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Source: Journal of Mammalogy, 89(3) : 541-548

Published By: American Society of Mammalogists

URL: https://doi.org/10.1644/07-MAMM-S-315R1.1

Journal of Mammalogy, 89(3):541–548, 2008

THE LOOMING CRISIS: INTERACTIONS BETWEEN MARINE MAMMALS AND FISHERIES

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Direct fisheries interactions pose a serious threat to the conservation of many populations and some species of marine mammals. The most acute problem is bycatch, unintended mortality in fishing gear, although this can transition into unregulated harvest under some circumstances. A growing issue in some fisheries is depredation, in which marine mammals remove captured fish from nets or lines. Depredation reduces the value of catch and may lead to a greater risk of entanglement and the potential for retaliatory measures taken by fishermen. The conservation threat caused by direct fisheries interactions is most dire for small populations of cetaceans and dugongs. Immediate action is needed to assess the magnitude of bycatch, particularly in many areas of Africa and Asia where little work has been conducted. New and innovative solutions to this problem are required that take account of the socioeconomic conditions experienced by fishermen and allow for efficient transfer of mitigation technology to fisheries of the developing world.

Key words: bycatch, cetaceans, conservation, depredation, fisheries, marine mammals, pinnipeds

Direct fisheries interactions pose a serious threat to many populations of marine mammals. The threat is particularly acute for small cetaceans and dugongs, because of their slow life histories and limited potential rates of increase. The serious nature of this threat is underscored by the recent extinction of the baiji (*Lipotes vexillifer*), a freshwater dolphin endemic to the Yangtze River, China. The extinction of this species was due, in large part, to bycatches in a variety of fisheries (Turvey et al. 2007).

At its annual meeting in Anchorage in May 2007, the Scientific Committee of the International Whaling Commission (International Whaling Commission, 2008:54) reflected on the demise of the baiji:

> The Scientific Committee expressed its great concern that, despite extensive scientific discourse for more than two decades, little effort was made to implement any real conservation measures for this species. In hindsight, the extinction of this species is not surprising; species cannot be expected to save themselves. The extinction of this species (the first human-caused cetacean extinction) also underscores the risk to other endangered species of small cetaceans and particularly to the vaquita. Such highly endangered species require swift and decisive human intervention before they are lost forever.

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The extinction of the baiji, the sole representative of the family Lipotidae, is a stark reminder of the vulnerability of small populations of mammals to a variety of anthropogenic threats. The baiji faced a long list of such threats, including habitat modification, range fragmentation, depletion of prey resources, and bycatch. Any and all of these threats could drive a marine mammal species to extinction.

In this paper I focus on one of the most pressing anthropogenic threats facing the world's marine mammals—direct interactions with commercial fisheries. Other threats have been reviewed elsewhere, including excellent summaries of the effects of habitat modification and ecological interactions with fisheries, published previously in this journal (DeMaster et al. 2001; Harwood 2001).

In using the phrase "direct interactions," I mean cases in which marine mammals come into physical contact with fishing gear, typically with adverse consequences for the animal, the catch, or both (Beverton 1985). For example, a marine mammal may become entangled or entrapped in fishing gear, resulting in the serious injury or mortality of the animal. If the animal is subsequently discarded, the process is termed bycatch. If the animal is captured unintentionally but retained for consumption or sale, the process is referred to as nontarget catch (Hall 1996). As noted below, in some areas of the world marine mammals are 1st taken as bycatch, then retained as nontarget catch, and finally become the target of the fishery (Dolar et al. 1994; Leatherwood and Reeves 1989; Razafindrakoto et al. 2004; Read et al. 1988). Marine mammals also may remove or damage fish captured in the gear, resulting in a reduction in the value of the catch (Read 2005). This behavior is known as depredation. Depredation can become a conservation issue if it results in an increased probability of bycatch or if it causes fishermen to take retaliatory measures against marine mammals.

In considering interactions between marine mammals and fisheries, it is important to note the profound ecological changes that the world's fisheries are causing to the structure and function of marine ecosystems. Fisheries removals have resulted in significant changes in trophic structure, species assemblages, and pathways of energy flow (Jackson et al. 2001; Myers and Worm 2003; Pauly et al. 1998). As reviewed by DeMaster et al. (2001), these ecological changes may have important and likely adverse consequences for populations of marine mammals.

At the same time, there is growing recognition within both the scientific and policy communities that traditional single-species approaches to management are inadequate. In the United States, for example, marine fisheries and marine mammals are typically managed under separate legislative mandates and sometimes by different agencies; these management schemes often have conflicting goals. There have been many recent calls for a more integrated and holistic approach to managing marine ecosystems and our impacts on them and, in particular, the concept of managing ecosystems themselves, rather than their individual components, has become increasingly popular. However, it is fair to say that although this is a laudable goal, we have no clear idea of how to bring about such change. Until we develop a more holistic approach, we will continue to manage 1 species at a time.

In this paper, I review the conservation threats to marine mammal populations caused by direct interactions with fisheries and list some of the current scientific, management, and policy needs in this area.

Threats to Marine Mammals from Fisheries Interactions

Direct fisheries interactions can pose a threat to marine mammal populations in several ways. Here I focus on 3 types of threat: bycatches from small populations, the transition from bycatch to market value, and depredation.

Bycatches from small populations.—The bycatch of marine mammals is a frequent event in the world's fisheries. In the United States, for example, the annual bycatch of marine mammals was more than 6,000 individual animals between 1990 and 1999 (Read et al. 2006). Most of these marine mammals were killed in gill-net fisheries. If American fisheries are representative of those in the rest of the world (a debatable proposition, to be sure), the global bycatch of marine mammals likely numbers in the hundreds of thousands, mostly in gill nets (Read et al. 2006).

Of course, large bycatches are not necessarily unsustainable. In particular, some pinniped populations can withstand very large bycatches. This is due, in large part, to the relatively high rates of potential population growth exhibited by some seals and sea lions, especially compared to that of cetacean and sirenian populations. The total potential biological removal for all stocks of marine mammals in the United States is almost 60,000 annually (Table 1). The potential biological removal is the number of animals that can be removed each year without preventing a stock from reaching or maintaining its optimal sustainable population level (Wade 1998). Only about 12% of United States marine mammal stocks (almost all cetaceans) experience bycatches that exceed their potential biological removal levels (Read and Wade 2000). In the remainder of this paper, therefore, I focus on unsustainable bycatches and specifically on cases where removals exceed a population's capacity for population growth.

Table 1.—Potential biological removal levels for marine mammals in the United States. Potential biological removal levels are calculated as a product of a minimum estimate of population size, potential rate of increase, and a recovery factor that takes into account population status. All data are taken from 2006 National Oceanic and Atmospheric Administration stock assessment reports (http://www.nmfs.noaa.gov/pr/sars/). Largest potential biological removal and Stock refer to the greatest allowable removal level for any stock in that region.

	Potential biological removal		
Region	Total	Largest	Stock (management unit)
Atlantic	11,736	5,493	*Phoca vitulina*
Pacific	22,055	8,333	*Zalophus californianus*
Alaska	25,010	15,262	*Callorhinus ursinus*

I wish to focus particular attention on small populations of marine mammals, which are inherently more vulnerable to bycatch removals than are larger demographic units. Small populations also are vulnerable to stochastic processes (e.g., inbreeding, natural disasters, or disease outbreaks) that may cause them to spiral toward extirpation. Some of these populations may have been reduced in size because of past removals from directed harvests, bycatch, or other human activity. Other populations of marine mammals occur naturally in small numbers, however, but are equally at risk. For example, some tropical delphinid cetaceans, such as false killer whales (*Pseudorca crassidens*), seem to occur around islands or atolls in very small and isolated populations (Barlow 2006). In such cases, understanding rates of connectivity among populations is critical to assessing the sustainability of removals. It is important to note that cetaceans and sirenians are particularly vulnerable to removals (such as bycatch) because of their limited rates of potential increase (Eberhardt and O'Shea 1995; Reilly and Barlow 1986).

The dugong (*Dugong dugon*) provides an excellent example of the threats posed to small populations of marine mammals from bycatches. Throughout most of its range, this species exists as relict populations, isolated by large areas in which dugongs have been extirpated (Marsh et al. 2002). Bycatch in gill nets is a significant, but largely unquantified, cause of mortality in many areas and is one of the primary threats to the existence of this species (Marsh et al. 2002). In many areas dugongs become entangled in large-mesh gill nets set by fishermen working from small, open boats. Such fisheries are poorly documented and in most developing countries there is seldom any attempt to estimate removal levels, let alone address the conservation consequences of the problem.

As noted above, pinniped populations tend to be more resilient to bycatch removals than other marine mammals because of their relatively high potential rates of increase. Nevertheless, some pinniped populations, such as the Australian sea lion (*Neophoca cinerea*) and New Zealand sea lion (*Phocarctos hookeri*), are impacted by direct fisheries interactions (Wickens 1995), with some evidence of population decline in the latter species (Chilvers et al. 2007). Indeed, one of the most endangered mammals is the Mediterranean monk seal (*Monachus monachus*), of which approximately 500 remain in the eastern Mediterranean basin and along the coast of northwestern Africa (Gucu et al. 2004). Monk seals are threatened by mortality in a variety of fishing gears (typically gill nets), together with depletion of food resources caused by overfishing and retaliatory measures taken by fishermen after depredation (Woodley and Lavigne 1991).

The vaquita (*Phocoena sinus*), a small porpoise endemic to the Upper Gulf of California, is also threatened by bycatch. The plight of the vaquita is particularly dire because the species exists only as a single relict population. Vaquitas are taken as bycatch in a variety of gill-net fisheries throughout its restricted range (Rojas-Bracho et al. 2006). From previous surveys and estimates of bycatch, we have a clear sense of the urgency of the crisis facing the vaquita (reviewed in Rojas-Bracho et al. 2006). When these past estimates are combined with a plausible rate of increase (4%), the population has likely been declining by 10% annually and as few as 150 animals remained in 2007 (Jaramillo-Legorreta et al. 2007). We have very few years before the vaquita follows the baiji out of existence.

Large body size is not a safeguard against bycatch. North Atlantic right whales (*Eubalaena glacialis*) face 2 primary threats: entanglement in fixed fishing gear and ship strikes. Only about 350 of these animals remain in an increasingly urban habitat (Kraus and Rolland 2007). Unlike smaller marine mammals, entangled right whales do not die immediately. Instead, they may carry fishing gear for months or years, before succumbing to infection or starvation (Moore et al. 2007). Entangled right whales endure a long, painful, and senseless death. As my colleague Michael Moore has noted, the entanglement of right whales may be viewed as much an animal welfare issue as it is a conservation crisis (Moore et al. 2007).

Like many cases of bycatch in passive fishing gear, we do not understand why right whales are prone to entanglement (Johnson et al. 2007). Nevertheless, more than three-fourths of the population bear scars of previous encounters with fishing gear, primarily lobster traps and gill nets—and these are the lucky ones. Since 1986, 18 right whales are believed to have died as a result of entanglement (Kraus et al. 2005).

The search for solutions to right whale entanglement is not limited by resources; more than US$45 million was spent in implementing the right whale recovery program from 2003 to 2006 (Reeves et al. 2007). Despite this vast investment, and the implementation of complex measures designed to prevent bycatch, there is no evidence that the number of entanglements has been reduced and the population shows no sign of recovery.

In very small populations, such as those of the vaquita and right whale (and many dugong populations), bycatches need to be eliminated completely to avert extinction. Because these populations are so small, bycatches are rare events. Thus, most fishermen seldom encounter a right whale, vaquita, or dugong in their gear. The rarity of such events hampers our ability to prevent them; experimentation is impossible and it may even be difficult to persuade fishermen that entanglements occur. Not surprisingly, therefore, it has proven extraordinarily difficult to eliminate the entanglements experienced by these species. As noted by Johnson et al. (2007:382):

> This is the crux of a remarkably challenging conflict between right whales and humans: how can an entire industry be regulated, at sometimes significant costs, to eliminate an event that a fisherman rarely observes? Yet how can it not be regulated, if each event has significance for a species on the brink of extinction?

For both right whales and the vaquita, the course of action recommended by most scientists is to remove all potentially entangling gear from areas in which these species occur (International Whaling Commission 2008; Reeves et al. 2007). Such drastic solutions are expensive, politically unpopular, and, at least to date, untried.

The transition from bycatch to market value.—As noted above, in some fisheries marine mammals are 1st taken as bycatch, then later retained as nontarget catch as fishermen discover their value as food or bait, and finally become the target of the fishery itself. Such transitions are facilitated by poverty and the rapid dispersal of modern human communities, which can lead to abrupt changes in local fishing traditions. The dire state of many of the world's artisanal fisheries suggests that marine mammals are likely to become more frequent targets of directed harvest in the future (DeMaster et al. 2001).

This process has played out with small cetaceans in several areas of the world, including Peru (Read et al. 1988), Sri Lanka (Leatherwood and Reeves 1989), the Philippines (Dolar et al. 1994), and Madagascar (Razafindrakoto et al. 2004). In all of these areas, the resulting harvest of dolphins and porpoises is unregulated and likely unsustainable.

The Peruvian case study exemplifies the consequences of a transition from bycatch to a directed harvest. The 1st observation of small cetaceans in Peruvian fish markets was made by Robert Clarke, who noted that Burmeister's porpoises (*Phocoena spinipinnis*) were commonly offered for sale in the port of Chimbote in 1960 (Clarke 1962). Mitchell (1975) noted that these porpoises were taken as bycatch in a gill-net fishery for sciaenids (croakers and their allies). Beginning in 1966, the Peruvian Ministerio de Pesqueria monitored the sale of porpoises and dolphins and published annual statistics on the weight of the landings (catches) of these small cetaceans.

Small cetacean landings were at a relatively low and stable level in Peru during the late 1960s but then increased dramatically when the industrial fishery for anchoveta (*Engraulis ringens*) collapsed in 1972 (Read et al. 1988). It seems likely that displaced anchoveta fishermen (many of whom had been drawn to the coast by the rapid growth of this fishery) turned to using gill nets in coastal waters. By the mid-1980s, more than 500 metric tons of small cetaceans were finding their way into the markets, representing approximately 10,000 dolphins and porpoises each year (Read et al. 1988). The directed harvest included dusky dolphins (*Lagenorhynchus obscurus*), common dolphins (*Delphinus delphis*), bottlenose dolphins (*Tursiops truncatus*), and other species. These animals were taken by a variety of methods, including drift nets that were used to capture the dolphins, turtles, and sharks that became the target of this particular fishery. By the late 1980s a directed harpoon fishery had developed, and dynamite was being used to stampede schools of dolphins into drift nets (Van Waerebeek and Reyes 1990).

In 1990, after increasing concern over the status of dolphin and porpoise populations expressed by Koen Van Waerebeek and his colleagues, the Peruvian government passed regulations prohibiting the capture and trade of small cetaceans (Van Waerebeek and Reyes 1994). Unfortunately, the ban was not enforced and the harvest continued to expand. Because the harvest was now illegal, the Ministerio de Pesqueria stopped publishing official landing statistics. Nevertheless, independent monitoring of Peruvian ports suggested that 15,000–20,000 animals were killed annually between 1990 and 1993 (Van Waerebeek and Reyes 1994).

Since that time, it appears that the magnitude of the directed harvest has decreased, although it still continues (Van Waerebeek and Reyes 2002). Interviews with fishermen (Majluf et al. 2002) and direct onboard observations (Van Waerebeek and Reyes 2002) also indicate that bycatches still occur. Products from the directed harvest and bycatch are landed surreptitiously by fishermen and then used for human consumption and bait. To date no estimates of the abundance of dolphins and porpoises exist in Peruvian waters, preventing any scientific assessment of the effects of these removals. Nevertheless, it seems likely that the large directed catches of small cetaceans in the 1980s led to depletion of some populations (Van Waerebeek and Reyes 2002).

It is important to note that directed harvests of marine mammals are not necessarily unsustainable (e.g., Gerber et al. 2007). The cases I have identified here all share several common attributes, most importantly that bycatches developed into unregulated harvests that have never been formally assessed for their sustainability.

The Peruvian case study is instructive in several regards. First, the direct harvest developed as a major fishery collapsed, leaving many fishermen to look for alternative livelihoods. The directed fishery developed rapidly and continued while Peru was in the throes of civil turmoil in the 1980s. Attempts to eliminate the harvest were unsuccessful (because of lack of enforcement) and only served to make it more difficult to monitor its magnitude. And finally, as is also the case in Sri Lanka, the Philippines, and Madagascar, there has been no systematic assessment of the effects of these removals on affected populations.

Depredation.—In their review of marine mammal–fisheries conflicts, DeMaster et al. (2001) focused on trophic interactions and particularly cases in which marine mammals and fisheries were in direct competition. Such interactions can be intensified if marine mammals remove or damage fish captured in fishing gear, resulting in a reduction in the value of the catch. This behavior is known as depredation. Depredation becomes a conservation issue when fishermen take retaliatory measures against marine mammals to protect their catch or gear or when the act of depredation increases the probability of marine mammals becoming entangled in fishing gear.

Depredation by marine mammals is a common phenomenon in many coastal fisheries (Read 2005). Early research on marine mammal depredation focused on interactions between pinnipeds and salmonid fisheries (e.g., Briggs and Davis 1972; Brown and Mate 1983). Some coastal odontocetes also engage in this behavior (Lauriano et al. 2004; Nitta and Henderson 1993; Zollett and Read 2006).

A more recent phenomenon, and the issue I will focus on here, is depredation of longline fisheries by larger odontocete cetaceans, in which the mammals intentionally remove captured fish (Donoghue et al. 2003; Gilman et al. 2006). Longlines can be fished near the top of the water column (pelagic) or near the seafloor (demersal). The gear consists of a long mainline from which branch lines extend, each terminating in a baited hook. Pelagic longlines have proliferated greatly since the United Nations prohibition on the use of high-seas drift nets and are now the most common means of capturing swordfish (*Xiphius gladius*) and tuna (*Thunnus*) in the world's fisheries (Lewison et al. 2004). Global effort in pelagic longline fisheries for tuna was estimated as approximately 1.4 billion hooks in 2000 (Lewison et al. 2004). Depredation by odontocetes appears to be increasing in frequency, geographic extent, and severity in these fisheries.

This behavior may have significant adverse effects for fisheries and odontocetes. The catch per unit effort of Patagonian toothfish (*Dissostichus eleginoides*) in a demersal longline fishery near the Crozet Islands in the southern Indian Ocean (2,350 km south of Madagascar) was reduced by more than 40% when killer (*Orcinus orca*) and sperm (*Physeter macrocephalus*) whales interacted with the gear (Roche et al. 2007). Sperm whales appear to use the longline fishery to improve greatly their foraging efficiency by taking hooked fish near the surface as the gear is retrieved. The loss to the Crozet fishery due to depredation by sperm and killer whales was estimated as approximately US$5 million per year (Roche et al. 2007).

Odontocetes feeding on hooked fish may become entangled in the branch or main lines, or become hooked as they attempt to consume captured fish. In Hawaii, for example, false killer whales take tuna and other fishes from pelagic longlines (Nitta and Henderson 1993). This behavior leads to entanglement (Baird and Gorgone 2005) and, occasionally, to mortality. Although only a small number of animals are killed each year in this manner, the population is very small (Barlow 2006), so a relatively large proportion of the population is removed annually, and the number taken exceeds the removal levels set under the United States Marine Mammal Protection Act. Odontocetes also can be at risk from retaliatory measures taken by fishermen as a result of real or perceived economic losses. Fishermen are known to shoot at a variety of marine mammal species engaging in depredation and to use other destructive means, such as small explosives, used to deter such behavior (Read 2005).

It is not yet clear how important depredation will prove to be for populations of marine mammals. The odontocete species involved have very low rates of increase, so removals in the form of bycatch will certainly be significant to some of these populations. The economic costs appear to be significant in many fisheries, which may lead to calls from fishermen for more extreme retaliatory measures, culls, or other responses. In addition, it is unclear how populations of marine mammals may depend on this form of food supplementation and how such populations might respond if this supplemental food was removed.

It seems likely that the incidence of depredation will spread throughout the world's oceans as prey populations decline, new fisheries emerge, and populations of marine mammals learn to exploit these new prey resources. Many ideas have been proposed to deter pinnipeds (Mate and Harvey 1986) and odontocetes (Donoghue et al. 2003; Gilman et al. 2006; Reeves et al. 2001) from engaging in depredation, but only a small number of these have been rigorously tested and few practical mitigation alternatives currently exist.

Research, Policy, and Management Needs

For those working in this field there is much to do before time runs out on species like the vaquita, right whale, and dugong. In this final section of the paper I highlight 3 areas that, if successfully developed, would greatly advance our efforts to address direct interactions between marine mammals and fisheries.

Rapid assessment of bycatches.—Bycatch is a global conservation problem for many marine mammals, but most research on assessment and mitigation has been conducted in a small number of fisheries in North and South America, Europe, Australia, and New Zealand. Very little information exists about the magnitude or impact of bycatch in most other areas, particularly in the artisanal fisheries of Africa, Oceania, and Asia, or in the industrial fisheries of the high seas.

There is a desperate need to address this knowledge gap by developing an assessment protocol that can be employed quickly and at little cost. I am currently working on a project that is testing one approach to developing such a rapid assessment system. We are developing and field testing a questionnaire-based protocol that will yield semiquantitative estimates of bycatch and fishing effort in data-limited fisheries of Africa. Our goal is to develop a standardized, yet flexible, survey template that may be applied broadly in a rapid and low-cost manner.

We have initiated the development and testing of this protocol in Africa and the western Indian Ocean, where very little quantitative information exists on the bycatch of marine mammals. We are building on earlier efforts by local researchers in this region, who employed a similar rapid-assessment approach to identify areas where the dugong still occurs (Marsh et al. 2002). We are developing a specific sampling design for each country that reflects the fisheries, species of concern, personnel availability, and cost, with the goal of maximizing the number of surveys to be completed. We are also paying particular attention to ground-truthing the results of these questions to address concerns over underreporting.

The goal of this work is to develop and field test a protocol that will allow quantification of artisanal fishing effort and bycatch of marine mammals (as well as other long-lived vertebrates) in data-deficient areas. It is our hope that this approach will allow us to identify fisheries in which immediate mitigation measures are required; observer programs are needed to determine whether bycatches are sustainable or not; and no further assessment is necessary. We are initially focusing on bycatch and fishing effort in gill-net and trawl fisheries, although the questionnaire can be modified to deal with other gear types.

It is too early to tell whether our approach will be effective and provide useful information; we are currently assessing preliminary results from several assessments. Regardless of the outcome of this project, however, we need some system with which to triage the world's fisheries and identify those areas where bycatches are unsustainable. It is highly likely that conservation problems exist but have not yet been identified in many of these areas (Read et al. 2006). The resources available for mitigation are extremely limited and we must invest wisely in those areas of greatest conservation concern.

Mitigation of bycatches in gill nets.—Bycatches of marine mammals occur most commonly in gill-net fisheries. This fishing gear is used widely throughout the world's fisheries, because it is relatively inexpensive to purchase and can be deployed from small vessels at little cost. Fishermen using gill nets often experience meager profits, complicating efforts to change fishing practices to reduce bycatches. At the present time, only 2 viable alternatives exist to reducing bycatches of marine mammals in gill-net fisheries: acoustic alarms (Barlow and Cameron 2003; Kraus et al. 1997) and area closures (Murray et al. 2000). These strategies are effective only under a restrictive set of circumstances that occur infrequently; their use is not practical in most cases (e.g., Dawson and Slooten 2005; Hodgson et al. 2007). Furthermore, both approaches are costly and unpopular with fishermen. Because of issues of cost and enforceability, neither approach is applicable to small-scale artisanal gill-net fisheries in the developing world, such as those that take the dugong and vaquita.

In the absence of other alternatives, therefore, there is a great need for effective mitigation measures to address bycatches of marine mammals in gill-net fisheries. As noted above, gill nets are popular because of their low cost, so fishermen using this type of gear may not be able to afford expensive mitigation measures. It is possible that simple modifications to gill nets, for example increasing the stiffness of the monofilament twine (Larsen et al. 2007), may achieve some measure of bycatch reduction, but there have been few efforts to test such ideas (see

Perrin et al. 1994). A comprehensive research program is required to generate, evaluate, and test modifications to gill nets that will reduce the bycatch rate of threatened and endangered marine mammals while maintaining or improving the livelihoods of fishermen. An ideal mitigation measure would reduce the effort or cost of dealing with bycatches, or increase the catch of target species, and thus improve the livelihood of a fisherman. This is a tall order, indeed, but one that is necessary if we are to address the problem of unsustainable bycatches of marine mammals in fisheries of the developing world.

Technology transfer.—Finally, we need a system in which successful measures used to mitigate can be made available to a global audience. Such a system of technology transfer requires several steps. First, researchers, managers, and fishermen need to have access to the results of field tests of potential mitigation measures, including both successful and unsuccessful trials. At the present time, the results of too many field tests are described in unpublished contract reports, unavailable to a global audience. There have been a few initial attempts to collate this material (e.g., Werner et al. 2006), but there has been no systematic effort to make this gray literature available over the Internet.

Second, researchers and managers working in the developing world require technical assistance to evaluate and test potential mitigation measures. The Food and Agriculture Organization of the United Nations is ideally suited to play a critical role in this regard but to date has not engaged fully in the issue of marine mammal bycatch.

Third, mitigation efforts in the developing world need an adequate source of funding. National fisheries agencies are unlikely to have the financial resources to plan, implement, and evaluate tests of fishing gear or practices designed to reduce the bycatch of marine mammals. A global marine mammal bycatch fund is needed to support such work. Such a fund also could play a critical role in the initial assessment phase described above.

Resumen

La interacción directa con las pesquerías representa una amenaza seria a la conservación de muchas poblaciones y de algunas especies de mamíferos marinos. El problema mas grave es la pesca incidental, la mortalidad no intencional en las artes de pesca, aunque esto puede derivar en la pesca irregulada bajo algunas circunstancias. Uno de los temas dentro de las pesquerías que crece en atención es la depredación, en donde los mamíferos marinos capturan peces de las redes o de las líneas de pesca. Esta depredación reduce el valor de la pesca y puede derivar en riesgo de enmallamiento y en la consecuente aplicación de medidas restrictorias no siempre positivas por parte de los pescadores. La interacción directa con las pesquerías representa la amenaza mas grave a la conservación de las poblaciones pequeñas de cetáceos pequeños y dugongos. Se requiere de acción inmediata para evaluar la magnitud de la pesca incidental, particularmente en áreas como África y Asia donde el trabajo que se ha llevado al cabo en esta materia ha sido casi nulo. Se requieren soluciones nuevas e innovadoras a este problema que tomen en cuenta las condiciones socio-económicas que experimentan los pescadores así como también permitir la transferencia eficiente de tecnología mitigante a las pesquerías de los países en desarrollo.

Acknowledgments

I thank T. J. O'Shea and D. K. Odell for inviting me to prepare this paper and for their extraordinary patience during its long gestation. An early version of the manuscript was improved by comments from D. Waples, T. Werner, and E. Zollett. I am particularly grateful to S. Dawson for his constructive and insightful comments, which greatly improved the quality of the paper. I thank the Consortium for Wildlife Bycatch Reduction, World Wildlife Fund (United States), the Lenfest Program, the Gordon and Betty Moore Foundation, and North Carolina Sea Grant's Fisheries Resource Grant Program for their support of my work on marine mammal–fisheries interactions. I also thank M. J. Villanueva for preparing the Spanish translation of the abstract. This paper is a contribution of Project Global, supported by the Gordon and Betty Moore Foundation.

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Special Feature Editor was Barbara H. Blake.