wet weight. Swedish Livsmedelsverket (2014a) reported in sample from the wound channel median and maximum lead concentrations of 146 and 1829 mg/kg wet weight.

The limit value for lead in meat of 0.10 mg/kg wet weight that applies to, among other things, meat from domestic animals and poultry within the EU. For game meat, there is

currently no EU common or national limit value for lead. However, the Swedish National Food Administration (Livsmedelsverket, 2020) considers that meat of game with lead contents exceeding this limit value should not be considered as safe food according to Article 14 of EU Regulation No. 178/2002. Exposure to lead can adversely affect public health. Especially foetuses and children in development, but also adults with high exposure for a long time, can be harmed. Therefore, it is justified to implement risk management measures.

Current advices and practise state that cutting away 10 cm around the bullet wound of game met would be sufficient to reduce the amount of lead in the edible parts.

Table D.1-32: Overview of advices

Country	Organisation	link
UK	Food Safety Authority	https://www.food.gov.uk/science/advice-to-frequent-eaters-of-game-shot-with-lead
Sweden	National Food Agency	https://www.livsmedelsverket.se/produktion-handel–kontroll/produktion-av-livsmedel/jakt#Bly%20i%20viltk%C3 %B6tt
Spain	Scientific Committee of the Spanish Agency for Food Safety and Nutrition Safety	http://www.aecosan.msssi.gob.es/AECOSAN/docs/documentos/seguridad_alimentaria/evaluacion_riesgos/informes_cc_ingles/LEAD_GAME.pdf
Germany	Federal Institute for Risk Assessment	https://www.bfr.bund.de/de/presseinformation/2011/32/bleihaltige_munitionsreste_in_geschossenem_wild_koennen_fuer_bestimmte_verbrauchergruppen_ein_zusaetzliches_gesundheitsrisiko_sein-127254.html
Norway	Norwegian Food Safety Authority	http://www.matportalen.no/matvaregrupper/tema/fjorfe_og_kjott/unngaa_kjott_rundt_saarkanalen_fra_hjortevilt_felt_med_blyammunisjon
Italy	ISPRA advice	http://www.isprambiente.gov.it/en/publications/reports/lead-in-ammunition-problems-and-possible-solutions

On their pages[147] providing guidance for lead ammunition in game meat FACE notes that:

All expanding lead core bullets fragment on impact and shed lead particles through the meat as the bullet penetrates. This is also true for lead shot. This gives rise to microscopic particles of lead widely distributed throughout the carcase. Expanding lead core bullets typically release thousands of fragments of varying size (including millions of nanoparticles) and the larger ones can be visualized using X-rays (Arnemo et al., 2016; Knott et al., 2010).

[147] https://www.leadammunitionguidance.com/lead-ammunition-in-game-meat/

The lead levels are greatest immediately surrounding the wound channel, but may remain detectable up to 30cm away depending on bullet type, bullet resistance during penetration and bullet velocity upon impact.

Attempts to remove lead ammunition from game meat can be successful at significantly reducing the levels of lead contamination. Research in Sweden has shown that proper handling of game shot with lead ammunition can effectively eliminate the risk (Kollander et al., 2014). The Federal Institute for Risk Assessment, Germany (BfR, 2011) states that cutting out large sections of meat around the bullet hole is not always enough to guarantee removal of lead.

Risk management options can include the application of appropriate game meat handling techniques, eating game shot with non-lead ammunition, or reducing their intake of game shot with lead ammunition.

FACE recommends following the advice from Sweden:

Follow the Swedish advice on game meat handling to trim away the majority of lead contaminated game meat:

- For game shot with bullets, remove the wound channel, defined as any meat that is visibly affected by the bullet (or bloodshot), and an additional 10cm of meat visibly unaffected by the bullet.
- For game taken with shot, remove any meat that is visibly affected, bruised or bloodshot. Remove any visible shot from the meat and cut away any damaged meat and gunshot holes. This is demonstrated here with pheasants: https://www.youtube.com/watch?v=vH_roSYGNC8
- All removed meat should be discarded and should not be used for human or animal consumption.

Recent research has shown that cutting away 10 cm from the bullet pathway may not be sufficient to keep the lead concentration at levels below 0.1 mg/kg wet weight. For example, Dobrowolska and Melosik (2008) found in meat from wild boar and red deer shot with expanding lead-based ammunition routinely used in hunting practices in Poland that all samples taken 15 cm from the bullet pathway had lead concentrations >0.1 mg/kg up to 16.9 mg/kg. In meat samples taken 25 and 30 cm away from the bullet pathway 11/20 (55 %) and 6/20 (30 %) samples, respectively, still exceeded 0.1 mg/kg. Swedish Livsmedelsverket (2014a) reported that in wild boar 27 % of meat samples taken 10 to 15 cm from the wound channel exceeded 0.1 mg/kg. Given that lead is a substance for which no threshold has been identified, relevant reduction (<0.1 mg/kg) or even elimination of the presence of lead would be desirable.

Cutting away meat around the wound channel further than 10 cm is considered as an option for risk management. In order to grasp the consequences of such a stricter recommendation an analysis can be performed using the following data and assumptions.

1. A bullet makes an entry and exit wound and cutting away meat around that wound channel makes roughly a cylinder of which the radius is the distance at which meat would have the be cut away, the height of the cylinder is different per animals and is determined by the animals' body dimensions.
2. Body dimension assumptions (width: roe deer 20-30 cm, deer 30-40 cm, moose 40-50 cm)

3. Density of meat 0.96 g/ml[148] using FAO (2012) data, no data was fond for game meat, instead data for cow (lean, no bone, raw) was used.

Using these assumptions we get to the following estimates of additional weight loos due to cutting further with different distances at which game meat should be cut away, see table Table D.1-34 and Figure D.1-13 Extra loss of meat due to cutting away meat around the wound channel

Table D.1-33: Meat loss due to cutting away at further distances from wound channel

	10 cm	15 cm	20 cm	25 cm
roe deer	0	8 to 11 kg	18 to 27 kg	32 to 47 kg
deer	0	11 to 15 kg	27 to 36 kg	47 to 63 kg
moose	0	15 to 19 kg	36 to 45 kg	63 to 79 kg

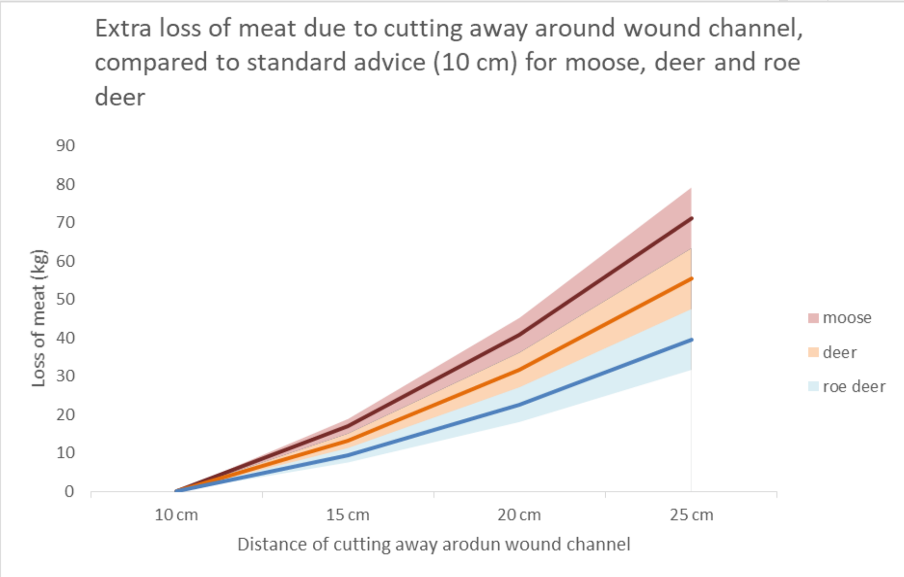


Figure D.1-13 Extra loss of meat due to cutting away meat around the wound channel

Even if cutting away of 15 cm would be recommended, the additional loss in meat (natural resources) would be substantial. Evaluating such an additional loss can be done by comparing market prices of game meat. Such values are announced on several website[149] and range from €13 to €20 per kilo. Using 13€ to avoid overestimation and assuming a 60 % mark up for butchers, retailer, etc. the price for hunters of such meat would be in the order of €4.8/kg (See Table D.1-34: value of cut away meat.

[148] http://www.fao.org/3/ap815e/ap815e.pdf

[149] https://www.jachtsite.be/wildprijzen & http://www.leonvandenberg.nl/files/wildprijslijst2017.pdf

Table D.1-34: value of cut away meat

Species	15 cm	Value (at 4.8 €/kg)
Roe deer	8 to 11 kg	36 to 54
Deer	11 to 15 kg	54 to 72
Moose	15 to 19 kg	72 to 90

ECHA's market research and stakeholder information would suggest that the price difference between lead and lead-free ammunition is in the order of €0.6- €1 per unit of ammunition.

Comparing the value of loss of meat to the prices of alternatives would then suggest that the incentive to use alternatives is larger than the incentive to cut away more meat.

Extrapolating the data above using the data from Thomas et al. (2020) on marketable meat would imply that an increase of loss of waste of 25 % could imply a reduction in supply of game meat for exports as well.

Table D.1-35 The annual tonnage and traded values of game meat reported by six EU nations in FAO (2018)

Six nations reporting trade data	Traded quantity in tonnes/y		Traded value in million Euros/y	
	Import	Export	Import	Export
	70 881	127 696	178.22	298.36

1) Croatia, Finland, Lithuania, Poland, Spain, Sweden
2) The 6 EU countries that reported trade data have 1 771 000 hunters (26.56 %) of the 6 667 770 reported in the EU in 2010 (FACE, 2010). Assuming a direct relationship between the numbers of hunters and the level of export trade gives an estimated export trade value in excess of 1123 million Euros a year for the whole of the EU
3) Data for principal species deer, rabbit, etc)

Removal of lead bullet fragments results in discarding of a considerable quantity of meat in large game animals. In Norway, discarding meat close to wound channels resulted in approximately 200 tonnes of contaminated meat being discarded annually, representing an economic loss of around €3m (Kanstrup et al., 2018).

Practicality

This option is not practical, meat is often a highly valued objective for the hunter as such and there will also be a tendency towards cutting less rather than more in order to obtain value for money (hunters in some MS pay a rather high price to obtain a license to take a animals.

Current modules in hunting exam already address issues such as ecology, and wildlife hygiene (including meat handling) and could also address the issue of cutting away more meat.

Furthermore, a measure as such is not practical for hunting smaller animals when they are taken with shot: the shot particles are distributed all over the impact zone and far beyond and cutting away all shot is not achievable in practice.

Effectiveness / Enforceability / Monitorability

Given that the measure is not practical, it's effectiveness, enforceability and monitorability are not further assessed.

RO5: Compulsory Information

See section 0.

D.1.5. Other Union-wide risk management options than restriction

Possible Union-wide risk management measures other than a restriction are outlined in the table below. None of the listed measures on their own are practical, or effective means of addressing all the risks posed by lead in ammunition. Nevertheless, some of the other Union-wide risk management measures could be used to support the preferred restriction option. The first column of the table indicates which risk management options could be combined with the proposed restriction for lead in fishing tackle.

Table D.1-36: Other Union-wide risk management options

Could support the preferred RO	Risk management option	Description of the option
Non-legislative measures		
YES	Voluntary education-only programmes	Grade et al. have reviewed and assessed the effectiveness, in terms of reduced uses of lead tackle and/or reduced mortality wherever data are available, of voluntary and education-only programmes both in Europe (UK, Sweden, Denmark) and North America (various US states and Canada) between 1980 and 2016 (Grade et al., 2019). It concludes that none of these voluntary and education-only programmes to manage risks from lead fishing tackle have proven to be effective, and that legislative measures had to be introduced after all. Another issue is that although attractive by avoiding conflict, voluntary programmes do not provide the guaranteed market incentives to fishing tackle manufacturers (Schulz et al., 2019). The ineffectiveness of pure voluntary and education-only programmes was also reported in the call for evidence by WWT (CfE #1247). Even if not efficient on its own, such a measure could support a ban on lead fishing tackle.
NO	Voluntary industry agreement to restrict the use of lead in fishing tackle	An initiative (Thomas and Guitart, 2010) was launched in 2009, The Federation of Hunting Associations of the European Union (FACE) signed an agreement with Birdlife International in 2004 under Directive 79/409/EEC (Birds Directive) seeking a phase-

		out of the use of lead shot in hunting in wetlands by 2009 at the latest (European Commission, 2004). However, this soft-law agreement has yet to be implemented, and is not legally binding.
YES	Information campaign to consumers to promote the use of non-lead fishing tackles	Lead alternatives seem slow to be adopted by the hunters either because they do not match the exact same properties of lead (e.g. easy to manipulate, high density), are too expensive or because often hunters may have preconceptions or beliefs justified or not on the added value of lead for fishing. Public information campaigns are designed to influence a target audience's behaviour. However, research has shown that such communication campaigns have moderate to strong effects on cognitive outcomes, less on attitudinal outcomes, and still less on specific behaviours (Rice and Atkin, 2012).
Legislations other than REACH		
NO	Product Safety Directive 2001/95/EC	This Directive addresses risks to consumers (termed health and safety of consumers) related to specific products and not risks related to a cumulated exposure from different products, or to risks posed to the environment. This measure would therefore not be appropriate.
NO	Environmental tax on lead fishing tackle placed on the market	Assuming that selling prices of today's ammunition product do not reflect the true environmental cost of the products. It could be possible to internalize these environmental costs by increasing the final product's selling price. The EU could achieve this by implementing an environmental tax on all lead ammunition This tax would be designed to make the lead ammunition more expensive than the alternatives. Taxation on ammunition could be used to influence the purchase behaviour of fishers in a more environmentally friendly direction.

		Such a tax could also motivate producers to design more sustainable alternatives (Sherrington et al., 2016). The existence of alternatives is indeed crucial to the prospects of reducing risks to health and the environment. Such taxes can also generate revenue that could be used to (i) support the European industry to transition towards the manufacturing of non-lead ammunition, (ii) launch R&D activities to work on 'degradable' alternatives, (iii) launch consumer's awareness campaign Despite being attractive, the set up of a harmonised taxation scheme is extremely complex to coordinate, and put in place at EU level. Taxation in general is not a harmonised measure across the EU. Therefore, whilst it might be effective in encouraging substitution, it is not likely that all Member States would introduce relevant taxes and thereby, not all EU citizens will be protected. This is therefore likely to lead to a non-harmonised situation where different Member States apply different tax rates (if at all). In addition, while this option would encourage manufacturers, and hunters to switch to non-lead ammunition it is difficult to predict the risk reduction that would result from a given fee, even if case studies exist (e.g. taxes on plastic bags) and have demonstrated that the sale of such products have significantly reduced when applying an environmental tax.
Other REACH processes		
NO	REACH authorisation	Lead is classified as Repr. Cat 1a, and is identified as a SVHC, so it could be included on the candidate list and prioritised for Annex XIV inclusion. However, authorising the use of lead would be a disproportionate measure as it would affect all uses of massive lead, not just the use of lead in ammunition and fishing tackle. In addition, REACH authorisation does not apply to imported articles. As a huge

		proportion of fishing tackle are imported, REACH Authorisation would not be appropriate to address the risk.
NO	REACH Article 68(2)	Lead in ammunition is potentially within the scope of this process (as it is classified as Repr. cat 1a) and is used for consumer uses. However, due to the need to carefully consider the impact of any measure proposed (not a requirement of Art 68.2) the Commission decided to request ECHA to prepare a restriction under Article 69(1).
NO	REACH Restriction on substances and mixtures for consumer uses classified as reproductive toxicants cat. 1A or 1B and listed in appendices 5 and 6 (Restriction entry 30)	Lead and its compounds are classified as reprotox. 1A in the CLP Regulation, and are listed in appendix 5 to entry 30. Nevertheless, Reprotox. substances that are present in articles are not within the scope of the restriction imposed by entries 30. Therefore this restriction entry cannot apply to lead fishing sinkers and lures.
NO	REACH Restriction on lead in articles – Article 69(4) (Restriction entry 63)	According to the restriction Entry 63 - paragraph 7: lead and its compounds 'shall not be placed on the market or used in articles supplied to the general public, if the concentration of lead (expressed as metal) in those articles or accessible parts thereof is equal to or greater than 0,05 % by weight, and those articles or accessible parts thereof may, during normal or reasonably foreseeable conditions of use, be placed in the mouth by children.' The associated guideline[150] clarifies in Table 2c the list of articles which are considered out of scope of the restriction due to non-mouthability/non-reachability under normal or reasonably foreseeable conditions of use. It includes "ammunition is typically out of the reach of children in normal or reasonably foreseeable conditions of use".

[150] Available at: http://echa.europa.eu/documents/10162/13563/lead_guideline_information_en.pdf/43269f58-7035-42ea-a396-268a17abb5ab

D.2. Outdoor sports shooting with shot shell ammunition

D.2.1. Use volume

AEMS reported production volumes for sport shooting with shot Table D.2-1

Table D.2-1: production volume of lead shot for sports shooting

Use Nr	Ammunition type	Estimate of total units of ammunition (millions per year in the EU)	Estimation of total units of non-lead ammunition (millions)	Amont of lead used
3	Shotshells for sports shooting	350 - 650	40	12 000 -15 000

Information on the consumption of lead on and EU wide scale is scarce, earlier assessments from AMEC and COWI reported that the annual volume of use of sports shooting cartridges on EU wide scale is in the same order of magnitude as the annual volume of use for hunting.

In response to the survey on use performed by AMEC within the framework of their work on abatement cost the estimated use of shot shell for sports shooting purposes was in the order of 600 million units per year equalling about 15 000 tonnes of lead per year. This data was given to the contractor then but was not reported in the final report as that report focussed on hunting.

D.2.2. Alternatives

D.2.2.1. Function of lead

ISSF[151] and FITASC[152] rules requires the use of lead shot with a gauge not greater than 12 mm, usually 12 mm is used. Shotguns must be smooth bored. They are invariably 12-gauge, single-triggered and over-under type — one barrel is placed above the other. They fire cartridges loaded with lead pellets: the weight of the pellet load must not exceed 24,5 grams per cartridge; the diameter of each pellet must not exceed 2,6 millimetres. Guns and cartridges are subject to official checks during the shooting program.

The ammunition that is used must 'Pellets must be made of lead, lead alloy or of any other ISSF approved material' but most commenters in the call for evidence indicated that in practice lead is most frequently used.

According to BIS Research[153] (Research, 2012) the most popular calibre for sport

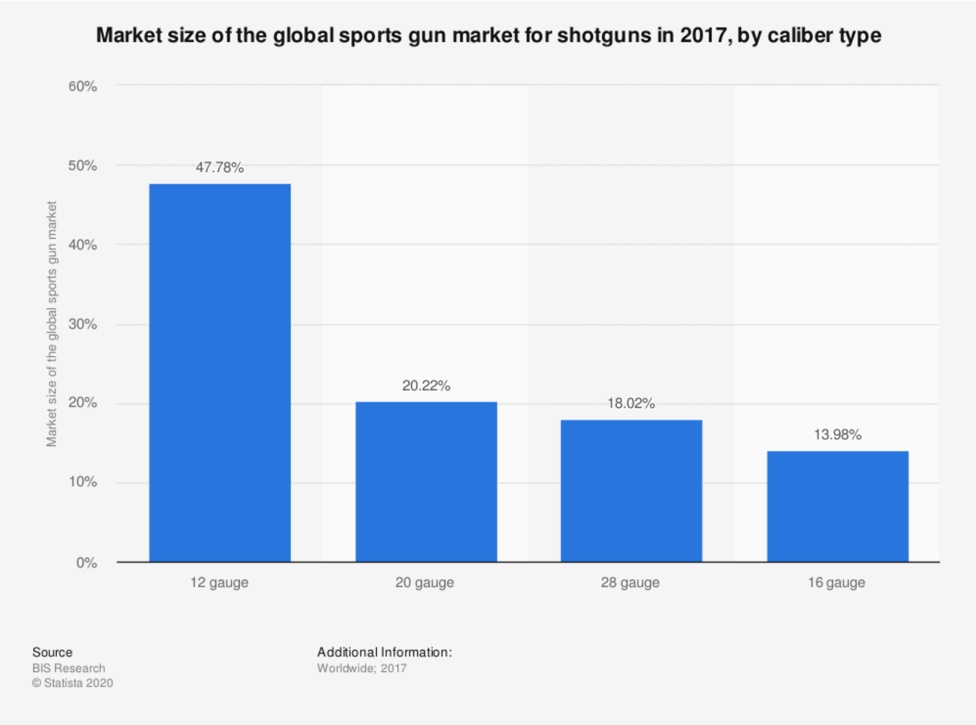
[151] https://www.issf-sports.org/getfile.aspx?mod=docf&pane=1&inst=462&file=1.%20ISSF%20Shotgun%20Rules_2020.pdf

[152] https://www.fitasc.com/upload/images/reglements/20191001_Rglts_CS_01012020_ENG.pdf

[153] Research. (2018). Market size of the global sports gun market for shotguns in 2017, by calibre type. Statista. Statista Inc.. Accessed: December 02, 2020. https://www.statista.com/statistics/994613/market-size-global-sports-gun-market-shotguns-caliber/

shooting is gauge 12 , followed by gauge 20,28 and 16 (see Figure D.2-1: market size of global sports gun market.

Figure D.2-1: market size of global sports gun market.



Shooting sports that use shotguns (e.g. trap and skeet, sporting clays) discharge lead projectiles over a diffuse area and a single cartridge may contain up to 36 g[47] of lead, but a 32 g load is the most common. In addition, large numbers of cartridges are used hence creating high lead shot densities in the impact area. The nature of trap and skeet shooting causes spent shot to land in a wide but predictable impact area. Sporting clays shooting typically takes place over 40-100 ha of land, and the continually changing layout of the course means that loadings of shot occur over a much wider area than for trap and skeet. Rifle and pistol shooting sports generally fire projectiles into backstops. Hence, these sports have lead accumulations in a more restricted area. Where projectiles are fired into earthen backstops lead may be readily removed from the backstops and recycled (Darling and Thomas, 2003).[48]

Typically for skeet/trap shooting a full box of 25 rounds is typically used (typically using 32 g lead per shot with 12 gauge ammunition). One round of trap or skeet shooting (25 shots) will add therefore add 800 g of lead per shooter to the impact area. A session of sporting clay shooting uses 50 or 100 rounds and typically 12 gauge ammunition is used (containing 32 g of lead per shot). A typical round of sporting clays (100 shots) will release 3.2 kg of lead per shooter to the impact area (Darling and Thomas, 2003).

Darling and Thomas (2003) noted that rifle/pistol target shooting sports that fire solid bullets into earthen backstops, while still presenting a potential environmental lead hazard, were less of a concern than shotgun sports (trap/skeet/sporting clays) due to the greater amount of lead per cartridge and the more diffuse fallout from discharged shot.

D.2.2.2. Suitability of non-toxic shot

The shot type and gauge that is required in sports shooting events (12 mm) is a load for

which commenters in the public consultation had indicated that many alternatives exist (at least for hunting purposes).

The suitability of alternatives has been discussed by Thomas who highlights that the ISSF rules prescribe the use of lead or other approves shot and that shot made from steel is not approved by the ISSF. In reaction to this (Thomas add source) argues that steel would be as suitable alternative because

1. volume of cartridges fired by competitors,
2. the parity with prices for lead cartridges,
3. the suitability of steel shot to be used in trap and skeet events,
4. and the ease of substitution for lead shot in conventional 12 and 20 gauge shotgun cartridges

According to ((Thomas and Guitart, 2013)) Olympic skeet and trap shooting regulations do not stipulate which gauge of shotgun can be used, only the shot load. Consequently, 12 gauge guns dominate the events because of the higher number of shot that can be fired at each target compared to those fired from 20 gauge guns. This facilitates the use of 12 gauge cartridges for Olympic shooting events. ((Thomas and Guitart, 2013)). Thomas presents a number of factory loads that are widely available and that could be considered as alternative for lead shot in shooting.

Table D.2-2: Characteristics of steel shot shotgun cartridges for clay target shooting made by major international cartridge companies in 12 and 20 gauge (ga). Velocity of shot is given as feet per second (fps), and meters per second (mps). All cartridges are 70 mm

Company and cartridge gauge	Shot mass (oz and g)	Shot size (English) and diameter (mm)	Muzzle velocity (fps and mps)
Kent Gamebore			
12 ga	1 oz 28.4 g	#7 (2.4 mm)	1290 fps: 393 mps
12 ga	7/8 oz 24.8 g	#7 (2.4 mm)	1350 fps: 451 mps
20 ga	7/8 oz 24.8 g	#7 (2.4 mm)	1215 fps: 370 mps
Federal			
12 ga	1 oz 28.4 g	#6,7 (2.6, 2.4 mm)	1375 fps: 419 mps
12 ga	11/8 oz 31.9 g	#7 (2.4 mm)	1145 fps: 349 mps
20 ga	¾ oz 21.5 g	#7 (2.4 mm)	1210 fps: 369 mps
Winchester			

12 ga	1 oz 28.4 g	#7 (2.4 mm)	1325 fps: 404 mps
20 ga	¾ oz 21.5 g	#7 (2.4 mm)	1325 fps: 404 mps
Remington			
12 ga	1 oz 28.4 g	#7 (2.4 mm)	1325 fps: 404 mps
20 ga	¾ oz 21.5 g	#7 (2.4 mm)	1325 fps: 404 mps
Rio Cartridges			
12 ga	1 oz 28.4 g	#7 (2.4 mm)	1325 fps: 404 mps
20 ga	7/8 oz 24.8 g	#7 (2.4 mm)	1325 fps: 404 mps

According to Thomas, the loads presented in table closely fit the ISSF requirements:

1. Given the lower density of steel shot versus lead shot, it is necessary to use steel shot of a larger diameter than the lead equivalent, coupled with an increase in shot velocity, to achieve the same ballistic efficiency and effective range. Thus a shot diameter of 2.6 mm might be advisable for Olympic trap shooting, in which targets may be broken at a longer distance than in skeet shooting. The ISSF regulations would, already, allow pellets of this diameter to be used (ISSF 2012)
2. The maximum allowable velocity of steel shot cartridges, as set by the International Proof Commission is 425 m/s (Government of Victoria 2011). A velocity of 390 m/s (for example) would equate with the same velocity of many lead shot cartridges, and still enable steel shot cartridges to perform well at the distances that trap and skeet targets are usually hit.

According to Thomas, the possibilities to substitute lead exist but would require approval of the ISSF and other federation to allow the use of non-lead shot.

In the call for evidence comments were submitted from the following organisations:

- International sports shooting federation (ISSF)
- Fédération Internationale de Tir aux Armes Sportives de Chasse (FITASC)

And various other shooting clubs and individual sport shooting clubs

Among the points most frequently brought forward are the following:

Ricochet in sports shooting ranges

The issue of ricochet and increase risk thereof when using steel shot has been widely discussed. Many of the commenters highlighted the risk of increased ricochet at shooting ranges due to the use of steel shot.

The Dutch shooting federation[154] highlighted that in the use of steel shot at shooting ranges they had no encountered any accidents related to ricochet of steel shot since the introduction of the general ban on the use of lead at shooting garages; objects on which steel shot could ricochet had been covered with wood.

Noise

In response to follow up questions, the FITASC submitted an extensive study on the possibilities to substitute lead with steel in sports shooting. This submission contained a comparative study in the levels of noise generated by both lead and steel and argued that using steel shot would require guns to generate higher pressure which would be associated with higher noise levels. These levels would be of such a degree they are no longer compliant with regulatory limits (the study quotes the French regulatory framework for noise).

In a number of EU countries, clay shooting ranges are subject to an authorisation procedure prior to their installation, during which the potential for noise and soil and pollution are investigated.

The essence of these regulation when it comes to noise is to limit the level of noise to avoid neighbourhood disturbances.

In their submission, FITASC argues that the use of steel shot would lead to more noise, this is based on a acoustics study that using steel sheet is associated with an increase of 11.5 % in pressure generated in the same gun, shooting similar loads. This increased pressure would is caused by the higher powder charge used for steel projectiles and cause an increase in noise during the detonation phase.

Such an increase in pressure would at 100 m distance cause an increase in noise of around + 6 to +9 db using steel. Measurements were performed using the NF s 31-160(20129)[155] and NF EN ISO 17201-1[156](December 2018) standards.

Taking into account the comparative noise levels measure at the same point of 83 db and (lead) and 92 db (steel) an increase of 6 db gives an increase in sound pressure of pf (0.796-0.282) 180 % and would constitute a breach of peace.

The submission does not argues to what extend this breach of peace is achieved by all shooting ranges and its representativeness is therefore not known.

The Finnish Bat on management of shooting ranges says on noise that

The possibilities for noise prevention at a shooting range depend on what the starting situation is like. If one starts implementing noise control measures from a situation where the shooting range does not have firing enclosures, noise berms or any other structures intended for noise abatement, one can achieve clear noise abatement results with enclosures and berms to the sides and the rear, for instance, from 5 to as much as 15 dB. However, if the starting situation is that the range already has relatively good enclosures, side berms and possibly other noise control measures implemented as well, it may be difficult to achieve an additional noise abatement of just 5 dB at the site

[154] Personal communication Sander Duivenhof

[155] French national standard uses in **Arrêté du 5 décembre 2006 relatif aux modalités de mesurage des bruits de voisinage (See :** https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000463330&dateTexte=20180803 **)**

[156] Acoustics — Noise from shooting ranges, see https://www.iso.org/standard/66940.html

And highlight that noise management is first and foremost a matter of location, it recommends using noise zones to avoid noise disturbance. The BAT states that, according to estimates, 285,000 people live (in Finland) the noise areas of public highways, and 500,000...600,000 in the noise areas of city streets. In total, around 1 000 000 people are estimated to be exposed to noise exceeding the guideline values (Saarinen A 2013). The number of people exposed to shooting range noise is less than 1 % of this.

The dossier submitter recognises that noise may be an issue but also highlights that without contextual information (population living around shooting ranges) this point is difficult to assess further.

Impact on guns

According to Thomas, there would be no impact on the guns from the use of steel shot cartridges for sports shooting.

Thomas argues that damage to the choke of barrels could occur and that this is a possibility with heavy magnum steel cartridge loads with large diameter shot (>3.6 mm) fired through barrels with abrupt large choke constrictions (i.e., full and extra full choke).

However, Tomas argues that such cartridges designed for long distance fowl hunting would never be admissible for Olympic events. Both the shot loads and the shot size of cartridges suited for Olympic shooting would permit ready passage of steel shot through any choke constriction. Skeet shooting uses the smallest barrel choke constriction of any event, so this concern does not exist. Trap shooting requires choke constrictions, and small steel shot of diameter 2.5–2.6 mm can be used in existing guns designed for lead shot cartridges. Modern competitive trap shotguns are designed with removable choke tubes of different choke constrictions, allowing competitors to select the choke constriction that gives them the optimal shot pattern at the distance they usually break clay targets. Coated steel shot, unlike lead shot, can also be retrieved easily from the fallout zones of shooting ranges using portable magnetic machinery, and be recycled, or possibly re-used.

D.2.3. Restriction scenarios & proposed action

Table D.2-3 Restriction options for sports shooting with lead gunshot

	Scenario	Comment
RO1	Ban on the **placing on the market** and **use** of **lead shot** for sports shooting	Effective, monitorable but Olympic and ISSF rules currently require the use of lead shot for skeet and trap disciplines
RO2	Ban on the **placing on the market** and **use** of **lead shot** for sports shooting with a derogation for **permitted retailers** to sell and **permitted individuals** to use (Olympic/ISSF elite level only; training and events) with permitting done by MS with annual reporting[157] to COM.	Effective (reduction of release ca. 50 %), practicable, monitorable
RO3	Ban on the **placing on the market** and **use** of **lead shot** for sports shooting with a derogation conditional that the use takes place at permitted sites/facilities with permitting done by MS with annual reporting[158] to COM where *[the risks to the environment (including wildlife and livestock) and humans (via the environment) are minimised and]* the following OCs and RMMs are implemented: • Regular [at least once a year] lead shot recovery with [>90 %] effectiveness (calculated based on mass balance of lead used vs lead recovered) to be achieved by appropriate means (such as walls and/or nets[159], and/or surface coverage); AND • Monitoring and treatment of surface (run-off) water to ensure compliance with the Environmental Quality Standards of the Water Framework Directive; AND • [Ban of any agricultural use within site boundary]	Effective (reduction of release less than 90 %), practicable, monitorable
RO4	RO2 and RO3	Effective (reduction of release higher than 90 %), practicable, monitorable

[157] Reporting should cover the number of retailers permitted to sell lead ammunition as well as the number of permitted individuals

[158] Reporting should cover the number of sites and volume of lead ammunition used at each site

[159] in some sources referred to as 'shot curtains'

RO5	Compulsory information on the hazard/risk of lead, transition periods and availability of alternatives at point of sale and on product packaging. Individual cartridges should be indelibly labelled (contains lead (Pb) shot, for sports shooting only [at permitted sites]).	Awareness raising could be achieved by information on the package of lead containing shot.

In case of no regulatory action, business as usual would continue and 33 425 tpa of lead would be released to the environment.

In the absence of data on how much lead shot is already recovered, it is assumed that the annual amount of lead recovered (regularly collected from surfaces without direct soil contact) to be 5 %, and 31 754 tpa of lead would be released to the environment (e.g., soil) without regular recovery or with long intervals between recovery of lead from soil by soil removal.

D.2.3.1. RO1: Ban of lead shot for sports shooting

Effectiveness

This risk option would be effective because it would result in a 100 % reduction of lead release for sports shooting with shot, it reduces the risks from lead for humans and the environment with risks from alternative(s) being much lower, it introduce the least compliance burden (i.e. no specific environmental risk management measures required), and has the highest cost benefit (steel shot is almost the same price as lead shot).

Practicality

Suitable alternatives are available. However, Olympic and ISSF rules currently require the use of lead shot for skeet and trap disciplines. Assuming that there will be no rule changes in the short term that would allow the use of alternative shot materials, and acknowledging the importance of participation in international sports shooting competitions to society, a complete ban on placing on the market and use of lead shot, including all sports shooting, may be considered to have an unacceptable socioeconomic impact for athletes and interested public following such sports events.

Monitorability

The risk option is implementable, easy to enforce and monitorable. In addition, it is consistent with the preferred restriction option for lead gunshot used for hunting, resulting in a blanket ban on the use of lead gunshot throughout the EU, irrespective of purpose. Such an approach would simplify implementation and enforcement of the overall restriction in terms of lead gunshot (as well as the existing restriction on the use of lead gunshot in wetlands) as it would not be possible to legally purchase lead gunshot for one purpose and use it for a restricted purpose.

D.2.3.2. RO2 Ban of lead shot with derogation for permitted athletes

This risk option is a ban on the placing on the market and use of lead shot for sports shooting but with a derogation for permitted retailers (to sell) and permitted individuals (to use). Member States would be responsible for granting permissions to permitted retailers and permitted athletes (such as with IOC status) and would report annually to Commission the number of retailers permitted to sell lead ammunition as well as the number of permitted individuals.

This risk option would be closest to the condition under which existing Member States with a ban on lead shot (such as Denmark, Sweden, Norway, Netherlands, Belgium) are permitting the use of lead shot for athletes participating at international competitions for skeet and trap.

Effectiveness

In the EU about 12 000 athletes with IOC status are participating in international competitions and would be eligible for a permit. Assuming athletes typically fire 40 000 to 60 000 "rounds" per year during training and competition and one "round" is consisting of 24 to 28 g of lead gunshot, would result in an annual emission of 11 520 to 20 160 tpa lead to the environment. Assuming that 5 % of the released lead shot would be recovered (regularly collected from a surface), in total 10 944 to 19 152 tpa of lead would be released to soil without frequent recovery. Compared to the baseline of 31 754 tpa Consequently, this risk option would result in a reduction of release to soil between 40 to 66 %, roughly 50 %.

Within this risk option, shooting with lead shot by the permitted athletes would continue at available shooting ranges, for which no additional environmental risk management measures would be required. Consequently, also no additional investment costs would arise.

Four of the five Member States with a ban on lead shot do not specify environmental RMMs to minimise the risk to the environment from the shooting by permitted athletes. Only Belgium specified that derogations are granted only if extra measures are in place to collect fired shot.

This restriction option would mainly (assumed 95 %) concern ranges at which lead shot is deposited on the soil with the possibility for lead mobilisation in soil. Based on the reduced release to environment (roughly 50 %) due to limiting the use of lead shot to permitted athletes, this restriction option would also reduce the overall risks to humans and the environment. However, the remaining risks would still be relevant to humans and environment taking into account that more than 10 000 tpa would still be release to soil.

Consequently, for this risk option relevant risks would remain. The dossier submitter considers that an EU wide harmonised action would be required to minimise those risks.

Practicality

Individual retailers will be permitted by Members States to sell lead shot.

This risk option ensures that athletes competing in international competitions will still be able to train and compete, permitted by the respective Member State to use of lead shot. Systems permitting athletes to train and participate in international competitions are already implemented in 5 EU Member States.

Recreational shooters need to switch to alternative shot material(s) which is available.

To implement this risk option only a shot transition time would be required such as 18 months because no risk management measures would need to be installed.

Monitorability

This risk option is monitorable because Member States would grant permissions to individual athletes and report to Commission.

D.2.3.3. RO3: Ban of lead shot with derogation for permitted sites

This risk option is a ban on the use of lead shot with derogation for ranges permitted by the Member State (with reporting to Commission) that have adequate risk management measures in place that allows a regular (at least one a year) recovery of lead shot (>90 %), to monitor surface water and to ban agricultural use within site boundaries.

This risk option would be closest to the condition under which existing Member States (such as Germany and Finland) are permitting the use of lead shot at sites having in place best available risk management measures to minimise lead release.

Effectiveness

In contrast to risk option 2, for which there would still be high emissions to the environment, the derogation of this risk option would minimise the environmental and human health risks by regular recovery of >90 % lead shot used at the site and additional measures.

The Dossier Submitter considers that lower recovery effectiveness, such as <50 % for example for ranges without any risk management measures or 50 to 90 % for ranges having available some risk management measure such as a berm, would mainly reflect the current situation where lead is deposited on and in the soil and a high recovery rate would also require removal of the soil. To reduce the risk without investment costs, the number of permitted shooters could be limited as described in RO2.

To achieve the recovery effectiveness of >90 %, combinations of different risk management measures such as walls and/or berms and/or nets (shot curtains) and/or surface coverage are required and would need to be installed taking into account the specific conditions of the site. Usually, a combination of two or three measures is required, that allows an efficient concentration of lead shot at limited area(s) with easy recovery. It should be noted that an already contaminated soil should not be covered with an airtight surface coverage to avoid anaerobic mobilisation of lead in the contaminated soil.

The costs of the described risk management measure to minimise the risks for humans and environment are high (approximately 300 000 to 600 000 EUR for a trap range with one line).

Even in case >90 % lead shot recovery is achieved, there are remaining risks from the use of lead for surface water, birds, human via environment, and soil at the end of service life:

- To avoid corrosion of lead shot deposited on the surface of the range, an appropriately short frequency of recovery is required. Based on information received from the German Shooting Sport and Archery Federation during the stakeholder survey, recovery of lead shot one to three time a year is performed on shotgun ranges with shot trap systems made of vertical nets or walls.
- Even in case of frequent lead shot recovery, there might be a risk of surface water contamination by lead particles or lead dust. To minimise this risk and to ensure compliance with the Environmental Quality Standards of the Water Framework Directive, appropriate risk management measures would be required to monitor and treatment of surface water.
- Since the upper soil layer of the whole range is expected to be contaminated above background levels from lead dust from shooting and unrecovered shot, any agricultural use (including hay and silage production) within site boundary should

be banned to minimise the risk for human via environment (food) and livestock and to ensure compliance with the respective legislations such as the Regulation 1881/2006 that limits lead in food for human consumption, Regulation 1275/2013 that limits lead in animal feed, and DIRECTIVE 2002/32/EC on undesirable substances in animal feed.

- The risk to birds from intake of lead shot and consequent primary poisoning cannot be eliminated because lead shot may always be on the surface of the deposition area of a range. The risk may be reduced e.g., by nets that trap, and collet shot and by conditions that make the ranges less attractive for birds to enter. Since birds are attracted by vegetation and trees, vegetation should be avoided as far as possible on ranges. A surface coverage is also expected the reduce the attractivity for birds.
- In the CSR (2020) a remediation plan at the end of service life is required. In case of regular recovery of >90 % of lead shot, the remaining risk for soil contamination is expected to be limited.

No comprehensive information is available on how many shooting ranges in the EU already have appropriate risk management measures in place to be able to regularly collect >90 % lead shot used. To calculate the baseline, less than 5 % is assumed (see "Baseline for lead in sports shooting"). Furthermore, no reasonable judgement can be made as to how many additional shooting ranges will in future be modified to allow appropriate recovery of >90 % lead shot. This information may become available only at a later time. Therefore, there is no suitable basis on which it can be judged how many shooting ranges would in future be set up for the appropriate use of lead shot. It is most likely that:

- the number of shooting ranges at which lead shot is permitted to be used will be limited due to the high investment costs, whereas at the remaining ranges alternative shot material could be used;
- the release of lead shot not recovered will be higher than the releases calculated for RO4 because not only permitted athletes (as in RO4) but also recreational shooters will be allowed to use lead shot at the permitted sites. Therefore, the release of lead shot not recovered is expected to be higher than 2 000 tpa as calculated for RO4 (see below).

Practicability

This restriction option acknowledges that continued use of lead gunshot may be considered to be acceptable to ensure participation in international competitions while minimising the risk to humans and the environment.

A recovery effectiveness of >90 % can readily be achieved for trap and skeet, which are Olympic disciplines. Examples of ranges with different combinations of risk management measures that can achieve 90 % recovery effectiveness or higher can be found in Germany and other Member States.

This risk option would allow also recreational shooters to use lead shot at the permitted ranges.

Achieving 90 % recovery is likely to be a significant challenge for FITASC sporting/compak disciplines as they are typically performed in natural/semi-natural areas with consequently limited possibility for lead recovery to take place. FITASC sporting rules currently prescribe the use of lead shot for sporting disciplines.

At temporary shooting ranges, it might not be possible to implement risk management measures to achieve a recovery rate of >90 %. To avoid risks to human and the environment from lead, alternative shot material is available to be used at such ranges.

The transition time to implement this restriction option is proposed to be 5 years to provide sufficient time for the shooting range operators, preferably in agreement with the relevant Member State authority, to implement the required risk management measures.

Monitorability

This restriction option is monitorable because Member States would grant permissions for sites and facilities and would report to Commission that operational conditions and risk management measures are implemented, and the required recovery effectiveness is achieved.

The effectiveness of >90 % lead shot recovery will be ensured by reporting the annual rounds of shooting and calculation of the mass balance of lead used versus lead recovered.

D.2.3.4. RO4: Ban of lead shot with derogation for permitted athletes at permitted sites

This risk option would ensure that lead is used only by permitted athletes (as for RO2) at permitted sites (as for RO3) with appropriate risk management measures in place to minimise the risks from lead shot for humans and environmental (e.g., by regular recovery of lead shot ≥90 %).

This risk option would be closest to the condition under which Belgium is permitting the use of lead shot for individual athletes with the condition to collect the fired shot (in the information provided by this Member State the condition has not been specified further).

Effectiveness

Based on information from ISSF and FITASC, about 12 000 athletes in the EU with IOC status are participating in international competitions and would be eligible for a permit. Assuming athletes typically fire 40 000 to 60 000 "rounds" per year during training and competition and one "round" is consisting of 24 to 28 g of lead gunshot, would result in an annual release of 11 520 to 20 160 tpa lead to the environment. Assuming that 90 % of the emitted lead shot would be recovered, 1 152 tpa to 2 016 tpa of lead would be released but not recovered regularly in the EU. This is the risk option with the lowest release of lead to the environment, except for RO1, which is the full ban.

Practicability

This risk option is practical as described for RO3 with the difference that recreational shooters would not be allowed to use lead shot; the use would be limited to permitted athletes training and competing in international competitions. Recreational shooter would need to use alternative shot material.

As for RO3, the transition time to implement this restriction option is proposed to be 5 years to provide enough time for the shooting range operators, preferably in agreement with the relevant Member State authority, to implement the required risk management measures.

Monitorability

As for RO3, this restriction option is monitorable because Member States would grant permissions for sites and facilities and athletes and would report to Commission that operational conditions and risk management measures are implemented, and the required recovery effectiveness is achieved.

The effectiveness of >90 % lead shot recovery will be ensured by reporting the annual rounds of shooting and calculation of the mass balance of lead used versus lead recovered.

D.2.3.5. RO5 Compulsory information

This RO requires compulsory information on the hazard/risk of lead, transition periods and availability of alternatives at point of sale and on product packaging. Individual cartridges should be indelibly labelled (contains lead (Pb) shot, for sports shooting only [at permitted sites]). It could be considered as a standalone measure, or in combination with any of the other ROs identified above.

Effectiveness

This risk option is not expected to lead to a significant reduction of unrecovered lead. However, by providing information on the hazard and risks of lead to the purchasing consumer, it is expected to be effective to increase awareness of the hazards and risk and to support the implementation of already recommended individual risk management measure to reduce individual lead exposure such as wearing face masks while shooting, changing clothes after shooting, hand washing after change of clothes.

It is also intended to enhance knowledge on the implementation of the restriction and encourage consumers to experiment with alternative ammunition.

Practicability

This risk option is practical because the information would be delivered at the point of sale to the customer.

The transition time for this restriction option is proposed to be 18 months to allow the manufacturers to implement the requirement for indelibly labelling the cartridges.

Monitorability

It supports other risk options with regards to enforcement; especially the indelibly label that lead is contained will improve inspection and enforcement.

D.3. Outdoor sports shooting with Bullets

D.3.1. Use Volume

AFEMS estimated the total volume of production according to table

Use Nr	Ammunition type	Estimate of total units of ammunition (millions per year in the EU)	Estimation of total units of non-lead ammunition (millions)	Amount of lead used (tonnes per year)
4a	Bullets for sports shooting (rimfire)	200 -400	0	6000 -7000
4b	Bullets for sports shooting (centerfire)	600 -900	0.35	14 000 to 16 000

D.3.2. Baseline

See main report

D.3.3. Alternatives

See main report

D.3.4. Restriction scenarios & proposed action

Table D.3-1 Restriction options for sports shooting with lead bullets

	Scenario	Comment
RO1	Ban on the **placing on the market** and **use** of **lead bullets** for sports shooting	No alternatives approved; Olympic and ISSF rules currently require the use of lead bullets
RO2	Ban on the **use** of **lead bullets** for sports shooting with a derogation conditional that the use takes place at permitted sites/facilities with permitting done by MS with annual reporting to COM where [*the risks to the environment (including wildlife and livestock) and humans (via the environment) are –minimised and*] the following OCs and RMMs are implemented: • Regular [*insert appropriate frequency*] lead bullet recovery with [≥90 %] effectiveness (calculated based on mass balance of lead used vs lead recovered) achieved by the means of bullet containment and a backstop berm covered with a roof and soil protection where needed (as described in the annex); AND • [Ban of any agricultural use within site boundary]	Effective (reduction of release less than 90 %), practicable, monitorable

RO3	Compulsory information to consumers (sports shooters) about the risk of lead in hunting education and labelling of risks of lead on the package at points of sale	Awareness raising could be achieved by information on the package of lead containing bullets.

In case of no regulatory action, business as usual would continue and 23 100 tonnes per years of lead would be released to the environment.

D.3.4.1. RO1: Ban of lead bullets for sports shooting

Effectiveness

This risk option would be effective because it would result in a 100 % reduction of lead release for sports shooting with bullets, it reduces the risks from lead for humans and the environment with risks from alternative(s) being much lower, and it introduce the least compliance burden (i.e. no specific environmental risk management measures required)

Practicality

A complete ban on placing on the market and use of lead bullets seems currently not be implementable because only few alternative bullets are available which are not (yet) approved by CIP.

Furthermore, the Olympic rules require the use of lead bullets. There are indications that alternatives may lack precision.

In addition, the risks from lead bullets in sports shooting can be minimised by using bullet containment.

Monitorability

The risk option would be implementable, easy to enforce and monitorable.

D.3.4.2. RO2: Ban of lead bullets with derogation for permitted sites

This risk option is a ban on the use of lead shot with derogation for ranges permitted by the Member State (with reporting to Commission) that have adequate risk management measures in place that allows a regular (at least one a year) recovery of lead bullets (>90 %), achieved by the means of bullet containment and a backstop berm covered with a roof and soil protection where needed.

This risk option would be closest to the condition under which existing Member States (such as Germany) are permitting the use of lead bullets at sites having in place best available risk management measures to minimise lead release. This risk option would also be closest to the requirements specified in the CSR.

Effectiveness

Bullet containment is an appropriate, efficient and effective measure to trap, regularly collect, and recycle lead bullets.

Required efficiency is >90 %, which would result in a release of lower than 2 310 tonnes per year. In practice, a suitable bullet containment allows up to 100 % recovery. Therefore, the calculated amount of lead not recovered of is expected to be a worst-case scenario and should in practice be lower.

A (backstop) berm covered with a roof and soil protection may for some disciplines be required for safety reasons in addition to a bullet containment but is not an appropriate containment on its own. This is because lead recovery from the soil of a berm requires recovery of lead from soil with the risk of lead mobilisation. Furthermore, lead recovery is far less than 90 % and there is a risk of surface water contamination that requires monitoring and treatment of surface water.

Even in case of 100 % lead bullet recovery, there are remaining risks for example from lead dust from shooting that is deposited on the ground of the range. Therefore, any agricultural use (including hay and silage production) within site boundary of the range is to be banned. A remediation plan at the end of service life is required according to the CSR (2020).

Practicality

In the CSR (2020) bullet containment is required. Also, in some Member States such as Germany appropriate bullet containment is a requirement.

Monitorability

This restriction option is monitorable because Member States would grant permissions for sites and facilities and would report to Commission that operational conditions and risk management measures are implemented, and the required recovery effectiveness is achieved.

The effectiveness of >90 % lead shot recovery will be ensured by reporting the annual rounds of shooting and calculation of the mass balance of lead used versus lead recovered.

D.3.4.3. RO3: Compulsory information

This RO requires compulsory information on the hazard/risk of lead, transition periods and availability of alternatives at point of sale and on product packaging. Individual cartridges should be indelibly labelled (contains lead (Pb) shot, for sports shooting only [at permitted sites]). It could be considered as a standalone measure, or in combination with any of the other ROs identified above.

Effectiveness

This risk option is not expected to lead to a significant reduction of unrecovered lead. However, by providing information on the hazard and risks of lead to the purchasing consumer, it is expected to be effective to increase awareness of the hazards and risk and to support the implementation of already recommended individual risk management measure to reduce individual lead exposure such as wearing face masks while shooting, changing clothes after shooting, hand washing after change of clothes.

It is also intended to enhance knowledge on the implementation of the restriction and encourage consumers to experiment with alternative ammunition.

Practicability

This risk option is practical because the information would be delivered at the point of sale to the customer.

Monitorability

It supports other risk options with regards to enforcement; especially the indelibly label that lead is contained will improve inspection and enforcement.

D.4. Lead in fishing tackle

D.4.1. Baseline considerations

D.4.1.1. Estimations of lead fishing tackle placed on the market in Europe

Lead sinkers and lures placed on the market

The lead fishing sinkers and lures placed on the EU market come essentially from two sources:

1) Lead fishing sinkers and lures manufactured within the EU27-2020
2) Lead fishing sinkers and lures imported from outside Europe

There is no overview, nor statistics available at the European level on the amount of lead in fishing sinkers and lures placed on the market in the EU27-2020, and the European Fishing Tackle Trade Association (EFTTA) representing the industrial sector does not hold such information either (Communication with EFTTA).

Similarly, there is no information available on the amount of lead fishing sinkers and lures imported to the EU27-2020, as the existing customs code[160] to identify the import of fishing tackle (#95079000) is not specific enough to differentiate the lead fishing sinkers and lures from all the other types of fishing tackle (e.g. poles, lines, fishing equipment).

To estimate the quantities in tonnes per year (tpa) imported and manufactured, plausible assumptions were made based on the information received via the call for evidence, and through the ECHA market survey. The assumptions made and quantities estimated are reported in Table D.4-1. The values presented in brackets present lower and upper bounds and can be used for sensitivity analysis if needed.

[160] Customs code are used in Eurostat database to report

Table D.4-1: Lead fishing sinkers and lures placed on the market in EU27-2020

Assumptions	Quantity [tpa]
Manufacturing in the EU: - Four EU manufacturers with a global market are each placing on the market ca 400 tpa of lead fishing sinkers and lures - Ten EU manufacturers with a local market are each placing on the market ca 50 tpa of lead fishing sinkers and lures - In every EU country (except DK where a ban is in place), ca. 1 tpa of lead fishing sinkers and lures would be manufacturing at smaller scale (home-casting, or casting by retailers)	1 300 tpa
Importing from outside EU: Based on the information in Table A.2-10, there is a 4.6 ratio (in value) between the imported fishing equipment and the one manufactured in Europe. This ratio was ca. 1 in 2000 (COWI, 2004). Even if the value imported/produced cannot be directly compared to the quantity imported/produced, and keeping in mind that the scope of the fishing equipment covered by the data in Table A.2-10 are broader than lead fishing sinkers and lures, the following plausible assumptions are proposed: - LOWER BOUND: quantity imported = twice the quantity produced in Europe - UPPER BOUND: quantity imported = four times the quantity produced in Europe	4 100 tpa (2 700 – 5 500)
Total quantity placed on the market in EU	5 400 tpa (4 000 – 6 800)

As a matter of comparison, in its 2004 report, COWI estimated that the quantity of lead consumption in EU25 for lead sinkers was between 2 500 and 6 000 tpa (COWI, 2004) The term 'consumption' is not defined in the COWI report, but the Dossier Submitter interprets this to mean 'placed on the market'.

Lead fishing nets, ropes and lines placed on the market

According to Table A.2-12, ca. 40 000 tpa of fishing nets are produced and imported yearly into the EU, while ca. 10 000 tpa are exported. This implies there are 30 000 tonnes of fishing nets placed on the EU market yearly. This tonnage estimate does not represent the tonnage of lead from fishing nets, ropes and lines placed on the market, as not all these fishing tackles are (fully) made of lead.

According to Tateda et al. (2014), fishing nets, ropes and lines might contain 30-60 % of lead. Based on these various assumptions, it is therefore estimated that the quantity of lead placed on the market in fishing nets, ropes and line is about 13 500 tpa (9 000 – 18 000 tpa).

D.4.1.2. Estimations of lead fishing tackle released to the environment

Available methodologies to estimate lead fishing sinkers and lure loss

There is not a unique and universal methodology to estimate the loss of lead fishing tackle to the environment. The Dossier Submitter identified different methodologies that are presented in Table D.4-2. In those methodologies, the quantity of lead fishing tackle is often determined 'indirectly' using different parameters. The use of one methodology versus another is dictated by the availability of data needed to use a methodology. For example, methodology #1 can only be used if one knows the average expenses for sinkers and lures per fisher and per year. Such information is not available at the European level for example and thus methodology #1 cannot be used.

Table D.4-2: Methodologies to estimate loss lead fishing sinkers and lures

#	Methodology	Description
1	Loss estimation based on the average expenses per fisher and year	This methodology assumes that the sinkers and lures are purchased annually by fishers in order to replace the lost ones ; thus the quantity of lead loss in the environment from lead fishing tackle can be estimated by monitoring the annual fishers expenses for lead fishing sinkers and lures. This methodology might over-estimate the quantity of lead lost in the environment. <u>Calculation</u>: Annual Loss = Number of fishers * average expenses for sinkers and lures per fisher per year * average retail costs of sinkers and lures
2	Loss estimation based on the quantity of lead placed on the market	This methodology assumes that the sinkers and lures are purchased annually by fishers in order to replace the lost ones ; thus the quantity of lead loss in the environment from lead fishing tackle can be estimated by monitoring the annual production and sales of lead fishing sinkers and lures. This methodology might over-estimate the quantity of lead lost in the environment. <u>Calculation</u>: Annual Loss = quantity placed on the market = quantity produced in Europe for the internal market + quantity imported
3	Loss estimation based on 'creel' surveys (i.e. fisher interview) or logbook entries	This methodology is based on fisher interviews or questionnaires upon their return after a fishing day, asking whether they had lost fishing sinkers and lures, and what was the average size of fishing sinker or lure lost. <u>Calculation</u>: Annual Loss = number of fishers * average loss per fisher per day trip * average weight of sinkers and lures lost * average number of fishing trip per year OR Annual Loss = number of fishers * average loss per fisher per year * average weight of sinkers and lures lost

4	Loss estimation based on 'diving excursions' or 'metal detection' campaigns	This methodology allows the estimation of lost lead sinkers and lures per m2 of a specific area. During a diving excursion or metal detection campaign, all kind of lost fishing tackle (weights, floats, hooks, fishing lines, etc.) are recovered by the searchers. The findings are then classified and quantified to estimate the amount of lost lead fishing sinkers and lures lost per m2 of a coastal area for example.

Sources: (Schroeder, 2010), literature search.

Literature review on fishing tackle loss

Table D.4-3: Estimation of lost lead fishing tackle in recreational fishing – literature review

#	Study	Year of the study	Geographical area	Scope	Estimated loss per fisher	Total estimated loss	Reasoning behind numbers
1	(Verleye et al., 2019)	2018	Belgium	Marine water only	700 g Pb/fisher/year	2 tpa of Pb	
2	(van der Hammen, 2019a)	2018-2019	The Netherlands	Fresh and marine waters	7.3 g Pb/fisher/year (freshwater) 43.2 g Pb/fisher/year (marine)	2.1 – 11.0 tpa of Pb (Average 7.3 in fresh) 12.2 – 32.0 tpa of Pb (Average 22.9 in marine)	Logbook
3	(Canada, 2018)		Canada		165 g Pb/fisher/year	462 - 500 tpa of Pb	Sales figure and estimated loss per fishers
4	(Marbouh, 2018)	2018	Morocco	Marine water Study area: 20 km of coast line	3.3 sinkers/km/day 3.8 sinkers/km/day	Extrapolation to Atlantic coastline (1835 km) 26.15 tpa of Pb	Interview with fishers
5	VBC Roerdal (2017)		The Netherlands	Freshwater	134 g Pb/fisher/year		
6	(Klein and Vink, 2013)	2013 - 2018	The Netherlands	Fresh and	60 g Pb/fisher/year	54 tpa of Pb	Recall

				marine waters	(freshwater) 135 g Pb/fisher/year (freshwater+high fishing frequency) 1 000 g Pb/fisher/year (marine)	(freshwater) 470 tpa of Pb (marine)	survey
7	Lassen et al. (2013)		Denmark		18 – 32 g Pb/fisher/year		
8	(Lloret et al., 2014)	2010 - 2012	Spain (Mediterranean coastal area)	Marine water Study area: 10.000 m²	0.049 sinkers/m² (2010) 0.076 sinkers/m² (2011)	38.460 kg of Pb (in 2010) 67.340 kg of Pb (in 2011)	Diving
9	(Department of Ecology, 2009) & (Schroeder, 2010)	2009	Washington	Fresh and marine waters	113 g Pb/fisher/year	63 tpa of Pb	
10	(Radomski et al., 2006)	2004	Minnesota, US	Freshwater	**15 lead fishing tackle lost per fisher/year** **Average lead weight of the lost fishing tackle: 11 g** **i.e. 165 g Pb/fisher/year**		Fishers interviews after fishing trip
11	(COWI, 2004)	2004	EU-25	Fresh and marine waters	100-300 g Pb/fisher/year	2 000-6 000 tpa of Pb	Survey

12	Andrusckiewicz et al. (2004)		Poland		1 – 5 sinker/fisher/fishing trip 1 277 g Pb/fisher/year		
13	(Scheuhammer, 2003)	1995	Canada US	Fresh and marine waters	Canada: 102 g Pb/fisher/year US: 113 g Pb/fisher/year	559 tpa in Canada 3 977 tpa in US	Sales figures
14	(Duerr and DeStefano, 1999)		United States	Shoreline (marine water)	0.01 - 0.47 sinkers/m² 0.03 - 13.57 pieces of fishing line/m² 0.01 - 0.30 hooks and lures/m² 0.02 - 0.06 other tackle items/m² (steel leaders, swivel hooks, floats, etc.).		Metal detector
15	(Duerr, 1999)		VS/Canada		0.18 sinkers/hour 0.23 lures/hour		Fishers interviews
16	Rijs (1996)					28 tpa of Pb (fresh) 26 tpa of Pb (marine)	Sales figures
17	(Scheuhammer and Norris, 1995)	1995			14 sinkers/fisher/year		Sales figures

18	Sears (1988)		UK, River Thames	Freshwater	1.0 – 16.3 sinkers/m^3 on the shore 0.9 – 6.2 sinkers/m^2 ≤1 m river sediment		
19	(Bell et al., 1985)	1985	Great Britain	Freshwater	2 to 3 sinkers per fisher per fishing day		Interview

Brief description of some studies:

STUDY 1 - (Verleye et al., 2019):

The study estimates the lead loss in Belgian marine waters based on a Dutch study (Van der Hammen (2016)) which estimates the Dutch fishing effort for different catches. Verleye et al. applies only a correction factor for the number of recreational sea anglers, then the lead loss for Belgium is estimated at more than 2 tonnes per year. Based on the estimated size of the recreational sea angler population, this amounts to 700 g of lead loss per angler per year. However, according to VLIZ (CfE #1034) this estimate does not take into account the technique-specific losses and should therefore be taken with caution.

STUDY 2 - (van der Hammen, 2019a):

This is a follow-up study to (Klein and Vink, 2013). The quantity of lead lost in the Netherlands is calculated using a different methodology. The assumptions are based on online screening (95 000 individuals) and logbooks. On the one hand the average lead lost per respondent is calculated and on the other hand the average lead loss for different fishing frequencies is determined. A previous study from Van der Hammen in 2016 estimated the number of recreational fishers for different fishing efforts (van der Hammen et al., 2016). These numbers of recreational fishers per fishing effort category were multiplied by the average lead loss per fishing effort category and ultimately added up. The total calculated amount of 7.3 tonnes of lead lost in freshwater (95 % CI: 2.1 – 11.0 ton) and 22.9 tonnes of lead lost in marine water (95 % CI: 12.2 – 32.0 ton) is considerable lower than the initial calculations of (Klein and Vink, 2013). Reasons for this were discussed: decreasing trend of recreational fishers in fresh and marine water; under- and overrepresentation of recreational fishers with high fishing efforts in (van der Hammen, 2019a) and (Klein and Vink, 2013) respectively; exclusion of deficient data points, weaknesses of methodologies used and small sample sizes. It is concluded/assumed that (Klein and Vink, 2013) constitutes an overestimate, whereas (van der Hammen, 2019a) constitutes an underestimate.

The study also reports the loss of lead per fishing trip (from the logbooks of 338 fishing trips): an average of 28 g lost per freshwater

fishing trip and an average of 130 g lost per marine fishing trip was determined.

STUDY 3 - (Canada, 2018):

The study uses as a starting point the results from the Radomski et al (2006) study which indicates that the average number of lead items lost by fisher is 15 per year, and the average weight per lost item is 11 g. Using these loss rates data and the total number of anglers in Canada (3.3 million in 2010), an estimated amount of lead lost in Canada was derived (500 tpa).

In addition, the Canadian study, as a matter of comparison, also use the total number of anglers in Canada, and the results from the 2017 National angler survey to provide an alternative estimate for the total uses and losses of sinkers and jigs in Canada. In this estimate, the average number of sinkers and jigs purchased per year, as reported to the angler survey (2017), is used as an estimate of the number of sinkers and jigs lost on average per angler each year. This approach assumes that sinkers and jigs are purchased to replace lost items. The estimated losses of lead to the environment is also adjusted, taking into account that not all anglers reported using lead sinkers and jigs. The angler survey results indicated indeed that 90 % of anglers use lead sinkers, and 65 % were aware that they used lead jigs. Using this methodology, the study reports an estimated amount of lead lost in Canada of 462 tpa.

STUDY 6 - (Klein and Vink, 2013):

The study estimates the amount of lead lost in fresh and marine water in the Netherlands. The calculation is based on a survey among readers of a sport fishing magazine (Visblad) that was conducted by Sportvisserij Nederland in 2008 (Brevé, 2009). Among the 1000 participants, in average 135 g of lead was lost per fisher per year in freshwater. As this reflects the loss of fishers with high fishing effort (30.7 days in comparison to the average of 13.7) the subsequent calculations were carried out with a rough estimate of 60 gr lead lost per fisher per year in freshwater. For marine water, the survey from 2008 determined an average loss of 1 129 g per fisher per year (only 49 marine recreational fisher participants). The value was rounded down to 1 000 g for the following calculations. In total, this study estimates 54 tonnes lead lost per year in freshwater and 470 tonnes lead lost per year in marine water. It is pointed out that the used input data does not entirely reflect the average Dutch recreational fisher.

STUDY 9 - (Schroeder, 2010) and (Department of Ecology, 2009):

In the Lead Chemical Action Plan the Washington State Departments of Ecology and Health gives estimates of the lead lost by recreational fishers in the state of Washington. The estimate is derived using the annual fishing licenses issued, with estimated 30 % thereof doing fly fishing and the assumption that every angler loses 4 ounces of lead (~113 g) per year. The total number of fishing weights lost annually is 63 tonnes (Schroeder, 2010) states 69 tonnes). It is not clear if the given estimate of 30 % fly fishers is subtracted from the total number of fishing licences issued or if 30 % of the fishing licenses issued are used as a base for the calculation. Total numbers of fishing licenses issued in Washington State seem to fluctuate. (Schroeder, 2010) states that the 30 % constitutes the ratio of fly fishers using lead. However, to the Dossier Submitter’s understanding of fly fishing, nowadays the majority seems to not use

lead in their flies, this might have been different in the past, though.

The Lead Chemical Action Plan gives a brief comparison of other estimates of lead lost in Washington State and furthermore, also estimated the costs to switch to non-lead shot and small fishing weight. For fishing, it was estimated an increase of costs by the factor of 1 - 4.5 depending on the material and type of weight used. The study looked into six different fishing weights including split shots and drop shots and considered metals like tungsten, brass, steel and tin.

STUDY 10 - (Radomski et al., 2006):

The study estimated the amount of lead lost in five Canadian large lakes using angler interviews to derive some of the assumptions used for the estimate calculation. It concluded on the following loss rates: 0.0081 large sinkers/hour, 0.0057 split shot sinkers/hour, 0.0247 jigs/hour, 0.0127 lures/hour and ~ 1 tonne of lead lost/6000 anglers/year.

The angler survey was conducted directly after the fishing trip. For five different categories of lead fishing tackle the loss per hour was estimated (Large sinkers, split shots, jigs, lures and hooks). The yearly average fishing tackle loss for every angler was in average 15 fishing lead items with an average weight of 11 g per lost item. These results were used by the Canadian governmental study (Canada, 2018) and the Moroccan research (Marbouh, 2018) as baseline for their estimate.

STUDY 11 - (COWI, 2004):

The study is calculating the amount of lead which is consumed yearly on the market – an underlying assumption seems that what is consumed equals what is lost in the environment. 'Consumption' is not defined in the report, but it seems to be understood as 'placed on the market'.

Estimations of the yearly lead fishing tackle consumption have been made in 7 EU countries: either based on domestic market estimation following manufacturers interview (CZ, DK, HU, UK) or based on lead fishing tackle loss estimates (NL), or based on estimations provided by national fishers associations (PL, SW). Based on the data for 7 countries, it was estimated an average 100 – 300 g/fisher/year loss of lead. This ratio was then extrapolated and applied to the estimated number of fishers (anglers) in Europe.

The study provides also estimated loss per capita, but this estimation was not retained by the Cowi study.

Estimated EU loss per capita was estimated to 4 500-13 500 tpa (vs estimated EU loss per fishers/anglers: 2 000-6 000 tpa).

STUDY 15 - (Duerr, 1999):

The study estimates the quantity of sinkers lost at 15 different sites with high angling effort in the United States (the shoreline and lake bottoms) by using a metal detector. A logistic model was developed in a previous study and used to correct the estimate (the model takes several factors that might affect the detection of sinkers into consideration (e.g. size and composition of the sinkers, depth the

sinker was buried, substrate type)). Additionally, interviews with anglers were conducted to determine the rate sinkers are lost (with around 800 interviews, including males, females, adults, children). The quantity of detected fishers was clearly dependent on the fishing effort. At not heavily fished vs. heavily fished shoreline areas the highest density was 0.01 vs. 0.47 sinkers/m², 0.03 vs. 13.57 pieces of fishing line/m², 0.01 vs. 0.30 hooks and lures/m² and 0.02 vs. 0.06 other tackle items/m² (steel leaders, swivel hooks, floats, etc.). At the shoreline, the use of the metal detector clearly showed that a high quantity of the sinkers were detected below the surface (detection of 12.7 % at the surface, 62.7 % at 0.1 – 2.5 cm deep, 16.1 % at 2.6 – 5.0 cm deep, 5.9 % at 5.1 – 7.1 cm deep, and 2.5 % at 7.6 – 10.0 cm deep. When sampling at the lake bottom, a similar trend was observed with 5 % detected at the sediment surface, 50 % at 0.1 – 2.5 cm deep, 25 % at 2.6 – 5.0 cm deep and 20 % at 5.1 – 7.5 cm deep. Results from the anglers' interview demonstrated for all sites combined (heavily and not heavily fished) a loss of 0.18 sinkers/hr, 0.14 pieces of line/hr, 0.23 hooks and lures/hr and 0.04 other tackle items/hr. […]

Table D.4-4: Estimation of lost lead fishing tackle in commercial fishing – literature review

Study	Year of the study	Geographical area	Scope	Total estimated loss [tpa of Pb]	Reasoning behind numbers
(COWI, 2004)	2004	EU-25	Commercial fishing only	2 000-9 000	Sales figures

Scenario developed by ECHA for the fishing sinkers and lures

Due to the limited information available at the European level, the methodology #3 (Loss estimation based on 'creel' surveys or logbooks) presented in Table D.4-2 was applied to estimate the amount of lead fishing sinkers and lures lost to the environment.

The methodology #3 was applied considering different assumptions for recreational fishing in freshwater and marine water. These assumptions and the final estimates associated to different scenarios (three) are presented in Table D.4-8. The lower estimated value for the scenario 1 based on the Van der Hammen (2019) study appears very low and does not seem plausible when compared to the study by Radomski et al. or the Canadian studies for example[161]. Indeed, it would mean that less than 20 g of lead is lost per fisher in an average year; this value is therefore not further considered.

After careful consideration of the various scenarios, the Dossier Submitter estimates that ca. **3 000 tpa (2 000 – 7 000)** of lead is released to the environment via the loss of lead fishing sinkers and lures. This value is used in the impact assessment. In addition, a sensitivity analysis is performed using the selected lower and upper boundary. Despite the level of uncertainties, this estimate seems plausible. 3 000 tpa of lead lost would indeed correspond to ca. 130 g of lead lost per fisher in an average year and represents ca. 50 % of the lead fishing tackle placed on the EU market each year.

Table D.4-5: Assumptions and estimations of lead fishing sinkers and lures released to the environment

				Source for the assumption
Assumptions applied to all scenarios				
Number of recreational fishers		23 Million		Appendix A
Number of marine recreational fishers		6.1 Million		
Number of freshwater recreational fishers		16.9 Million		
Scenario 1	*Low*	*Central*	*High*	*Source for the assumption*
Average loss per fisher in freshwater	7.3 g/fisher/year	34 g/fisher/year	60 g/fisher/year	Average loss low values from (van der Hammen, 2019a)
Average loss per fisher in marine water	43.2 g/fisher/year	522 g/fisher/year	1000 g/fisher/year	
Estimated yearly lost with scenario 1	**380 tpa**	**3 750 tpa**	**7 110 tpa**	Average loss high value from (Klein and Vink, 2013) Average loss central values is the average of low and high
Scenario 2	*Low*	*Central*	*High*	*Source for the assumption*

[161] Cf previous section - (Radomski et al., 2006) and (Canada, 2018) reporting 165 g of lead lost per fisher per year (freshwater).

				Source for the assumption
Average loss per fisher (g/fisher/year)	100	200	300	Average loss values from (COWI, 2004) Average loss central values is the average of low and high
Estimated yearly lost with scenario 2	**2 300 tpa**	**4 600 tpa**	**6 900 tpa**	
Scenario 3	*Low*	*Central*	*High*	*Source for the assumption*
Average loss per fisher (g/fisher/year)	113 g/fisher/year	139 g/fisher/year	165 g/fisher/year	Average loss low values from (Schroeder, 2010) Average loss high value from (Canada, 2018) and (Radomski et al., 2006) Average loss central values is the average of low and high
Estimated yearly lost with scenario 3	**2 500 tpa**	**3 000 tpa**	**4 000 tpa**	

Scenario developed by ECHA for the fishing nets, ropes and lines

Fishing nets, ropes and lines are used by fishers until they either cannot be repaired anymore or are abandoned, lost or discarded at sea. Because there is no available information, assumptions were made to gauge the quantity of lead contained in fishing nets, ropes and lines that are released yearly to the environment. These assumptions, and the final estimates are presented in Table D.4-6 below.

Table D.4-6: Assumptions and estimations of lead in fishing nets, ropes and lines released to the environment

Assumptions	Value	Source
Fishing nets, ropes and lines placed one the market	30 000 tpa It is assumed that the nets, ropes and lines are purchased annually by fishers in order to replace the lost, broken or disposed ones	Cf. section 0 - PRODCOM
Fishing nets, ropes and lines abandoned, lost or discarded in the environment	1/5 of the fishing nets, ropes and lines	(EU Commission, 2018)
Average proportion of lead in fishing nets, ropes and lines	45 % (30 % - 60 %)	(Tateda et al., 2014)
By 2025, 50 % of nets, ropes and lines currently abandoned, lost or discarded at sea should be collected	50 % reduction of abandoned, lost or discarded nets, ropes and line by 2025	SUP Directive (EU) 2019/904 [162] supported by Directive (EU) 2019/883
Estimated releases of lead from fishing nets, ropes and lines to the environment: **3 000 tpa (2 000 – 4 000) per year until the 2024** **1 500 tpa (1 000 – 2 000) per year from year 2025** **34 500 tonnes (23 000 – 46 000) over the 20-year study period**		

In conclusion, the Dossier Submitter finds that despite several uncertainties, the estimated releases of lead from fishing nets, ropes and lines to the environment seem plausible. For example, extrapolating the amount of lead in fishing nets, ropes and lines estimated by Sweden and Denmark (before the ban) to the European fishing fleet, and applying the same proportion of abandoned, lost or discarded fishing tackle (i.e. 20 %), similar release estimates are obtained.

D.4.1.3. Existing EU member state legislation

EU wide action on fishing tackle

The newly adopted EU 'Single Use Plastic and Fishing Gear' Directive (EU) 2019/904 (aka SUP directive) is addressing the issue of fishing gear[163] that is lost or intentionally disposed on the sea. The SUP Directive sets an extended producer responsibility (EPR) schemes which aims for the fishing gears at setting a minimum collection rate of 50 %

[162] https://www.europarl.europa.eu/legislative-train/theme-new-boost-for-jobs-growth-and-investment/file-single-use-plastics-and-fishing-gear-reducing-marine-litter-from-plastics

[163] 'fishing gear' is defined in (EU) 2019/904 as 'any item or piece of equipment that is used in fishing or aquaculture to target, capture or rear marine biological resources or that is floating on the sea surface, and is deployed with the objective of attracting and capturing or of rearing such marine biological resources'.

and a recycling target of 15 %, both to be met by 2025. The SUP Directive is also requesting the development of a standard on the circular design of fishing gear, and the duty for Member States to organise and put in place Awareness Raising activities.

Even if the directive is initially intended to reduce plastic waste and is targeting fishing gear containing plastic/polymer (cf. Article 2 of SUP Directive), the scope and intention of the SUP Directive is broad enough to impact in a positive manner the nets, ropes and lines made of both plastic and lead.

National ban on the use of lead in fishing tackle

Table D.4-7: National ban on lead in fishing tackle (EU members)

Country	Scope	Entry into force
Denmark	According to the 'lead act', fishing tackle for angling may not be **imported and sold if it contains lead in a concentration higher than 0.01 %.** This applies both to **recreational fishing, and to commercial fishing (sinker, lines and cables)**. The act entered into force in 2002 for the recreational fishing tackle. Various transitional periods were applied to the commercial fishing equipment (EiF between 2007 and 2012). The ban prohibits the import and sale, but not the use. Recreational fisher may legally have only three sinking lines/yarn on board of their fishing vessel. Source: Danish Statutory Order no. 856 of 5th September 2009 https://eng.mst.dk/media/mst/69075/Blybekendtg%C3%B8relse%20-%20BEK%20nr%201082 %20af%202007 %2009 %2013 %20oversat%20til%20engelsk.pdf	2002

In addition to the Danish national ban, some voluntary actions to limit the use of lead fishing tackle are taking place at national level.

Table D.4-8: Voluntary actions on lead in fishing tackle (EU members)

Country	Scope	Start date
Belgium	The national programme of measures for Belgian marine waters (Measure 29D) implementing the Marine Strategy Framework Directive (2008/56/EC) is promoting alternatives to lead fishing weights. The Federal Action Plan for marine litter (Belgian State 2017) proposes, in line with the above measure, encouraging the introduction of alternatives to lead fishing weights.	2015
The Netherlands	In 2018, the Green Deal (GD) 222 'Non-lead recreational fishing' was concluded in the Netherlands. This GD aims to reduce the use of lead weights in recreational angling, including self-casting, by 30 % by 2021 and to phase them out completely by 2027. In addition, efforts will be made towards the supply and promotion of sustainable alternatives to lead fishing weights. An evaluation of the GD is planned for 2021 to determine whether the voluntary agreements between the participating parties are achieving the desired results and whether any additional measures can be formulated to achieve the stated objectives.	2018
Sweden	Some voluntary local bans on the use of lead sinkers exists in some rivers.	-

Sources: CfE #909, #1034, and #1247

Other non-EU legislation

Table D.4-9: Non-EU ban on lead in fishing tackle

Country	Scope	Entry into force
United Kingdom	Ban both on the **import and the sale** of **fishing weights between 0.06 g (number 8 split shot) and 28.35 g (1 oz)** - Larger weight were thought not to be a serious risk to birds and those below 0.06 g were permitted because they were small and non-lead weights of this size could not be manufactured at that time. Source: Control of Pollution (Anglers' Lead Weights) Regulations 1986 - 21st November 1986[164] amended in 1993[165]	1987
England and Wales	Ban on the **use** of fishing weights between **0.06 g (number 8 split shot) and 28.35 g (1 oz)**. There is not a single, Environment Agency (EA) national byelaw (i.e. local rules) regarding the use of lead to weight angling lines. Instead, there are eight regional byelaws, each in force in a particular EA region in England and Wales. Lead may not be used to weight fishing lines, but lead incorporated into fishing line, or a fishing lure for example are all exempt from the legislation. Source: ECHA market survey, EFTTA	1987

D.4.2. Conclusions on alternatives for sinkers and lures

Technically feasible alternatives to lead are widely available on the market. A number of recent studies (Canada, 2018, Thomas, 2019) describe and assess the existing alternatives to lead in terms of composition, price and market acceptance. These assessments comprise thirteen alternatives[166]:

- Bismuth
- Brass
- Bronze
- Ceramic/Glass
- Copper
- Concrete
- High density polymer
- Stainless Steel / Rebar
- Stones or pebbles
- Tin

[164] https://www.legislation.gov.uk/uksi/1986/1992/made

[165] https://www.legislation.gov.uk/uksi/1993/49/made

[166] The comment CfE #1034 from the call for evidence is referring also to 'coated lead' marketed as an 'alternative to lead'.

- Tungsten
- Zamac
- Zink

The Dossier Submitter undertook a market survey between June and September 2020 to identify the available alternatives on the European market. This section presents a summary of the latest review and information available.

D.4.2.1. Technical feasibility of alternatives

This chapter presents the outcome of the assessment on the technical feasibility of alternative both to replace lead in the fishing tackle, but also the technical feasibility of the alternatives for the manufacturers of fishing tackle.

Technical function and key properties of lead

The main functions of lead in fishing tackle is to provide additional weight in order to (i) cast and set the bait or lure at a certain location and distance (up to 200 m), and/or to (ii) sink the immersible fishing tackle e.g. the line and fishing hook, or the net, while allowing fishing (CfE #1034).

In addition, the following properties of lead are the main reasons why lead is so broadly used in fishing tackle.

Table D.4-10: Main physical properties of lead and associated functionality

Physical property	Associated functionality	Lead
Density/mass	Minimise the dimensions of the fishing tackle to improve the distance and accuracy of the casting and provide mass to the fishing line so it can stay in the desired location/position.	HIGH 11.34 g/cm^3
Hardness	Impact on the feel and noise.	SOFT (Mohs scale: 1.5)
Ductility [1]	Important for split shot applications, i.e. to pinch the split shot on a fishing line and remove it if needed.	LOW
Malleability [2]	Important for split shot applications, i.e to pinch the split shot on a fishing line and remove it if needed.	HIGH
Melting point	Possibility for home-casting.	LOW - 327°C
Corrosion resistance	Use in salty marine water.	HIGH
Appearance	A smooth finish would avoid the cut or wear of the fishing line.	Smooth appearance

Note: [1]: Ductility is a measure of a material's ability to undergo significant plastic deformation before rupture or breaking, which may be expressed as percent elongation or percent area reduction from a tensile test.

[2]: Malleability, a similar property as ductility, is a material's ability to deform under compressive stress; this is often characterized by the material's ability to form a thin sheet by hammering or rolling. Both of these mechanical properties (ductility and malleability) are aspects of plasticity, the extent to which a solid material can be plastically deformed without fracture. Also, these material properties are dependent on temperature and pressure.

It should be noted that the importance of lead properties varies according to the type of fishing tackle application and sometimes the fisher's preference as well. For example, malleability and softness are key for split shot sinkers applications, while hardness might be preferred for other types of sinkers, since hard materials make noise that is said to attract some fish.

Technical assessment of the alternative raw material to replace lead

Table D.4-11 compares the main physical properties of lead and its alternatives.

Density/mass:

In order to allow a good casting of the fishing line and maintain it in the desired position, sinkers and lures need to be small and heavy. For that, it needs to have the highest weight in the smallest volume (i.e. a high density). In addition, for some fishing applications, smaller sinkers or lures are desirable because they are less likely to get hung up on obstacles and less likely to be seen by the fish. For other applications, an increase in the sinker or lure size can reduce snags because larger sinkers slide over cracks that smaller sinkers could get caught in.

Ceramic, concrete and stones are the least dense material. With a density of approx. 2. g/cm^3, it means that a sinker/lure made of one this substance must be more than three times the volume of a lead sinker/lure in order to achieve a given mass.

The densities of zamac (6.6 g/cm^3), zinc (7.1 g/cm^3), tin (7.3 g/cm^3), stainless steel (7.9 g/cm^3), copper and its alloys (bronze and brass), and bismuth (9.8 g/cm^3) are all less than that of lead. For bismuth sinkers and lures, a relatively small increase in volume (16 %) will achieve the same mass as a lead sinker/lure. The other alternative sinkers/lures must be between 30 % and 71 % larger in volume respectively than lead sinkers/lures for a given mass. For many applications, these differences in sizes are not significant enough to affect performance, but when considering medium to heavy sinkers and lures the applications seem more limited due largely to their relatively low densities by comparison to lead.

High density polymer may achieve a density similar to lead which make an interesting substitute to fulfil the mass/density criteria.

The density of tungsten (19.3 g/cm^3) is significantly higher than lead and therefore, for a given mass, tungsten sinkers are 41 % smaller in volume than lead sinkers for a given mass, which is desirable for applications that benefit from small sinker size. Tungsten as a putty could for example be used to replace lead split shot affixed on the fishing lines.

Hardness:

The hardness of a sinker or a lure can affect performance in several ways. Sinkers and lures made from hard materials are less likely to deform when they hit rocks or other hard objects. Hard sinkers also make more noise when they contact rocks or other hard objects, which might be desirable in some application because the noise can attract fish. Hard sinkers may be also more resistant in some cases since they tend to bounce off a

snag.

Lead has a hardness of 4.2 on the Brinell scale and a hardness of 1.5 on the Mohs' scale, which makes it softer than all of the alternative materials except pure tin. Pure tin has a Brinell hardness of 3.9, and Mohs hardness of 1.5. Bismuth and tin alloy are somewhat harder than lead while ceramic, stainless steel and tungsten sinkers and lures are significantly harder than lead.

Malleability (and ductility):

Soft, malleable raw materials are the preferred option for fishing tackle applications where the tackle is pinched onto the fishing line, such as split shot sinkers. Lead is a soft, highly malleable metal, it has also a low ductility, i.e. lead can undergo significant plastic deformation before rupture or breaking. These physical properties allow to pinch the split shot on a fishing line but also to remove it if needed for re-use on a different line.

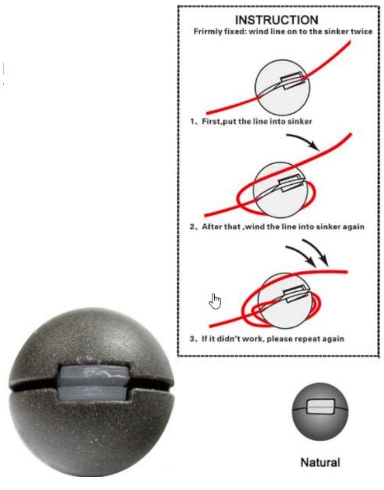
Copper and its alloys (bronze and brass) are malleable, but less than lead.

Bismuth is malleable but it has a higher ductility and therefore would be likely to crack if used for split shot sinkers.

Ceramic is not malleable and is relatively brittle (lack of ductility) so it is not a candidate for split shot sinkers.

Due to their limited malleability, steel and pure tungsten are not good candidates for split shot applications. Nevertheless, tungsten could potentially be used for split shot applications[167] in limited size/weight ranges, and could be fixed on the fishing line using 'knotting' rather than 'clamping' (as for lead split shots) as shown in Figure D.4-1.

Figure D.4-1: Tungsten split shots ('knotted' on the fishing line)



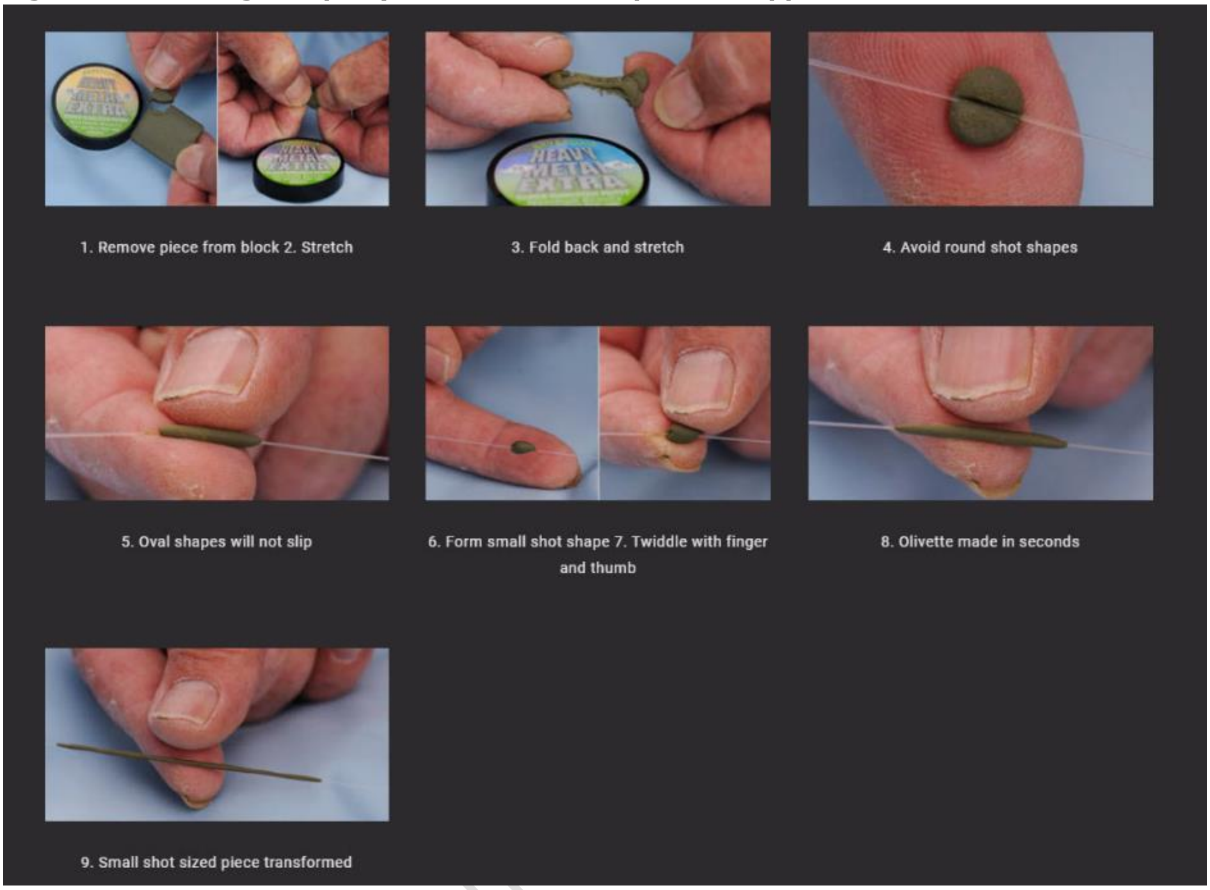
Source: image from Made-in-China.com website

On the contrary, tungsten putty, which is a 'dough' made of tungsten and a polymer powder, is extremely malleable and ductile and could also be used as an alternative to lead split shots: small quantity of tungsten putty can be warmed up and moulded with fingers and then applied and removed easily from fishing line as shown on . Tungsten putty does not harden when drying.

[167] No concrete example found on the EU market of such an application. Examples exists on the US market, and from

Tin is malleable like lead and frequently used for split shot applications (ECHA market survey (2020)). However, tin is less ductile (more brittle) than lead which might cause tin split shot sinkers to break particularly if the sinkers are reused.

Figure D.4-2: Tungsten putty – alternative to split shot applications



Source: https://www.kryston.com/getting-the-best-from-heavy-metal/

Melting point:

The low melting point of lead (327° C) makes it possible for fishers to mould and home-cast their own lead sinkers and lures at home. The low melting points of bismuth, brass, tin, zamac and zinc, ranging from 232° C to 420° C, make home-casting feasible.

On the other hand, the high melting point of bronze, copper, stainless steel and tungsten, ranging from 950° C to 3 400° C, prohibit the home-casting of sinkers and lures with these raw materials.

The production of ceramic products requires also firing at temperatures exceeding 760°C, so home production of ceramic sinkers would not be feasible.

The home-production of high-density polymer sinkers and lures could be feasible using 3D printing technology.

Sinkers or lures made of concrete, or with stones/pebbles could be manufactured at home (DIY), as the production of these types of material do not require complex equipment.

Corrosion resistance:

Corrosion resistance is a key physical property of fishing sinkers and lures to be used in saline marine water. The identified alternatives are in general corrosion resistant

materials. It should be noted that to be used an alternative for fishing tackle applications, carbon steel would need to be coated with corrosion preventive coating or special treatment, otherwise it will rust. Zinc is also reported to 'rust' more easily than lead.

Appearance:

Lead has a versatile appearance; it can be matte or looks shiny after polishing. A shiny appearance can be a positive asset in certain types of fishing tackle application, but in other cases, such as fishing in clear water, a matte aspect might be preferred for the lead sinker or lure.

Copper and its alloys (bronze and brass), stainless steel, tungsten, zinc and zamac sinkers and lures can be produced both with matte and with shiny, bright surfaces.

Coated lead, ceramic, concrete, high density polymers, stones and pebbles sinkers and lures are usually matte and tin split shots appears shinier than their lead equivalent.

Table D.4-11: Comparison of the main physical properties of lead and its alternatives

	Density [g/cm3]	Hardness	Ductility/ Malleability	Melting Point [°C]	Corrosion Resistant	Appearance
Lead	11.3	Soft Mohs: 1.5 Brinell: 4.9	High malleability Low Ductility	327	Yes	Versatile (matte or shiny)
Coated lead	11.3	Soft	=	327	=	-
Bismuth	9.8	Mohs: 2.5 Brinell: 7	-	271	=	-
Brass	8.7	Mohs: 3 - 4	-	232	=	=
Bronze	7.7 to 8.7	?	-	950	=	=
Ceramic/Glass	2 to 6	Mohs: 7.5	-	> 760	=	-
Copper	9	Mohs: 2.5 - 3	-	1 085	=	=
Concrete	2.3	?	-	N.A.	=	-
High Density polymer	up to 11	?	-	N.A.	=	-
Stainless Steel	7.9	Brinell: 123	-	1 510	=	=
Stones/pebble	1.6	?	-	N.A	=	-
Tin	7.3	Mohs: 1.5 Brinell: 3.9	=	232	=	-
Tungsten	19.3	Brinell: 294	= (for putty only)	3 400	=	=
Zamac	6.6	?	-	380	=	=
Zink	7.1	Mohs: 2.5	-	420	-	=

Legend:

?	*Unknown*
=	*Similar to lead*
+	*Better than lead*
-	*Worse than lead*

Technically feasibility of the manufacturing process (manufacturing of fishing tackle using alternative raw material)

As described in Appendix A, lead fishing sinkers are manufactured by pouring molten lead into moulds of various sizes and shapes, and jigs and jig heads are commonly produced using spin casting.

From a technical point of view, it is possible to switch existing lead sinkers and lures production equipment to manufacture sinkers or lures with alternative raw materials that have similar properties (such as melting point, malleability, hardness). For example, moulding process and equipment to produce lead fishing sinkers and lures could also be used to process metals with low melting point such as zamac, bismuth or tin, although different moulds may be required due to the different densities of the raw material compared to lead.

The production of tin split shot may require greater precision than the production of lead split shot to prevent damage to the fishing line from the hard edges on tin sinkers.

Bismuth expands as it solidifies and therefore may require the use of high-quality milled moulds (Scheuhammer and Norris, 1995). Due to their low melting point, bismuth, tin or zamac sinkers and lures could also be manufactured by individuals at home using lead sinker/lure moulds.

Manufacturers switching from lead to stainless steel would be required to make significant capital investments in equipment. The high melting point and hardness of steel make it impossible to manufacture stainless steel sinkers using a moulding operation. Stainless steel sinkers can be produced using machining operations. An alternative to investing in steel machining equipment would be to transfer the production of the stainless-steel sinkers and lures to a supplier with steel machining capabilities. It should also be noted that stainless steel can be easily machined into symmetrical shapes (e.g. egg sinkers, bullet or worm weights) but machining steel into non symmetric shapes (e.g. pyramid) might be more complicated – this might limit the available shapes and configurations of stainless steel sinkers. Sinkers can also be made of carbon steel but would need to be coated to prevent corrosion.

Ceramic sinkers are produced in a mould and then fired in a high temperature furnace. In a similar way as steel, the production of ceramic fishing tackle could be done by companies specializes in the production of ceramic elements.

While tungsten sinkers can be produced using a moulding operation, the high melting point of tungsten (3 400°C) eliminates the possibility of switching lead sinker and lure moulding equipment to tungsten sinker and lure production. A switch from lead to tungsten would require significant capital investment unless the tungsten sinkers were produced by companies already processing tungsten. It should be noted that pure tungsten can be forged or extruded as well. Tungsten powder can also be mixed with a polymer-based dough to produce tungsten putty, the manufacturing of this alternative does not seem to require complex equipment other than mixing tank and equipment.

Tungsten jig heads are generally manufactured by injection moulding; some machining and soldering may also be needed depending on the complexity of the final jig.

Regarding the energy needed to produce alternative sinkers and lures, the lower melting point of bismuth and tin does not imply lower energy costs than those for equivalent lead sinker production. On the contrary, tin, bismuth and zamac will induce higher energy cost than lead for melting them. Indeed, to calculate the energy to melt a metal,

other parameters than the melting point have to be taken into account: specific heat constant, specific latent heat of fusion.

The high melting point, specific heat constant and specific latent heat of fusion of tungsten, steel but also ceramics, result in even much higher production costs because of the energy costs and the long cooling times. Table D.4-12 provides an overview of the energy needed to melt lead and various alternatives.

Table D.4-12: Energy needed to melt different raw material

Substance	Melting point [°C]	Specific heat constant [kJ/kg.°C]	Specific latent heat of fusion [kJ/kg]	Energy to melt 1 tonne [kJ]	Energy to melt 1 tonne [kWh]
Lead	327	0.129	22.4	62 003	17.22
Bismuth	271	0.13	52.2	84 830	23.56
Tin	232	0.24	59	109 880	30.52
Zamak 5	380	0.419	110	260 840	72.46
Tungsten	3400	0.132	190	636 160	176.71
Steel (SS)	1510	0.468	500	1 197 320	332.59
Steel (carbon)	1425	0.49	481	1 169 450	324.85

As mentioned before, there are a wide variety of shapes, sizes and styles of sinkers and lures, each of them is designed to meet specific fishing requirements which depend on the type of fish, water and bottom conditions, fishing technique, but also fisher preference. The manufacturing process should therefore allow the production of a huge variety of shapes.

D.4.2.2. Risk reduction capacity of alternatives

Detailed information on human health and environmental hazard of the alternatives are available in Appendix C.

D.4.2.3. Availability and prices of alternatives

Results of the ECHA 'mystery shopping' exercise

The availability and price of the raw material that could be used to replace lead is discussed in section C.2. This section is only focussing on the availability and price of the final products, i.e. the fishing tackle. It is based essentially on information collected during the ECHA market survey, and in particular through a mystery shopping exercise performed between June and September 2020 (cf. Appendix E.4).

Information on fishing tackle type, name and reference, description including weight and

alternative material, manufacturer, manufacturing site location (when available), price, were collected from multiple websites placing fishing tackle on the European market. The data collected do not represent the full market of alternatives, but with almost 1 000 different entries recorded and representing 40 different brands, this market survey database is likely the most accurate overview of the EU market of non-lead fishing tackle.

Except for the split shots, prices of sinker or lure are expressed per tonne rather than unit or package to facilitate the comparison between the different alternatives.

Split shot sinkers

More than 10 different alternatives to lead split shots were identified in essentially three different formats:

- Tin split shots in different shapes and sizes
- Tin styl in different sizes
- Tungsten putty to be moulted on the fishing line (cf. Figure D.4-1)

Tin split shots from size 3SSG (the biggest split shot size – i.e. 4.8 g) till size n°6 (i.e.0.1 g) are commonly available as they are the size of lead split shots banned from being placed on the market in UK. The main manufacturer of tin split shot is located in the UK.

The smallest size of tin split shots identified during the ECHA market survey is a size #8 (i.e. 0.06 g). In addition, tin styls that can also be used as lead split shot alternative are available up to size n°12 (i.e. 0.02 g).

There was no alternative found for the smallest dust split shot (i.e. size n°13 – 0.01 g), but the use of a single split shot size n°13 on a fishing line is questionable. Indeed, as a rule of thumb 1 g of fishing split shot is needed on a fishing line per foot[168] of water depth.

The prices of the alternatives (box of split shots or tungsten putty) ranges from €4.4 to €13.3. A box of tin split shots is in average three times more expensive than the lead version, and there seems to be also less split shots per box in the non-lead version as shown on Figure D.4-3.

Tungsten putty’s box price ranges between €7 and €12 depending on the brand (exact weight contained in the packaging could not be determined).

[168] 1 foot = 0.3 m.

Figure D.4-3: price difference between lead (on the right-hand side of the picture) and non-lead split shots

Source: personal shopping from the Dossier Submitter – picture taken in December 2019 in a retailer shop in France

<u>Sinkers</u>

Almost 600 non-lead sinkers were identified in various shapes and sizes. This represents ca. 60 % of the alternatives identified during the ECHA mystery shopping. It was not always possible to identify systematically the alternative material used to replace lead. In some cases, the non-lead sinkers are marketed as 'lead-free', 'non-lead' or 'non-toxic' without any additional details. Tungsten and tin ranked among the most popular alternative for the sinkers ≤ 50 g (see Table D.4-13 and Table D.4-14 for the list of non-lead material).

The following alternatives were identified:

- Bismuth
- Brass
- Copper
- Concrete
- High density polymer
- Stainless Steel
- Stones or pebbles
- Tin
- Tungsten
- Zamac
- Zinc

None of the alternative sinkers identified during the ECHA market survey was found to contain bronze, or ceramic but as many non-lead sinkers had no specific information on their composition, it is not possible to conclude if these raw materials are used or not in Europe as an alternative to lead in the manufacturing of sinkers.

Figure D.4-4 presents the distribution of non-lead sinkers according to their weight. There are more options available on the market for sinkers ≤ 50 g.

Figure D.4-4: repartition of non-lead sinkers per weight

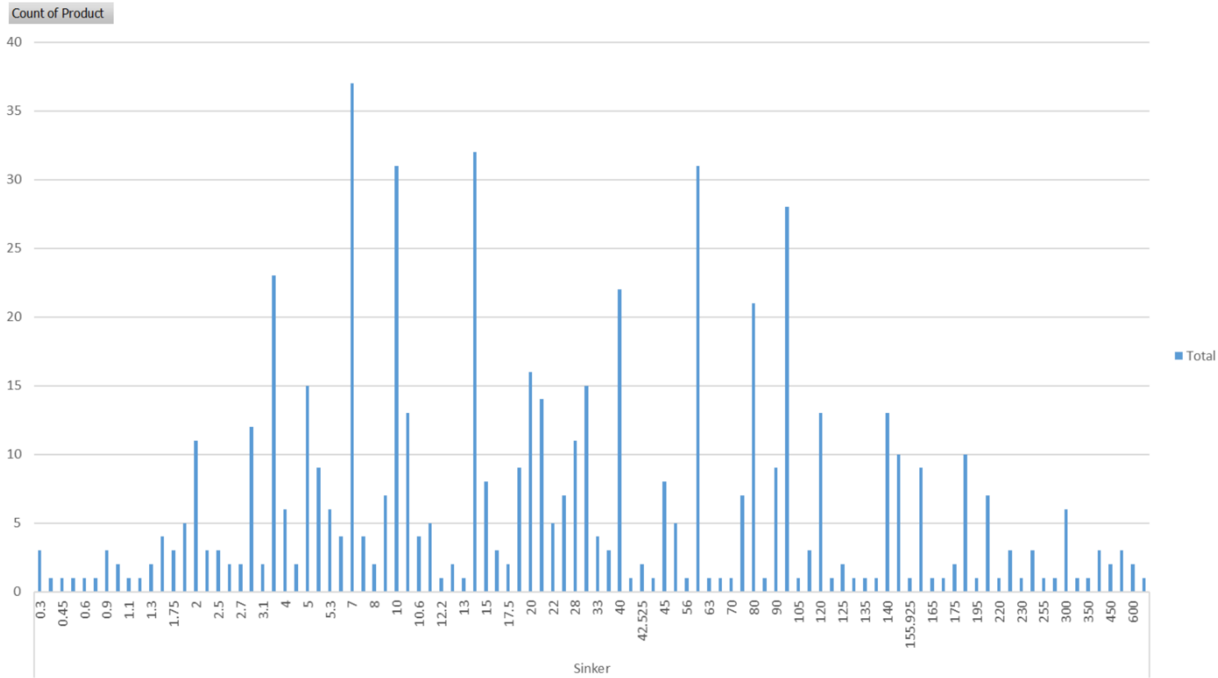


Table D.4-13 and Table D.4-14 present an overview of the alternative raw material, and the retailing price of the non-lead sinkers, i.e. the price paid by the consumer in the shop or on Internet. It should be noted that sinkers ≤ 50 g tend to be more expensive than those > 50 g.

Table D.4-13: Non-lead sinkers ≤ 50 g – overview of alternative material and retailing prices

Alternative	Count	Lowest retailing price [€/t]	Average retailing price [€/t]	Highest retailing price [€/t]
Tungsten	154	213 000	445 000	4 900 000
Tin	93	28 000	107 000	617 000
Non-lead (material not specified)	90	23 000	114 000	366 000
Steel or steel alloy	25	35 000	93 000	322 000
Composite (lead-free)	14	52 000	123 000	268 000
Natural stone	10	32 000	105 000	238 000
Brass	7	122 000	245 000	557 000
Heavy concrete	4	23 000	25 000	27 000

Zinc	3	88 000	161 000	263 000
Bismuth	2	221 000	282 000	342 000
Concrete	2	45 000	48 000	50 000
Total Sinkers	**404**	**23 000**	**239 000**	**4 900 000**

Table D.4-14: Non-lead sinkers > 50 g – overview of alternative material and retailing prices

Alternative	Count	Lowest retailing price [€/t]	Average retailing price [€/t]	Highest retailing price [€/t]
Non-lead (material not specified)	98	14 000	26 000	57 000
Steel or steel alloy	30	6 000	28 000	111 000
Composite (lead-free)	18	14 000	29 000	58 000
Tin	18	22 000	26 000	33 000
Heavy concrete	15	9 000	14 000	20 000
Natural stone	11	5 000	11 000	23 000
Zamac	6	11 000	12 000	14 000
Zinc	6	66 000	77 000	89 000
Mineral	5	25 000	32 000	42 000
Cast iron	3	14 000	18 000	22 000
Concrete	2	22 000	24 000	25 000
Tungsten	2	221 000	226 000	231 000
Copper	1	21 000	21 000	21 000
Total Sinkers	**215**	**5 000**	**28 000**	**231 000**

When looking at the ratio between the price of the raw material, and the average retailing price of the fishing sinker of similar weights (i.e. 50 g ≤ and > 50 g), the ratio is in the same order of magnitude for lead and tungsten (Table D.4-15). This ratio suggests that, when looking at the highest price, there might be a substantial mark-up on the retailing price for some high-end prices of tungsten sinkers. Considering for example the highest retailing price for tungsten sinkers ≤ 50 g, the calculated ratio between the raw material and the retailing price is 196, i.e. ten times higher than the ratio for the average retailing price of tungsten sinkers.

Table D.4-15: Ratio between raw material and retailing prices

	Raw material price [€/t]	Average retailing price [€/t]	Ratio (average retailing price/ raw material price/)
Lead sinker ≤ 50 g	1 500	30 000	20
Tungsten sinker ≤ 50 g	25 000	445 000 (213 000 – 4 900 000)	18 (9 – 196)
Tin sinker ≤ 50 g	15 000	107 000 (28 000-617 000)	7 (2 – 41)
Lead sinker > 50 g	1 500	15 000	10
Tungsten sinker > 50 g	25 000	226 000	9
Tin sinker > 50 g	15 000	26 000 (22 000 – 33 000)	2 (1.5 – 2.2)

Lures (trolling spoon, jig, jig head, wobbler, fly etc.)

Non-lead lures were identified in various shapes and sizes during the ECHA mystery shopping to replace lead. It was not always possible to identify systematically the alternative material used to replace lead. In some cases, the non-lead lures are marketed as 'lead-free', 'non-lead' or 'non-toxic' without any additional details.

Tungsten ranked among the most popular alternative for the sinkers ≤ 50 g and is used in various types of lures (cf. example below in Figure D.4-5).

Lead is being phased out from lures by the major manufacturers, except for the jigs, and jig-head where lead still dominate the market.

Figure D.4-5: Alternative to lead (tungsten) in fishing lure (hard lure)

Source: Reproduction from Tukana fishing (online magazine)

The following alternatives were identified:

- Brass
- Composite
- Stainless Steel
- Tin
- Zinc

Figure D.4-6 presents the distribution of non-lead lures according to their weight. There are more options available on the market for sinkers ≤ 50 g, which can be explained by the main function the lure, which is to attract fish.

Figure D.4-6: repartition of non-lead lures per weight

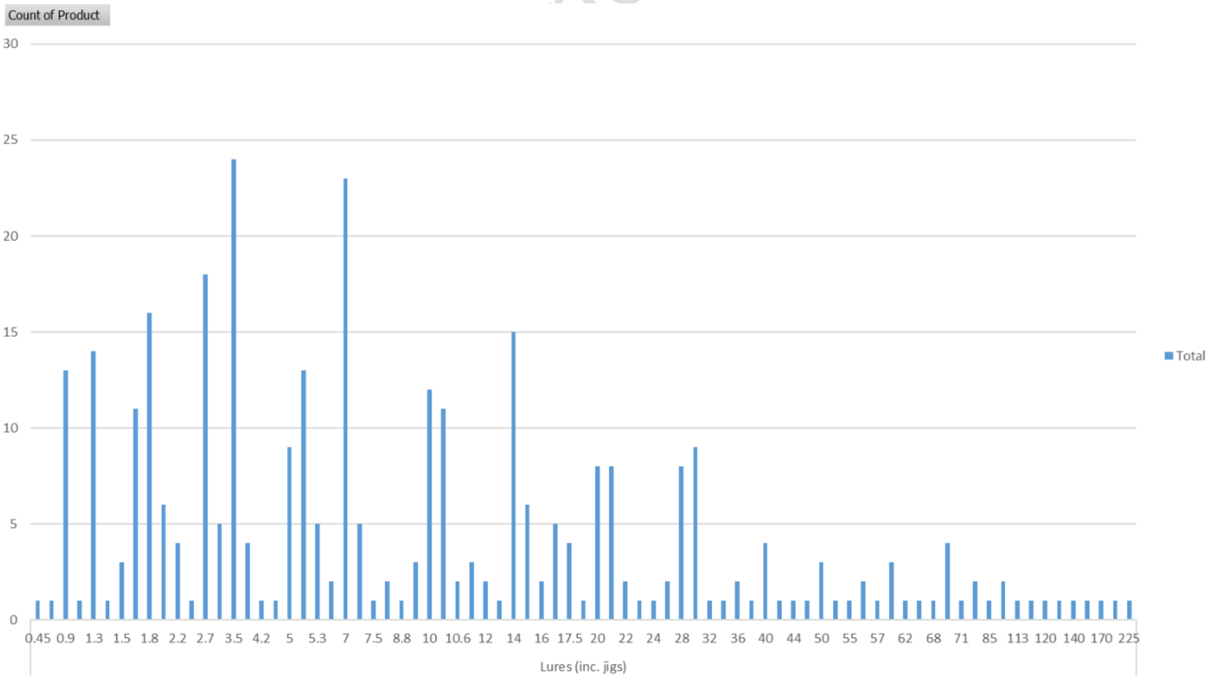


Table D.4-16 and Table D.4-17 present an overview of the alternative raw material, and the retailing price of the non-lead lures, i.e. the price paid by the consumer in the shop or on Internet. Similar to the observation made for the sinkers, it should be noted that lures ≤ 50 g tend to be more expensive than those > 50 g.

Table D.4-16: Non-lead lures ≤ 50 g – overview of alternative material and retailing prices

Alternative	Count	Lowest retailing price [€/t]	Average retailing price [€/t]	Highest retailing price [€/t]
Tungsten	209	248 000	729 000	5 000 000
Non-lead (material not specified)	46	39 000	279 000	1 500 000
Zinc	14	125 000	223 000	318 000
Composite (lead-free)	12	76 000	154 000	390 000
Tin	11	62 000	114 000	198 000
Steel or steel alloy	6	50 000	127 000	265 000
ABS plastic	4	374 000	734 000	1 265 000
Brass	3	167 000	181 000	208 000
Total	**305**	**39 000**	**576 000**	**5 000 000**

Table D.4-17: Non-lead lures > 50 g – overview of alternative material and retailing prices

Alternative	Count	Lowest retailing price [€/t]	Average retailing price [€/t]	Highest retailing price [€/t]
Zinc	20	67 000	106 000	140 000
Non-lead (material not specified)	9	59 000	161 000	285 000
Composite (lead-free)	3	46 000	63 000	87 000
Tin	1	56 000	56 000	56 000
Total	**33**	**46 000**	**115 000**	**285 000**

Wire for fly fishing

There are heavy wires and line, essentially used for fly fishing that are labelled ‘Non-toxic – non-lead’. Tungsten is used instead of lead in these lines. Both lead and non-

lead lines are sold in some shops, while others have completely gone over to non-lead fishing lines. During the round table event, the German fishing association also confirmed that lead has almost totally disappeared from this type of application in Germany.

Non-lead wire is twice more expensive than lead wire.

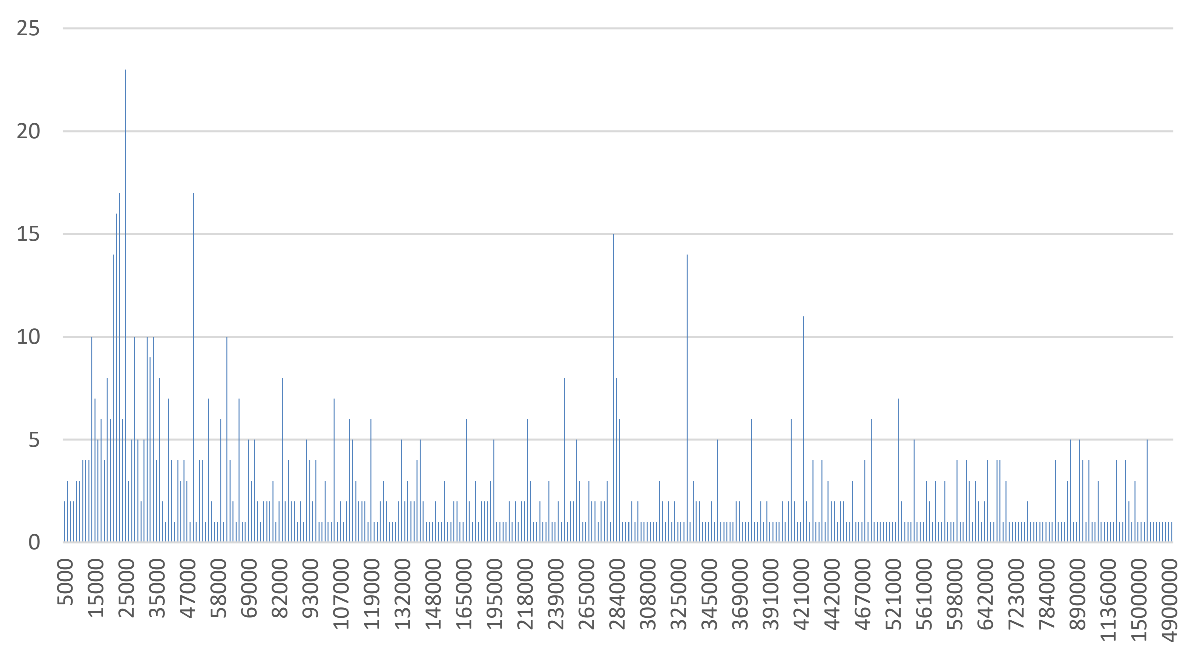
Alternatives techniques to lead dropping

Carp fishing can be performed without lead dropping. The lead dropping technique is a recent 'invention' from some fishing tackle manufacturers.

Costs of alternatives selected for the economic impact assessment

As depicted in Figure D.4-7, the price distribution of sinkers and lures contains outliers at the end of the tail, and in particular in the highest prices (e.g. sinkers or lures > €4 million/tonne).

Figure D.4-7: Price distribution for non-lead sinkers and lures



Source: ECHA mystery shopping exercise

To address this issue in the price distribution, and to proceed with the cost estimates, only observations inside the 5-95 percentile range were used. In addition, a truncated average price was calculated by dropping the 5 % lowest and highest prices of the data for the sinkers, and for the lures.

Table D.4-18: Non-lead sinkers and lures ≤ 50 g – retailing prices for the SEA (based on 5-95 percentile range of the full dataset)

Sinkers and Lures (incl. jigs) ≤ 50 g	Count	Lowest price [€/t]	Average price [€/t]	Highest price [€/t]
Tungsten	320	213 000	512 000	1 463 000
Non-lead (material not specified)	130	23 000	164 000	878 000
Tin	100	28 000	104 000	463 000
Steel or steel alloy	30	35 000	101 000	322 000
Composite (lead-free)	26	52 000	137 000	390 000
Zinc	17	88 000	212 000	318 000
Natural stone	10	32 000	105 000	238 000
Brass	9	122 000	189 000	350 000
Heavy concrete	4	23 000	25 000	27 000
ABS plastic	4	374 000	734 000	1 265 000
Bismuth	2	221 000	282 000	342 000
Concrete	2	45 000	48 000	50 000
Total Sinkers and lures ≤ 50 g	**654**	**23 000**	**324 000**	**1 463 000**

Table D.4-19: Non-lead sinkers and lures > 50 g – retailing prices for the SEA (based on 5-95 percentile range of the full dataset)

Sinkers and Lures (incl. jigs) > 50 g	Count	Lowest price [€/t]	Average price [€/t]	Highest price [€/t]
Non-lead (material not specified)	103	14 000	38 000	285 000
Zinc	24	66 000	101 000	140 000
Steel or steel alloy	23	15 000	33 000	111 000
Composite (lead-free)	19	14 000	32 000	87 000
Tin	18	22 000	26 000	33 000
Heavy concrete	8	14 000	17 000	20 000
Mineral	5	25 000	32 000	42 000
Cast iron	3	14 000	18 000	22 000
Natural stone	3	14 000	19 000	23 000
Concrete	2	22 000	24 000	25 000
Tungsten	2	221 000	226 000	231 000
Copper	1	21 000	21 000	21 000
Total Sinkers and lures > 50 g	**211**	**14 000**	**43 000**	**285 000**

Country specific information on the availability, use and fishers' acceptance of non-lead sinkers and lures (recent studies)

Belgium

The use of lead in fishing tackles remains widespread in Belgium. For example, a recent survey carried out in Belgium by VLIZ (Flanders Marine Institute) indicated that 6 % of anglers use currently only alternatives (CfE #1034).

According to a survey carried out in November 2019 during Hengelexpo with 65 respondents (half of them being marine fishers), the most commonly used alternative to lead sinkers and jigs is stone (36 %), followed by composite (16 %), steel (11 %), tungsten (11 %) and rebar (9 %). Other alternatives such as zinc, copper and glass are used to a much lesser extent. Of the frequently used alternatives, the general properties of stone were judged to be by far the best (7.9/10 on average), while the other options

only achieved average scores of between 5.2 and 6.6/10 (VLIZ - CfE #1034).

Germany

The environmental ministry of NRW in Germany commissioned a study (from LFV Westffalen und Lippe) in 2015 about the impact of the fishing tackle material on fishing performance and usability of the alternative fishing tackle (Olaf Niepagenkemper, 2015). Different types of alternative (material, weight and shape) fishing tackle available on the European market (from shops and webstores) were tested in real fishing conditions by eight experienced fishers. The fishers were asked to report on various criteria such as the quality of the alternative, its usability (fixing/removing on a fishing line), the ability to cast at the expected distance, the sinking properties, the risk of breaking the fishing line, the diversity of the applicability domain of the alternatives (is it limited to specific type of fishing?), but also their overall impression (subjective judgment). Table D.4-20 reports the different types of alternative fishing sinkers tested, and the outcome of the test.

Table D.4-20: Outcome of the NRW study

Alternative tested	Outcome of the test
Copper: - 20 – 40 g pear-shaped sinkers	The test concluded that copper sinkers were an appropriate alternative.
Tin: - split shots	Tin is very supple and malleable and is therefore a good alternative to split shot sinkers for fine float fishing. The only disadvantage reported was that tin sinkers were significantly larger than that of lead.
Stainless steel: - split shots - 20 – 40 g pear-shaped sinkers - 80 – 100 g sinkers	The sinkers tested received negative outcome from the fishers due to their poor design. The main points of criticism were the risk of breaking the line due to sharp edges, the poor practicability and the poor quality of the product tested. The study reports that other stainless steel tackle exist on the market that are of better quality than the one tested, unfortunately due to time limitation the other stainless steel tackle could not be purchased and tested on time.
Stone: - 5 g olive-shaped sinkers - 20 – 40 g pear-shaped sinkers - 80 – 100 g sinkers	All alternatives in stone were rated as satisfactory by the fishers. The biggest disadvantage of the stones is their very low specific weight. As a result, the volume of an 80 g stone is approximately twice that of a lead. This leads to poor ratings, especially in terms of throwing and flying properties and sinking properties, especially for the irregularly shaped pebbles. The testers' subjective judgment, however, was ambivalent. The smooth natural materials are visually very appealing. It was negatively

	noted that the long, movable eyelets, which are glued or stuck into the stone, have a lot of potential for line entanglements when throwing. The connection between the eyelets and the stones was in many cases insufficient. Some stones came loose from the eyelet during long casts and thus represented a certain risk potential for other people and objects on the opposite bank. Overall, the testers came to the conclusion that stone lead can represent a sensible alternative for certain areas of fishing.

Source: (Olaf Niepagenkemper, 2015)

- Tin and stainless-steel split shots
- 5 g stone olive-shaped sinkers
- 20 – 40 g stone, copper and stainless-steel pear-shaped sinkers
- 80 – 100 g stone, and stainless-steel sinkers

The Netherlands

Within the frame of the green deal the independent laboratory KIWA tested 116 different alternatives to lead fishing sinkers and jigs. All these alternatives are available on the Dutch market. The outcome of the tests is that 50 % of the alternatives are made out of iron, steel, concrete, pebble and tungsten, the other 50 % were made from mainly zinc, tin, and copper (as a substance or as alloy such as zamac or brass). Nickel was also available as an alternative. The majority of split shot sinkers is made in tin, the other types are essentially made of zamac (ca 50 %).

The tests spotted also the presence of lead in some of the alternatives marketed as non-toxic (Sportvisserij Nederland – CfE #909).

Sweden

In 2007, the Swedish Chemicals Agency carried out a study (KEMI, 2007) and performed a review of available alternatives for different types of recreational and commercial fishing tackle:

- Split shot: alternative identified were tungsten and zinc. Split shot made of alternative were ca. 70 % more expensive than lead ones. Where lead split shot was sold in the same shop as the alternatives, non-lead sales only account for 25 % of the sales.
- Sinkers: alternative to lead identified were iron.
- Wires for fly fishing: Tungsten was used as an alternative. Some shops were already selling only non-lead wires.
- Lures (such as trolling spoon, jig head, wobbler and fly): zinc, bismuth, tungsten and iron were identified in various types of lures. Lead was being phased out by the major Swedish manufacturers.
- Nets: no alternative identified when the study was carried out
- Trawls: in Sweden, lead was already phased out as a sinker in all trawls except for bottom trawls for crayfish fishing. The alternatives identified were chain, or a rubber sweep, which is a steel cable with a disc of rubber.
- Purse seine: steel cable identified as an alternative to net.

Canada

Tin, steel, and bismuth sinkers and bismuth jigs were previously found to be the most common commercially available alternatives in Canada (Scheuhammer, 2003).

A recent Canadian study (Canada, 2018) reported the results of an angler survey organised in 2017 (N=240). In the survey, 90 % of anglers reported that they used lead sinkers, and 5 % did not know what their sinkers were made from. Tungsten and brass were the most commonly reported alternatives used by 8 % of anglers reporting using sinkers made of these materials; 6 % reported using steel sinkers and 5 % reported using sinkers made of composite materials. Only 2 % of anglers reported using tin and bismuth sinkers. The survey was also asking about the use of jigs. With regard to jigs, 65 % of anglers reported using lead jigs, and 19 % did not know what their jigs were made from. For jigs, steel is the most commonly reported alternative material used with 20 % of anglers using steel jigs. The next most popular were brass jigs (13 %) and composites (11 %). Tungsten jigs and tin jigs were used by5-6 % of anglers. Use of bismuth jigs were reported by only 1 % of anglers.

D.4.3. Approach taken for the impact assessment and key assumptions

D.4.3.1. Risks to be addressed

Except in some specific fishing practices, fishers do not intentionally lose or release their lead fishing tackle in the environment. The main sources of release identified for the sinkers and lures are:

- Unintentional loss of lead fishing tackle, for example when a line breaks, when the tackle is pulled out of the tackle clip/swivel, or when the tackle gets stuck in a natural obstacle (e.g. stones, branches, trees, foliage etc)
- Unintentional spillage of small size fishing tackle on the shore by the fishers (e.g. split shots)
- Deliberate dropping of backlead or lead sinker during carp fishing for example. This practice is recommended by some fishing tackle suppliers.
- Lack of appropriate waste management (i.e. lead fishing tackle ends up in household waste)

With regard to nets, ropes and lines, Deloitte, in a study commissioned by the EU Commission, identified the following three main sources of release to the environment (Deloitte, 2018):

- Intentional dumping
- Accidental loss
- No appropriate formal waste management (e.g. landfilling, difficult to recycle or separate from the plastic)

Lead fishing sinkers and lures which may be lost or discarded in aquatic (freshwater and marine) or terrestrial environments vary in shape, and range in weight from 0.01 g (dust split shot size n°13, or styl weight n°11) to several kilos (e.g. downrigger marine weight to catch sharks for example).

In addition, to its widespread distribution and pollution of European water bodies due to its long lifetime in water, lead presents also a particular risk for the wildlife (cf. section 1.5 of the Annex XV report) when lead fishing tackles are ingested by birds either

because they are mistaken for food, or because of secondary ingestion (e.g. piscivorous bird ingesting a fish still attached to a lead fishing tackle). Waterbirds, scavengers, non-waterfowl avian species, and mammals suffer serious adverse effects, and even die from lead fishing tackle ingestion.

Lead is not only toxic for the wildlife, it is also toxic to humans of all ages and affects various organs (e.g. kidney, heart). However, the greatest public health concern is neurodevelopmental toxicity of lead in children. Indeed, children can be detrimentally affected when they suffer from elevated blood lead levels due to (i) ingestion, mouthing, chewing of small lead fishing tackle, (ii) hand to mouth exposure when manipulating lead fishing tackle, and (iii) inhalation of lead fumes and dust generated by fishing tackle home-casting hobby.

The manufacturing of lead fishing tackle also results in lead exposure at industrial sites, but as this is regulated under Occupational Health and Safety regulations, such exposure is not identified as a risk to be addressed by this restriction proposal.

With regard to neurotoxic effects, there is no known safe blood lead level for children. Reducing blood lead levels in children will therefore benefit society and individuals. Documented effects of lead on the nervous system in children include cognitive function decrements that lower IQ and academic performance; behavioural effects that include conduct disorder and heightened risk of attention deficit, impulsivity, and hyperactivity; psychological effects including depression, withdrawal, and anxiety; and decrements to sensory and motor function. (cf. section 1.6 of the Annex XV report).

One additional reason to take action against lead in fishing is the risk of environmental pollution at the waste stage. Lead fishing tackle when disposed of cannot be easily separated and recycled because they often consist of a mix of 'plastic' and lead. This is true for both the lead sinkers and lures, but also for the nets, ropes and lines.

Broken angling lines (with lead sinkers and lures still attached to the lines) are disposed of as household waste by fishers (CfE , ECHA).

According to the Eunomia and Deloitte studies (Deloitte, 2018), less than 3 % of nets, ropes and lines used by commercial fishers are currently recycled in Europe, and most of them (if not lost during fishing) are land filled.

If lead fishing tackle that contains lead ends up in household waste, a large proportion of it would be incinerated. The purification of the flue gases from such waste incineration plants today is relatively effective. Most of the lead thus ends up in the ash and in most cases goes to landfill. Prohibiting lead in fishing tackle might therefore contribute to reduced lead levels transfer in soils in the longer term.

For all these reasons, reducing or banning the use of lead in fishing tackle will therefore be beneficial both to wildlife and children.

D.4.3.2. Overview of the restriction options assessed

A problem analysis was carried out to identify potential restriction options that would address the various risks identified.

In order to address the issue and its main drivers, the following restriction options are considered and further analysed:

- RO1: Ban on placing on the market material and equipment for home-casting activities
- RO2: Ban on using fishing tackle rig or equipment intended to drop off lead sinkers

- RO3a: Ban on placing on the market and using lead fishing sinkers and lures
- RO3b: Ban on placing on the market and using fishing nets, ropes and lines containing lead
- RO4: Ban on placing on the market lead fishing sinkers and lures
- RO5: Ban on using lead fishing sinkers and lures
- RO6: Ban with a derogation for lead split shots conditional to the placing on the market in spill proof and child resistant packaging
- RO7: Compulsory information to consumers at the point of sale (e.g. about the presence, toxicity and risk of lead, but also availability of alternatives…)

For RO3a, and RO4, when information on cost elements was available (albeit with some uncertainties), the Dossier Submitter undertook a quantitative impact assessment of the restriction option proposed. For these scenarios, a LOW, and HIGH assessments were performed which correspond to different scopes of fishing tackle. Sensitivity analysis has been undertaken on key uncertainties as well.

In the other cases, i.e. RO1, RO2, RO5 and RO7, either because (i) the available information suggested that the potential costs were low in comparison to those of other restriction options and/or (ii) because of the lack of quantitative information available. The Dossier Submitter has performed a qualitative assessment of those restriction options.

The preferred restriction option is described in detail in section 2 of the Annex XV report, only supporting information is available in this Appendix.

The discarded and less preferred options are also described and analysed in this appendix.

D.4.3.3. Key assumptions for the impact assessment

The Table D.4-21 below summarises the common key assumptions used by the Dossier Submitter to assess the various restriction options. The values presented in brackets present the lower and upper bound used for sensitivity analysis.

Table D.4-21: Main assumptions used for the impact assessments (lead in fishing tackle)

Topic	Assumption
Geographical scope	EU27-2020
Study period	20 years from the expected entry into force of the proposed restriction, i.e. 2022 till 2041 included
Fishers (year 1 of the study period)	
Number of recreational fishers	23 000 000 fishers This includes 6 100 000 marine fishers, and 16 900 000 freshwater fishers.
Number of licences for recreational fishing	12 000 000 fishers [1]

Number of commercial vessels equipped with sinkers and lures	Ca. 14 000 vessels
Lead in fishing placed on the market (year 1 of the study period)	
Proportion of sinkers and lures with a weight ≤ 50 g	55 % of all sinkers and lures
Lead in all sinkers and lures	5 400 tpa (4 000 – 10 000)
Lead in lines, rope and nets	13 500 tpa (9 000 – 18 000)
Total lead in fishing tackle	18 900 tpa (13 000 – 28 000)
Lead lost in the environment (year 1 of the study period)	
Loss from sinkers and lures ≤ 50 g	1 650 tpa (1 100 – 3 850)
Loss from all sinkers and lures (≤ and > 50 g)	3 000 tpa (2 000 – 7 000)
Loss from lines, rope and nets	3 000 tpa (2 000 – 4 000)
Loss from all fishing tackle	6 000 tpa (4 000 – 11 000)
Transition period (TP) - only for RO3a, RO4, RO5 and RO6	
TP for sinkers and lures ≤ 50 g	3 years
TP for sinkers and lures > 50 g	5 years
Home-casting of sinkers and lures [2]	
Proportion of European fishers that would perform home-casting	5 % of the European fishers (i.e 1.15 million fishers)
Quantity of fishing tackle produced from home-casting placed yearly on market in Europe	30 % Including: 10 % for personal consumptions 20 % for sale retail

Source: Appendix A and Appendix 0

Notes: [1]: it corresponds to the low boundary of the number of fishers estimation in Appendix A

[2]: worst case estimate based on US EPA study from 1994 (US EPA, 1994), and assuming the same statistics would be applicable in 2020 in Europe. These assumptions are only used to allow the comparison between the different restriction options (and in particular calculate the release estimates of RO4), it cannot be used to establish a baseline for the home-casting activity (i.e. to reflect the current situation in Europe).

D.4.4. Assessment of RO3a – Ban on placing on the market and using lead fishing tackle

RO3a HIGH is essentially described in detail in section 2 of the Annex XV report as part of the proposed restriction option, this section includes only additional supporting information and further comparison between RO3a LOW and RO3a HIGH.

D.4.4.1. Introduction – Description and scope of RO3a

RO3a is a ban on placing on the market and using lead fishing tackle. This restriction option is assessed using two different boundaries: LOW, and HIGH. These boundaries correspond to different types and /or weights of lead fishing tackle. Lead fishing nets, ropes and lines are excluded from the scope of RO3a. A ban on placing on the market and using lead fishing nets, ropes and lines is specifically covered under the restriction option RO3b (cf section D.4.5.3).

The LOW boundary of RO3a can be seen as a smaller subset of the HIGH boundary by focusing on lead fishing tackle that would have a weight below 50 g (i.e. lead sinkers, and lures below 50 g).

The cut-off value of 50 g was set because lead fishing tackle that tends to be ingested by birds have a maximum weight of 50 g. Fishing tackle weighing less than 50 g and having a size of less than 2 cm in any dimension, are indeed often mistaken for food or grit ((Franson et al., 2001, Grade et al., 2019, Grade et al., 2018, Pokras et al., 2009, Scheuhammer and Norris, 1995) and CfE #1207 and #1247).

It should be noted that the 50 g proposed threshold is consistent with existing restrictions on lead in fishing tackle which are usually based on size or weight and are directed at small sinkers and jigs (<25.4 mm in any dimension proposed in the U.S., 28.36 g in England and Wales, and 50 g proposed in Canada), because larger sinkers are believed to be infrequently associated with cases of lead poisoning in birds. Only Denmark has so far put in place a comprehensive ban on all dimensions and types of lead fishing tackle (even though the Danish ban is on import and placing on the market only).

The need to investigate both the proposed LOW and HIGH boundaries is justified, because lead is not only an issue for wildlife, the home-casting of lead sinkers and lures of all weight and dimensions present indeed also a risk for the human health.

<u>Alternative cut-off values for RO3a (dismissed options)</u>

Even though, according to COWI, and based on the UK and Danish experience, split shots would account for 10 % of the total lead (in weight) placed on the market (COWI, 2004).A ban on only certain types of sinkers or lures, for example on split shots only, has not been considered and is not justified, because many different types of sinkers and lures have been found to be ingested by birds. Indeed, birds do not ingest only split shot; worm weights, egg sinkers, bass casting sinkers, and small lead jigs have also been found in birds (cf. Section 1 of the main report). In addition, most of the home-casting activity is associated to the manufacturing of non-split fishing tackle. A restriction option that would therefore only restrict split shot sinkers would not reduce any human health risks associated with the home-casting of non-split shots.

A ban similar to the one in place in the England and Wales and limited to the range **between 0.06 g (number 8 split shot) and 28.35 g (1 oz)** was also not considered

for the following main four reasons:

1. Birds can ingest fishing tackle weighing up to 50 g (cf. Section 1 of the main report)
2. The smaller the size of the fishing tackle, the bigger the surface area, and therefore the bigger the bioavailability after ingestion, and the risk of severe acute effect. (CfE #1092).
3. Authorised dust split shot (i.e. with a weight bellow 0.06 g) can be pilled on a fishing line to reach the weight of a banned sinker (CfE #1092)
4. Alternatives to dust split shots (i.e. with a weight bellow 0.06 g) seem to exist on the market (CfE #1092) either in the form of a split shot or as putty.

D.4.4.2. Transition period

Some supply chain actors (manufacturers, retailers sometimes hand in hand with their suppliers) have already invested in the past resources in R&D (human, and financial) in order to develop alternatives to lead fishing tackle (ECHA market survey). These attempts have not been successful so far, either due to lack of consumer demand for alternative fishing tackle or because the manufacturers and retailers recognised themselves that the alternatives developed at that time do not fulfil the today's s requirements and policies of their company in term of environmental and societal engagement for the protection of the environment and the circular economy principle in general.

Sufficient time for industry to react to RO3a, a ban without TP would mean an immediate closure of the remaining European lead fishing tackle producers, and a loss of activities for the retailers as there is currently in Europe not enough capacity in the production of alternatives to absorb the existing market. In addition, sufficient time is needed to investigate the use of new alternative. Therefore, different transition periods have been investigated: a 3-year transition period for RO3a LOW, and a 5-year transition period for RO3a HIGH.

D.4.4.3. Human Health and environmental impact

Releases reduction estimates – comparison between RO3a LOW and RO3a HIGH

Using the key assumptions described in Table D.4-21, and in particular the following ones:

- Geographical scope and study period
- Lead lost in the environment (year 1 of the study period)
- Proportion of sinkers and lures with a weight ≤ 50 g
- Transition period (TP)

The estimated releases reductions over the 20-year study period associated to RO3a LOW and RO3a HIGH are summarised in the table below. The values presented in brackets present the lower and upper bound used for sensitivity analysis.

Table D.4-22: Lead release reduction associated to RO3a LOW and RO3a HIGH over the 20-year study period

	Remaining lead releases in the environment	Lead releases reduction compared to the baseline
Baseline (i.e. no EU action)	94 500 tonnes (63 000 – 186 000)	-
RO3a LOW (i.e. ban on sinkers and lures ≤ 50 g)	66 450 tonnes (44 300 – 120 550)	28 050 tonnes (18 700 – 65 450) i.e. 30 % reduction compared to the baseline
RO3a HIGH (i.e. ban on all sinkers and lures)	46 200 tonnes (30 800 - 73 300)	48 300 (32 200 – 112 700) i.e. 51 % reduction compared to the baseline

Risk to wildlife reduction estimates – comparison between RO3a LOW and RO3a HIGH

As indicated in section 1.5 of the main report, waterbirds, scavengers, non-waterfowl avian species, and mammals usually ingest sinkers and lures weighing less than 50 g, mistaking them as grit or stones, or ingested by piscivorous birds when catching fish with attached tackle. However, larger birds may also ingest heavier weights (Franson et al., 2003, Grade et al., 2019) in smaller proportions.

Human health risk reduction – comparison between RO3a LOW and RO3a HIGH

During the ECHA market survey, some stakeholders indicated that the home-casting activity might be more frequent among the marine fishers (i.e. for sinkers heavier than 50 g.) than the freshwater fishers. Nevertheless, there was no figure available to back up such statement, in addition the stakeholders reporting this information were from countries were marine fishing is an important part of the recreational fishing (e.g. the Netherlands). As home-casting equipment is available for manufacturing 'at home' all types and sizes of sinkers and jigs, including also split shots (cf. Appendix A), the Dossier Submitter cannot conclude with certainty whether, in EU27-2020, home-casting is more predominant for sinkers and lures > 50 g.

As RO3a would ban both the sale and use of lead fishing tackle, the opportunity for fishers to melt and home-cast their own sinkers and jigs would in theory be reduced. This is essentially because the use of lead fishing tackle would not be permitted. As a consequence, fewer people would be exposed to lead fumes and dust, and in particular the children living in the same household as the fisher casting lead.

There is no recent information available on the scale of the home-casting activity in Europe, but based on US EPA study from 1994 (US EPA, 1994), and assuming the same statistics would be applicable in 2020 in Europe: one could assume that ca. 5 % of the European fishers would perform home-casting (cf. assumption on home-casting reported

in Table D.4-21). RO3a could potentially therefore reduce the exposure of up to 1.15 million European fishers and their families to lead fumes and vapours.

However, it should be noted that the proposed restriction does not intend to supervise individuals in their private home during (i.e. to check if they are home-casting), but only when fishing, i.e. to check if individuals are not using (home-casted) lead fishing tackle. Therefore, the efficiency of the measure to guarantee the reduction of the risk cannot be 100 % guarantee. In addition, there is a non-negligible risk to increase the home-casting practice, as some fishers might not be aware or understand the risk of such an activity for their own health, and their family's health.

D.4.4.4. Economic impacts

EU industry R&D and compliance costs - comparison between RO3a LOW and RO3a HIGH

Table D.4-23 presents the assumptions to calculate the R&D and industry compliance costs of RO3a LOW and RO3a HIGH. The values presented in brackets present the lower and upper bound used for sensitivity analysis.

Table D.4-23: Assumptions to calculate the EU industry compliance costs

Assumptions	RO3a LOW	RO3a HIGH
Generic assumptions		
Study period [1]	2022-2041	
Quantity of fishing tackle produced yearly [4]	1 300 tpa	
Proportion of sinkers and lures≤ 50 g [1]	55 %	
Transition period for sinkers and lures ≤ 50 g [1]	3 years	3 years
Transition period for sinkers and lures > 50 g [1]	NA	5 years
Discount rate [3]	4 %	
Price of a silicone mould [4]	€20	
Average length of life a silicone mould [4]	2 years	
Price of a steel mould [4]	€3 500 (2 000-5 000)	
Average length of life a steel mould [4]	20 years	
Price difference to process an alternative material other than lead with the same technology as lead (raw material price + nrj difference) [4]	€7 000 / tonne (500-13 500)	

Price difference to process an alternative material other than lead with a different technology than lead and/or steel moulds (raw material price + nrj difference) [4]	€12 000 / tonne (500-23 500)
Assumptions for EU company with a global market	
Number of EU company with a global market [4]	3
R&D costs for EU company with a global market [4]	€75 000
Number of fishing tackle moulds per global company [4]	4 000 (1 000-7 000)
Proportion of silicon moulds per global company [4]	30 %
Assumptions for EU company with a global market	
Number of EU company with a local market [4]	10
R&D costs for EU company with a local market [4]	€5 000
Number of fishing tackle moulds per local company[4]	600 (100-1 000)
Proportion of silicon moulds per local company [4]	100 %

Sources:

[1]: Key assumptions presented in Table D.4-21

[2]: ECHA market survey and/or information reported in Appendix A

[3]: SEA restriction guidance available at

[4]: Estimated EU production of fishing tackle in Table D.4-1

[5] Average price of alternative presented in section 0 (Table D.4-18 and Table D.4-19)

Based on the assumptions set in the table above, the R&D costs for the EU industry were estimated and assumed to be spread out over the shortest transition period when alternatives are developed. The best estimate of the R&D costs was ~€235 000 (NPV – 20 years) for RO3a LOW and HIGH. These costs are low compared to the industry compliance costs.

The industry compliance costs (aka reformulation costs) associated to RO3a LOW and RO3a HIGH include (i) raw material prices difference between lead and its alternative, (ii) changes to the manufacturing process (capital investment), (iii) and energy costs difference between lead and its alternative. It is assumed that existing manufacturing facilities will not switch to a total different technology (e.g. from lead moulding to plastic injection, or tungsten technology for example), and in case the investment in machinery would be too significant, other industrial actors already equipped with such machinery would take over the market. Therefore, the capital costs considered are essentially

linked to the purchase of new moulds. The type of moulds and their standard replacement rate has also been considered: for example, 'steel/iron moulds' have a life-length much longer than silicone moulds, which means that their replacement would need to be foregone by the sector. The calculation of the reformulation costs also takes into account that some alternative fishing tackle could only be produced using steel/iron moulds (due to the higher melting and casting temperature).

The reformulation is assumed to start one year before the first transition period has elapsed, and the same yearly quantity (in tpa) of fishing tackle is assumed to be produced during the study period.

Table D.4-24 presents the compliance costs for the European Industry for both R3a LOW and R3a HIGH.

Table D.4-24: EU industry compliance costs for RO3a LOW and HIGH

EU industry compliance costs	Total costs [€NPV-20 years]	Annualised costs [€]
RO3a LOW (sinkers and lures ≤ 50 g)	€86 million (including €5 million for capital investment)	€6 million (including €400 000 for capital investment)
RO3a HIGH (all sinkers and lures)	€146 million (including €8 million for capital investment)	€11 million (including €600 000 for capital investment)

Costs for the fishers - comparison between RO3a LOW and RO3a HIGH

It is assumed that the fishers will purchase non-lead alternative once the review periods are elapsed, and that fishers will keep on purchasing the same quantity of fishing tackle per year as of today. Table D.4-25 and

Table D.4-26 present the assumptions and the costs for the fishers of RO3a LOW and RO3a HIGH . The values presented in brackets present the lower and upper bound used for sensitivity analysis.

Table D.4-25: Assumptions to calculate the costs for the fishers

Assumptions	RO3a LOW	RO3a HIGH
Study period [1]	2022-2041	
Quantity of fishing tackle purchased yearly by fishers[1]	5 400 tpa (4 000 – 10 000)	
Proportion of sinkers and lures≤ 50 g [1]	55 %	
Transition period for sinkers and lures ≤ 50 g [1]	3 years	3 years
Transition period for sinkers and lures > 50 g [1]	NA	5 years
Discount rate [3]	4 %	
Number of fishers [1]	23 000 000 fishers	
Average retail price of fishing sinker or lure ≤ 50 g made of lead [2]	€30 000 / tonne	
Average retail price of fishing sinker or lure ≤ 50 g made of an alternative [4]	€324 000 / tonne (23 000 – 1 463 000)	
Average retail price of fishing sinker or lure > 50 g made of lead[2]	€15 000 / tonne	
Average retail price of fishing sinker or lure > 50 g made of an alternative [4]	€43 000 / tonne (14 000 – 285 000)	

Sources:

[1]: Key assumptions presented in Table D.4-21

[2]: ECHA market survey and/or information reported in Appendix A

[3]: SEA restriction guidance available at

[4] Average price of alternative presented in section 0 (Table D.4-18 and Table D.4-19)

Table D.4-26: Costs for fishers for RO3a LOW and HIGH

Costs for fishers	Total costs [€NPV-20 years]	Annualised costs [€]
RO3a LOW (sinkers and lures ≤ 50 g)	€8 700 million (~0 – 43 000 million)	€640 million (~0 – 3 100 million)
RO3a HIGH (all sinkers and lures)	€9 300 million (~0 – 48 000 million)	€680 million (~ 0 -3 500 million)

Cost effectiveness - comparison between RO3a LOW and RO3a HIGH

RO3a LOW and RO3a HIGH are anticipated to reduce lead releases to the environment respectively by about 28 050 tonnes and 48 300 tonnes over a 20-year analytical period according to Table D.4-22. Considering the total costs of the proposed restriction options (i.e. the costs for fishers), the cost-effectiveness of RO3a LOW and RO3a HIGH are estimated in the table below.

Table D.4-27: Cost effectiveness for RO3a LOW and HIGH

	Cost effectiveness
RO3a LOW (sinkers and lures ≤ 50 g)	€311 per kg of lead release avoided (~0 – 1 517)
RO3a HIGH (all sinkers and lures)	€193 per kg of lead release avoided (~0 – 996)

Other economic impacts

The information available in this section only supports the analysis carried out in the main report.

<u>Impact of RO3a LOW and HIGH on the fishers' yearly expenses for fishing</u>

The average yearly additional expense for a fisher is calculated using the following formula:

$$Additional\ expense\ per\ fisher\ and\ year = \frac{Annualised\ costs\ for\ fishers}{Estimated\ number\ of\ fishers}$$

To estimate the impact on the fishing expenses for a fisher, the following assumptions (cf. Appendix A) have been taken forward:

- Number of fishing days per fisher per year: 15 days / year
- Average yearly expenses for fishing per fisher: €1 000 / year
- Average yearly expense for fishing tackle and lures per fisher: €100 / year

Table D.4-28: Additional expense for a fisher associated to RO3a LOW and HIGH

	RO3a LOW	RO3a HIGH
Additional expense per fisher per year in euros	€28 / year	€30 / year
Additional expense for sinkers and lures in %	+28 %	+30 %
Additional expense for fishing in %	+3 %	+3 %
Additional expense per fishing day	€1.86 / fishing day	€1.98 / fishing day

Fishers/Consumers' willingness (survey)

Various small scale surveys carried out locally by authorities, fishers associations, or individuals, report in a qualitative manner the fishers willingness to move and/or to pay for 'environmental friendly' alternatives to lead. Some examples of those surveys are available in Table D.4-29.

Table D.4-29: Example of surveys

Country	Information	Source
Belgium	Survey carried out in Nov.2019 during Hengelexpo. 65 respondents (half of them active in marine fishing). 98 % said they were aware of the fact that lead is a toxic substance. Asked whether environmentally friendly alternatives to lead fishing weights should be the norm, 65 % of respondents answered 'yes', 3 % answered 'no' and 32 % abstained.	CfE #1034 - WLIZ
The Netherlands	National survey carried out in 2007 in the Netherlands via a fishing magazine (Hét VISblad) with 1 011 respondents (fishers with average age 55 years old – 95 % fishing in freshwater). 54 % of the respondents do not know what are the possible alternatives to lead fishing tackle. Nevertheless, 95 % of the respondents answered that they were willing to use an alternative for lead as a fishing sinker if this would be a reasonable alternative. Also 72 % of the respondents were willing to pay more for such an alternative. In addition, 100 % of the respondents who declared the highest loss of lead (> 2.5 kg / year) indicated	CfE #909 - (Sportvisserij Nederland)

	that they were willing to pay more for non-lead alternatives.	

D.4.5. Other assessed restriction options analysis (qualitative assessment)

The restriction options below are described in a systematic manner using the following criteria:

- Restriction option description including the expected response from the value chain
- Practicality of the restriction option: e.g. implementability, availability of alternatives, restriction costs, affordability…
- Effectiveness of the restriction option: targeted risk and risk reduction potential
- Enforceability of the restriction option
- Monitorability of the restriction option

D.4.5.1. Assessment of RO1 - Ban on placing on the market material and equipment for home-casting activities

Description

Lead fishing sinkers and lures can be made by fishers at home for retail and/or personal use. This is called home-casting (cf. Appendix A). The purchase of home-casting equipment and lead ingot and scrap, necessary for home-casting of lead fishing sinkers is currently legal.

Exposure to lead may cause severe adverse health effects such as brain damage in children, miscarriages, and hypertension. RO1 may assist in preventing exposures and potential risks to human health, and in particular children, which may result from the lead vapours or fumes created when making sinkers, and lures at home.

As a restriction on the home-casting activities itself is not possible (it is performed in the private sphere and cannot be enforced), RO1 intends to tackle the root of the home-casting, and to ban the placing on the market of lead and home-casting equipment for home-casting activities. The restriction option RO1 as proposed, would also prohibit the production of fishing sinkers by individuals who purchase lead shot (ammunition), and cut a groove in the shot creating a split shot fishing sinker.

As a potential additional benefit, not being produced anymore the home-casted lead fishing tackle could not be lost anymore in the environment and ingested by birds. Nevertheless, this restriction option assumes that the expected response from the fishers to such a ban would be to buy lead fishing sinkers from retailers instead of producing them themselves. The main reason is that lead fishing sinkers and lures would still be allowed to be placed on the market, and they remain by far the cheapest and most versatile type of sinkers and lures.

Practicality

RO1 is considered implementable without transition period as alternatives to home-casted sinkers and lures exist. Fishers can indeed purchase fishing sinkers and lures from Internet of from shops. Even though, no monetisation of the costs has been made, fishing sinkers and lures purchased from retailers are expected to be a bit more

expensive for the fishers than the one they would produce at home. Such a price difference is considered affordable for the fishers.

Effectiveness

Using the following assumptions:

- Baseline release estimates in Table D.4-21
- Home-casting estimates in Table D.4-21 and in particular assuming that home-casting is performed by 5 % of the fishers

RO1 could potentially therefore:

- Reduce the exposure of up to 1.15 million European fishers and their families to lead fumes and vapours.
- No reduction of release to the environment of lead fishing sinkers and lures is expected as the restriction option is only targeting home-casting

Although RO1 is targeted to a specific risk (exposure to lead vapours and fumes), the proposed restriction option cannot be targeted to the equipment and raw material solely used for lead tackle home-casting. Indeed, the raw material and the equipment used for home-casting are not specifically marketed for melting and moulding lead: the same equipment can be used to produce also fishing tackle with other metals with low melting point. In addition, as described in Appendix A, home-casting can also be performed using day to day kitchenware such as 'backing moulds', and any kind of lead can be used as a raw material for home-casting.

Because of the above-mentioned reasons, it is difficult to predict what would be the effectiveness of such a measure, and if such a measure would really address and target the risk identified for human health.

In addition, and considering the expected fisher behaviour as response to this ban, RO1 would not address the risk identified for wildlife, and in particular the ingestion of lead fishing tackle by birds.

Therefore, as a conclusion, RO1 is considered not effective to target the identified risks both for the human health and the environment.

Enforceability

Even though the enforcement of RO1 would be done at the point of sale of lead and home-casting equipment, it might be impossible to enforce RO1 as the raw material and the equipment targeted by the proposed measure are not dedicated to lead. Therefore RO1 is considered not enforceable.

Monitorability

It would be difficult to monitor the effectiveness of RO1 as there is no real baseline, and the proposed restriction does not allow to target only material and equipment used for lead home-casting.

D.4.5.2. Assessment of RO2 - Ban on using fishing tackle, rig or equipment intended to drop off lead sinkers

Description

RO2 intends to tackle the issue of intentional drop off of sinkers. Indeed while most of lead fishing sinkers are inadvertently lost by the fishers while fishing, some practices imply a deliberate and intentional release of lead sinker to the environment. RO2 aims at

addressing this issue and the associated risk of ingestion of lead fishing sinker by birds.

The restriction option RO2 as proposed, would ban the use during fishing of equipment/tackle as well as rig set up that are intended to intentionally drop off lead sinkers.

It should be noted that a ban on placing on the market specific equipment marketed/intended to drop off sinkers is not part of the restriction option, because REACH can only restrict the placing on the market, and the use of substance (on its own, in mixture, or in article).

The expected response from the fishers to RO2 would be to stop buying and using equipment/tackle or rig intended for the intentional drop off sinkers.

The drop off sinkers is essentially performed by carp fishers. As depicted in Figure D.4-8, carp fishers may use two types of lead sinkers: a 'backlead' and a main sinker located at the end of the rig close to the hook.

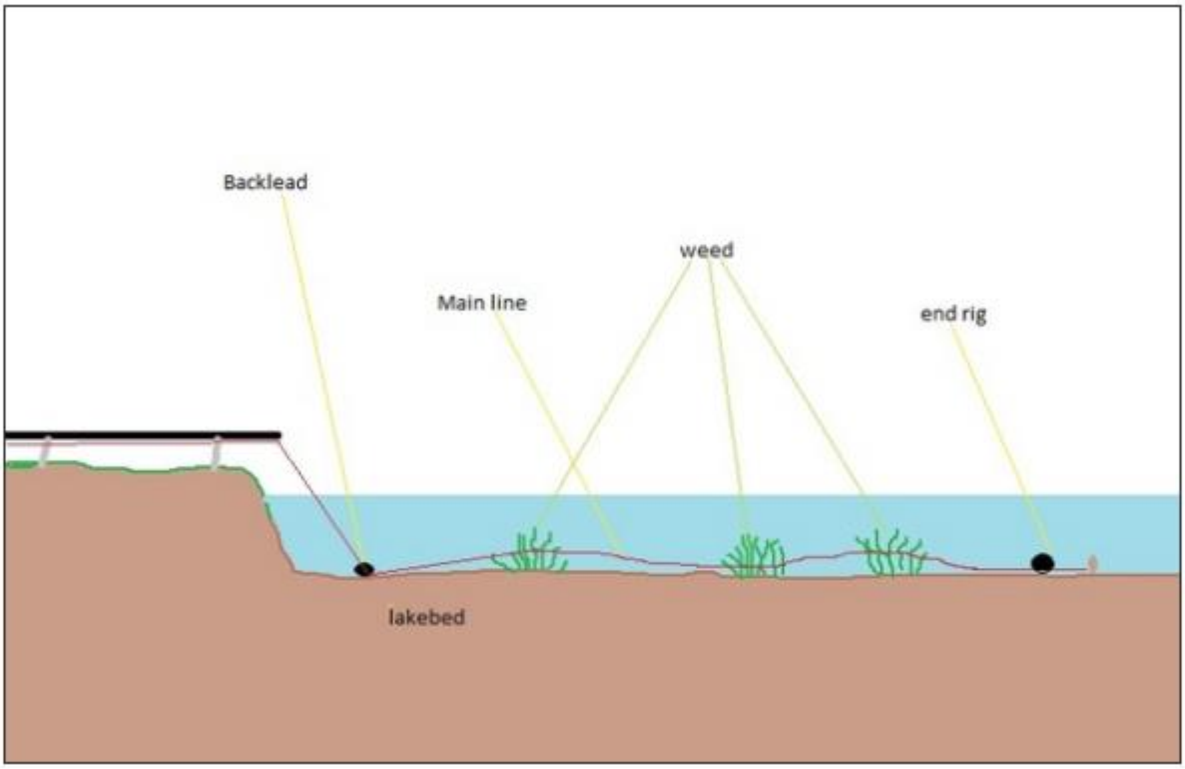


Figure D.4-8: Backlead and main sinker setup for carp fishing
Source: Image reproduced from http://blog.anglinglines.com/ramblings-of-a-carp-angler-backleads/

A 'backlead' is usually a small sinker between 5 and 50 g that has some form of plastic or wire type attachment for placing on and removing from the main line following a cast. The backlead is lowered into the water so as the line sinks slowly to the lakebed creating a fairly tight line from the backlead to the rig set up. Backlead keeps the fishing line low in the water so that a carp being played doesn't go through the lines of other rods. 'Backlead' can also keep the fishing line low in the water or on the bottom near to the rig which can reduce the risk of the carp detecting the line and spooking.

The main sinker placed at the end of the rig close to the hook aims at keeping the hook closed to the bottom where carps are feeding.

There are potentially two issues identified with the carp fishing sinkers.

The first issue is related to the backlead. Indeed, when a fisher get a run, he has two focal points for the line to tighten too. The first is the backlead itself, and the second is the rig set up where the main sinker is. It is not until the backlead has ridden the main line down to the rig that the fisher has the full control of the fish which can cause some issues with fish kiting and being out of control. Therefore system exists that allow the backlead to detach from the main fishing line once the fishing line has been casted.

The second issue is related to the main sinker itself. Some new practice, also known as 'drop off lead' are emerging and are promoted by some fishing tackle providers (e.g. https://www.facebook.com/watch/?v=901389037271788). The drop off practice consists in using a specific tackle or rig in order to detach intentionally the main sinker from the main line (cf. Figure D.4-9 and Figure D.4-10). According to fish21, the purpose of this drop off is to reduce the weight on the line when fighting a big fish, and therefore maximise the catch rate (fish21, 2017).

Figure D.4-9: main lead sinker intentional drop off – example of a tackle
Source: picture from korda.co.uk

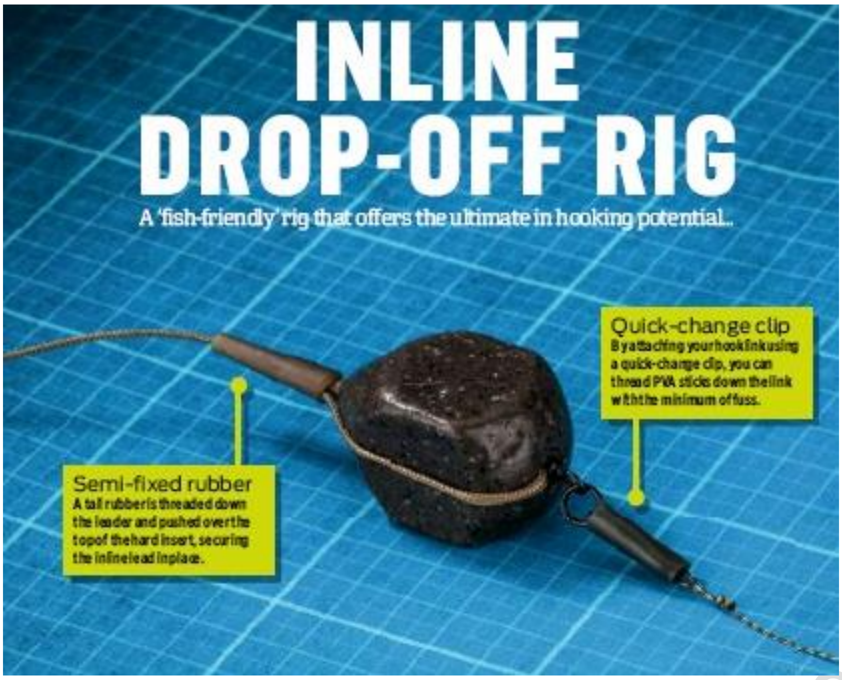


Figure D.4-10: main lead sinker intentional drop off – example of an inline rig
Source: picture 'angling time' magazine

<u>Practicality</u>

RO2 is considered implementable and practical for fishers as alternatives to the intentional drop off of sinkers do exist both for the main sinker and for the backlead.

With regard to the main sinker intentional drop-off, many carp fishers in Europe do not drop off their main sinkers. Such a practice is not needed to catch a fish.

As far as the backlead issue is concerned, tackle exist that prevent the loss of the backlead such as magnetic backlead, or captive backlead. The captive backlead has for example one end fixed to the bank with a length of cord attached to the backlead which is clipped onto the main line and lowered into the water.

In addition to this special equipment/tackle to prevent the loss of the backlead in the environment, backlead made in alternative material, such as stone or stainless-steel, are also readily available on the market (ECHA market survey).

It should be noted that fishing carp can also be done without any backlead at all.

<u>Effectiveness</u>

The 'drop off lead' practice is a marginal practice in Europe but contrary to all other releases of lead fishing tackle to the environment, the release of the lead sinker to the environment is done deliberately by the fisher. The proposed measure is therefore effective, even so limited in term of impact. It gives also a strong signal to fishers that intentional dropping is not a practice to pursue.

<u>Enforceability</u>

RO2 would require an enforcement at the fishing point.

REACH inspectors might not be the most appropriate inspectors to perform this type of inspection. Nevertheless, the enforcement on the site of uses could be delegated and performed by the existing national relevant enforcement authorities for the fishing matters, i.e. either fishing associations or local area authorities or ministries depending

on the EU country. These inspectors, usually fishers themselves or used to perform fishing inspections (licence, equipment, fish), are assumed to be knowledgeable, and skilled to recognise intentional drop off techniques or equipment.

RO2 is therefore considered enforceable.

Monitorability

Assuming that less equipment placed on the market, means less use, RO2 could be monitored using regular mystery shopping survey or exercise to monitor both the placing on the market of fishing tackle, rig or equipment intended to drop off sinkers, but also promotion videos or tutorials on fishing tackle providers and fishers websites.

D.4.5.3. Assessment of RO3b - Ban on placing on the market and using lead fishing nets, ropes and lines

Description

RO3b is a ban on placing on the market and using fishing nets, ropes and lines containing lead, i.e. where lead is embedded/part of the structure of the nets, ropes and lines (cf. Appendix A).

This restriction option would essentially affect commercial fishers and a limited number of recreational fishers.

Lead sinkers that can be added to the nets, ropes and lines are not included in this restriction option, as they would be covered by RO3a (LOW and HIGH).

Practicality

According to the information received via the call for evidence, some of the identified alternatives in fishing nets, ropes and lines have poor resistance to corrosion (e.g. zinc, and iron). The corrosion may have an adverse effect on the textile in the net (e.g. discoloration), and reduce the length of life of fishing nets, ropes and lines (CfE #1199).

Steel, zinc and/or iron which are identified as alternatives to lead in fishing nets, ropes, and line have also a lower density than lead, which means that the volume of the fishing nets, ropes, and line is increasing compared to the lead one. Fishing nets, ropes and lines made of alternative therefore take up more space and weight on the fishing vessels and are more difficult to handle for the fishers (CfE #1143). The Danish authorities reported for example that the volume of zink lines that are used to make gill nets are 3 to 4 times greater in volume to comparable lead sinking lines, which reduces their weight in water by the weight of the water displaced. To achieve the same weight in water as lead lines it is therefore necessary to make zink lines approximately 50 % heavier than lead lines (CfE #1220).

Zinc alloys is also stiffer than lead and therefore more difficult to manipulate.

Replacing lead with iron may have an impact on the working environment of commercial fishers as a noise occurs when the nets strike the boat.

Tungsten is a heavy but difficult to work with and too expensive to be used in nets, ropes and lines manufacturing (CfE #1199, and #1220).

The Danish EPA reported via the call for evidence (CfE #1220) several studies carried out in Denmark in 2014 and 2015 on the usability of the non-lead fishing nets (made of lead line). The studies, were carried out after the entry into force of the ban on placing on the market lead fishing lines and cables, and confirm the above-mentioned issues

reported by the manufacturers; i.e.:

1. Poorer working environment for the fishers as a result of a reduction of deck space and more difficult working conditions.

2. Problems with space on board the vessel as nets using alternative sinking lines take up more than a 1/3 more space than nets with lead sinking lines.

3. Reduced vessel stability as a result of the increased weight of nets, eventually leading to exceeding what is allowed according to rules by the Danish Maritime Authority.

Some solutions to the above-mentioned issues could be either to reduce the number of nets transported on board, and/or rebuild/rearrange the deck area. Both of these solutions would nevertheless imply important costs for the commercial fishers, and might reduce the profitability of the fishing trips if less nets can be embarked on the fishing vessel.

The Danish EPA indicates also that the issues are not yet fully visible in the sector, because the ban is only on the placing on the market (not on the use), and as professional fishing using yarn has been reduced by about 40 % within the last 10 years in Denmark, the consequence is that many professional fishers have big stocks of old nets containing sinker lines that can replace old ones and therefore reduce the demand for new lead free fishing lines and nets.

As a conclusion, it appears that alternative fishing lines, and associated fishing nets, are not yet fully developed or tested.

<u>Effectiveness</u>

RO3b is not proportional to the risk identified for human health and the environment.

From a human health exposure point of view, workers dealing with the production and maintenance of lead fishing nets, lines and ropes are working in industrial settings, under the supervision of the OSH regulation, and OSH occupational health checks are performed every year (CfE #1033 and #1199). The industrial manufacturing and maintenance are out of scope of the current work. Nets, ropes, and lines are not typically home-casted as they consist of lead strings and rosary covered by a woven plastic. In addition, as lead is mostly enclosed in nets, ropes and lines there is no direct contact between lead and the hands of the fishers.

With regard to the risk for the wildlife, nets, ropes and line do not wear out (Danish EPA, CfE #1220), and lead from this type of fishing tackle is not typically ingested by birds (UK EPA, CfE #936). Therefore a ban on placing on the market and using lead in fishing nets, ropes and lines would have no impact on the risk associated to the lead ingestion by birds.

Because of the above-mentioned reasons, RO3b would have no impact to reduce the identified risks (inhalation of fumes and vapours, hand to mouth, and ingestion by birds), and is therefore considered not effective to target the identified risks.

However, if the goal would be to reduce the general contamination of the environment by lead that will ultimately undergo decomposition into various molecular lead species and be distributed through the physical environment and through the food chain, then it may be prudent for the decision maker to also consider restrictions on lead in fishing nets, ropes and lines. The estimated releases reductions of lead associated to RO3b

would be 25 000 tonnes over the 20-year study period (considering a 3 years transition period).

Enforceability

In a similar manner as RO3a, the enforceability of RO3b could be performed both at the point of sale, and at the point of use, even if the second aspect might be more difficult to achieve in practice by REACH inspectors.

Monitorability

Similar to RO3a.

D.4.5.4. Assessment of RO4 - Ban on placing on the market lead fishing sinkers and lures

Description

Contrary to RO3a, RO4 is focusing only on the placing on the market of lead fishing sinkers and lures.

The idea behind this restriction option is that: as less lead fishing tackle would be placed on the market, less may enter the environment where it can become available to birds for ingestion.

Practicality

RO4 is practicable and implementable. Alternatives are technically possible, and available on the market (cf. section D.4.2). A long enough transition period would be needed for the industry to adapt its manufacturing tools and equipment (cf. practicality of RO3a).

Effectiveness

Restricting the placing on the market of lead fishing tackle would in theory reduce the emissions of lead to the environment.

Nevertheless, this restriction option would still allow the possession and use of lead fishing tackle. For example, allowing the fishers to fish with their existing stockpile of lead fishing sinkers and lures they would have at home until they run out of them.

In addition, under this restriction option, the home-casting of lead fishing tackle would also still be possible, as fishing with 'home-made' lead sinkers, and lures would still be permitted.

Therefore, a ban solely on the placing on the market will not reduce the releases of lead to the environment as quickly, and within the same magnitude as RO3a. The identified issues for the wildlife would remains years after the entry into force of this restriction option due to the existing stockpile of lead fishing tackle ; and a zero-release cannot also be achieved because of the possibility for the fishers to continue the lead home-casting within this restriction option.

Therefore RO4 would be less effective in term of environmental emission reduction than RO3a. It is difficult to predict how much and how quickly the lead emissions from lead in fishing would be avoided, nevertheless using the following assumptions:

- Baseline release estimates in Table D.4-21
- Transition periods set in Table D.4-21

- Home-casting estimates in Table D.4-21 and in particular assuming that home-casting for personal use would represent about 10 % of the quantity of lead fishing tackle placed yearly on market in Europe, and that the same proportion would still be released to the environment

The best estimated releases reductions over the 20-year study period associated to RO4 are summarised in the table below.

Table D.4-30: Lead release reduction associated to RO4 over the 20-year study period

	Remaining lead releases in the environment	Lead releases reduction compared to the baseline
Baseline (i.e. no EU action)	94 500 tonnes (63 000 – 186 000)	-
RO4	51 030 tonnes (34 020 – 84 570)	43 470 tonnes (28 980 – 101 403) i.e. 46 % reduction compared to the baseline

With regard to human health, a restriction option to only restrict the placing on the market of lead fishing tackle would not reduce any human health risks associated with the ingestion of fishing tackle (PICA, children, fishers pinching split shots on their line), and with home-casting activities, as fishers would still be allowed to pursue the home-casting for their personal consumptions/uses.

On the contrary, one may expect that a ban solely on placing on the market, without any associated other action (e.g. awareness on the hazard of lead home-casting) would be counter beneficial, and might increase the number of fishers involved in home-casting as home-casting would be the only way to get lead fishing tackle, and do not change the fishing habits. As a collateral effect, this might also increase a bit the lead releases in the environment.

Enforceability

Enforcement of R04 could be done as follows:

- Spot checks of imported fishing tackle (customs).
- Manufacturer site inspections.
- Retailers site inspections.
- Retailers website inspections.

Laboratory testing, using HPLC, to check the presence of lead in selected fishing tackle or paper-based inspection could be used by the enforcement authorities.

Monitorability

The presence of lead and non-lead fishing tackle on the market could be monitored using the same methodologies as the one used by the Dossier Submitter to perform the market survey: contact fishing tackle manufacturers, importers, retailers, consult website and social media pages. Mystery shopping campaigns on website and in retailers' shops could also be conducted for the same purposes.

D.4.5.5. Assessment of RO5 - Ban on using lead fishing sinkers and lures

Description

Different from RO3a, RO5 is focusing only on the use of lead fishing sinkers and lures.

The idea behind this restriction option is that: as less lead fishing tackle would be used, less may enter the environment where it can become available to birds for ingestion.

Without any other accompanying measures (such as education of the fishers, and communication campaign), and because lead fishing tackle would still be available for purchase, the most probable, and expected behaviour of the fishers, is that they would still continue using lead fishing sinkers and lures, and they would not use alternatives despite the ban in place.

Practicality

RO5 is practicable and implementable. Alternatives are technically possible, and available on the market (cf. section D.4.2).

Enforceability

The enforcement of RO5 will have to be carried out on the sites of use, i.e. on fishing spots. REACH inspectors might not be the most appropriate inspectors to ensure the respect of the restriction provision. Nevertheless, the enforcement on the site of uses could be performed by the existing national relevant enforcement authorities for the fishing matters, i.e. either fishing associations or local area authorities or ministries depending on the EU country. These inspectors, usually fisher themselves are used to perform fishing inspections (licence, equipment, fish). Having said that, it might be difficult, even for skilled inspector, to distinguish only visually a lead fishing tackle from one made with an alternative metal.

A ban only on the use of fishing tackle might therefore not be enforceable.

Effectiveness

Even though such a measure could, in theory, be as effective as a ban on placing on the market. In practice, the effectiveness of the measure on its own might be limited especially due to the enforceability challenges.

Monitorability

It will be difficult to monitor RO5 other than relying on European wide fisher surveys.

Another option would be to monitor the lead fishing tackle placed on the market; this would give an indirect indication of the effects of RO5.

D.4.5.6. Assessment of RO6 - Derogation for lead split shots conditional to the placing on the market in spill proof and child resistant packaging

Description

RO6 is a modified version of RO3a HIGH. RO6 looks at some requests from stakeholders asking for a derogation from a restriction proposal for lead split shots and in particular dust lead split shots, similar to the UK ban.

Split shots may be lost in the environment either due to unintentional loss when a line breaks, or due to unintentional spillage on the shore when handling the split shots packaging/container.

Indeed, a survey conducted in the United States in 1986 highlighted that for every split shot sinker used, up to six might be spilled and lost (Lichvar, 1994). Similar losses of 2 to 7 split shots per fishers' fishing day were also reported in various studies at local sites in Great Britain in the late 80's (Bell et al., 1985, Cryer et al., 1987, Forbes, 1986).

To address this particular issue, many split shots are already placed on the market in spill proof and child resistant packaging, but not all of them. Some split shots can indeed still be purchased in bulk plastic packaging as shown on Figure D.4-11.

RO6 is therefore investigating the ban from the market of lead split shots unless lead split shots are sold in spill proof and child resistant packaging. RO6 could therefore be interpreted as a variant of RO3a HIGH.

Figure D.4-11: Split shots sold in plastic bag
Source: picture from amazon.com

<u>Effectiveness</u>

Similar to RO3a HIGH, RO6 entails the replacement of most of the lead by alternatives. Nevertheless as lead would still be permitted for the smallest dust split shots (≤ 0.05 g), and despite the spill proof design of the packaging, such split shots could still be lost inadvertently during the fishing practice when pinching the split shot sinker on the line. The release reduction of RO6 is therefore estimated to be in the same order of magnitude of RO3a HIGH but a bit lower than RO3a HIGH. It is not possible to quantify the release reduction of RO6 as there is no information available on the proportion of sinkers lost in the environment that are dust split shots.

In addition, considering that the smallest the lead tackle size, the highest surface area and bioavailability potential, those dust split shot sinkers that could still be inadvertently lost in the environment will have the biggest negative impact on wildlife when ingested by birds.

RO6 with its spill and child proof packaging aims also at better protecting the children from accessing and ingesting split shot, nevertheless the non-ingestion of lead split shot cannot be 100 % warranted as lead split shot could still be bitten with the teeth to secure them on a fishing line.

Practicality

Same as RO3a HIGH. In addition, spill proof and child resistant packaging already exist for split shots. So it is technically and economically feasible to place split shots on the market in such a packaging.

It should nevertheless be noted that alternatives to lead-split shots already exist, which are either placed on the market in spill proof and child resistant packaging, or placed on the market in a format that prevent the unintentional spillage on the shore (e.g. tungsten putty). More details on the alternative to lead split shots is available in section D.4.2.

Enforceability

Same as RO3a HIGH (for the ban on use part).

Monitorability

Same as RO3a HIGH (for the ban on use part). RO6 could also be monitored indirectly by monitoring the sales of lead fishing tackle.

D.4.5.7. Assessment of RO7 - Compulsory information to consumers at the point of sale

Description

According to Pokras et al. (2009), many fishers may simply not be aware that lead fishing tackle causes ecological harm, or may cause harm to their health. Indeed:

- Lead fishing sinkers and lures under the scope of the proposed restriction are never labelled according to the CLP regulation: articles are exempted from the CLP labelling requirements.
- Few years ago, lead home casting was promoted, and training course were proposed by some National fishing associations (source ECHA market survey). The Danish EPA reported also that in 2000, few years prior to the entry into force of the ban on lead fishing tackle (for recreational fishing), the Danish Sports Fishermen's Association was providing courses on home casting of lead fishing sinkers (Lassen C, 2004).

This is why, with the proposed restriction option, retailers will be requested to inform at the point of sale the consumers about the presence, toxicity and risk of lead to human health and the environment. They will also be asked to inform that alternatives to lead fishing tackle are available.

This information could be displayed by the retailers in a similar way as a price tagging or advertisement campaign that is performed on regular basis by a shop or website owner.

The restriction obligation would apply to all lead fishing tackle placed on the market (no size restriction), and would be accompanied with a transitional period of six months to allow the lead fishing tackle retailers to put in place the necessary information for their customers in the shop shelves or on their website.

It should be clear that the retailers will not be asked to label, re-label or package individually all the fishing tackle they sell, nor should they request from their suppliers that they would label, re-label or package individually the fishing tackle supplied. No additional packaging should be created or generated to fulfil this requirement. Indeed, fishing tackle placed on the market often has no packaging but is sold in bulk. The aim of

the restriction proposal is not to increase the packaging of products. An information 'corner', or some poster, sufficiently visible, understandable and in the national language of the customer could be sufficient to fulfil this requirement. The choice or format of the information is left to the retailer.

RO7 could be compared as the initial step in a change management process which is to make aware and engage stakeholders about the importance of the issue and leverage that concern as a catalyst for a positive change in their behaviour. Such an approach has been highlighted in recent publications. For example, according to Schulz et al. (2019), the initial step to change fishers and hunters behaviour toward lead fishing tackle and ammunition is to have stakeholders recognising the importance of the lead issue both for the human health and the environment, and "use that concern as a catalyst for a positive change in their consumer purchasing behaviour"(Schulz et al., 2019).

<u>Effectiveness</u> (target and risk reduction)

It is difficult to evaluate the effect of communication and awareness raising on consumers behaviour, and in particular how much such action, on its own, would impact the releases of lead to the environment.

The proposed measure could also have a positive impact in reducing the home-casting habit, by alerting fishers about the risk of lead for their health, and in improving the hygiene habits when manipulating lead fishing tackle; again, the extent of the effect on human-health cannot be ascertain and quantified.

Fishers value fishing with lead fishing tackle, and value home-casting activities for many different and complex reasons. Changes to values are unlikely to occur after education and informational campaigns because values are central to one's identity and are relatively stable over the course of a lifetime (Fulton et al., 1996). Therefore, according to Grade et al. (2019), rather than attempting to change values (e.g. 'fishing with lead is bad' type of message), another strategy is to promote messages that match the values of the fishers. In the case of lead fishing tackle, it may be beneficial to focus on messages that appeal to egoistic values in addition to biospheric[169]. Implementing information that focus on the human health hazards of lead, for example, might appeal to those expressing fewer concerns about wildlife health but are more concerned about their own personal well-being.

Another issue is that although attractive, this type of information on its own does not provide the guaranteed market incentives to fishing tackle manufacturers (Schulz et al., 2019), and therefore does not ensure that more alternatives would become available to the fishers, and therefore that lead release reduction would be substantial.

Several peer-reviewed studies have affirmed how warning labels or tags are likely to be ignored when there is a low perception of hazard. Wogalter et al. further observed that "familiarity [with the product] was negatively related to willingness to read warnings" which has subsequently been corroborated by the vast majority of scientific studies on this topic (Wogalter et al., 1991).

<u>Practicality</u>

[169] According to (Stern et al., 1999) 'egoistic' means 'maximizing individual outcomes', and 'biospheric' can be defined as 'caring for non-human nature and the biosphere itself'.

The proposed restriction would require the importers, only-representatives, retailers and the web retailers of fishing tackle (including the non-specialised website such as Amazon, eBay, Wish, or Alibaba) to (i) inform their customers (till the transition period enters into force), but also (ii) ensure, and check that lead is not present in the fishing tackle placed on the market. The retailers' compliance costs, i.e. the costs to implement the restriction condition related to consumers information at point of sale, are estimated to be null, because they are considered as part of the normal business and maintenance of the shops or websites.

Enforceability

In terms of enforcement, it is assumed that enforcement authorities would conduct spot checks retailers site inspections, and retailers' website inspection after the entry into force of the proposed restriction option. The inspection would consist of a 'visual inspection' to check if information on the hazard and risk of lead are made available to consumers either (i) on the shelfs of shops where the lead fishing tackle are sold, or (ii) on the packaging of the fishing tackle itself (if appropriate), and (iii) on the website in case of e-commerce.

Monitorability

The direct effect, i.e. reduction of releases to the environment, of the proposed restriction (RO7 on its own) is difficult to monitor. Nevertheless, the efficiency of the proposed reduction could be monitored indirectly by conducting market survey and mistory shopping exercices at the point of sales (shops, webstores and social media).

D.4.6. Other Union-wide risk management options than restriction

Possible Union-wide risk management measures other than a restriction are outlined in the table below. None of the listed measures on their own are practical, or effective means of addressing all the risks posed by lead in fishing tackle. Nevertheless, some of the other Union-wide risk management measures could be used to support the preferred restriction option. The first column of the table indicates which risk management options could be combined with the proposed restriction for lead in fishing tackle.

Table D.4-31: Other Union-wide risk management options

In support of the preferred RO	Risk management option	Description of the option
Non-legislative measures		
YES	Voluntary education-only programmes	Grade et al. have reviewed and assessed the effectiveness, in terms of reduced uses of lead tackle and/or reduced mortality wherever data are available, of voluntary and education-only programmes both in Europe (UK, Sweden, Denmark) and North America (various US states and Canada) between 1980 and 2016 (Grade et al., 2019). It concludes that none of these voluntary and education-only programmes to manage risks from lead fishing tackle have proven to be effective, and that legislative measures had to be introduced after all. Another issue is that although attractive by avoiding conflict, voluntary programmes do not provide the guaranteed market incentives to fishing tackle manufacturers (Schulz et al., 2019). The ineffectiveness of pure voluntary and education-only programmes was also reported in the call for evidence by WWT (CfE #1247). Even if not efficient on its own, such a measure could support a ban on lead fishing tackle.
NO	Voluntary industry agreement to restrict the use of lead in fishing tackle	In June 2015, EFTTA called[170] on the fishing trade and the angling community to voluntarily stop manufacturing, importing, retailing and using angling weights (sinkers) made of lead above the size of 0.06 grams and replace them with suitable lead free alternatives by 2020 at the latest. In 2020, this voluntary agreement did not come to

[170] Available on: https://www.eftta.co.uk/media-centre/news/eftta-position-statement-on-angling-lead-weights-sinkers

		true.
YES	Information campaign to consumers to promote the use of non-lead fishing tackles	Lead alternatives seem slow to be adopted by the recreational fishers, either because they do not match the exact same properties of lead (e.g. easy to manipulate, high density), are too expensive or because often fishers may have preconceptions or beliefs justified or not on the added value of lead for fishing. In some countries (e.g. Belgium, The Netherlands, Germany), projects have been launched in order to present and introduce the lead alternatives to fishers, some initiative often includes free testing of alternatives in order to erase some subjective beliefs with reg. to non-lead fishing sinkers (CfE #1034). Public information campaigns are designed to influence a target audience's behaviour. However, research has shown that such communication campaigns have moderate to strong effects on cognitive outcomes, less on attitudinal outcomes, and still less on specific behaviours (Rice and Atkin, 2012).
YES	Granting of fishing-licence conditional to a mandatory training on the risk of lead and lead home-casting	There is no harmonised licencing system in Europe and holding a licence or a permit is not always compulsory to fish (cf. Annex A), therefore this option cannot be implemented EU-wide. Nevertheless, even if not efficient on its own, such a measure could support a ban on lead fishing tackle in countries where the granting of a licence is conditional to passing an exam (e.g. in Germany)
YES	Fee collected from licences purchase	There is no harmonised licencing system in Europe and holding a licence or a permit is not always compulsory to fish (cf. Annex A), therefore this option cannot be implemented EU-wide. Nevertheless, even if not efficient on its own, such a measure could support the European industry to transition to non-lead fishing tackle manufacturing. For example, assuming 12 million of licences granted yearly in Europe, and adding a 10 cts fee to support the transition to non-lead fishing tackle. This additional small fee would generate yearly €1.2 million. Such a fee collection could be organised by the fishing association or using some EU founding program.
YES	Retailer voluntary scheme to sell only fishing tackle from authorised sources	

Legislations other than REACH		
NO	Product Safety Directive 2001/95/EC	This Directive addresses risks to consumers (termed health and safety of consumers) related to specific products and not risks related to a cumulated exposure from different products, or to risks posed to the environment. This measure would therefore not be appropriate.
NO	Environmental tax on lead fishing tackle placed on the market	Assuming that selling prices of today's fishing tackle do not reflect the true environmental cost of the products. It could be possible to internalize these environmental costs by increasing the final product's selling price. The EU could achieve this by implementing an environmental tax on all lead fishing tackle. This tax would be designed to make the lead fishing tackle more expensive than the alternatives. Taxation on lead fishing tackle could be used to influence the purchase behaviour of fishers in a more environmentally friendly direction. Such a tax could also motivate producers to design more sustainable alternatives (Sherrington et al., 2016). The existence of alternatives is indeed crucial to the prospects of reducing risks to health and the environment. Such taxes can also generate revenue that could be used to (i) support the European industry to transition towards the manufacturing of non-lead fishing tackle, (ii) launch R&D activities to work on 'degradable' alternatives, (iii) launch consumer's awareness campaign, or (iv) support marine/freshwater litter projects such as beach clean-up activities. Although there are currently no examples of such environmental taxes for fishing tackle, case studies do exist on products like plastic bags where the sale of such products have significantly reduced (Sherrington et al., 2016). Nevertheless, despite being attractive, the set up of a harmonised taxation scheme is extremely complex to coordinate, and put in place at EU level. Taxation in general is not a harmonised measure across the EU. Therefore, whilst it might be effective in encouraging substitution, it is not likely that all Member States would introduce relevant taxes and thereby, not all EU citizens will be protected. This is therefore likely to lead to a non-harmonised situation where different Member States apply different tax rates (if at all).

		In addition, while this option would encourage manufacturers, and fishers to switch to non-lead fishing tackle, it is difficult to predict the risk reduction that would result from a given fee, even if case studies exist (e.g. taxes on plastic bags) and have demonstrated that the sale of such products have significantly reduced when applying an environmental tax. In addition, home-casted fishing tackle would not be subject to a fee unless they are sold. As such, the quantity of home-casted sinkers would not be expected to decrease as a direct result of the fee (in fact it may increase as consumers attempt to avoid the fee on purchased sinkers) possibly undermining the intended change expected from the fee. For these reasons, this option is abandoned.
Other REACH processes		
NO	REACH authorisation	Lead is classified as Repr. Cat 1a, and is identified as a SVHC, so it could be included on the candidate list and prioritised for Annex XIV inclusion. However, authorising the use of lead would be a disproportionate measure as it would affect all uses of massive lead, not just the use of lead in ammunition and fishing tackle. In addition, REACH authorisation does not apply to imported articles. As a huge proportion of fishing tackle are imported, REACH Authorisation would not be appropriate to address the risk.
NO	REACH Article 68(2)	Lead in fishing tackle is potentially within the scope of this process (as it is classified as Repr. cat 1a) and is used for consumer uses. However, due to the need to carefully consider the impact of any measure proposed (not a requirement of Art 68.2) the Commission decided to request ECHA to prepare a restriction under Article 69(1).
NO	REACH Restriction on substances and mixtures for consumer uses classified as reproductive toxicants cat. 1A or 1B and listed in appendices 5 and 6 (Restriction entry 30)	Lead and its compounds are classified as reprotox. 1A in the CLP Regulation, and are listed in appendix 5 to entry 30. Nevertheless, Reprotox. substances that are present in articles are not within the scope of the restriction imposed by entries 30. Therefore this restriction entry cannot apply to lead fishing sinkers and lures.
NO	REACH Restriction on lead in articles – Article 69(4)	According to the restriction Entry 63 - paragraph 7: lead and its compounds 'shall not be placed on the market or used in articles supplied to the general

	(Restriction entry 63)	public, if the concentration of lead (expressed as metal) in those articles or accessible parts thereof is equal to or greater than 0,05 % by weight, and those articles or accessible parts thereof may, during normal or reasonably foreseeable conditions of use, be placed in the mouth by children.’ The associated guideline[171] clarifies in Table 2c the list of articles which are considered out of scope of the restriction due to non-mouthability/non-reachability under normal or reasonably foreseeable conditions of use. It includes "Fishing rods and weights: these have obviously sharp and pointed part of articles such as fishing hooks and are typically out of the reach of children in normal or reasonably foreseeable conditions of use”.

[171] Available at: http://echa.europa.eu/documents/10162/13563/lead_guideline_information_en.pdf

D.5. Benefits to the environment

D.5.1. Monetisation of impact on birds

A key objective of the restriction proposal is the reduction of lead poisoning in both terrestrial birds (including predatory/scavenging birds) and waterbirds in the EU as a consequence of the ingestion of lead ammunition and lead fishing tackle.

Partwise monetisation of this externality of the use of lead shot is possible at least for terrestrial birds ingesting lead shot under the following assumption. It is possible to value the premature death of an individual game bird by the opportunity cost of not being able to shoot it. This opportunity cost can be approximated by the stocking cost incurred to raise one bird of the same species. Stocking costs for 17 game bird species for which lead gunshot ingestion represents a risk have been gathered by the Dossier Submitter through a market survey made in the EU 27-2020[172]. However, these 17 species do not represent the total number of species at risk of lead poisoning in the EU identified by the Dossier Submitter (see Annex XV for further details).

The following tables (Table D.5-1 and Table D.5-2) present three scenarios with different mortality rates for 17 wild bird species (game birds) at risk of lead poisoning from lead gunshot and the market price of a captive-bred bird (per species) that would need to be released annually in the EU to replace wild birds that died due to the ingestion of lead gunshot. Justification for the selection of the mortality rates are provided in the Annex XV report (environmental risk characterisation section). The Dossier Submitter has used the central scenario (1 % mortality rate) for the monetisation.

Table D.5-1 Number of birds in the EU for 17 wild birds' species (game birds) at risk of lead poisoning and mortality rates scenarios following ingestion of lead shot, used in the monetisation approach carried out by the Dossier Submitter.

Scientific name	Common name	Wild birds in EU 26 (total number of individuals) [173]	Birds to be replaced (0.5 % mortality rate)	Birds to be replaced (1 % mortality rate)	Birds to be replaced (2 % mortality rate)
Alectoris barbara	Barbary Partridge	27 500	138	275	550
Alectoris chukar	Chukar	634 035	3 170	6 340	12 681

[172] The Dossier Submitter carried out an extensive market research to identify market prices of the many hunted bird species in the European Union. The Dossier Submitter identified more than 120 breeders/sellers across 17 countries, from which the pricing information was gathered either by email or by means of online searches. When the prices were available in currency other than EURO, they were converted to EURO using the exchange rate of the day. After the data collection was completed, the Dossier Submitter proceeded to examine the pricing information and to determine the lowest, the highest and the average prices for each of the bird species.

[173] Updated information for Romania was not available and will be gathered during the opinion making process by the Dossier Submitter. Therefore, for the purpose of monetising the benefits EU 26-2020 information has been considered.

Alectoris graeca	Rock Partridge	76 046	380	760	1 521
Alectoris rufa	Red-legged Partridge	11 827 726	59 139	118 277	236 555
Bonasa bonasia	Hazel Grouse	1 474 787	7 374	14 748	29 496
Coturnix coturnix	Common Quail	1 931 604	9 658	19 316	38 632
Lagopus lagopus	Willow Grouse	606 638	3 033	6 066	12 133
Lagopus muta	Rock Ptarmigan	343 367	1 717	3 434	6 867
Lyrurus tetrix	Black Grouse	1 381 382	6 907	13 814	27 628
Perdix perdix	Grey Partridge	1 690 342	8 452	16 903	33 807
Phasianus colchicus	Common Pheasant	4 234 623	21 173	42 346	84 692
Columba livia	Rock Dove	34 943 404	174 717	349 434	698 868
Columba oenas	Stock Dove	799 283	3 996	7 993	15 986
Columba palumbus	Common Woodpigeon	34 886 805	174 434	348 868	697 736
Streptopelia decaocto	Eurasian Collared-dove	18 717 237	93 586	187 172	374 345
Streptopelia turtur	European Turtle-dove	4 988 325	24 942	49 883	99 767
Scolopax rusticola	Eurasian Woodcock	2 039 131	10 196	20 391	40 783
Total (rounded)			***600 000***	***1 200 000***	***2 400 000***

Table D.5-2 Economic value of 17 captive-bred bird's species (per bird) that should be released annually in the EU to replace wild birds died due to the ingestion of lead gunshot.

Scientific name	**Common name**	**Low price (€) per bird in the EU -2020**	**Medium price (€) per bird in the EU -2020**	**High price (€) per bird in the EU -2020**
Alectoris barbara	Barbary Partridge	20	37	50
Alectoris chukar	Chukar	18	36	50
Alectoris graeca	Rock Partridge	15	25	40
Alectoris rufa	Red-legged Partridge	10	20	35

Bonasa bonasia	Hazel Grouse[174]	34	34	34
Coturnix coturnix	Common Quail	1	3	10
Lagopus lagopus	Willow Grouse	13	13	13
Lagopus muta	Rock Ptarmigan	13	37	63
Lyrurus tetrix	Black Grouse	135	268	445
Perdix perdix	Grey Partridge	8	20	47
Phasianus colchicus	Common Pheasant	3	18	50
Columba livia	Rock Dove	4	17	30
Columba oenas	Stock Dove	2	3	5
Columba palumbus	Common Woodpigeon	18	36	75
Streptopelia decaocto	Eurasian Collared-dove	2	5	7
Streptopelia turtur	European Turtle-dove	14	14	85
Scolopax rusticola	Eurasian Woodcock[175]	25	25	30

In addition to the cost of buying captive-bred birds for release, the Dossier Submitter calculated how many captive-bred birds would have to be released to compensate for the loss due to the ingestion of lead shot taking into account the higher mortality rate of captive birds in the months following release into the wild. Andreotti et al. (2018) reported for captive-bred waterbirds a natural mortality of 72.7 %, when released into the wild. The Dossier Submitter is not aware of specific mortality rates for all terrestrial species and therefore assumed that the upper bound of mortality rate of captive birds in the months following the release into the wild could be similar to that of waterbirds. However, information provided by different sources on pheasants seems to support this assumption for this species. Madden et al. (2018) report that natural mortality (excluding shooting) of reared pheasants from release to the start of shooting season in February runs at 61 %; an Italian regional authority[176]"reports that *"the release of farmed game should be limited to the hunting period, in order to minimize natural mortality, which can reach an incidence of 80 % in the first 20 days after release".*

For all captive-bred terrestrial species at risk of lead poisoning the same post-release mortality into the wild was assumed. In Table D.5-3, the Dossier Submitter built two

[174] The Dossier Submitter received an answer from one breeder only. Therefore, the same value is currently used as low, medium, high price. In the public consultation 2021, it is expected to gather additional information to refine this estimate.

[175] The Dossier Submitter received an answer from two breeders only. Therefore, the same value is currently used as low and medium price. In the public consultation 2021, it is expected to gather additional information to refine this estimate.

[176] Additional evidence is described at: http://www.sterna.it/AggCartVocCD/cap_i_principale_000007.htm (Regione Emilia Romagna, ASSESSORATO AGRICOLTURA, ECONOMIA ITTICA, ATTIVITA' FAUNISTICO-VENATORIE).

restocking scenarios to calculate how many captive-bred birds would have to be released into the wild in order to balance population losses through lead poisoning.

Table D.5-3 Replacement scenarios to calculate how many captive-bred birds would have to be released into the wild to compensate for the loss due to the ingestion of lead shot for 17 game birds species

	Lower bound restocking cost assuming 1:1 replacement (€) **SCENARIO A**			**Upper bound restocking cost assuming 1:7 replacement (€)** **SCENARIO B**		
	Low price	*Central price*	*High price*	*Low price*	*Central price*	*High price*
Barbary Partridge	2 750	10 278	27 500	19 250	71 947	192 500
Chukar	57 063	230 366	634 035	399 442	1 612 562	4 438 245
Rock Partridge	5 703	18 916	60 837	39 924	132 415	425 858
Red-legged Partridge	591 386	2 345 832	8 279 408	4 139 704	16 420 826	57 955 857
Hazel Grouse	250 714	501 428	1 002 855	1 754 997	3 509 993	7 019 986
Common Quail	9 658	65 404	386 321	67 606	457 829	2 704 246
Willow Grouse	38 218	76 436	152 873	267 527	535 055	1 070 109
Rock Ptarmigan	21 975	126 016	429 209	153 828	882 110	3 004 461
Black Grouse	932 433	3 695 197	12 294 300	6 527 030	25 866 378	86 060 099
Grey Partridge	67 614	338 566	1 588 921	473 296	2 369 959	11 122 450
Common Pheasant	63 519	782 186	4 234 623	444 635	5 475 303	29 642 361
Rock Dove	698 868	5 840 540	20 966 042	4 892 077	40 883 783	146 762 297
Stock Dove	7 993	25 577	79 928	55 950	179 039	559 498
Common Woodpigeon	3 139 812	12 495 819	52 330 208	21 978 687	87470735	366 311 453
Eurasian Collared-dove	187 172	868 480	2 620 413	1 310 207	6079359	18 342 892
European Turtle-dove	349 183	698 366	8 480 153	2 444 279	4888559	59 361 068
Eurasian Woodcock	254 891	509 783	1 223 479	1 784 240	3568479	8 564 350
Total (rounded)	***6 700 000***	***28 600 000***	***114 800 000***	***46 800 000***	***200 400 000***	***803 500 000***

The Dossier Submitter assumes that the aggregate opportunity cost for restocking approximately 1 200 000 terrestrial birds (related to EU 26) from these 17 species that are currently lost per year due to lead poisoning is close to the average value between scenario A and scenario B presented in Table D.5-3 and amounts to approximately €114 million per year. As discussed in the Annex XV report, this captures only part of the bird species that are vulnerable to lead poisoning from different sources of lead (in ammunition and fishing tackle) in the EU.

However, it does assume that all birds lost due to lead poisoning would actually be restocked. This assumption is supported by abundant evidence that restocking of birds for hunting purposes is a common practice in many EU Member States. For example,

Mazzoni della Stella (2019)[177] reports that in southern Europe, especially in Spain and Portugal, the release of captive-bred red-legged partridges and pheasants is widespread; in Germany, Austria, Belgium, The Netherlands, Luxembourg and particularly in France releases of pheasants, grey partridges and red-legged partridges are very common. Based on various sources, Madden et al. (2018) report that each year approximately 25-50 million pheasants are released in the UK. Seiler et al. (2000) describe several releases of captive-bred birds (including black grouse) aimed at the supplementation of local population. However, specific restocking data are not available for all hunted species. The Dossier Submitter therefore uses €114 million per year as best estimate of the direct benefit of avoiding the premature death of terrestrial birds from lead poisoning. However, it should be noted that this figure does not include benefits to birds beyond the 17 species reported in Table D.5-1, including some iconic species such as the Eurasian griffon (*Gyps fulvus*), nor does it include other indirect benefits discussed in the restriction report.

[177] https://www.cacciamagazine.it/piccola-selvaggina-come-si-gestisce-in-europa.

Annex E: Stakeholder consultation

During the preparation of this Annex XV restriction proposal, the Dossier Submitter has maintained an open and interactive dialogue with relevant stakeholders: industry associations, companies at different level of the supply chains, but also fishers, hunters and sport shooters associations, NGOs and Member States Competent Authorities (MSCA).

The consultation of the stakeholders has been made using various means such as written consultation via calls for evidence, market study, but also through targeted calls, emails and dedicated meetings or roundtable.

E.1. Call for evidence

A call for evidence to support the preparation of this Annex XV restriction proposal was open on the ECHA website between 03/10/2019 and 16/12/2019. It was focusing on specific topics such as:

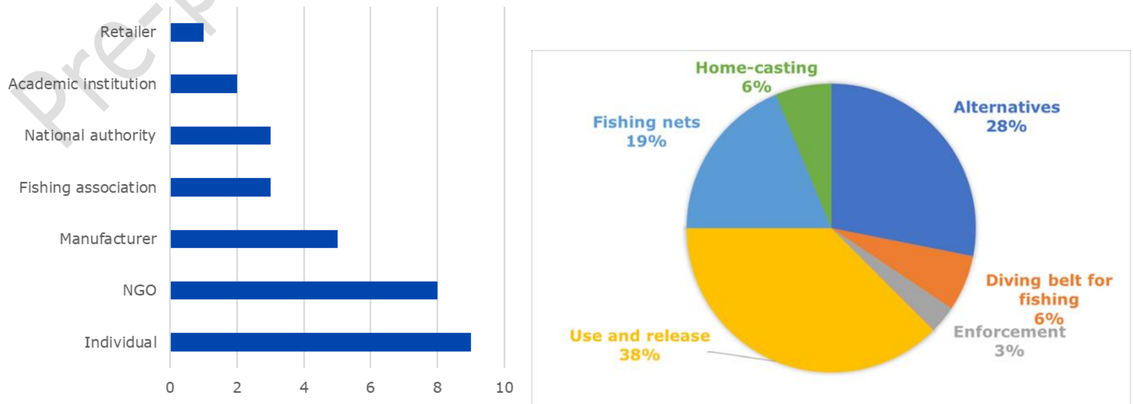
- Information on quantities of lead used and/or released to the environment and the resulting human health or environmental impacts
- Current best practice (including effectiveness) to minimise lead exposure to humans or the environment during use
- Alternatives
- Information on other socio-economic impacts in response to a possible restriction, and in particular costs and benefits to affected actors, e.g. producers (including producers of alternatives), professionals, consumers.

The background note for the call for evidence gives more details on the specific questions that were asked to the stakeholders[178].

In total 383 comments were received during the 2-month call for evidence, essentially from citizens (222 comments). Most of the comments were related to hunting and sport shooting.

In addition, 31 comments were submitted on the use of lead in fishing tackle. These comments were essentially submitted by citizens and NGOs as depicted in Figure E.1-1.

Figure E.1-1: Participation to the call for evidence on lead in fishing tackle, and main topics of interest



[178] Available at: https://echa.europa.eu/documents/10162/7d96a4a1-c102-8f8b-46e3-96d682b1818c

The comments provided during the call for evidence were considered by the Dossier Submitter. In some cases, some follow-up exchanges have been organised by email, phone or meeting in order to clarify the information provided.

E.2. Workshop, meeting and round table

A workshop with hunting and sport shooting stakeholder was organised in ECHA premises on 10 and 11 February 2020[179].

A roundtable on lead in fishing tackle was organised via Webex on 18 November 2020. There were 26 participants (lead fishing tackle manufacturers, alternative producers, fishing associations, NGOs and EU Commission), and the main topics discussed were:

- The European fishing tackle market and supply chain
- Drivers and barriers to substituting lead
- 'Home casting' of lead fishing tackle
- Role of fishing associations

E.3. Cooperation with other EU / international bodies

ECHA worked together with the European Food Safety Agency to derive its conclusion on Human Health impacts With EFSA a specific evaluation was set-up to investigate lead on game meat for consumption

ECAH worked together with the European Environmental Agency on art 12 (Bird Directive) database concerning the population of birds in the EU-27.

A group of experts[180] from UNEP/ (CMS[181]) were consulted to gather additional information on EU birds species; especially species for which specific literature was limited at the EU level.

E.4. ECHA market surveys

The Dossier Submitter undertook several market studies:

- On lead in hunting and sport shooting:
    - bird breeders in different EU countries were contacted to gather prices of several EU game birds species
    - a market study was undertaken to assess the availability and prices of alternatives to lead shot and lead ammunition
- On lead in fishing tackle: a 'mystery shopping' exercise was carried out on between June and September 2020 (consulting more than 80 retailer websites). Through this exercise, about 1 000 different non-lead fishing sinkers and lures were identified, and the following information were stored in the database:
- On lead in fishing tackle: a market study was also carried out where more than 100 stakeholders were contacted either directly or via European associations (EFTTA, GIFAP, EAF, CIPS, FIPS, ATA, national fishing associations) – the stakeholders represented both lead and non-lead fishing tackle manufacturers,

[179] Summary of the workshop available at https://echa.europa.eu/-/lead-in-hunting-and-sports-shooting-workshop

[180] UNEP/CMS ad hoc Expert Group. At the request of the Dossier Submitter they provided information on the likelihood of ingestion by European bird species of lead ammunition in terrestrial environments and lead fishing weights.

[181] Convention on Migratory Species.

retailers, fishers association, and NGOs. Amazon, the web retailer was also consulted, but did not respond to any of our requests.

The market surveys have proven to be crucial in identifying costs and impacts of the different restriction options, as well as the availability and costs of alternatives. The information collected during the market study have been used in the preparation of this dossier.

E.5. Questionnaire to Member States and questionnaire to stakeholders on sport shooting ranges

In May 2020, a questionnaire (referred to as MS survey, 2020) on sport shooting ranges was submitted to invite MSCA (or any other national body acting on behalf of MSCA) to assist the Dossier Submitter on gathering information related to sport shooting.

The questionnaire prepared by the Dossier Submitter consisted of three main sections: information on type and numbers; information on national or regional bans; information on legal permits, procedures, best management practices and remediation; plus a final section including data related to lead exposure of humans.

In June 2020 a questionnaire (referred to as Stakeholders questionnaire, 2020) on sport shooting ranges was submitted to invite some stakeholders to answer a short list of specific questions related to sport shooting. Stakeholders invited included among others FITASC, International Biathlon Union, Swedish, Finnish, German sport shooting associations.

E.6. Other

The Dossier Submitter interviewed with several veterinary experts to gather information on the risk of lead poisoning from sports shooting to livestock and the potential for human exposure and risks from consumption of livestock products (e.g. meats, milk) containing lead.

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