

Global sperm whale (*Physeter macrocephalus*) depredation of demersal longlines

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We surveyed the literature, colleagues and Pender Island abstracts to compile observations of sperm whale (*Physeter macrocephalus*) depredation on demersal longlines worldwide. Depredation is defined here as observations of damaged fish, lost fish, reduction of expected catch, and damaged hooks. There are records of depredation or possible depredation of demersal longlines occurring in three regions globally. Depredation has been recorded in the southern hemisphere including (from west to east) Chile, Patagonia and the Falklands, South Georgia, Prince Edward, Crozet, and Kerguelen Islands; depredation is also likely to occur near Heard and McDonald Islands (CCAMLR 1994, Ashford et al. 1996, Capdeville 1997, Crespo et al. 1997, Nolan and Liddle 2000, González and Olivarría, Roche et al. 2006, Kock et al. 2006). In the North Pacific, depredation has been recorded in the Gulf of Alaska (Hill and Mitchell 1998, Hill et al. 1999, Straley et al. 2006, Sigler et al. 2006). In the North Atlantic, depredation has been recorded in waters around Norway, the southern coast of Greenland and the Davis Strait between Newfoundland and Greenland (Dyb 2006, Nils Oien pers. comm., Paul Winger pers. comm.).

In the Gulf of Alaska, depredation occurs in the sablefish (black cod, *Anoplopoma fimbria*) and Pacific halibut (*Hippoglossus stenolepis*) fisheries (Hill et al. 1999, Straley et al. 2006, Sigler et al. 2006). In the North Atlantic, depredation occurs in the fisheries for Greenland halibut (*Reinhardtius hippoglossoides*), Atlantic halibut (*Hippoglossus hippoglossus*), Atlantic cod (*Gadus morhua*) and Greenland cod (*Gadus ogac*) (Dyb 2006, Nils Oien pers. comm.). In the Southern Ocean, depredation occurs in the fishery for Patagonian toothfish (*Disosstichus eleginoides*) (Purves et al. 2004, González and Olivarría 2002) and it is possible that sperm whales also depredate on fisheries for Antarctic toothfish (*Dissostichus mawsoni*) (Abe and Iwami 1989, Koch et al. 2006). The fisheries mentioned above operate demersal longline gear from platforms varying in size from independently owned vessels (e.g., <18m in the Gulf of Alaska) to large freezer factory ships (e.g., 50m in length in the North Pacific and Southern Ocean). See Karpouzli and Leaper (2004) for observations of possible depredation on deep-water trawlers in the North Atlantic by male sperm whales in the Greenland halibut fishery.

All fishing grounds where depredation is reported to occur overlap with known natural feeding grounds of sperm whales. The species of fishes recorded during sperm whale depredation is often the same species reported to be found in the stomachs of sperm whales taken by whalers who years earlier were operating at the same sites. For example, Patagonian toothfish were commonly found in sperm whale stomachs sampled at whaling stations in South Georgia (Ashford et al. 1996). In the North Pacific, fish were commonly found in sperm whale stomachs taken in the eastern Gulf of Alaska while squid was more common in whales taken in the Bering Sea and western Aleutians (Okutani and Nemoto 1964). Depredating sperm whales appear to be selective in prey choice. For example, in Alaska and Southern Chile, by-catch is not regularly taken off of the lines, indicating that sperm whales might have the ability to select the type of fish they depredate (Straley 2005, Hucke-Gaete et al. 2004). Presumably, what longliners have done is make it easier for the sperm whale to forage by hauling their natural prey items closer to the surface.

In general, lone males or small groups (2-7 individuals) participate in depredation activities (Purves et al 2004, Hill and Mitchell 1998). However, the numbers may be larger at some sites and perhaps increasing: 1-30 (mean = 4.1) at Crozet (Roche et al. 2006); most often solitary, but 2-3 common and up to 10 at South Georgia (Kock et al. 2006); and 1-2 initially and now 10-15 in Greenland (J. Dyb unpublished data). To date, all animals identified by eye (Alaska, Crozet and Kerguelen Islands, Greenland, Argentina) and by genetic sex determination (Gulf of Alaska) have been large subadults or adult males (Straley 2005, C. Guinet, J. Dyb and M. Purves unpublished data). Off the coast of Patagonia, Argentina, there is a single (unconfirmed) report of groups of 10-15 females taking turbot (Rolf Ambjornsen pers. comm.). Interactions (sometimes aggressive) between sperm whales and killer whales have been observed at the hauling stations of longliners in the Falkland Islands (Nolan and Liddle 2002), Crozet Island (Jerome Maison pers. comm., C. Guinet unpublished data), Prince Edward Island (Tilney and Purves 1999) and in Chile (Hucke-Gaete et al. 2004).

Few reports of entanglement, injury or death in longline gear have been recorded. Such entanglements are costly and dangerous to fishermen and can force fishery closures. Entanglements in fishing gear with no apparent serious injury have been reported in South Georgia (Ashford et al. 1996, Purves et al. 2004, Koch et al. 2006), the Falkland Islands (Helen Otley pers. comm.), Crozet and Kerguelen Islands (C. Guinet unpublished data) and Alaska (Angliss and Lodge 2003, Angliss and Outlaw 2005). Deaths attributed to gear entanglements have been recorded in South Chile (Salas 1987, Hucke-Gaete et al. 2004) and Greenland (J. Dyb unpublished data). Reports of fishermen shooting whales with guns and harpoons in the artisanal fishery off Southeast Chile represent potentially fatal threats provoked by frustration with reduced catches due to sperm whale depredation (González and Olivarría 2002).

It is difficult to estimate the loss of fish due to depredation. Estimates of fish loss are generally conservative because it is not possible to attribute an empty hook (bait removed or disintegrated) to depredation. Additionally it can be difficult to distinguish whether other species, such as sharks or killer whales, have contributed to the damage or loss of hooked fish. Damage and loss of fish has significant economic and management implications for both fisherman and fishery biologists tasked with assessing fish stocks. In general, depredation by sperm whales seems to be low to moderate, but it is highly variable in extent both among and within fishing areas. The frequency of sperm whales present during fishing operations varies widely from 0 –

100%. Illustrative figures include: 16% of sampling days during the annual sablefish longline survey in the Gulf of Alaska (Lunsford et al. 2006); 39% of hauls in Sitka, Alaska (Straley et al. 2006); 24.2% of hauls near South Georgia (Purves et al. 2004) and 57% and 33% of hauls at Crozet and Kerguelen Islands, respectively (Roche et al. 2006). The rate of depredation, quantified in varying ways, also fluctuates widely. Illustrative figures include 0.6% of annual sablefish catch for Alaska and catch is reduced by 1.8% when depredation occurs (Sigler et al. 2006, Lunsford et al. 2006) and 3% of catch in the Sitka fishing grounds which extends approximately from Dixon Entrance to Cape Ommaney (Straley et al. 2006). At South Georgia, 3% of catch is removed by sperm whales (Purves et al. 2004) and at Crozet and Kerguelen Islands about 12% of the catch is removed (Roche et al. 2006).

At several sites it is possible to document the ontogeny of depredation -- the length of time from the onset of longline fishing in an area, to the first reports of depredation, to depredation being widespread. Illustrative examples can be drawn from Alaska where longlining began in the late 1800's, expanded to the Gulf of Alaska in 1982, and the first reported case of depredation occurred in 1978 (T. O'Connell unpublished data). However, widespread reports of depredation did not occur until after 1997. It is important to note that the fishery moved from a "derby" style to "IFQ" (Individual Fishing Quota) in 1995. Concomitantly, the fishing season increased from 10 days to 8.5 months, overlapping with the summer months during which sperm whales presence in the Gulf of Alaska increases by a factor of two (Mellinger et al. 2004). In Greenland, longlining began in 1980, depredation was first recorded in 1995, and became widespread in 1997/1998, coincident with a decline in the squid fishery and a noted look of emaciation in sperm whales in the area (Dyb 2006; J. Dyb unpublished data). In the Southern Ocean, longlining started for Patagonian toothfish near South Georgia in 1985/86 and near Kerguelen Island in 1991/1992. Depredation was first recorded around 1994 at South Georgia and became widespread over most of the Southern Ocean in the 1996/1997 season (Kock et al. 2006). At Crozet and Prince Edward Islands, the onset of the Patagonian toothfish fishery and the spread of depredation occurred within a few years between 1994 and 1996 (C. Guinet unpublished data). Documenting the chronology of depredation is confounded not only by a lack of reporting but also, in the Southern Ocean, by the IUU fishing fleet (Illegal, Unregulated and Unreported) whose operations and locations are not known.

Longline fishing operations appear to provide an easier foraging method for sperm whales presumably because the whales remove fish as the line is hauled reducing time at depth (Thode et al. 2004). Depredation occurs in several areas globally where longline fisheries operate in natural sperm whale foraging areas, in which the fishing operations target traditional prey of sperm whales and in which fishing vessels may attract whales acoustically, visually and/or by discard. Much of the documentation is unpublished and the published accounts are often anecdotal. The situation highlights the need for systematic data collection to better understand the nature and magnitude of the interaction and to design effective mitigation measures. Prevention and mitigation is likely to be most successful when the costs or risks to sperm whales are greater than the benefits, the association between the fishing vessel and food can be broken, and/or the opportunity for interaction is reduced by separating fishing and whales in space and/or time. Interesting exceptions to the rules -- areas where there is longline fishing but no sperm whale depredation -- such as the eastern North Atlantic, the eastern Aleutian Islands and Bering Sea, South Africa, New Zealand, and the Ross Sea -- are worthy of study for possible clues to mitigation and prevention.

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