POISONOUS METAL

METHYLMERCURY IN SHARK TISSUE SAMPLES FROM THE EUROPEAN MARKET

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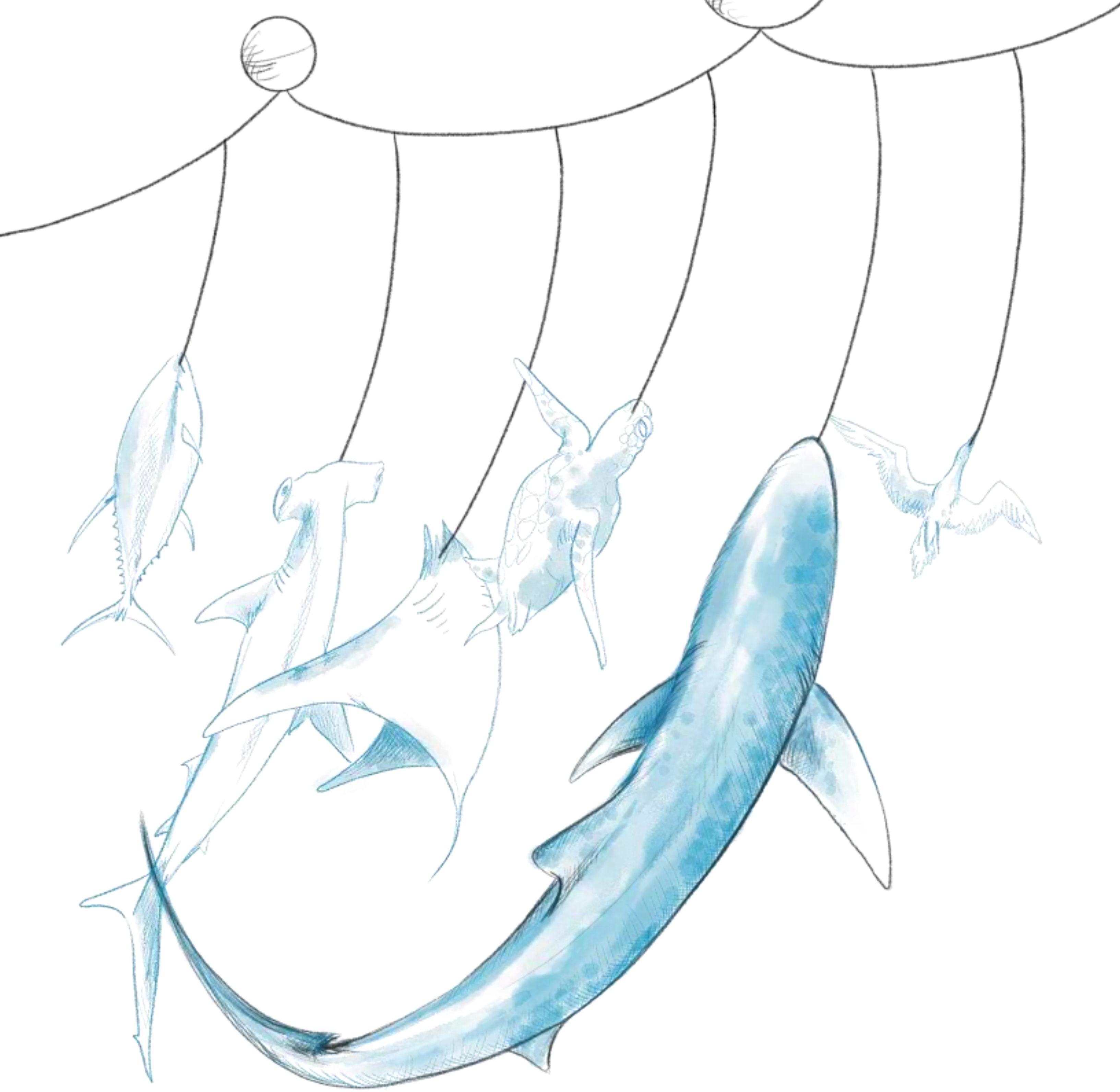

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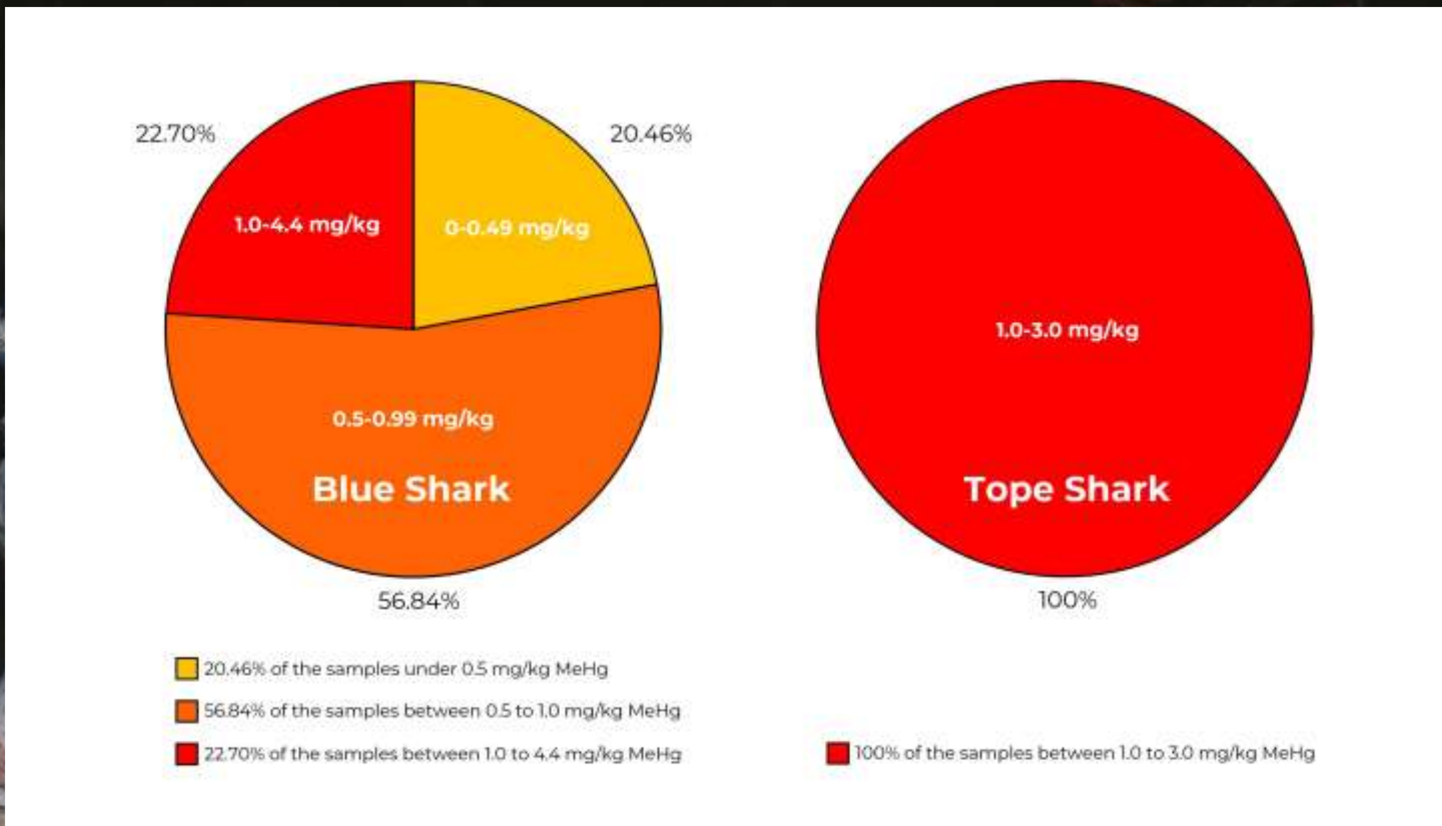
POISONOUS METAL

METHYLMERCURY IN SHARK TISSUE SAMPLES FROM THE EUROPEAN MARKET

Poisonous metal: Methylmercury in shark tissue samples from the European market

Abstract

The international shark meat trade remains largely overlooked compared to the shark fin industry, despite the European Union (EU) being a key stakeholder in both markets. Spain in particular plays a central role as the world's largest exporter of shark meat. Beyond ecological impacts, shark meat consumption raises significant public health concerns due to contamination with methylmercury (MeHg), a potent neurotoxin that bioaccumulates in marine predators. This study investigates MeHg concentrations in blue shark (*Carcharhinus glaucus*) and tope shark (*Galeorhinus galeus*) meat available in European markets. A total of 51 samples (44 blue shark, seven tope shark) were collected from restaurants, fishmongers, and supermarkets across Europe, predominantly from the North Atlantic (FAO Area 27) and East Atlantic (FAO Area 34). Of these, 32% exceeded maximum permitted level of 1.0 mg/kg, set by Switzerland, the EU, and the WHO. While 22.7% of blue shark samples exceeded this threshold, all tope shark samples surpassed it, though the sample size was limited (n=7). These findings highlight substantial health risks, particularly given that MeHg accumulates in human tissue with a half-life of approximately 60 days and is especially harmful to foetal and child neurodevelopment. Moreover, mislabelling of shark products increases consumer exposure risks. In conclusion, nearly one-third of shark meat samples exceeded regulatory safety limits, underscoring the need for stricter monitoring, clearer labelling, and consumer advisories. The study strongly recommends minimizing, or ideally avoiding, shark meat consumption due to its potential serious health hazards.



Unloading blue shark and swordfish from the Portuguese vessel Mestre Bobicha, Ponta Delgada, Azores, Portugal

1. Introduction

While awareness of the negative implications of the international shark fin trade is steadily increasing, the scale and consequences of the shark meat trade are still under the radar. Yet, the EU is a major player, just as in the shark fin industry, with its exports and imports accounting for 22% of the international trade in shark meat. As in the shark fin trade, Spain plays a significant role in international trade, by acting as the largest exporter of shark meat globally, followed by Portugal (Niedermüller et al. 2021). While the shark fin trade focuses on the threat to shark populations, the issue of shark meat also raises health concerns for consumers. This is because methylmercury (MeHg), a highly toxic substance, often contaminates shark meat in excess.

The main source of methylmercury in humans is predatory fish. Primarily large species at higher trophic levels, such as sharks, have high concentrations of methylmercury. Bioaccumulation of mercury is the cause: as the trophic level and size of the animals increase, so does the concentration of the neurotoxic substance in their tissue. However, contamination is not distributed homogeneously across the respective size but varies between different species (Matulik et al. 2017).

In general, however, it can be said that by consuming marine animals at higher trophic levels, such as sharks, humans expose themselves to higher concentrations of methylmercury, a known potent neurotoxin.

In nature, mercury occurs naturally, e.g. through volcanism, as well as from anthropogenic sources (Figure 1). Advancing industrialization has led to a significant increase in the latter over recent centuries, with examples including coal power plants and mining (Lamborg et al. 2014). While mercury often occurs in less toxic forms on land, highly toxic methylmercury accounts for 80-100% of the total mercury in fish. The reason for this is the methylation of mercury through microbial and chemical processes, mostly in the sediment of water bodies (Celo et al. 2006)

The pronounced accumulation of MeHg in living organisms has an evolutionary cause. In the past, the ocean was a partly nutrient-poor habitat where its aquatic inhabitants had to develop processes over the course of evolution to accumulate essential substances in their tissue. However, this also facilitated the accumulation of toxic substances and led to the accumulation of methylmercury in the animals' tissue (Kruse and Bartelt 2008). The phenomenon of accumulation can be attributed to the fact that methylmercury is a positive ion, which enables it to form bonds with negative ions, such as chlorides. Consequently, methylmercury can also accumulate in humans via chlorides, since the latter are fat-soluble and skin-soluble. Subsequent to ingestion, the half-life of methylmercury in the human body is 60 days (Kruse 2010). The regular consumption of contaminated foods, such as tuna, swordfish, shark or whale meat, therefore results potentially in an escalating degree of contamination.

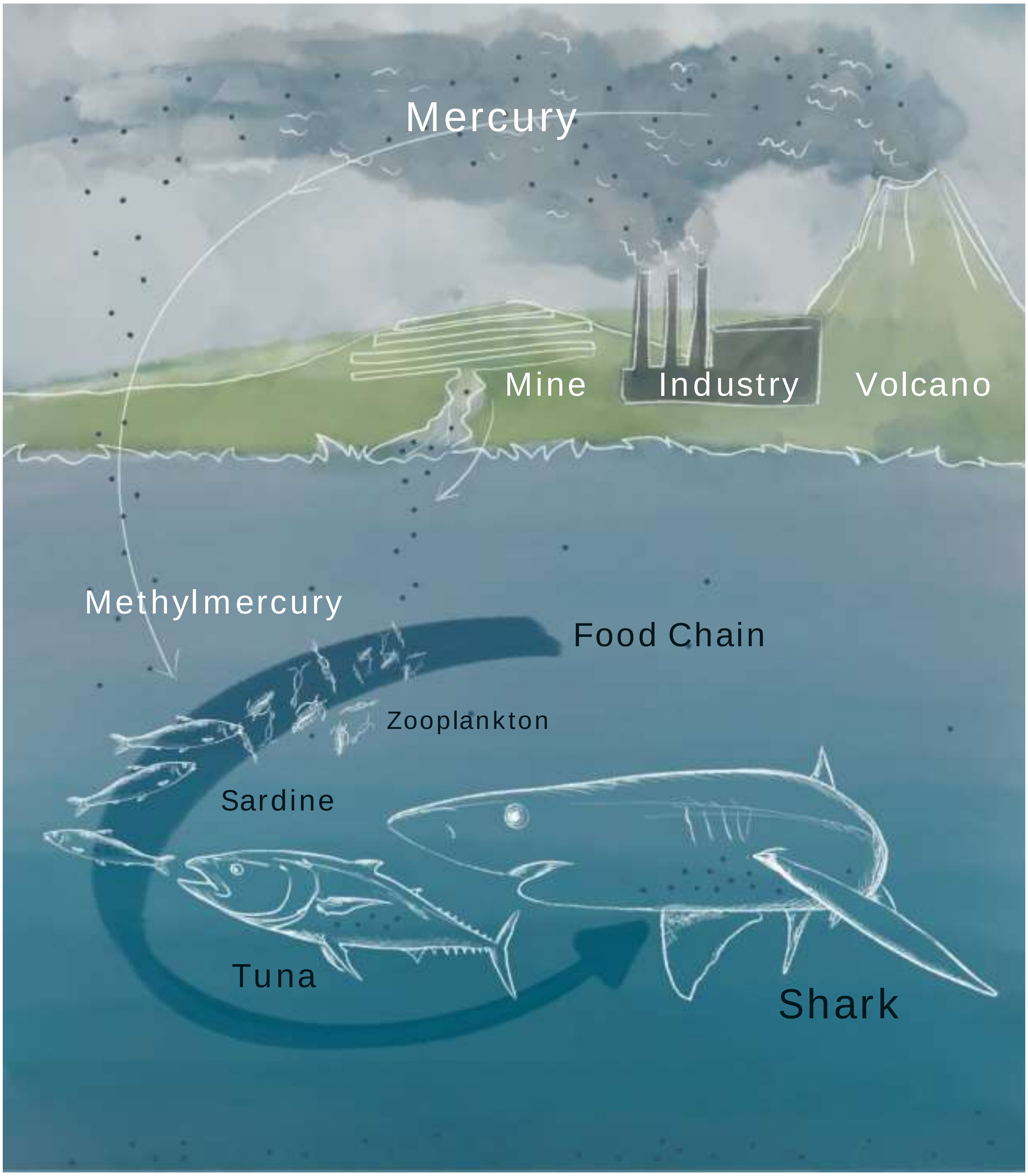


Figure 1: Mercury pathway in nature: Mercury is released into the sea from natural (volcanoes) and anthropogenic sources (coal-fired power plants or mines). Through bioalkylation, mercury in water is converted into methylmercury (MeHg) and enters the food chain via phytoplankton and zooplankton. With each trophic level, there can be an increasing accumulation of MeHg in animals. Large fish, such as sharks, at the end of the food chain can therefore have very high levels of MeHg contamination. (Graphic by Nicola Schlagenwerth, Stop Finning Deutschland e.V.).

The high toxicity of methylmercury has been shown in a multitude of studies (e.g. Díez 2008, Hong et al. 2012) with detrimental effects on human health. Studies show that Methylmercury can cause both neurological and behavioral disorders. Symptoms range from tremors, memory and motor disorders to kidney damage, effects on the immune system and possibly cancer, as some reports suggest (Hong et al. 2012, WHO 2021). The fetal nervous system in particular has been demonstrated to exhibit heightened sensitivity to neurotoxic substances, such as MeHg (Gundacker et al., 2012). While the benefits of fish consumption (Ruxton 2011, Chen et al. 2022), even during pregnancy are discussed in different studies (Bramante et al. 2018, Taylor et al. 2018), the health risk of highly MeHg contaminated food must be addressed, as studies of Grandjean et al. (1993) have shown, that human milk during the nursing period, seems to be an important source of methylmercury exposure in infants.

However, not only does MeHg cause non-specific irreversible damage to the nervous system, it also affects cognitive performance and leads to a demonstrable reduction in IQ. The study by Bellanger et al. (2013) showed that this cognitive decline is not an isolated case, but rather on a measurable scale. The authors even calculated the specific economic loss caused by reduced cognitive performance due to MeHg in the EU.

In order to prevent MeHg poisoning, both the European Union and Switzerland have issued guidelines setting maximum levels for mercury in food (EC No 2023/915, Swiss law from the Federal Food Safety and Veterinary Office: RS 817.022.15). In both cases, the maximum authorised level of mercury in shark species is 1 mg/kg.

The purpose of this brief study is to investigate methylmercury concentrations in shark samples from European supermarkets, fishmongers, and restaurants and identify potential health risks arising from it. Therefore, blue shark (*Carcharhinus glaucus*), the most common shark species on the European market as well as a small sample of tope shark (*Galeorhinus galeus*), were chosen as the objects of this study and analysed by a German ISO-certified laboratory for the contamination with the neurotoxin. The ISO certification ensures that the laboratory operates according to internationally recognized quality and reliability standards, guaranteeing the accuracy and credibility of the analytical results.

Galeorhinus galeus

„Caçao " in Portuguese „tobe shark" in English or „Hundshai" in German. It's all the same: *Galeorhinus galeus*

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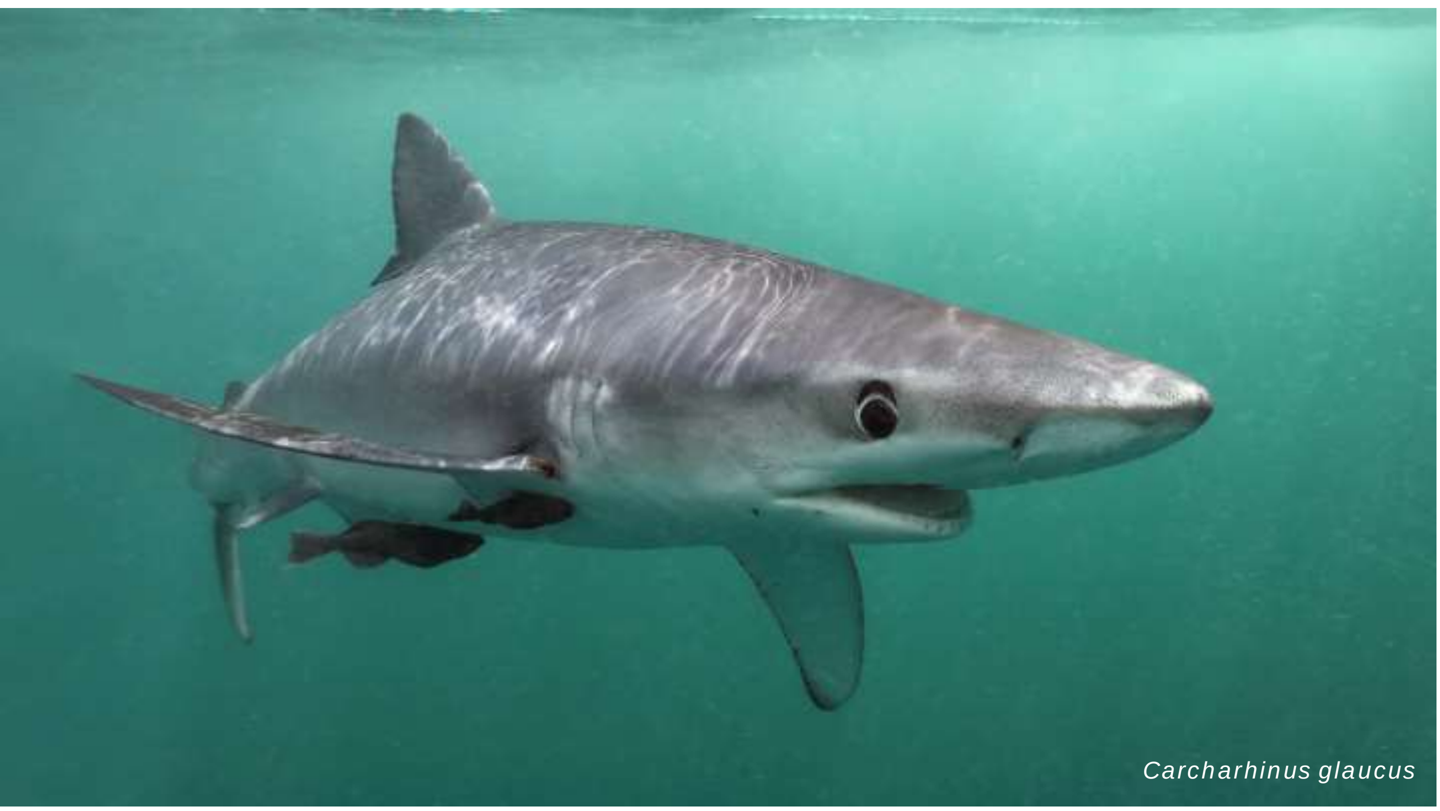
2. Method & Results

Overall, 44 samples of blue shark (*Carcharhinus glaucus)* and seven samples of tope shark (*Galeorhinus galeus*) were obtained from restaurants, fish- and supermarkets across Europe, originating predominantly from the FAO (Food and Agriculture Organization) Major Fishing Areas 27 (North Atlantic, n=20) and 34 (East Atlantic, n=20) (Table 1, Figure 2, Supplementary 1). For three samples, originating from German and UK markets, the fishing area is unknown. Samples, consisting of muscle tissue were purchased frozen or fresh and the immediately deep-frozen after procurement. Due to the purchase of processed products, such as shark steaks, no information on the size or sex of the animals is available. The analysis for methylmercury revealed an overall mean value of 0.91 mg/kg (median: 0.71 mg/kg), with a minimum of 0.22 mg/kg and a maximum of 4.4 mg/kg MeHg for the samples of C. glaucus (Figure 2). For the samples from the North Atlantic waters, the mean was 0.86 mg/kg (min: 0.3 mg/kg; max: 3.5 mg/kg), while the mean of the samples from the East Atlantic was 0.84 mg/kg MeHg (min: 0.46; max: 2.0 mg/kg).

Of the 44 overall examined samples, ten samples (22.7%) showed values of 1.0 mg/kg MeHg or higher.

To compare the results from *C. glaucus*, a smaller subsample of tope shark (*Galeorhinus galeus*, n=7) was also examined for its level of MeHg contamination (Table 1, Supplementary 2). All samples of tope shark were acquired from the Spanish market.



Carcharhinus glaucus

Species	Fishing area	n	Mean ± Std. (mg/kg)	Median (mg/kg)	Min. (mg/kg)	Max. (mg/kg)
	Methylmercury contamination of Blue shark and Tope shark					
Blue shark *C. glaucus*	Overall	44	0.91 ± 0.78	0.71	0.22	4.40
	East Atlantic	20	0.84 ± 0.40	0.73	0.40	2.00
	North Atlantic	20	0.86 ± 0.73	0.65	0.30	3.50
Tope shark *G. galeus*	Overall/ East Atlantic	7	2.00 ± 0.70	3.60	1.10	3.00

Table 1: Contamination of Carcharhinus glaucus and Galeorhinus galeus with Methylmercury in mg/kg. Data are given as the sample size (n), the mean ± standard deviation (Std.), followed by the median and the range (Min minimum, Max maximum).

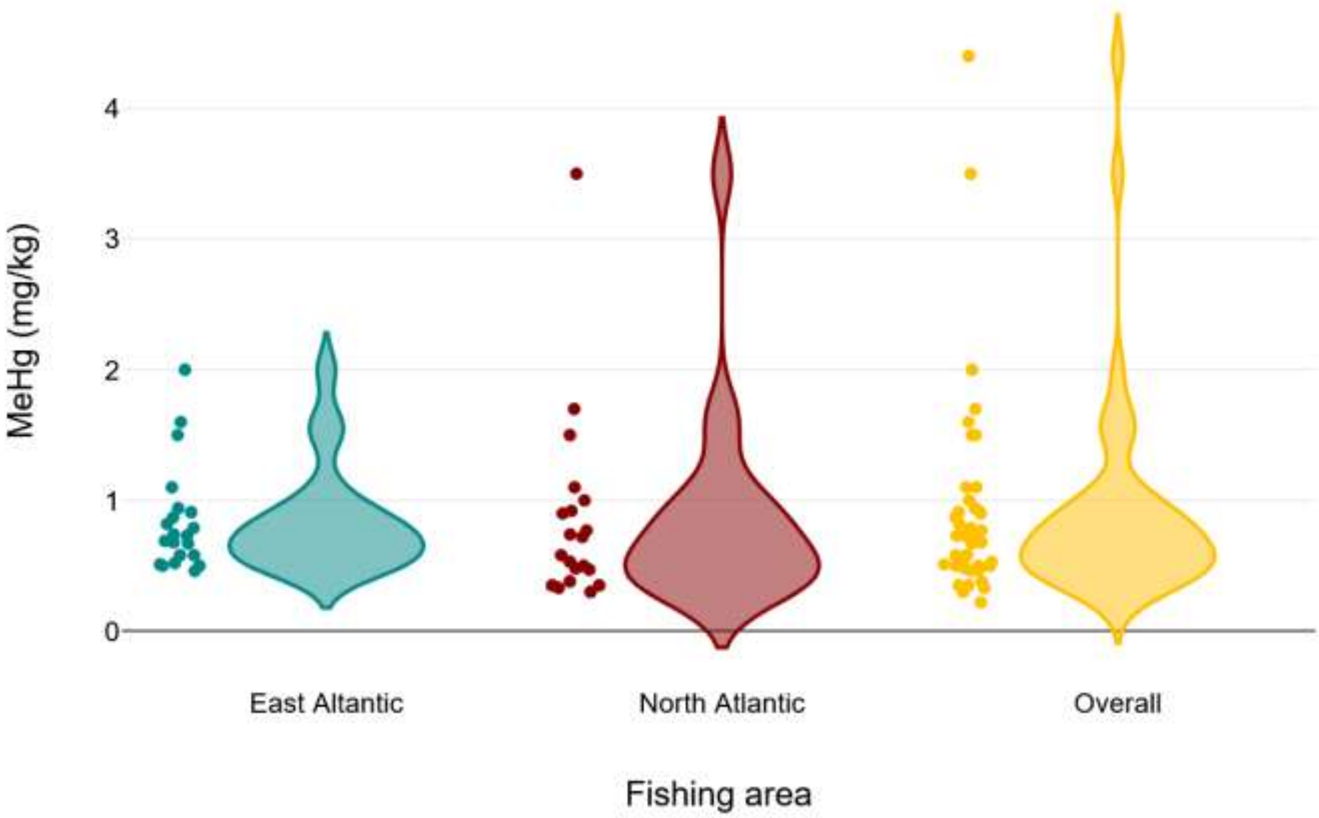


Figure 2: Contamination of MeHg (mg/kg) from the individual samples of Carcharhinus glaucus (dots) and the proportional distribution (violins) for the two main FAO Major Fishing Areas (green, Area 32; East Atlantic; red, Area 27 - North Atlantic) as well as the overall values (yellow).

3. Discussion

By analyzing 51 shark samples from the European food market, this brief study provides a fact-based foundation for a discussion about the health implications of shark products.

With a mean value of 0.91 mg/kg MeHg, the results of the study clearly show a high level of MeHg contamination of the blue shark samples. While the median as well as mean value is below the allowed maximum level of mercury (1 mg/kg) in shark products of the European Union and Swiss Confederation, 22.7% of the blue shark samples exceed the allowed level. For tope sharks, the picture is even more drastic, with all samples (100%) showing values above the allowed maximum level (mean: 2 mg/kg MeHg). While the results show a pronounced difference in contamination levels for both species, the small sample size of tope sharks (n=7) must be kept in mind. Although the tope shark is mainly demersal, occurring near the bottom, it is also frequently found in the pelagic zone of the open ocean. The two species therefore have considerable overlap in their lifestyle and diet (Froese & Pauly 2025). These results could potentially indicate differences in the contamination level between different species, missing information on other relevant factors, such as age and size of the specimens. While the data situation makes it difficult to assess this question, other studies highlighted the correlation between body length and MeHg contamination (Kiszka et al. 2015). But also a variety of other factors, such as origin, growth rate and prey spectrum appear to have an influence on the MeHg accumulation (Matulik et al. 2017, Riesgo et al. 2023).

Even though some aspects cannot be discussed in depth due to the available data, the key message of the study is clear: almost a third (32%) of the studied shark samples exceeded the allowed maximum level, not only highlighting MeHg contamination in sharks, but above all raising stark health concerns for the consumption of blue and tope shark, and of other species of shark in general.

While occasional consumption of neurotoxic foods does not immediately lead to symptoms of poisoning, shark products carry the risk that they are often mislabelled or are even sold under false or imaginative names, such as Rock salmon or Huss in the UK and other English-speaking countries; Schillerlocke in Germany and German-speaking Switzerland; or veau de mer, roussette or saumonette in France and French-speaking Switzerland (e.g. Hobbs et al. 2019, Niedermeier et al. 2023). This can lead to people consuming more highly contaminated shark meat than they are aware of. Research by journalists Jacobson et al. (2025) revealed that the latter scenario is not hypothetical, but very real. They discovered that Brazil, the world's largest importer of shark meat, has distributed it to millions of schoolchildren as part of Brazil's National School Feeding Programme, as well as to daycare centres, hospitals, prisons and other institutions. As mentioned above, unborn babies, infants and young children are particularly at risk from methylmercury, which may cause neurodevelopmental problems including intellectual disability, seizures, vision and hearing loss, delayed development and more, raising serious concerns on the food security of shark products (WHO 2021).

Vigo, Galicia, Northern Spain. Europe's largest shark landing site, mainly blue shark.

4. Conclusion

The findings of this study highlight the potential health risk posed by the consumption of shark meat and concur with other studies in the scientific literature. The authors of this study therefore emphasise that the consumption of shark products should be minimised or, ideally, avoided altogether.

Carcharhinus glaucus

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Transparency:

The study was funded and conducted by NGOs dedicated to protecting the ocean and sharks in particular. Nevertheless, the data and the analyses based on it were carried out to the best of our knowledge and belief in accordance with scientific standards.

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Supplementary

Supplementary 1: Sample data of Carcharhinus glaucus *with the country where the sample was bought shopping region), this fishing as well as the FAO Major Fishing Area (FAO area) according to the declared information at the markets. Results of the analysis of methylmercury (MeHg) contamination is given as mg/kg.*

Blue shark (*Carcharhinus glaucus*)				
Nr.	**Shopping region**	**Fishing area**	**FAO area**	**MeHg (mg/kg)**
1	Switzerland	Azores	27.10.a	0,47
2	Switzerland	Azores	27.10.a	0,38
3	Switzerland	Azores	27.10.a	0,53
4	Switzerland	Azores	27.10.a	0,58
5	Switzerland	Azores	27.10.a	0,35
6	Switzerland	Azores	27.10.a	0,35
7	Switzerland	Azores	27.10.a	0,77
8	Switzerland	Azores	27.10.a	0,33
9	Switzerland	Azores	27.10.a	0,48
10	Switzerland	Azores	27.10.a	0,30
11	France	Bay of Biscay	27.8	3,5
12	France	North Atlantic	27	1,7
13	Spain	Central Atlantic	27.12	0,50
14	Spain	North Atlantic	27	1,5
15	Spain	North Atlantic	27	0,72
16	Spain	North Atlantic	27	0,90
17	Spain	North Atlantic	27	0,74
18	Spain	North Atlantic	27	1,1
19	Spain	North Atlantic	27	0,92
20	Spain	North Atlantic	27	1,0
21	UK	n.a.	n.a.	0,50
22	UK	n.a.	n.a.	0,22
23	Spain	East Atlantic	34	1,1
24	Spain	East Atlantic	34	0,94
25	Spain	East Atlantic	34	0,79
26	Spain	East Atlantic	34	0,69
27	Spain	East Atlantic	34	0,50
28	Spain	East Atlantic	34	0,50
29	Spain	East Atlantic	34	0,87
30	Spain	East Atlantic	34	0,46
31	Spain	East Atlantic	34	0,52
32	Spain	East Atlantic	34	0,91
33	Spain	East Atlantic	34	0,82
34	Spain	East Atlantic	34	0,67
35	Spain	East Atlantic	34	0,74
36	Spain	East Atlantic	34	0,58
37	Spain	East Atlantic	34	0,51
38	Spain	East Atlantic	34	0,68
39	Spain	East Atlantic	34	0,58
40	Spain	East Atlantic	34	0,73
41	Spain	East Atlantic	34	1,5
42	Spain	East Atlantic	34	2,0
43	Spain	East Atlantic	34	1,6
44	Germany	n.a.	n.a.	4,4

Carcharhinus glaucus

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Supplementary 2: Sample data of Galerohinus galeus *with the country where the sample was bought shopping region), this fishing as well as the FAO Major Fishing Area (FAO area) according to the declared information at the markets. Results of the analysis of methylmercury (MeHg) contamination is given as mg/kg.*

Tope shark (*Galeorhinus galeus*)				
Nr.	**Shopping region**	**Fishing area**	**FAO area**	**MeHg (mg/kg)**
H1	Spain	North Atlantic	27	1,4
H2	Spain	North Atlantic	27	2,1
H3	Spain	North Atlantic	27	1,6
H4	Spain	North Atlantic	27	3,0
H5	Spain	North Atlantic	27	1,1
H6	Spain	North Atlantic	27	2,8
H7	Spain	North Atlantic	27	2,0

Galeorhinus galeus

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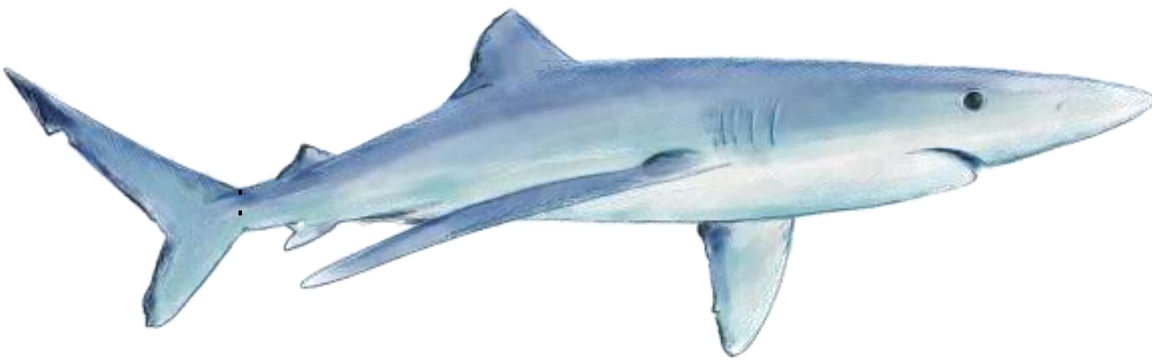

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