Marine Mammals and Fishery Sustainability

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ABSTRACT: Many fish stocks targeted by fishermen are also a primary food source of marine mammals. Normally this would be viewed as competition for a common resource. With the passage of the Marine Mammal Protection Act (MMPA) in 1972, marine mammals are protected which has aided in the recovery of numerous species. Along the West Coast, the MMPA has been highly successful in the recovery of most stocks of California sea lions and Pacific harbor seals, and it has resulted in more frequent interactions with commercial and recreational fishermen, causing damage to fishing gear and loss of catch. Non-lethal methods to eliminate or reduce pinniped predation have been unsuccessful. This paper summarizes the issue of marine mammal depredation in general, examines some of the economic damages, and discusses efforts to minimize these interactions.

KEY WORDS: California sea lion, damage, depredation, deterrence, fishermen, Marine Mammal Protection Act, marine mammals, MMPA, Pacific harbor seal, *Phoca vitulina richardsi*, pinnipeds, sea lions, seals, *Zalophus californianus californianus*

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INTRODUCTION

In reviewing the agenda for this conference on vertebrate pests, an interesting pattern was noted. The titles are overwhelming skewed towards terrestrial issues, not marine ones. Perhaps there is a very good reason for this. Those of us in the profession of protecting, conserving, and managing living marine resources do not normally think of marine mammals as pests. Rather, as the leading Federal agency responsible for research, management, and stewardship of our nation's coasts and oceans, the National Oceanic and Atmospheric Administration (NOAA), views them as a part of the marine ecosystem, competing for the same marine resources targeted by fishermen. A good majority of the public also views these creatures as charismatic and emblematic of a functioning and diverse ecosystem.

This view is not shared by commercial and recreational fishermen alike. In 1972, the U.S. Congress passed the Marine Mammal Protection Act (MMPA), which removed management authority for pinnipeds from state governments and vested it with the Federal government. The MMPA was implemented specifically to recover marine mammal stocks to the optimum population levels, and it did this by "protecting" stocks, not managing them. While the activities of fishermen are routinely restricted to prevent overfishing, minimize bycatch, or promote the objectives of marine protected areas, predation by marine mammals on the same fish species essentially goes unabated.

Whether marine mammals are characterized as competitors or pests is not important. Rather, the extent of the economic impacts created when marine mammals and humans interact, and the success in efforts to minimize those impacts, are really the key issues at stake. The term "depredation" is used to refer to the predatory act of damaging or ravaging a fisherman's catch. Marine mammal depredation can create financial losses to commercial fishermen and/or negatively impact the outdoor experiences of recreational fishermen, whether it be through the direct interference with removing or destroying fish caught in gear, removing bait from traps and off hooks, or damaging fishing gear during the process of depredation (Beeson and Hanan 1996, NMFS 1997, Weise and Harvey 2005).

The MMPA provides NOAA's National Marine Fisheries Service (NMFS) with conservation and management responsibility for more than 140 stocks of whales, dolphins, porpoises, seals, and sea lions. However, it is only a small handful of these stocks that interact with fishermen and therefore can be considered pests, or advantaged competitors, depending upon one's perspective. Probably the more infamous marine mammal species interacting with fishermen along the West Coast are the California sea lion (*Zalophus californianus californianus*) and the Pacific harbor seal subspecies (*Phoca vitulina richardsi*). The reason for this notoriety is that while some pinniped populations in the Pacific Ocean have declined and have been listed under the Endangered Species Act (e.g., Steller sea lions and Hawaiian monk seals), the opposite has occurred for California sea lions and Pacific harbor seals, whose populations have increased at an annual rate of 5-8% since the early 1970s (Caretta et al. 2007).

The purpose of this paper is to present a series of findings, including estimates of the economic damages created by these marine mammals in California and efforts to minimize these interactions. The paper begins by briefly summarizing the scale of marine mammal predation and life history characteristics of the two key marine mammal predators along the West Coast.

FINDINGS

A Global Issue

While the issue of depredation has been well documented in a number of recreational and commercial fisheries in the United States, it is a widespread phenomenon that goes far beyond U.S. shores. Depredation is highly variable among marine mammal species, gear types, and ocean areas (Table 1). Marine mammals that have been observed depredating include sperm and killer whales, seals and sea lions, dolphins, and sea otters on such fishing gears as longline gear, troll, trawl, pot and jig gear, and trammel, gill and fyke nets, and hook-and-line gear. Depredation has also been recorded in both hemispheres of the Atlantic and Pacific Oceans, the Southern Ocean, and the Baltic and Mediterranean Seas. In addition, there have been reports of depredation on aquaculture installations by pinnipeds in the northwest Pacific (e.g. Canada, Washington).

Major West Coast Predators

Carretta et al. (2007) reports that California sea lions residing along the West Coast occur from southern Mexico to southwestern Canada. The entire population cannot be counted, because all age and sex classes are never ashore at the same time; censuses are conducted of the pups in July as a proxy for stock status (Figure 1). Based on pup counts, the data indicate an increased annual population growth rate of 5.4% since the early 1970s (Carretta et al. 2007). The number of California sea lions off Washington, Oregon, and California was estimated at more than 161,000 sea lions in 1994 (NMFS 1997) and is now estimated to range from 237,000 to 244,000 (Carretta et al. 2007).

California sea lions are opportunistic feeders that prey on a variety of fish and cephalopods, mainly northern anchovy, Pacific sardine, Pacific whiting, Pacific mackerel, jack mackerel, shortbelly rockfish, and squid (Lowry et al. 1991).

The Pacific harbor seal subspecies found along the West Coast inhabits nearshore coastal and estuarine areas from Mexico to Alaska. A complete count of all harbor seals in California is impossible because some are always away from the haulout sites, but based on the most recent harbor seal counts (Lowry and Maravilla-Chavez 2005) the harbor seal population in California is estimated to number 34,233. According to Carretta et al. (2007), the California harbor seal stock appears to be stabilizing and may possibly be reaching its carrying capacity (Figure 2).

Pacific harbor seals are opportunistic feeders, preying on a wide variety of marine resources (e.g., herring, cod, flounder), cephalopods (e.g., octopus), and invertebrates (e.g., shrimp and amphipods) (Pitcher and Calkins 1979, Bigg 1981).

For both pinniped species, NOAA estimated a minimum total biomass consumption of about 217,400 metric tons annually by sea lions and seals in Washington, Oregon, and California, and found that it amounted to almost half of what is harvested in commercial fisheries (NMFS 1997).

Interactions with Fishermen

California sea lions and Pacific harbor seals interact in some way with almost all commercial fisheries on the West Coast (NMFS 1997). The principal impacts are damage to catch and gear, and potential indirect impacts on the fish stocks. NMFS (1997) inventoried the fisheries affected and reported that impacts occurred in the West Coast salmon troll fishery, tribal in-river, gillnet, and setnet fisheries; California setnet and drift gillnet fisheries for halibut, seabass, and swordfish/sharks; California herring gillnet fishery; Puget Sound salmon net-pen facilities; California live bait operations; California round-haul fisheries; and lobster, crab, and live-fish trap fisheries. For these fisheries, impacts vary (NMFS 1997). Pinnipeds depredate fish caught in gear or damage the catch, such as removing a large portion of the hooked fish's body, leaving the carcass unsuitable for sale. They also remove bait out of traps and off hooks, thereby making the gear ineffective. Fishing gear can also be damaged, making it unusable.

Interactions between pinnipeds and recreational fishermen also have been reported coast-wide (NMFS 1997). Harbor seals and sea lions are known to depredate salmonids from sport hook-and-line gear in the commercial passenger fishing vessel (CPFV), and private skiff fisheries in coastal waters, inshore bays, estuaries, and rivers (Beeson and Hanan 1996, Hanan 2004, Weise and Harvey 2005). California sea lions steal crab bait and destroy crab rings or pots from recreational fishermen fishing from boats or from docks. Sea lions directly affect CPFV fishing by consuming bait and chum and depredating hooked fish throughout the year in southern California (Hanan et al. 1989, Beeson and Hanan 1996), with sea lions consuming Pacific barracuda, rockfish, mackerel, kelp, and barred sand bass (Beeson and Hanan 1996). Miller et al. (1983) found that fewer fish were caught by CPFVs when a sea lion was present. Frequently, skippers move the boats to other fishing areas when sea lions are present, resulting in additional fuel costs and loss of fishing time (Miller et al. 1983, Hanan 2004). Despite these efforts, sea lions often follow the boats to the new locations.

In the salmon troll fisheries off the West Coast, Miller et al. (1983) estimated that the depredation rate ranged around 2% in 1980. Beeson and Hanan (1996) estimated the rate to have increase to 12% in 1995 and speculated that the increase reflected the growth in sea lion population size during that timeframe. In a study of the salmon fisheries in Monterey Bay, Weise and Harvey (2005) estimated the depredation rates of hooked salmon in the commercial fisheries by sea lions to widely range inter-annually from 12.5% of the legal catch in 1997 to 71.1% in 1998.

Weise and Harvey (2005) estimated that in the recreational CPFV salmon fishery in Monterey Bay, sea lions took as high as 26.3% of the catch in 1998 and as low as 2.5% in 1999. For the skiff portion of the recreational salmon fishery, sea lion depredation rates in 1998 were as high as 31%. Weise and Harvey (2005) report that that the increased depredation rates

Table 1. Summary of global reports of depredation by marine mammal species, prey, fishing gear type involved, and location. (Between-column relationships are not indicated and not to be implied.)

Predator Species	Depredation On:	Gear Type	Location
Killer and false killer whale; sperm whale; California sea lion; Stellar sea lion; harbor seal; South African fur seal; grey seal; Foca monk seal; northern fur seal; bottlenose dolphin; rough-toothed dolphin; Dall's porpoise; sea otter	Sablefish; tuna; swordfish; halibut; turbort; Patagonia toothfish; eels; groundfish; cod; sportfish; salmon; pollock; flounder; lobster; squid; mackerels; bait fish	Longline; commercial passenger fishing vessels (CPFV)-rod and reel; gill/ trammel nets; trawl; troll; fyke nets; pots; purse seines; aquaculture facilities	United States (PNW, Alaska, Hawaii, Florida, North Carolina); Canada; Brazil; Chile; Southern Ocean; Sweden; Scotland; Spain; Baltic Sea; Turkey; South Africa; Australia; Coral Sea

Sources: Brotons et al. 2008, Dahlheim 1988, Dalla Rosa and Secchi 2007, Donigson et al. 2007, Gilman et al. 2006, Güçlüsoy 2008, Hanan et al. 1989, Hill et al. 1999, Hucke-Gaete et al. 2004, Kock et al. 2005, Lehtonen and Suuronen 2004, Lunneryd et al. 2003, Mesnick et al. 2006, Perez 2006, Price and Nickum 1995, Read et al. 2003, Wickens 1994, Zollett 2004.

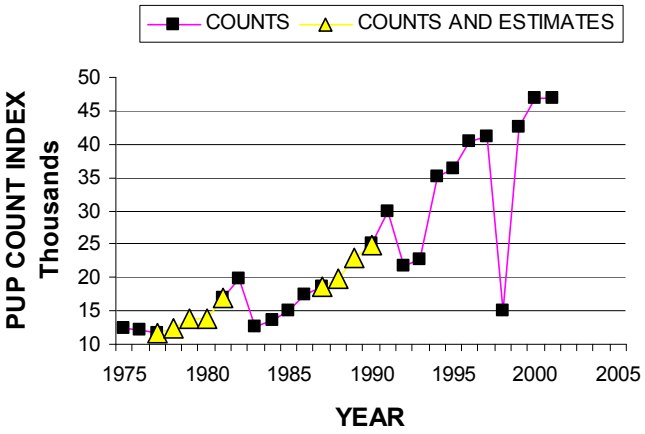

Figure 1. U.S. pup count index for California sea lions from 1975-2001 (from Caretta et al. 2007).

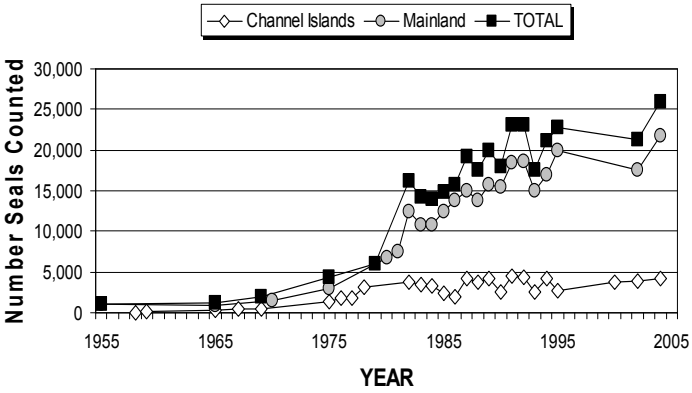

Figure 2. Harbor seal haulout counts in California during May/June (from Caretta et al. 2007).

in 1998 for both the commercial and recreational salmon fisheries were most likely the result of the large El Niño event that occurred during 1997-98, which is believed to be related to resulting shifts in prey availability and abundance.

Economic Impacts

Pinniped interactions inflict substantive economic or financial loss on fisherman. Efforts to quantify these economic losses are few. This next section provides a brief overview of the magnitude of these losses, with values adjusted for inflation to 2007 dollars using the Bureau of Labor Statistics Inflation Calculator (BLS 2008).

Weise and Harvey (2005) conducted a study that estimated the value of gear loss in addition to the value of fish loss resulting from pinniped interactions with commercial salmon fishermen in Monterey Bay between 1997 and 1999. The estimated annual losses from this study, in 2007 dollars, ranged from $307 thousand to $718 thousand (Table 2). Total revenue losses as a result of sea lion depredation in the commercial fishery ranged annually between 14.4% and 84.4% of the total salmon fishery revenues (Weise and Harvey 2005).

In a study that examined losses to both the California recreational and commercial fisheries between 1999 and 2002, Hanan (2004) found, with values adjusted for inflation, losses to range from $457 thousand to $1.5 million (Table 3). In his study, Hanan (2004) only examined the value of fish loss and did not include the value of gear loss. For the recreational fisheries, the data from Hanan (2004), with values adjusted for inflation, estimated annual losses ranging from $750 thousand to $5.9 million (Table 4). A substantial portion of these recreational fishing losses were the result of the value of lost days fishing. Hanan (2004) determined that the high values of time lost corresponded to higher interaction rates for lost fish, lost gear, or lost bait (Table 4).

In a dated study by Miller et al. (1983) catch and gear losses caused by California sea lions in seven major California fisheries was estimated (Table 5). The largest dollar losses occurred in the commercial salmon troll fishery, the CPFV fishery, the Pacific herring fishery, and the halibut gillnet fishery. Adjusted for inflation, fish and gear loss amounted to $994 thousand and $136 thousand, respectively. The gillnet fisheries experienced the greatest gear damage followed by the CPFV bottomfish fishery.

Table 2. Estimates of monetary impact of California sea lion interactions with commercial fishermen resulting in gear and fish loss in Monterey Bay from 1997 to 1999 (adapted from Weise and Harvey 2005). Values adjusted for inflation to 2007 dollars using the Bureau of Labor Statistics Inflation Calculator. (*Note*: Commercial revenues are not lost value; these values show the percentage of value of lost fish compared to total revenue fishermen earned).

Year	1997	1998	1999
Percentage fishery sampled	6.3	10.9	8.6
Value of Gear Loss	$66,700	$76,400	$27,800
Value of Fish Loss	$485,000	$642,000	$278,800
subtotal, Gear and Fish Loss	***$551,700***	***$718,400***	***$306,600***
Commercial revenues	**$3,425,000**	**$760,800**	**$1,088,000**
Equivalent percentage of commercial revenue lost	14.2	84.4	25.6

Table 3. Estimated economic loss caused by sea lion depredation in California commercial fisheries from 1999-2001 (adapted from Hanan 2004). Values adjusted for inflation to 2007 dollars using the Bureau of Labor Statistics Inflation Calculator.

Year	1999	2000	2001	2002
Value of Fish Loss	$457,000	$1,073,000	$1,449,000	$659,000

Table 4. Estimated economic loss caused by sea lion depredation in California recreational fisheries from 1999-2001 (adapted from Hanan 2004). Values adjusted for inflation to 2007 dollars using the Bureau of Labor Statistics Inflation Calculator.

Year	1999	2000	2001	2002
Fish Loss	75,100	58,700	51,000	81,000
Value of Fish Lost	$47,000	$35,000	$29,000	$46,000
Fish Loss Using Differential	101,900	79,600	69,200	109,900
Value Using Differential	$63,410	$47,900	$34,500	$63,000
Number of Lost Bait	301,500	130,300	103,300	199,900
Bait Value	$112,000	$47,000	$36,000	$69,000
Gear Lost Value	$27,100	$15,400	$41,900	$84,500
Gear Lost Value with Differential	$287,000	$163,000	$443,000	$893,000
Lost 8 Hour Days	691	224	31	208
Value Lost Days	$1,721,000	$538,300	$72,000	$476,000
Differential Lost 8 Hour Days	2,190	710	98	659
Value Lost Days Using Differential	$5,451,000	$1,710,000	$230,000	$1,519,500
Total Value Lost	**$1,907,000**	**$636,000**	**$179,000**	**$679,000**
Total Value Lost Using Differential	**$5,913,000**	**$1,967,000**	**$750,000**	**$2,545,000**

Efforts to Minimize Interactions

Until the MMPA was reauthorized in 1994, commercial fishermen could injure or kill a marine mammal that was causing immediate damage to their catch or gear so long as other non-lethal efforts first had been tried. After reauthorization, fishermen and members of the public were permitted to use only non-lethal deterrence methods to prevent pinnipeds from damaging property.

A variety of measures have been utilized or considered for minimizing interactions with fisheries, including harassment, aversive conditioning, exclusion from selected areas, and non-lethal removal methods (NMFS 2003). With the exception of one permanent relocation effort, non-lethal deterrence measures are usually effective on a short-term basis in most situations, but over the long-term with repeated use, they are usually ignored or tolerated by the pinnipeds (NMFS 1997). Even sea lions and seals captured and placed in temporary captivity return the following season (NMFS 1997).

With passage of the MMPA amendments of 1994, Congress recognized the limits of non-lethal deterrence of pinnipeds in protecting salmonids listed under the Endangered Species Act (ESA) along the West Coast. Section 120 was added, which allowed states to apply

Table 5. Depredation rates and dollar losses for catch and gear in California commercial and recreational fisheries for 1979-80. Values adjusted for inflation to 2007 dollars using the Bureau of Labor Statistics Inflation Calculator (adapted from Miller et al. 1982).

Fishery	% Depredation	Catch Loss	Gear Loss
Commercial Salmon Troll Fishery	1.90%	$689,000	$31,000
Salmon Partyboat Fishery	0.32%	$15,000	$900
Salmon Recreational Skiff Fishery	0.02-0.18%	$5,800	0
Partyboat Fishery for Bottomfish	–	$68,000	$27,000
Pacific Herring Fishery	0.46-0.62%	$102,000	$11,000
Hook and Line Fishery	0.44%	$3,800	0
Gill Net Fisheries			
Shark	0	0	$2,000
Halibut	6.94%	$81,000	$61,000
White Seabass	2.00%	$9,400	0
Rockfish	1.4%	$6,500	0
White Croaker	7.1%	$7,500	$2,500
Barracuda	2.2%	$830	0
Bonito	6.5%	$3,200	$960
Flyingfish	6.4%	$500	0
Total		**$993,600**	**$136,000**

for authority to lethally remove California sea lions or Pacific harbor seals to protect salmonids. In 1994, Washington requested authority to remove 5 sea lions near Seattle after unsuccessful attempts in non-lethal deterrence actions. Lethal removal was authorized by NMFS under a number of conditions, but none were lethally removed. Three sea lions were eventually relocated to Sea World of Orlando in 1996 for permanent captivity and public display (NMFS 2007). In 2006, the states of Oregon, Washington, and Idaho applied to NMFS for authority to lethally remove California sea lions at Bonneville Dam to protect listed salmonids in the Columbia River as again, aggressive non-lethal deterrence methods were unsuccessful. NMFS is continuing to evaluate the states' application.

In March 2007, Representative Brian Baird (D-WA) and colleagues introduced H.R. 1769. Known as the Endangered Salmon Predation Prevention Act, it amends the MMPA by authorizing the Secretary of Commerce to issue 1-year permits for the lethal taking of California sea lions if the Secretary determines that alternative measures to reduce sea lion predation on listed salmonid stocks in the Columbia River are inadequate. In August 2007, the House Subcommittee on Fisheries, Wildlife and Oceans held a hearing including testimony from NOAA (NMFS 2007). No action has occurred since then.

There have also been efforts to find an effective, long-term approach to eliminating or reducing pinniped predation. NMFS worked with the fishing industry to develop a more powerful acoustic deterrence device, called "pulsed power", which generates both a compression wave and a noise at higher decibels, that could be effective in open waters but may affect other species (NMFS 2001). In 2003, the California Coastal Commission rejected the agency's coastal zone consistency determination for ocean testing, and NMFS postponed the field testing of the device. Laboratory tests have shown mixed effectiveness of the device on sea lions when operated at lower levels (NMFS 2001).

DISCUSSION

The MMPA has been a highly successful tool in the recovery of most stocks of seals and sea lions along the West Coast. But this success story has been met with consequences. Coincident with the expansion of pinniped populations has been the reported increase in pinniped depredation (NOAA Fisheries 1997, Hanan 2004, Weise and Harvey 2005). Further, the expansion of these pinniped populations coincides with declining salmon and steelhead populations along the same coast (NOAA 2007). Of the 52 population groups of salmonids recognized as spawning in California, Oregon, Idaho, and Washington, 27 are now listed as threatened or endangered under the ESA, which underscores the severity of these declines. It was the events of pinniped predation on returning salmonids that alerted Congress of the potential conflict between the objectives of the MMPA and ESA and prompted it to act over a decade ago.

In the 1994 amendments to the MMPA, Congress directed that a scientific investigation be conducted to determine whether these two pinniped species were having a significant negative impact on the recovery of salmonid fishery stocks listed under the ESA, or were having broader impacts on the coastal ecosystems of Washington, Oregon, and California. NMFS completed the investigation in 1997. One of its conclusions was that current mitigation measures used to reduce or eliminate pinniped predation on salmonids, or minimize interactions with fisheries, had limited or

short-term effectiveness. The report cited that the increased number of pinnipeds coastwide had created new problems and issues that must be addressed by new technologies and techniques, in order to effectively deter pinnipeds from fishery conflicts and from marinas where human safety issues arise.

The pulse power effort is one example where NMFS attempted to develop an alternative technique. However, while the device seemed promising, NMFS also has a responsibility to minimize collateral impacts. This case demonstrates the need to develop deterrence technologies that can be applied on a broad basis (e.g., multiple fishing boats) with little or no adverse impacts on the environment, and without serious injury to the sea lions or other marine mammals.

The NMFS Fisheries report (1997) also recommended implementing site-specific management authority that would allow state and Federal officials to lethally remove pinnipeds where necessary to protect ESA-listed salmon and other marine resources (NMFS 2001). The agency has made it clear that lethal removal of pinnipeds is an action of last resort by state or Federal resource managers. Further, this recommendation only addresses the individual problem animals, which cause most of the conflicts, and is not intended to reduce or cull local pinniped populations (NMFS 2001).

NMFS has appeared before Congress three times since 2000 to express its views on the MMPA, most recently in August 2007. At that briefing before the House Subcommittee on Fisheries, Wildlife and Oceans, NMFS reaffirmed that its recommendations based on its 1997 report were still valid. The agency also noted that the lethal removal of problematic marine mammals is no different than in terrestrial situations where the method is similarly used for many high-profile species of terrestrial animals to control wildlife damage to other species, or to property and resources valued by people (NMFS 2007).

At the 2007 hearing, NMFS also spoke to H.R. 1769, stating that it agreed in concept with the bill, that is, the lethal take of certain pinnipeds may be warranted to promote the conservation and recovery of certain stocks of salmonids or other fish (NMFS 2007). However, the agency noted that as currently drafted, the bill would neither fully realize the goals of the MMPA nor address the full scope of issues related to pinniped conflict in the United States (NMFS 2007). Just as it has done at previous MMPA congressional hearings, the agency made it clear that any such effort for lethal removal be achieved though a well-considered process to determine which pinnipeds would have to be removed to provide appropriate protection for at-risk fish stocks. NMFS notes that the existing MMPA Section 120 contains a process for this purpose, which has been difficult to implement effectively. The agency has offered its services to work with the Committee in making changes to the existing Section 120 process consistent with the intent of H.R. 1769, that when combined with sound principles of wildlife management, could achieve the goals and objectives of the MMPA.

Resource managers and the public must find solutions that conserve all species in ecosystems, especially those that are severely depressed or listed under the ESA, while allowing optimum yield for healthy living marine resources. Against the backdrop of pinniped interactions with listed fish and fishermen, NOAA has moved resource management to a broader strategy designed to improve the health and productivity of coastal and marine ecosystems. Known as "ecosystem-based management," NOAA has adopted this approach based on the fundamental understanding that an ecosystem is "a geographically specified system of organisms (including humans), their environment, and the processes that control their dynamics" (Burgess et al. 2005). Because humans are also a player in NOAA's vision, it is important that the human dimension be factored into resource management decisions.

In conclusion, it must be said that the MMPA has provided strong protections for all marine mammals, regardless of their population status, for more than 35 years. Any efforts to modify or lessen its effectiveness by allowing the removal of pinnipeds, even for essential resource management purposes, will be perceived as reducing protections for marine mammals, and thereby weakening the Act. Further, efforts to implement bills such as H.R. 1769, or any other effort to streamline the process for using lethal removal of pinnipeds, will be highly controversial. Notwithstanding, many non-governmental organizations promote the protection of marine mammals without full consideration of the ecosystem context. It is these organizations that need to be brought into the debate to ensure that their interests are met; however, they also need to understand that once certain goals have been reached, the management of the marine environment, rather than full protection of marine mammals, should be the operating norm in an ecosystem-based style of management.

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