REPORT OF THE WORKSHOP ON INTERACTIONS BETWEEN CETACEANS AND LONGLINE FISHERIES

APIA, SAMOA : NOVEMBER 2002

New England Aquarium Aquatic Forum Series Report 03-1

New England Aquarium

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Edited by
Michael Donoghue
Randall R. Reeves
Gregory S. Stone

Production and editorial assistance by Lisa Spalding

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Copies of this report are available by contacting:

Global Marine Programs Division
New England Aquarium
Central Wharf, Boston, MA 02110
617-973-5288
gstone@neaq.org

Cover photo: Sperm whales and killer whales around toothfish longliner, Crozet Islands, Indian Ocean, 2002.
Photography by Jerome Maison

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INTRODUCTION

The problem of depredation by cetaceans on longline gear occurs worldwide, and has been recorded in a wide range of longline fisheries dating to at least the early 1950s. Depredation was defined in the context of this workshop as *"the removal of hooked fish or bait from longlines by cetaceans."* This was distinguished from predation, which was defined as *"the taking of free-swimming fish (or other organisms) by cetaceans."*

The nature and extent of cetacean interactions with the world's longline fisheries vary by region, target catch species, and gear deployment method. Killer whales (*Orcinus orca*) have been observed or implicated in interactions with longline fisheries in many areas, taking a variety of fish species from the gear. In the South Pacific, there have been numerous reports of fishery interactions with "whales," possibly meaning false killer whales (*Pseudorca crassidens*) and/or pilot whales (*Globicephala* spp.) in addition to killer whales. In most instances in this region, however, species identification is uncertain. As many as eight species of dolphins have been observed in the vicinity of longlines in the South Pacific, and some may have been involved in bait removal. Additionally, sperm whales (*Physeter macrocephalus*) have been documented to take Patagonian toothfish ("Antarctic cod"; *Dissostichus eleginoides*) in the Southern Ocean, as well as sablefish ("black cod"; *Anoplopoma fimbria*) and other fish species in the eastern Gulf of Alaska.

With the rapid growth of domestic longline fisheries in the South Pacific, reports of interactions with cetaceans have increased. It is unclear whether this is due to inaccurate reporting of shark damage to fish, an increase in the number of cetaceans in the fishing areas, or the transmission of behavioral traits associated with depredation from one group of cetaceans to another. It is also possible that the reported increase in depredation reflects the fact that local fishermen are now encountering a similar scale of problem to that experienced by distant-water fishermen from other nations who operated in these waters in earlier years.

In any event, people involved with the longline industry perceive that interactions with cetaceans are having an adverse economic impact because depredation causes loss of catch, gear, and time and otherwise increases vessel operating costs. Furthermore, financial losses sustained by an individual fisherman in the South Pacific could lead him to take actions that harm cetaceans, animals that are normally held in high regard by people throughout the Pacific.

In addition to the economic consequences of depredation by cetaceans, there are environmental concerns. For example:

(1) Losses due to depredation are not accounted for in the processes of assessing fish stocks and setting quotas. While some of the depredation may constitute "replacement" of natural predation on the targeted fish stocks and therefore should not be counted as part of fishery removals, this question presents a major analytical challenge.
(2) Depredation causes loss of catch and may lead to an increase in fishing effort, with associated negative environmental effects.
(3) Depredation can be regarded as a modification of natural foraging behavior, and it sometimes involves prey that are not known to be a normal part of the predator species' diet.
(4) Attempts at depredation may result in cetaceans becoming hooked or entangled, causing death or serious injury.

With support from the Oak Foundation, the U.S. Marine Mammal Commission, and the New England Aquarium and in collaboration with the South Pacific Regional Environment Programme (SPREP), a workshop was convened in Apia, Samoa, 11-15 November 2002, to review available information on cetacean interactions with longlines and to consider potential approaches to mitigation. Participants represented a range of interests, including the fishing industry, management, science, and conservation. The workshop agreed that answers to the key questions identified would help all stakeholders to understand the nature and extent of cetacean depredation on longlines. Such an understanding should help to address, and perhaps even solve, this longstanding and growing problem.

BACKGROUND PAPERS

A number of background papers were developed specifically for presentation and consideration at the workshop. All background papers can be obtained by contacting their authors directly (see workshop participant list annex). Summaries of these papers are as follows:

Interactions between Taiwan's distant-water longline fleet and cetaceans – John Y. Wang and Shih-chu Yang

This paper (presented by Wang) included a brief history and general description of Taiwan's tuna/billfish longline fleet, especially in the SPREP region. Although Taiwan is substantially involved in longline fishing for sharks and demersal fish as well as tuna and billfish, those portions of the fleet targeting sharks and demersal species were not considered due to time limitations and difficulties with obtaining information. Four people involved in Taiwan's tuna/billfish longline fishery were interviewed. Their comments revealed that interactions between cetaceans and longline gear are common. However, they appeared unaware of any obvious pattern as to where cetacean interactions are more likely to occur.

Although depredation of the target species by cetaceans is the main problem, some cetaceans also steal bait from hooks. Most of the depredation of the target species occurs when longlines are being hauled. On average, when depredation occurs, about 30 to 60% of the catch is taken, but losses can vary from 0 to 100%. The economic loss due to depredation by cetaceans is difficult to estimate. It was reported that cetaceans sometimes herd fish to the longlines, which results in increased catches if the fish can be retrieved before the cetaceans take them. Two of the people interviewed considered the losses to cetaceans to be a natural cost of engaging in this kind of fishery.

All of the individuals interviewed said that there was no way to avoid interactions with cetaceans. Methods used to date (e.g., harpooning, hanging cetacean parts on longlines, banging metal pipes) have had limited effectiveness. From the interviews, it was clear that species identification of cetaceans by fishermen is problematic.

The only nuisance species mentioned by name was the killer whale. Other implicated species were almost always described as dark to black-colored with a rounded head. Although cetaceans can get hooked, entanglement in lines is more common. Some cetaceans are killed or injured by longline fishermen with harpoons.

A survey of cetaceans landed at the Tungkang and Nanfang Ao fishing ports was conducted in 1994 and 1995. Seventy-six and 24 cetaceans observed at Tungkang and Nanfang Ao, respectively, came from longline vessels. Of these, 23 had been hooked in the mouth or throat region, 11 had been entangled, 53 had been harpooned, and the nature of the interactions with longline fishermen was unknown for 13 carcasses (due to their condition). Almost all of the common bottlenose dolphins (*Tursiops truncatus*) and rough-toothed dolphins (*Steno bredanensis*) had been hooked, whereas most of the pantropical spotted (*Stenella attenuata*), spinner (*S. longirostris*) and striped (*S. coeruleoalba*) dolphins appeared to have died after becoming entangled in lines. A Risso's dolphin (*Grampus griseus*) had been hooked.

Only a very small proportion (<1%) of the total number of cetaceans landed at either port were "blackfish" (i.e., killer, false killer, pilot, or possibly pygmy killer [*Feresa attenuata*] or melon-headed whales [*Peponocephala electra*]) and none of the deaths could be attributed directly to longline gear. Most of the cetaceans taken are likely discarded at sea or consumed onboard because the legal protection of cetaceans in Taiwan under the Wildlife Conservation Law makes it risky to land them. Therefore, the number of carcasses recorded at the fishing ports should be considered an underestimate of the number killed.

It was concluded that the level of cetacean mortality in longline fisheries is considerably higher than generally assumed.

Comparative analysis of the interactions between killer whales/sharks and the tuna/swordfish fishery in southern and southeastern Brazil - Luciano Dalla Rosa and Eduardo Secchi

This paper (presented by Secchi) described the pelagic longline fishery for tuna (*Thunnus* spp.) and swordfish (*Xiphias gladius*) off Brazil (see Secchi and Vaske 1998). Differences were shown between the depredation by killer/false killer whales and sharks on tuna and swordfish. These differences included characteristics of the bites, frequency of operations and trips involving shark and killer/false killer whale interactions, relative magnitude of losses caused by depredation, and proportions of tuna and swordfish depredated by the two types of predators. Blue, hammerhead, shortfin mako, and carcharhinid sharks commonly prey on longline-caught fish, leaving clearcut, semicircular, relatively small bites. Killer and false killer whales tear the body of the fish, leaving torn borders, and often only the fish's head remains on the hook.

The frequency of operations and trips with shark depredation was significantly higher than the frequency of operations involving killer/false killer whale depredation. However, when both whales and sharks were involved in depredation in the same fishery, the numbers of fish damaged by killer/false killer whales as a proportion of the total catch in operations and trips were significantly higher than the corresponding values for shark damage. Killer/false killer whales took hooked swordfish significantly more frequently than hooked tuna, whereas sharks took significantly more hooked tuna than swordfish. The authors hypothesized that cetaceans were more likely to depredate on swordfish because they are fished closer to the surface (between 40 and 80m). They considered the overall financial loss to the fishery as a result of whale depredation to be small.

Bycatch of three cetacean species was reported: Risso's dolphin (either hooked or entangled), killer whale, and false killer whale. Risso's dolphins might be hooked when stealing the bait (the main bait is the Argentine squid). None of the reported incidents of bycatch resulted in the immediate death of the cetacean. The lightness of monofilament longline might allow the cetacean to swim to the surface when hooked. Bycatch of birds and turtles, especially the former, is high in this fishery. Losses to fishermen (either by depredation or bait stealing) can lead to increased fishing effort, which may in turn increase the number of interactions and result in increased pressure on the stocks of the target species.

Mitigation attempts by fishermen included changing fishing locations and shooting the whales.

In Brazil, hooked fish might be removed by cetaceans at any time during a set, whereas in other areas such removal is thought to occur mainly during hauling. This difference is related to the average depth of sets: e.g., in Fiji, lines are set at 300-500 m, whereas in the Brazilian swordfish fishery, they are set much shallower (45-80m).

Interactions between odontocetes and the artisanal fisheries for Patagonian toothfish off Chile - Eduardo Gonzales and Carlos Olavarría

This paper was presented verbally at the workshop by Secchi on behalf of the authors. It reviewed available information on cetacean interactions with the Chilean artisanal fishery for Patagonian toothfish. In the eastern South Pacific and particularly in Chile, only minimal research has been undertaken on interactions between fisheries and marine mammals. Published sources provide only anecdotal evidence of depredation by cetaceans. Frequent interactions with sperm whales have been reported in the toothfish fishery. The Chilean artisanal fleet (vessels <18m long) is authorized to fish for toothfish from the border with Peru (18º21'S) south to latitude 47ºS. Catches are concentrated in the south of the country, where fishermen have reported the incidence of interactions with sperm whales to be especially high.

Although these interactions have not been evaluated systemically or quantitatively, there are reliable reports of damage to fish on the lines, and also to the sperm whales, which have been shot with guns or harpooned. On some occasions, explosives have been used to keep odontocetes away from fishing gear.

Observers were present on four trips undertaken in 1999/2000, between 33°S and 46ºS, totaling 47 days of observation on artisanal vessels. On three of the trips, cetaceans were observed during the fishing activities, viz. ten Risso's dolphins (one sighting), 125 southern right whale dolphins (*Lissodelphis peronii*; one sighting), and 25 sperm whales (22 sightings). Risso's dolphins approached the vessel when the boat was hauling the line, coming as close as 50m. Right whale dolphins were sighted moving in four compact groups while the boat was recovering a line. These dolphins did not approach the boat. Sperm whales were most often seen in the direction where the fishing lines were set, but most of the whales did not approach the vessels. On one occasion an adult male approached to within 10m of the vessel. Most of the sightings were of solitary whales, presumably males. Most groups contained less than three animals. From radio communications with other vessels in the area, 23 reports of sperm whales near fishing boats were recorded.

Fishing gear damage was reported on six out of 39 observed sets. Damage included cut hooks on four occasions and mainline entanglement on two occasions. In four cases, no toothfish were caught after sperm whales had been observed in the area, and on 14 other occasions only small toothfish (<2 kg) were caught after the presence of whales had been noted. Nevertheless, the catch of toothfish was not significantly different in the presence or absence of sperm whales.

A sperm whale was found dead, entangled in a fishing line, on one occasion. There are frequent reports of fishermen using rifles, harpoons, and bottles filled with fuel and dynamite to keep whales away from their gear. Generally, these attempts are unsuccessful and result only in injury to whales.

Killer whale and sperm whale interactions with longline vessels in the Patagonian toothfish fishery at South Georgia – Martin Purves, D. J. Agnew, E. Bulguerias, C. A. Moreno and B. Watkins

This paper, presented by Purves, was based on data recorded by CCAMLR (Commission for the Conservation of Antarctic Marine Living Resources) observers in the demersal toothfish fishery at South Georgia (Subarea 48.3) in the South Atlantic Ocean between 2000 and 2002. Longlines were deployed in depths of 300 to 2000m, concentrated along the 1000m contour. Sperm whales were the marine mammals most frequently observed in the vicinity of vessels when lines were being hauled; they were recorded as present during 24% (n=1400) of hauling observations. Killer whales were the second most frequently observed marine mammals, recorded as present during 5% (n=304) of hauling observations.

High inter-vessel variation was noted for interactions with both species. For example, one vessel had sperm whales present during only 5% of hauling observations, while another vessel had interactions during 70%. Killer whale presence ranged from 1 to 19%, depending upon the vessel. The positions of longline sets on 25 out of the 36 voyages during the 2000, 2001, and 2002 seasons were plotted and compared to locations of sightings of killer and sperm whales during line hauling. Cetacean interactions occurred over a wide geographic range and were mostly dependent on the amount of fishing effort on the different grounds. Interactions occurred more frequently in some areas, suggesting the existence of "hotspots" for interactions.

Killer whale pods were generally small, consisting of two to eight animals (57% of observations). Solitary animals were reported for 13% of the observations, and larger pods, consisting of 15 or more animals, for only 8%. Sperm whales were most often solitary when interacting with fishing vessels (43% of observations). Two to three animals together were relatively common (49%), but larger groups were infrequent. A maximum of 12 sperm whales was observed in the vicinity of a vessel when then line was being hauled. Interactions with killer whales were most often observed in the afternoon (46% of sightings) or morning (33%). Relatively few night interactions were reported. After sunset until midnight, killer whales interacted with hauls during 18% of observations, but from midnight to sunrise this occurred during only 3% of observations. Interactions with sperm whales followed a similar pattern, with most interactions in the afternoon (56%) and in the morning after sunrise (43%). Interactions at night were less than 1% of observations.

To quantify the level of depredation by cetaceans, catch rates (expressed as kg/hook and number of fish/1000 hooks) were calculated for hauls when either killer whales or sperm whales were present, and compared to rates for hauls when no cetacean presence was recorded. The results showed that the catch rates of toothfish were significantly lower ($P < 0.05$) when killer whales were present during hauling (0.15 kg/hook; 21.5 fish/1000 hooks) than when no cetaceans were present (0.29 kg/hook; 48.5 fish/1000 hooks). The same trend was not observed, however, for catch rates when sperm whales were present during hauling (0.32 kg/hook; 51.9 fish/1000 hooks). Catch rates were in fact slightly higher in the presence of sperm whales than when no cetacean presence was noted.

It is likely that sperm whales were attracted to areas with high catch rates, but in areas with lower catch rates, depredation by sperm whales may have caused catches to drop off. During hook-line observations on a longliner in the 2001 season, it was noted that hooks with only the lips of toothfish (no head or body) were recorded more often when sperm whales were in the vicinity of the vessel. Sperm whales were noted as being present during 84% of the observations when "lips only" were found on hooks. This suggests that sperm whales take whole fish off the line, leaving only the lips and making estimates of depredation levels difficult. In contrast, depredation by killer whales was characterized by the occurrence of damaged fish, often with only the heads on returning hooks. "Lips-only" were also observed when killer whales were present.

Some mitigation measures have been tried to reduce interactions with cetaceans, although there have been no quantitative studies of their effectiveness. These measures include the deployment of "seal scarers" when hauling; tying magnets to the fishing line; switching off onboard acoustic equipment during line hauling; offal retention during line hauling; delaying hauls when killer whales are present; and interrupting hauls, buoying-off lines, and steaming away from hauling sites when killer whales appear.

Further investigations are needed to determine the extent of cetacean interactions, to address the problem of depredation, to standardize observer protocols to ensure that valuable data are collected, and to assess and implement mitigation strategies (initially at least, under controlled experimental conditions).

Sperm whale depredation in the demersal longline fishery for sablefish in the Gulf of Alaska: research needs and approaches to mitigation – Jan Straley, Tory O'Connell, Greg Beam, Sarah Mesnick, Anne Allen, and Liz Mitchell

Straley and Beam presented this paper on behalf of their team of co-authors who, in cooperation with fellow fishermen, scientists, and resource managers, are seeking to develop a research program on sperm whale interactions with coastal longline fisheries in the eastern Gulf of Alaska.

Demersal longline fishing in the eastern Gulf of Alaska is conducted from boats less than 18m long using baited circle hooks. The hooks are attached to gangions, spaced every 1m along a line set from the back of the boat. A set can range from 1.5 to 4mi in length with 2500 to 6000 hooks per set in 200-500 fathoms of water. Soak time is 5 to 8hr, sometimes overnight.

Sablefish depredation by sperm whales on longline gear was first reported in the eastern Gulf of Alaska in 1978. The fishery was year-round until the early1980s when fleet expansion resulted in a shortened season. In 1994, the entire quota was caught in two weeks. In 1995, individual fishing quotas were implemented. This had the effect of reducing overall effort while allowing the season to remain open for eight months, March to November. It also gave sperm whales more opportunities to interact with the fishery, and by 1997 reports of depredation had increased dramatically. A domestic sablefish survey in the Gulf of Alaska examined catch rates from 1999 to 2001 for all sets with sperm whales present. Catch rates were 23% lower for sets with evidence of depredation than for sets without evidence of depredation.

Fishermen and scientists believe that the depredation occurs on gear that is 360 fathoms deep, but there is no empirical evidence to support this belief. Sperm whales are not known to take fish off the line before the gear is being hauled. It is likely that some whales use the sound of the hydraulics as a cue to indicate when the buoy line is being hauled, although such cueing is not always evident. Sperm whales have been reported to "wait" near the flag and buoys, apparently anticipating the fishermen's return. On such occasions, the whales appear to be associating the presence of fishing gear with opportunities for depredation, even when the fishing vessel itself and the noise from hydraulics are absent. Additionally, whales follow boats and linger near them while the lines are soaking. Some boats attract sperm whales, but it is unclear why. In any event, depredation has increased in recent years, and boats that previously experienced no interactions are now reporting depredation.

It is unknown how sperm whales take fish off longlines. A few fishermen report that they can “feel” the presence of whales on their longlines. Some sperm whales have evidence of contact with lines or even past entanglements on their bodies – e.g., scars at the base of the flukes, grooved indentations along the side of the head apparently caused by a line running through the mouth. Fish come aboard mangled and shredded with just a head or lips attached to a hook, but it is thought that sperm whales also take whole fish, leaving no trace of depredation. Sperm whales have been observed feeding on sablefish and halibut offal near the boats during haulback, sometimes side-lunging through the discards. It is uncertain whether discarded non-target organisms and the offal from target species serve as attractants to sperm whales; alternatively, these could represent sources of “free” food and have the effect of deterring the whales from depredation on caught fish.

Fishermen have tried various methods of deterrence, including “dropping the whales off” on a competing vessel, hauling at night, and stopping hauling and waiting for the whale(s) to leave. Most fishermen have resigned themselves to the fact that it will take more effort to catch their quota. This means higher costs and results in increased bycatch; it may also increase the damage to the ocean floor caused by fishing.

More information is needed to solve or reduce the problem of sperm whale depredation on longlines. It is important to determine the individual identities of animals involved in depredation. Photographs and sound “signatures” can be useful in this regard. Also, in order to tease out the significance of differences in boat “behavior,” it is essential to know and compare the characteristics of boats that have and have not experienced depredation. How depredation occurs, including the spatial and temporal patterns of interactions, will be critical for solving or reducing this problem. It will also be important to understand whether (and how) this behavior is transmitted and learned by sperm whales. An improved understanding of the population and social structure of the whales in the Gulf of Alaska would be useful. Acoustic applications need to be explored, such as masking or dampening the sounds that are used by the whales as cues.

Depredation of tuna by whales and sharks in the western and central Pacific Ocean – Tim Lawson

Deirdre Brogan from the Secretariat for the Pacific Community (SPC) Oceanic Fisheries Programme presented this paper on the author’s behalf. It summarized observer data on whale and shark damage sustained by longline vessels in the western and central Pacific Ocean between 1995 and 2000.

The geographical distribution of reports of whale-damaged fish was similar to that of reports of shark-damaged fish. Both types of damage were reported throughout most of the range of observer coverage. The overall level of whale damage on longline-caught fish was relatively low at 0.8 %, while shark damage was significantly higher at 2.1%. It was noted that these levels are considerably lower than those previously reported by Hirayama (1975), who indicated that 10.45 % of longline-caught tuna in the western tropical Pacific Ocean had been damaged by sharks.

No major differences were found between the levels of damage sustained in the fisheries of three Exclusive Economic Zones – two tropical (Federated States of Micronesia and Solomon Islands) and one subtropical (Fiji). The percentages of whale and shark damage sustained by species groups and by individual species were also presented. Whales seemed to prefer yellowfin and bigeye tuna, whereas sharks preferred wahoo, yellowfin, blue marlin, spearfish, striped marlin, skipjack, and swordfish.

Fisheries-cetacean interactions in the Indonesian Seas – Benjamin Kahn

The Republic of Indonesia is the world's largest archipelago with more than 17,000 islands, spanning 1/7th of the length of the Equator. A large variety of habitat types are available, and at least thirty different cetacean species have been observed in Indonesian waters. Cetacean habitats include large rivers and mangrove areas, as well as coastal and open-ocean environments. Many forms of marine life move between the Indian and Pacific Oceans via the Indonesian archipelago. Because of its exceptional diversity of habitats and species, there is high potential in Indonesia for interactions between cetaceans and fisheries.

Indonesia is seeking to establish a more decentralized and transparent system of governance. For fishery management, the two most notable changes already in effect are the introduction of laws related to regional autonomy and the establishment of a Ministry of Marine Affairs and Fisheries. The main characteristics of Indonesia's marine fisheries include:

- Annual catch estimated in1997 at 4.5 million tonnes;
- Multi-species, multi-gear;
- Some 94% of capture by small-scale fishermen;
- Total fishing fleet currently estimated at 402,000 vessels (334,000 in 1988);
- 57% of fleet consists of non-powered boats, 55% of remainder use outboard engines.

The data needed for fishery management, including information on cetacean interactions, are either not publicly available or considered insufficiently reliable for stock assessment and estimation of sustainable harvesting levels.

Since about 1990, there has been a very large increase in the number of Taiwanese longliners operating in the Indonesian EEZ and in territorial/nusantara (internal, archipelagic) waters of Indonesia. These boats catch yellowfin and are thought to compete with Indonesian coastal fishermen. Boats may be up to or in excess of 100 gross tonnes. The Indonesian longline fishery is centered along the western coasts of Sumatra, Java, Bali, and Nusa Tenggara. The main species targeted are bigeye and yellowfin. Some vessels use deep longline gear to target bigeye. As in other parts of the Indian Ocean, the area of operations for the Indonesian coastal longline fleet is expanding. Moreover, Indonesian/Korean joint-venture vessels are becoming more widespread, operating in waters outside the Indonesian EEZ.

Given the insufficiency and poor quality of data from the Indonesian tuna fisheries nationwide, information on the nature and extent of cetacean depredation is extremely limited. However, some reports from the 1970s note that such interaction was occurring frequently in Indonesian waters, especially in the Banda Sea tuna fishery. In addition, the diversity and relatively high abundance of cetaceans in these waters, together with the intensive fishing effort for tuna, suggest that cetacean depredation may be significant. A comprehensive assessment is obviously needed to characterize and quantify the problem. Research needs in relation to tuna longline fisheries in particular include:

- Additional field data (observers, strandings/catches in which fishery interaction is likely implicated);
- Interviews with fishermen and organizations;
- Fact-finding visits to key regional ports, e.g., Benoa, Bitung, Kupang;
- Governmental/institutional capacity building;
- Monitoring of fishing areas with high cetacean diversity/abundance (Banda Sea);
- Ecological research on species known or suspected to be involved in depredation.

Although data from Indonesia's fisheries are fragmentary and sparse, the combined information from various Southeast Asian countries indicates that bycatch and targeted catch represent the primary threat to small cetacean populations, both coastal and oceanic, some of which have been drastically reduced. The extent of the problem in Indonesia is hard to quantify in the absence of relevant fisheries data and of any direct observer programs for the large-scale fleets (considered the only reliable way to obtain quantitative data on bycatch). An assessment of cetacean bycatch in commercial fisheries within the Indonesian EEZ is urgently needed.

Operational interactions between marine mammals and the Patagonian toothfish (*Dissostichus eleginoides*) fishery off southern Chile - R. Hucke-Gaete, C.A. Moreno, and J.A. Arata

Studies of the interactions between marine mammals and the toothfish fishery in southern Chile (39º S- 57º S) have been carried out through the Fondo de Investigación Pesquera (Fisheries Research Fund). The specific objectives are to: (1) identify the marine mammal species that interact with the fishery, (2) develop indices of relative presence of marine mammals during fishing activities, and (3) characterize and quantify the effects of marine mammals on the fishery, and vice-versa, per fleet and per area.

In Chile, the toothfish fishery started as exploratory in 1955. Artisanal and industrial operations now extend along the entire coast, with the former taking place north and the latter south of 47ºS. The artisanal component is limited only by the size of the vessel and the characteristics of the longline (max. 18m – 12,000 hooks per line), and no fishing quotas are applied. Industrial vessels receive individual quotas that correspond to a percentage of the total allowable catch (TAC) as determined by public auction.

The study area includes waters south of 39ºS. Scientific observers have embarked from Valdivia (39ºS) and Ancud (42ºS) (artisanal) and Punta Arenas (53ºS) (industrial). Ten surveys have been completed, three on-board industrial vessels between April – October 2002, and seven on artisanal vessels between May – November 2002. Observers note the times and locations of interactions with marine mammals. Fish remains, as well as damaged fish attributed to marine mammal predation, are measured to assess preferences for species and sizes of captured fish. Depredation rates were calculated, per line and per fishing trip, as the number of damaged fish divided by the total number caught (damaged and undamaged) times 100 (method adapted from Yano and Dahlheim 1995).

Photo-identification techniques have been used to identify individuals, particularly sperm whales. An acoustic protocol has been developed to detect whales at night and also to examine the relationships between the type and rate of vocalization and the rate of depredation. A Geographic Information System (GIS) will be used to assess the spatial and temporal extent of interactions as well as to identify hotspots. A Generalized Linear Model (GLM) will be used to determine which factors affect interactions, and factor strength in explaining the depredation rates will be assessed through a deviance analysis (stepwise method).

The results of two surveys on-board industrial vessels (late spring 2001 and late autumn 2002) were included in the paper. Almost all operational interactions occurred in the mid-axis of the Pacific-South American continental platform slope. During the summer of 2001 a total of 36 hauls were monitored, and interaction was judged to have occurred in 19 of these (53%), based on the recording of heads, lips, and damaged trunks of toothfish. In a further 12 hauls (33%), there was no evidence of depredation even though cetaceans were noted to have been present. In the other five hauls (14%), no cetaceans were observed, nor were damaged fish. On one occasion, a dead sperm whale was retrieved after being entangled in the line.

During late autumn, a total of eight hauls were monitored. Evidence of interaction was noted on one of these (12.5%) – the head of a toothfish was observed on a hook while a single sperm whale was in the vicinity of the ship. The presence of solitary sperm whales was recorded during three of the other seven hauls.

During the 2001 spring-summer survey, a total of 72 toothfish lips, nine heads, and one trunk possibly damaged by cetaceans were measured. When the presence of sperm whales was recorded, most of the evidence of interaction consisted of toothfish lips. When only killer whales were observed to be present, one lip and various heads were found. Seabirds were observed feeding on the surface near the whales, although no offal was discarded from the ship during this period. Finally, when only pilot whales were present, no damaged fish were found on the line, and therefore no evidence was obtained for depredation by this species. When mixed-species sightings of cetaceans were recorded, the diversity of types of fish remains on the hooks appeared to increase. The authors tentatively stated that cetaceans damaged or consumed 82 toothfish during the observed hauls in spring-summer 2001, corresponding to 2.27% of the total number of toothfish caught (n = 3,600) in the observed hauls.

When sperm whales and killer whales were both present during a haul, the depredation rate decreased to nil. On at least one occasion, the observer reported that when killer whales arrived in the area, the sperm whales modified their surface behavior, grouping in a tight and parallel formation (possibly a defensive formation).

During the first survey (late austral spring 2001) three sperm whales were identified by conspicuous markings on the dorsal fin and flukes. Photos are being incorporated into a catalogue.

Observer coverage on artisanal boats spanned the period May – November 2002. Hauls on these boats generally involve 800 – 1200 hooks. Operational interactions with marine mammals were reported to have occurred on the continental slope mainly off Toltén (39.2ºS, 73.2ºW) and the coasts of Osorno (40.5ºS, 73.7ºW). Few incidents of interaction with cetaceans were reported. This, however, might be due to the efforts of fishermen to minimize interactions that are usually detrimental to the catch. Most of the interactions reported were with otariids *(Otaria flavescens* and *Arctocephalus australi*s), as confirmed by accounts of observers watching the sea lions eat fish from the line. It is a common practice among artisanal fishermen to refrain from setting the line once a whale's blow has been seen. They generally simply move to another place. If they are hauling, they cut the line, put on a buoy, and set the line again. On some occasions, observers reported that the fishermen attempted to shoot or ram the whales and pinnipeds. On one survey, at least eight pinnipeds (possibly *A. australis*) were shot and killed. On another occasion, a sperm whale was shot as it approached the vessel. Its reaction was to fluke-up and defecate. In another instance, the near-ramming of what was supposed to be a sperm whale turned out to have been a near-miss of a group of eight blue whales *(Balaenoptera musculus*)!

A total of 37 complete hauls by artisanal boats were monitored, and interactions were recorded in eight of these (22%). In 20 hauls (54%), the presence of marine mammals was recorded, but there was no evidence of damaged fish. In the remaining 17 hauls (46%), neither marine mammal presence nor damaged catch was reported.

Four toothfish lips, one head, and one trunk were reported during artisanal surveys. The mean depredation rate for artisanal fishing operations during winter corresponded to about 1% and ranged from 0% to 29%. Considering that the total depredation rate (corrected for the proportion attributed to pinnipeds) was 0.474% and the mode and median were 0, the impact of depredation by cetaceans on the fishing yield appears to be low. No whales were photo-identified during artisanal surveys.

The authors tentatively conclude that the overall impact of depredation on the Chilean toothfish fisheries is fairly low, and also that the occasionally high-impact interactions are not necessarily related to the number of cetaceans present. Instead, such instances may involve particular individuals that have acquired the habit of longline depredation. Interactions south of Cape Horn mostly involve sperm whales and killer whales, while interactions with otariids seem to be more important in south-central Chile (at least during the autumn and winter months). Entanglement of sperm whales in the line has been recorded on two occasions (one fatal). Counter-measures implemented by artisanal fishermen include the shooting and ramming of marine mammals. An educational approach and the continuation of scientific observer programs are recommended.

Is acoustic deterrence right for you? – Ken Baldwin, Greg Stone, and Scott Kraus

The purpose of this presentation (given by Baldwin) was to clarify some basic definitions of terms, define a simple sonar model, elucidate concepts in that model, and relate those elements to the general question of how acoustic devices might be used to mitigate depredation. The basic sonar model has three components: generation, propagation, and reception of sound. In the present context, these would be the sound source – an acoustic deterrence device; the medium – the ocean; and the receiver – a marine mammal. The medium can be further defined as propagation loss due to spreading, attenuation, and boundaries, and the marine mammal can be further defined by its auditory response, which is basically detection threshold. When these concepts are combined with the ambient noise in the ocean, it becomes possible to define zones of audibility and influence, as proposed by Richardson (1989). Development of the gillnet pinger was presented as a case study to demonstrate these concepts and reasoning.

Pingers were shown to have the desired effect of significantly reducing the bycatch of harbor porpoises (*Phocoena phocoena*) in gillnets in the Gulf of Maine (USA). Two studies of animals in the wild were presented to demonstrate the importance of understanding the fundamental behavioral responses of marine mammals to pinger sounds. A study of pinger sound propagation in Australia was cited as evidence of boundary effects in shallow-water propagation.

Pinger technology is advancing rapidly. The ability exists to fabricate robust, low-maintenance pingers. Understanding of two of the components in the simple sonar model – source and propagation medium – is fairly well developed. In most fisheries and for most cetacean species, acoustic deterrents remain untested. Further acoustic studies are needed for many cetacean species. The social structure, habitat use, and communication mechanisms of relevant cetacean species (in the present instance, killer whales, other "blackfish," and the sperm whale) are poorly understood in many of the areas where conflicts with longline fisheries have been reported.

COUNTRY REPORTS

Representatives of a number of Pacific Island countries presented summaries of their pelagic longline fisheries and interactions with cetaceans.

Samoa

Peter Watt reported that the tuna longline fishery started in Samoa in 1994, with approximately 25 small *alias* (locally built aluminum twin-hulled vessels around 8m in length). The local *alia* size is now larger, and 120 of 155 vessels in the fleet are *alias* of 9-11m length. These boats use a drum to deploy 6-10mi of line with 300-500 hooks. The remainder of the fleet consists of 35 larger (11-25m) catamarans or mono hulls.

The licensing system recognizes five classes of boats according to size (<11m, 11-12.5m, 12.5–15m, 15-20.5m, >20.5m). These boats have different fishing capabilities, e.g., small *alias* usually go out for 2 days, 11-15m vessels for 4-6 days, 15-20.5m boats for 6-10 days, and the largest boats for periods of up to 6 weeks.

The Samoan tuna longline industry has grown quickly and has had to deal with many management issues, including limiting the number of boats and addressing safety concerns. The value of the industry has grown rapidly and is now Samoa's major export earner, with an export value of 48.5 million tala in 2001.

Cetacean interactions with these fisheries are a recent but growing phenomenon. During the last year, Samoa's Fisheries Division and the industry started to collect data in the log sheets of larger vessels on catches affected by whales. These data have not yet been analyzed. Many larger boats reportedly have had whole sets taken. Loss over the last month was estimated at about 10%.

The size of the area fished has increased over the years. Fishermen are now moving further offshore – up to 70mi offshore for the small *alias* alone. Catch per unit effort (CPUE) in 1994 ranged from 75-100kg/100 hooks, but has decreased significantly and is now between 50-60kg/100 hooks. Boats over 15m length are not allowed to fish close to the coast (within 15mi). Regardless of whether cetacean depredation significantly affects CPUE, all reports suggest that the interaction has grown. (Samoan participants noted that they had never seen dolphins hooked on longlines, but that one whale had been reported as having become entangled.)

Papua New Guinea (PNG)

Vagi Rei and Kenny Leana reported a similar situation to Samoa with respect to cetacean interactions in PNG, where the tuna longline fishery started in 1995 and grew rapidly. There are now 46 tuna longline boats of 25-50m, but no smaller boats. The PNG fishery is 100% locally owned.

There are three major fishing areas – the southern Coral Sea (fished by vessels targeting yellowfin and based at Port Moresby; the Solomon Sea (shared with Solomon Islands), and the Bismarck Sea (northern fishing ground, with the greatest reported frequency of cetacean interactions). The fishing boats move seasonally and target yellowfin and bigeye. A mother boat is often used to collect the catch, so that boats can keep fishing.
Some recent reports have suggested up to 50-60% depredation rates, e.g., in one set 58 tunas were caught and 56 were taken by whales (identified by the clean cuts made). The skipper observed whales taking fish during hauling. Some boats have deliberately avoided whales. Early in the development of the domestic longline fishery, sharks caused damage to hooked fish. Whales were reported to scare sharks away, but now whales are eating the fish. Cetacean interaction appears to be increasing as the fishing industry expands, and this is of concern to fishermen.

The PNG government has responded to industry concerns this year through a workshop conducted by the NGO Ocean Alliance, who undertook a research cruise in the *R.V. Odyssey*. They reported 32 species of cetaceans in PNG waters, highly concentrated in the Bismarck Sea where 350 sperm whales were sighted in 18 separate groups. There were 84 sightings of other species, including two species new to PNG waters (the sei whale [*Balaenoptera borealis*] and Risso's dolphin). Ocean Alliance also investigated the distribution of pilot whales, and obtained video footage of sharks biting yellowfin tuna. A copy of the Ocean Alliance report on fishery interactions is available from Barbara Roy. A forum was convened to discuss results of the research with all stakeholders. *Odyssey* is planning to return to PNG as funds permit.

The PNG government has made a commitment to declare a whale sanctuary, and is interested to develop education and awareness (there is interest in the promotion of whale watching). The fishing industry has agreed to support the development of a management plan. Everyone is very interested to know the real degree of interaction.

In association with UPNG/WWF, the government plans to start an observer program for whales. Research work by Ingrid Visser of New Zealand has shown that killer whales attack and eat sharks in PNG waters.

Fiji

Dave Lucas (Solander Pacific) reported on interactions between cetaceans and longliners in Fijian waters. Unlike the days of pole and line fishing, when no interactions were observed, depredation by cetaceans has gradually become a major problem. The interactions are mainly with what the fishermen report to be pilot whales, but also to some extent with killer whales.

Examination of the rates of depredation for the nine vessels in the Solander Pacific fleet showed that the vessel with the highest rate was four times more likely to experience interactions than the vessel with the lowest rate. (Participants agreed that this was most likely related to noise signatures, and that damping vessel noise was a plausible initial approach to mitigation that should at least be tried.

Solander Pacific have been keeping records since early 2000. The data have been collated and losses estimated, including time, operating costs, and lost fish. Lucas estimated a loss of FJ$5 million for his company in the year 2002 attributable to cetacean depredation. With a total of 95 licenses in Fiji, he estimated the total loss to the fishing industry as a whole at FJ$20 million per annum. He stressed that the industry was concerned, and needed to figure out a way to deal with the interaction, as it is seen a significant problem.

(During the ensuing discussion, several participants expressed reservations about the assumptions made and the methodology employed in estimating losses due to depredation by cetaceans in Fijian waters. It was nonetheless accepted that the interactions there have significant economic consequences.)

WORKING GROUP REPORTS

Having received and discussed the background material, participants agreed to form three working groups to develop a Plan of Action. The reports of the three working groups follow.

I. Report of Working Group on Depredation

Quantification of losses

There is a need for standard methods to quantify longline losses due to depredation (caused not only by cetaceans but also by other organisms such as sharks, bony fish, and squid). Such quantification has been attempted for several demersal and pelagic longline fisheries around the world, and some of these attempts are summarized below:

Demersal sablefish fishery in Alaska (USA):

Sigler et al. (2002) used data from a longlining research vessel to estimate a 23% decline in catch when depredation by sperm whales was inferred.

<u>Demersal toothfish fishery in Chile:</u>

Hucke-Gaete et al. (see Background Papers for a summary) analyzed observer data for the Chilean industrial fleet and concluded that during the spring/summer season, 2.27% of the total fish caught on observed sets were damaged, probably mostly by sperm whales. During the winter season when there was less observer coverage, they estimated that less than 1% of the total catch was damaged.

<u>Demersal toothfish fishery at South Georgia:</u>

Data collection for this fishery follows a standard CCAMLR protocol designed to make possible calculation of the percentage of total fish catch that is damaged by depredation (see Purves et al., Background Papers, for a summary). Observer coverage for licensed vessels is 100%.

Supplementary data on cetacean interactions are collected in a standard manner by observers. At the beginning of each haul, the observer scans for marine mammals and records their approximate abundance within visual range of the bridge. Any interactions with marine mammals during the haul are recorded as well. These data were used to estimate the relative degree of involvement in depredation by killer whales and sperm whales. Killer whales were involved in 1-19% (mean 5%) of the hauls in which an interaction (depredation) was possible (judging by the fact that a marine mammal was present); sperm whales, in 5-70% (mean 24%).

Purves et al. also compared the CPUE (kg/hook) for hauls in which interaction was possible, with those in which no cetaceans were observed in the vicinity. The CPUE when killer whales were present averaged 0.15kg/hook; when sperm whales were present, 0.32kg/hook. These values compared with an average CPUE of 0.29kg/hook when no cetaceans were present.

Pelagic tuna/billfish fishery off Brazil:

The objective of the study by Dalla Rosa and Secchi (see Background Papers for a summary) was to compare the extent of shark damage and whale damage in this fishery. Using on-board observer data, they estimated that 5.6-100% (mean 45%) of the total fish caught per set and 0.48-47% (mean 12%) of the total fish caught per trip were damaged by killer whales. Corresponding estimates for shark damage were 2.5-100% (mean 21%) and 0.4-28% (mean 7%). They noted that the frequency of depredation by sharks was much higher than that by cetaceans.

South Pacific tuna/billfish fisheries in general:

SPC observers follow data-collection protocols similar to CCAMLR observers, and every fish caught on observed trips is assessed for whale and shark damage (D. Brogan, pers. comm.). No requirement or standard procedure is included for collecting whale sightings data. Observer coverage for the western and central Pacific overall is about 0.01%, compared with about 1% in the South Pacific. National observer coverage in the PNG EEZ is in the range of 5-20%, and 20% coverage is the target level for all areas of the South Pacific. From onboard observer data, Lawson et al. (see Background Papers for a summary) estimated that 0.8% of all caught fish in the observed South Pacific longline operations (including tuna, billfish, etc.) were damaged by whale depredation (current through 2000). The corresponding estimate for shark damage was 2.1%.

Fiji tuna/billfish fishery:

Dave Lucas attempted to estimate the financial cost of depredation to his company's fishing operations, using tons catch/longline set as the measurement unit, and the following reasoning: If 2 tons of fish was landed on Day 1 and 200kg on Day 2, then whale depredation caused the company to lose 1.8 tons of fish plus one day's operational costs. If the catch on Day 3 "returned" to the 2-ton level, no further loss was imputed. However, if instead the vessel spent Day 3 relocating to a new fishing area to avoid further depredation, the foregone earnings on 2 tons of fish, plus another day's operational costs, were imputed. By this method, Lucas estimated that $(Fiji)1.9million had been lost from January through early November 2002 and some $(Fiji)5 million since 2000. It should be noted that most workshop participants had strong misgivings about Lucas's assumptions and methodology, but also that Lucas felt several "intangible" losses to individual fishermen had been unaccounted for in his calculations.

Samoa:

A program to collect data on cetacean sightings and interactions with longline operations has been in place in Samoa for approximately one year. Vessel captains are provided with special forms to complete and return to the Ministry of Fisheries.

Japanese longline fishing operations in the Indian Ocean:

Nishida and Shiba (2002) analyzed data provided by Japanese fishing masters. Completed forms were returned for 27%, and later only 15%, of the trips. Two data sets were available, one consisting of logsheet records of damaged fish, by species and by predator (killer/false killer whale vs. shark), and the other of total number of fish caught (based on provisional data). Of 1117 sets for which depredation was reported, 381 were considered to have involved killer whales or false killer whales, and 699 were considered to have involved sharks.

The number of damaged fish as a percentage of the total fish caught on depredated sets ranged from 1% (striped marlin) to 19% (bigeye) – overall average about 13%. These authors further calculated the number of damaged fish as a percentage of the total reported catch (not distinguishing between depredation by whales and depredation by sharks). The resulting index was about 3% although this value was thought to be negatively biased. Nishita and Shiba indicated that depredation rates were particularly high around the Seychelles in the western Indian Ocean.

Standard index of depredation rate

The working group concluded that the standard index of depredation rate should be the number of damaged fish as a percentage of the total number of fish caught in a given fishery.

Such an index may underestimate the true impact of depredation because, e.g., some fish that would have been caught are scared away from the longlines, and some caught fish may be stripped away entirely, leaving a bare hook and therefore no evidence of depredation. Alternatively, the index could be negatively biased if damage by sharks and other organisms is wrongly attributed to whales.

Whenever possible, fish mass, rather than simply number of individual fish, should be used to calculate the index. (Note: Fish length can often be used as a proxy for estimating fish mass.)

II. Report of Working Group on Mitigation

Best advice to fishermen

For each of the following proposals, if trials are undertaken, there needs to be a way to evaluate fishing success or avoidance of whale depredation – i.e., some kind of standardized assessment.

Before Setting,

<u>Avoid hotspots</u>:

Individual fishermen will draw on their own experiences;
Lack of analysis of extensive data from logbooks and other sources;
Monitor relevant seasonal behaviors (e.g., whales hanging around outside harbors).

Research needs:

Analyze available data (from both domestic and distant-water fishing companies) to identify hotspots and seasonal timing of interactions.

Prepare standardized information sheet (the Samoan reporting sheet could be a useful template).

Need not be compulsory for all fishermen – only those who are interested and keen need to collect data (as is currently the situation in Alaska).

Use dedicated observers when possible, especially on larger vessels where there is room to accommodate them.

<u>Steam away from cetaceans</u>:

Don't set when cetaceans are in the vicinity (or if you do, accept there might be losses).

Research needs:

Review available data on success or failure of resetting in areas where depredation has occurred.

Establish caloric needs of most common cetacean species involved in depredation (might a group of whales be satiated for the next 24 hours after removal of fish from a set?).

Develop an appropriate reporting sheet.

<u>Learn to identify species:</u>

Fishermen need to be able to identify cetacean species (and where possible individuals) so that they can make informed assessments of the likelihood of depredation – trained observers can assist.

Passive acoustic (i.e., listening) devices such as hydrophones may be useful to fishermen. Recorded vocalizations may provide information on presence and species identification (e.g., in the Gulf of Alaska, only one pod of killer whales is known to depredate, and it has a distinctive vocal signature).

Decoy behavior (one vessel attempts to have whales follow it, away from others):

Worth trying, but whales may not follow, and it requires cooperation between fishermen.

During the Set,

Fishermen should learn to identify species:

No need to abandon set if a species is unlikely to depredate.

Terminate set if only a small amount of gear in water:

Retrieve gear and move elsewhere

Stop attaching hooks for significant distance (5 miles?) with course change if whales sighted:

Information is needed from fishermen who have tried this.

Only attach hooks at deepest part of set if whales seen during set:

Maximum normal dive depths may be less than 400m, but we really don't know.

Don't chum during set:

It may attract sharks or whales.

Seek information from fishermen who chum concerning the composition of their catches.

During the Soak,

Acoustic deterrence if whales seen (e.g., tuna bombs):

Anecdotal information only – probably would have been more widely reported if successful.

Potentially hazardous to whales – may cause serious injury.

During the Haul,

Mask noise of hauler as much as possible:

Muffle pumping system (e.g., mount on rubber mountings).

Isolate from hull.

Retain unused baits on board:

Continual discharge of unused baits may provide free meal for whales and attract them to vessels.

Additional research needs

A dedicated vessel, prepared to work in hotspot areas with relatively high likelihood of depredation behavior, would be of considerable value.

Use underwater video:

Could deploy underwater video camera to investigate underwater behavior of target species and sharks/whales when there is whale activity around boat, e.g., polecams, National Geographic crittercams, dropcams, etc.

Produce good identification guides for most common species:

Wang and Dolman offered to produce 100 laminated boards for key species.

Each of the following species should have a standardized code on the board –

"Blackfish"

- Killer
- False killer
- Pygmy killer
- Melon-headed
- Short-finned pilot

Dolphins

- Rough-toothed
- Spinner
- Pantropical spotted
- Common bottlenose
- Indo-Pacific bottlenose
- Risso's
- Striped
- Short-beaked common
- Long-beaked common
- Fraser's

SPC agreed to print and circulate copies of the board.

Dedicated surveys:

Recommended as a means of identifying species mix and distribution.

Wherever possible, acoustic surveys should be undertaken at the same time as visual surveys.

Collation of fisherman survey forms:

The distribution of species could be assessed from fishermen's reports held by SPC and FFA.

Remote sensing technology:

> Satellite and/or radio tags may provide valuable information on distribution of toothed whales, but they are expensive and not always reliable. Also, there are ethical issues regarding attachment.

Acoustic remote sensing:

> Tethered sonobuoys may not work efficiently for high-frequency sounds such as those made by delphinids.

Possibilities for mitigation

Use of firearms

Lethal Deterrence:

Use of live ammunition is not recommended. Among other concerns are that it would result in opposition from NGOs and possibly also lead to consumer action (e.g., product boycotts).

Rubber Bullets:

Some participants thought trials would be useful, especially in situations where whales gather at the stern of a vessel and engage in depredation as the line is hauled. While this approach might make fishermen feel better, the long-term implications are quite unknown.

The working group agreed that:

- there are significant legal issues connected with any use of firearms, particularly in the marine mammal protection legislation of many countries;
- less harmful approaches are preferable; and
- cetaceans are intelligent animals, whose behavior can change quickly in response to environmental stimuli – so the use of rubber bullets might simply drive animals to depredate further away from the vessel (and out of range of firearms).

Other Possibilities:

It was agreed that there is no single, simple solution, and that a mix of approaches might minimize the chances for whales to learn how to overcome any single mitigation approach. Surveys to establish species occurrence, movements, and distribution would be a necessary prerequisite to any mitigation trials.

One suggestion was to investigate the possibility of incorporating some kind of repellent into the mainline that would seep out gradually, keeping whales away from the line.

Another option might be to establish areas where whales are able to find fish that are not popular with fishermen – e.g., fish aggregating devices (FADs) could be established in areas outside the main fishing grounds to provide sources of "easy" food for whales, assuming that the fish attracted to such devices are species or size classes generally targeted by commercial vessels. Hopefully, those pods of whales that are involved in depredation would spend more of their time around the FADs and thus encounter longlines less frequently. Unanchored FADs with radio beacons would be cheap to construct and deploy. Samoa, with a small EEZ, might offer the best option for research into this option. One possible consequence of this approach, if successful, might be that whales would move in from other areas.

An anchored FAD might be necessary in the first instance to see whether or not it attracted cetaceans (surveys could be conducted before and after deployment).

Is a Significant Reduction Possible?

There are reports of a significant degree of cetacean depredation in the South Pacific region since the 1960s. In the earlier days, pelagic longline fishing was conducted by Japanese, Korean, and Taiwanese fleets.

It is acknowledged that there is certainly a problem, but it is still unclear whether or not the problem is increasing in its scope.

It was agreed that reliable and accurate reporting by fishermen is essential. Good data will be of enormous assistance, and to get cooperation from fishermen requires confidence-building (e.g., feedback from researchers).

Small differences in approaches to fishing methods may make a significant difference in depredation. In particular, those vessels that have lower catch rates should be examined for the specific differences between them and those vessels that have higher rates of depredation.

Furthermore, fishermen at the workshop felt strongly that:

- Fishing effort should be capped at present levels;
- IUU fishing should be better addressed by management agencies;
- There should be better scientific assessments of fishery resources.

Recommendations

- Standardized data-collection forms should be required throughout the region to establish whether the same species are the main causes of depredation in PNG, Fiji, Samoa, etc.

- It is generally preferable to train local people in standardized data collection. This is a less expensive and possibly more reliable option than bringing in vessels that are costly to operate and have foreign crews who will not spend much time in the area.

- Educational and research training programs for fishermen in the South Pacific region are very desirable, so that sightings and reports of whales are more reliable.

- Surveys are required to establish which species are present in an area. Absolute abundance estimates would be very difficult to obtain, but both aerial (to establish occurrence and distribution) and vessel surveys (for confirmation of species and stock identity) could contribute to estimation of relative abundance and (possibly) detection and measurement of trends.

- Because of the relatively small size of its EEZ, and the commitment of the industry to a research program, Samoa would be a particularly good site to develop such a program.

- As a general comment, long-term approaches to mitigation are likely to be more successful than short-term fixes.

- Awareness of whale species by all members of the fishing industry would be of considerable value in gaining a better understanding of which species present in the area. This could also be useful for at least crude types of trend analyses.

- Carcass retrieval is an important part of an overall research and monitoring strategy. Massey University in New Zealand conducts necropsies of beachcast or bycaught marine mammals, and its facilities, personnel, and other resources should be exploited to the extent possible in facilities various aspects of carcass salvage, tissue sampling, and analysis. Alternatively or in addition, an experienced researcher or researchers might conduct training courses in each country.

- Sloughed skin could be collected and sent to Auckland University for molecular genetic analysis to identify species and sex.

III. Report of Working Group on Awareness

Participants agreed that it was important to increase awareness of the interactions between cetaceans and longline fisheries, and this group's charge was to develop the outlines of an appropriate strategy in that regard. The priorities would be to communicate the problems identified and seek commitments by national, regional, and international agencies to address them.

Key Targets

It was agreed that the targets for raising awareness should be:

- National regulatory agencies
- Regional/international bodies – identify relevant treaties and agreements
- The general public in producer and consumer countries.

The following international/regional organizations and groups were identified as key target audiences that should be provided with the outcomes from this workshop:

- SPC, SPREP (particularly the RMMCP list-serve), PIF, SCTB (scientific), FFA (economic), IOTC, IATTC, ICCAT
- DWFN fisheries agencies, e.g., JFA

- CCAMLR, IWC, CMS
- WDCS, IFAW, Ocean Alliance, TNC, WWF, APEX, GP, CI

Additionally, the following countries and national groups were identified:

- Whalewatching nations (Tonga, French Polynesia, Cook Islands, Vanuatu)
- Tourism industry (dive)
- Fishing industry
- Fisheries/marine resources ministries, environment and conservation ministries, tourism ministries.

Any material to raise awareness should incorporate the following main points:

- Identification of issue(s)
- Actual impacts
- Measures attempted
- Solutions sought.

Furthermore, the following elements were considered to be important components in an awareness strategy:

- Simple message – whales are coming into conflict with longline fisheries
- Complex message – there may be additional, more complex interactions in the marine ecosystem (we do not know for sure)
- Undesirable impacts – losses to communities and governments, undesirable forms of "mitigation" attempted (e.g., shooting cetaceans)
- General information on oceans, bycatch, marine biodiversity, anthropogenic impacts
- Communication to environmentalists – potential for undesirable forms of "mitigation" unless all stakeholders are involved in developing a solution
- Communication to fishermen – impacts on the industry
- Cetacean/longline issues need to be incorporated into South Pacific Whale Sanctuary and national sanctuary issues (i.e., cetacean/longline conflict should not be seen as an isolated issue).

Possible Approaches

A number of approaches should be employed to reach the target audiences, for example the following:

- Tourism industry (diving and whalewatching) – regional magazine articles;
- Fishing industry and organizations – brochures, posters (Note that this should be a proactive approach and fishermen should not be made to feel uncomfortable about the issue);
- Fisheries/marine resources ministries, environment and conservation ministries, tourism ministries – supply a copy of the Action Plan and workshop report;
- General public – brochures, posters, website? – increase awareness on the need to resolve the issue (e.g., PNG marine mammal forum);

- Information in brochure should be fair and balanced – endorsement by industry associations preferable;
- Lead agency needed to promote awareness. How it is communicated is important – need to distinguish between species that depredate tuna and those that have traditionally been hunted in South Pacific, particularly humpback (*Megaptera novaeangliae*) and sperm whales.

Media Choices

First stage of awareness – production of brochure with species identification and issues related to cetacean interaction with longlines. The brochure should be balanced and fair and produced in appropriate vernacular languages.

Radio and newspaper.

Websites – SPREP (regional marine mammal site); SPC-OFP?

Curriculum input for schools in the region. Incorporate cetacean/longline issue into broader sustainability and conservation issues.

Input to SPC observer program.

Ensuring Reliable, Balanced Presentation of Message

Recommend that SPC with SPREP produce a brochure that is endorsed by credible/authoritative organizations.

ACTION PLAN

Elements of the draft reports of the working groups, along with items specifically raised and discussed in plenary, were amalgamated into the following stand-alone document for wide circulation and use by all interested parties.

PLAN OF ACTION AND PRIORITIES FOR RESEARCH TO REDUCE DEPREDATION ON LONGLINES BY CETACEANS

1. INTRODUCTION

Participants in the first technical workshop on "Cetacean Interactions with Commercial Longline Fisheries in the South Pacific Region: Approaches to Mitigation" met at the headquarters of the South Pacific Regional Environment Programme (SPREP) in Apia, Samoa, from 11-15 November 2002 with the following objectives:

- To begin an assessment of depredation on longlines by cetaceans in the South Pacific and globally
- To identify and provide best current information on possible mitigation measures
- To agree on actions and research priorities to address this global problem.

The 32 participants from 11 countries included industry representatives, fishermen, scientists, managers and representatives of regional inter-governmental and non-governmental organizations.

The purposes of this plan are to:

- Provide an informed assessment of the depredation problem
- Identify the key issues, questions arising, priorities for research and recommended actions
- Provide the best present information on approaches to mitigation, and
- Raise awareness and understanding of depredation issues and the need for action amongst key fisheries and conservation management stakeholders.

Participants defined depredation in the present context as "the removal of hooked fish or bait from longlines by cetaceans." This was distinguished from predation, which was defined as "the taking of free-swimming fish (or other organisms) by cetaceans."

Participants gratefully acknowledged the financial support provided by the Oak Foundation, the U.S. Marine Mammal Commission, and the New England Aquarium. They further acknowledged and thanked SPREP for hosting the workshop.

2. BACKGROUND

Worldwide, many marine capture fisheries are in serious decline. Over the past decade, pelagic fisheries have increased their share of the global market, and longline fishing in particular has undergone a rapid expansion. Since the United Nations prohibition on large-scale high seas driftnet fishing in 1994, a number of Asian fleets have increased their longline effort. Additionally, with the general acceptance of Exclusive Economic Zones under the provisions of the United Nations Convention on the Law of the Sea, many countries have developed their own longline fisheries. This growth in domestic fishing effort is particularly apparent in many Pacific Island nations, where pelagic fishes such as tunas and billfishes are the target species. Furthermore, some demersal longline fisheries have expanded rapidly, particularly in the Southern Ocean (e.g., for Patagonian toothfish).

Concomitant with the expanding longline fishing effort, the scale of interactions between longline fisheries and cetaceans has increased. Reports about the removal by cetaceans of fish caught on commercial longlines (depredation) indicate increases both in the frequency of such events and in the number of cetacean species involved. The problem is now documented in all oceans and many fisheries. Cetaceans implicated in the depredation include the sperm whale and a variety of smaller toothed whale species.

Possible explanations for the recent increase in reports of depredation include:

- Increased fishing effort and/or increased rates of reporting
- Increases in abundance or changes in distribution of some cetacean populations
- Increased ecological competition and spatial overlap with fisheries
- Incorrect attribution of shark damage to whale damage
- That as opportunistic predators, toothed cetaceans are quick to take advantage of ‘new’ food sources in their environment, or alternatively that depredation is a learned behavior and has been rapidly transmitted
- A combination of the above.

At the 2001 Regional Workshop to progress a South Pacific Whale Sanctuary, SPREP was requested to provide the best available scientific evidence on the interactions between whales and fisheries in the region. The Technical Workshop in Samoa was conceived, in part, as a response to that Request.

Although the depredation workshop was originally envisioned as a meeting specifically to address the issue of removal of hooked fish by cetaceans, it became clear as planning progressed that other issues are associated with this interaction. In particular, the incidental take of cetaceans in longline gear and the removal of bait from hooks by dolphins were identified as additional concerns.

3. SCOPE OF DEPREDATION ISSUES

The problem of depredation by cetaceans occurs worldwide and has been recorded in longline fisheries dating at least to the early 1950s. In all of the world’s oceans, killer whales have been reported to interact with longline fisheries for a variety of fish species. In the South Pacific, there are numerous reports of fishery interactions with small and medium-sized toothed whales, although species identification is uncertain. Furthermore, at least eight species of dolphins have been observed in the vicinity of longlines and some may have been involved in bait removal. Additionally, sperm whales are known to remove Patagonian toothfish from demersal longlines in the Southern Ocean, as well as sablefish and other fish species in the eastern Gulf of Alaska.

In addition to the possible explanations outlined above under “Background,” the reported increase in depredation may simply reflect the fact that local fishermen in the South Pacific are now encountering a problem that had long been experienced at a similar scale by distant-water fishermen from northern nations operating in the South Pacific since the 1950s. Nevertheless, from the perspective of the fishing industry, depredation causes loss of catch, gear and time, and it adds to vessel operating costs. The adverse economic impact is an obvious concern. Furthermore, the financial losses to individual fishermen could lead them to take negative actions towards cetaceans, which are normally held in high regard throughout the South Pacific.

In addition to the economic losses, depredation has environmental consequences. For example, losses due to depredation are not usually accounted for in the fish stock assessment and quota allocation processes (although in some instances depredation may overlap with natural predation and therefore not affect fish stock assessment). The loss of catch due to depredation may lead to increased fishing effort, with associated environmental effects. Depredation also may represent a modification of cetacean foraging behavior and involve atypical prey for some cetaceans. It can at least occasionally lead directly to incidental catch (bycatch) of cetaceans.

The problem of longline depredation, especially in the South Pacific region, is surrounded by uncertainties – scientific, technical, and economic. It was therefore agreed that identifying priorities for assessment and framing key questions that arose during the workshop would help stakeholders to better understand the extent of, and elements involved in, the depredation issue. Such an understanding is fundamental to reducing, and hopefully solving, this problem.

4. PRIORITIES FOR ASSESSING THE DEPREDATION PROBLEM

Priorities identified by the workshop were:

- 4.1 Consolidation and analysis of existing scientific and industry data or reports on cetacean and shark depredation
- 4.2 Standardization of methodology, and selection of a standard index of depredation
- 4.3 Priority data
- 4.4 Data limits
- 4.5 Predator identification workshop
- 4.6 Training
- 4.7 Opportunities to assess interactions in the initial phase of developing domestic longline fisheries.

4.1 Consolidation and analysis of existing scientific and industry data or reports on cetacean and shark depredation

Depredation is not a new phenomenon and has been reported for both sharks and cetaceans since at least the early 1950s in many areas, including much of the Indo-Pacific. Existing data need to be consolidated to facilitate comparative analyses and investigate regional differences in depredation rates. Such analyses could incorporate and correlate fishing methods and cetacean ecology to assist with mitigation.

4.2 Standardization of methodology, and selection of a standard index of depredation

A preliminary review of key papers during the workshop revealed differences in definition and also methodology. It was clear that there is currently no standard index of depredation.

Existing reports quantify depredation as:

- Damaged fish as a percentage of the catch in affected sets exclusively
- Damaged fish as a percentage of the overall number of caught fish or weighed catch
- Revenue lost to industry
- Others.

The workshop concluded that the standard index of depredation rate should be damaged fish (number or weight) as a percentage of the total catch in a given fishery. However, such an index may underestimate the true impact of depredation because, e.g. some fish that would have been caught are scared away from the longlines, some caught fish may be stripped away entirely leaving a bare hook and therefore no evidence of depredation. Alternatively, the index could be positively biased if damage by sharks and other organisms has been wrongly attributed to whales.

There is a need for standard methods to quantify longline losses due to depredation caused not only by cetaceans but also by other organisms such as sharks, bony fish and squid. To standardize data collection for a given fishery region, it may be necessary to convene a group of experts to develop appropriate methods and data sheets. The data should be archived in a central location and made available for independent analysis, subject to agreed terms of control and ownership.

4.3 Priority data

Data crucial to assessment as well as to the development of mitigation measures can come from the following sources (in order of reliability):

- Dedicated research cruises.
- Independent observers
- Fisheries logbooks
- Port sampling.

Data required to assess the scope and nature of the depredation issue might include:

- Details on depredation, predators, and their behavior, e.g.:
    - Did depredation occur, and if so at which stage of operations?
    - Could depredation be attributed to a particular predator category, e.g., cetaceans/sharks/squid/bony fish/other? (See proposed predator identification workshop, below.)
    - On what basis was the predator identified (head only, tooth marks, etc.)?
    - Were whales observed in the vicinity of fishing activity?

- Vessel, operational, and environmental details, e.g.:
    - Vessel description and operating procedures
    - Total catch – number and weight
    - Time and latitude/longitude of set (beginning and end)
    - Number of hooks deployed
    - Other data relevant to CPUE (may be cross-correlated with ship's log)
    - Meteorological and oceanographic data

- Linking depredation and vessel characteristics (both design and operational) to examine the reasons why different vessels within a partic ular fishery often experience markedly different levels of depredation.

4.4 Data limits

It is important to acknowledge that assessment of these fishery interactions is challenging given the current lack of understanding of the problem and the limited knowledge of status, dynamics, and behavioral ecology of cetacean populations in the South Pacific and elsewhere. Key uncertainties include:

- Attribution of fish damage to predator categories (e.g., cetacean vs. shark)
- Full extent of depredation, e.g.:
  - Should all empty hooks be attributed to depredation?
  - Depredation of the same fish by multiple predators
- Indirect catch losses:
  - Interference with target species – predators scare fish away from lines
  - Removal of baits
- Status and trends of cetacean populations
- Acoustic behavior of cetaceans involved in depredation
- Migratory patterns and movements of cetaceans.

4.5 Predator identification workshop

A technical scientific workshop that focuses on predator identification is clearly needed. Such a workshop should involve fishing skippers, biologists with regional fisheries and/or cetacean expertise, and individuals from observer programs. Ideally, some focused field and laboratory work would be completed prior to the workshop, to ensure informed discussions and a positive outcome.

The key question to be addressed is, How can confidence be increased in the way fishermen, on-board observers, and others distinguish between the various potential predators when assessing damage to longline-caught fish? Important elements might include:

- Additional training of observers and skippers/crew
- Consensus on clear cases – what types of damage can be attributed with 100% confidence to a specific category or species of predator?
- Accept that for some percentage of damaged catch, the true predator is unknowable.

Educational or training tools produced from such a workshop might include videos on predator species identification and laminated sheets illustrating the types of damage caused by different predators.

4.6 Training

Training is essential to ensure quality-control of data that are collected and to increase regional coverage by observer and other data-collection programs.

4.6.1 Establish new partnerships and programmes

Regional and national observer programmes to monitor longline fishing currently have limited opportunities to address the depredation problem. Thus, it is important to establish new partnerships and programmes with interested and/or affected nations and industries. Recent national and industry initiatives, such as those in Papua New Guinea and Samoa, may offer such opportunities.

4.6.2 Core components of training programmes to assess cetacean depredation should include:

- Standardized data collection and data quality
- Improved assurance that fish damage can be attributed to the correct predator category – shark/cetacean/squid/bony fish
- Cetacean species identification at sea (including acoustic techniques)
- Best practices for effective and long-term mitigation.

4.6.3 Other training opportunities

While it is not possible to use data from strandings or bycatch for quantitative assessments of whale depredation, such events represent rare and important opportunities to train fishermen and observers about the biology, anatomy and identification features of predator species.

Established networks that investigate strandings (and bycatch) should collect data on:

- Obvious evidence of longline interactions (such as stranded animals with hooks in mouth, longline scarring and/or entanglement, etc.)
- Hook location
- Stomach contents.

4.7 Opportunities to assess interactions in the initial phase of developing domestic longline fisheries

There is a lack of baseline data and statistics to corroborate alleged increases in depredation rates as a fishery develops. Therefore it is important to monitor meticulously the development of any new fishery for interactions with cetaceans.

The Cook Islands could be considered a particularly good area for monitoring the effects of longline fishing on cetacean behavior, as it has a relatively new domestic fishery and is just opening its northern EEZ to longlining vessels from South Pacific-based operations.

5. PRIORITIES FOR MITIGATION AND CURRENT INFORMATION ON BEST PRACTICE

For a number of reasons, including the legal protection that is afforded to cetaceans by various statutes and the desirability of finding solutions that will work in the long term, participants recommended that only non-lethal methods be employed to discourage or avoid depredation.

In addition, participants acknowledged that while much work is needed to develop and field-test a mitigation strategy for any of the fisheries discussed, the following suggestions presently have merit in attempting to reduce depredation by cetaceans:

- Vessel and gear noise management, both in the design and operation of the vessel. To the extent that is practical, noise should be minimized while traveling to fishing grounds and during fishing operations (e.g. turn off echo sounder, reduce noise of winch, propeller)
- Consider changes in fishing season, gear, setting and hauling times, and fishing areas
- Avoid hotspots – areas where cetaceans congregate
- Check (visually and/or acoustically) for potential predators before setting or hauling and try to avoid doing either when cetaceans are in the vicinity
- Suspend or delay hauling if depredation is noticed (demersal longlining only)
- Improve the abilities of fishermen to identify cetacean species
- Avoid chumming or discarding offal and bait in the vicinity of fishing locations
- Encourage fishermen to communicate their experiences with mitigation, and their concerns about depredation, e.g., via the list-serve
- When feasible, use a decoy vessel to distract cetaceans away from the fishing area
- Try setting dummy/false gear to mislead the cetaceans and direct them away from the fishing area
- Encourage scientists or observers to travel aboard longline vessels to provide expert advice on species identification and behavior.

The workshop strongly encouraged research and development of acoustic and other approaches to mitigation. It was noted that no acoustic deterrent is presently available to offer as a "quick fix" for this problem. In fact, the use of acoustic devices could just as easily have a "dinner-gong" effect.

Participants emphasized the need for rigorous scientific trials to demonstrate effectiveness before broad-scale adoption of any particular mitigation device or procedure.

6. NETWORKING AND COMMUNICATION OF ACTION PLAN

Participants agreed that the outcomes of the workshop should be communicated to the following target audiences:

- National regulatory agencies (fisheries, environment/conservation)
- Regional/international agencies
- The longline fishing industry.

It was strongly recommended that emphasis should be given to providing a proactive message that would continue to foster positive involvement by the fishing industry.

Participants also agreed on the need to establish an electronic list-server to develop and maintain access to information and for networking.

7. RECOMMENDED ACTIONS

Participants agreed to ensure that their own networks receive a copy of this Action Plan.

The following international/regional organizations and groups were identified as key target audiences that should be provided with this Action Plan and the report from the workshop:

- For the Pacific Islands region SPREP to distribute to:

    - SPREP Focal Points
    - SPC Fisheries and FFA (including respective observer programs and their national focal points)
    - PIF Marine Sector Working Group
    - SPREP's Second RMMCP Meeting (February 2003)
    - Pacific Islands Roundtable for Nature Conservation
    - Interim Secretariat for the WCPTC and SCTB.

- For elsewhere:

    - UNEP, FAO, UNDP
    - NMFS, WPRDMC, US MMC
    - IOTC, IATTC, ICCAT
    - DWFN fisheries agencies
    - CCAMLR, IWC, CMS
    - WDCS, IFAW, Ocean Alliance, TNC, WWF, APEX, GP, CI.

SPC and SPREP (*inter alia*) should jointly produce a brochure that summarizes this Action Plan, and that includes information on how to identify cetacean species. This brochure could be used as a popular summary of the issues to generate public and media interest and as a template for use in other regions.

SPREP should establish the aforementioned list-server.

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APPENDIX I

Agenda

DAY 1

Welcome

10 a.m. Welcome from Director of SPREP, Tamari'i Tutangata

Prayer

10.20 a.m. Opening Address :
Hon. Tuisugaletaua Sofara Aveau, Minister of Fisheries, Samoa

10.30 a.m. Arrangements for meeting (Mike Donoghue)

10.40 a.m. Review of papers prepared for workshop and reference material

11 a.m. Morning Tea

11 – 1 p.m. Time to allow people to read papers

1 – 2 p.m. Lunch

2.p.m. Adoption of agenda and appointment of rapporteurs

2.30 p.m. Overview and statement of problem (Randall Reeves)

3 p.m. Afternoon Tea

3. 15 p.m. Summary of interaction in various fisheries in South Pacific (presented by representatives from Forum Fisheries Agency, Secretariat for the South Pacific and John Wang):

- Key features of local longlining techniques
- Depths of sets, lengths of lines, hauling equipment used
- Auditory and other possible cues

4.30 p.m. Status of toothed whale populations in the South Pacific (Greg Stone)

5 p.m. Close of session

DAY 2

9 a.m. Interactions in various fisheries in other regions:
Latin America – Edu Secchi
Indonesia – Benjamin Kahn
South Africa/Falkland Islands – Martin Purves

10 a.m. Discussion

10.30 a.m. Morning Tea

10.45 a.m. Interactions in various fisheries in other regions, continued:

Alaska and Hawaii - Jan Straley
Fiji - Dave Lucas

11.45 a.m. Discussions - Comparison of depredation behaviour as observed in different fisheries:

- What cues are used by the cetaceans?
- When is depredation observed?
- Where is depredation observed? Can the areas be defined?
- Are the same individuals regularly and repeatedly observed?

12.30 p.m. Lunch

1.30 p.m. Discussion - Assessment of significance of interactions in the South Pacific region and globally

2.15 p.m. Attempts at mitigation by fishers:

- South Pacific
- Other areas

3 p.m. Afternoon Tea

3.20 p.m. Opportunities for gear modification (Ken Baldwin)

4 p.m. Designation of small working groups to examine and discuss key issues, especially mitigation and research needs.

EVENING Reception at SPREP

<u>DAY 3</u>

9 – 10 30 a.m. Working groups convene and hold discussions

10.30 a.m. Morning Tea

10.45 a.m. Working Groups report back – discussion

12.30 p.m. Lunch

1.30 p.m. Identification of key elements of a Plan of Action

2.30 p.m. Identification and setting priorities for research needs

3 p.m. Afternoon Tea

3.15 p.m. Working groups discuss Plan of Action and research needs

DAY 4

Rest day (or half-day) for delegates not writing report – visit to Alipata Marine Protected Area

DAY 5

Review and adoption of draft report

Ongoing communication – establishment of list-server

Adoption of agreed media statement and process for adoption and distribution of final report

APPENDIX II

Participant List

ALASKA:

1. Jan Straley
   University of Alaska
   1332 Seward Avenue
   Sitka AK 99835, USA
   Email: Jan.Straley@uas.alaska

2. Greg Beam
   Fisher
   P.O. Box 1994
   Alaska 99835
   Email: gregbeam@att.net
   Ph: 425 418 4375

AUSTRALIA:

3. Benjamin Kahn
   Director, Apex Environmental
   P.O. Box 591
   Clifton Beach
   Cairns 4879, Queensland
   Ph: (61) 7 40590270
   Fax: (61) 7 40590849
   Email: bkahn@attglobal.net

4. Stephen Powell
   Policy officer
   Marine & Water Division
   Environment Australia
   Canberra ACT 2601
   Tel: (02) 6274 1806
   Fax: (02) 6274 1006
   Email: Stephen.Powell@ea.gov.au

5. Sarah Dolman
   Whale and Dolphin Conservation Soc.
   P.O. Box 163
   Watson ACT 2602,
   Australia
   Ph: (61)0 262 541754
   Fax: (610) 262 783956
   Email: sarahd@wdcs.org

CANADA:

6. Randall Reeves
   IUCN
   27 Chandler Lane, Hudson
   Quebec JOP 1H0, Canada
   Email: rrreeves@total.net

7. John Wang
FormosaCetus Research &
Conservation Group
310 7250 Yonge Street
Thornhill, Ontario, Canada L4J-7X1
Ph: (905) 709 7014
Email: pcrassidens@rogers.com

FIJI:

8. Dave Lucas
Solander (Pacific) Ltd
P.O. Box 178
Fiji
Ph: 679 3314819
Fax: 679 3314 973
Email: dave@solander.com.fj

9. Pio Manoa
Greenpeace
Fiji
Ph: (679) 3312 861
Fax: (679) 3312784
Email: Pio.Manoa@fj.greenpeace

SOUTH GEORGIA:

10. Martin Purves
MRAG Ltd.
47 Princes Gate
London SW 72 BP, UK
Ph: (44) 278 3324 5828
Email: martinpurves@lycos.com

BRAZIL:

11. Educardo Secchi
Marine Mammals Research Team
University of Otago
P.O. Box 56
Dunedin, NZ
Ph: (643) 479 0412
Fax: (643) 479 8336
Email: edu.secchi@xtra.co.nz

NEW ZEALAND:

12. Michael Donoghue
Dept of Conservation, NZ
124 Colville Road
R.D.4 Coromandel, NZ
Email: donoghue@ihug.co.nz
mdonoghue@doc.govt.nz

NEW CALEDONIA:

13. William Sokimi
SPC
B.P. D5 98848 Noumea
Ph: (687) 262000
Fax: (687) 263818
Email: WilliamS@spc.int

14. Deirdre Brogan
SPC
BP D5 98848 Noumea Cedex
Tel: (687) 262000
Fax: (687) 263818
Email: Deirdreb@spc.int

PAPUA NEW GUINEA:

15. Vagi Rei
Marine Officer
Dept of Environment & Conservation
P.O. Box 6601 Boroko
PNG
Tel: (675) 325 0195
Fax: (675) 325 0182
Email: vagirei@yahoo.com.au

16. Barbara Roy
Wildlife Enforcement Officer
Dept of Environment
P.O. Box 6601, Boroko
PNG
Tel: (675) 325 0195
Fax: (675) 325 0182
Email: cons@daltron.com.pg
pngccap@datec.com.pg

17. Kenny Leana
Consultant
P.O. Box 5405
Boroko, 111
PNG
Tel: (687) 262000
Fax: (687) 263818
Email: kjlen59@yahoo.com.au

UNITED STATES OF AMERICA (continental):

18. Gregory S. Stone
Vice President
Division of Global Marine Programs,
New England
Central Wharf Boston, MA 02110
Ph: 617 973 5288
Fax: 617 973 0242
Email: gstone@neaq.org

19. Ken Baldwin
Chase Ocean Engineering Lab
University of NH
Durham NH 03924, USA
Ph: 603 862 1898
Email: kcb@cisunix.unh.edu

SAMOA:

20. Lui Bell
Dept of Lands, Survey & Envt
Private Mail Bag
Apia
Ph: (685) 30965
Fax: (685) 25856
Email: ulafala@lesamoa.net

21. Atonio Mulipola
Fisheries Dept
Apia
Ph: (685) 20369
Email: Fisheries@samoa.ws
a_mulipola@hotmail.com

22. Sue Miller
Facilitator
Samoa MPA Project
P.O. Box 1386, Apia
Ph: (685) 70402
Fax: (685) 25856
Email: sue.miller@samoampa.com

23. Savali Time
Senior Fisheries Officer
Apia
Ph: (685) 20369
Email: SGTime@lesamoa.net

24. Toetu Pesaleli
Fisheries Officer
Apia
Tel: (685) 20369
Fax: (685) 24292
Email: Fisheries@samoa.ws

25. Anama Soloa
Fisheries Officer
Apia
Ph: (685) 20369
Email: asolofa@hotmail.com

26. Oloialii Koki Tuala
Manager, Apia Export Fish Packer
Apia
Ph: (685) 26127
Fax: (685) 22508
Email: aef1@samoa.ws

27. Peter Rasch
Fishing Boat Captain
Apia

28. Chris Hewson
Ph: (685) 26127
Fleet manager, Apia Fish Packers
Apia
Fax: (685) 22508
Email: aef1@samoa

29. Anisi Christian Tua
Fisheries Division
MAFFM
Samoa

30. Michael Forsyth
Fisheries Division
MAFFM
Samoa
Tel: (685) 22047
Email: ocean-half@yahoo.com

TAIWAN:

31. Shih-Chu Yang
5 – 5, #78, Chung-mei 13 st.
Hualien City
Taiwan R.O.C.
Ph: (886) 3 8221681
Email: chu815@ms14.hinet.net

SECRETARIAT:

32. Job Opu
Marine Species Officer
SPREP
Ph: (685) 21929
Fax: (685) 20231
Email: jopu@sprep.org.ws

33. Me Misi-Alaia
Programme Assistant
SPREP
Ph: (685) 21929
Fax: (685) 20231
Email: mem@sprep.org.ws