Spatial, Temporal and Dietary Overlap Between Harbour Seals *Phoca vitulina* and Fisheries in Erimo, Japan: Conflict at sea?

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ABSTRACT
Harbour seals are protected in Japan due to their restricted range, low population numbers and previous decimation by hunting, habitat damage and being caught incidentally in fishing nets. Since protection began in the mid-1980s, the total number of harbour seals in Japan has rebounded. With the rise in seal numbers, increased conflict with fisheries has occurred through depredation and the belief that seals compete with fisheries for prey. However, competition is unlikely if seals and fisheries take mostly different prey species and obtain fish from different areas or at different times. We studied the diet and foraging behaviour of harbour seals in Erimo, site of the largest population of harbour seals in Japan, from 2011-2012. We used satellite tags to track their movements through space and time, hard parts and DNA techniques to identify prey items in seal scats, then compared these results to local fisheries data. Of the 46 scats analysed, none contained salmon remains. Gadoids, sculpins and snailfish occurred in >70% of the scats. In contrast, the same species accounted for <15% in the mass of fisheries catches from 2009-2011. The foraging range of harbour seals overlapped with fisheries in all seasons, especially in autumn.

KEYWORDS: marine mammal-fisheries interactions, competition, depredation, harbour seal, foraging behaviour, home range, diet analysis

INTRODUCTION

Harbour seals are protected in Japan due to their restricted range, relatively low population numbers when compared to other pinnipeds and because they were decimated in the past by hunting, habitat damage and being caught incidentally in fishing nets. Since protection began in the mid-1980s, the total number of harbour seals in Japan has rebounded and is currently estimated at over 1,000 individuals. In Japan, the distribution of the harbour seal is restricted to the coast of eastern Hokkaido which is affected by the Oyashio current (cold water). There are 8 rookeries in total. From north to south, they are Yururi and Moyururi islands in Nemuro, two sites in Hamanaka, three sites in Akkeshi and Cape Erimo (Fig. 1). Of these, Cape Erimo has the largest population of harbour seals in Japan and is also the southernmost in the western Pacific, with numbers there increasing since they were protected in the mid-1980s from about 150 seals (Fujii et al. 2006) to more than 600 at present (Kobayashi 2011).

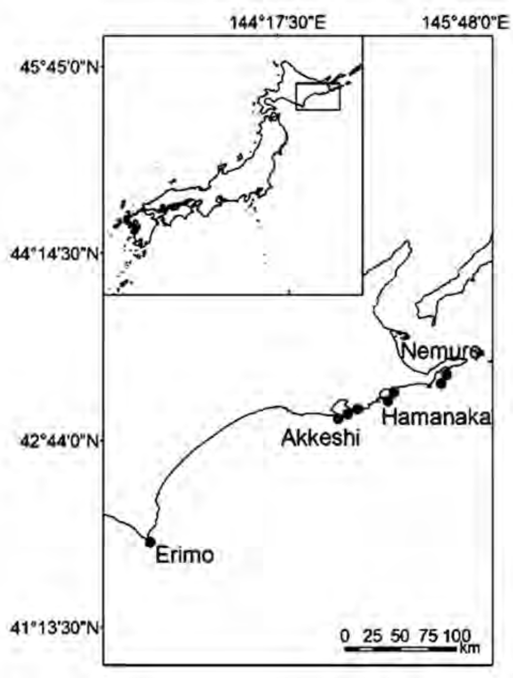

Fig. 1. Locations of the eight harbour seal rookeries in Japan.

With the increase in seal numbers, increased conflict with fisheries (in particular, salmon fixed-net fisheries) has occurred through damage to fish caught in nets and the perceived notion that seals compete with the fisheries for prey. An annual cull to remove 'problem' seals, which enter fish nets and thereby already reduce their overall population number, has thus been proposed. It is widely believed that such measures will minimize fish damage and increase the amount of fish available to fisheries. However, little is known about the foraging ecology of harbour seals in Japan. Without information on the diet and foraging behaviour of harbour seals, it is very difficult to assess competition (if it is occurring at all) between seals and fisheries and even more difficult to predict the impacts of a cull on harbour seals, the surrounding ecosystem and fisheries yields. Harbour seals have already been decimated in the past by human activities and a cull could reverse their populations back to historic lows. Our study therefore focussed on compiling basic but critical information on the seals' diet and foraging behaviour throughout the year then comparing this to fisheries data.

Erimo is the site of the largest population of harbour seals in Japan and therefore an important stronghold for this species. Erimo residents and conservation groups are interested in the behaviour of the local harbour seal population and there is a growing interest in protecting the habitat and resources required by this species. A general change in people's attitudes towards the hunting of marine mammals and the growth of the ecotourism industry has also fuelled interest in protecting the harbour seal. The results of our study will help identify important areas and fish stocks to aid in the conservation of the harbour seal in Japan. By knowing when and where harbour seals forage, fishermen can decide how best to time the opening/closing and deployment/retrieval of fish nets to avoid by-catching seals (and thereby prevent their fish catches from being damaged by them). With this in mind, our objectives were to: (1) determine the home range (encompassing the foraging range) of harbour seals and any changes that occur throughout the seasons; (2) determine the year-round diet of harbour seals, in terms of the prey species eaten and the relative quantity of each species eaten and; (3) examine overlap between harbour seals and fisheries by comparing the prey species, relative quantity of each species and where and when prey are taken by both the harbour seals and fisheries.

METHODS

Harbour seal home range

On July 2, 2011, one harbour seal pup was captured and tagged with an Argos satellite tag (Wildlife Computers SPOT5). Messages were processed using the DAP processor software provided by Wildlife Computers. We set the tag to attempt transition every 44.5s when wet and 89.5s when dry (indicating that the seal had probably hauled out). To conserve battery life, we limited the number of transmissions to a maximum of 300 per day.

To assess differences in foraging behaviour between seasons, we calculated a separate home range for summer (June-August), autumn (September-November) and winter (December-February). The home ranges of the seal were calculated using adaptive local convex hulls, developed by Getz et al. (2007). Adaptive local convex hulls are generated using a non-parametric kernel method, based on a generalisation of the minimum convex polygon (MCP), and perform well around coastline boundaries. They are especially suitable for analysing auto correlated, location-dense datasets such as those obtained from satellite tags. The software for this method of home range analysis is available as a free, downloadable package (available from http://locoh.cnr.berkeley.edu), called the R statistical package (R Development Core Team 2009). As our interest was in the foraging distribution of harbour seals, we eliminated locations associated with haul out behaviour. Both 50% of core and 90% of overall foraging ranges were calculated for each seal, in each season. All foraging ranges were visualised and displayed using ArcGIS 10 (ESRI, Redlands, CA).

Harbour seal diet

Harbour seal scats were collected once a month from July to October, 2012 (the months fisheries are active and kayaking to the haul out site is possible) so that any seasonal changes in the harbour seal's diet could be determined. The target sample size was a minimum of 60 scats per season (spring, summer, autumn) to enable sufficient, statistical accuracy (Trites & Joy 2005). Scats were washed through 0.5mm sieves and prey were identified to the lowest possible taxon from the hard parts (e.g., otoliths, cephalopod beaks, crustacean shells) retrieved. The percentage contribution of each prey species to the harbour seal's diet was determined, by calculating the percentage of the frequency in occurrence of each prey species in all scats.

Overlap between harbour seals and fisheries

Data on the locations of fish nets, the species caught, their respective weights by species and when each species was caught, were obtained from 2009 to 2011 from the Erimo fisheries cooperative and Marinenet, Hokkaido (www.fishexp.hro.or.jp). The locations of fish nets were mapped using ArcGIS 10 then compared with the harbour seal foraging ranges. Similarities in biomass composition between harbour seal prey and fishery catches were assessed using Pianka's niche overlap index (Pianka 1973). Temporal overlap was considered, by comparing the daily and monthly haul out patterns (as a measure of activity or non-activity in harbour seals) of harbour seals obtained from the satellite tag and the times that fish nets were opened/closed and deployed/retrieved. We also compared the prey species identified in scats collected from different seasons with the species caught by fisheries during the same time periods. These measured variables indicated which prey species are most likely to be competed for (if at all), the type of fisheries which are most likely to be affected by harbour seal depredation, which foraging areas are affected and when they are important to harbour seals.

RESULTS

Harbour seal foraging behaviour

The tag transmitted 288 locations (91 in summer, 145 in autumn and 52 in winter) of quality 1, 2 or 3 (out of a total of 1231 locations). The sizes of the seal's 90% home ranges in summer, autumn and winter were 41.73 km^2, 26.07 km^2 and 4.18 km^2 respectively and the 50% home ranges were 2.93 km^2, 0.93 km^2 and 1.43 km^2 respectively. The farthest straight line distances travelled from the haul out were 15.22 km, 8.77 km and 6.04 km in summer, autumn and winter respectively. The foraging ranges overlapped 1 net in summer and 4 nets in autumn (Fig. 2). There was no overlap in winter.

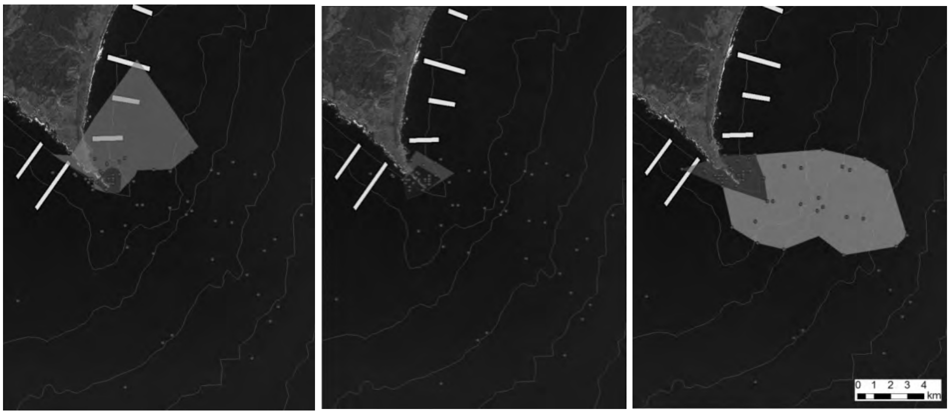

Fig. 2. 50% and 90% home ranges of the harbour seal tagged in July 2011.

The tagged harbour seal hauled out least during high tide, from about 12-7 pm (Fig. 3). Summer and autumn haul out patterns were similar but in winter, there was less distinction between high and low tide haul out patterns. The seal also hauled out less overall in winter.

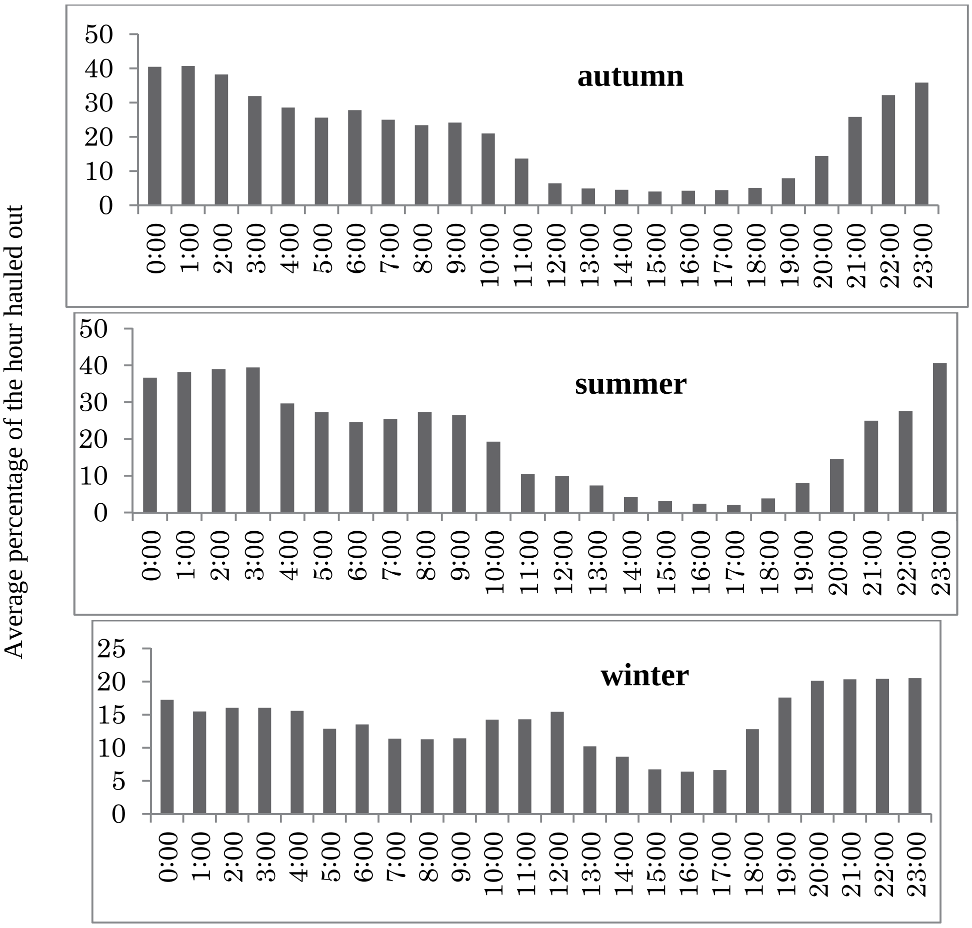

Fig. 3. Haul out patterns of the harbour seal in summer, autumn and winter, 2011.

Harbour seal diet

A total of 46 scats were collected, 15 during summer and 31 during autumn. The average minimum number of species per scat was 1.47 and the average minimum number of prey items per scat was 3.25. In both seasons, the top prey species were pollock, sculpins and snailfish (Fig. 4). Salmon was by far the most important species caught by Erimo fisheries, with a total of 4,357t caught in 2011. After salmon, pollock and cephalopods were the most important (Fig. 5). Dietary overlap as assessed by the Pianka index between fisheries and harbour seals was only 0.03 in summer and 0.11 in autumn.

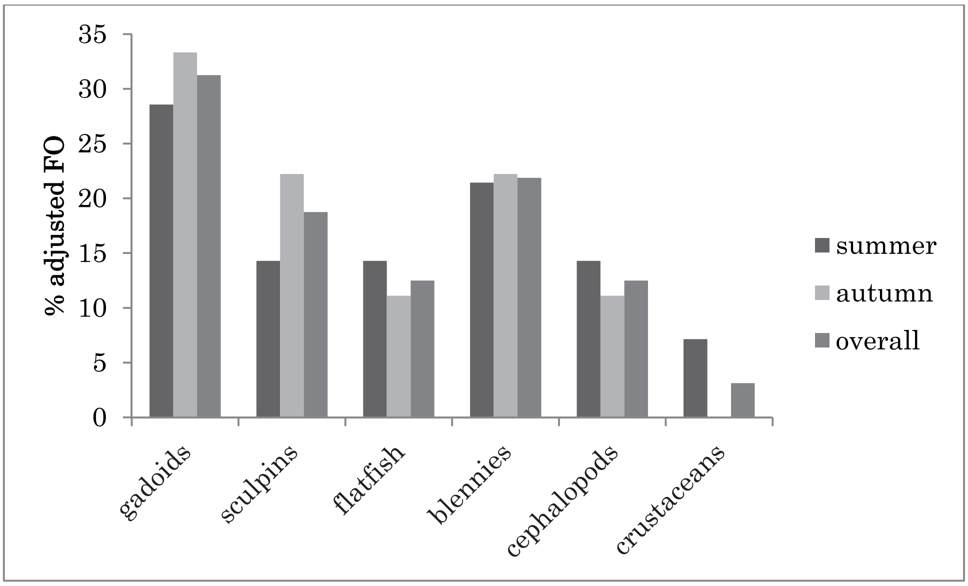

Fig. 4. Frequency of occurrence of prey items in harbour seal scats.

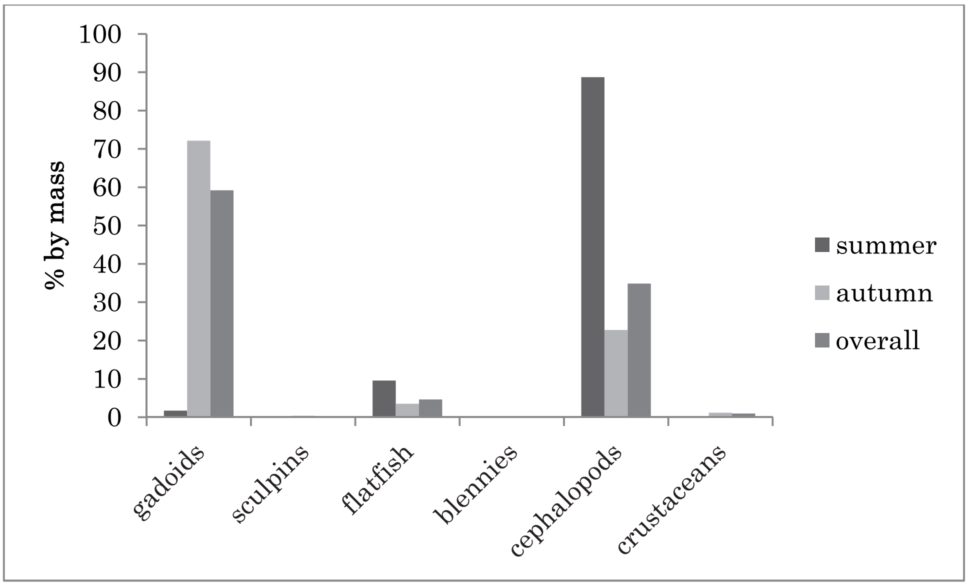

Fig. 5. Percentages of fishery catches of harbour seal prey groups by mass.

DISCUSSION

The foraging range of the seal changed through the seasons, with the largest 90% home range seen in summer and the smallest in winter. However, the smallest 50% home range occurred in autumn, indicating that the seal's foraging was most focussed in a smaller area during this time. These results indicate that prey density may be highest in autumn and winter, negating the need of seals to forage over large areas in order to meet their daily nutritional requirements. Autumn is also when fisheries catches are highest and is the main fishing season in Erimo. Thus seals and fisheries may be able to find sufficient prey within a reasonably small area, without competing.

Diet among harbour seals was fairly similar between summer and autumn, with pollock, Japanese Irish lords and snailfish consisting of the main items of prey. In contrast, the main species caught by far at fisheries in Erimo, was chum salmon. After salmon, the most important species caught by fisheries were gadids and cephalopods. Most catches were made in the autumn.

In conclusion, harbour seals appear to be foraging in the same areas as fisheries, but eat mostly different prey species. Depredation is probably unique to seals which have learned the behaviour and is not widespread as is what is currently believed.

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