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Science and Implementation Considerations of Mitigation Techniques to Reduce Small Cetacean Bycatch in Fisheries

Considérations en matière de science et de mise en application des techniques d'atténuation visant à diminuer les prises accidentelles de petits cétacés dans les pêches

December 10th, 2005
Manchester Grand Hyatt San Diego,
San Diego, California, USA

Le 10 décembre 2005
Manchester Grand Hyatt San Diego,
San Diego, Californie, É-U

Jack Lawson

Fisheries and Oceans Canada / Pêches et Océans Canada
Marine Mammal Section / Section des mammifères marins
PO Box 5667, NWAFC, 80 East White Hills Road
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Foreword

This document does not originate from a process under the coordination of the Canadian Science Advisory Secretariat (CSAS). However, it is being documented in the CSAS Proceedings series as it presents some key scientific information related to the advisory process.

Avant-Propos

Le présent document est issu d'un atelier qui ne faisait pas partie du processus consultatif scientifique coordonné par le Secrétariat canadien de consultation scientifique (SCCS). Cependant, il est intégré à la série de Comte rendus du SCCS car il présente certains renseignements scientifiques clés, liés au processus consultatif.

SUMMARY

Like many governmental organisations with a mandate to protect marine ecosystems, the Department of Fisheries and Oceans (DFO, Canada), is required to address the issue of fisheries bycatch for marine species such as the harbour porpoise. Under Canada's Species at Risk federal legislation, practical methods to quantify and mitigate such bycatch are important components of Management or Recovery Plans for marine mammal species. Scientists from Canada and a number of other countries have been developing and testing a variety of bycatch mitigation measures.

To present and evaluate the theoretical, practical, and political considerations to implement mitigation techniques designed to reduce the bycatch of small cetaceans in fisheries, a workshop was convened in conjunction with the 16th Biennial Conference on the Biology of Marine Mammals in San Diego, California in December, 2005.

The range of presentations was broad: from overviews of the global scope of small cetacean bycatch, to a detailed review of harbour porpoise bycatch management in Denmark. Despite much study there is still no consensus as to why small cetaceans become entangled in nets and trawls. The diverse contexts and mechanisms of bycatch have dictated a variety of mitigation approaches such as passive and "smart" acoustic pingers, modified nets, non-net alternatives, and operational modifications.

There can be management challenges to implementing small cetacean bycatch mitigation, since there has been relatively little emphasis and study directed towards addressing questions of the efficacy of bycatch mitigation, or defining clear implementation criteria.

SOMMAIRE

Comme plusieurs organisations gouvernementales qui ont un mandat de protection des écosystèmes marins, le Ministère des Pêches et Océans (MPO, Canada) doit évaluer le problème des captures accessoires par les pêches commerciales d'espèces marines comme le marsouin commun. Sous la Loi sur les espèces en péril du Canada, des méthodes pratiques pour quantifier et limiter ces captures accessoires sont des composantes importantes des plans de gestion et de rétablissement des espèces marines. Les scientifiques du Canada et de nombreux autres pays ont développé et essayé une gamme de mesures d'atténuation des captures accessoires.

Pour présenter et évaluer les considérations théoriques, pratiques et politiques de la mise en œuvre de techniques d'atténuation visant à réduire les captures accessoires de petits cétacés par les pêches, un atelier fut organisé conjointement à la 16ème Conférence Biennale sur la Biologie des Mammifères Marins tenue à San Diego, Californie, en décembre 2005.

Les présentations ont couvert une large étendue de sujets: de revues globales des captures accessoires de petits cétacés à une revue détaillée de la gestion de ce problème au Danemark. Malgré toute la recherche, il n'y a toujours pas de consensus sur les raisons pouvant expliquer pourquoi les petits cétacés s'emmêlent dans les filets et les chaluts. Les divers contextes et mécanismes des captures accessoires ont engendré différentes approches d'atténuation comme les émetteurs acoustiques ("pingueur") passifs et "intelligents", les filets modifiés, les solutions de rechange sans filet, et des modifications opérationnelles.

Des défis de gestions peuvent découler de la mise en œuvre des mesures d'atténuation des captures accessoires de petits cétacés puisqu'il n'y a eu que peu d'emphase et d'études dirigées sur l'efficacité de ces mesures ou sur la définition précise et claire de critères d'évaluation de la mise en œuvre.

INTRODUCTION

Like many governmental organisations with a mandate to protect marine ecosystems, the Department of Fisheries and Oceans (DFO, Canada), is required to address the issue of fisheries bycatch for marine species such as the harbour porpoise. Under Canada's Species at Risk federal legislation, practical methods to quantify and mitigate such bycatch are important components of Management or Recovery Plans for marine mammal species. Many governments, in addition to international NGOs, have listed marine mammal bycatch in fishing gear as an important conservation issue. In response to this, scientists from a number of countries have been developing and testing a variety of mitigation measures. I was strongly encouraged by colleagues to convene this review – particularly to address the newest mitigation approaches.

This workshop provided a collegial atmosphere within which to present and evaluate the theoretical, practical, and political considerations to implement mitigation techniques designed to reduce the bycatch of small cetaceans in fisheries. Discussions amongst participants also served to highlight problems and directions for further research. I thank those who presented, and those who attended the meeting.

The agenda was ambitious, and additional topics were raised which presenters provided data/information that would stimulate debate.

With the refreshments for the two breaks, (DFO provided the LCD projector, screen rental, computer, and laser pointer), and after participants (Appendix A) registered at $20 U.S., there was a small surplus of funds left (slightly over $100). As agreed, these funds were donated on behalf of the workshop to the Marine Mammal Society's student travel fund.

I prepared this proceedings of the workshop in response to interest from both those that attended and others in the marine mammal community. I have added figures and tables from the PowerPoint files provided by presenters that serve to better illustrate the text included in the abstract. Before publishing the document at CSAS (http://www.dfo-mpo.gc.ca/csas/Csas/Home-Accueil_e.htm), I distributed a draft to those who attended the workshop. Once approved, the final version was also posted (along with PDF versions of the workshop presentations) on the Centre of Excellence for Marine Mammalogy web site (http://www.osl.gc.ca/mm/en/).

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ABSTRACTS AND WORKSHOP DISCUSSION NOTES FOR LEAD-OFF TALKS

Scope Of The Small Cetacean Bycatch Problem Worldwide

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Fisheries bycatch poses a significant threat to many populations of small cetaceans, but there are few published estimates of the magnitude of these outside North America and Europe. It is possible to estimate total small cetacean bycatch in U.S. fisheries from data contained in the stock assessment reports required by the U.S. Marine Mammal Protection Act. The mean annual bycatch of small cetaceans during this period was approximately 3,000 (Table 1). More than 80% of this bycatch occurred in gill net fisheries (Figure 1). Annual bycatches declined significantly over the decade, primarily due to a reduction in the number of harbour porpoises taken in the Gulf of Maine, after the implementation of take reduction measures in a demersal gill net fishery. It is possible to derive a crude first estimate of small cetacean bycatch in the world's fisheries by expanding U.S. bycatch with data on fleet composition from the Food and Agriculture Organization. The annual global bycatch of small cetaceans is in the hundreds of thousands (Table 3); these removals are likely to have significant demographic effects on many populations. Better data are needed urgently to fully understand the impact of these interactions.

Workshop Discussion

Dr. Read indicated during follow-up discussions that there are many other bycatch issues in addition to small cetaceans (e.g., pinnipeds, large whales, marine turtles, etc.).

In response to a query, Dr. Read indicated that the data for the U.S. bycatch estimates were extracted for 150 stocks in three regions of the U.S., and were primarily data from fisheries observer programmes.

An average of 3,000 pinnipeds and 20 large whales are bycaught in U.S. fisheries yearly (Table 1).

Dr. Read indicated that worldwide over 300,000 cetaceans a year are bycaught in fishing gear (Table 2). Most of these are smaller species, with the estimates derived by scaling up U.S. bycatch rates to effort in these global fisheries (Dr. Perrin has suggested that the Asian bycatch levels may be underestimated.)

Marine turtle bycatch estimates are similar to those for cetaceans, so these mammal results are realistic.

Table 1. Estimated marine mammal bycatch, by generic group, in recent U.S. fisheries.

Year	Cetaceans	Pinnipeds	Total
1990	5,100	2,091	7,191
1991	3,460	3,497	6,957
1992	2,861	5,808	8,669
1993	2,682	3,593	6,276
1994	3,515	3,598	7,113
1995	2,931	3,169	6,100
1996	3,737	2,493	6,230
1997	2,543	2,910	5,453
1998	1,668	2,352	4,020
1999	1,791	2,355	4,146
Mean	**3,029**	**3,187**	**6,215**

Data Source: NOAA Fisheries Stock Assessment Reports.

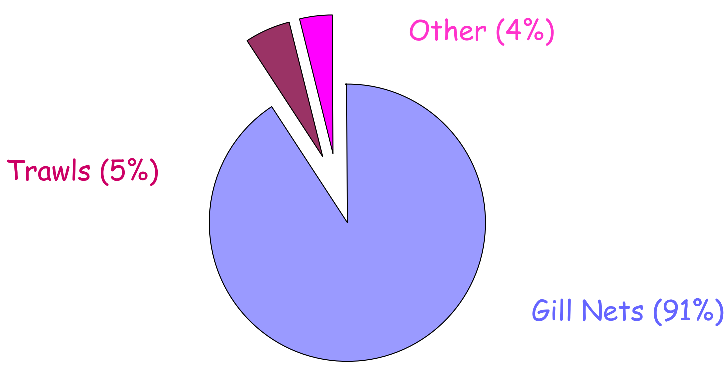

Figure 1. Proportion of U.S. marine mammal bycatch by gear type.

Table 2. Global cetacean bycatch estimates for the years 1990-1994.

	Number of Gill Net Vessels
Global	215,883
U.S.	2,288
U.S. Proportion	0.011
Global Bycatch	**307,753**

Data Source: FAO Fisheries Global Information System.

Relative to the scale of fishing effort, little research is being conducted on possible mitigation measures. Mitigation efforts have reduced bycatch where they have been tried, but only on a small scale.

Several participants raised examples to show that we need further research on marine mammal abundance and mortality estimation in U.S. fisheries, and particularly in a number of countries in Asia.

Why And How Are Small Cetaceans Caught In Fishing Gear?

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Despite a considerable effort in the last 10 years or more towards developing solutions to the wide spread bycatch of harbour porpoises in bottom set gill nets, the reasons why porpoises become entangled in these nets are still obscure. A number of hypotheses have been put forward to explain the observations made, but there does not seem at the moment to be a consensus as to which hypotheses are the most plausible. The existing knowledge about harbour porpoises, in particular their target detection abilities, and the circumstances leading to bycatch has, however, improved considerably in recent years. We believe that this knowledge can be used to reduce the number of plausible hypotheses, and ultimately lead the way towards long-term solutions to the bycatch problem. In the presentation we will try, in a logical fashion, to confront the various hypotheses with the existing knowledge about harbour porpoises and bycatch, and hopefully stimulate a fruitful discussion about why harbour porpoises are caught in gill nets.

Workshop Discussion

Studies of captive harbour porpoises suggest that they should be able to detect and avoid an underwater gillnet at a minimum of 2 m distance. Porpoises avoided gillnets at 3-6 m during studies by Kastelein *et al*. and by 3-5 m during studies by Mooney *et al*. (both captive experimental conditions with low ambient noise levels).

Recent data suggests that the source level for harbour porpoise sonar might exceed 200 dB; this could add 20 m to gillnet detection distances (theoretically)! Dr. Kastelein suggested that sonar source level might be related to body size – and these experimental porpoises are quite large animals.

Several participants suggested that porpoises (and other small cetaceans) may not use their sonar all the time, and therefore may be at greater overall risk of entanglement. A participant described studies showing that 90% of “sonar silent” periods were of less than 20 seconds duration; only 4% of “silent” periods were greater than 50 seconds long (although the detector attached to the experimental subject would not pick up quieter clicks [e.g., <170 dB]). Prior to the onset of these “silent” periods the porpoises were using intense click trains to look ahead 50 m – although they might still be at risk as they moved forward during subsequent silent periods. The strongest sonar sounds for known study animals were equal to 180 dB.

Another study (Verfuss *et al*. 2005) suggested that captive porpoises use their sonar all of the time. However, it was pointed out that these authors tested this supposition with captive animals given tasks to perform in an experimental tank, rather than wild porpoises who are also eating and being social; perhaps these wild porpoises switch to another sonar mode when they are close to prey?

Dr. Larsen described the "bottom grubbing" behaviour of porpoises (head oriented downwards and searching the bottom sediments) which may cause sonar to be directed away from the direction of the animal's drift. That is, one reason for entanglement of porpoises, despite their use of biosonar, is that the animal's sonar is locked onto another target rather than the gillnet. Several participants felt that this acoustical "tunnel vision" seemed an unlikely explanation. Related to this, several participants felt that entanglements might result from a lack of attention on the part of the animals, particularly if they were travelling in social groups or chasing prey.

Alternately, perhaps the porpoises are simply incorrectly classifying the target (net) as not a risk.

In some cases, participants described incidents where gillnets were used by porpoises as barriers against which they could herd and trap fish, thereby increasing the possibility that the porpoises themselves could become entrapped.

Dr. Lawson suggested that porpoises might investigate the gill nets out of curiosity after they detect them using vision or sonar and subsequently become entangled.

In conclusion, it was felt by most participants that these explanations are not mutually exclusive – there may well be multiple causes for small cetacean entanglement, despite their sonar use.

While these were presented and discussed in subsequent presentations, the group raised solutions to reduce such entanglement risks, including using means to alert the porpoises to the net's presence or increasing the net's target strength (through coatings, pingers, etc.) to cetacean sonar signals.

Dr. Larsen and other participants suggested research to address these echolocation issues:

(1) detection experiments in which captive cetaceans are tasked with detecting and classifying underwater targets of varying composition, at varying distances and under varying ambient noise conditions (and perhaps with lone individuals versus mother/calf pairs and social groups)

(2) with new hardware developments, it should be possible to deploy more data loggers on wild porpoises for recording of sonar and animal orientation

(3) observe behaviour around nets (Dr. Larsen described the DIDSON sonar recordings of porpoises in the pool at Fjord & Belt, Kerteminde; this 1.2 – 1.8 MHz active sonar system allows real-time imaging of animals as they move about an underwater environment in the dark; it offers an exciting opportunity to study their behaviour near nets in conditions in which they must use their sonar, although the system is relatively narrow beam and costs $100,000)

(4) studies of prey capture tactics to determine if and when small cetaceans are at highest risk of entanglement near nets

(5) trials with nets with high target strength (e.g., coatings or mesh size and composition) to test porpoises target classification problem

(6) trials with alerting devices affixed to nets

Dr. Read suggested that bottlenose dolphins are almost silent around nets, so other sensory modalities are in use by this species at these times – could this also be true for harbour porpoises? Verfuss' captive porpoises appear to use echolocation more frequently than dolphins so perhaps this is a species-specific or "cloudy water" habitat issue?

Net Knowledge: A Review of Cetacean Bycatch in Trawl Fisheries

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In the past several decades, the expanded use of trawl nets globally has led to increased interactions between marine mammals and trawl gear, causing injury or death to animals and costing fishers time and money. Researchers must understand the behaviours and/or foraging patterns that play a role in cetacean bycatch for mitigation strategies to be successfully implemented. Past and current research has tested several gear modifications and acoustic devices to reduce cetacean bycatch in trawl fisheries. Exclusion devices have been successful at reducing cetacean bycatch in trawl fisheries; however, the results have been variable, and room for improvement exists. To date, acoustic pingers have not been successful at reducing cetacean bycatch in trawl gear, but research on alternative acoustic deterrent systems is underway. In formulating bycatch mitigation plans, scientists and managers must consider that strategies which successfully reduce bycatch may differ depending on area, species, and fishery. In addition, due to annual and seasonal variability, multiple mitigation methods may be more effective than relying on a single strategy.

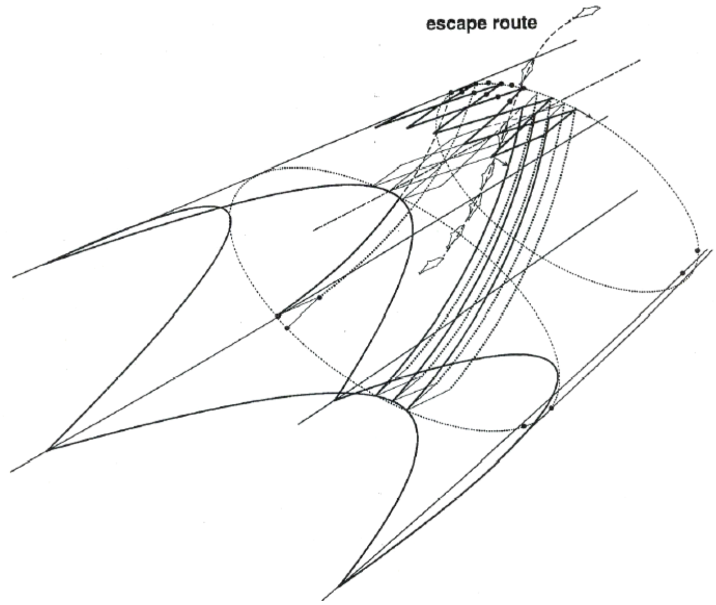
Workshop Discussion

Erika Zollett suggested that, in addition to studies of when or where cetaceans get caught, perhaps research should also investigate ways to modify gear or techniques to mitigate bycatch once the animals are within trawl gear (the "how"). Since the features of this type of bycatch are variable, not all approaches will work equally well.

Gibson and Isakssen (1998) installed full-scale, sieve-like marine mammal exclusion devices (MMED) in front of the cod end of fishing trawl nets. These were to act as a sieve whereby fish pass through, but larger objects such as marine mammals and sea turtles are diverted to an "escape hatch". During tests in a flume tank they demonstrated that there was 100% exclusion of "dummy" seals from cod end, but 50% were not successfully ejected in that their flippers became entangled.

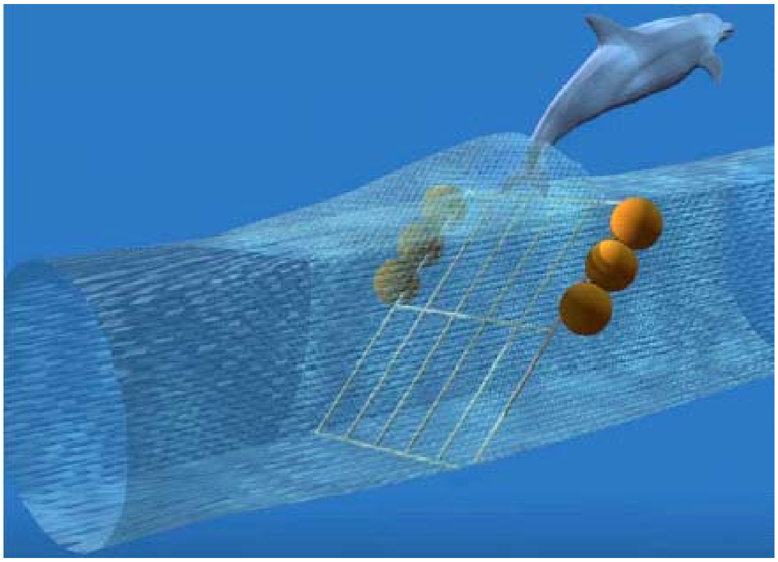
Erika Zollett described the results of the CETASEL cetacean selectivity project in which researchers employed captive animal tests to determine the efficacy of internal barrier grids in reducing bycatch in trawl nets. The system proved feasible (Figure 2), but results are incomplete.

Recent Sea Mammal Research Unit (SMRU) tests have been the most ambitious for excluder devices (e.g., Figures 3 and 4). While they have found limited handling difficulties for such excluder systems, some fish escaped during early trials. They tested mortality rates in animals after they passed through these devices by watching system with underwater video cameras.



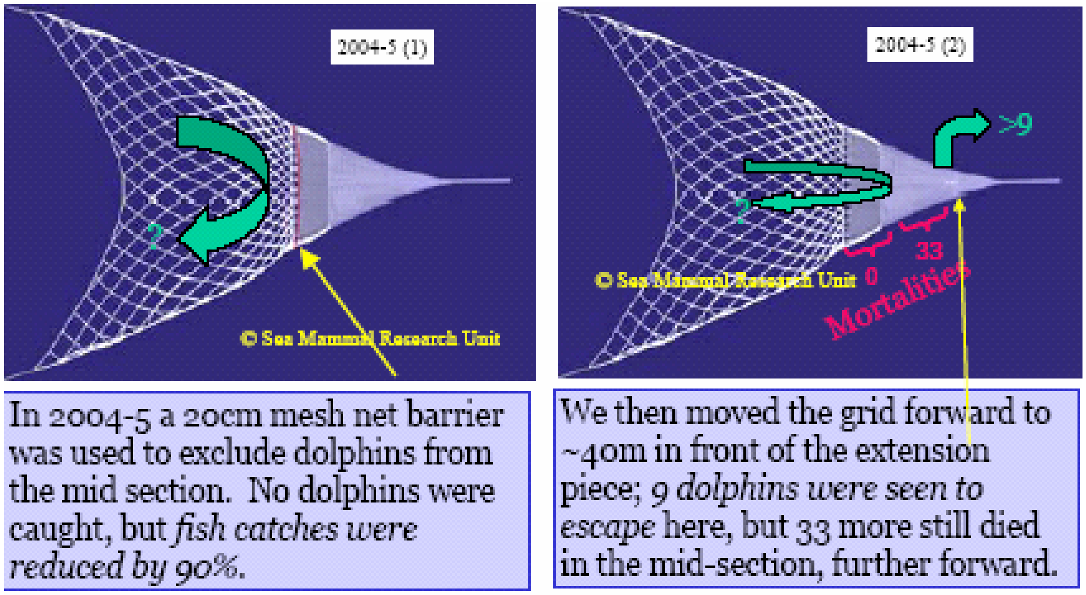
From: de Haan *et al*. 1998. CETASEL final report.

Figure 2. Barrier grid system developed in an effort to reduce bycatch in trawl nets as part of the CETASEL (CETAcean SELectivity) Project (1994-1997).



From: Northridge. 2003. Further development of a dolphin exclusion device. Final Report to DEFRA, Project MF0735.

Figure 3. Dolphin exclusion device to allow cetacean to bypass the cod end of a trawl net system.



From: Northridge *et al*. 2005. Investigations into dolphin bycatch in a pelagic trawl fishery. ICES CM/X.19.

Figure 4. Dolphin exclusion device developed by the Sea Mammal Research Unit to allow cetaceans and pinnipeds to bypass the cod end of a trawl net system.

During the CETASEL project, research focussed on testing acoustic deterrent devices as a means to exclude animals from entering nets and getting caught. The results of the trials in captivity indicated there were behavioural changes, including increased swimming speed, respiration, and surfacing rates, and decreased swimming depth. Since the tests were in captivity, it is unknown if habituation to these deterrent sounds would occur in the wild, or if the same behaviours observed in captivity would also occur in the wild. If they did, then it is unknown if these behavioural responses would benefit animals, and if they would be excluded from entering trawl nets. The experiments suggested that multiple solutions may be more successful and that the success of acoustic deterrence may differ depending on context.

Dr. Larsen indicated that one needs to define the problem is in the first place; this source of bycatch mortality may result from routine fishing by dolphins inside the nets, rather than an accidental entry to the trawl net system. Dr. Kastelein agreed with this point, and revealed that there is a new European Union project aimed at reducing bycatch in trawl fisheries using sound projection systems that are designed to displace dolphins from trawling operations without interfering with their echolocation (Figure 5).

Dr. Ridoux reported that the rate of cetacean bycatch is not spatially uniform: 75% of cetacean bycatch occurred during one week in the sea bass fishery. This suggests the possibility of employing operational mitigation as an alternate means to reduce cetacean bycatch (see Lawson's related talk). Dr. Merrick reminded participants that the small cetacean NW Atlantic trawl fishery Take Reduction Plan has to be in place soon, and to meet target bycatch reduction levels it may be easier to close fisheries in hot spots or during periods of high bycatch than to rely on development and deployment of new deterrent technologies.

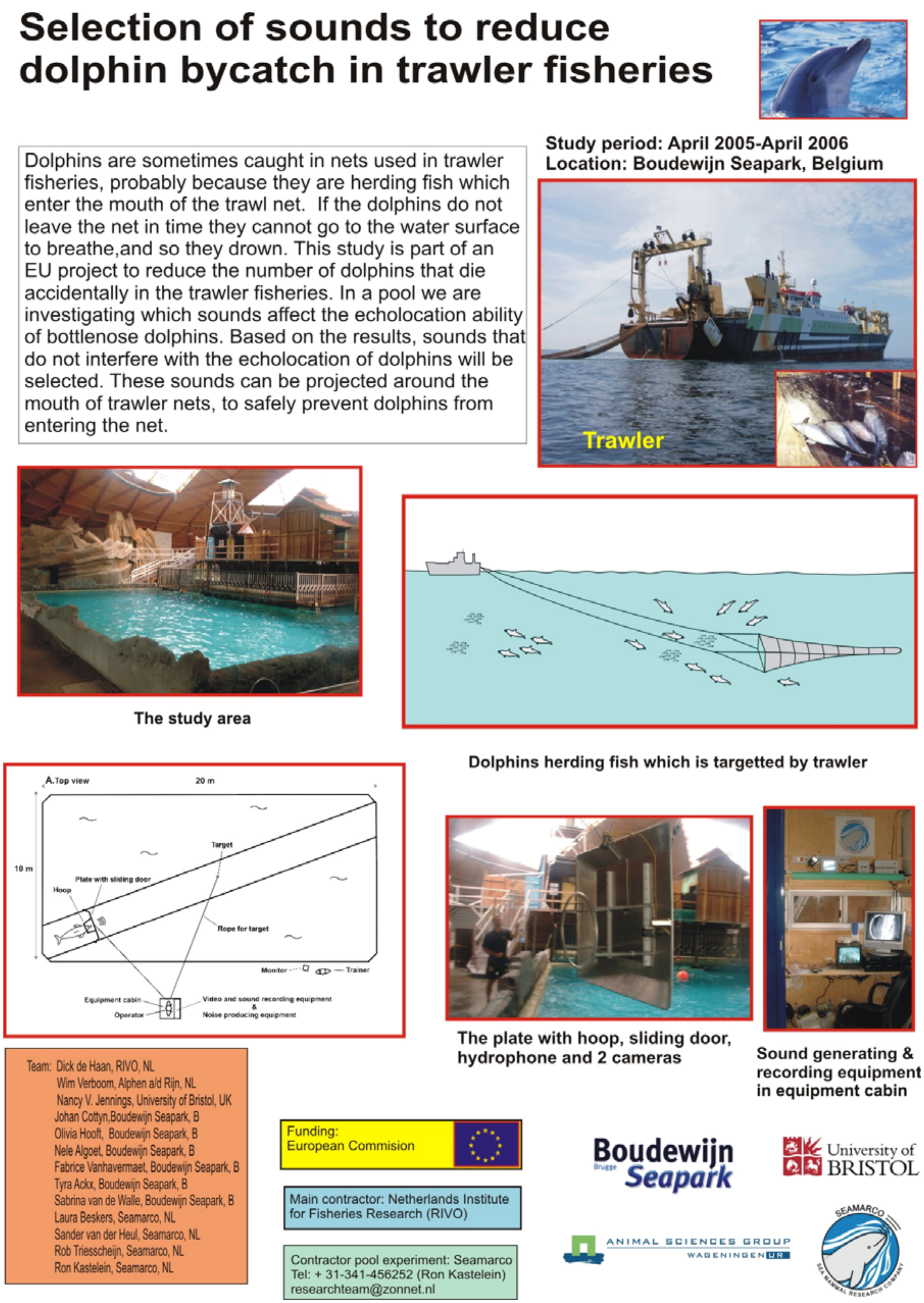


Figure 5. European Union research project to mitigate cetacean bycatch in trawl systems using sound.

Mr. Pleskunas suggested that fishing operations might allow escapement of some fish as a means to get animals to follow the trawl rather than entering the upstream capture end. Other bycatch mitigation measures for trawling operations suggested by members of the workshop included turning off as many lights as possible during night time operations, lowering head ropes, and ceasing fishing if many dolphins are present. The noises associated with putting the propulsion systems in and out of gear during line retrieval appears to be the cue used by Alaskan sperm whales to depredate long line fisheries (see relevant talk at this conference). Drs. Cornish and Lawson opined that trawl fisheries seem to suffer bycatch due to cetacean attraction to their nets so there may be a specific motivation for the animals to seek out trawling operations, and therefore the necessity for different mitigation approaches (e.g., how can we to stop social learning of fishery interactions?).

In summary, it was felt by many participants that acoustic mitigation technology still deserves investigation. With significant experimental trials underway, Dr. Kastelein suggested closer coordination of international research efforts on this problem through the use of a follow-on working group.

Alternatives To Gillnets For Some Fisheries (e.g., Fish Pots For Groundfish)

Philip Walsh

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For many fisheries in Atlantic Canada, there are inherent problems related to gear. Ghost fishing by lost gillnets and destruction of fish from the inability of harvesters to haul gear during inclement weather are just two problems that have significantly contributed to unaccounted mortality in the Atlantic cod fishery. Bycatch of non-target fish species, marine mammals, and sea turtles also needs to be addressed. The use of rigid-framed, baited pots as an alternative harvesting method for cod in Newfoundland and Labrador was tested using a number of designs. The catch rates of pots were compared to standard 5½ -in mesh gillnet (91.4 m or 50 fathom length), and handline commercial gears; catches from pots indicate that commercial amounts of cod could be harvested, especially since pots outperformed gillnets two to one, for number of cod caught. Pots were more effective than gillnets at catching a range of year-classes, thus reducing the pressure exerted on any particular year-class through fishing. While fish could remain alive for up to 10 days in a pot, these pots may be best utilized by setting and hauling in the same day, and maybe several times per day. A detailed comparison of fish quality captured by gillnets, longlines and pots should be conducted at various times of year. For instance, gillnet soak times greater than 24 hours (during Dec) caused about half the cod catch to be spoiled and not usable; whereas pot soak times of much greater duration had no adverse affect on quality. Overall, 97.5% of all fish harvested in pots were cod and the majority of the non-target species captured in the pots could be released alive and in good physical condition. The four by-catch species were Acadian redfish (*Sebastes facciatus*), eelpout (*Macrozoarces americanus*), pollock

(*Pollachinus virens*) and American plaice (*Hippoglossoides platessoides*). Baited cod pots offer an alternative to gillnets for some fisheries given their apparent multiple advantages over gillnets. Since the pots can be built and deployed by fishermen, they may be a preferred mitigation approach in countries unable to use pinger technologies.

Workshop Discussion

Cod pot fish traps, as alternatives to longlines and gillnets in groundfish operations, have proven to be as effective in fisheries for Pacific cod and Atlantic cod in Norway.

Recently, the Newfoundland-based Centre for Sustainable Aquatic Resources has had further success with implementation of cod pot designs for which cost and handling requirements have also been minimized. The tests were conducted with 28 to 45 ft vessels, equipped with a mast, boom (with swivel), and preferably, a crab hauler. At a build cost of $300 to $450 CAN per pot, depending on construction approach, and approximately $0.25 to $2 CAN per pot per soak for bait, they proved to be a cost-effective alternative to gillnets in this fishery (Figure 6). To conserve deck space, the pots have been designed to be as light as possible and to collapse when stored (Figure 7). Fishing trials showed that fishermen required approximately five minutes to haul and reset one of these pots, and the vessel fuel costs to deploy and tend these pots were comparable to other fishing methods. The catches of cod in terms of number and size were equal to or greater than gillnets set in the same areas, and there were no observed fish mortalities in pots; after 48 hours of soak time in gillnets as much as half of the caught fish were destroyed.

Dr. Merrick suggested that this system might still evoke bycatch concerns for whales, turtles, and other marine species due to interactions with the traps' rope anchoring and float systems; there needs to be further study on bycatch levels before concluding that these fish pots are a "perfect" alternative solution to gill nets. Rather, fish pots might be viewed as an incremental solution relative to gill nets.

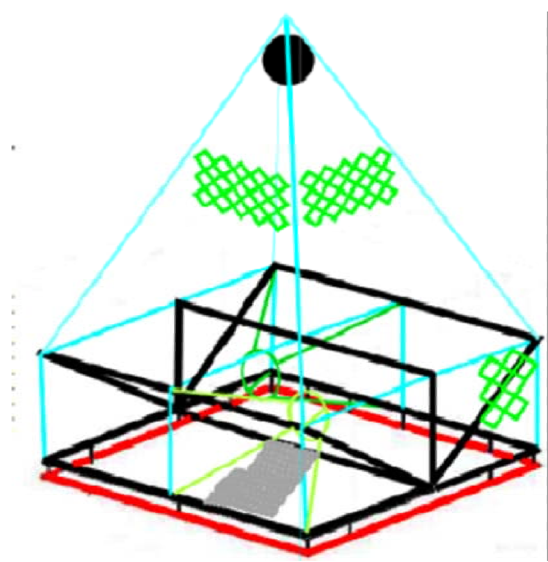

Figure 6. A successful cod pot design tested in Newfoundland, Canada.

Figure 7. The cod pots were designed to fold flat to conserve deck space. Here 15 are shown stacked on the aft deck of a small fishing vessel.

“High Density” Nets to Enhance Their Detection by Small Cetaceans

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Small cetaceans are increasingly caught as fishing by-catch throughout the world. Gillnets comprised of barium sulphate and nylon have been developed to reduce by-catch of harbour porpoise (*Phocoena phocoena*). Results of three years of field tests in the Bay of Fundy, Canada demonstrate its utility as a silent, more easily applied replacement to acoustic pingers in groundfish gillnet fisheries. Demersal species cod, haddock and pollock catch rates did not differ between $BaSO_4$ and 100% nylon nets. Experimental tests revealed that $BaSO_4$ nets do reflect echolocation-type signals of harbour porpoise and bottlenose dolphins (*Tursiops truncatus*) better than their control nets. Porpoise surfacing and echolocation behaviour were investigated with respect to both net types in a fjord on Vancouver Island. The distribution of click intervals (measured via T-POD) shifted to longer intervals when the barium sulphate net was used, indicating a greater target distance. The net's greater opacity has also led to reduced seabird by-catch (due to 10% by weight, 3% by volume of the fine white particle $BaSO_4$ filler). A shortcoming related to gear effectiveness is that small cetaceans do not continuously echolocate (dependent on species and activity). The barium sulphate net's attributes, however, include increased stiffness, such that a colliding cetacean might have a higher probability to "bounce off" of it compared to conventional nylon, thereby possibly reducing entanglement rate. Consequently, a number of factors/mechanisms are at play and presumably vary with angle of cetacean approach, twine thickness, fishing environment/practices and cetacean species. Practical advantages of barium sulphate nets include their price (10% more than monofilament nylon) and they are more easily integrated into fishing operations than pingers (no batteries, extra equipment, easier enforcement). Further experimental field testing of "high density" nets in a variety of situations is recommended.

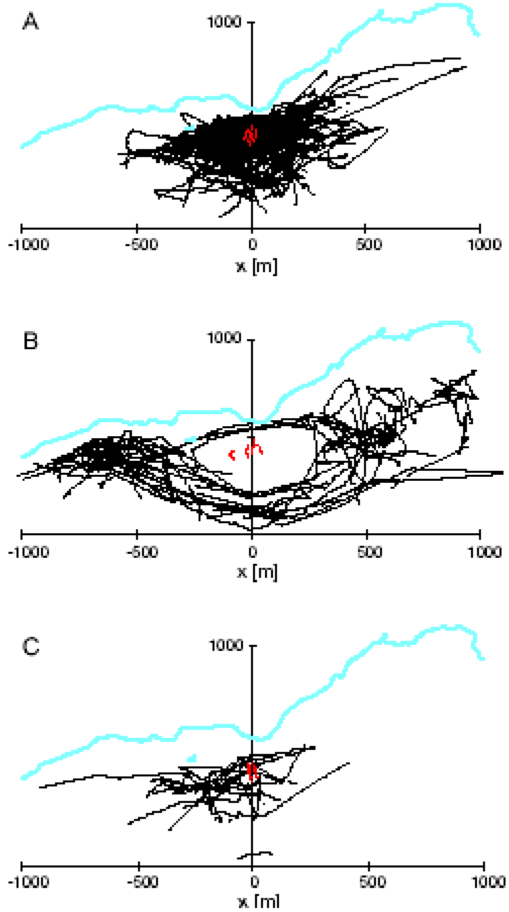
Workshop Discussion

Dr. Trippel discussed the historical rationale for researching methods to reduce harbour porpoise bycatch in fisheries of the Bay of Fundy, Canada. Since operational costs and the risk of habitat exclusion (Figure 8) are issues for pinger deterrent systems, researchers have begun to investigate the modification of the net materials themselves as a means to reduce bycatch.

Gillnets coated with barium sulphate cost 10% more than wholly nylon nets, last longer due to greater scratch resistance, require no extra equipment to handle, and likely result in higher compliance as it is easier to monitor and enforce coated net usage than deterrent pinger systems.

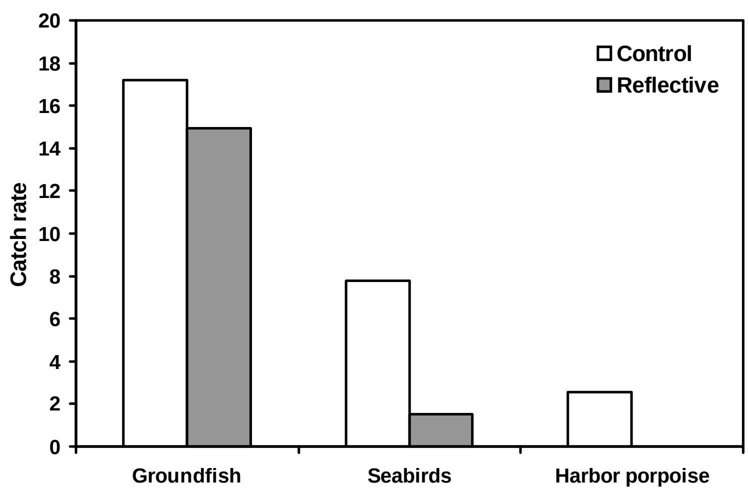
While the results have been compounded somewhat by distributional or abundance shifts in harbour porpoises in the study are, there do appear to be reduced bycatch rates in nets and ropes coated with iron oxide or barium sulphate.

The mechanism by which coated nets work to reduce bycatch was debated during the workshop. While the acoustic target strengths may be greater for higher density (coated) nets, the physical nature of the nets is such that they are also denser (stiffer) and may behave differently. That is, they may not catch and hold porpoises as easily as uncoated nets. Dr. Larsen presented evidence that gillnet stiffness may affect target species selectivity resulting in a reduction in catch of large fish; results from a controlled test of iron oxide nets in the Danish gill net fishery, conducted a few years ago, showed that CPUE for cod in the iron oxide nets was only 70% of the CPUE in the uncoated control nets (see Figure 9 for groundfish catch rates in coated and uncoated nets during Dr. Trippel's studies).



From: Culik *et al*. 2001.

Figure 8. Pingers may displace porpoise from habitat (**A** porpoise movements in baseline trials, **B** movements with pingers activated, **C** movements after pingers deactivated).



From: Trippel *et al*. 2003.

Figure 9. Tests of acoustically reflective mesh nets showed that, while they still caught fish, there was a reduction in bycatch of seabirds and harbour porpoise.

One participant suggested that the coated nets had higher optical visibility in water so that porpoises could more readily detect the nets. However, a reduction in porpoise bycatch occurs when nets are deployed at depths of 100 meters, where there is very little ambient light.

Unlike Dr. Trippel's group, Tara Cox reported no difference in echolocation behaviour by small cetaceans in the vicinity of coated experimental nets.

In summary, members of the workshop felt that researchers should conduct experiments to examine the question of stiffness versus acoustic properties. If the reduction in bycatch is primarily a function of the stiffness of the coated nets, then modifying the net materials themselves could be a low-cost solution since different nylon could be used (rather than incorporating more expensive coatings).

"Traditional" Pingers

Ron Kastelein
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Acoustic alarms or pingers were first developed to reduce entanglement of baleen whales in standing nets. Later, adapted versions of these pinger (still home-made) were used to keep porpoises away from gillnets. Thereafter, commercial pingers were developed which seemed successful in reducing porpoise bycatch. Unfortunately these pingers were developed based on an audiogram of a porpoise which assumed that this species is most sensitive for 10 kHz signals. However, a later study showed that the hearing of porpoises is most sensitive for ultrasonic signals (120-130 kHz). Now several commercial pingers are available, each with its own acoustic characteristics. Some pinger manufacturers have developed very loud pingers with the aim to keep dolphins away from nets. Lately, concerns have been raised about the effects of pingers on other marine fauna. Existing commercial pingers can be greatly improved if findings from behavioural-acoustic studies would be incorporated in their acoustic design. Suggestions will be made about the optimal pinger characteristics based on presently available knowledge.

Workshop Discussion

Dr. Kastelein presented research directed at assessing the efficacy of acoustic pingers as bycatch deterrents in net fisheries. Much of this research started in 1993 in the Netherlands using captive animals, and followed three parallel tracks (a stepwise approach): (1) behavioural studies of captive porpoises in and around nets, (2) determination of porpoises' distance of gillnet detection by echolocation, and (3) deterrence of porpoises from nets with aversive sound. An approach using captive animals allows for less expensive studies that allow for carefully-designed research questions and clear answers.

Studies demonstrated that harbour porpoise echolocation click parameters differ from those of other small cetaceans (higher frequency clicks, narrow bandwidth, relatively low source level and longer duration clicks; Figure 10). Such an echolocation system imposes limits in terms of the distance at which the porpoises can detect a gillnet (Figure 11). A range of studies have subsequently shown that the harbour porpoise's hearing abilities are different than other small cetaceans, and more sensitive at higher frequencies (corresponding to the range of their echolocation system; Figure 12). In conjunction with studies of fish hearing, Dr. Kastelein suggested that ultrasonic pingers may deter porpoises very well with less collateral disturbance of other marine mammal or fish species (e.g., species-specific effect).

By careful study and design, pingers can be built with target characteristics focussed in the best hearing range of the small cetaceans of interest, rather than that of pinnipeds – thus potentially mitigating the "dinner bell" effect whereby the pingers can attract other species that have learned to come to the nets in search of trapped fish.

In the future, it is possible that interactive pingers may be the preferred acoustic means to mitigate porpoise bycatch (if economically feasible) due to: (1) good acoustic characteristics that are less audible to other fauna, and species- or group-specific, and (2) lower duty cycle that emits less noise pollution and results in less habituation and longer battery life (and less chemical pollution from disposed batteries). Potential dangers of such pingers include the risk of hearing damage (and need for ramp up), and fright responses whereby the sudden onset of an interactive pinger causes undirected flight into nearby nets.

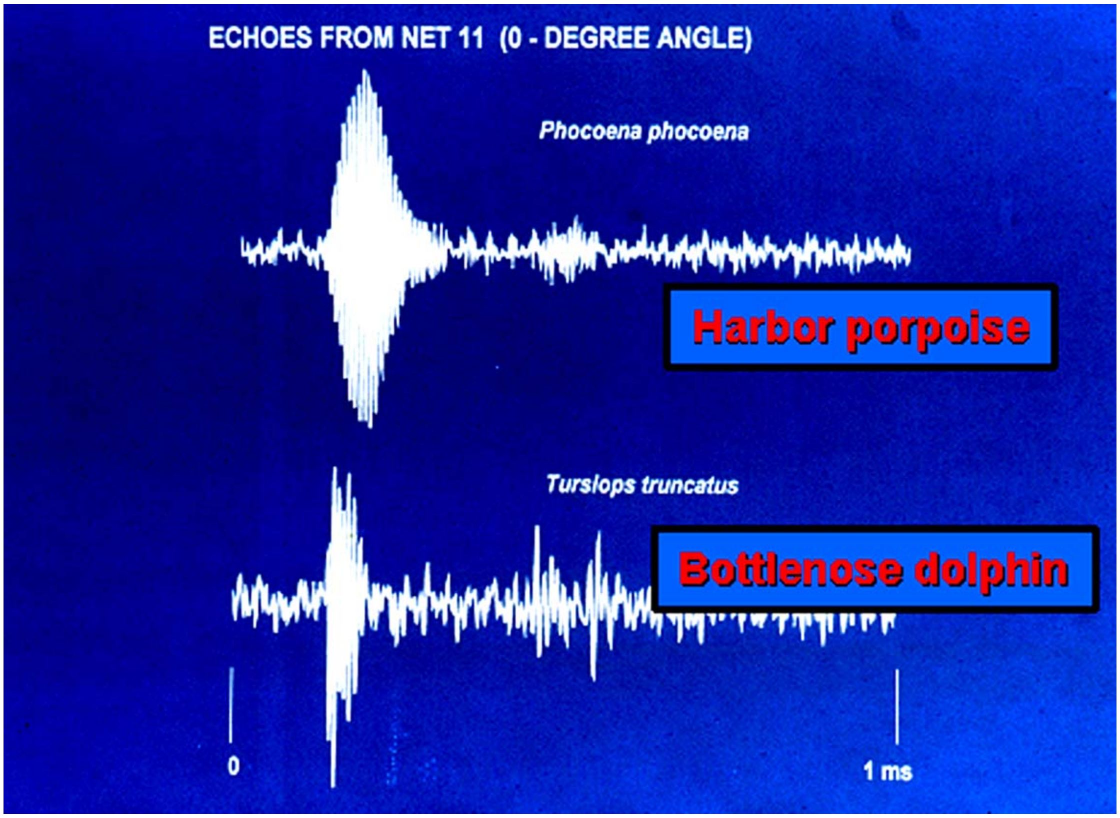

Figure 10. Studies of captive harbour porpoise echolocation click characteristics showed them to be different than those of bottlenose dolphins in duration, and other parameters.

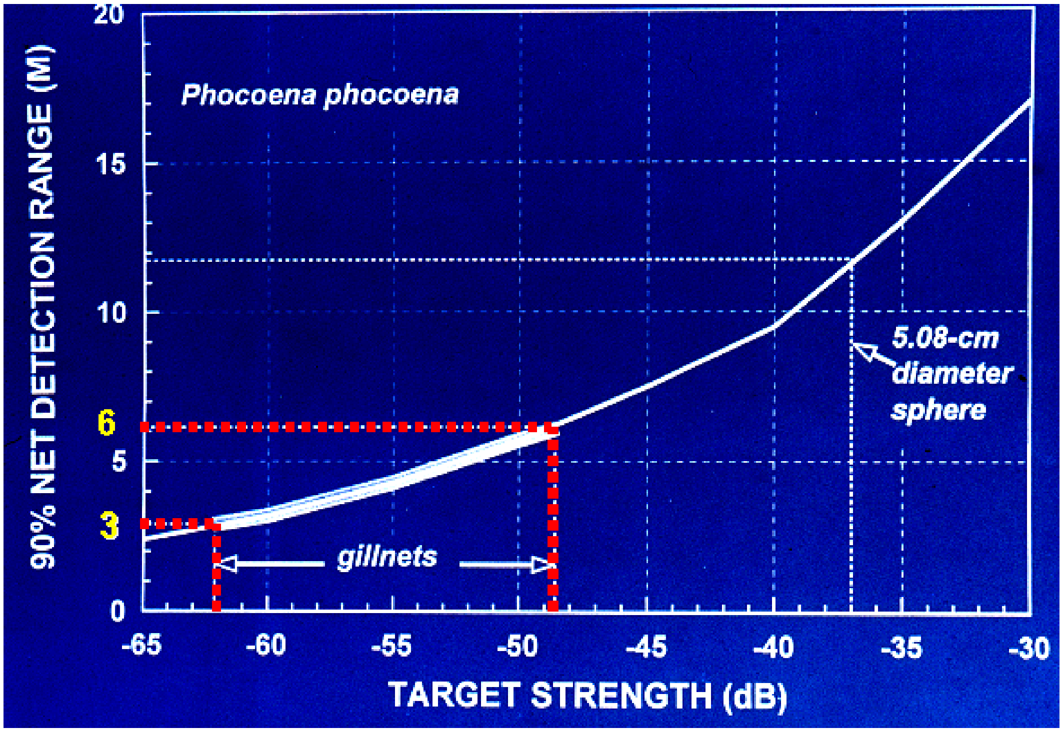

Figure 11. Studies of captive harbour porpoises showed that at best (perpendicular approach) these animals can detect gillnets at ranges of 3 to 6 meters.

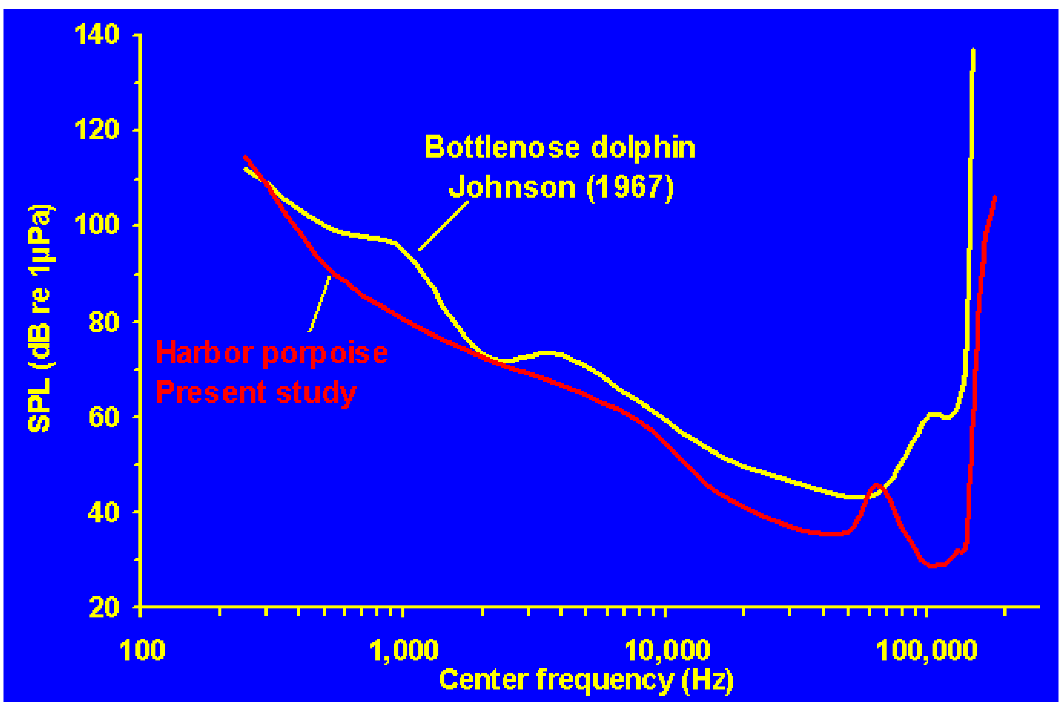

Figure 12. Studies of captive harbour porpoises showed that their hearing abilities are different than other small cetaceans, and more sensitive at higher frequencies (corresponding to the range of their echolocation system).

The Truly Alerting Device - TAD Pingers

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Pingers have been shown in all studies to work by driving porpoises away from nets, with a consequent reduction in the number of echolocation clicks that can be detected close to the pinger. There is evidence that porpoises often encounter nets without becoming entangled and anecdotal evidence suggesting that sometimes porpoises are silent and are then at higher risk of entanglement. A signal closely resembling a very brief train of porpoise clicks at 130dB re 1uPa repeated every 4 seconds has been shown to greatly (from 2.5 to 18×) increase the number of clicks detected beside this 'truly alerting device'. Alerting alone may be enough to reduce bycatch, but this is not known at present and fishery trials are needed. With a power consumption around 1% of a pinger a TAD would have a battery life several times longer and monitoring of TADs in use could be by manufacturer's date stamp only.

Workshop Discussion

Mr. Pleskunas presented the "truly alerting device" (TAD) which broadcasts a acoustic signal closely resembling a very brief train of porpoise clicks at 130dB re 1u Pa, repeated every 4 seconds. This allows for a much longer battery life. The practicality of the TAD remains to be determined although it is easy to build, deploy(it is light and small), keep and therefore perhaps more acceptable to fishers. It is difficult to keep traditional pingers in one piece and operational in real-life situations.

It was suggested that the TAD might be combined with hollow metal spheres so that once small cetaceans are alerted by the TAD signal, they will be better able to perceive the signals reflected from the omnidirectional target spheres on the net.

At the recent ECS conference Nick Tregenza had a poster that showed that a TAD attached to a T-POD (autonomous echolocation click detector)could be used in experiments to compare porpoise echolocation with and without exposure to the TAD's signal. Such a system could be used to assess whether the TAD functions as another form of "dinner bell" to alert the cetaceans to the presence of a net (although this seems to apply more to pinnipeds).

Mr. Pleskunas recommended that researchers should model mitigation devices such as this to meet the operational demands of fishermen, not *vice versa*. Such an approach should yield the greatest acceptance and compliance.

Reference: Tregenza and Fisher. 2004. TAD effect. European Cetacean Society conference poster.

The "Interactive" Pinger, An Environmentally Friendly Alternative to Beacon-Mode Pingers

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Acoustic alarms (pingers) have proven to be efficient to mitigate porpoise bycatch, and will become progressively mandatory in gillnet fisheries in the North Sea and part of the Baltic Sea from June 2005. This study tested an "interactive" pinger concept, where displacement sounds are only emitted when the pinger is triggered by porpoise bio-sonar. It was conducted in 2002-05 on free-ranging porpoises at Fyns Hoved, Denmark. The behaviour responses of the porpoises were evaluated through their surfacing positions relative to the pingers. The surfacing positions were obtained using a digital theodolite from a 20 m high cliff. Sub-project 1 tested the displacement effect of a single device; subproject 2 the behaviour of porpoises around a linear array of four pingers in a simulated bottom-set gillnet setup. Only data within a 400 m range of the pingers were analysed, based on the theoretical auditory detection range and precision of tracking. The displacement efficiency was evaluated by the porpoises' overall movement pattern, the median of the minimum approach distance to the pinger (MAD), and the comparison of several parameters between the dives where a displacement sound was emitted (S-dives) and dives during *Baseline* conditions (B-dives). In both sub-projects the porpoises were significantly displaced from the near vicinity of the active pinger compared to baseline, but not expelled from an excessively large area (MAD: sub-project 1 ~114 m; sub-project 2 ~75 m). A significant effect on dive-parameters in the S-dives compared to B-dives disappeared in the subsequent or second dive after the S-dive. The sound emissions from a single interactive pinger were equivalent to only 1-3% of the sound emissions from a traditional, beacon mode pinger, representing a considerable reduction in noise pollution. This reduced emission rate will lower the risk of seal damage to fishing gear (less "dinner bell" effect).

Workshop Discussion

The "interactive pinger" is designed to emit the same acoustic signals as the Aquamark 100, but only when triggered by the echolocation signals of a nearby harbour porpoise. In this presentation preliminary field tests were described with intriguing results.

The concept requires porpoises to vocalize, thus the need for "enticing" sounds to stimulate the animals to make sounds, which increases the drain on the unit's battery

These pingers may not scare all porpoises away, but instead only those that have not become habituated to the sounds of this pinger (e.g., a habituation effect; see next talk).

Several participants suggested that the documented occasional “unresponsive” porpoises might be those with hearing impairment.

Habituation and Habitat Exclusion of Harbour Porpoises in a Simulated Gillnet Fishery with Pingers

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A large number of harbour porpoises are by-caught in gillnets. As a consequence, use of pingers is now mandatory in a wide range of EU gillnet fisheries. The purpose of this study was to investigate habitat exclusion and habituation to pingers in a simulated fishery where pingers were deployed and recovered repeatedly. The fieldwork was carried out from mid April to mid October 2005 in a high density porpoise area of the Great Belt, Denmark.

Acoustic data loggers (T-PODs) detected the presence of harbour porpoises. Seven T-PODs were deployed in two impact areas (0.6 km^2) and at three control stations. Distances from control station to nearest pinger were 2.5, 3 and 5 km, respectively. Fifteen SafeWave 30-160 kHz sweep, 155 dB (Figure 13) and 55 Airmar 10k Hz 132 dB pingers (Figure 14) were deployed in each area. To simulate fishery procedures the pingers were cyclically activated and deactivated for 50 days, each ON or OFF period lasting between one and five days.

The presence of harbour porpoises was significantly lower during periods with active pingers. Harbour porpoise encounters gradually increased from 6% and 8% of the control station levels during the first exposure period to 62% and 32% during the last exposure period for the Safewave and Airmar pingers, respectively. This indicates a gradual partly habituation to both pinger types during the 50 days experiment. Similar responses to both pinger types were found.

Pingers also affected the control areas, where median click rates decreased by 30% when pingers were active compared to inactive. This effect, however, was less pronounced for the encounter rate.

Pinger sounds could be measured about 2 km away, while porpoise behaviour was altered up to 5 km away. This indicates that the effect on porpoise behaviour may extent outside the acoustic range of pingers and that the maximum range of effect remains to be studied.

Previous studies have shown that porpoises habituate to pingers that are continuously active for a long period of time. Our results indicate that porpoises also habituate to pingers when these are activated and deactivated cyclically, resembling real fishery, and that habitat exclusion is an important consideration.

Workshop Discussion

Studies have shown that harbour porpoises habituate to pingers that are continuously active for a long period of time. However, pingers may still work as "alerting devices" (see previous talks), even though harbour porpoises habituate to them and are not excluded from a pinger array over time.

Several participants suggested that long-term exposure to pinger sounds may cause reduced fitness due to disturbance-related stress.

A participant suggested that pingers may change harbour porpoise echolocation behaviour and hence "reduced numbers", based on T-POD counts (even if numbers of porpoise near the T-POD actually remained the same). However, visual cues during field experiments suggest the presumed decline in echolocating porpoises is a true decrease in local abundance.

A participant suggested that context (ambient noise, animal activity) is important, and might explain the difference among the harbour porpoise distribution patterns in response to pinger sounds.

Many felt that the evidence of habitat exclusion and other behaviour changes makes it clear that the goal(s) of this type of mitigation approach must be clear before they are implemented.

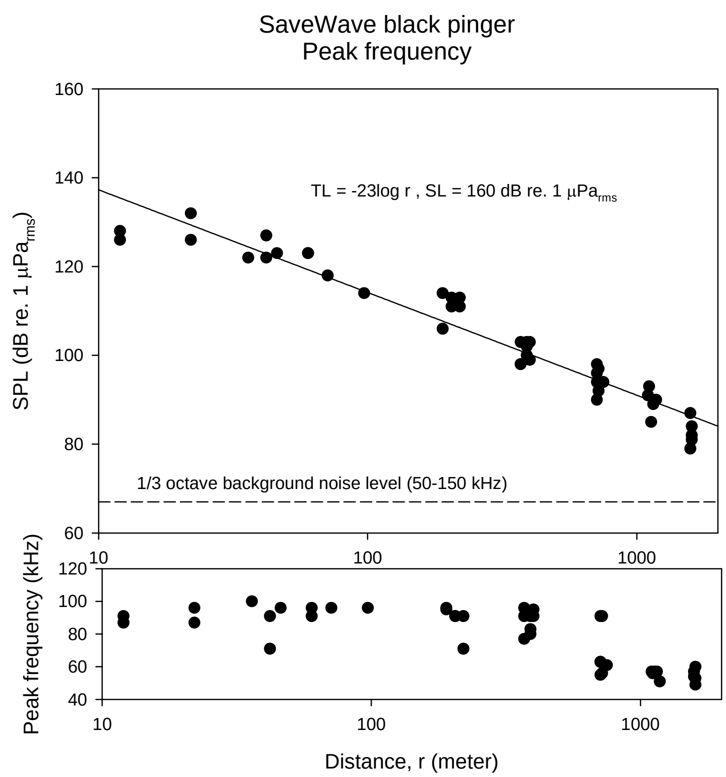

Figure 13. Detection curve for sounds from a SaveWave 30-160 kHz pinger, measurable to 1600 m. The signal was heard by human listeners to at least 2000 m, and would be theoretically detectable to approximately 10 km.

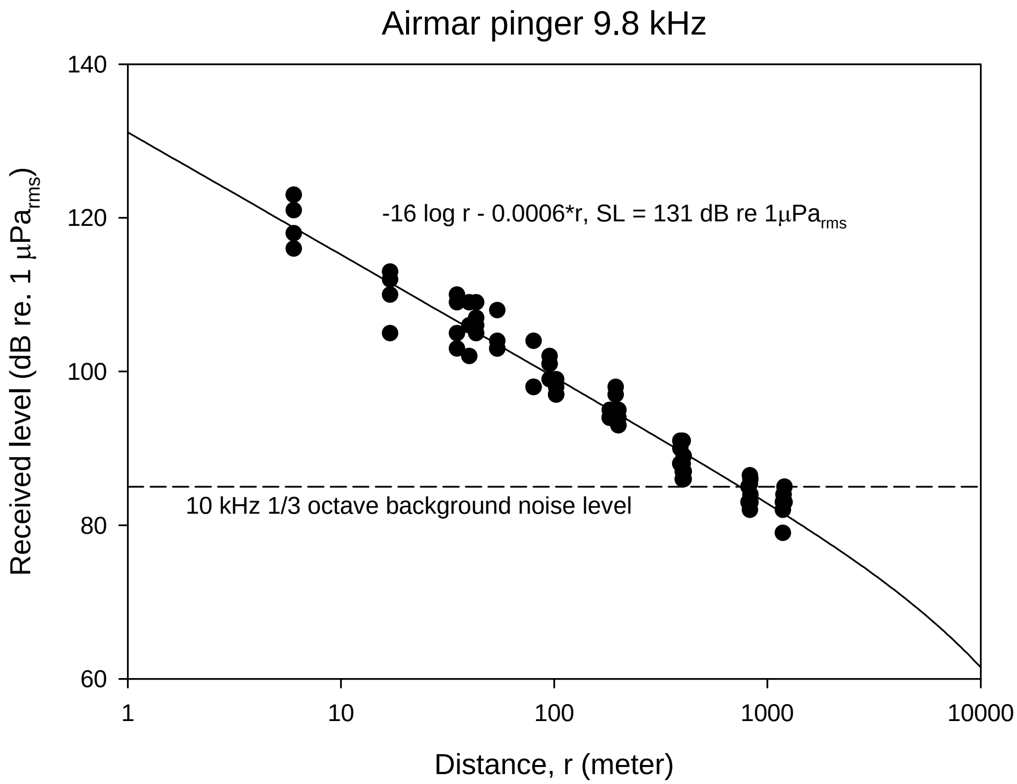

Figure 14. Detection curve for sounds from a Airmar 10 kHz pinger, measurable to 1200 meters. The signal was heard by human listeners to 2000-4000 meters, and would be theoretically detectable to approximately 10 km

Operational Methods To Reduce Bycatch

Jack Lawson
Department of Fisheries and Oceans, Northwest Atlantic Fisheries Centre, P.O. Box 5667, St. John's, NL, Canada A1C 5X1

In addition to mechanical (e.g., modified nets, fish pots) and acoustic (e.g., pingers) means to reduce bycatch, fisheries managers must also consider operational methods whereby certain fisheries types, fishing areas, and/or fishing seasons are limited or closed (Figure 15). Such temporal or spatial reductions in fishing effort can be triggered in reaction to bycatch occurrence, or proactively where it is predicted that bycatch will occur as a result of marine mammal aggregations. In either case, there must be evidence that these closures will affect an overall reduction in bycatch, and not simply a redistribution of fishing effort (and bycatch) to other areas or times. While closed areas and times may coincide with, or be the basis for, conservation strategies such as marine reserves, conservation areas, or protected areas, this will not always be the case. In addition to managing effort, fishers might deploy their gear in non-traditional ways to reduce bycatch. For instance, it has been suggested that gillnets designed so that their bottom margins are a metre above the seafloor might reduce the entanglement by bottom-feeding porpoises (Figure 16).

These operational methods are adaptive, and do not have to be onerous for fishers if care is taken in design and collaboration. For instance, in several Canadian fishing areas, there are marked, but short-term increases in porpoise bycatch in several fisheries. By altering the timing of the fishery by a few weeks, or suspending fishing effort in the few areas of highest traditional bycatch, porpoise bycatch could be reduced without a significant reduction in landed value. While such operational methods to reduce bycatch may be less costly for fishers in developing countries compared with new gear or pingers, nonetheless these methods do assume that enforcement is possible either through observer coverage or remote surveillance. As for other mitigation approaches, consultation with and support from affected fishers is critical to their success.

Workshop Discussion

Dr. Lawson presented a variety of operational methods that might be useful in reducing small cetacean bycatch in net fisheries. These approaches might require little additional equipment on the part of fishers, and in the case of spatial or temporal fishing suspensions, no changes to gear deployment methods at all.

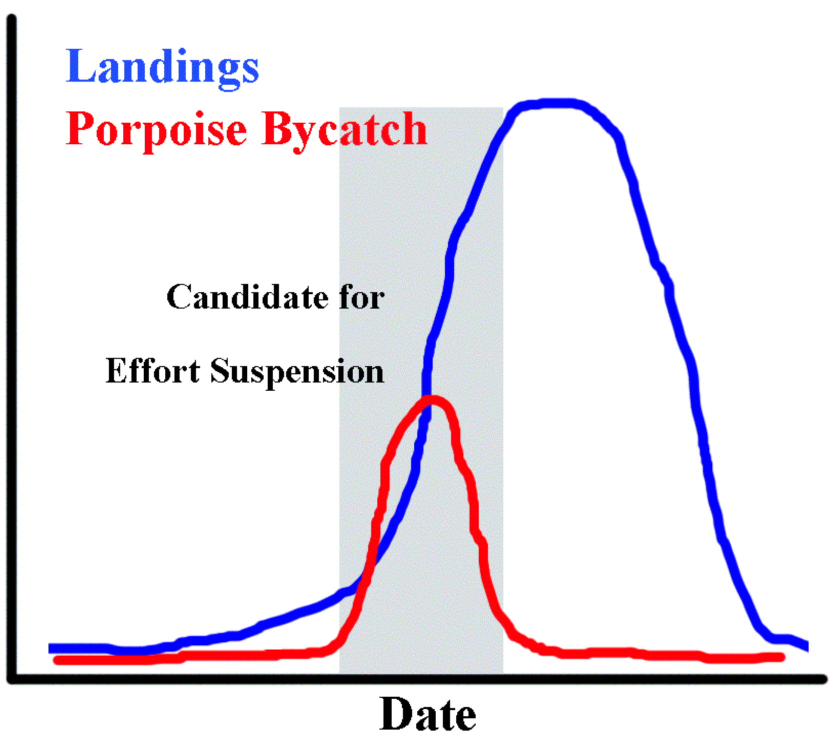

Figure 15. An operational method to reduce bycatch can be to alter the timing of the fishery by a few weeks, or suspending fishing effort in the few areas of highest traditional bycatch, such that porpoise bycatch could be reduced without a significant reduction in landed value.

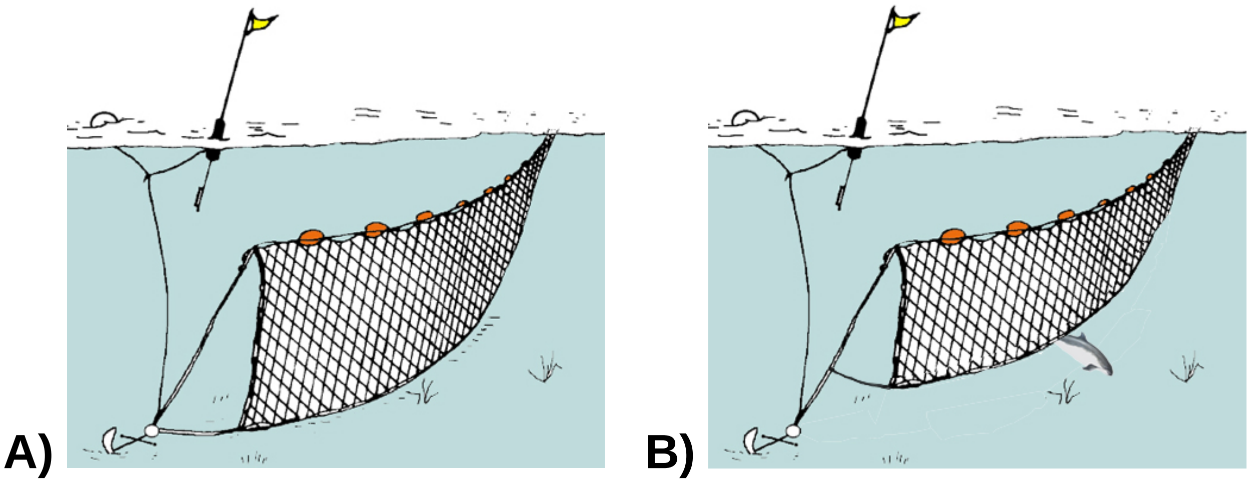

Figure 16. A gear modification as simple as deploying gillnets one meter off the seafloor (B) may reduce bycatch by allowing bottom-feeding small cetaceans to pass below the net.

Challenges to Implementing Marine Mammal Take Reduction Plans in the U.S.

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Reducing bycatch of marine mammals in U.S. fisheries presents many challenges. Despite a legislative mandate to reduce serious injury and mortality (bycatch) of marine mammals in commercial fisheries to insignificant levels approaching a zero rate, the process of developing and implementing take reduction plans outlined in the Marine Mammal Protection Act (MMPA) is extremely data and resource intensive. As a result, it has only been implemented in some of the fisheries for which the process is mandated. Specific challenges at the plan drafting stage include having adequate information not only on what species or stocks are being impacted by fishing activities, but also on the nature of the fishery interactions so as to identify and gauge the potential effectiveness of various mitigation strategies. Confidence in the data used to develop the plan is key to obtaining support by fishermen and the public to fully implement the plan, especially if the strategies developed will have significant impacts on fishing effort and harvesting capabilities. Legal challenges include fully integrating marine mammal mitigation strategies into the overall fishery management plan, which may also include measures to prevent overfishing of the target species as well as measures to reduce bycatch of other species, such as sea turtles, seabirds, and non-target finfish, all of which are implemented under different legal authorities. Management challenges include having adequate financial and personnel resources to convene the take reduction teams required by law to assist in the development of take reduction plans, to implement the plans in the strict timeframes mandated by the MMPA, to enforce the regulatory requirements of the plan, and to monitor the effectiveness of the plan in meeting its bycatch reduction objectives. This requires placing a high priority on marine mammal mitigation activities within a system of other competing fishery management requirements and resource needs. Challenges to public support and compliance with the plan by all affected fishermen include effective communication on the requirements of the plan, and ongoing monitoring to evaluate fishery compliance and the effectiveness of the mitigation measures. In discussing these challenges, the author provided a summary of the legislative requirements of the MMPA for convening Take Reduction Teams and developing Take Reduction Plans, and some specific examples of challenges regarding efforts to reduce marine mammal bycatch in mid-Atlantic and southeastern U.S. fisheries.

Workshop Discussion

Participants agreed that stakeholder involvement early in the management design and implementation process is critical to its success. In the United States, the statutory mandate requiring the government to take action, even in the absence of consensus from stakeholders on what action should be taken, has been a strong motivational factor in getting representatives to participate in the development of take reduction plans.

Participants reiterated that monitoring and enforcement of regulatory requirements to reduce marine mammal bycatch is critical. Long-term success requires an adaptive management approach, where teams are reconvened at periodic intervals to assess the effectiveness of the take reduction plans and implementing regulations, and to make changes as necessary. As currently implemented, take reduction team membership is for “life” - and indeed such continuity is essential for the success of the adaptive management process.

Several participants felt that an “industry pays” requirement for monitoring and mitigation should be pursued, as it invokes enhanced stakeholder buy-in and acceptance of the data from fishermen. There are currently questions as to the priority for government regulators to invoke a take reduction team meeting for a fishery or fisheries when bycatch levels are below Potential Biological Removal (PBR) levels, when there are other fisheries where either take reduction teams do not exist or where take reduction plans are proving ineffective. It was noted that there must be sufficient flexibility in the regulations to allow ongoing bycatch reduction research on gear or fishing techniques, even if it allows fishermen to fish in otherwise closed areas. Regulations must also be written such that all management options remain open, should conditions change. And, when developing such regulations, there must be encouragement of research to further refine management strategies.

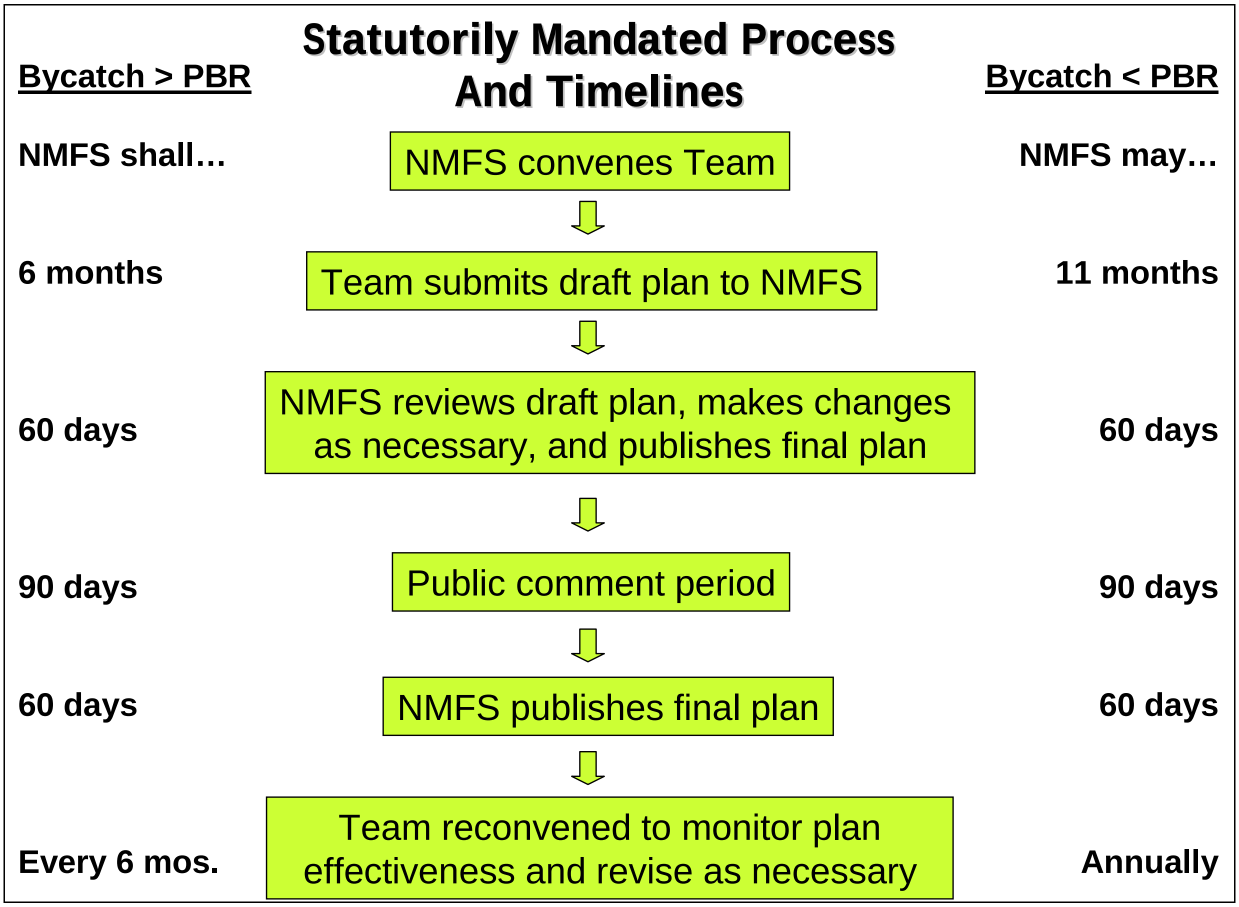

Figure 17. NMFS Take Reduction Plan development and implementation is driven by strict timelines. PBR is the Potential Biological Removal level for the population of interest.

Harbour Porpoise Bycatch Management in Denmark, 2005

Steven Benjamins
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In 2005, the Danish government released an action plan to reduce bycatch of harbour porpoise (*Phocoena phocoena*), in response to new European Union legislation on small cetacean bycatch mitigation measures that came into force in 2004. This E.U. legislation calls for introduction of pingers in various fisheries across Europe, the development of a marine mammal bycatch observer scheme, and a gradual phase-out of pelagic driftnets in the Baltic sea.
The Danish action plan was drafted in close cooperation with representatives of the Danish Fishermen's Association. An important component to this plan is a government programme to provide financial support for purchase and deployment of approximately 12,000 pingers, which will be managed by the Danish Fishermen's Association for their members. Duration and reliability trials are currently underway to determine which

pinger is best suited for widespread use in Danish gillnet fisheries. Technical difficulties will need to be addressed to ensure widespread use by fishermen. In addition, there remains scepticism among many fishermen that bycatch of harbour porpoise is a problem. So far, the Danish fisheries inspection agency has not received a clear mandate on how to enforce these new pinger regulations.
However, various research projects that are currently underway will hopefully address some of the remaining problems with this new bycatch mitigation programme.

Workshop Discussion

There was discussion amongst participants as to the Danish government's large purchase of pingers. Concerns about stakeholder acceptance, efficacy of the units chosen, and habitat impacts were raised.

A participant described how the relatively impoverished Philippine fishers may have greater reluctance to adopt mitigation measures at the cost of landed value, and their government lacks the regulatory framework to enforce bycatch reduction.

Dr. Merrick noted that economic analyses of mitigation impacts are critical to U.S. take reduction team deliberations.

It was pointed out that mitigation measures can add value to fisheries, not just costs! For example, circle hook usage results in better tuna catches without the added cost of removing other non-target species, as would be the case with regular hooks).

Modelling of Mitigation Effectiveness

Jack Lawson
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Non-target bycatch, such as marine mammals, is perceived to be a significant issue in many fisheries. In response to this, there has been increased research in means to reduce or eliminate such bycatch. However, much less emphasis and study has been directed towards addressing questions underlying the reasons for, and measure to eliminate, such bycatch. Stakeholder support for efforts to mitigate bycatch can be better achieved through a number of steps: (1) clearly define the bycatch problem before implementing mitigation - precautionary approaches notwithstanding (using trained observers, bycatch reporting, surveys of marine mammal abundance), (2) clearly define bycatch mitigation objectives (e.g., zero mortality vs. sustainable bycatch, evidence of recovering populations), (3) quantify mitigation impacts using risk analyses (e.g., when is mitigation no longer necessary, or of sufficient benefit relative to cost?) where all costs of mitigation approaches must be considered (current and future efficacy, price, logistics, costs to marine life, costs to fishermen), (4) if possible, provide either a staged set of mitigation approaches (from least to most costly or invasive), or a variety of options, (5) conduct research prior to, during, and after mitigation is used. It must be recognized that any management plan must be robust and flexible enough to accommodate new research findings, and the possible changing priorities of stakeholders and governments.

Workshop Discussion

Participants agreed with the presenter that a clear definition of the bycatch problem must be achieved before implementing mitigation measures, precautionary approaches notwithstanding. Such a definition is only possible with information gathered through trained observers, adequate bycatch reporting, surveys of mammal abundance, and other research.

Participants also agreed that a clear definition of the bycatch mitigation objectives must exist. E.g., is the goal of the mitigation to yield zero mortality, sustainable bycatch, or some other outcome? Due to the nature of fishery or social factors, bycatch may be unavoidable completely, so scientists may have to model their mitigation recommendations for sustainable or recoverable marine mammal losses.

Dr. Lawson pointed out that while rarely done in practice, all costs of mitigation approaches must be considered by managers. These include the current and future efficacy of the mitigation methods, the price of implementing the methods, the logistical requirements to deploy and monitor (and enforce!) the mitigation measures, the costs to marine life (such as through habitat loss for some species from ensonification by pingers), and the costs to fishermen in terms of both implementation and lost productivity.

Ideally, scientists should be able to provide managers with either (1) a staged set of mitigation approaches (from least to most costly or invasive), or (2) a variety of mitigation options from which to choose (Figure 18).

Now it is possible to quantify mitigation results and impacts using a variety of risk analysis approaches.

Several participants noted that it is essential to conduct research prior to, during, and after mitigation measures are employed. Scientifically-based monitoring is essential to determine the need for, or success of, mitigation measures.

Dr. Perrin pointed out that in some countries, it is difficult to differentiate incidental from intentional bycatch – especially where incomes are extremely low and the bycaught animals may represent an important source of food or additional income.

Finally, Dr. Lawson raised the issue that there is often a temporal component to a bycatch mitigation strategy: how long is the mitigation plan designed to affect its objective[s]? The duration of the planned mitigation efforts may have significant impacts on its chances of success, the risk to the targeted marine mammal population, and its acceptance by managers and stakeholders.

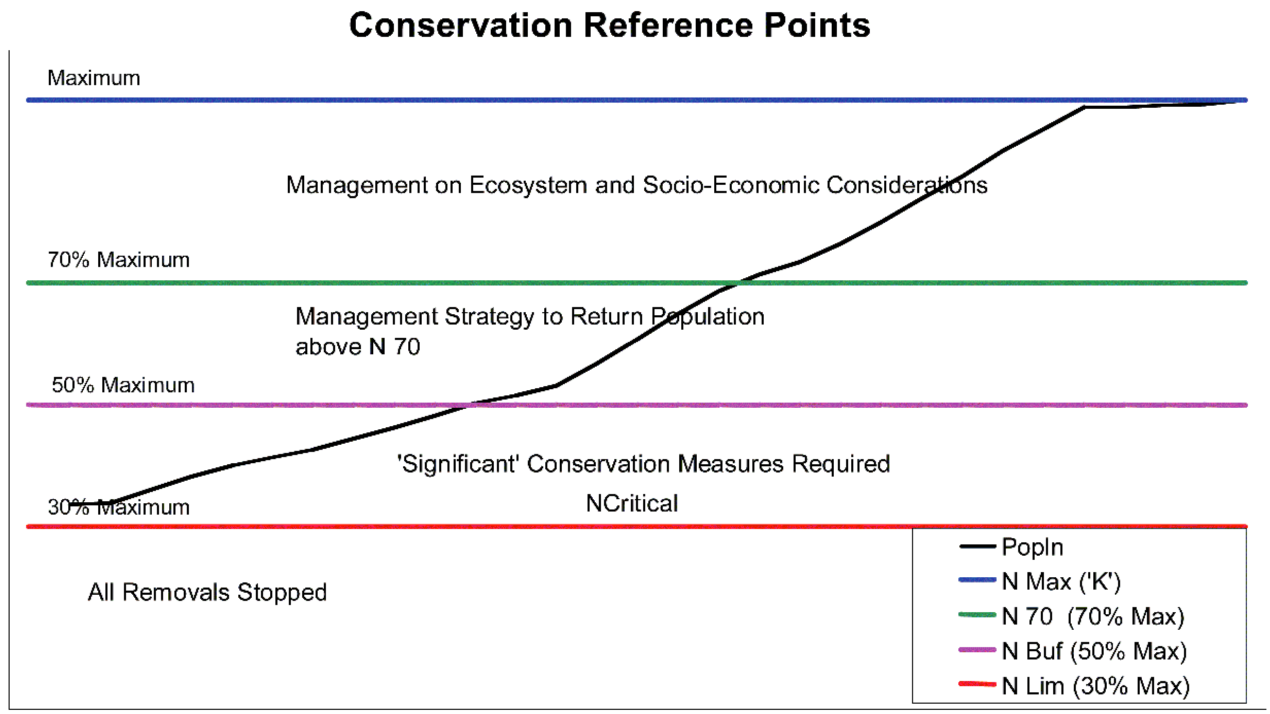

Figure 18. A Canadian marine mammal population management strategy based on clearly-defined and measurable abundance reference points. Different marine mammal population levels trigger different management actions, and implicit in the strategy is the concept of "risk" if the indicated actions are not enacted.

APPENDIX A: Workshop Agenda

0900 - **Scope of the Small Cetacean Bycatch Problem Worldwide**
As this aspect of the topic has been covered in detail by several workshops and scientific committees recently, the bycatch workshop covered topics where much effort is now concentrated

0930 - **Why and How Are Small Cetaceans Caught in Fishing Gear?**
A review of the reasons why, and the ways how, small cetaceans are bycaught in gear. Are small cetaceans caught in nets due to a detection or target classification problem? Why are dolphins and larger whales caught in pelagic trawls?

1015 - **Bycatch Mitigation Approaches**[1]

(1) Mechanical methods to reduce bycatch
- new net technologies to facilitate release or exclusion
- alternatives to gillnets for some fisheries (e.g., “fish pots” for groundfish)
- “high density nets” to enhance their detection by small cetaceans

(2) Acoustical Methods to Reduce Bycatch
- “traditional” pingers
- “responsive” pingers

(3) Operational Methods to Reduce Bycatch
- modified net deployment patterns, depths, etc.
- closed areas, seasons, or times

1515 - **Experiences in the Challenges of Management and Public Support of Mitigation Implementation**
- voluntary implementation
- legal approaches

1600 - **Modelling of Mitigation Effectiveness**
- risk analysis (e.g., when is mitigation no longer necessary, or of sufficient benefit relative to cost? How do we test mitigation effectiveness - when do we know these things work?)

1700-1730 - **Wrap up and Final Discussions•**
can there be different objectives for mitigation (i.e., zero mortality vs. sustainable removals)

[1] A review of the **practicality** and **costs** of these approaches took place during these discussions, including issues of cost (e.g., cost of gear, cost of lost fishing effort, cost of reduced fish catch), technical challenges (e.g., support equipment and materials required, battery disposal for pingers), and collateral impacts on other marine fauna.

Appendix B: Registered Attendee List

(Workshop presenters indicated with bold typeface.)

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