Marine Mammal – Longline Bycatch Mitigation Workshop Abstracts

GENERAL SESSION

Overview on the interactions between marine mammals and the pelagic longline fishery in the subtropical western South Atlantic

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Interactions between marine mammals and pelagic longline fisheries in the subtropical western South Atlantic have been reported since the early 1980s. The nature of such interactions includes bait stealing (e.g. by Risso's, *Grampus griseus*; common dolphins, *Delphinus delphis* and fur seals *Arctophoca* sp.), depredation of the catch (by killer, *Orcinus orca* and false killer whales, *Pseudorca crassidens*) and bycatch either by hooking or entanglement in the line (all the above species). The magnitude and consequences of these interactions are not well understood. Nevertheless, depending on the magnitude, consequences could potentially range from short-term behavioural changes to population decline if bycatch affects a small local population. The ultimate goal of reducing bycatch or depredation requires understanding the spatio-temporal distribution patterns of marine mammals, the fishing activities and the environmental factors that inflate interaction probabilities. Here we provide an overview of the interactions between marine mammals and the pelagic longline fishery operating off southern Brazil and Uruguay, with emphasis on factors influencing depredation and bycatch. We analysed data on bycatch of marine mammals and depredation of killer/false killer whales in the Uruguayan pelagic longline fishery for the period 1996-2007. We also analysed data on killer/false killer whale depredation of pelagic longline catches in southern and south-eastern Brazil from 2001 to 2007. In both countries, data were collected by trained onboard observers. In Uruguay, total bycatch per unit of effort (BcPUE) was 0.0150 marine mammals/1000 hooks and the highest values (0.2 approx.) were recorded between 37°-38° S and 49°-51° W. Generalized linear models (GLMs) showed that the bycatch of cetaceans was influenced by depth, with increased bycatch over the continental slope (mean=1270 m). The bycatch of pinnipeds was influenced by sea surface temperature (minimum and range per set), latitude (second order term) and season. Pinniped bycatch occurred mainly in winter, between 34°-37°S (mean=35.9°S), in waters with temperatures ranging from 9.4 to 20.1°C (mean=16.6°C) and that varied between 0.2 and 5.6 °C per set (mean=1.6°C). The depredation rate (DR - calculated as the percentage of total fish caught damaged by cetaceans in areas of 1x1 degrees) was 0.37% and was higher in autumn. Swordfish (*Xiphias gladius*) presented the highest values of DR and higher frequency of positive selectivity values (43.9% of sets – according to Ivlev index) indicating a preference by predators. Although fishing vessels operated between 19° to 40.5° S and 20° to 54° W, depredation occurred between 25°-40.5° S and 27°-53° W in 67 of the 1029 sets monitored. GLMs were also used to evaluate the effect of variables on the number of fish depredated. Distance to coast, year, vessel, capture of shortfin mako shark (*Isurus oxyrinchus*) and billfish (Istiophoridae), latitude, minimum SST, slope and variation of SST were important variables in explaining depredation. Most interaction events (bycatch

and depredation) occurred within the Brazil-Malvinas(Falklands) Confluence Zone, an area of high productivity where the fishing effort of the pelagic longline fleet is more intense.

In Brazil, killer and false killer whale depredation was observed on 10% of the sets and on 0.6% of the fish catch. Cetaceans damaged 83 of 775 tuna, *Thunnus* spp. (10.7%) and 81 of 429 swordfish (18.9%) caught. Depredation on swordfish was significantly higher than on tuna ($\chi 2 = 13.53$, $df = 1$, $p < 0.0002$). GLMs were used to test the hypothesis that the number of depredated tuna and swordfish was affected by environmental, biological and operational variables. The selected model indicated that the likelihood of depredation significantly increased westward and as distance to the 200m isobath and depth increased. Sets with depredation occurred mainly between 48°W and 52°W (68%) and at locations with depths ranging from 500 to 1500m (34.7% of the sets and 51% of damaged fish). Therefore, in both countries, spatial changes in setting locations could be an alternative to reduce interactions if the tradeoff between yield of target species catches and operational costs is positive to the industry.

Cues, Creaks, and Decoys: using underwater sound as a tool to study sperm whale depredation
Aaron Thode

In 2004 the Southeast Alaska Sperm Whale Avoidance Project (SEASWAP) began deploying passive acoustic recorders on longline fishing gear in order to identify sounds that may attract whales to fishing activity. We found that when hauling, longline vessels generate distinctive sequences of sounds that are detectable for several kilometers. The recorders are also able to detect the presence and relative activity of sperm whales, and thus we were able to associate these hauling sounds with increases in sperm whale acoustic activity. When the vessel controls are manipulated in such a way to mimic a haul (even when no gear is in the water), we found whales would arrive on site within fifteen minutes. The combined use of underwater recorders and video cameras also allowed us to identify "creak" sounds that whales make while depredating. By deploying recorders with federal sablefish surveys over two years, we found a high correlation with sperm whale creak rate detection and the amount of visual evidence for depredation. We have thus started to use passive acoustics as a low-cost, remote sensing method to quantify depredation activity in the presence and absence of various deterrents (e.g. O'Connell *et al* presentation). A final, unusual, twist in our use of underwater sound is the development of acoustic "decoys" as a potential means of attracting animals away from locations of actual fishing activity. The decoys broadcast longline hauling sounds when activated by a radio signal, and passive acoustic recorders are used to determine if and when whales approach either the decoy or true haul. Data from a trial deployment in 2011 will be presented. The use of passive acoustics has permitted us to test deterrent concepts much more rapidly and cost-effectively than otherwise possible.

PHYSICAL GEAR MODIFICATIONS

Testing longline hooks in the mouths of marine mammals

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A series of five longline hooks (M-16, M-18, K-16, K-18 and J-9) were tested to measure the forces required to pull these hooks through the soft and hard tissues in the mouths of small toothed whales and to document the resulting tissue injuries. Tests were conducted on fresh-stranded specimens of three species of pelagic delphinid cetaceans - short-finned pilot whales (*Globicephala macrorhynchus*), Risso's dolphins (*Grampus griseus*) and false killer whales (*Pseudorca crassidens*). Intact heads were secured to a fixed stanchion and hooks were serially placed in the mouth at multiple positions along the dorsal lip and lower jaw. Forces were collected with an in-line force gauge and downloaded to a computer for analysis. The polished steel (Mustad M and J), and carbon forged (Korean) hooks types behaved in measurably different ways during these tests. M- 16, M-18 and J-9 hooks, embedded in soft tissues, all straightened under maximum forces that ranged from 50 – 225 kg, depending upon the hook gauge. These hooks straightened enough to expose the sharpened tip barb, which sliced through the lip tissue, releasing the hook, usually intact. The resulting wounds were typically linear slices, which ran from the site of hook penetration on the deep lip to the lip's lateral margin. Korean carbon forged did bend during mechanical tests, but they did not open to expose the sharp tip barb, and thus, did not slice through lip tissues. Instead, the hook either broke or tore through the lip. In addition, these hooks would generally break at relatively high loads (70-250 kg) at a very consistent position along their length - just behind the barb. This type of failure often left shards of the hook tip in the soft tissue of the gum. The resulting wounds from K hooks were large, irregular, jagged, tissue lacerations and tears. The different behaviors of these two hook types were consistent across all species tested. Thus, their mechanical behavior appeared to depend upon the material from which the hook was manufactured. Additional mechanical tests were conducted to determine if the hooks used in the longline fishery could fracture the mandible (lower jaw) of these pelagic odontocetes. Only the M-18 and K-18 hooks were large enough to be placed into the mouth around the lower jaw. Both of these hook types fractured the jaws in short-finned pilot whales and Risso's dolphins. These results add to the evidence that longline hooks can cause serious injury to the jaw of these species.

Mitigating odontocete by-catch and depredation in longline fisheries: non-lethal physical and psychological deterrence at the hook

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In 2009, the Australian Government and other regional agencies embarked on a project to mitigate the economic and conservation impacts of toothed whale depredation and by-catch in two major pelagic longline fisheries. The impetus for the project arose from concerns tabled a workshop held in Apia (Samoa) in 2002. This project provides a rare opportunity to tackle both problems simultaneously. The aim was (i) to develop two devices that physically or psychologically deterred depredating whales by simulating gear tangles (several fisher reports indicate these are avoided), and (ii) assess their effectiveness under rigorous experimental conditions in an operational environment.

Due to the fishing gear being within diving range of toothed whales, the devices were necessarily complex. Each design, dubbed the 'chain device' and the 'cage device', comprised a trigger mechanism that allowed each device to remain clear of a baited hook to facilitate unimpeded fishing. Tension caused by a caught fish caused the deterrent structure to be deployed. In the trial gear, the devices were set on alternate branchlines (treatment-control experiment) so that a number of factors could be compared, such as fish catch rate, depredation rate and by-catch rate, and a number of operational elements. An additional 'non-trial' section was set (effectively all controls), so edge effects could be detected. Results from an earlier exploratory trip, using TDRs, indicated that the addition of a device to the fishing gear that weighted 100g would not impact on the soak depths reached any more than the combined effects of tide, current and surface wind.

From 94 sets, 119,844 hook hauls were monitored, with ~83% of those occurring in the Fiji EEZ for logistical and economic reasons. The catch rate was higher on the treatment (protected) hooks (Chain device: 0.0470+0.0019 fish caught per hook; Cage device: 0.0472+0.0020) compared with control (unprotected) hooks (0.0404±0.0013 fish caught per hook), suggesting the devices either attracted more fish, or deterred more predators. There was also evidence of an edge effect, with the branchlines in the non-trial section catching less than the controls in the trial section (0.0260±0.0008 fish caught per hook in the non-trial section).

Depredation by the three main predator groups recorded – toothed whales, cookie cutter sharks and pelagic sharks – was highest on controls hooks in both the trial and the non-trial sections. Interestingly, cookie cutter shark damage was much more frequent than damage by the other two groups and depredation damage by pelagic sharks was around the same order of magnitude as for toothed whales, suggesting shark damage also has an extensive economic impact on the fishery. Specifically for toothed whales, there were 27 depredation events, 24 of which occurred on control hooks. The remaining 3 occurred on lines with devices attached that did not deploy; they may have behaved somewhat like control branchlines. Of the 27 depredation events, there were 7 occasions where at least two fish were caught consecutively, thus providing insights into 'feeding choice'. On each occasion, the fish on the control (unprotected) branchline was depredated, while the fish caught on the adjacent branchline with a device attached (protected) was not.

There were 4 toothed whales by-caught during the study – 3 false killer whales and 1 melon-headed whale – all on control branchlines. Each was released alive by cutting the branchline, thus all retained an entanglement and their fate remains unknown. Interestingly, neither of these species was observed before or during the fishing event throughout the study, while pilot whales were observed on 6 occasions although were not observed by-caught. Therefore, observing the presence of specific toothed whale species may not be a good indicator of an increased likelihood of a depredation by or by-catch event of that species.

A number of operational aspects were studied – fish survival, fish size, hauling speed and device triggering success – all having positive results. These are outlined in the final report.

Many of the outcomes of this study were positive and provide encouragement for ongoing research in this space, although further funds are required before this would be possible. Some longline fishing companies have expressed a desire to continue using the devices in a commercialised context, although some aspects of product refinement and costing need to be explored and addressed before large-scale manufacture and implementation would be possible. The development of trigger mechanisms and delivery of small structures to the hook present opportunities for hybridisation; when the technology becomes available, small acoustic deterrence devices could be incorporated alongside the chain and cage. The final report for this project should become available on the Australian Antarctic Division website towards the end of 2013, with at least to publications following soon after in peer reviewed journals.

Assessment of the efficiency of "spiders" and net sleeves as depredation mitigation measures in pelagic longline fishery
Njaratiana Rabearisoa

Depredation belongs to negative interactions between large marine megafauna and fisheries and is defined as the damage or removal of fish or bait from the fishing gear by predators, such as toothed whales, sharks, birds or squids. Those interactions lead to several negative impacts affecting the species involved (bycatch, shift in their feeding habits and hunting strategies), fishermen (financial loss induced by fish damage and search for new fishing areas) and stock assessment aspects (underestimation of catch report). Nevertheless, this issue remains poorly studied in the frame of pelagic longline fisheries, and especially in the Indian Ocean.

This work aimed at studying short-finned pilot whale (*Globicephala macrorhynchus*), false killer whale (*Pseudorca crassidens*) and pelagic shark depredation impacting pelagic longline fleets operating in the southwest Indian Ocean. Shark depredation events were more frequent but toothed whales damaged more fish on the fishing gear. 19.5% of the catch was lost to depredation in the Seychelles archipelago, and this area is considered as a depredation "hot-spot". Those interactions highlight a spatiotemporal synchrony between fishing activities and predators' abundance, in particular toothed whales.
Several depredation mitigation measures have been tested so far but their long-term efficiency are still to be proved. Innovative devices based on fishing gear modifications and aiming at protecting capture were designed and tested. Two fishing trips were conducted in Seychelles in 2007 and 2008 to assess the efficiency of "spiders" and "socks" towards toothed whale depredation. Preliminary results underlined operational constraints to routinely deploy those devices during full-scale fishing operations. Based on those results, a third generation of physical deterrent device, the DEPRED (DEPREDation mitigation device by preventing predator attacks and protecting capture), was trialled in Reunion Island in the interaction between bottlenose dolphins (*Tursiops aduncus*), spinner dolphins (*Stenella longirostris*) and small pelagic fish used as bait. In our study this interaction is considered as a scale model of those staging toothed whales and pelagic longline capture in the open ocean. At short term, this device proved to be quite effective, but a habituation behavior was observed for a group of *Tursiops aduncus* which interacted regularly during fishing experiments. Nevertheless, the promising results obtained during the field tests gave us valuable insights to go further for the development of a new prototype, our approach being fully consistent with the ecosystem approach to fisheries.

ACOUSTICS

A field test of interactive acoustic deterrents in the North Carolina pelagic longline fishery

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Many species of small toothed whales interact with pelagic longlines by taking bait and hooked fish (depredation) and occasionally becoming entangled or hooked in the gear (bycatch). We are in the preliminary stages of conducting a field test of Dolphin Interactive Dissuasive (DiD) devices in the North Carolina pelagic longline fishery, which experiences depredation of catch and bait by short-finned pilot whales and perhaps other odontocetes. The devices are designed to remain silent until triggered by odontocete echolocation signals and to then produce 5-500 kHz broad band, frequency modulated signals with sound pressure levels of up to 175 dB re1µPa at 1m. Our research goals are to: (1) determine whether these devices can be used practically in this fishery; (2) assess the interactive function of the devices; and (3) conduct a preliminary test of their efficacy in reducing the incidence of depredation. Between 2 July and 26 September 2013 we deployed these devices on 14 sets (active) and we have collected data from eight sets without the devices (control). In addition, we attached a digital acoustic recorder (DMON), recording continuously at a sampling rate of 120 kHz on five active sets. To date we have found no significant difference in CPUE (lbs fish retained/hour soak time/1000 hooks) between active and control sets, although our statistical power is low. Pilot whales were not observed during the control sets and no depredation of bait or catch was reported during these sets. Pilot whales were observed around longline gear during five active sets; depredation of catch was reported during five active sets and of bait during four active sets. Our analysis of recordings from the DMON suggest that the devices, at times, may trigger each other, even in the absence of echolocation. We are continuing these trials, so that we can obtain a larger sample of active and control sets and refine our evaluation of the efficacy of these devices.

Simon Northridge

Pinger tests in the UK have so far been in gillnet and pelagic trawl fisheries. Several devices have been tested and they all seem to minimise bycatch of harbour porpoises. Significant operational issues cannot be ignored. Pingers seem to work by exclusion – two experiments with pingers have shown this as well as some experiments with ADDs. But not all ADDs have the same effect – one of two types tested seems less aversive to porpoises. But porpoises are generally very easy to scare and keep away from nets, and only very rarely get caught on longlines. Other species have been less well studied. Common dolphins' reactions to several acoustic deterrent devices were tested under the EU Necessity project. An extreme reaction in French experiments was not replicated in other experiments. Berrow et al. 2008 concluded that the devices don't work with common dolphins. This is not consistent with results from California (different type of pinger) nor with our own results from a pair trawl fishery (different context). Pinger trials in a midwater trawl fishery have shown very mixed results. Two pinger types, and two much louder sound sources, had no effect on common dolphin bycatch (which occurs when the animals are feeding inside nets), while one pinger type seems to be effective in minimising bycatch of this species in this gear. Bottlenose dolphins and other species need to be examined in much more detail. Anecdotal evidence suggests that bottlenose dolphins are not easily scared by pingers. They have been reported very close to fish farms with active ADDs, they have also been reported to attack pingers. Main conclusions are that some species react readily to pingers, other not so. Those reactions are dependent not only on the nature of the sound source (not just its peak amplitude) and on context. There are now quite a few acoustic devices on the market or near-market for use in longlines, but none seems to have been rigorously tested so far.

Aaron Mooney

Avoiding killer whale depredation in Alaskan longline fisheries

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University of Alaska

Killer whale (*Orcinus orca*) depredation occurs when whales damage or remove fish caught on longline gear. This research incorporates mixed methods to evaluate: 1) spatio-temporal depredation trends, 2) depredation effects on groundfish catch rates, and 3) socio-economic implications of depredation avoidance and changing fishing practices due to whale interactions. Fishermen change their fishing practices to avoid depressed catch rates associated with depredating whales, but these changes can be costly for the fleets. These measures employed by the fleet are moderately effective at whale avoidance but are generally considered short-term fixes for a long-term problem.

OTHER MITIGATION METHODS

Using Avoidance to Minimize Depredation in the Longline Fishery in Alaskan Waters

Jan Straley

Both sperm and killer whales remove primarily sablefish, but also halibut, from demersal longline gear in Alaskan waters. The Southeast Alaska Sperm Whale Avoidance Project (SEASWAP) deployed satellite tags on 21 sperm whales from 2007 to 2014. Movements of sperm whales were provided in near real time to fishermen via the Alaska Longline Fisherman's Association (ALFA) website. Describing the movement patterns of sperm whales in the GOA may provide a means to avoid whales by coupling satellite tracking with acoustics and individual sighting histories. If whales have long term associations and if their presence can be predicted in the GOA, documenting areas and timing of frequent use by sperm whales, in particular the skilled depredators would provide a means to minimize interactions between fishing operations and sperm whales. Fishermen could avoid fishing when whales are predicted to be present, thereby reducing the opportunity for depredation in Alaskan waters.

Interactions of killer whales with Patagonian toothfish longline fisheries in the Crozet islands EEZ: changes in fishing behaviour towards mitigation?

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Depredation on Patagonian toothfish longline fisheries by killer whales in the Crozet EEZ (southern Indian Ocean) cause significant economic losses to the fisheries (estimated to 5.3 Millions €/yr), and also greatly impact conservation marine mammals populations. With such need for mitigation solutions to that issue, we investigated a set of operational factors that would potentially reduce interactions with killer whales, which are responsible for most depredation. We used both fishing and photo-identification datasets spanning from 2003 to 2013 to model variations of Catch Per Unit Effort (CPUE) in absence and presence of killer whales through Generalized Linear Mixed Models (GLMM) integrating space and time auto-correlation effects. Three operational factors were identified as influencing significantly depredation levels:

- i) the use of short longlines (<5000m) in absence of killer whales: whales will have access to smaller proportions of longlines in case they find the vessel during hauling.
- ii) the displacement of vessels on distances >40 nm in presence of killer whales. Whales are more likely to loose track of vessels over that distance.
- iii) the use of longline hauling speed > 50 hook.min^{-1} in presence of killer whales decreases the time needed by the whales to remove great proportions of fish.

In addition to these factors, we examined group specific killer whale behaviour and emphasized two variables reducing interaction probabilities:

- i) fishing areas with low killer whale presence probability
- ii) specific period of the year when some killer whale groups favour natural prey (October-December).

These findings were converted as recommendations to fishing vessels which tested them in real at-sea fishing conditions. Preliminary analyses suggest that vessels that modified their fishing behaviour according to these factors significantly reduce depredation which suggests their possible extension to other fisheries confronted to the same issue elsewhere in the world. However, the results emphasized that most factors' efficiency also relies on other variables (e.g. simultaneous presence of fishing vessels, distance between their fishing areas, etc.) which still need to be assessed and added to models in a short future.

Marine Mammal depredation on demersal Patagonian toothfish fishery in Crozet and Kerguelen exclusive Economic Zone. Can fish traps solve that issue?

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Interactions between killer whales (*Orcinus orca*), sperm whales (*Physeter macrocephalus*), fur seals (*Arctocephalus sp.*) and longline fishing operations are reported by observers onboard fishing vessels targeting Patagonian toothfish (*Disostichus eligenoides*) in Crozet and Kerguelen Exclusive Economic Zones (EEZ), between 2003 and 2012. In Crozet EEZ, the reported interactions involved killer whales and sperm whales while sperm whales and fur seals are observed in the Kerguelen EEZ. Interactions were observed over the whole fishing areas and for all seasons. In the absence of fish remains on hooks an adapted methodology had to be developed to estimate depredation rates and fish losses. First, depredation levels was assessed by comparing the CPUE (fish weight/hook) on each longline set in the absence/presence of marine mammal species alone or in co-occurrence for a given geographical area, second, depredation level was assessed by the differences in the proportion of patagonian toothfish, targeted by killer whales and sperm whales versus grenadier (*Macrourus sp.*) which remained untouched. Both methods provided highly consistent results. In Crozet and Kerguelen EEZ, fish losses due to depredation reached 33.9 % and 5.9 % respectively, with killer whales responsible of most Crozet depredation and sperm whales of most Kerguelen losses. Losses were proportional to the number of killer and sperm whale interacting with the line. Over the 2003-2012 financial losses were estimated to reach 5.3 Million €/yr. In a way to reduce depredation level, alternative fishing methods were tested. In summer 2010, a dedicated fishing campaign (ORCASAV) tested several models of existing and especially designed fish traps. While providing encouraging results, trap fishing failed to reach CPUE high enough to sustain an economically viable fishery and therefore alternative methods to reduce depredation have to be implemented.

Testing a passive deterrent on longlines to reduce sperm whale depredation in the Gulf of Alaska

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In Alaska, sperm whale depredation on longline sets has increased since implementation of the Individual Fishing Quota program in 1995. A collaborative effort (SEASWAP) between fishermen, scientists, and managers has undertaken research to evaluate this depredation with a primary objective to develop and test a passive deterrent. Commercial longliners, fishing for their own sablefish quotas during the regular season, fished our beaded (lucite beads attached to gangions) and control gear and set recorders to collect acoustic data.

Although there was a decrease in depredation events on the beaded gear compared to the control, it was not a significant effect ($p=0.3643$).