Fisheries Research 267 (2023) 106827

Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

Short communication

Predator damaged eel caught in coastal fisheries of the Baltic Sea

Andreas C. Bryhn[a,*], Sven Gunnar Lunneryd[b], Sara Königson[b]

[a] Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Coastal Research, Skolgatan 6, 74242 Öregrund, Sweden
[b] Swedish University of Agricultural Sciences, Department of Aquatic Resources, Institute of Coastal Research, Turistgatan 5, 45330 Lysekil, Sweden

ARTICLE INFO

Keywords:
European eel
Seal
Cormorant
Depredation
Small-scale coastal fisheries

ABSTRACT

Fish stock assessment may be constrained by incomplete knowledge on all mortality sources. Seal and cormorant raiding fishing gear to access the catch has been asserted by fishers to be a considerable problem in the small-scale European eel fishery along the Swedish Baltic Sea coast. We analysed logbook data and found predator losses in fisheries at 13.6 ± 12.6% among catches landed in 16 Swedish harbours in subdivisions 25, 27 and 29 of the Baltic Sea in 2019–2021. These numbers were used to assess the total predator damage along this coast at 12 ± 10 tonnes of caught eel at a landings value (about 10% of the retail value) of 105,000 ± 97,000 euros in 2020. This may constrain prospects of the declining commercial small-scale coastal eel fishery. Moreover, this quantitative estimate may be useful in future assessments of the local stock component, with potentially important implications for ecological, economic and social sustainability.

1. Introduction

Quantifying all mortality components is essential for fish stock assessment (Trochta and Branch, 2021; Punt et al., 2021; Björnsson et al., 2022). In addition, damage by predators to the catch and gear may constrain the livelihood of fishers (Königson et al., 2006; Kindt-Larsen et al., 2023). European eel (*Anguilla anguilla*; henceforth eel) is a fish species, which spawns in the Sargasso Sea (W. Atlantic Ocean), but grows to its adult stage in or near Europe, northern Africa or western Asia (Moriarty and Dekker, 1997; Demirci et al., 2020). Natural eel reproduction has never been observed, but the species is regarded as semelparous (Tesch and Thorpe, 2003), and the one, vastly distributed, population is most likely also panmictic, which follows from an apparent absence of geographically connected genetic differences (Enbody et al., 2021). The eel stock is affected by both natural and various kinds of anthropogenic mortality. In different parts of the world, a wide range of animals, such as sharks (Béguer-Pon et al., 2012), cormorants (Carpentier et al., 2009), herons (Feunteun and Marion, 1994), egrets (Carpentier et al., 2009), teleost fish (Miyake et al., 2018; Griffioen et al., 2022), otters, minks (Bonesi et al., 2004), seals (Königson et al., 2006), and whales (Wahlberg et al., 2014; Westerberg et al., 2021), are known to predate on anguillid eels. Some of these predators also raid fishing gear to access their prey (Pardalou and Tsikliras, 2020; Kindt-Larsen et al., 2023; Mitchell et al., 2023).

During the past centuries (Dekker and Beaulaton, 2016), and particularly since the 1980s, recruitment of eel to continental waters has decreased dramatically (ICES, 2022; Dekker et al., 2021). This has prompted measures for a sharply decreased eel fishery in Sweden and eel landings have diminished sharply concurrently with diminishing eel landings in other European countries (ICES, 2022).

The small-scale coastal fisheries in the Baltic Sea consist of fishers fishing on their own with small vessels (below 12 m) that go out to sea over the day and then return to their home harbour. In the past, fishers targeted multiple species such as salmon, cod, and eel. However salmon and cod fisheries have been stopped or severely constrained, and the eel fishery is also heavily regulated. Small-scale coastal eel fisheries in Sweden use passive gears, which are deployed up to a few hundred metres from the shore, and at depths down to about 12 m Passive gears are classified as LIFE (low impact and fuel efficient) fishing gear due to their low energy use, effective species selectivity, and low gear construction costs (Suuronen et al., 2012). Small-scale coastal fisheries are widely appreciated for their contribution to local economies and livelihoods (Swedish Environmental Protection Agency, 2012; Salmi et al., 2022). Their role in cultural heritage and local ecological knowledge (Garavito-Bermúdez, 2016; Salmi et al., 2022) is also acknowledged.

In addition, small-scale coastal fisheries are promoted for being ecologically sustainable including low carbon dioxide emissions, using selective gears, having low impact on bottom sediments, and being geographically bound, and this together will expect small-scale coastal fishers to have the potential to sustain viable fish stocks in the long-term

* Corresponding author.
E-mail address: andreas.bryhn@slu.se (A.C. Bryhn).

https://doi.org/10.1016/j.fishres.2023.106827
Received 26 April 2023; Received in revised form 27 July 2023; Accepted 16 August 2023
Available online 21 August 2023

(Swedish Board of Fisheries, 2010; Pascual-Fernandez et al., 2020). Small-scale coastal fisheries are therefore recognised to improve sustainability of Swedish fisheries (Björkvik et al., 2020a).

The remaining and decreasing eel fishery in coastal parts of the Baltic Sea (ICES, 2022) also competes with a number of eel predator species. Along the Swedish west coast, harbour seal (*Phoca vitulina*) used to be a fierce competitor for eel with the fishery while attacking fyke nets (Königson et al., 2006, 2007) and harbour seals are also present in the Baltic Sea. In the Baltic Sea, seabird predation, mainly by the great cormorant (*Phalacrocorax carbo sinensis*), has been estimated at about 340 tonnes of eel annually (Hansson et al., 2018). Hansson et al. (2018), however, estimated eel consumption by seal species in the Baltic Sea at 0 tonnes per year, but it is worth noting that the study in question disregarded predator attacked captured eel in fishing gear, because seals living near fishing gear tend to have a non-representative diet, which reflects the species caught in the gear (Lundström et al., 2010). Studies such as Lundström et al. (2007), Lundström et al. (2010) and Hjorth Scharff-Olsen (2019) investigated the diet of grey seals (*Halichoerus grypus*) in the Baltic Sea and typically found eel as a relatively limited share of grey seal food choice in the area. Yet, it is a widely communicated experience among eel fishers along the Swedish Baltic Sea (Fig. 1) coast that their gears are regularly attacked by seal (Andreas Bryhn, SLU, pers. obs.; see also Björkvik et al., 2020b for an interviewed eel fisher in the area) and that decreased eel landings are mainly due to seal depredation and seal damaged gears (Svels et al., 2019). Seals and cormorants are found all along the Swedish coastline (Strömberg et al., 2012a; b; Jones et al., 2022) and predator damage can be found where there are seals and cormorants and thereby in a majority of the different small-scale coastal fisheries.

This study aims at quantifying depredation in the Swedish commercial (professional) small-scale coastal eel fishery 2019–2021. Information on the spatial variation in depredation in a fishery is important to be able to identify where appropriate and effective management measures, such as predator-safe fishing gear, could be introduced. Quantifying the depredation on eel can also shine light on whether seal and cormorant depredation is a substantial source of mortality on the eel substocks. These results may potentially be used in future eel stock assessments in Sweden and elsewhere in the Baltic Sea.

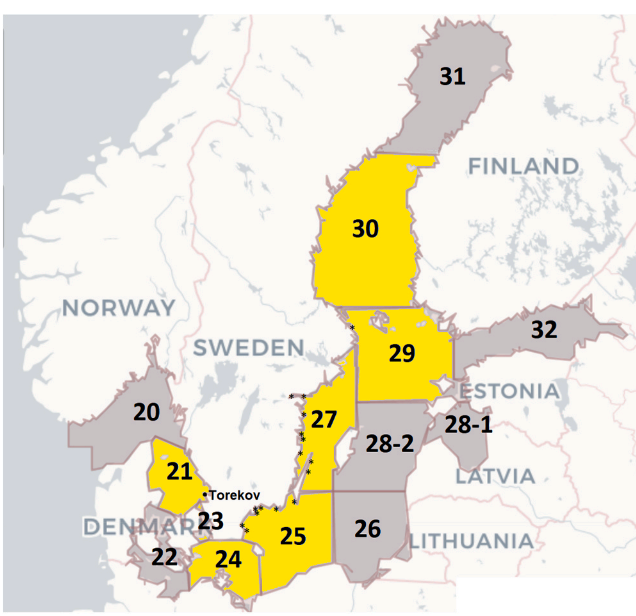

Fig. 1. The subdivisions of the International Council for the Exploration of the Sea in the Baltic Sea and the eastern North Sea. In Swedish coastal waters, eel is fished in subdivisions 21, 23, 24, 25, 27, 29 and 30, which have been highlighted with yellow colour. Torekov is the northernmost fishing site in subdivision 21. Black asterisks (*) mark harbours listed in the Appendix (subdivisions 25, 27 and 29). Base map: www.openstreetmaps.org (Open Data Commons Open Database License).

2. Materials and methods

Eel fishing in Sweden has been performed for human consumption purposes since the Stone Age (Boethius, 2018). Today, there are about 130 licensed eel fishers along the Swedish coast, who mainly use fyke-nets or larger poundnets to target the life stages yellow eel or silver eel (ICES, 2022). The gear use does not have any documented specific pattern across subdivisions. However, the fishing season tends to start earlier in the year the larger the distance from Torekov in Fig. 1, largely depending on the eel migration patterns. The analysed dataset comes from the Swedish Agency of Marine and Water Management (SwAM). Logbook data on specified predator damaged catch were studied for 2019–2021, a request that started 2018 although the responsible authority did not demand from the fisher to distinguish between different predators.

Licensed commercial fishers in Sweden are required to keep records of their fishing operations in accordance with the EU official logbook system and national requirements. Depending on the size of the boat, there are two ways for a fisher to report his or her fishing effort and catch. Either, fishers report their daily catch, net type, number and location of nets on a monthly basis. Most fishers fishing for eels, however, have vessels below 12 m and thereby fill in a monthly logbook. In the monthly logbook the effort is summarised by fishing gear in number of gears and the number of days that the gear has been in the water. The monthly catch and whether there has been predator interaction or not is also recorded per month.

Predator damaged catch cannot be sold and is not subtracted from landings quotas. However, some fishers may fail to separate between discards and predator damaged catch since they lack the incentive to do so, even though predation occurs all along the coastline (Jens Persson, Swedish Agency for Marine and Water Management, pers. comm). Thus, reported zero damage at any port during three years was regarded as highly unlikely and was not used in the statistical analysis. Thus, a first screening of the data was made to detect in which fisheries predator damaged eels were reported, and then, ports where predator damage was reported during at least two years out of three, were singled out from the dataset. The ratio of predator damaged eel to total landings, and percentual loss by predators were subsequently calculated. Statistical significance at $p \leq 0.05$ was tested using Generalised Linear Modelling (McCullagh and Nelder, 2019), applying the software Brodgar (www.brodgar.com).

3. Results

Fig. 2 shows the catch damaged by predators and landings in the Swedish coastal eel fishery 2019–2021. Predator damaged eel was most commonly reported in subdivisions 25 and 27. In some subdivisions, no predator damaged eel was recorded. The average landings value in 2020 was 94 SEK (about 9 EUR) per kg of eel. The corresponding values in 2019 and 2021 were not available.

Since very little damaged eel was reported in most subdivisions, 16 harbours with fisheries landings having reported depredated catch from at least two out of three years were singled out, and the loss of catch by predators in % was calculated for each year and harbour (Fig. 3; data in Appendix, Table A1). Out of these harbours, 7 were located in subdivision 25, 8 in subdivision 27, and 1 in subdivision 29 (Fig. 1). There were no significant differences between subdivisions, and no significant trends, in terms of loss of catch by predators.

. The predator damaged eel loss in fisheries ranged from 0% to 65.2%, with a mean value of 13.6% and a standard deviation of 12.6 percentage units. Provided that the Swedish non-damaged coastal landings amounted to about 86 tonnes in 2020 (ICES, 2022), and a

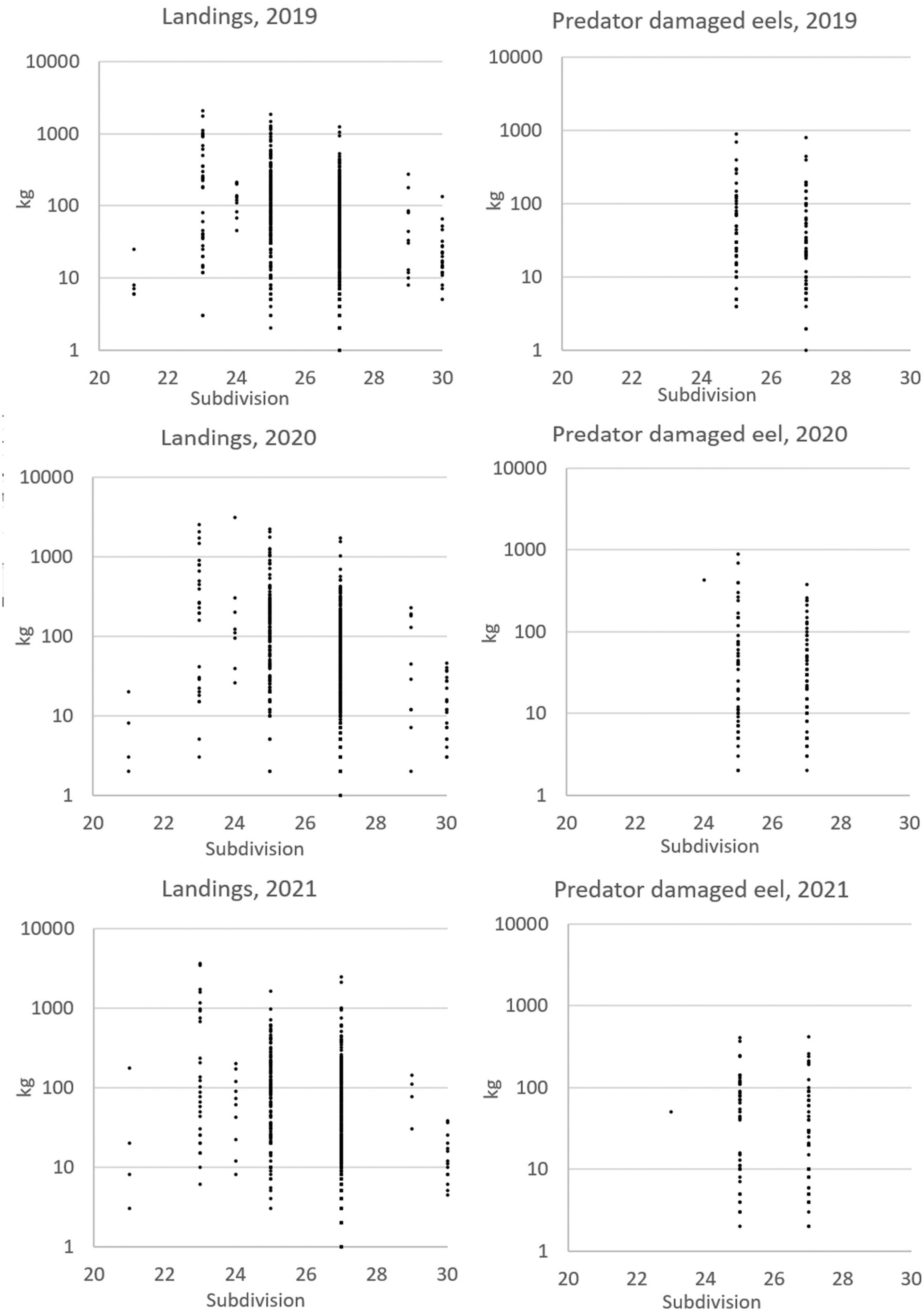

Fig. 2. Catch damaged per fishing vessel by predators and landings in the Swedish coastal eel fishery 2019–2021. Log scales on the y-axes should be noted.

landings value of 9 euro/kg, the predator induced losses in coastal fisheries corresponded to 12 ± 10 tonnes and 105,000 ± 97,000 euros that year. The retail value of eel in Sweden is, however, much higher than the landings value (approximately 49–110 euros/kg according to various Swedish fish product retail websites in 2023).

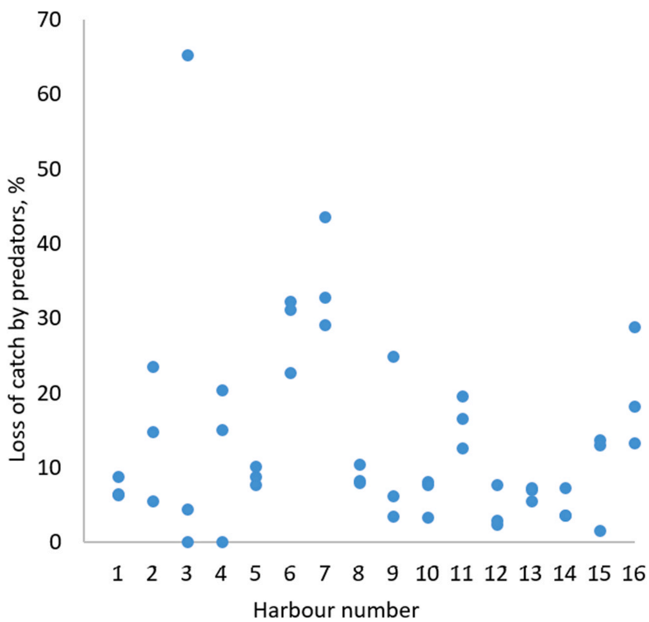

Fig. 3. Loss of catch by predators (%) 2019–2021. Data are displayed by the home harbor of the fishing vessel and are listed in the Appendix, Table A1.

Table 1
Total catch damaged by predators and total landings in the Swedish coastal eel fishery 2019–2021.

ICES subdivision	Catch damaged by predators, kg	Landings, kg	Loss of catch damaged by predators, %
21	0	292	0
23	50	43,302	0.12
24	430	6117	6.6
25	13,623	90,566	13.1
27	11,367	97,119	10.5
29	7	1953	0.36
30	0	1206	0

4. Discussion and conclusions

Depredation on fishing gear is a widely discussed topic globally, among stakeholders in coastal regions, in policymaking, and in the scientific literature (Pardalou and Tsikliras, 2020; Kindt-Larsen et al., 2023; Mitchell et al., 2023). This study quantifies the depredation losses in small-scale coastal eel fisheries 2019–2021 in Baltic Sea subdivisions 25, 27 and 29 at 13.6 ± 12.6%. Such results have never been published before for the Baltic Sea, to the best of our knowledge.

It should be noted that damaged catch is only one in several ways in which predators cause losses for fishers (Königson, 2011; Calamnius, 2018). In addition to the observed predator damaged eel in the fishing gears, there is an unknown mortality by predators that consume eel with help of the gear as an obstacle in the vicinity of the gear. This is called "hidden damage" and cannot be directly observed (Fjälling, 2005). Thus, the total eel loss for the small-scale coastal fishery due to predators feeding in the fishing grounds is probably higher than our estimates.

The damage estimate in this study is lower than the 18% damage estimate reported by Königson et al. (2006) from the Swedish west coast in 2001. We therefore find it plausible to suspect that damage along the Swedish Baltic coastline but located in other subdivisions (Table 1) is underreported due to a lack of incentives for fishers to report. Reasons for great differences in ICES subdivisions could be flaws in data handling, or local fisher group behavior in many subdivisions. However, these possible reasons are admittedly quite speculative, and merit further investigation. Numbers determined in this study and reported by Königson et al. (2006) could possibly be used in future eel stock assessments. Depredation on fishing gear is normally classified as part of fishing mortality, albeit often neglected and unaccounted for (Chopin, 1996a,b; Uhlmann and Broadhurst, 2015; Hanselman et al., 2018).

The results showed high depredation in subdivisions 25 and 27 (Table 1). These subdivisions are the areas where eel landings are the highest but also areas where a large part of the grey seal population along the Swedish Baltic coastline is found. Suuronen et al. (2023) reported that well over 25% of the grey seal population of the whole Baltic Sea inhabits central Sweden (subdivision 27). During the last two decades, the grey seal population has increased significantly (17% per year) in the southern Baltic (Suuronen et al., 2023). In this area, 3,166 (8% of the population) seals were counted in 2020 out of a total count of 40,075 individuals. This observation provides an indication of the grey seal impact. The cormorant population within the EU has also increased from 3,500 pairs in 1960 to 220,000 pairs in 2012 with concentrations around the Baltic (CorMan; http://ec.europa.eu/environment/nature/cormorants/home_en.htm). This development coincided with a sharp decrease in eel recruitment.

Unfortunately, damage could not be specified by predator species in this study because that information was not specified in logbook data. Marks at the eel by the sharp beaks of a cormorant and by the teeth of a seal could be difficult for the fisher to distinguish between, but severe damage such as half cut eels, are doubtlessly seal damaged. However, it can still be assumed that the bulk of the damage origins from grey seals in this area, which is supported by interviews with local fishers (Svels et al., 2019). In earlier studies evaluating depredation in Baltic coastal fisheries from logbook data, voluntary logbook data and detailed data collected through field studies, data revealed that the main contributor to the depredation was grey seals (Königson et al., 2007; Königson et al., 2009).

Regarding the proportion of damage caused by seals or cormorants directly linked to the eel fishery, there is one study from Sweden on catch and gear data from the daily voluntary logbooks kept by professional inshore fishers during 2005 and 2006 where the fishers were asked to specify the cause of the damage. Cormorant damage was estimated at 2% and seal damage at 15% of all emptyings (Strömberg et al., 2012b).

To conclude, this study has shown that in 2020, predators damaged 13.6 ± 12.6 tonnes of eel caught in fishing gear along the Swedish Baltic Sea coast, at a landings value of 15,000 ± 97,000 euros. To which extent this damage was caused by seals compared to cormorants could, however, not be determined analysing these data.

CRediT authorship contribution statement

Author ACB conceived the research idea, did most of the statistical analysis and wrote most of the article. Author SGL contributed substantially to the writing. Author SK did some of the statistical analysis and contributed substantially to writing the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

All data are available in the manuscript.

Acknowledgements

We would like to thank two anonymous peer reviewers for helpful and constructive comments to an earlier version of the paper. The study had no external funding.

Appendix

Table A1
Catch damaged by predators and landings per year for 16 landing harbous (see Fig. 1 for locations) in subdivisions 25, 27 and 29 during 2019–2021.

Harbour	ICES subdivision	Year	Catch damaged by predators, kg	Landings, kg	Loss of catch by predators, %
1	27	2019	36	373	8.8
2	27	2019	20	344	5.5
3	29	2019	0	216	0
4	25	2019	0	2225	0
5	27	2019	20	210	8.7
6	25	2019	2190	7478	22.7
7	25	2019	555	1137	32.8
8	25	2019	355	3964	8.2
9	25	2019	1041	3157	24.8
10	27	2019	203	2474	7.6
11	27	2019	475	3299	12.6
12	27	2019	30	1286	2.3
13	27	2019	67	891	7.0
14	25	2019	299	3771	7.3
15	25	2019	75	4990	1.5
16	27	2019	3521	8689	28.8
1	27	2020	27	400	6.3
2	27	2020	50	290	14.7
3	29	2020	5	109	4.4
4	25	2020	388	2206	15.0
5	27	2020	40	355	10.1
6	25	2020	3251	7180	31.2
7	25	2020	660	1605	29.1
8	25	2020	370	3175	10.4
9	25	2020	66	1880	3.4
10	27	2020	67	1948	3.3
11	27	2020	800	4007	16.6
12	27	2020	100	1210	7.6
13	27	2020	73	922	7.3
14	25	2020	207	5573	3.6
15	25	2020	872	5557	13.6
16	27	2020	1754	7903	18.2
1	27	2021	14	205	6.4
2	27	2021	40	130	23.5
3	29	2021	30	16	65.2
4	25	2021	775	3039	20.3
5	27	2021	26	311	7.7
6	25	2021	2182	4603	32.2
7	25	2021	615	799	43.5
8	25	2021	290	3338.5	8.0
9	25	2021	51	786	6.1
10	27	2021	249	2830	8.1
11	27	2021	980	4011	19.6
12	27	2021	30	1018	2.9
13	27	2021	46	798	5.5
14	25	2021	102	2700	3.6
15	25	2021	252	1687.5	13.0
16	27	2021	1008	6656.5	13.2

References

Béguer-Pon, M., Benchentrit, J., Castonguay, M., Aarestrup, K., Campana, S.E., Stokesbury, M.J.W., Dodson, J.J., 2012. Shark predation on migrating adult American eels (*Anguilla rostrata*) in the Gulf of St. Lawrence. PLoS ONE 7, e46830.

Björkvik, E., Boonstra, W.J., Hentati Sundberg, J., 2020b. Why fishers end up in social-ecological traps: a case study of Swedish eel fisheries in the Baltic Sea. Ecol. Soc. 25 (1), 18.

Björkvik, E., Boonstra, W.J., Hentati-Sundberg, J., Österblom, H., 2020a. Swedish small-scale fisheries in the Baltic Sea: decline, diversity and development. In: Pascual-Fernández, J., Pita, C., Bavinck, M. (Eds.), Small-Scale Fisheries in Europe: Status, Resilience and Governance. MARE Publication Series, vol 23. Springer, Cham.

Björnsson, B., Sólmundsson, J., Woods, P.J., 2022. Natural mortality in exploited fish stocks: annual variation estimated with data from trawl surveys. ICES J. Mar. Sci. 79, 1569–1582.

Boethius, A. 2018. Fishing for ways to thrive: Integrating zooarchaeology to understand subsistence strategies and their implications among Early and Middle Mesolithic southern Scandinavian foragers. PhD thesis, Lund University, Lund.

Bonesi, L., Chanin, P., Macdonald, D.W., 2004. Competition between Eurasian otter *Lutra lutra* and American mink *Mustela vison* probed by niche shift. Oikos 106, 19–26.

Calamnius, L. 2018. Salmonids and grey seals (*Halichoerus grypus*). Aqua licentiate theses 2018:1. Swedish University of Agricultural Sciences, Uppsala.

Carpentier, A., Marion, L., Paillisson, J.-M., Acou, A., Feunteun, E., 2009. Effects of commercial fishing and predation by cormorants on the *Anguilla anguilla* stock of a shallow eutrophic lake. J. Fish. Biol. 74, 2132–2138.

Chopin, F., Inoue, Y., Arimoto, T., 1996b. Development of a catch mortality model. Fish. Res. 25, 377–382.

Chopin, F., Alverson, D.L., Inoue, Y., Arimoto, T., Suuronen, P., Sangster, G.I., 1996a Sources of unaccounted mortality in fish capture technologies. In: Developing and Sustaining World Fisheries Resources: The State of Science and Management (Proceedings of the 2nd World Fisheries Congress, Brisbane, 28 July–2 August, 1997). (eds D.A. Hancock, D.C. Smith, A. Grant and J.P. Beumer), CSIRO Publishing, Collingwood, pp. 149– 156.

Dekker, W., Beaulaton, L., 2016. Climbing back up what slippery slope? Dynamics of the European eel stock and its management in historical perspective. ICES J. Mar. Sci. 73, 5–13.

Dekker, W., van Gemert, R., Bryhn, A., Sjöberg, N., Wickström, H., 2021. Assessment of the eel stock in Sweden, spring 2021. Aqua Reports 2021. Sveriges lantbruksuniversitet,, Drottningholm, p. 12.

Demirci, S., Akar, Ö., Şimşek, E., Demirci, A., Yalçın Özdilek, Ş., 2020. Biological parameters and current status of European eel (*Anguilla anguilla* Linnaeus, 1758)

from Asi River, Northeastern Mediterranean region, Turkey. J. Appl. Ichthyol. 36, 918–923.
Enbody, E.D., Pettersson, M.E., Sprehn, C.G., Palm, S., Wickström, H., Andersson, L., 2021. Ecological adaptation in European eels is based on phenotypic plasticity. PNAS 118, e2022620118.
Feunteun, E., Marion, L., 1994. Assessment of Grey Heron predation on fish communities: the case of the largest European colony. Hydrobiologia 279, 327–344.
Fjälling, A., 2005. The estimation of hidden seal-inflicted losses in the Baltic Sea set-trap salmon fisheries. ICES J. Mar. Sci. 62, 1630–1635.
Garavito-Bermúdez, D., 2016. Learning ecosystem complexity: a study on small-scale fishers' ecological knowledge generation. PhD Thesis Stockh. Univ., Stockh.
Griffioen, A.B., Janssen, W., Menke, T., Wilkes, T., Winter, H.V., 2022. Does tagging transparent fish increase predation risk? A laboratory study with glass eel (*Anguilla anguilla*) and sea bass (*Dicentrarchus labrax*). J. Fish. Biol. 100, 184–191.
Hanselman, D.H., Pyper, B.J., Peterson, M.J., 2018. Sperm whale depredation on longline surveys and implications for the assessment of Alaska sablefish. Fish. Res. 200, 75–83.
Hansson, S., Bergström, U., Bonsdorff, E., Härkönen, T., Jepsen, N., Kautsky, L., Lundström, K., Lunneryd, S.-G., Ovegård, M., Salmi, J., Sendek, D., Vetemaa, M., 2018. Competition for the fish – fish extraction from the Baltic Sea by humans, aquatic mammals, and birds. ICES J. Mar. Sci. 75, 999–1008.
Hjorth Scharff-Olsen, C. 2019. Geographical variation in the diet within and between the harbour seals (*Phoca vitulina*), grey seals (*Halichoerus grypus*) and Baltic ringed seals (*Pusa hispida*) inhabiting the greater Baltic Sea. PhD thesis, University of Copenhagen.
ICES, 2022. Report of the Joint EIFAAC/ICES/GFCM Working Group on Eels (WGEEL). ICES,, Copenhagen.
Jones, D., Ovegård, M., Dahlgren, H., Danielsson, S., Greger, M., Landberg, T., Garbaras, A., Karlsson, A.M.L., 2022. A multi-isotope approach to evaluate the potential of great cormorant eggs for contaminant monitoring. Ecol. Indic. 136, 108649.
Kindt-Larsen, L., Berg, C.W., Hedgärde, M., Königson, S., 2023. Avoiding grey seal depredation in the Baltic Sea while increasing catch rates of cod. Fish. Res. 261, 106609.
Königson, S., Fjälling, A., Lunneryd, S.G., 2007. Grey seal induced catch losses in the herring gillnet fisheries in the northern Baltic. NAMMCO Sci. Publ. 6, 203–213.
Königson, S., Stridh, H., Lunneryd, S.G., Sundqvist, F., 2009. Grey seal predation in cod gillnet fisheries in the central Baltic Sea. J. Northwest Atl. Fish. Sci. 42.
Königson, S.J., Lundström, K.E., Hemmingsson, M.M.B., Lunneryd, S.-G., Westerberg, H., 2006. Feeding preferences of harbour seals (*Phoca vitulina*) specialised in raiding fishing gear. Aquat. Mamm. 32, 152–156.
Lundström, K., Hjerne, O., Alexandersson, K., Karlsson, O., 2007. Estimation of grey seal (*Halichoerus grypus*) diet composition in the Baltic Sea. NAMMCO Sci. Publ. 6, 177–196.
Lundström, K., Hjerne, O., Lunneryd, S.-G., Karlsson, O., 2010. Understanding the diet composition of marine mammals: grey seals (*Halichoerus grypus*) in the Baltic Sea. ICES J. Mar. Sci. 67, 1230–1239.
McCullagh, P., Nelder, J.A., 2019. Generalized linear models, 2nd Ed. Routledge,, Boca Raton.
Mitchell, J.D., Drymon, J.M., Vardon, J., Coulson, P.G., Simpfendorfer, C.A., Scyphers, S. B., Jackson, G., 2023. Shark depredation: future directions in research and management. Rev. Fish. Biol. Fish. 33, 475–499.
Miyake, Y., Takeshige, A., Itakura, H., Itoh, H., Onda, H., Yamaguchi, A., Yoneta, A., Arai, K., Hane, Y.V., Kimura, S., 2018. Predation on glass eels of Japanese eel Anguilla japonica in the Tone River Estuary. Jpn. Fish. Sci. 84, 1009–1014.
Moriarty, C., Dekker, W., 1997. Management of the European eel. In: Fisheries Bulletin, 15. Marine Institute,, Dublin.
Pardalou, A., Tsikliras, A.C., 2020. Factors influencing dolphin depredation in coastal fisheries of the northern Aegean Sea: implications on defining mitigation measures. Mar. Mammal. Sci. 36, 1126–1149.
Pascual-Fernandez, J., Pita, C., Bavinck, M., 2020. Small-Scale Fisheries in Europe: Status, resilience and governance. MARE Publication Series 23. Springer,, Cham.
Punt, A.E., Castillo-Jordán, C., Hamel, O.S., Cope, J.M., Maunder, M.N., Ianelli, J.N., 2021. Consequences of error in natural mortality and its estimation in stock assessment models. Fish. Res. 233, 105759.
Salmi, P., Linke, S., Siegrist, N., Svels, K., 2022. A new hope for small-scale fisheries through local action groups? Comparing Finnish and Swedish experiences. Marit. Stud. 21, 309–323.
Strömberg, A., Lunneryd, S.-G., Fjälling, A. 2012a. Mellanskarv – ett problem för svenskt fiske och fiskodling? (Great cormorant – a problem for Swedish fishery and aquaculture?) Aqua reports 2012:1. Sveriges lantbruksuniversitet, Öregrund. 31 p. (In Swedish with English summary).
Strömberg, A., Svärd, C., Karlsson, O. 2012b. Dietstudier av gråsäl (Halichoerus grypus) i Östersjön och knubbsäl (Phoca vitulina) i Skagerrak och Kattegatt insamlade 2010 (Diet studies of grey seal in the Baltic Sea and harbour seal in the Skagerrak and Kattegat, collected in 2010). Report 5:2012. Naturhistoriska Riksmuseet, Stockholm (in Swedish).
Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D., Rihan, D., 2012. Low impact and fuel efficient fishing—Looking beyond the horizon. Fish. Res. 119-120, 135–146.
Suuronen, P., Lunneryd, S.-G., Königson, S., Coelho, N., Waldo, Å., Graugaard, N., Eriksson, V., Svels, K., Lehtonen, E., Psuty, I., Vetemaa, M., 2023. Reassessing the management criteria of growing seal populations: the case of Baltic grey seal and coastal fishery. Mar. Policy 155, 105684.
Swedish Board of Fisheries. 2010. Småskaligt kustfiske: regeringsuppdrag att beskriva det småskaliga kustnära fisket i Sverige samt föreslå hur detta fiske kan förstärkas (Small-scale coastal fisheries: a government condition to describe small-scale fisheries in Sweden and suggest how they could be strengthened). Fiskeriverket, Göteborg (in Swedish).
Swedish Environmental Protection Agency. 2012. Steg på vägen: fördjupad utvärdering av miljömålen 2012 (Steps along the way: deepened evaluation of the environmental goals 2012). Naturvårdsverket rapport 6500. Naturvårdsverket, Stockholm (in Swedish).
Tesch, F.W., Thorpe, J., 2003. The eel. 5th edition. Wiley-Blackwell, Hoboken,.
Trochta, J.T., Branch, T.A., 2021. Applying Bayesian model selection to determine ecological covariates for recruitment and natural mortality in stock assessment. ICES J. Mar. Sci. 78, 2875–2894.
Uhlmann, S.S., Broadhurst, M.K., 2015. Mitigating unaccounted fishing mortality from gillnets and traps. Fish Fish 16, 183–229.
Wahlberg, M., Westerberg, H., Aarestrup, K., Feunteun, E., Gargan, P., Righton, D., 2014. Evidence of marine mammal predation of the European eel (*Anguilla anguilla* L.) on its marine migration. Deep Sea Res. Part I Oceanogr. Res. Pap. 86, 32–38.
Westerberg, H., Amilhat, E., Wahlberg, M., Aarestrup, K., Faliex, E., Simon, G., Tardy, C., Righton, D., 2021. Predation on migrating eels (*Anguilla anguilla* L.) from the Western Mediterranean. J. Exp. Mar. Biol. Ecol. 544, 151613.