Aquatic Mammals 2020, *46*(6), 609-622, DOI 10.1578/AM.46.6.2020.609

Fishermen and Pinniped Interactions: The Perception of Fishermen in Baja California, Mexico

Alejandro Arias-Del-Razo,[1] Gisela Heckel,[2] Yolanda Schramm,[3] and Andrea Sáenz-Arroyo[4]

[1]*Departamento de Ciencias Químico-Biológicas, Universidad de las Américas Puebla, San Andrés Cholula, México*
[2]*Centro de Investigación Científica y de Educación Superior de Ensenada, Carretera Ensenada-Tijuana 3918, Zona Playitas, Ensenada, Baja California, México*
[3]*Facultad de Ciencias Marinas, Universidad Autónoma de Baja California, Ensenada, México*
E-mail: yschramm@uabc.edu.mx
[4]*El Colegio de la Frontera Sur, Unidad San Cristóbal, San Cristóbal de Las Casas, México*

Abstract

Fisheries–pinniped interactions are a major issue that threatens pinniped conservation and the fishing economy. Pinnipeds can get entangled in fishing gear, while fishermen may lose or have part of their catch and gear damaged. This study analyzed the perceptions of fishermen who work around five islands with important colonies of pinnipeds in the Pacific Ocean west of the Baja California Peninsula, Mexico. This is an area that, despite its high diversity of marine mammals, has very few studies regarding their interactions with fisheries. Interviews with fishermen were carried out to estimate interactions, and a survey of entanglement rates of pinnipeds was conducted. The results showed that 65.7% of fishermen perceived the California sea lion (*Zalophus californianus*) as the species that interferes most often with their work. This species was entangled more frequently in the fisheries of bony fish that used lines and gillnets than invertebrate fisheries that used traps and direct capture. The Pacific harbor seal (*Phoca vitulina richardii*) was also mentioned as a source of interference, albeit on a lesser scale. Pinniped interactions did not seem to have a significant economic impact because the frequency in invertebrate fisheries was low, and these fisheries provided most of the income. However, interaction with lobster traps has the potential to grow as seen in other regions. Of the four species of pinnipeds that were included in this survey, only California sea lions were found with signs of entanglement from gillnets, although these were less than 1% of the total counted animals of this species on every island. Perhaps due to the good health of the ecosystem, conflicts between fishermen and pinnipeds in this region are lower than in other parts of the world. This study enables the conflict between fishermen and pinnipeds to be put in the context of the trajectory of impact on marine ecosystems.

Key Words: California sea lion, *Zalophus californianus*, ecosystem-based management, fishing cooperatives, food webs, interaction with fisheries, Pacific harbor seal, *Phoca vitulina richardii*, marine mammal conservation

Introduction

Fisheries and Pinniped Interactions

Negative interactions between fisheries and some species of marine mammals have been considered a serious threat to the populations of the latter (Read, 2008). The direct interactions can be classified into (1) incidental mortality, or bycatch, where the marine mammal is caught in the fishing gear but later discarded; (2) non-target catch when the marine mammal is kept and used for food or bait; and (3) cases where marine mammals may also remove or damage the fish caught in the fishing gear, known as depredation (Read, 2008). Pinniped mortality associated with fishing operations can reach thousands of animals each year in regions such as the west coast of the United States (Barlow et al., 1994; Moore et al., 2009). Depredation can also be a serious conservation problem when it leads to an increase in bycatch or retaliatory measures by the fishermen (Read, 2008).

Around the world, the conflicts between fishermen and marine mammals have become a problem that threatens both the marine mammal populations and the fisheries' economy (Read et al., 2006). For example, risk evaluations using the Australian sea lion (*Neophoca cinerea*) and the New Zealand fur seal (*Arctocephalus forsteri*) showed that due to their long lifespans and low reproductive rates, even small increases in their mortality, such as results from conflicts with fisheries, can significantly jeopardize their conservation status (Goldsworthy & Page, 2007). Worldwide, 80% of seal species have some form of negative effect on fishing or aquaculture operations (Wickens, 1995; Costalago et al., 2019).

In Sweden, for example, fishermen attribute total economic losses of up to 110,000 euros (per 50 fishermen) to the Atlantic harbor seal (*Phoca vitulina vitulina*) (Lunneryd, 2001). Interactions of this magnitude can have important repercussions, not only for the fisheries, but also for these predators. In the Moray Firth, Scotland, Thompson et al. (2007) reported that between 1993 and 2004, the harbor seal population decreased between 2 and 5% every year; their records indicated that between 66 and 237 seals die by gunshots every year in this region. Demographic models found that these deaths accounted for the observed seal population decline. Surveys of salmon fishermen in the Gulf of Bothnia showed that most of them (81%) believe that seals have a significant impact on salmon stocks and that all seals were responsible for predation in their fishing gear (77%); furthermore, almost half of the fishermen (47%) supported lethal methods to control the seal populations (Kauppinen et al., 2005).

On the east coast of the U.S., the bycatch of Atlantic harbor seals, gray seals (*Halichoerus grypus*), and harp seals (*Phoca groenlandica*) has been documented in the New England sink gillnet and the Mid-Atlantic gillnet fisheries (Orphanides, 2011). From 2012 to 2016, 54 pinnipeds, mostly gray and harbor seals, were recorded by onboard observers as seriously injured by fishing gear, and many more were registered as bycatch without apparent injuries and later released (Josephson et al., 2019). Other indirect evidence of these interactions are stranded animals. From 1997 to 2008, on the coast of North Carolina, of 1,847 marine mammal strandings reported, 4% corresponded to Atlantic harbor seals (n = 73), with at least nine individuals showing signs of their stranding being the result of interaction with fisheries, including fishhooks and gillnet entanglement (Byrd et al., 2014).

On the U.S. west coast, the estimations of these interactions are even higher. Bycatch estimations for 1992 were around 1,204 Pacific harbor seals (*Phoca vitulina richardii*) and 3,418 California sea lions (*Zalophus californianus*), mainly in gillnets (Read et al., 2006). One of the most affected fisheries is the commercial salmon fishery. Pacific harbor seals are known to consume pre-spawning salmon (*Oncorhynchus tshawytscha*; Wright et al., 2007), and California sea lions consume the salmon from fishing gear (Weise & Harvey, 2005; Scordino, 2010). Fisheries interactions with California sea lions have also been documented both in recreational and commercial hook-and-line fisheries, with the severity varying by year, locality, and type of fishing (Scordino, 2010). This includes the halibut (*Hippoglossus stenolepis*), Pacific herring (*Clupea pallasii*), California anchovy (*Engraulis mordax*), mackerel (*Scomber japonicus*), tuna (*Thunnus* spp.), shark (more than 16 species), swordfish (*Xiphias gladius*), and squid (*Loligo opalescens*; DeMaster et al., 1985; Barlow et al., 1994) fisheries. Pinniped interaction with bait pens in California in 2002 was calculated as a loss of approximately $2.3 million (Scordino, 2010).

Mariculture activities are also subject to interactions with pinnipeds. In British Columbia, salmon farmers have estimated losses due to pinniped predation of up to 10 million Canadian dollars every year (Fraker, 1996; Jamieson & Olesiuk, 2001). Nonetheless, the amount of economic loss attributed to pinnipeds may be overestimated since most pinniped attacks have not been directly observed, and damage to salmon pens could also be due to flotsam, cleaning, boat propellers, and improper net handling (Rueggeberg & Booth, 1989).

In Mexico, there are few formal records of conflicts between fisheries and pinnipeds, but it is known that illegal hunting of California sea lions persists (Zavala-González & Mellink, 2000), likely as a retaliation measure by affected fishermen. In Todos Santos Bay, Baja California, 153 dead individuals were found during surveys of stranded pinnipeds. Of these, 26 had human-related wounds; 24 of these were California sea lions; and 18 of these had gunshot wounds (Bravo et al., 2005). However, since there are no other records of these deaths, it is hard to estimate the size of the problem. In a review of marine mammal standings in Mexico, Gómez-Hernández et al. (2020) point out that due to the increase in coastal economical activities, an increase in interactions between fisheries and marine mammals can be expected, especially between artisanal fishermen and the California sea lion in the Gulf of California.

Many fishermen believe that California sea lions compete with their fisheries. According to fishermen of Guaymas, Sonora, in the Gulf of California, these animals forage on the same species that they traditionally fish; thus, they attribute 58% of their daily catch as lost to sea lions (Fleischer & Cervantes-Fonseca, 1990). In contrast, in the southern region of the Gulf of California, Aurioles-Gamboa et al. (2003) reported that the sea lion's diet included only 5% (in terms of relative importance of its diet) of commercial fish species. Yet, the entanglement percentages (7 to 9%) in this area were the highest in the Gulf of California (Zavala-González & Mellink, 2000; Aurioles-Gamboa et al., 2003). Entanglement can result in distress, pain, trauma, infection, and skin and muscle lesions, as well as the inability to move, feed, and conduct regular behavior. Therefore, it can be considered a significant and global issue with respect to the welfare of marine mammals and the quality of the marine environment (Butterworth & Sayer, 2017).

Artisanal Fisheries of the Northwest Mexican Pacific

Fisheries along the Pacific coast of Baja California are based on the use of a common pool of resources by the community known as cooperatives. These cooperatives are groups of fishermen organized under Mexican law that have used relatively successful common property management to avoid the "tragedy of the commons" (Hardin, 1968, p. 1244), meaning overexploitation and non-care of shared resources. These cooperatives have implemented clear rules, catch quotas, memberships, supervision, and even the establishment of marine reserves in some cases (Rossetto et al., 2015). The lobster (*Panulirus interruptus*) fishery from which these cooperatives gather most of their resources has been certified as a sustainable fishery by the Marine Stewardship Council (Phillips et al., 2009). These are artisanal fisheries, comprising only 500 members distributed among nine fishing cooperatives from ten towns (Phillips et al., 2009), established along 1,400 km of coast.

This particular scenario provides the opportunity to evaluate the interaction of fishermen and pinnipeds in an area that supplies approximately 17.5% (considering the combined fishing production of Baja California and Baja California Sur states) of the Mexican national fishing products by weight (Comisión Nacional de Acuacultura y Pesca [CONAPESCA], 2018), and where important colonies of four species of pinnipeds are also found (Arias-Del-Razo et al., 2017). Fisheries–pinniped interactions are well studied in the U.S. and Europe, but less is known about these interactions in other countries where socioeconomic conditions and governmental regulations are different. In the case of the Mexican Pacific, there are only indirect observations available (Bravo et al., 2005). These interactions can have important ecological, economic, and social repercussions; therefore, it is important to fully comprehend their extent.

In the present study, fishermen's perceptions of the impact from two of the most prominent species of pinnipeds in the region, the California sea lion and the Pacific harbor seal, on their fishing activities was assessed as an exploratory study. These fishermen belong to three cooperatives that work on four islands—San Jeronimo, Natividad, Asuncion, and San Roque—off the west coast of the Baja California Peninsula. The Guadalupe fur seal (*Arctocephalus philippii townsendi*) was excluded due to its limited distribution (Aurioles-Gamboa et al., 2010; Arias-Del-Razo et al., 2017), and the northern elephant seal (*Mirounga angustirostris*) was excluded because this species does not feed along the coast (Aurioles-Gamboa et al., 2006). Divers of an aquaculture company were also interviewed as this is the primary economic activity on Todos Santos Island. Finally, an entanglement index of pinnipeds (the proportion of entangled relative to total counted animals) was calculated on these islands as an independent line of evidence of conflicts between fishermen and pinnipeds.

Methods

Study Area

Pacific harbor seal populations in Mexico are distributed from the Coronados Islands near the border with the U.S. in the north to Asuncion Island in the south (Arias-Del-Razo et al., 2017; Lubinsky et al., 2017). California sea lions share this distribution but also inhabit the southern part of the peninsula and the Gulf of California (Szteren et al., 2006; Arias-Del-Razo et al., 2017). Taking this distribution as a reference, five islands were selected in the Pacific Ocean, west of the Baja California Peninsula, Mexico. From north to south, the islands are Todos Santos, San Jeronimo, Natividad, San Roque, and Asuncion (Figure 1). On these islands, with the exception of San Roque, colonies of northern elephant seals, California sea lions, and Pacific harbor seals can be found. Only harbor seals inhabit San Roque Island.

The fishing resources of highest value around these islands have been given in concession by the Mexican government to fishing cooperatives, granting them exclusive rights. Besides fishing, these cooperatives also carry out surveillance, resource management, and, in some cases, conservation efforts. On Todos Santos Island, an aquaculture company has the concession for the surrounding waters.

Interviews

Semi-structured interviews with fishermen who worked around the islands of the study area were conducted from February to July 2014. The interviews had open and closed questions (Gruber, 2014), and were supported by images of the pinniped species that can be found there. They were asked about their fishing activities, type of gear used, target species, and whether any animal interfered with their fishing. Next, the interviewees observed a series of whole-body photographs of each of the four species of pinnipeds present in the region and were asked to identify each one. In cases where the interviewees said their fishing activities had been interfered with by a pinniped

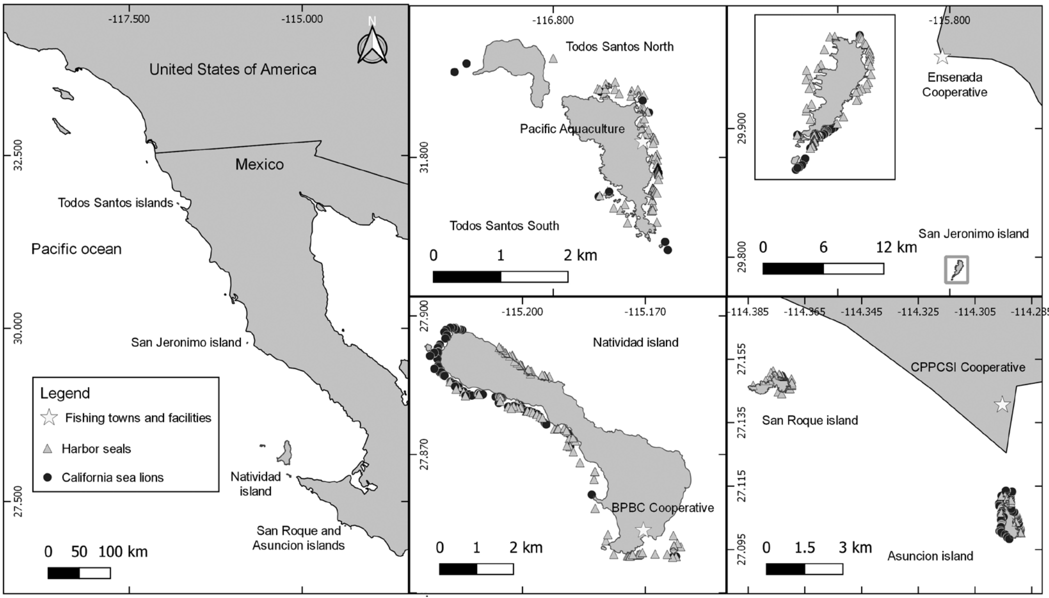

Figure 1. *Left:* Overall view of the study area, showing the location of the Baja California Peninsula in Mexico and the five islands involved in this study. *Right:* Close views of each island, showing known locations of Pacific harbor seal (*Phoca vitulina richardii*) (triangles) and California sea lion (*Zalophus californianus*) (circles) rookeries, as well as fishing communities or facilities.

but failed to identify the species, their answer was corrected to match the species identified in the pictures. (The full questionnaire is available in the "Supplementary Material" section on the *Aquatic Mammals* website: https://www.aquaticmammals-journal.org/index.php?option=com_content&view=article&id=10&Itemid=147.)

The next set of questions inquired how often interactions with pinnipeds occurred, how they occurred, species they predated on, losses or damage to the gear, and if the pinnipeds were injured during these interactions. This set of questions was repeated for each species of pinniped to which the fisherman pointed. In the final part of the interview, they were asked to describe their most recent day of fishing, what they were fishing for, if they interacted with a pinniped, and how it occurred.

Additionally, members of each cooperative's board of directors were interviewed to gather general data such as the number of fishermen in the cooperative, the target species, and what percentage of the cooperative's income each fishery represented.

In total, 77 fishermen from three fishing cooperatives were interviewed (islands where they work are in parentheses): Cooperativa Ensenada (San Jeronimo Island), Cooperativa Buzos y Pescadores de la Baja California (BPBC; Natividad Island), Cooperativa de Produccion Pesquera California de San Ignacio (CPPCSI; San Roque and Asuncion Islands), as well as an aquaculture company: Unidad de Produccion Acuicola de Peces Pacifico Aquaculture S de RL de CV (Todos Santos Island). On average, 24% of the fishermen who belonged to those organizations were interviewed. The mean age of the interviewees was 40 ± 11 y, and they had 20 ± 12 (SD) y of fishing experience.

Entanglement Index

Pinniped surveys were conducted in the study area during the summer (June to August) of 2010. Each island was circumnavigated using a small boat, 20 to 50 m from the shore. Each island was surveyed for 1 d by taking photographs of the whole shoreline. This catalogue of photographs was reviewed to identify entangled animals. An entangled animal shows a scar or exposed flesh around the neck due to the nylon thread cutting through the skin. When found, they were counted, and an estimation of the proportion of entangled animals from the total count was calculated per species, per island. This method does not account for entangled animals that were at sea at the time of the surveys.

Statistical Analyses

Chi-square contingency tests were used to analyze the data obtained from the surveys, looking for independence between the following pairs of variables: (1) interviewees' correct identification of pinnipeds and the island where they work; (2) the marine animal that most affects their fishing activities and the island where they work;

(3) the fishermen's ages and the incidence of California sea lions interfering with their fishing activities; (4) the fishing methods used by each fisherman—diving and trapping; diving, trapping, and fishing (for bony fishes); or only fishing—and if they reported interference from sea lions in their work (Pacific harbor seals were omitted in this analysis due to the low number of fishermen reporting them); (5) frequency of sea lion interference and the island where they work; (6) whether there was interference with sea lions in their last day of work and the island where they work; and (7) the target fish species with reports of sea lion interference and the island where they work. For the third analysis, fishermen's ages were grouped into 10-y groups. For analyses four through seven, interviews from Todos Santos were excluded as they do not perform wild catches.

Results

Fishermen reported catching a range of species, with the most targeted species varying by island (Table 1). Among the most mentioned ones were lobsters (*Panulirus interruptus*), ocean whitefish (*Caulolatilus princeps*), and yellowtail amberjack (*Seriola lalandi*). Other frequently mentioned species were sea snails (*Megastraea undosa* and *M. turbanica*) and sea cucumber (*Parastichopus parvimensis*), as well as green abalone (*Haliotis fulgens*) and pink abalone (*Haliotis corrugate*). On Todos Santos, the aquaculture company grows and commercializes white seabass (*Atractoscion nobilis*) and largemouth bass (*Micropterus salmoides*). They also grow totoaba (*Totoaba macdonaldi*), but they do not yet sell it commercially (Table 1).

The most successfully identified pinniped by the interviewees was the California sea lion (77.9%), followed by the northern elephant seal (76.6%) and the Pacific harbor seal (72.7%). Few fishermen correctly identified the Guadalupe fur seal (1.3%), which is not usually seen around these islands. Most of them wrongly identified it as the California sea lion (57.1%). The mean rates of successful identification were similar on all islands ($\chi^2 = 5.72$; $df = 9$; $p = 0.767$).

When asked which species interfered most frequently during their fishing activities, the most common answer was the California sea lion, followed by other animals such as octopuses, sharks, and the California sheephead (*Semicossyphus pulcher*; Table 2). Only two fishermen mentioned the Pacific harbor seal as the animal that interfered most often. This perception was different between islands ($\chi^2 = 31.7$; $df = 9$; $p < 0.001$). In Asuncion and San Roque, more fishermen mentioned sea lions in comparison with the other islands, while 3.6% of fishermen in Asuncion and San Roque, and 25% in Todos Santos pointed to the harbor seal as a source of interference (Table 2).

An effect of the age of fishermen (categorized as < 30, 30-39, 40-49, 50-59, and > 59 y) was not

Table 1. Species most commonly targeted by fishermen at each island. The numbers in each cell represent the rank based on the number of mentions in the interviews. The species not mentioned by fishermen are denoted by "NM."

Target species	Asuncion and San Roque	Natividad	San Jeronimo	Todos Santos
Invertebrates				
Lobster (*Panulirus interruptus*)	2	1	1	NM
Sea snails (*Megastraea undosa* and *M. turbanica*)	4	2	6	NM
Sea cucumber (*Parastichopus parvimensis*)	11	3	2	NM
Red sea urchin (*Strongylocentrotus franciscanus*)	NM	13	3	NM
Blue abalone (*Haliotis fulgens*) and yellow abalone (*H. corrugata*)	5	8	15	NM
Bony fish				
Yellowtail amberjack (*Seriola lalandi*)	3	7	NM	NM
Ocean whitefish (*Caulolatilus princeps*)	1	6	5	NM
Largemouth bass (*Micropterus salmoides*)	NM	NM	NM	2
Totoaba (*Totoaba macdonaldi*)	NM	NM	NM	3
Rockfish (*Sebastes* spp.)	NM	NM	4	NM
Algae				
Kelp (*Macrocystis pyrifera*)	15	4	10	NM

Table 2. Percentage of fishermen who reported interference by pinnipeds and other animals per island; the contingency table results indicate that there is independence between islands in these answers.

Island	California sea lion	Harbor seal	Other animals	No animals interfere
Asuncion and San Roque	89.3	3.6	3.6	3.6
Natividad	55.6	0.0	18.5	25.9
San Jeronimo	44.4	0.0	29.4	23.5
Todos Santos	0.0	25.0	0.0	75.0
Contingency table test	($\chi^2 = 31.7$; $df = 9$; $p < 0.001$)			

found on whether or not they reported interference by the California sea lion in their fishing activities ($\chi^2 = 4.25$; $df = 4$; $p = 0.373$).

The following results do not include the aquaculture company on Todos Santos because interviewees there did not report interference with California sea lions in their activities. The products with the highest value in this region for these cooperatives (i.e., lobster, abalone, sea cucumber, and sea snail) are extracted by diving (including placement of lobster traps). There was an association between the negative perception towards the sea lion and whether a fisherman only dives (including placing lobster traps), dives and fishes (bony fishes), or only fishes ($\chi^2 = 20.94$; $df = 2$; $p < 0.001$). Of the fishermen who only dive, 65.4% said they had experienced interference from sea lions, while 87.5% of fishermen who both dive and fish, and 86.4% of fishermen who only fish reported interference from sea lions.

The majority of the cooperatives' members who reported interference from California sea lions said this occurred almost daily (80.9%), whereas most others said it happened once a week (17%), and a few said this occurred once per month (2.1%). This reported frequency of interference from sea lions was independent from the island on which fishermen worked ($\chi^2 = 5.91$; $df = 4$; $p = 0.205$). However, when fishermen were asked if they had experienced any interference from pinnipeds during their last day of fishing, only 21.1% on average reported having some kind of interference from a pinniped. No association was found between the interference from pinnipeds on the last day of fishing and the island where fishermen worked ($\chi^2 = 5.89$; $df = 2$; $p = 0.052$).

Based on fishermen's responses, it appears that California sea lions interfere more with the bony fish fisheries than with invertebrates. The affected fisheries change significantly between islands ($\chi^2 = 68.36$; $df = 18$; $p < 0.001$). In Asuncion, San Roque, and Natividad, fishing of ocean whitefish, which includes gillnets, was the one most reported by fishermen as having interference, followed by yellowtail (Table 3); while in San Jeronimo, interference is more often reported in the rockfish (*Sebastes* spp.), California halibut (*Paralichthys californicus*), and white seabass fisheries. The white seabass was also the third most affected fishery in Asuncion, San Roque, and Natividad (Table 3). Perceived product loss includes animals consumed entirely, bitten, and discarded, as well as unsuccessful catches due to animals scared by the pinnipeds or released due to fishing gear damage.

Only two fishermen mentioned the Pacific harbor seal as the animal that interferes most often. Nevertheless, as the interviews continued, more fishermen mentioned they had interactions with this seal (< 25%), as well as the following fisheries: whitefish and rock basses (*Paralabrax* spp. and Serranidae) in Asuncion and San Roque, and California halibut in the same islands and San Jeronimo (Table 4). Also, in San Jeronimo, harbor seals interfere with lobster traps (by consuming the bait) and the white seabass. In Natividad, no fisherman reported interactions with the harbor seal. In the aquaculture company on Todos Santos, a diver claimed that approximately once every 3 mo harbor seals break into the enclosures and eat a few largemouth bass (Table 4).

According to interviews with the three cooperatives' boards of directors, lobster was the main source of income together with abalone in the case of Asuncion and San Roque (Table 5). Incomes from bony fishes were low in all cooperatives; nevertheless, in Asuncion and San Roque, they extracted more species of fish than the other two cooperatives. The second most important source of income for these cooperatives were other invertebrates such as sea snail and sea cucumber. The aquaculture company on Todos Santos markets white seabass and largemouth bass, but interviewees did not specify details about their profits (Table 5).

Regarding the damage to fishing gear caused by pinnipeds, according to fishermen, in Asuncion, the most common damage by California sea lions were to fishing lines (39%), nets (36%), and traps (32%). Only 25% of the fishermen said pinnipeds did not cause any damages. In Natividad, 74% of

Table 3. Percentage of fishermen who reported interaction of California sea lions (*Zalophus californianus*) with the fishing of different species and their perceived product losses, expressed as percentage of captured individuals ± its standard error. Losses marked with † indicate that only one fisherman from this area was able to estimate the losses.

Species	Asuncion and San Roque	Natividad	San Jeronimo
Whitefish	67.9	33.3	11.1
Product loss	26 ± 20	35 ±2 0	75†
Yellowtail	42.9	22.2	0.0
Product loss	33 ± 23	24 ± 10	0
Halibut	25.0	0.0	16.7
Product loss	25 ± 15	0	52 ± 23
White seabass	32.1	18.5	16.7
Product loss	40 ± 31	33 ± 38	52 ± 23
Rock bass	10.7	14.8	0.0
Product loss	19 ± 12	38 ± 21	0
Lobster	17.9	11.1	0.0
Product loss	11 ± 5	7 ± 1	0
Sardine	21.4	0.0	0.0
Product loss	15†	0	0
Octopus	10.7	0.0	0.0
Product loss	43 ± 50	0	0
Rockfish	0.0	0.0	44.4
Product loss	0	0	34 ± 26

Table 4. Percentage of fishermen who reported interactions of Pacific harbor seals (*Phoca vitulina richardii*) with the fishing of different species and their perceived product losses, expressed as percentage of captured product ± its standard error. Losses marked with † indicate that only one fisherman from this area was able to estimate the losses.

Species	Asuncion and San Roque	Natividad	San Jeronimo	Todos Santos
Whitefish	3.6	0	0	0
Product loss	30†	0	0	0
Halibut	3.6	0	5.6	0
Product loss	6†	0	30†	0
Rock bass	7.1	0	0	0
Product loss	30 ± 0	0	0	0
Lobster	0	0	5.6	0
Product loss	0	0	Highly variable†	0
White seabass	0	0	5.6	0
Product loss	0	0	30	0
Largemouth bass	0	0	0	25
Product loss	0	0	0	2 or 3 fishes every 3 mo

the fishermen reported no damage by pinnipeds, and only 11% recalled losing lines and hooks. In San Jeronimo, 56% of fishermen did not report damage to their gear by pinnipeds, while 11% reported broken lines and traps. In Todos Santos, only one diver said that Pacific harbor seals break into enclosures, but it did not happen often; this was the only case of reported damages by harbor seals.

According to the interviewees, the most common measures taken to reduce the interference of pinnipeds are (1) do nothing (36%), (2) hit the boat with

Table 5. Percentage of earnings per product for cooperatives and companies that have concessions on each island in the study area according to the interviews with the cooperatives' boards of directors

Island	Main income	Other income
Asuncion and San Roque	90% lobster and abalone	10% sea snail, sea cucumber, bony fish, crab, octopus, and kelp, all together
Natividad	60% lobster	24% sea cucumber, 15% sea snail, and 1% kelp
San Jeronimo	75-80% lobster	20-25% sea cucumber, sea urchin, crab, and bony fishes, all together
Todos Santos	100% white seabass and largemouth bass	

a metal object to produce noise (14%), (3) move to another area (10%), and (4) stay away from the islands (5%). To protect the lobster traps, three fishermen from San Roque and Natividad mentioned that they place a baited trap, and when a sea lion chases them, they leave this trap and quickly move to another area to place the rest of the traps. Another fisherman from Natividad also mentioned that using reinforced traps has reduced the interference of sea lions. In additional comments from the cooperative members, four fishermen (5%), all from Asuncion, mentioned that some sort of pinniped population control is necessary.

The only entangled pinniped species observed during these surveys was the California sea lion. An entangled animal was considered any animal with visible signs of neck injury since, from a distance, it is often not possible to assess if the nylon is still attached. On Asuncion Island, only four female and two juvenile sea lions were found entangled out of 1,928 individuals counted; thus, the percentage of entangled animals was 0.31%. On San Roque Island, no entangled pinnipeds were found. On Natividad, five females and one male sea lion were found entangled out of 1,365 sea lions on the island (i.e., 0.44%). On San Jeronimo, one female and one subadult male were found entangled out of 1,426 sea lions (i.e., 0.14%). Finally, at Todos Santos, only one male was found entangled, but since the total count was only 105 sea lions, the percentage on this island was the highest, 0.95%.

Discussion

From the interviews conducted, it is possible to conclude that there is a perceived conflict between fishermen and the California sea lion, and to a lesser extent, with the Pacific harbor seal. The northern elephant seal was the most correctly identified pinniped, but it was not mentioned by the fishermen, nor was the Guadalupe fur seal. Elephant seals feed in pelagic waters (Le Boeuf et al., 2000; Aurioles-Gamboa et al., 2006); nevertheless, in California, it is common to find them caught in fishing nets (Barlow et al., 1994). Unfortunately, there is no information regarding the possible interactions between the Guadalupe fur seal and the fisheries due to its limited distribution.

Fishermen from the cooperatives reported experiencing interference from California sea lions, although this was not generalized as the percentage of fishermen who reported interference from sea lions varied among islands (Table 2). In Asuncion and San Roque, fishermen reported more interference from sea lions but less so in Natividad and San Jeronimo. It is worth noting that in Asuncion and San Roque, the fishermen rely more on fish as opposed to shellfish (according to the interviews); while in Natividad and San Jeronimo, their main targets are invertebrate species. The fishermen who rely more on diving and placing traps reported less interference from pinnipeds than those who also fish with lines or nets. This suggests that the interferences from sea lions in each cooperative depends on the fishing method and target species. Fishing of bony fishes produces more interference from sea lions towards fishermen. Considering that most of the income of western Baja California's cooperatives comes from the exploitation of lobster and abalone (Table 5), the interaction between sea lions and commercial activities seems to have a low economic impact due to the lower interaction with valuable species that are their main source of income.

Of the fishermen who reported having interactions with sea lions, 81% mentioned that it occurs almost daily, but only 21% of the interviewed fishermen said they had an interaction with a sea lion during their last day of fishing. Disparity between reported interferences and actual observations of the phenomenon can be expected (Sepúlveda et al., 2007), but this discrepancy may be the result of estimation errors by the researcher, an overestimation of the interferences by the fishermen, or a combination of both. To obtain better estimates, it is important to use a combination of local knowledge and scientific observations such as understanding the local fishing methods and using onboard observers.

Besides the predation on fishing gear and the subsequent damage to fishermen, these interactions can also be detrimental to pinnipeds in the form of entanglement, hook ingestion, and being hunted by fishermen (Baraff & Loughlin, 2000). In Baja California, Shester & Micheli (2011) estimated that for every $3,000 of products caught with gillnets, one California sea lion is caught as well. From these threats to pinnipeds, perhaps the easiest to note and count is the entanglement of live animals. This occurs when an animal tries to predate on fish inside a net and gets entangled in it. In some cases, pinnipeds have enough strength to tear the net and escape; however, in many occurrences, they escape with the net filament around their necks. This leads to infections and finally to death by asphyxia when their necks continue to grow. The entanglement indexes found in these islands are one more indication that although there is a conflict between the California sea lion and the fisheries of this region, its magnitude is much lower (< 1%) than in other areas. In La Paz Bay, where gillnet fishing is more common, the entanglement index has been reported to be as high as 9% (Aurioles-Gamboa et al., 2003). A review of worldwide entanglement in pinnipeds found that the overall entanglement average was 0.37%, and that 22 of 33 extant pinniped species (67%) had entanglement records. In addition, the most common species entangled were the Antarctic fur seal (*Arctocephalus gazella*) and the California sea lion, the latter with a positive trend (Jepsen & de Bruyn, 2019). This coincides with the results of this study in which the only species with signs of entanglement was the California sea lion.

Pacific harbor seals were also mentioned by the fishermen as interfering in their activities. However, fishermen who reported interference with harbor seals said this occurred less frequently and that they lose less product than when sea lions interfere with their fishing (Table 4). According to the fishermen, of those fisheries in which the harbor seal interferes, only halibut and rock basses have been recognized as important components of the animal's diet in this region (Elorriaga-Verplancken et al., 2013; Alamán de Regules, 2014; Durazo Rodríguez, 2015). Diet studies along its distribution have concluded that the harbor seal feeds on the more abundant species within their range (Brown & Pierce, 1997; Lunneryd, 2001; Riemer & Mikus, 2006), so it can be assumed that their feeding on caught prey by fishing gear is part of this opportunistic behavior.

In this study, interactions between sea lions and fishermen occurred mainly in bony fish fisheries, but they also affected lobster trap fisheries (Table 3). When comparing data against the closest region with information about fisheries–pinniped interactions—California in the U.S.—the affected fisheries there do not correspond with those fisheries affected in Mexico as determined in the present study (DeMaster et al., 1985; Barlow et al., 1994; Weise & Harvey, 2005; Scordino, 2010); and when comparing affected fisheries with California sea lion diet studies in the study area, only two matches were found: the rockfish and the halibut (Espinosa de los Reyes-Ayala, 2007). This could mean that the fish that sea lions take from the fishing gear probably do not represent their preferred prey species. Whitefish has only been known as part of their diet in the southern Gulf of California, with an importance index of 3.6% (Szteren & Aurioles-Gamboa, 2013). Espinosa de los Reyes-Ayala (2007) suggests that the California sea lion is an opportunistic predator that consumes a few resources in large quantities as well as many species with low frequency.

Lobster and abalone populations in particular have declined in other sites of the California Current such as the coast of California (Rogers-Bennett et al., 2002; Iacchei et al., 2005); and, coincidentally, interferences between sea lions and lobster fisheries have increased in those places (Barlow et al., 1994; Weise & Harvey, 2005; Read et al., 2006). In contrast, in the Vizcaino region of Baja California, cooperatives had an income of $21.3 million in 2010 (Lluch-Belda, 2011) from the extraction of lobster (1,500 tons) and abalone (500 tons). This is a significant proportion of income for the small villages of this region and, according to board members of the cooperatives, lobster represents most of the cooperatives' income, meaning that interferences of pinnipeds with this activity can potentially have important economic impacts. In this study, only 18% of the fishermen interviewed reported that sea lions interfered with lobster trapping, mainly by stealing the bait and damaging the traps in the process. This contrasts with Shester (2008), who also studied artisanal fishing cooperatives on the Pacific side of Baja California Sur, south of the current study area, and reported no interactions between sea lions or any other marine mammal and lobster traps. Fishermen from Natividad Island (located in Baja California Sur) mentioned that their interaction with sea lions has decreased since they started using stronger traps and setting up decoy traps farther away from the live traps to distract predators.

In the 1990s, southern California fishermen who used traps to catch lobsters and crabs reported the loss of half of their traps due to California sea lions (Beeson & Hanan, 1996), while earlier studies did not find this interaction (Miller et al., 1983; DeMaster et al., 1985). This suggests that either sea lions recognized the traps as a food source and have learned to take advantage of them or that the competition for food has increased due to ecosystem depletion. It is important to mention that since Beeson & Hanan (1996), there have been no more recent reports on the subject in California.

In some other countries, such as Canada, the U.S., Scotland, Ireland, England, or Chile, where fishermen experience direct interactions with pinnipeds, they have requested culls to reduce the size of populations (Lavigne, 2003; Kauppinen et al., 2005; Sepúlveda et al., 2007; Gruber, 2014). However, in this study, only 5% of the fishermen from Baja California's cooperatives have expressed similar desires. Most interviewed fishermen believed that there is nothing to be done because they are protected species; therefore, they have developed a variety of techniques to avoid encounters (e.g., noise, decoy traps, and reinforcement of their traps). The perceptions and opinions found are probably due to the relatively small magnitude of the impact of these conflicts in Baja California. Interactions between fishermen and pinnipeds may be more frequent in places where overfishing is depleting the stocks of the pinnipeds' preferred prey (Baraff & Loughlin, 2000), but also may be due to the shrinking of the trophic chain (Pauly & Maclean, 2003). Even when their preferred prey is not directly targeted by fisheries, though lower levels of the trophic chain are, these alterations can have an impact on the primary resources and, in consequence, on the abundance of their prey. Thus, apex predators are forced to feed on lower levels of the trophic chain or on less preferred prey, thus competing with those fisheries.

In recent decades, pinnipeds, especially California sea lions, have been observed to suffer shortages of food during ocean climate events such as "El Niño" (Trillmich & Limberger, 1985; DeLong et al., 1991), but they also need to cope with the anthropogenic impacts that have depleted the ecosystems and that continue to shrink the trophic chains, an effect that Pauly & Maclean (2003) have called "squashed pyramids" (p. 53). Additionally, climate change is producing major impacts in the Gulf of California where the sea lion population reached a peak of around 43,834 individuals in 1991 and, since then, has declined to around 15,291 in 2019 as a result of a three-decade sustained warming of the sea surface waters in that region. This translates into lower primary and secondary productivity, thus causing pinnipeds to have higher foraging costs (Adame et al., 2020). Negative interactions with fisheries and a decline in the abundance of the Pacific sardine (*Sardinops sagax*) in the beginning of the 1990s have also been proposed as causes of this decline (Szteren et al., 2006). This highlights the importance of studying the interactions between fisheries and pinnipeds as they can provide important information regarding ecosystem health as its decline may lead to a higher number of interactions.

Artisanal fisheries along the west coast of Baja California are a good example of successful resource management (McCay et al., 2014). The relatively good health of these fisheries relies on their good practices and low levels of human population and demand. Therefore, the anthropogenic impact on marine ecosystems is relatively low (Halpern et al., 2008; Shester & Micheli, 2011; Suuronen et al., 2012). This could explain why there seems to be less confrontation between fishermen and pinnipeds here in comparison to other regions, such as the northeastern coast of the U.S. (Orphanides, 2011; Byrd et al., 2014; Gruber, 2014; Josephson et al., 2019), where human population density and exploitation rates of marine fisheries are higher than in the current study area (National Marine Fisheries Service [NMFS], 2014).

In contrast with the rest of the islands, the perception of aquaculture divers in Todos Santos towards the pinnipeds was mainly positive. They only reported that Pacific harbor seals have occasionally torn their nets, entered their enclosures, and ate some fish. They did not mention any trouble with sea lions, although this seems to be the result of having surface protections that make it difficult for birds and pinnipeds to access the enclosures. Since the 1980s, aquaculture activities in California have used different deterrence measures to protect their enclosures from pinnipeds, such as low intensity sound generators (pingers), but these have shown low efficiency and have been replaced with acoustic harassment devices (AHDs) which are more effective but can cause hearing damage to some species (Reeves et al., 1996; Würsig & Gailey, 2002). Pingers have also been shown to double the interaction with California sea lions as they produce a "dinner bell" effect (Carretta & Barlow, 2011). Physical barriers have been successful in many cases, although they must be strong and high enough to deter sea lions (Würsig & Gailey, 2002).

Another part of these interactions is the decline in commercial fish stocks. Fishermen around the world see other marine predators as their direct competitors, blaming them for the decline in their fisheries productivity (Lavigne, 2003). Ecosystem simulations on cod biomass in the Baltic Sea have shown that its biomass is more driven by fishing mortality, climate change, and nutrient load rather than by seal predation; this contradicts the general perception that increasing seal populations are having a negative effect on fish biomass (Costalago et al., 2019). In these fishing cooperatives of Baja California, those that have implemented marine reserves, like Isla Natividad, have higher fish biomass despite the presence of large rookeries of California sea lions and Pacific harbor seals (Arias-Del-Razo et al., 2019).

So, can successful fisheries coexist with abundant populations of pinnipeds? Our opinion is that it is possible if fishermen use the correct tools, such as marine reserves, biological monitoring, and fishing quotas, to ensure the health of the marine ecosystem. The frequencies of interactions between fishermen and pinnipeds can be expected to remain relatively low when marine mammals have enough prey available. In the opposite case, when stocks are overexploited and the trophic chain is shrinking, it is possible that more seals will look for prey in fishing gear.

Considering the ecological, social, and economic impacts that fisheries–pinniped interactions can have, it is remarkable that there are so few studies on the subject in an area with such high diversity of pinnipeds such as the Baja California Peninsula. These interactions are difficult to quantify and, therefore, challenging to manage (Costalago et al., 2019). The main methods to study them are stranding records, entanglement indexes, onboard observers, and interviews with fishermen such as we have reported upon herein. New methods, like remote electronic monitoring (REM), have been proven effective at detecting artisanal fisheries bycatch, including pinnipeds (Bartholomew et al., 2018). However, to obtain a full overview, it is important to continue gathering and analyzing information from all these sources and methods, as well as to compare between regions with different ecosystems, levels of exploitation, target species, fishing gear, and social and economic characteristics.

Acknowledgments

This study was funded by the Consejo Nacional de Ciencia y Tecnología (CONACyT; Ciencia Básica, 2012-01, Project Number 179451) and the Secretaría de Medio Ambiente y Recursos Naturales (SEMARNAT; 2006-01, Project Number 23702); PI: Y. Schramm. A. Arias-Del-Razo received a scholarship from CONACyT during the preparation of this manuscript. We thank the fishermen and cooperative board members from Cooperativa de Producción Pesquera California de San Ignacio, Cooperativa Buzos y Pescadores de la Baja California, and Cooperativa Ensenada, as well as the Unidad de Producción Acuícola de Peces Pacífico Aquaculture S de RL de CV for their cooperation and help. Special thanks to P. Durazo, R. Alamán, E. Fernández, C. Tapia, and G. Ruiz for their help during fieldwork. Our special thanks to Martin Alejandro Serrano Meneses who proofread the manuscript.

Literature Cited

Adame, K., Elorriaga-Verplancken, F. R., Beier, E., Acevedo-Whitehouse, K., & Pardo, M. A. (2020). The demographic decline of a sea lion population followed multi-decadal sea surface warming. *BioRxiv*. https://doi.org/10.1101/2020.03.09.984716

Alamán de Regules, R. (2014). *Hábitos alimentarios de la foca de puerto,* Phoca vitulina richardsi*, en la Bahía Todos Santos, Baja California, México* [Feeding habits of the harbor seal, *Phoca vitulina richardsi*, in Todos Santos Bay, Baja California, Mexico] (Master's thesis). Universidad Autónoma de Baja California, Ensenada, Baja California, Mexico.

Arias-Del-Razo, A., Schramm, Y., Heckel, G., Milanés-Salinas, Á., Garcia-Capitanachi, B., Lubinsky-Jinich, D., & Franco-Ortiz, M. (2017). Distribution of four pinnipeds (*Zalophus californianus*, *Arctocephalus philippii townsendi*, *Phoca vitulina richardii*, and *Mirounga angustirostris*) on islands off the west coast of the Baja California Peninsula, Mexico. *Aquatic Mammals*, *43*(1), 40-51. https://doi.org/10.1578/AM.43.1.2017.40

Arias-Del-Razo, A., Schramm, Y., Heckel, G., Sáenz-Arroyo, A., Hernandez, A., Vazquez, L., & Carrillo-Muñoz, A. I. (2019). Do marine reserves increase prey for California sea lions and Pacific harbor seals? *PLOS ONE*, *14*(6), e0218651. https://doi.org/10.1371/journal.pone.0218651

Aurioles-Gamboa, D., Elorriaga-Verplancken, F., & Hernández-Camacho, C. J. (2010). The current population status of Guadalupe fur seal (*Arctocephalus townsendi*) on the San Benito Islands, Mexico. *Marine Mammal Science*, *26*(2), 402-408. https://doi.org/10.1111/j.1748-7692.2009.00350.x

Aurioles-Gamboa, D., Koch, P. L., & Le Boeuf, B. J. (2006). Differences in foraging location of Mexican and California elephant seals: Evidence from stable isotopes in pups. *Marine Mammal Science*, *22*(2), 326-338. https://doi.org/10.1111/j.1748-7692.2006.00023.x

Aurioles-Gamboa, D., García-Rodríguez, F., Ramírez-Rodríguez, M., & Hernández-Camacho, C. (2003). Interaction between the California sea lion and the artisanal fishery in La Paz Bay, Gulf of California, Mexico. *Ciencias Marinas*, *29*(3), 357-370. https://doi.org/10.7773/cm.v29i3.151

Baraff, L. S., & Loughlin, T. R. (2000). Trends and potential interactions between pinnipeds and fisheries of New England and the U.S. west coast. *Marine Fisheries Review*, *62*(4), 1-39.

Barlow, J., Baird, R. W., Heyning, J. E., Wynne, K., Manville II, A. M., Lowry, L. F., Hanan, D., Sease, J., & Burkanov, V. N. (1994). A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the USA and Canada and the east coast of the Russian

Federation. *Reports of the International Whaling Commission*, Special Issue 15, 405-425.

Bartholomew, D. C., Mangel, J. C., Alfaro-Shigueto, J., Pingo, S., Jimenez, A., & Godley, B. J. (2018). Remote electronic monitoring as a potential alternative to on-board observers in small-scale fisheries. *Biological Conservation*, *219*, 35-45. https://doi.org/10.1016/j.biocon.2018.01.003

Beeson, M. J., & Hanan, D. A. (1996). *An evaluation of pinniped–fishery interactions in California. A report to the Pacific States Marine Fisheries Commission (PSMFC)*. California Department of Fish and Game. http://aquaticcommons.org/id/eprint/2094

Bravo, E., Heckel, G., Schramm, Y., & Escobar-Fernández, R. (2005). Occurrence and distribution of marine mammal strandings in Todos Santos Bay, Baja California, Mexico, 1998-2001. *Latin American Journal of Aquatic Mammals*, *4*(1), 15-25. https://doi.org/10.5597/lajam00066

Brown, E. G., & Pierce, G. J. (1997). Diet of harbour seals at Mousa, Shetland, during the third quarter of 1994. *Journal of the Marine Biological Association of the United Kingdom*, *77*(2), 539-555. https://doi.org/10.1017/S002531540007185X

Butterworth, A., & Sayer, S. (2017). The welfare impact on pinnipeds of marine debris and fisheries. In A. Butterworth (Ed.), *Marine mammal welfare: Human induced change in the marine environment and its impacts on marine mammal welfare* (pp. 215-239). Springer International Publishing. https://doi.org/10.1007/978-3-319-46994-2_13

Byrd, B. L., Hohn, A. A., Lovewell, G. N., Altman, K. M., Barco, S. G., Friedlaender, A., Harms, C. A., McLellan, W. A., Moore, K. T., & Rosel, P. E. (2014). Strandings as indicators of marine mammal biodiversity and human interactions off the coast of North Carolina. *Fishery Bulletin*, *112*(1), 1-23. https://doi.org/10.7755/FB.112.1.1

Carretta, J. V., & Barlow, J. (2011). Long-term effectiveness, failure rates, and "dinner bell" properties of acoustic pingers in a gillnet fishery. *Marine Technology Society Journal*, *45*(5), 7-19. https://doi.org/10.4031/MTSJ.45.5.3

Comisión Nacional de Acuacultura y Pesca (CONAPESCA). (2018). *Anuario estadístico de acuacultura y pesca 2018* [Statistical yearbook of aquaculture and fisheries 2018]. CONAPESCA. https://www.gob.mx/conapesca/documentos/anuario-estadistico-de-acuacultura-y-pesca

Costalago, D., Bauer, B., Tomczak, M. T., Lundström, K., & Winder, M. (2019). The necessity of a holistic approach when managing marine mammal–fisheries interactions: Environment and fisheries impact are stronger than seal predation. *Ambio*, *48*(6), 552-564. https://doi.org/10.1007/s13280-018-1131-y

DeLong, R. L., Antonelis, G. A., Oliver, C. W., Stewart, B. S., Lowry, M. C., & Yochem, P. K. (1991). Effects of the 1982-83 El Niño on several population parameters and diet of California sea lions on the California Channel Islands. In F. Trillmich & K. Ono (Eds.), *Pinnipeds and El Niño* (Vol. 88, pp. 166-172). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-76398-4_18

DeMaster, D., Miller, D., Henderson, J. R., & Coe, J. M. (1985). Conflicts between marine mammals and fisheries off the coast of California. In J. R. Beddington, R. J. H. Beverton, & D. M. Lavigne (Eds.), *Marine mammals and fisheries* (pp. 111-118). Allen and Unwin.

Durazo Rodríguez, R. P. (2015). *Variación espacio-temporal de los hábitos alimentarios de la foca de puerto (*Phoca vitulina richardii*) en México* [Spatio-temporal variation of the feeding habits of the harbor seal (*Phoca vitulina richardii*) in Mexico] (Master's thesis). Universidad Autónoma de Baja California, Ensenada, Baja California, Mexico.

Elorriaga-Verplancken, F., Morales-Luna, L., Moreno-Sánchez, X. G., & Mendoza-Salas, I. (2013). Inferences on the diet of the eastern Pacific harbor seal (*Phoca vitulina richardii*) at the southern end of its distribution: Stable isotopes and scats analyses. *Aquatic Mammals*, *39*(4), 415-421. https://doi.org/10.1578/AM.39.4.2013.415

Espinosa de los Reyes-Ayala, M. G. (2007). *Variabilidad espacial de la dieta del lobo marino de California (*Zalophus californianus californianus, *Lesson 1828)* [Spatial variation in the diet of California sea lion (*Zalophus californianus californianus,* Lesson 1828)] (Master's thesis). Centro de Investigación Científica y de Educación Superior de Ensenada, Baja California, Mexico. https://cicese.repositorioinstitucional.mx/jspui/handle/1007/1868

Fleischer, L. A., & Cervantes-Fonseca, F. (1990). Abundancia de lobos marinos (*Zalophus californianus*) en la región de Guaymas, Sonora, México y su impacto en la pesca ribereña [Abundance of sea lions (*Zalophus californianus*) in the Guaymas region, Sonora, Mexico and their impact on coastal fishing]. In L. A. Fleischer (Ed.), *Estudios sobre el lobo marino en el noroeste de México* [Sea lion studies in northwestern Mexico] (pp. 41-59). Secretaria de Pesca.

Fraker, M. (1996). *Interactions between salmon farms and marine mammals and other species*. BC Salmon Farmers Association.

Goldsworthy, S. D., & Page, B. (2007). A risk-assessment approach to evaluating the significance of seal bycatch in two Australian fisheries. *Biological Conservation*, *139*(3-4), 269-285. https://doi.org/10.1016/j.biocon.2007.07.010

Gómez-Hernández, G., Seingier, G., Elorriaga-Verplancken, F., & Heckel, G. (2020). Status and scope of marine mammal stranding research in Mexico. *Journal of Coastal Conservation*, *24*(1), 1-6. https://doi.org/10.1007/s11852-019-00725-8

Gruber, C. P. (2014). *Social, economic, and spatial perceptions of gray seal (*Halichoerus grypus*) interactions with commercial fisheries in Cape Cod, MA* (Master's thesis). Duke University, Durham, North Carolina. https://dukespace.lib.duke.edu/dspace/handle/10161/8473

Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., D'Agrosa, C., Bruno, J. F., Casey, K. S., Ebert, C., & Fox, H. E. (2008). A global map of human impact on marine ecosystems. *Science*, *319*(5865), 948-952. https://doi.org/10.1126/science.1149345

Hardin, G. (1968). The tragedy of the commons. *Science*, *162*(3859), 1243-1248. https://doi.org/10.1126/science.162.3859.1243

Iacchei, M., Robinson, P., & Miller, K. A. (2005). Direct impacts of commercial and recreational fishing on spiny lobster, *Panulirus interruptus*, populations at Santa Catalina Island, California, United States. *New Zealand Journal of Marine and Freshwater Research*, *39*(6), 1201-1214. https://doi.org/10.1080/00288330.2005.9517386

Jamieson, G. S., & Olesiuk, P. F. (2001). *Salmon farm pinniped interactions in British Columbia: An analysis of predator control, its justification and alternative approaches* (Canadian Science Advisory Secretariat Research Document 2001/142). Fisheries and Oceans Science.

Jepsen, E. M., & de Bruyn, P. J. N. (2019). Pinniped entanglement in oceanic plastic pollution: A global review. *Marine Pollution Bulletin*, *145*, 295-305. https://doi.org/10.1016/j.marpolbul.2019.05.042

Josephson, E., Wenzel, F., & Lyssikatos, M. C. (2019). *Serious injury determinations for small cetaceans and pinnipeds caught in commercial fisheries off the northeast U.S. coast, 2012-2016* (Northeast Fisheries Science Center Reference Document 19-05). NOAA Fisheries, Northeast Fisheries Science Center. https://doi.org/10.25923/d98x-ng86

Kauppinen, T., Siira, A., & Suuronen, P. (2005). Temporal and regional patterns in seal-induced catch and gear damage in the coastal trap-net fishery in the northern Baltic Sea: Effect of netting material on damage. *Fisheries Research*, *73*(1-2), 99-109. https://doi.org/10.1016/j.fishres.2005.01.003

Lavigne, D. (2003). Marine mammals and fisheries: The role of science in the culling debate. In N. Gales, M. A. Hindell, & R. Kirkwood (Eds.), *Marine mammals: Fisheries, tourism and management issues* (Vol. 2006, pp. 31-47). CSIRO Publishing.

Le Boeuf, B. J., Crocker, D. E., Costa, D. P., Blackwell, S. B., Webb, P. M., & Houser, D. S. (2000). Foraging ecology of northern elephant seals. *Ecological Monographs*, *70*(3), 353-382. https://doi.org/10.1890/0012-9615(2000)070[0353:FEONES]2.0.CO;2

Lluch-Belda, D. (2011). *Informe del proyecto PEACC Baja California Sur PESCA* [PEACC Baja California Sur PESCA project report]. Secretaria de Desarrollo Económico, Medio Ambiente y Recursos Naturales. https://docplayer.es/17872479-Informe-del-proyecto-peacc-baja-california-sur-pesca-coordinador-dr-daniel-lluch-belda.html

Lubinsky-Jinich, D., Schramm, Y., & Heckel, G. (2017). The Pacific harbor seal's (*Phoca vitulina richardii*) breeding colonies in Mexico: Abundance and distribution. *Aquatic Mammals*, *43*(1), 73-81. https://doi.org/10.1578/AM.43.1.2017.73

Lunneryd, S. G. (2001). Fish preference by the harbour seal (*Phoca vitulina*), with implications for the control of damage to fishing gear. *ICES Journal of Marine Science: Journal Du Conseil*, *58*(4), 824-829. https://doi.org/10.1006/jmsc.2001.1073

McCay, B. J., Micheli, F., Ponce-Díaz, G., Murray, G., Shester, G., Ramirez-Sanchez, S., & Weisman, W. (2014). Cooperatives, concessions, and co-management on the Pacific coast of Mexico. *Marine Policy*, *44*, 49-59. https://doi.org/10.1016/j.marpol.2013.08.001

Miller, D. J., Herder, M. J., & Scholl, J. P. (1983). *California marine mammal–fishery interaction study, 1979-1981* (National Marine Fisheries Service Administrative Report LJ-83-13C). Southwest Fisheries Science Center.

Moore, J. E., Wallace, B. P., Lewison, R. L., Žydelis, R., Cox, T. M., & Crowder, L. B. (2009). A review of marine mammal, sea turtle and seabird bycatch in USA fisheries and the role of policy in shaping management. *Marine Policy*, *33*(3), 435-451. https://doi.org/10.1016/j.marpol.2008.09.003

National Marine Fisheries Service (NMFS). (2014). *Fisheries of the United States, 2014* (Current Fishery Statistics). National Oceanic and Atmospheric Administration, U.S. Department of Commerce. https://www.st.nmfs.noaa.gov/commercial-fisheries/fus/fus14/index

Orphanides, C. D. (2011). *Estimates of cetacean and pinniped bycatch in the 2009 New England sink gillnet and Mid-Atlantic gillnet fisheries* (Fisheries Science Center Reference Document 11-08). National Marine Fisheries Service. https://repository.library.noaa.gov/view/noaa/8621

Pauly, D., & Maclean, J. (2003). *In a perfect ocean: The state of fisheries and ecosystems in the North Atlantic Ocean*. Island Press.

Phillips, B., Bourillón, L., & Ramade-Villanueva, M. (2009). Case Study 2: The Baja California, Mexico, lobster fishery. In T. Ward & B. Phillips (Eds.), *Seafood ecolabelling: Principles and practice* (pp. 259-268). Wiley. https://doi.org/10.1002/9781444301380.ch12

Read, A. J. (2008). The looming crisis: Interactions between marine mammals and fisheries. *Journal of Mammalogy*, *89*(3), 541-548. https://doi.org/10.1644/07-MAMM-S-315R1.1

Read, A. J., Drinker, P., & Northridge, S. (2006). Bycatch of marine mammals in U.S. and global fisheries. *Conservation Biology*, *20*(1), 163-169. https://doi.org/10.1111/j.1523-1739.2006.00338.x

Reeves, R. R., Hofman, R. J., Silber, G. K., & Wilkinson, D. M. (1996). *Acoustic deterrence of harmful marine mammal–fishery interactions: Proceedings of a workshop held in Seattle, Washington, 20-22 March 1996* (NOAA Tech. Memo. NMFS-OPR-10). National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Riemer, S. D., & Mikus, R. (2006). Aging fish otoliths recovered from Pacific harbor seal (*Phoca vitulina*) fecal samples. *Fishery Bulletin*, *104*(4), 626-630.

Rogers-Bennett, L., Haaker, P. L., Huff, T. O., & Dayton, P. K. (2002). Estimating baseline abundances of abalone in California for restoration. *Reports of California Cooperative Oceanic Fisheries Investigations*, *43*, 97-111.

Rossetto, M., Micheli, F., Saenz-Arroyo, A., Montes, J. A. E., De Leo, G. A., & Rochet, M-J. (2015). No-take marine reserves can enhance population persistence and support the fishery of abalone. *Canadian Journal of Fisheries and Aquatic Sciences*, *72*(10), 1503-1517. https://doi.org/10.1139/cjfas-2013-0623

Rueggeberg, H., & Booth, J. (1989). *Interactions between wildlife and salmon farms in British Columbia*. Canadian Wildlife Service.

Scordino, J. (2010). *West coast pinniped program investigations on California sea lion and Pacific harbor seal impacts on salmonids and other fishery resources*. Pacific States Marine Fisheries Commission.

Sepúlveda, M., Pérez, M. J., Sielfeld, W., Oliva, D., Durán, L. R., Rodríguez, L., Araos, V., & Buscaglia, M. (2007). Operational interaction between South American sea lions *Otaria flavescens* and artisanal (small-scale) fishing in Chile: Results from interview surveys and on-board observations. *Fisheries Research*, *83*(2-3), 332-340. https://doi.org/10.1016/j.fishres.2006.10.009

Shester, G. G. (2008). *Sustainability in small-scale fisheries: An analysis of ecosystem impacts, fishing behavior, and spatial management using participatory research methods* (Doctoral dissertation). Stanford University, Stanford, California. https://searchworks.stanford.edu/view/7911652

Shester, G. G., & Micheli, F. (2011). Conservation challenges for small-scale fisheries: Bycatch and habitat impacts of traps and gillnets. *Biological Conservation*, *144*(5), 1673-1681. https://doi.org/10.1016/j.biocon.2011.02.023

Suuronen, P., Chopin, F., Glass, C., Løkkeborg, S., Matsushita, Y., Queirolo, D., & Rihan, D. (2012). Low impact and fuel efficient fishing—Looking beyond the horizon. *Fisheries Research*, *119-120*, 135-146. https://doi.org/10.1016/j.fishres.2011.12.009

Szteren, D., & Aurioles-Gamboa, D. (2013). *Elementos traza en hueso de* Zalophus californianus *en el golfo de California: Una evaluación comparativa de áreas potencialmente contaminadas* [Trace elements in *Zalophus californianus* bone in the Gulf of California: A comparative assessment of potentially contaminated areas]. *Ciencias Marinas*, *39*, 306-315. https://doi.org/10.7773/cm.v39i3.2268

Szteren, D., Aurioles-Gamboa, D., & Gerber, L. R. (2006). Population status and trends of the California sea lion (*Zalophus californianus californianus*) in the Gulf of California, Mexico. In A. Trites (Ed.), *Sea lions of the world* (pp. 369-403). Alaska Sea Grant College Program, University of Alaska, Fairbanks. https://doi.org/10.4027/slw.2006.25

Thompson, P. M., Mackey, B., Barton, T. R., Duck, C., & Butler, J. R. A. (2007). Assessing the potential impact of salmon fisheries management on the conservation status of harbour seals (*Phoca vitulina*) in north-east Scotland. *Animal Conservation*, *10*, 48-56. https://doi.org/10.1111/j.1469-1795.2006.00066.x

Trillmich, F., & Limberger, D. (1985). Drastic effects of El Niño on Galapagos pinnipeds. *Oecologia*, *67*(1), 19-22. https://doi.org/10.1007/BF00378445

Weise, M. J., & Harvey, J. T. (2005). Impact of the California sea lion (*Zalophus californianus*) on salmon fisheries in Monterey Bay, California. *Fishery Bulletin*, *103*(4), 685-696.

Wickens, P. A. (1995). *A review of operational interactions between pinnipeds and fisheries* (FAO Fisheries Technical Paper). Food and Agriculture Organization.

Wright, B. E., Riemer, S. D., Brown, R. F., Ougzin, A. M., & Bucklin, K. A. (2007). Assessment of harbor seal predation on adult salmonids in a Pacific Northwest estuary. *Ecological Applications*, *17*(2), 338-351. https://doi.org/10.1890/05-1941

Würsig, B., & Gailey, G. A. (2002). Marine mammals and aquaculture: Conflicts and potential resolutions. In R. R. Stickney & J. P. McVey (Eds.), *Responsible marine aquaculture* (pp. 45-60). CABI Publishing. https://doi.org/10.1079/9780851996042.0045

Zavala-González, A., & Mellink, E. (2000). Historical exploitation of the California sea lion, *Zalophus californianus*, in Mexico. *Marine Fisheries Review*, *62*(1), 35-40.