7. Conflicts between marine mammals and fisheries off the coast of California

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Introduction

Marine mammal–fishery interactions can result in both revenue losses to fishermen and mortality of marine mammals. These interactions can involve damage to captured fish, damage to nets and gear, reduced catch rates due to scaring of target species, reduced availability of target species, and incidental entanglement. The purpose of this chapter is to describe two research projects that have been supported by the National Marine Fisheries Service to document the nature and extent of marine mammal–fishery interactions in California. The first project was contracted out to the California Department of Fish and Game, and was directed by Dan Miller (California Fish & Game, Monterey office). The second project is part of the research programme of the Coastal Marine Mammal Project (Southwest Fisheries Center, La Jolla, California). This study, the cooperative Marine Mammal Salvage Program, was originally headed by John Hendersen, and is currently directed by Larry Hansen.

Marine mammal–fisheries interaction study

Beginning in July 1979, the Southwest Fisheries Center and the Southwest Regional Office of the National Marine Fisheries Service jointly sponsored a contract with the California Department of Fish and Game to determine the nature and extent of interactions between marine mammals and all commercial and recreational fisheries in California. The results of the first year of this study are summarised in an annual report (Miller 1981), and a summary of its first two years is given Miller *et al.* (1982) and Herder (1982).

In this contract, an effort was made to determine the loss of fish and damage to gear due to marine mammals by questioning fishermen who had recently completed trips and by sending out observers on fishing trips when possible. In addition, an effort was made to monitor the incidental take of marine mammals in various fisheries. Miller (1981) reported that there was considerable concern on the part of the gill-net and trammel-net fishermen and salmon trollers that information on incidental take of marine mammals may eventually curtail their operations. Estimates of fish loss and gear damage were generally available for all fisheries, whereas estimates of marine mammal take were not available for most fisheries.

Seven fisheries were identified in which a consistent loss of fish and/or damage to gear was occurring (Table 7.1): the commercial salmon trolling fishery, the California

Table 7.1 The value of fish and gear depredated by marine mammals annually (data from Miller *et al.* 1982).

Fishery	Fish lost ($)	Gear lost ($)	Total ($)
Salmon fisheries			
commercial troll	274 000	12 220	286 220
commercial sport boat	6 000	360	6 360
skiff	2 300	0	2 300
Klamath River – subsistence	74 000	10 000	84 000
Total salmon	365 300	22 580	378 880
sport boat non-salmon	27 000	10 730	37 730
Pacific herring	57 100	4 550	61 650
Gill-net	63 360	57 070	120 430
Total fisheries	503 760	94 930	598 690

halibut gill-net fishery, the Native American gill-net fishery in the Klamath River, the commercial sport-boat fishery out of San Diego, the Pacific herring fishery, the partyboat and skiff salmon fisheries, and the round-haul fisheries for anchovy and mackerel. In addition interactions between the southern California squid fishery and California sea-lions and short-finned pilot whales were described (Miller *et al.* 1982), but financial losses were not quantified. Significant interactions with marine mammals were not observed in the following fisheries: the pier fishery, the shoreline hook-and-line sport fishery, the bottomfish skiff fishery, the partyboat bottom-fish fishery north of Morro Bay, the lamprey fishery of the Eel and Klamath rivers, the night and surf smelt fisheries, the bottom-trawl fishery, the lobster fishery, and the swordfish spearing fishery.

The largest financial loss due to interactions with marine mammals was reported from the commercial salmon trolling fishery. A minimum loss of $130 000 during the month of May 1980 was estimated. This estimate does not include losses due to gear damage. The total value of salmon landed in California during May was about $5 000 000. Miller *et al.* (1982) reported that roughly two-thirds of the total value of fish and gear lost due to marine mammals occurred in this fishery (Table 7.1).

The marine mammal species primarily involved in the salmon fishery interactions is the California sea-lion (*Zalophus californianus*). During the 113 observed trips made in 1979–80, only one sea-lion was shot at. Miller (1981) reported that more animals were probably taken in 1979 than are indicated by this one observation. The annual loss of salmon from the recreational catch and from the skiff fishery was much less than for the ocean salmon fishery (Table 7.1).

Miller (1981) reported that the Klamath River Native American (subsistence) gill-net fishery was the most difficult fishery to monitor. He also reported that this is the fishery that is thought to be most affected by marine mammal predation. Harbour seals (*Phoca vitulina*) have been observed to remove netted salmon quickly from the nets (Miller 1981). Entanglement of harbour seals in nets was observed, as well as harbour seals and California sea-lions being shot near the nets (Miller 1981). Herder (1982) reported that roughly 926 salmonids were damaged out of a total harvest of 6800

(14%). If fishermen were to replace these with market fish, this would represent a total loss of roughly $84 000, or $2400 per fisherman.

Losses to marine mammals from the commercial sport-boat fishery were negligible in central California, roughly 2.5% of the total catch in southern California, and over 6% in Baja California (Miller 1981). This loss was primarily due to predation by California sea-lions. The estimated losses computed from definite loss values varied between 15 141 fish and 18 272 fish (Miller *et al.* 1982). Pacific bonito was the most frequently lost fish. Other fish lost included: Pacific mackerel, kelp bass, California barracuda, and several species of rockfish. The value of fish and gear loss in southern California varied between $37 000 and $38 800.

The gill-net and trammel-net ocean fisheries were also significantly impacted by marine mammal predation. In waters off Baja California, 12.5% of the catch was lost to sea-lion predation (Miller 1981). In southern California waters, the estimated fish loss was 2.2%; most of this loss was due to California sea-lions. Losses occurred in the following fisheries (Miller *et al.* 1982): shark drift gill-net fishery ($1400), California halibut gill-net and trammel-net fishery ($72 700; depredation rate of 10.1%), white seabass gill-net fishery ($7980; depredation rate of 10.4%), rockfish set-gill-net fishery ($18 060; depredation rate of 1.6%), white croaker gill-net fishery ($3978; depredation rate of 7.1%), and Pacific bonito gill-net fishery ($1652; depredation rate of 6.5%).

The Pacific herring fishery was difficult to monitor because nets are fished both day and night and are often left unattended. Both California sea-lions and harbour seals have been observed foraging on netted fish. In this fishery, damage to the gear (the nets) may be more significant than loss of fish. Three different types of nets are used in this fishery: gill-nets, lampara nets, and purse-seine nets. Fishermen in this fishery are more concerned with sea-lions frightening fish out of the nets than they are with the actual number of fish eaten by sea-lions that enter nets (Miller *et al.* 1982).

The dip-net squid fishery of southern California was estimated to have lost over $36 000 due to interactions with California sea-lions and short-finned pilot whales (*Globicephala macrorhynchus*) in 1980 (Miller 1981). Fish in the catch are not eaten, but the frightening of squid away from the dip-net area results in a considerably lower catch per unit effort. The squid fishery in Monterey primarily uses lampara nets, and

Table 7.2 Comparison of percentage of catch lost to marine mammal predation from interviews with fishermen and from observed trips at sea. (Figures in parentheses indicate numbers of fish.)

	Data source	
Fishery	At sea (%)	Interviews (%)
commercial salmon (ocean)	2.4 (113)	3.2 (1506)
partyboat salmon	0.64 (72)	1.35 (157)
partyboat salmon	0.0 (13)	0.0 (20)
partyboat bottomfish		
gill-net and trammel-net (bottomfish)		
southern California	0.7 (35)	2.2 (125)
central California	0.0 (5)	2.4 (13)

interaction with marine mammals is relatively rare. The potential for frightening off fish and foraging by marine mammals in the round-haul net fishery for anchovy and mackerel was reported to be high. Data are currently not available on the value of the fish lost, but efforts are underway to determine this.

Miller (1981) provided information on fishery–marine mammal conflicts from at-sea trips and from interviews. A comparison of these techniques is currently underway. However, a preliminary comparison of these two data sets indicates that data from interviews will generally give higher estimates of fish lost to marine mammals than will data from at-sea trips (Table 7.2). Subsequent analyses will need to identify factors that may be contributing to differences between these two sampling techniques. One interpretation of these results is that fishermen overestimate the loss of fish due to marine mammal predation. An alternative hypothesis is that fishermen may be fishing differently when observers are on board. Obviously, many other hypotheses can be generated, and more information is needed to test any of them.

Marine mammal mortality in California fisheries

Miller *et al.* (1982) estimated that 300 California sea-lions were taken each year by shooting in the commercial salmon trolling fishery (Table 7.3). This was determined by interviewing fishermen. There were no reported mortalities of marine mammals associated with the commercial salmon sport-boat fishery, the recreational skiff fishery for salmon, the non-salmon commercial sport-boat fishery, or the Pacific herring fishery. In the shark drift-gill-net fishery, 49 California sea-lions were entangled in 177 at-sea days sampled (Miller *et al.* 1982). This represents a mean catch rate of 0.28 $\pm$0.19 California sea-lions per net-night. Other marine mammals 'taken' included two short-finned pilot whales, three grey whales (*Eschrichtius robustus*), and one baleen whale, but the interaction rates were too low to quantify. Miller *et al.* (1982) estimated that between 678 and 1227 sea-lions were drowned between September 1980 and September 1981 in shark drift gill-nets. Mortality was also reported in the shark set-gill-net fishery and the California halibut gill-net and trammel-net fishery. No mortality was observed in the white sea bass, rockfish, white croaker, California barracuda, Pacific bonito, or flyingfish fisheries (Miller *et al.* 1982), but a few entanglements were reported by fishermen.

In the Monterey Bay halibut gill-net fishery, the estimated marine mammal mortality in June 1980 was 45 California sea-lions, 15 harbour seals, and 15 harbour porpoise (*Phocoena phocoena*). These numbers were determined after 25 days of at-sea observations. No additional marine mammal mortality was reported for the rest of the year (20 observer-days reported by Miller *et al.* 1982). In June 1981, Miller *et al.* (1982) estimated mortalities of 22 harbour seals and 22 California sea-lions. The pinnipeds in 1980 and 1981 were juveniles (Miller *et al.* 1982). In May of 1982, this fishery moved north into Bolinas Bay. D. G. Ainley *et al.* (personal communication) reported that a large number of birds, 13 harbour porpoise and 15 harbour seals were found along a 40-mile stretch of coast. Of the 13 harbour porpoises found, 7 were 'fresh'; 4 had obviously been captured in nets. Historically, the number of stranded harbour porpoises averages 2.1 animals per year, a much lower rate. Additional studies are currently being planned to determine the seasonality of marine mammal mortality due to this fishery, and to assess future trends.

Miller *et al.* (1982) estimated that 10 sea-lions and as many as 30 pilot whales are

Table 7.3 The estimated marine mammal mortality in California fisheries for 1980 (data from Miller *et al.* 1982 and D. G. Ainley *et al.* personal communication).

Species	Fishery	Number
California sea-lions	commercial salmon trolling	300
	Klamath River gill-net	7[a]
	ocean gill-net + trammel-net	1209
	squid round-haul net	10
	anchovy-mackerel round haul	20
	trawl fishery	25
		1571
harbour seal	Klamath River gill-net	22[a]
	ocean gill-net	95
	in-shore gill-net	15[a]
		132
elephant seal	ocean gill-net	**25**
harbour porpoise	ocean gill-net	15
	in-shore gill-net	13[a]
		28
pilot whales	squid round-haul nets	30
	ocean gill-nets	30
		60
grey whale	ocean gill-net	**3**
baleen whale	ocean gill-net	**1**
total all fisheries		**1820**

[a]Actual count, total not estimated.

taken in the squid round-haul fishery in southern California (see Table 7.3). These estimates are based on limited information, as very few at-sea trips were made available by the fishermen. Sea-lions and pilot whales are shot at by fishermen in the squid dip-net fishery, but mortality is thought to be minimal.

In round-haul net fisheries for anchovy and mackerel, Miller *et al.* (1982) estimated that 20 California sea-lions were drowned per year. They also speculated that pilot whales may be taken in this fishery, but thought it likely that pilot whale mortality would be more common in the squid round-haul net fishery.

Finally, Miller *et al.* (1982) reported that a small number of sea-lions (see Table 7.3) are drowned by entering operating trawl nets; most have been drowned, but some lived and were returned to the water. Sea-lions are known to follow trawl nets and feed on smaller fishes passing through the webbing.

The impact of the incidental mortality presented in Table 7.3 is difficult to predict and will only be briefly discussed. Population estimates are only roughly known for some of the impacted species (Table 7.4). Relative to their maximum *per capita* growth rate, only the incidental take of California sea-lions and short-finned pilot whales is

Table 7.4 Estimated population size and percentage fishery-related mortality rate for marine mammals that occur off the coast of California.

Species	Population	Mortality from fisheries (%)	References
California sea-lion[a]	45 000 – 60 000	3–4	Le Boeuf and Bonnell (1980)
Pacific harbour seal			
Oregan border to Pt Conception	17 000		Miller *et al.* (1982)
Channel Islands	3 000	< 1	Stewart and Yochem (1982)[1]
	20 000		
northern elephant seal	60 000 – 90 000	< 1	Le Boeuf and Bonnell (1980)
harbour porpoise[b]			
short-finned pilot whales[b]	400 – 2 000	3–15	Dohl (1980), Stewart and Yochem (1982)
grey whale	16 000	< 1	Reilly (1981)

[a] US population only.
[b] California population.

significant. More information on the population size of harbour porpoise is needed to determine the significance of the observed level of take. In all cases where incidental take occurs, the age and sex composition of the take is unknown.

Coastal marine mammal salvage programme

Additional information on marine mammal–fisheries interactions can be collected via salvage of beached marine mammals. In 1979, the Southwest Fisheries Center (SWFC) initiated a co-operative programme among San Diego area researchers to inspect and salvage stranded marine mammals from beaches in San Diego County. Dead marine mammals are recovered routinely in this programme by staff of the Coastal Marine Mammal Project, SWFC. In addition to collecting basic data (species, sex, morphometrics, photographs) from each stranding, the staff also thoroughly inspects each carcass for external wounds or trauma which might be human related. Carcasses which are judged not excessively decomposed (usually having been dead less than approximately 48 hours) are collected intact and subsequently undergo a thorough necropsy by a marine mammal veterinarian.

Events leading to traumatic death of marine mammals may, but will not always, result in a carcass exhibiting injuries, wounds, or other obvious signs of the cause of death. Gunshot wounds are usually readily detectable even in decayed carcasses. Because of firearm restrictions on virtually all beaches in San Diego County, shooting of already beached dead animals seldom occurs, hence any bullet wound is likely to have been incurred while the animal was alive. Cetaceans which are found with severed flukes and missing terminal vertebrae can generally be assumed to have been entangled in a net, though it is not evident whether these animals died as a direct result of the

injury or suffocated in a net and were subsequently cut loose. Live, 'tailless' whales, both grey whales (*Eschrichtius robustus*) and short-finned pilot whales, have been observed in southern California. Suffocation resulting from entanglement in a net results in tissue damage which is difficult to detect, and evidence for suffocation is often circumstantial. The presence of gastric contents and vomitus in the oesophagus, and froth or foam in the trachea suggests suffocation. The presence of food in the stomach generally indicates some form of sudden, untimely death, as chronically ill marine mammals which strand generally have empty stomachs.

In 1980, 16% (3 of 19) of the recovered sea-lions showed evidence of human-related mortality; all four of the salvaged pilot whales showed evidence of fishery interactions. In 1981, 34 marine mammal specimens were fresh enough to autopsy; all but four of these were sea-lions. Gunshot wounds were the most common cause of death (37%). The next most frequent cause was hypoglycemia (18%; Hansen 1981). We hope that the data collected from this type of research will provide enough information to ascertain what proportion of the total mortality is due to human activities, including commercial and recreational fisheries.

Conclusion

A financial loss of approximately $600 000 per year was found to be related to marine mammal–fishery interactions in California. Over half of this loss was from salmon fisheries. This represents damage to the catch and to gear, and does not include losses due to frightening of fish from nets or from reducing the availability of target species. The incidental mortality of marine mammals is roughly 1800 animals per year. Though not known precisely, the *per capita* mortality rate due to fishery interactions is probably only significant for California sea-lions and short-finned pilot whales. Without information on stock discreteness and the age–sex composition of the take, it is not possible to determine the impact of fishery-related mortality on any of the populations involved. Because of problems relating to placing observers on commercial fishing boats, the age–sex composition of animals caught incidental to commercial fishery activities will have to be inferred from salvaged marine mammals. Studies directed at monitoring population trends of impacted species will have to be continued to ensure that this type of human activity does not adversely affect any of the stocks of marine mammals that occur off the coast of California. Studies directed at mediating losses to fishermen are currently underway by both the California Department of Fish and Game and the National Marine Fisheries Service.

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