Interactions between harbour seals *(Phoca vitulina)* and coastal fisheries along the Swedish west coast: an overview

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ABSTRACT

The conflicts between seals and fisheries along the Swedish west coast have intensified during the last decades, concurrently with the increase in the harbour seal population size. This study presents published information about interactions between harbour seals and fisheries in the Kattegat-Skagerrak, in addition to new information on the seal by-catch rate and an overview of fisheries suffering from seal damage. Several fisheries have reported interactions with seals, principally fisheries with fyke nets, gill nets and static gear. Development of mitigation measures has been focused on the eel fishery with fyke nets, in which the use of stronger net material has significantly decreased the damage frequency from seals and has yet maintained the catches at satisfactory levels. Under-water filming at fyke nets together with studies of the prey preferences of seals has shown individual specializations in certain foraging techniques. For example, eel may not be a common prey for harbour seals in general, but, it was chosen in preference to other species by seals attacking fyke nets. There is a lack of current data concerning the diet of harbour seals. Previous studies, based on material from the 1970s and 1980s, have shown that locally and seasonally abundant prey is preferred. Due to the non-existent information about the food choice, current assessments of the ecological role of harbour seals in Sweden cannot be evaluated.

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INTRODUCTION

Interactions between seals and fisheries can be divided into operational and ecological interactions. Operational interactions arise when seals cause damage to fishing gear and catch, and when seals are incidentally by-caught in fishing gear. Ecological interactions can be either direct or indirect. Direct ecological interactions include the consumption of commercial species by seals and the reduction of important seal prey by fisheries. Indirect ecological interactions include the consumption of prey and predators of commercial species by seals, the reduction of prey and predators of important seal prey by fisheries and the dispersal of seal borne fish parasites.

The harbour seal *(Phoca vitulina)* is the prevalent seal species along the west coast of Sweden and occurs from the southern Kattegat to the northern Skagerrak. Grey seals *(Halichoerus grypus)* are rarely seen in this region. Bounty programmes during the first half of the 20th century severely reduced the harbour seal population in the Kattegat-Skagerrak and the population size was estimated to less than 2,000 animals in the 1960s (Heide-Jorgensen and Härkönen 1988). During the second half of the 20th century harbour seals were considered endangered and complete protection was initiated. Since then, the population has recovered and was estimated to comprise 16,000 animals in 2007 (Olsen *et al.* 2010). Concurrent with the increase in population size, conflicts between seals and fisheries have intensified. Fishermen first reported interactions with harbour seals in the late 1980s, and the reports increased substantially in the 1990s, mostly in the eel *(Anguilla anguilla)* fishery. The total economic loss caused by seal damage to catch and gear in Sweden, *i.e.* including the Baltic Sea, has been estimated to approximately 5 million Euros in 2004 (Westerberg *et al.* 2006). Initial concerns were focused on seal damage to catch and gear, but the increasing seal population has shifted the emphasis to ecological interactions.

This paper provides an overview of interactions between harbour seals and coastal fisheries along the Swedish west coast. We show results from pertinent studies, with emphasis on the development of effective mitigation measures in the fyke net eel fishery. Further, we present new data on the by-catch of harbour seals in different fisheries and an overview of fisheries subjected to damage. Information from the following sources has been used: the official logbooks, a voluntary logbook database kept by contracted fishermen and results from dedicated field studies.

OPERATIONAL INTERACTIONS

Fisheries subjected to damage by harbour seals

The official logbooks provide information about fisheries incurring damage caused by seals. In Sweden, all licensed commercial fishermen are required to record their operations in accordance with the official logbook system and national

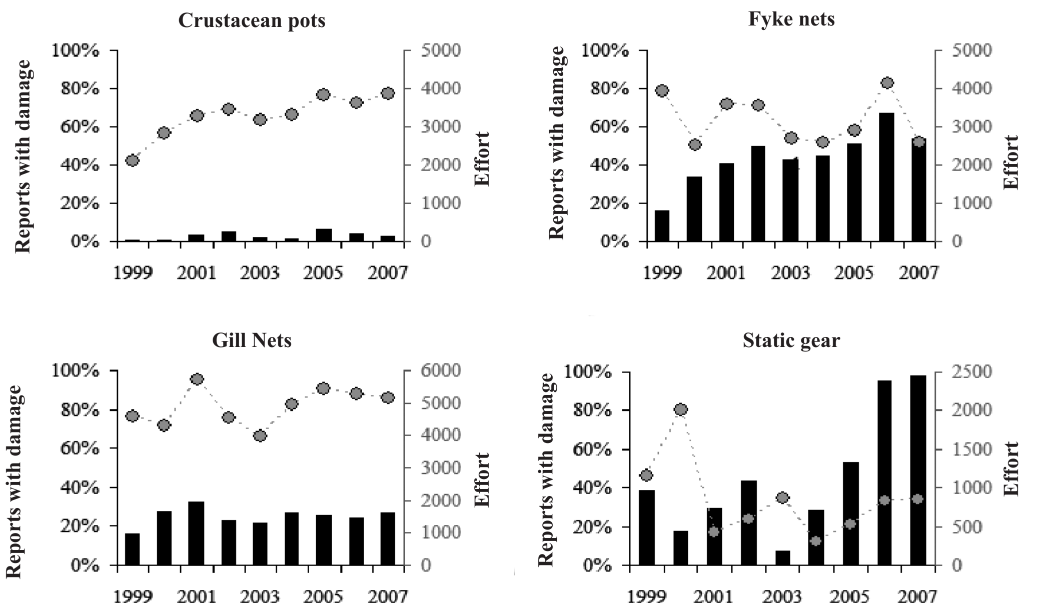

Fig. 1. *The amount of fishing effort from the Coastal journal with reported seal damage for fishing boats with lengths under 10 m in the Kattegatt-Skagerrak. Bars indicate the proportion of journals with reported seal interactions and circles indicate the yearly effort in 1,000 pot-days for crustacean pots, 1,000 fyke-net-days for eel fyke nets, km net-days for gill nets (different forms of bottom-set nets) and gear-days for static gear (salmon and eel traps).*

requirements, and to report these records to the Swedish Board of Fisheries. There are two methods for fishermen to report fishing effort and catch, which are dependent on the size of the boat. Skippers of fishing vessels that are 10 m or longer must submit daily reports of their gear type and number, catch and fishing location. Skippers of fishing vessels less than 10 m are only required to maintain a monthly logbook, known as the Coastal journal. In the Coastal journal catch and associated data are summarized by gear type and month and the coordinates of the vessels home port are reported instead of exact fishing locations. Information regarding seal damage to fishing gear or catch can be recorded in both types of reports, however this is not mandatory. Along the Swedish west coast the majority (78% of all vessels) of the inshore fisheries using fyke nets, gill nets, traps and pots is conducted by fishermen using boats smaller than 10 meters. Therefore, the Coastal journal is the primary source of fishery data. The summary nature of these data means they cannot be used to quantify seal damage, since an interaction could range from a single event to severe interactions during the whole period. Nevertheless it is possible to get relative information about the level of seal damage in different fisheries. Analysis from data derived from the Coastal journal has been carried out (Fig. 1), including crustacean fisheries with pots, eel fishery with fyke nets, gill-net fisheries, principally for flatfish, gadoids, piked dogfish *(Squalus acanthias)* and edible crab *(Cancer pagurus)*, and fisheries with large static gear, such as pound nets, targeting eel and salmon *(Salmo salar)*.

Between 1996 and 2006, the Swedish Board of Fisheries set up a voluntary logbook database scheme. The initial aim was to document any seal-induced damage and catch losses, and the level of marine mammal and bird by-catch. The initial focus of the effort was the trap net fishery in the northern Baltic Sea due to the prevailing conflict with grey seals. Fishermen were asked to submit daily reports on catch, effort and detailed information about the interactions with seals. However, information was also received sporadically from fishermen from the central Baltic Sea and the Swedish west coast. Participating fishermen, chosen from personal contacts and recommendations, were paid a small fixed fee for every time they checked and emptied their nets and recorded the catch and damage data. Regular contacts were maintained between the Swedish Board of Fisheries and the fishermen in order to monitor the quality of the record-keeping. Occasionally personal inspections were also made for this purpose. These data have formed the basis for calculating the financial costs of seal-induced damage (Westerberg *et al.* 2000), for evaluating new improved fishing gear (Lunneryd and Fjälling 2004, Hemmingsson *et al.* 2008) and acoustic harassment devices (Fjälling *et al.* 2006), and for studies of the damage process itself (Fjälling 2005, Königson *et al.* 2007a). Although questions about by-catch were included in the voluntary logbook forms from the beginning, it was not until 2001 that a specific effort was made to gather this information. In return for doubling the compensation for logbook keeping to 2 Euros per entry, fishermen were now expected to record damage from both sea birds

Table 1. Compilation of reported seal damage in the voluntary logbook, including the number of reports during 2001 to 2006. Fyke nets are used for eel fishery, gill nets are different forms of bottom-set nets and static gear is large traps targeting salmon and eel.

Fishing gear	No of fishermen	No of daily entries	No of entries with seal interaction	Proportion of entries with seal interaction
Fyke net, ordinary	12	2,752	924	34%
Fyke net with modification ('seal safe')	11	1,491	269	18%
Gill nets	5	222	61	27%
Static gear	2	828	24	3%

Table 2. Compilation of reported by-catch of harbour seals in the voluntary logbook, including the number of seal deaths reported and the total effort during 2001 to 2006. Static gear is large traps targeting salmon and eel. Fyke nets are used for eel fishery, gill nets are different forms of bottom-set nets and the by-catch per unit effort (CPUE) is calculated as the mean of all entries during all years and the confidence interval (95%) is derived from a bootstrap calculation.

Fishing gear	No of fishermen	Fishing effort	Units	No of seals	By-catch CPUE	Confidence interval (95%)
Fyke nets	12	214	(fyke-net days)•10^3	2	0.008	0-0.016
Gill nets	5	2,625	km net-days	19	0.010	0.003- 0.021
Static gear	3	1,250	gear days	15	0.014	0.007-0.022

and seals, and by-catches of sea birds, marine mammals, and non-target and undersize fish. Voluntary logbook data from the west coast is not as extensive as data from the Baltic region, but it contains 5,293 entries from 18 fishermen from the period 2001 and 2006, on which this study is based.

According to the Coastal journal reports, fisheries using fyke nets, gill nets and static gear have been subjected to damage by seals at relatively high levels during the last decade, whereas the crustacean pot fisheries are not severely affected (Fig. 1). Most reports in the Coastal journal for the static gear fisheries contain at least one seal interaction during 2006 and 2007 (Fig. 1), but according to the voluntary logbook only 3% of the daily entries had a seal interaction which indicates that the damage is of minor extent. The fyke net fishery is the second most affected, and up to 67% of all monthly reports to the Coastal journal include notes of seal interactions (Fig. 1). The voluntary logbook supports this, a third of all daily entries with ordinary fyke nets (*i.e.* not modified), have reported seal interactions (Table 1). Damage by seals in the gill-net fisheries is also commonly reported in the Coastal journal (Fig. 1), as well as in the voluntary logbook (Table 1).

Interactions with harbour seals in the eel fishery

The eel fishery along the west coast is an economically important part of the small-scale fishing industry in Sweden and has suffered substantial damage in the last decades. The fishery, generally a one-person operation, is conducted with fyke nets in shallow inshore areas. Damage to the fyke nets consists of small holes and larger tears, up to 20cm, most often found in the fish bag where the catch is gathered (Fig. 2). Even a small hole in the fish bag is sufficient to permit the entire catch to escape. Eels can be damaged by seals biting through the fish bag and sometimes eels are dragged out through the meshes and bitten in halves, if not completely removed. Damage to the entrance of the fyke nets has also been reported, originating from seals trying to force themselves into the gear to reach the catch.

Seasonal variation in damage to fyke nets

There is seasonal variation in the occurrence of damaged fyke nets, with more damage occur-

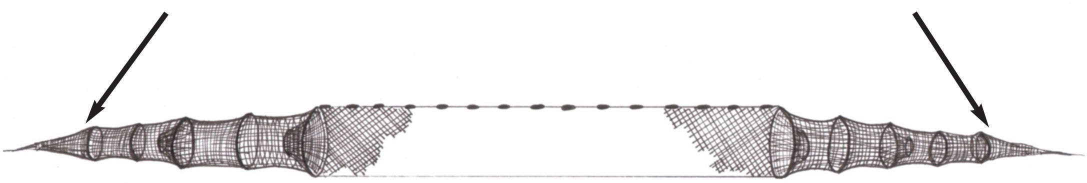

Fig. 2. *Schematic drawing of a fyke net. Arrows indicate fish bags, where the catch is gathered.*

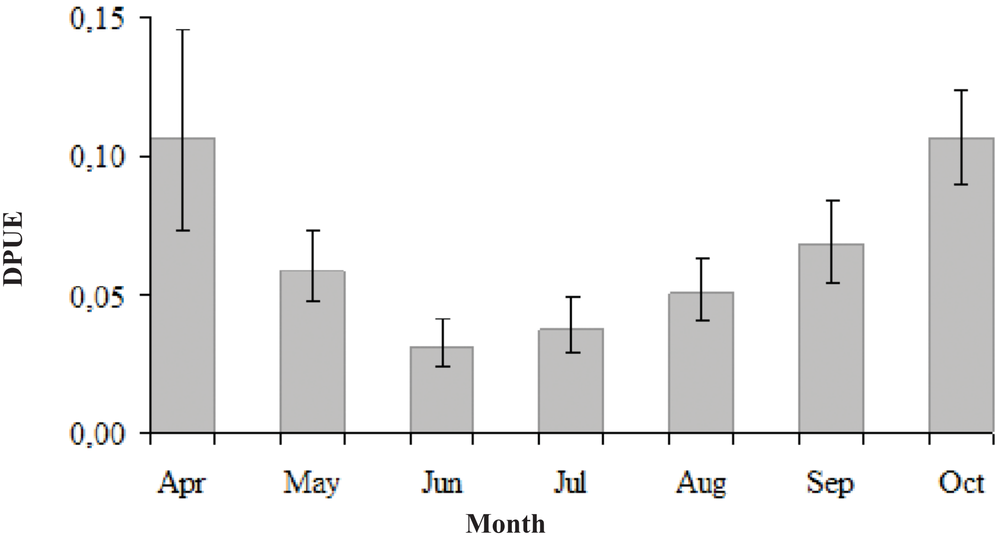

Fig. 3. *Damaged fish bags per unit effort, DPUE (number of damaged fish bags • (total number of fish bags • number of days)-1), in the Kattegat-Skagerrak eel fishery with fyke nets on a monthly basis 1999-2004. The fyke nets were checked 2065 times, by seven different fishermen. Error bars indicate 95% confidence interval. Data from Königson et al. (2007b).*

ring during spring and autumn and less during summer (Fig. 3). This might be explained by intensified human activities in coastal areas and a reduction in food intake of the seals due to breeding during summer (Königson *et al.* 2007b).

Identification of seals attacking fishing gear

To identify animals (species and, if possible, individuals) responsible for the damage and to study their behaviour, fyke nets were observed both from land and by under-water video in different areas with documented gear damage. During 150 hours of observations from land, carried out in two areas at dusk and dawn during 2001, harbour seals were the only observed animals in the vicinity of the gear, documented on 18 of 45 occasions, except for a cormorant *(Phalacrocorax carbo)* observed once (Königson *et al.* 2003). Under-water video established the harbour seal as the principal species attacking fyke nets. In more than 600 hours of daytime video at fyke nets baited with several fish species in 1999 and 2000, there were two visits by harbour seals, but the seals were never observed to attack the gear (Königson *et al.* 2003). In another study, infra-red sensitive cameras were used to conduct night-time video supervision of a fyke net baited with eels (Königson *et al.* 2003). From the end of October to the end of December 2001, approximately 500 hours were recorded and a harbour seal was observed raiding the gear on 5 occasions. On 4 of these occasions the seal could be identified using its pelage pattern as the same individual. The seal stayed in the vicinity of the fyke net for 20-30 minutes and aggressively attacked the net. During the subsequent inspection the fish bag usually contained a few damaged eels or was completely empty. All visits to the fyke net were observed during darkness, between 20:17 hr and 07:50 hr.

Prey preference of harbour seals attacking fyke nets

Several other species than eel are also caught in fyke nets, including Atlantic cod *(Gadus morhua)*, viviparous blenny *(Zoarces viviparous)* and European flounder *(Platichthys flesus)*. Knowledge of which species are the target of the seal attacks is important in developing effective mitigation methods. Eel fishermen claim that seals are raiding the fishing gear because of the eels caught therein, while diet studies based on scat analysis indicate eels are rare prey items among harbour seals in the Kattegat and Skagerrak (Härkönen 1987, Härkönen and Heide-Jørgensen 1991). In a study where harbour seals were offered several species of dead fish, herring, gadoids and flatfish species were preferred while eel was mostly rejected (Lunneryd 2001). To study the prey preference of harbour seals attacking fyke nets, Königson *et al.* (2006) enclosed live fish in fyke nets in three different areas 2001 and 2003. The fish were arranged pair-wise in fyke nets, with eel in one fish bag and either cod, flounder and viviparous blenny in the other fish bag. The preference for eel was statistically significant. Eel was preferred on 97%, 97% and 89% of the occasions for the combinations eel-cod, eel-flounder and eel-viviparous blenny, respectively. Thus, it seems that the presence of eel was the main reason why seals attacked the gear. Further, the stomach contents of some seals culled close to fyke nets, placed in the same area as the study mentioned above, contained only eels.

Other studies have documented that individual seals regularly visit certain sites (Thompson and Miller 1990, Bjørge *et al.* 1995, Tollit *et al.* 1998, Ramasco 2008), which indicates individual specialisations in certain foraging techniques. An active prey-species selection has also been suggested by other studies, where the relative abundance of prey showed low correlation to their contribution to the seal diet, indicating a preferential selection of species (Tollit *et al.* 1997, Hall *et al.* 1998). Specialised prey selection was suggested also in the study by Lunneryd (2001). In that study, seal visits occurred on only 30% of the total number of feeding opportunities, in spite of the fact that seals were constantly present in the area. The temporal and spatial aggregations of the seal visits were not randomly distributed, indicating that only a minority of the seals in the area fed from the offered fish. As a consequence of niche separation in a seal population, individual animals may feed more efficiently in a diversity of habitats, implying that individual seals can be regarded as specialist predators, while the population at large could be viewed as generalist predators.

Mitigation of the conflict using modified fyke nets

Development of modified fyke nets has been conducted jointly by the Swedish Board of Fisheries and commercial fishermen between 1999 and 2004. Both voluntary logbook data from local fishermen and dedicated field studies have been used to evaluate the modified fyke nets. The principal modification was to the fish bag, where the catch is gathered and where the bulk of damage was found. Fyke nets with fish bags consisting of ordinary material (knotless net with No. 4 nylon twine and mesh size 11 mm bar measure) were compared to 5 different modified fyke nets whose fish bags were constructed of stronger material (knotless net, No. 6 nylon twine, with mesh size 8, 9 and 11 mm bar measure, and knotted net, No. 6 nylon twine, with mesh size 9.8 and 11 mm bar measure).

The decrease in damage frequency was statistically significant in all of the fyke nets with modified fish bags compared to the ordinary fyke nets (Königson *et al.* 2007b). No statistically significant differences in catch efficiency were found between ordinary and modified fyke nets in the fisheries experiments carried out by the Swedish Board of Fisheries, whereas results obtained from the fishermen showed significantly lower eel catches in fyke nets modified with knotless twine with the smallest mesh sizes (8 and 9 mm). The differences were relatively small however and no differences were found in the subsequent modification trials. Although modified fyke nets were attacked, the damage was less severe as compared to the control fyke nets, with a marked decrease in larger tears (Königson *et al.* 2007b).

Exclusive use of modified fyke nets will increase the energetic costs of seals trying to tear through the stronger material, and will decrease the reward as compared to ordinary fyke nets. Thus the behaviour of raiding fyke nets might be abandoned when modified fyke nets are used and it might be less likely that new seals adopt it. Königson *et al.* (2007b) studied the complete replacement of ordinary fyke nets with modified fyke nets in different areas. They found that the damage frequency decreased and the eel catch increased in areas where modified fyke nets were used exclusively, compared to areas with only ordinary fyke nets. Even though damage to the catch still occurred in the modified fyke nets, holes or tears in the net were rarely seen

Table 3. Extrapolation of a yearly sum of by-caught harbour seals between 2001 and 2006 in commercial fisheries along the Swedish west coast, excluding trawls. The mean yearly fishing effort from both the official logbooks is multiplied with the calculated mean by-catch CPUE from the voluntary logbook during the same period (Table 2). The relation between the sum of effort from the voluntary logbook (between 2001 and 2006) and the mean yearly effort (from both the official logbooks) is shown as coverage. The 95% confidence interval is derived from a bootstrap calculation of the by-catch CPUE.

Fishing gear	Fishing effort	Units	Coverage	By-catch (no. of seals)	Confidence interval (95%)
Fyke nets	3,197	(fyke net-days)•10^3	7%	26	0-52
Gill nets	11,858	km-net-days	22%	116	41-253
Static gear	590	gear-days	212%	8	4-13
Sum				**150**	**45-318**

and fish escape was reduced markedly. However, seals were still able to extract eels through the meshes and bite them in halves.

By-catch of harbour seals along the Swedish west coast

Data from the voluntary logbook gathered between 2001 and 2006 were used to obtain information on by-catch of harbour seals in different fisheries. During the data entry work fishermen were contacted to confirm the by-catch reports, and in some cases by-catches were entered at this stage. A total of 36 harbour seals were reported by-caught between 2001 and 2006 by 7 fishermen (Table 2). Two fishermen caught 28 seals which indicated that by-catches were not normally distributed. Further, the data could not be transformed to normality because of the extremely skewed results (*i.e.* the majority of fishermen recorded a zero value while a few recorded catching several seals). Therefore, confidence limits for the mean by-catch were estimated by bootstraping with repeated re-sampling using 2,000 iterations (Efron and Tibshirani 1986).

Extrapolation of the total by-catch was accomplished by multiplying the by-catch CPUE from the voluntary logbook with a mean yearly fishing effort from the official logbook and the Coastal journal between 2001 and 2006. Based on this, the yearly by-catch in commercial fyke net, gill net, and static gear fisheries along the Swedish west coast between 2001 and 2006 was estimated to be 150 harbour seals, with a 95% confidence limit between 45 and 318 (Table 3). The highest estimate (116 animals) was from the gillnet fishery, but this figure is the most uncertain of our estimates. The total gill-net fishing effort contained in the voluntary logbook data is large (22%) as compared to the total fishing effort during one year, but it only represents data from 5 fishermen. Despite this uncertainty it is thought that those fishermen constitute a representative sample of the total fishing effort and that the data are reasonable. By-catches in the small fyke nets that are used along the west coast are rare, based on our knowledge of the fishery and the construction of the gear. By-catches in trawls and recreational fisheries are not covered in this study.

Based on this study it appears that the by-catch of harbour seals is not more than some hundred animals per year. This is below the results from a telephone inquiry carried out in 2002 concerning by-catches of seals in the Swedish fishing industry in 2001 (Lunneryd *et al.* 2004). A total of 220 randomly selected commercial fishermen was interviewed, all of whom had provided details of their fishing efforts in their logbooks. The sample corresponded to 16.6% of all Swedish fishing vessels in service during 2001. For the Swedish west coast the total by-catch was estimated to be 410 harbour seals, and the trawl segment contributed with 18% of the by-catch (Lunneryd *et al.* 2004). The difference in estimates between the different studies exemplifies the problems with by-catch surveys. For example, an enquiry could result in an overestimation, because a respondent may sum by-catches over a longer period than

Table 4. Prey-species composition of harbour seals in the Koster archipelago during the periods 1977-1979 and 1989. Figures indicate percentage by weight. Data obtained from Härkönen (1987) and Härkönen and Heide-Jorgensen (1991).

Prey species		Weight percentage 1977-1979	1989
Eel	*Anguilla anguilla*	<0.1	<0.1
Herring	*Clupea harengus*	8	21
Sprat	*Sprattus sprattus*	1	3
Cod	*Gadus morhua*	20	23
Whiting	*Merlangius merlangius*	6	8
Blue whiting	*Micromestius poutassou*	3	7
Norway pout	*Trisopterus esmarkii*	6	11
Poor cod	*Trisopterus minutus*	7	4
Other cod related species	*Gadiformes*	9	3
Viviparous blenny	*Zoarces viviparus*	0	6
Sandeels	*Ammodytidae*	7	3
Wrasses	*Labridae*	3	1
Lemon sole	*Microstomus kitt*	15	6
American plaice	*Hippoglossoides platessoides*	7	2
Other flatfish species	*Pleuronectidae*	5	1
Other species		3	1

requested, in this case a specified year. Even if estimates from the voluntary logbook are deemed to be reliable, there is still a chance that some by-catches are unreported, and then an extrapolation is an underestimate.

ECOLOGICAL INTERACTIONS

Food choice and fish consumption of harbour seals in the Kattegat-Skagerrak

Published studies on the prey selection of harbour seals in Sweden are based on faecal scats from the 1970s and 1980s (Härkönen 1987, Härkönen 1988, Härkönen and Heide-Jørgensen 1991), whereas current data are lacking. The performed studies indicated that harbour seals in the Kattegat-Skagerrak preferred locally and seasonally abundant prey, which is consistent with observations from other areas (*e.g.* Olesiuk 1993, Thompson *et al.* 1996, Brown and Pierce 1998, Brown *et al.* 2001). In all, over 30 species of fish were found, but only a few species contributed substantially. In the Koster archipelago in the Skagerrak, cod, lemon sole *(Microstomus kitt)*, herring, sandeels *(Ammodytidae)*, poor cod *(Trisopterus minutus)* and American plaice *(Hippoglossoides platessoides)* were the most common species by weight in the earlier study (Härkönen 1987) (Table 4). Findings a decade later indicated a change in prey choice (Härkönen and Heide-Jørgensen 1991). The importance of herring, Norway pout (*Trisopterus esmarkii)*, blue whiting *(Micromesistius poutassou)* and viviparous blenny seemed to have increased while the importance of American plaice and lemon sole had decreased (Table 4). The contribution of cod to the diet seemed to remain at approximately the same level.

Prey consumption by harbour seals

The energy required by harbour seals in the Skagerrak was estimated to be 4,680 kcal per day by Härkönen and Heide-Jørgensen c 1991). Combined with prey energy values they calculated the food consumption to between 3.7 and 4.2 kg fish per day, depending on diet composition. Bjørge *et al.* (2002) estimated the average daily consumption rate of harbour seals along the Norwegian west coast to be 4 kg fish. Based on this, but together with diet data based on material principally collected in the 1970s, Hansen and Harding (2006) estimated that the yearly cod consumption in the Kattegat-Skagerrak was 252 kg and 326 kg per individual for young and adult animals, respectively. Additional studies are required to obtain a current understanding and assessment of harbour seal diet and prey consumption in this region.

Competition for fish resources

Due to the complexity of marine food webs, outcomes of interactions between seals and fisheries are hard to predict even when seals and the fishery compete for the same species. Relationships among seals, fisheries and fish stocks depend not only on factors associated with the seal population but also on sizes, structures and inter-species interactions of the prey populations. To estimate prey consumption and, in extension, competition with fisheries and possible ecosystem effects, information on seal abundance, prey species and size composition, and energetic requirements are required. It is also necessary to obtain information on abundance and natural mortality of the prey species, and the impact of the fishery on the prey, including species and sizes, by-catches and discards. These parameters have various amounts of uncertainty and spatial and temporal variability. Seals may have both positive and negative impacts on the fish stocks and do not necessarily compete with fisheries even when they feed in the same areas. For example, if seals feed on a predatory fish which in turn feeds on commercially important species, the net result can be positive for the fishery which has been discussed in the case of Cape fur seals *(Arctocephalus pusillus)* in South Africa (Yodzis 2001) and harbour seals in Norway (Bjørge *et al.* 2002). However, since the available information on food habits of harbour seals in the Kattegat-Skagerrak is outdated and may not reflect the present diet, it is not possible to evaluate the level of overlap and ecological interactions between the seals and fisheries.

Although only a small number of the seals in the population target eels (Königson *et al.* 2006), this predation may represent an important level of mortality in the local eel stock. Thus, this may have a serious impact on both a depleted and vulnerable fish species and the local fishery. Likewise, seal predation on local stocks of trout *(Salmo trutta)* which spawn in small freshwater creeks, as they migrate to and from the sea could have a significant negative impact. Similar scenarios have been discussed by Yurk and Trites (2000) in Canada and Carter *et al.* (2001) in the United Kingdom.

Parasitic anisakid nematodes in harbour seals

Fish parasites that use seals in their cycles can reduce the value of infected commercial fish considerably. Three species of parasitic anisakid nematodes occur in the Kattegat-Skagerrak harbour seal population, *Pseudoterranova decipiens* (sealworm), *Anisakis simplex* (whaleworm) and *Contracaecum osculatum*. Both *P. decipiens* and *A. simplex* are clearly visible in the flesh of infected fish. They are unattractive to consumers and can also infect humans when consumed in raw or undercooked fish. Infected parts or the whole fish fillet must be removed in a time-consuming and expensive process. However, only *P. decipiens* and *C. osculatum* have seals as true final hosts. The life cycles of these nematodes follow a mainly benthic path involving crustaceans and demersal fish (McClelland 2002). *A. simplex* follows a pelagic path where the final host is generally a cetacean. Nevertheless it can be found as larvae in seals but usually does not develop to the adult stage in pinnipeds. *C. osculatum* is only found in the mesenteries of infected fish and is generally not considered as a problem to the fishing industry (Young 1972).

There are no current data about parasitic infections in Swedish harbour seals. A study based on seals (n=165) which died in the seal epizootic 1988, collected from the Kattegat-Skagerrak, showed that *P. decipiens* was the most common parasite, followed by *C. osculatum* and *A. simplex*, in that order (Lunneryd 1991). The infection rate of P. decipiens was highest in the northern Skagerrak, although low compared to other areas, with a decreasing trend southwards. In another study (Lunneryd *et al.* 2001), the infection rate of *P. decipiens* in fish was examined during the recovery of a Skagerrak seal population after the 1988 seal epizootic. No correlation was found between the size of the seal population and the transmission of parasites to fish.

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