Paper for the Hoki Fishery Management Company Environmental Steering Group discussion on possible approaches to mitigating fur seal bycatch in the hoki fishery

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1. Introduction

This report summarises information available on ways to mitigate marine mammal incidental captures in trawl fisheries. Extensive searches were made of library databases, including Abstracts of Science and Fisheries Abstracts (ASFA), Fish and Fisheries Worldwide, BIOSIS Previews, Web of Science, Department of Conservation (DoC) and NIWA library catalogues. Keywords used included: marine mammals, seals, sea lions, bycatch, incidental capture, gear technology, trawl fishing, excluder devices, grids.

It was evident that little relevant information was available in the standard journal literature. Email contact was made with marine mammal and technologists known to be working in the field of marine mammal bycatch and its mitigation, through known contacts and through a general marine mammal listserver. Internet search engines were used to search on the subject as well as government, research institute, and university websites: Australian fisheries organisations (AAD, AFFA, AFMA, BRS), Department of (DEFRA), Department of Fisheries and Oceans (DFO) in Canada, Food and Agriculture Organisation (FAO), ICES, and National Marine Fisheries Service (NMFS).

This summary has concentrated on work relating to pinnipeds, as much of the cetacean bycatch mitigation work is related to the use of acoustic deterrents on passive fishing gear. Cetacean mitigation work is discussed where there are similarities between the approach to mitigation for pinnipeds and for cetaceans.

2. Abundance and trends of New Zealand fur seals

New Zealand fur seals (*Arctocephalus forsteri*) are distributed around the New Zealand coastline, on offshore islands, and on sub-Antarctic islands (Mattlin 1987) and in South and Western Australia (Shaughnessy 1994, 1999). The species was heavily exploited during the 18th and 19th centuries and protection was given to it in 1894, but restricted licences were still issued for seal harvest in certain locations (Mattlin 1987). In 1978, New Zealand fur seals were given total protection under the New Zealand Marine Mammal Act. It appears that fur seals are now recolonising areas where they were historically present (Dix 1993, see Harcourt 2001).

In New Zealand waters, recent fur seal population estimates are available only for a few discrete populations. Data are not often comparable because counts were made by different methods and at different times of the year. Wilson (1981) summarised population surveys undertaken in the 1970s and estimated population size within the New Zealand region at between 30 000 and 50 000 animals. During the last 10 years, estimates for populations have stabilised (Snares

Islands) or increased (Bounty Islands, Nelson-Marlborough region, Otago, and Cook Strait), and evidence suggests that the numbers of haulouts and rookeries are increasing ((see Baird & Bradford 2000 for summary).

There are few published data for the rookeries on the west coast of the South Island. The main fur seal breeding colonies are at Open Bay Islands and Cascade Point (about 165 km from the hoki spawning grounds) and at Cape Foulwind (about 100 km north of the hoki spawning grounds).

Estimates of fur seal pups at the main rookeries on the west coast of the South Island in late January-early February 1999 and 2000 showed an average decline of more than 50% when compared with the average estimate of pup numbers for 1992–98 (H. Best, Department of Conservation, unpublished data). Best (pers. comm.) notes that these low numbers coincided with a period of strong La Niña conditions when fur seals may have had difficulty in obtaining their preferred fish species. Best considers that this climatic effect also impacted on the pup numbers estimated for late January-early February 2001; these numbers were higher than the previous two years, but were still lower than the 1992–98 average. Overall, Best (pers. comm.) concludes that the main rookeries off the west coast of the South Island are either stable, with periodic fluctuations, or declining.

Males arrive to breed in October or November and females arrive to pup in mid November and early December (Mattlin 1987, see Bradshaw et al. 1999). Females suckle their pups for about 300 days and during this time are actively foraging. Most males leave the rookery in mid-January, and outside the breeding season fur seals occupy haulouts around the New Zealand coastline (see Bradshaw et al. 1999). There is a seasonal influx of males to west coast rookeries and haulouts during the hoki season (Wilson 1992).

3. Diet and foraging

New Zealand fur seals dive deeper and for longer than any other studied fur seal. They forage mainly at night over the continental shelf and slope (see Lalas & Bradshaw 2001). Lactating New Zealand fur seals are restricted in their foraging by the necessity to repeatedly return to shore to feed their offspring for about 10 months of the year. Harcourt et al. (1995) showed that most dives by lactating females from an Otago rookery in the summer months were made at night, and the deepest dives were made near dawn and dusk. Bouts of dives at night were longer than those during the day and often continued throughout the night.

Lactating fur seals are capable of diving to depths greater than 250 m and may stay submerged for more than 8 minutes (Mattlin et al 1998). Significant seasonal differences were recorded for mean dive depth, dive duration, and bottom time, with increases from summer to winter for dives ≥ 6 m: 35% of winter dives (June-August) were 100 m or deeper and 27% were to less than 20 m. These fur seals spent about 47% of their time at sea diving to depths of 6 m or more. In winter, about 30% of dives were under 3.5 min in duration. Thus, it appears that fur seals are vulnerable to capture when the net is in depths of less than 100 m during shooting and hauling.

Mattlin et al. (1998) concluded that: relatively shallow dives and nocturnal feeding during summer suggests seals are feeding on pelagic and vertical migrating prey species; deeper dives and more dives in daylight hours during autumn and winter suggests that the prey species may include benthic, demersal, and pelagic species; that deeper dives enable seals to forage along or off the continental shelf (within 10 km) of the rookery studied (at Open Bay Islands); and that these deeper dives may be to the benthos or to depths in water column where spawning hoki are concentrated. Females from this rookery spend most of their time at sea and may be capable of foraging up to 750 km from the rookery on longer foraging trips (Mattlin 1995), though lesser distances were traveled during July-August when the west coast hoki season is at its peak.

Different sampling and analysis techniques have been used to ascertain the diet of New Zealand fur seals, with earlier studies based on diagnosis of fleshy remains in stomachs and revealing octopus (*Octopus maorum*), barracouta (*Thyrsites atun*), and arrow squid (*Nototodarus sloanii*) (Street 1964, Sorenson 1969). Arrow squid and octopus also predominated in the regurgitation and scat analysis of Otago Peninsula fur seals (Tate 1981), but scat analysis of fur seals at Kaikoura and Cape Foulwind showed that lanternfish (various species of Myctophidae) predominated at Kaikoura during April to August, whereas aruhu (*Auchenoceros punctatus*) predominated at Cape Foulwind in February-April, anchovy predominated in May to August, and silverside was an important prey here during April (Carey 1991). In this study, hoki was the only commercial species that appeared to be targeted by seals (Carey 1991). The proportion of hoki in the diet varied between sites, with Kaikoura having highest incidence, especially in May, whereas at Cape Foulwind, hoki comprised a smaller proportion (nearly exclusively from February).

Fish predominate in scats and cephalopods in regurgitated samples. Lanternfish were numerically dominant throughout the year in scats from fur seal colonies on the Otago Peninsula (Fea et al. 1999). Aruhu and red cod (*Pseudophycis bachus*) also featured in scats, but arrow squid was numerically dominant in the regurgitated samples. Larger prey species were considered more important in the overall biomass represented in the scats, especially jack mackerel (*Trachurus* spp.) and barracouta.

The dietary analyses suggested that these Otago fur seals foraged over the outer edge of the continental shelf in 100–200 m through winter and spring, and into deeper waters of 150–200 m during summer and autumn (Fea et al. 1999). Lanternfish were present in samples throughout the year (offshore foraging), but aruhu, sprat, and juvenile red cod and arrow squid only in winter-spring, and large arrow squid predominated in summer and autumn. Jack mackerel species, barracouta, and octopus were dominant in winter and spring. Further, lanternfish and arrow squid rise in the water column at night when fur seals exhibit shallow foraging (Harcourt et al. 1995, Mattlin et al. 1998).

4. Interaction between fur seals and fishing gear

The mechanisms of the capture of fur seals in trawl nets include aspects of the fishing gear (gear design, headline height), fishing strategy used (time of tow, tow duration), gear malfunction, location and timing of the fishing effort and of the fur seal foraging effort, rookery location, common occurrence of the species targeted by the fur seals and the fishery, and fur seal behaviour. Nationality of vessel, year (season), day-night, area, and 10-day fishing period were all significant predictor values in an investigation of the factors that may influence fur seal bycatch in the west coast hoki fishery (Baird & Bradford 2000).

Knowing when and how the animals are caught, and when they are most vulnerable, is further information required to develop effective mitigation programmes and codes of practice. Observers note that the sound of the winches acts as the “dinner gong” for fur seals. The presence of many fur seals in the water around the vessel, certain fishing practices, and problems associated with fishing gear operations have been the main comments by observers about tows with fur seal captures. Some examples of these include: the net may be raised closer to the surface because the vessel makes a turn; the trawl doors are crossed; the winches are slow or require some work and thus the net is held at the surface; other gear such as the netsonde monitor or transducer requires attention during the tow; difficulties in setting results in the net being partially hauled and then shot again; or offal discharge during shooting or trawling (MFish observer logbook comments). Fur seals attempt to feed from the codend and also dive or swim into the opening of the net as it is being hauled. This activity occurs during night and daylight hours.

5. Approaches to reducing bycatch of marine mammals

Methods to mitigate marine mammal captures in commercial fisheries have been mainly devised for gill-net and drift-net fisheries, primarily for cetacean species in the northern hemisphere. These methods are primarily designed to act as deterrents, though some are designed to allow the marine mammal to escape. Methods tested in New Zealand are included in the summaries below which are largely drawn from Stewardson & Cawthron (2004).

5.1 Acoustic deterrents

Stewardson & Cawthron (2004) review the usefulness of acoustic deterrents. Low-intensity acoustic deterrents or "**pingers**" are designed for use in mitigating dolphin and porpoise interactions with gillnets by alerting the animal to the presence of an object (net). Pingers are thought to have no significant effect on the fish catch, and their effectiveness may be species specific, even within pinniped species. This method appeared to have a localised effect at keeping Hector's dolphins (*Cephalorhynchus hectori*) from set-nets in Akaroa Harbour, but did not deter animals from entering the harbour.

Pingers were deployed around the mouth of a bass (*Dicentrarchus labrax*) pelagic trawl in U.K. waters and found to be ineffective for mitigating cetacean bycatch (Northridge 2003). Further tests are underway in the albacore pair trawl fishery in Irish waters (Anon. 2003). Another idea is to use an acoustic alarm in the back of the net to be used before any manoeuvre of the vessel (Anon. 2002). Other acoustic devices to deter cetaceans are being tested with Dutch trawlers, with eight per trawl (Anon. 2002).

High-intensity acoustic devices or "**acoustic harassment deterrents**" (AHD) are designed to scare animals away (by reducing any predatory behaviour) from structures such as marine farms. Some temporary effect of scaring seals around salmon farms in the Marlborough Sounds may result from the use of AHDs, but they may need to be used as part of a suite of measures. Concerns with the use of these devices include the effect they may have on the animals' sensory capabilities and behaviour, habituation to the sound, displacement from critical habitat of the "target" mammal as well as other marine mammals, and lack of knowledge on the effect on the fish species (see Stewardson & Cawthorn 2004). The testing of AHD use in the hoki fishery in the early 1990s was abandoned because of mechanical and design problems. Tests with another type of AHD proved ineffective as a deterrent to fur seals around hoki vessels.

Further acoustic developments include the invention of the **seal scarer,** which is designed to prevent seal attacks on caged fish and works on impact by emitting sounds that are scary to the animal. Predation was not significantly reduced by the use of these scarers. Deterrents that create underwater shock waves have equivocal results where they have been tested in the field, although repeated gunshots into the water near the net has met with some success at scaring seals away. Similarly, the use of cherry bombs or cracker shells has little impact (see Stewardson & Cawthorn 2004). Lastly, recordings of killer whale vocalisations were not effective as a longterm deterrent.

5.2 Sensory deterrents

Deterrents aimed at impacting on the senses of marine mammals include the use of emetics in "bait" thrown to the seals, diesel-soaked material tied to the net, killer-whale decoys, and non-lethal bullets. None were successful as long-term deterrents for the marine mammal problems under consideration and most would be potentially dangerous to operate in trawl fisheries, even if they were considered worth attempting.

5.3 Excluder devices

Various exclusion devices are being developed and tested as mitigation measures for cetacean and pinnipeds captures in trawl fisheries. These devices consist of a metal grid (through which fish can escape) that is placed in the net ahead of the cod-end and serves to deflect the animal out through an escape hatch.

The **Sea Lion Exclusion Device** (SLED) being tested in New Zealand is described in Stewardson & Cawthorn (2004). Concerns about the most recent version of SLED used in the New Zealand squid trawl fishery include: survival of the Hooker's sea lions after they have exited the escape hatch, and loss of the target species. Tests of the SLED in the west coast hoki fishery suggested that large hoki were retained, and some faster-swimming fish species escaped, whereas in the Cook Strait fishery, smaller fish were caught as "stickers' in the scoop of the cover net. Fine mesh inside the scoop may prevent this. The target catch showed no obvious damage that could be attributed to the SLED. Stewardson & Cawthorn (2004) do not comment on the successful escape of fur seals from the net.

A **Seal Exclusion Device** (SED) being trialled for use in the blue grenadier (hoki) fishery in Australian waters. Richard Tilzey (pers. comm.) notes that initially the use of SEDs suffered from the following problems: excessive loss of fish, blockage of the grid by fish, seal exit also acting as an entrance when a bottom escape hatch was used, grid acted as a feeding station for seals, incidence of capture for no-SEDs was lower than that for closed SEDs (based on small number of captures but may indicate a potential problem with the SED acting as an "attractant". As with the SLED, the forward facing escape hatch has served to lessen fish loss. Measurement of the survival rate of the seals is complicated by the small number of incidents spread over the different combinations of nets, SED types, and SED placement. SEDs are recommended for use in the South East Trawl Fishery only in midwater nets in areas frequented by seals on vessels that have large fishing decks to enable stowage of the SED between shots.

Tests with an **dolphin exclusion device** trial with on a pair trawler in Scotland to mitigate dolphin bycatch are inconclusive and have highlighted problems with mesh size in the escape cover net, as well as with the sound emitted from the grid sensor and the easy detection of the grid by the animals. The latter two points were thought to have caused the dolphins to turn in the net and swim out as no animals were filmed swimming out through the escape hatch.

The CETASEL project tested a series of ropes hung inside the pelagic trawl net to deter the passage of dolphins, but it was not possible to make any conclusions on their effectiveness. In a UK Sea Mammal research Unit project designed to test an exclusion device, too few dolphins were encountered to make any conclusions, but the work is ongoing (Northridge 2003).

5.4 Methods to close the net on hauling

Fishers and researchers in Australia have discussed the possibility of closing the net on its descent (Richard Tilzey pers. comm.). Ways to achieve this with a bottom net included: the vessel would make a sharp turn when shooting the net to bring the trawl doors closer together, and shooting the net with different warp lengths (but this increased the chance of net malfunction). Some method of linking the doors until a prescribed depth was reached was considered impossible because of stresses involved, operational dangers, and possibility of doors malfunctioning.

5.5 Management measures

Various management measures aimed at rescuing marine mammal bycatch include: Codes of Practice (e.g., New Zealand hoki fishery, http://www.hokinz.com), limit on bycatch (e.g., 30 seals a year in the Australian blue grenadier fishery), effort reduction, time and area closures, and alternative fishing methods.

A reduction in fishing effort should reduce incidental captures, especially if targeted at certain times or areas with higher bycatch and those gear types with the highest capture rates (Anon. 2002). The effectiveness of any closure is dependent on the time (diurnal, seasonal) and area chosen for closure and must be framed within some management target for bycatch reduction (Anon. 2002). This type of management action may result in displacement of fishing activity in time and space as well as in a change of gear type used to harvest the target species. For this type of management, the known capture rate must be shown to be consistent each year and must be monitored after the event. Likely effects must be modeled using predictions on the result of closure, such as redirection of fishing effort.

5.5 Further comments

Some other suggestions from various researchers in USA are listed. Some nets had a "blowout slit" near the cod-end that would break if too many fish were caught and if Stellar sea lions were trapped in the cod-end. This was high enough in the net to keep most of the fish catch, but low enough to allow the sea lions to escape. This was used on joint-venture vessels and was discontinued when the fishery became a national fishery only (Tom Loughlin pers. comm.). Time and area restrictions are imposed on groundfish fleets in the North Pacific and Alaskan waters where they may interact with Stellar sea lions, largely due to resource competition, but also the possibility of bycatch. No restrictions are placed on the gear used.

6. References

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