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# Angler perceptions of California sea lion (*Zalophus californianus*) depredation and marine policy in Southern California



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## ABSTRACT

California sea lions (*Zalophus californianus*) off the coast of Southern California are known to damage both commercial and recreational fishing activities, causing decreases to fish catch and damage to gear. Their increasing population has intensified the potential for conflict between sea lions and anglers, likely requiring changes to current legislation. The recreational fishing community in Southern California is a valuable and largely underutilized source for information and potential solutions to management and legislative problems. This recreational fishing survey-based study conducted in 2013 utilized personal interviews, conducted in the field with recreational anglers and commercial passenger fishing vessel (CPFV) crews in Southern California, to gather data on: (a) the occurrence and impact of sea lion depredation on the local fishing, (b) angler awareness and opinions on current legislation, and (c) the conflict between fishing activities and conservation efforts. Results show that surveyed CPFV operators and private boaters had the most conflict with sea lions and perceive them as more of a problem than anglers on piers, jetties or kayaks. The conflict was also reportedly more prevalent in San Diego County compared to the other counties surveyed (Orange, Los Angeles and Ventura). Participating CPFV operators were overwhelmingly in support of a government culling program for sea lions, while recreational angler respondents did not feel that a control program was necessary. These CPFV operators reported more money lost, and were willing to pay more for an effective deterrent device. There was also a consensus among respondents that fish catch is declining, yet anglers were unsatisfied with the effectiveness of current legislation designed to increase fish stocks. These data will provide a better understanding of California sea lion depredation in Southern California and its effect on recreational anglers in order to aid future mitigation efforts. Additionally, these results provide stakeholder feedback on local marine protected areas and other fisheries management legislation, and build a foundation for future conservation and education programs.

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## 1. Introduction

California sea lions (*Zalophus californianus*) are regular and year-round inhabitants off Southern California [37,6,9], and they breed primarily on the offshore Channel Islands during the months of June and July [36,42]. Their position as top predators, relatively long lifespan and ability to accumulate anthropogenic toxins make California sea lions (CSL) effective sentinel species<sup>1</sup> [43,34,7]. Overall, their population has been increasing since monitoring began in 1975, with the most recent stock assessment estimating 296,750 California sea lions and an annual growth rate of 5.4% [49]. In the last three decades, this population growth has intensified the possibility of conflict between sea lions and fishing

activities [27]. California sea lions are known to damage both commercial and recreational fishing activities, causing decreases to fish catch and damage to gear [13,24,49]. Sea lion depredation in California has been studied primarily in commercial fisheries with a focus on salmonids [4,13,52,49]. A few studies from Southern California have investigated Commercial Passenger Fishing Vessel (CPFV) operations [13,24,49] and only one study involved anglers fishing from private boats [35]. California sea lion interaction with onshore marine fishing from piers has not been previously investigated. Southern California has shown the highest reported incidence of depredation from CPFV operations by sea lions in the state, yet data are relatively scarce for this area, except for the San Diego fleet [13,49]. Current deterrent devices have been proven ineffective [49,22,46], and the recent trend of sea lion population growth may further increase the conflict with anglers. Considering that California sea lions are protected under the Marine Mammal Protection Act (MMPA) of 1972 – which makes it illegal for anglers to kill or seriously harass these animals

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E-mail address: [mbearzi@earthlink.net](mailto:mbearzi@earthlink.net) (M. Bearzi).<sup>1</sup> Sentinel species represent “barometers for current or potential negative impacts on individual—and population-level animal health” [7].

– an increase in conflict between anglers and sea lions could necessitate changes or additions to marine regulatory legislation.

Further, regulating fisheries involves economic costs borne by anglers [45]. These costs can lead to conflicts among anglers, regulatory agencies and scientists, despite the fact that all parties share a goal of maintaining plentiful fish stocks [20]. For instance, marine protected areas (MPAs) in Southern California were recently implemented in the hope of restoring and protecting the local fisheries [21,28]. These areas restrict fishing efforts, and this cost to anglers has been a contentious issue since the implementation of the MPAs, deepening the gap between fishing interests and environmental/conservation interests [20]. Data shows, however, that when socioeconomic costs are considered and anglers are consulted during the planning stages of regulatory legislation, that legislation is more effective [44,50]. It is becoming increasingly recognized that anglers' observations and knowledge from their time spent at sea can be a useful tool in marine conservation planning [47].

The recreational fishing community in Southern California is a valuable and largely underutilized source for information and potential solutions to management and legislative problems. Recreational anglers are stakeholders affected by marine policy, so understanding their experience and perception of marine mammals, depredation and marine legislation can lead to more effective conservation and utilization of fisheries, as well as better protection of marine mammal species. This survey-based study utilized personal interviews from a total of 364 surveyed recreational anglers and CPFV crews to establish:

- (1) General fishing habits of surveyed anglers and their level of experience in this area.
- (2) Surveyed anglers' general knowledge of California sea lion behavior, how often they observe sea lions, and their opinions toward the animals.
- (3) How often anglers in Southern California experience sea lion depredation and what level of impact it has on the recreational fisheries in this area.
- (4) Current knowledge and usage of sea lion deterrent devices among surveyed anglers and their potential demand for new technologies.
- (5) Current opinions of recreational anglers toward sea lions compared to dolphins.
- (6) Awareness and opinions among recreational anglers of current legislation and policy affecting recreational fishing as well as their perception of a possible conflict with environmental/conservation interests, and their suggestions for addressing and resolving such conflict.

These data will direct future efforts to decrease California sea lion depredation by providing a better idea of the extent and nature of the conflict with recreational anglers in Southern California. Our results also provide stakeholder feedback on conservation programs and marine mammal legislation in order to evaluate the effectiveness of fisheries management programs such as the MPA system. Having this gauge of the Southern California recreational fishing community outlooks on a variety of current and critical issues will be essential in improving communication between anglers, policymakers, and conservationists.

## 2. Methods

### 2.1. Survey design

The survey was designed to ensure a logical flow of questions and to keep the length under 10 min, with an average of approximately 7 min per survey. The questions were organized into six sections corresponding to our stated objectives in order to ensure all

necessary data were collected. The first section was comprised of questions to establish anglers' fishing habits to be able to categorize them by typical variables (time fishing in the area, type of fishing, targeted species, etc.). The second section covered angler observations of sea lions, their knowledge of sea lion behavior as well as their opinions toward these animals. The third section had questions about angler experiences with depredation from California sea lions, and how they felt depredation affects their fishing and the general fishing community in the area. The fourth section included questions about angler use of deterrent devices, how effective they believed current deterrents are, and potential demand for new effective deterrents. The fifth section covered angler encounters with and opinions of dolphins compared to sea lions, and whether any other marine mammals were culprits of depredation. The final section was comprised of questions about angler opinions on current marine conservation legislation (MPAs and MMPA), their opinions on a possible conflict between angler and conservation interests, and suggestions to address and resolve this conflict.

The survey was developed using a mixed method approach and was comprised of both quantitative (rating) and qualitative (open ended) questions to increase the strength of the study, as suggested by Creswell and Plano Clark [10]. The surveys followed the general guidelines outlined by Fowler [18] to ensure that all respondents understood the questions and all technical terms were explained correctly. In addition, opportunistic surveys were conducted by OCS staff prior to the beginning of this study to guarantee the wording and flow of questions did not lead respondents to any answers. No ethics committee was involved in the evaluation of this study, as the survey required no special permissions, and there was no contact with animals or testing of any deterrent devices. Surveys were anonymous and no personal data were taken on any of the survey participants. Participants were informed that all data collected during the interviews would be used for scientific and educational purposes only.

### 2.2. Data collection

Surveys were carried out at public boat launch ramps, fishing piers and CPFV landings from Ventura County to San Diego County from June to October 2013 (Fig. 1). Sites were chosen to encompass all major recreational fishing sites in Southern California as shown by data collected through the California Recreational Fisheries Survey.<sup>2</sup> Each site was sampled only once to ensure results reflected natural fishing pressure across Southern California.

After a training session to familiarize them with survey and safety protocol, teams of at least two Ocean Conservation Society (OCS) volunteers were assigned to each pier and boat launch ramp to take opinion surveys on angler fishing habits, sea lion depredation, and the knowledge and effectiveness of current marine legislation. Surveys were taken both in English and Spanish by bilingual OCS staff. The surveys were conducted as a 7 min face-to-face interview where OCS trained personnel asked questions and recorded answers on a prepared answer sheet (Appendix A). This ensured that all questions were addressed (even if interviewees did not have an answer), and that there was no redundancy of interviews. At the piers, teams attempted to interview all anglers present at the time; at boat launches, teams spent blocks of five hours from 14:00 to 19:00 trying to intercept all anglers as they returned from fishing trips. For CPFV landings, a slightly modified survey (Appendix B) was used. Each landing was visited once as boats returned from trips and all agreeable crewmembers present were interviewed. This survey was modified as several of the original questions were irrelevant and/or redundant for CPFV operators who consistently run trips from the

<sup>2</sup> Data available at [www.recfn.org](http://www.recfn.org).

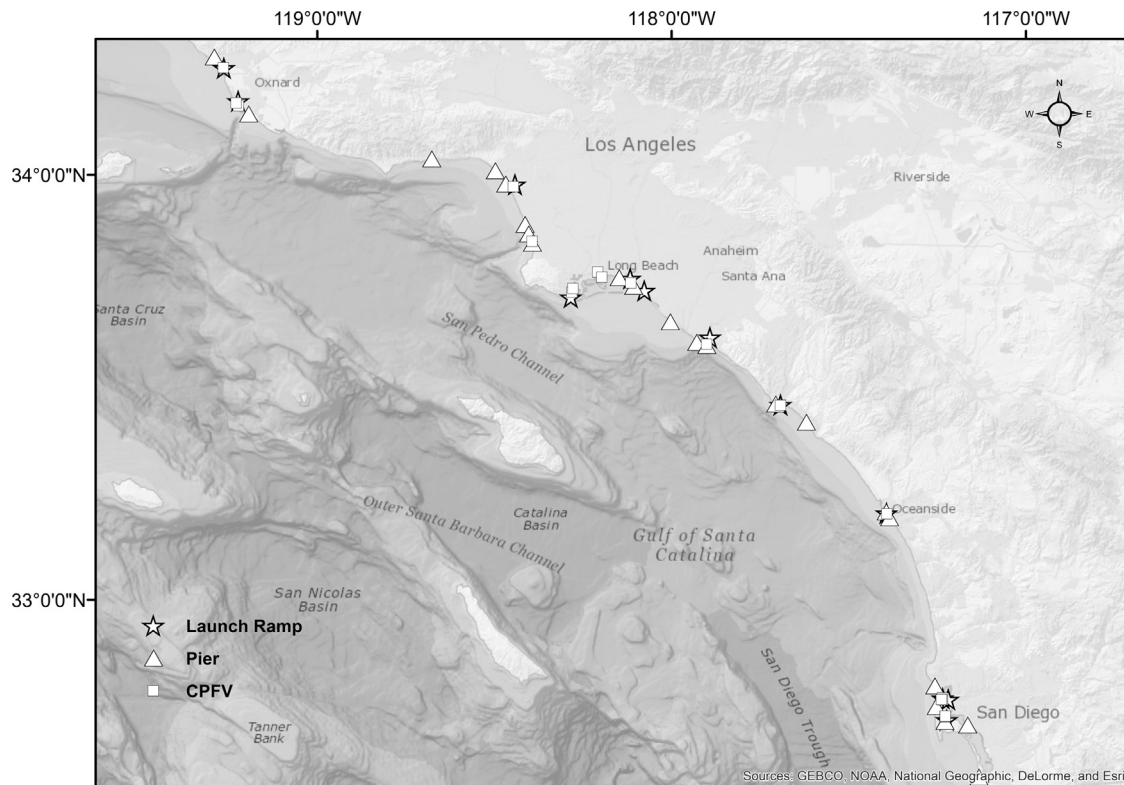


Fig. 1. Map of all sites surveyed in Southern California.

same landing. When data were combined the irrelevant/redundant questions were left blank for CPFV crew.

### 2.3. Data analyses

Survey results were compiled into an Excel database. Survey sites were mapped using ArcGIS v. 10.2.1 (Esri). R (R Development Core Team, 2008) was used for data analyses. The questionnaire responses were fitted to generalized linear models using the nlme package. The results were then plotted using the sjPlot package in R. The results were statistically significant if  $p < 0.05$ .

## 3. Results

A total of 364 surveys, of which 300 from anglers and 64 from CPFV crewmembers, were collected from 53 sites consisting of 19 CPFV landings, 12 launch ramps and 22 piers across four counties (Ventura, Los Angeles, Orange and San Diego; Fig. 1) during the 2013 Summer and Fall months.

### 3.1. Overview of fishing habits

General fishing habits for anglers and CPFV crewmembers are summarized in Table 1. Recreational anglers reported fishing by piers ( $n=201$ : 66.67%), boats ( $n=149$ : 49.67%), CPFVs ( $n=96$ : 32%), jetties ( $n=40$ : 13.3%), beaches/shores ( $n=13$ : 4.33%), kayaks ( $n=9$ : 3%) and surfboards ( $n=1$ : 0.33%). Surfboarding was excluded from analysis due to extremely low sample size. Surveyed CPFV crewmembers were comprised of captains and deckhands ( $n=28$ : 43.75% and  $n=36$ : 56.25%, respectively).<sup>3</sup> CPFV crewmembers worked an average of 226 days per year, significantly more than recreational anglers

fishing (mean = 46 days per year;  $p=5.11 \times 10^{-37}$ ,  $t=-21.37$ ,  $df=90$ ). The majority of anglers fished primarily with hook and line ( $n=299$ : 99.67%). Anglers also reported spearfishing ( $n=19$ : 6.33%), trolling ( $n=32$ : 10.67%), netting ( $n=12$ : 4%), and using traps/pots ( $n=12$ : 4%).

### 3.2. Knowledge (and opinions) on California sea lions

Angler and CPFV crewmember knowledge and opinions on California sea lions are outlined in Table 2. Anglers from San Diego County reported more sightings of California sea lions than anglers from other counties ( $p < 0.01$ ,  $SE=0.12$ , Fig. 2a). In a GLM comparing recreational anglers and CPFV crew, CPFV crewmembers were significantly more likely to report seeing sea lions compared to recreational anglers ( $p=1.02 \times 10^{-7}$ ,  $SE=0.12$ ). Private boaters and recreational anglers on CPFVs were significantly more likely to report CSL sightings than anglers fishing from piers, beaches/shores, jetties, and kayaks ( $p < 0.001$ ,  $SE=0.13$ ;  $p < 0.01$ ,  $SE=0.11$ , Fig. 2b). Beach anglers were significantly less likely to report CSL sightings than anglers fishing from other platforms ( $p=0.03$ ,  $SE=0.24$ , Fig. 2b). When sightings of sea lions were compared by seasons fished in a GLM, anglers who fished in autumn reported seeing sea lions significantly more often than anglers fishing in other seasons ( $p=4.94 \times 10^{-4}$ ,  $SE=0.18$ ).

Anglers who had been fishing in Southern California longer reported more knowledge of sea lion behavior ( $p=5.24 \times 10^{-11}$ ,  $SE=0.04$ ). CPFV operators reported significantly more knowledge of sea lion behavior than recreational anglers ( $p=7.59 \times 10^{-11}$ ,  $SE=0.12$ ).

### 3.3. California sea lion depredation

The impact of California sea lion depredation to anglers and CPFV crewmembers is summarized in Table 3 along with patterns in sea lion depredation activities. In a GLM comparing CPFV crew to recreational anglers with respect to perceived impact of depredation, CPFV operators were significantly more likely than recreational

<sup>3</sup> Two of the CPFV captains were also the owners of the fishing boat and three CPFV crewmembers also worked on private boats.



**Table 1**

General fishing habits for anglers and CPFV crewmembers. The responses represent a subset of the total surveys taken because some anglers and crewmembers chose not to answer certain questions. Fish species targeted by fewer than 15% of anglers and CPFV crewmembers are not reported.

	Angler N (%)	CPFV N (%)
Language		
English	279 (93%)	64 (100%)
Spanish	21 (7%)	0 (0%)
County <sup>a</sup>		
Santa Barbara	15 (5%)	0 (0%)
Ventura	57 (19%)	12 (18.75%)
Los Angeles	124 (41.33%)	24 (37.50%)
Orange	100 (33.33%)	6 (9.38%)
San Diego	118 (39.33%)	22 (34.38%)
Years fishing in Southern California		
0–1 years	40 (13.33%)	1 (1.56%)
2–5 years	36 (12%)	5 (7.81%)
5–10 years	37 (12.33%)	7 (10.94%)
> 10 years	187 (62.33%)	51 (79.69%)
Seasons fished <sup>a</sup>		
Winter	134 (44.82%)	55 (85.94%)
Spring	163 (54.52%)	63 (98.44%)
Summer	291 (97.32%)	64 (100%)
Fall	154 (51.51%)	62 (96.88%)
Distance from shore <sup>a</sup> (nautical miles)		
Onshore–300 m	225 (75%)	0 (0%)
300 m <sup>-1</sup> nm	20 (6.67%)	0 (0%)
1 nm <sup>-5</sup> nm	55 (18.33%)	14 (21.88%)
5 nm <sup>-10</sup> nm	48 (16%)	27 (42.19%)
10 nm <sup>-20</sup> nm	54 (18%)	41 (64.06%)
> 20 nm	85 (28.33%)	39 (60.94%)
Channel Islands	57 (19%)	33 (51.56%)
Type of bait <sup>a</sup>		
Live bait	218 (72.91%)	64 (100%)
Frozen	154 (51.51%)	34 (53.13%)
Chum	44 (14.72%)	26 (40.63%)
Jig/Lure	99 (33.11%)	22 (34.38%)
Targeted fish species <sup>a</sup>		
Mackerel	102 (35.92%)	6 (9.38%)
Barracuda	33 (11.62%)	29 (45.31%)
Bass	122 (42.96%)	43 (67.19%)
Yellowtail	73 (25.70%)	44 (68.75%)
Surf Perch	46 (16.20%)	3 (4.69%)
White Sea Bass	34 (11.97%)	17 (26.56%)
Halibut	97 (34.15%)	17 (26.56%)
Sharks/Rays	68 (23.94%)	1 (1.56%)
Rockfish	72 (25.35%)	45 (70.31%)
Tuna	39 (13.73%)	23 (35.94%)

<sup>a</sup> Multiple response question.

anglers to report that sea lion depredation has a negative impact on Southern California fishing ( $p=6 \times 10^{-8}$ ,  $SE=0.06$ ). When compared to anglers from other platforms, private boaters were more likely to believe CSL have an adverse effect on Southern California fishing than anglers on piers, jetties, beaches/shores and kayaks ( $p=0.03$ ,  $SE=0.08$ , Fig. 3a).

Anglers in San Diego County were significantly more likely to report interference from CSL than anglers in all other counties ( $p=0.02$ ,  $SE=0.14$ , Fig. 3b). CPFV operators reported interference from sea lions significantly more often than recreational anglers when analyzed in a GLM against recreational anglers ( $p < 2 \times 10^{-16}$ ,  $SE=0.13$ ).

Private boaters and anglers fishing on CPFVs were significantly more likely to report interference from CSL when compared to anglers fishing from piers, jetties, beaches/shores, and kayaks ( $p < 0.001$ ,  $SE=0.15$ ;  $p < 0.001$ ,  $SE=0.12$ , Fig. 3c). CPFV crewmembers reported a significantly higher average loss of \$25,231.58 annually due to sea lion depredation compared to the average annual loss of \$192.55 by anglers ( $p=7.18 \times 10^{-4}$ ,  $t=-4.07$ ,  $df=18$ ). Compared to other counties in a GLM, anglers in San Diego County were more

**Table 2**

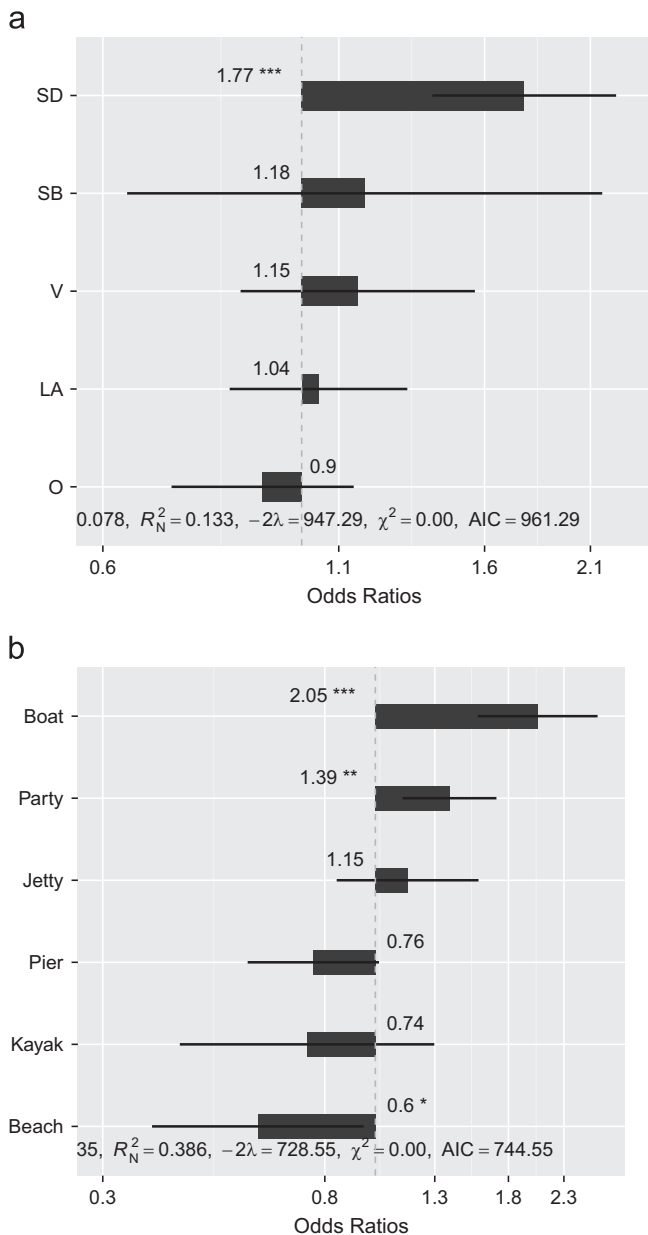
Recreational angler and CPFV crewmember general knowledge of California sea lions (CSL).

	Angler N (%)	CPFV N (%)
Occurrence of CSL sightings when fishing		
Every time	140 (46.98%)	54 (84.38%)
Most of the time	66 (22.15%)	8 (12.50%)
Occasionally	78 (26.17%)	2 (3.125%)
Never	14 (4.70%)	0 (0%)
Group size of CSL when fishing		
1	91 (31.93%)	0 (0%)
2–5	82 (28.77%)	9 (14.06%)
6–10	14 (4.91%)	4 (6.25%)
11–20	17 (5.96%)	6 (9.38%)
Varies	81 (28.42%)	45 (70.31%)
Perceived CSL abundance in Southern California		
Abundant	195 (65%)	62 (96.88%)
Moderate	58 (19.33%)	2 (3.13%)
Rare	13 (4.33%)	0 (0%)
Not sure	34 (11.33%)	0 (0%)
Perceived change in CSL population numbers		
Increase	135 (45.15%)	62 (96.88%)
Decrease	54 (18.06%)	1 (1.56%)
No change	29 (9.70%)	0 (0%)
Not sure	81 (27.09%)	1 (1.56%)
Perceived knowledge of CSL behavior		
A lot	20 (6.73%)	7 (10.94%)
Moderate amount	34 (11.45%)	31 (48.44%)
Little	123 (41.41%)	22 (34.38%)
Nothing	120 (40.40%)	4 (6.25%)
Perceived knowledge of CSL feeling pain		
Yes	265 (88.33%)	48 (75%)
No	19 (6.33%)	5 (7.81%)
Nothing	16 (5.33%)	11 (17.19%)

likely than anglers from other counties to report an increase in sea lion depredation over the last decade ( $p=3.66 \times 10^{-4}$ ,  $SE=0.10$ ), and anglers who had been fishing longer in the area were more likely to report an increase in depredation ( $p=4.85 \times 10^{-5}$ ,  $SE=0.05$ ).

### 3.4. Current opinions on deterrent devices

Angler and CPFV crew opinions on sea lion deterrent devices are summarized in Table 4. Anglers from private boats and CPFVs were more likely to support both nonlethal and lethal deterrent devices than anglers from other platforms ( $p=0.01$ ,  $SE=0.20$ ;  $p=0.03$ ,  $SE=0.16$ , Fig. 4a and b). Private boaters and anglers fishing on CPFVs were also significantly more likely to support the use of lethal methods ( $p < 0.001$ ,  $SE=0.06$ ;  $p=0.04$ ,  $SE=0.05$ ). Pier anglers were significantly less likely to support lethal methods than anglers fishing from other platforms and CPFV crewmembers ( $p=0.05$ ,  $SE=0.06$ ). GLM analysis shows that anglers who reported more interference from sea lions were more likely to support nonlethal deterrent devices ( $p=3.72 \times 10^{-5}$ ,  $SE=0.06$ ). Another GLM revealed that whether an angler or CPFV crew believed that sea lions feel pain did not affect their support of nonlethal or lethal deterrents ( $p=0.26$  and  $p=0.62$ , respectively). Anglers fishing from private boats expressed higher interest in purchasing an effective nonlethal deterrent device than anglers on other platforms ( $p=0.01$ ,  $SE=0.13$ , Fig. 4c). Pier anglers were significantly less likely to express interest than anglers on other platforms ( $p=0.02$ ,  $SE=0.14$ , Fig. 4c). When compared in a GLM, CPFV operators were significantly more likely to express interest in purchasing an effective nonlethal deterrent than recreational anglers ( $p=2.84 \times 10^{-9}$ ,  $SE=0.12$ ).



**Fig. 2.** (a) Angler sightings of sea lions, analyzed by county using a GLM (SD=San Diego, SB=Santa Barbara, V=Ventura, LA=Los Angeles, O=Orange). (b) Sightings of California sea lions across recreational fishing platform, analyzed with a GLM. Party indicates anglers who reported fishing on CPFVs, or "party boats". Stars indicate level of significance, a bar to the right of the center line indicates a positive effect, to the left indicates a negative effect.

### 3.5. Effect of other marine mammals on Southern California fishing

Angler experiences with dolphins, and their opinions on the effect of marine mammals (other than sea lions) on fishing in Southern California, are summarized in Table 5. In a GLM comparing fishing platform with reported dolphin sightings, private boaters and anglers fishing from CPFVs reported seeing dolphins significantly more than anglers fishing from other platforms ( $p=2.01 \times 10^{-4}$ ,  $SE=0.15$ ;  $p=0.004$ ,  $SE=0.12$ ). Pier anglers were significantly less likely to report seeing dolphins than CPFV crewmembers and all other types of anglers ( $p=0.002$ ,  $SE=0.16$ ). CPFV crew reported significantly more dolphin sightings than recreational anglers ( $p=8.02 \times 10^{-4}$ ,  $SE=0.14$ ). Fishing platform did not significantly affect whether anglers reported other marine

**Table 3**  
 Anglers and CPFV crew reported incidence of interference from California sea lions while fishing, and perceptions of possible trends in the problem.

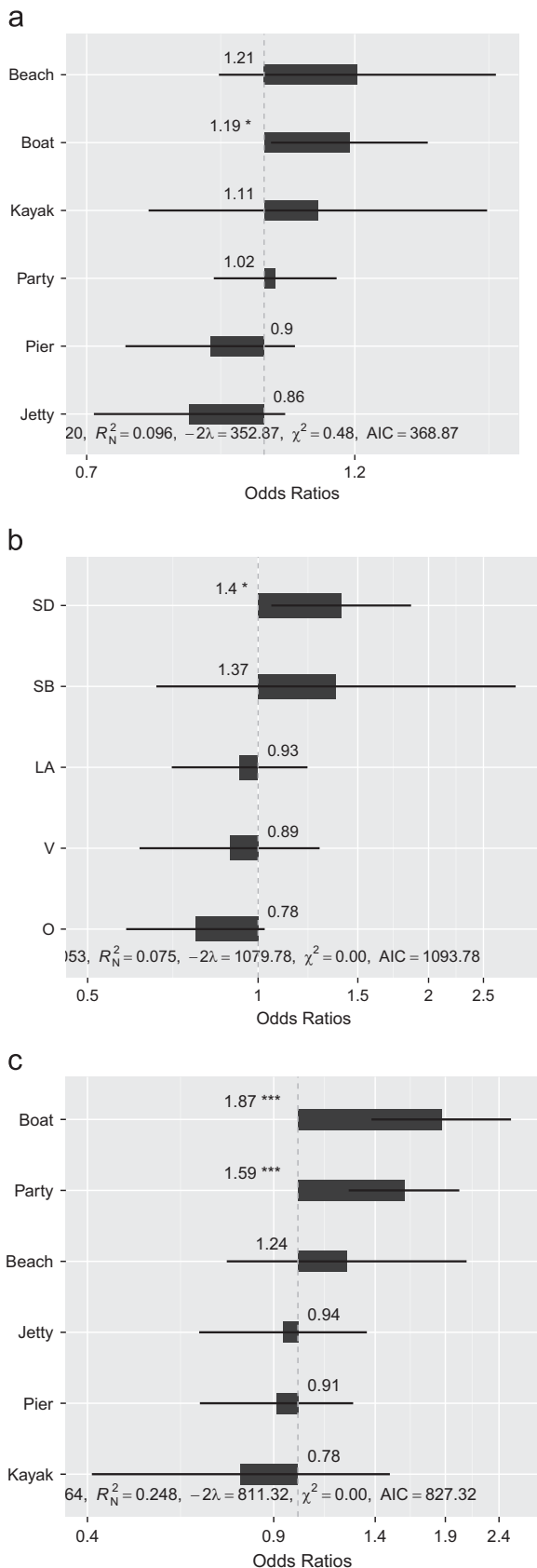
	Angler N (%)	CPFV N (%)
CSL depredation impacts fishing in Southern California		
Yes	160 (53.69%)	61 (95.31%)
No	107 (35.91%)	3 (4.69%)
Not sure	31 (10.4%)	0 (0%)
Occurrence of CSL interference with anglers/CPFVs		
Every time	44 (14.81%)	34 (53.13%)
Most of the time	47 (15.82%)	25 (39.06%)
Occasionally	105 (35.35%)	5 (7.81%)
Never	101 (34.01%)	0 (0%)
Type of interference <sup>a</sup>		
Steal fish from nets	10 (5.03%)	1 (1.56%)
Steal fish from hooks	150 (75.38%)	63 (98.44%)
Damage gear	62 (31.16%)	41 (64.06%)
Damage fish catch	88 (44.22%)	53 (82.81%)
Scare fish	139 (69.85%)	63 (98.44%)
Steal bait	44 (21.61%)	43 (67.19%)
Seasonal difference in CSL depredation <sup>a</sup>		
More in fall	8 (2.68%)	0 (0%)
More in summer	62 (20.81%)	21 (32.81%)
More in winter	8 (2.68%)	0 (0%)
More in spring	13 (4.36%)	7 (10.94%)
No difference	110 (36.91%)	39 (60.94%)
Not sure	112 (37.58%)	2 (3.13%)
CSL bait preference		
No difference	116 (38.80%)	19 (29.69%)
Live bait	131 (43.81%)	44 (68.75%)
Frozen	0 (0%)	0 (0%)
Chum	1 (0.33%)	1 (1.56%)
Jig/Lure	0 (0%)	0 (0%)
Change in CSL depredation rate in last decade		
Increase	123 (41.55%)	54 (85.71%)
Decrease	28 (9.46%)	0 (0%)
No change	48 (16.22%)	9 (14.29%)
Not sure	97 (32.77%)	1 (1.59%)

<sup>a</sup> Multiple response question.

mammals interfered with fishing. There was no statistical difference between the number of anglers who believed dolphins feel pain and the number who believed sea lions feel pain (89% and 86%, respectively,  $n=364$ ).

### 3.6. Opinions on marine policy and conservation

Angler opinions on current marine policy and conservation are summarized in Table 6. In a series of GLMs comparing recreational anglers to CPFV crew, CPFV crew were more likely than recreational anglers to know that sea lions are protected by law ( $p=1.09 \times 10^{-6}$ ,  $SE=0.06$ ), and significantly less likely to believe that they should be protected ( $p < 2 \times 10^{-16}$ ,  $SE=0.06$ ). CPFV crew were also more likely to be aware of the Marine Mammal Protection Act ( $p < 2 \times 10^{-16}$ ,  $SE=0.06$ ), and the marine protected areas ( $p=1.06 \times 10^{-8}$ ,  $SE=0.06$ ) than anglers. CPFV crew were significantly more likely to believe that there is a conflict between anglers and conservationists than anglers ( $p=1.82 \times 10^{-6}$ ,  $SE=0.12$ ). Anglers fishing on CPFVs were significantly less likely to believe that MPAs help repopulate fish than anglers on other platforms ( $p=0.02$ ,  $SE=0.07$ , Fig. 5a). When compared with other fishing platforms, beach anglers and anglers fishing on CPFVs were significantly more likely to report a conflict between angler and conservation interests ( $p=0.01$ ,  $SE=0.25$ ;  $p=0.04$ ,  $SE=0.12$ , Fig. 5b). Opinions on where the conflict between angler and conservation interests lies, as well as suggestions for bridging the gap between the two parties, are summarized in Table 7.

**Table 4**

Angler and CPFV crew opinions on; (a) mitigation efforts for CSL depredation, (b) effectiveness of current deterrent methods, (c) interest in learning more about or purchasing a sea lion deterrent, and (d) views about using lethal methods to control sea lion populations.

	Angler N (%)	CPFV N (%)
<b>(a)</b>		
How sea lion depredation should be controlled		
No control	168 (56.95%)	3 (4.69%)
Nonlethal methods	100 (33.90%)	35 (54.69%)
Lethal methods	58 (19.66%)	51 (79.69%)
Relocate sea lions	46 (15.59%)	8 (12.50%)
Party responsible for controlling sea lions <sup>b</sup>		
Government	165 (56.31%)	49 (77.78%)
Anglers	75 (25.60%)	25 (39.68%)
CPFV crew	32 (10.92%)	39 (61.90%)
No one	41 (13.99%)	0 (0%)
Favor level for non-lethal deterrents		
Strongly in favor	68 (22.74%)	23 (35.94%)
Moderately in favor	76 (25.42%)	11 (17.19%)
No opinion	76 (25.42%)	21 (32.81%)
Moderately opposed	39 (13.04%)	1 (1.56%)
Strongly opposed	40 (13.38%)	8 (12.50%)
<b>(b)</b>		
Effective non-lethal deterrents		
Boat hazing/circling	22 (9.02%)	0 (0%)
Scent deterrent	42 (17.21%)	1 (1.61%)
ABSRT <sup>a</sup>	82 (33.61%)	8 (12.9%)
Projectile	60 (24.59%)	15 (24.19%)
Pounding on hull	22 (9.02%)	6 (9.68%)
Horn/Bell/Whistle	42 (17.21%)	2 (3.23%)
Explosive sound source	112 (45.9%)	8 (12.90%)
Continuous frequency	49 (20.08%)	7 (11.29%)
<b>(c)</b>		
Interest in learning more about non-lethal deterrents		
Yes	60 (20.20%)	34 (53.13%)
No	202 (68.01%)	25 (39.06%)
Maybe	20 (6.73%)	5 (7.81%)
Don't care	15 (5.05%)	0 (0%)
Interest in purchasing effective non-lethal deterrent		
Yes	70 (23.49%)	36 (56.25%)
No	216 (72.48%)	21 (32.81%)
Maybe	12 (4.03%)	7 (10.94%)
Price range for potential deterrent		
< \$20	27 (39.13%)	5 (15.63%)
\$20–50	24 (34.78%)	0 (0%)
\$50–100	12 (17.39%)	2 (6.25%)
\$100–200	4 (5.80%)	5 (15.63%)
\$200–500	2 (2.90%)	8 (25%)
> \$500	0 (0%)	12 (37.50%)
<b>(d)</b>		
Favor level for lethal deterrents		
Strongly in favor	41 (13.80%)	49 (76.56%)
Moderately in favor	24 (8.08%)	9 (14.06%)
No opinion	35 (11.78%)	4 (6.25%)
Moderately opposed	35 (11.78%)	0 (0%)
Strongly opposed	162 (54.55%)	2 (3.13%)
Government should have lethal population control for CSL		
Yes	89 (29.87%)	60 (93.75%)
No	185 (62.08%)	2 (3.13%)
No opinion	24 (8.05%)	2 (3.13%)
Deterrent methods that scare fish <sup>b</sup>		
Lethal methods	121 (43.21%)	8 (12.70%)
Non-lethal methods	173 (61.79%)	41 (65.08%)
Neither	84 (30%)	20 (31.75%)

<sup>a</sup> Active bioacoustic startle response trigger.

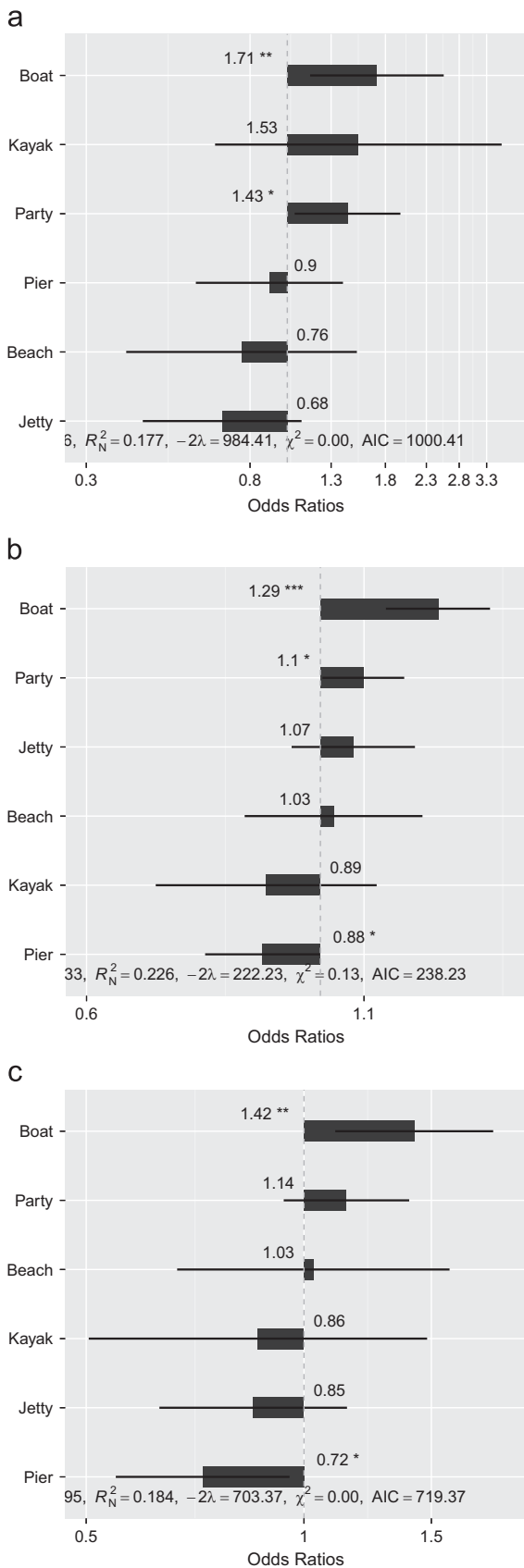
<sup>b</sup> Multiple response question.

## 4. Discussion

### 4.1. Overview of fishing habits

The majority of the surveyed anglers (62%) had been fishing in Southern California for more than 10 years, adding reliability to the

**Fig. 3.** (a) Perceived impact of CSL depredation on fishing analyzed by fishing platform. (b) Reported incidence of interference of California sea lion depredation on Southern California fishing analyzed by county. (c) Reported incidence of CSL interference with fishing analyzed by fishing platform.



**Fig. 4.** (a) Support for the use of non-lethal deterrent devices analyzed by fishing platform. (b) Support for the use of lethal methods to control depredation analyzed by fishing platform. (c) Interest in purchasing an effective non-lethal deterrent device in the future analyzed by fishing platform.

**Table 5**

Angler experiences with dolphins, and opinions on whether marine mammals (other than CSL) affect fishing in Southern California.

	Angler N (%)	CPFV N (%)
Other marine mammals impacting fishing		
Yes	75 (25.34%)	23 (36.51%)
No	198 (66.89%)	40 (63.50%)
Not Sure	23 (7.77%)	0 (0%)
Species that impact fishing in the area <sup>a</sup>		
Dolphins	32 (45.07%)	13 (59.09%)
Whales	6 (8.45%)	0 (0%)
Seals	17 (23.94%)	9 (40.91%)
All	16 (22.54%)	0 (0%)
Occurrence of dolphin sightings when fishing		
Every time	88 (29.43%)	24 (37.50%)
Most of the time	62 (21.40%)	26 (40.63%)
Occasionally	110 (36.79%)	13 (20.31%)
Never	37 (12.37%)	1 (1.56%)
Frequency of dolphins sighted with CSLs		
Every time	2 (0.76%)	4 (6.35%)
Most of the time	2 (0.76%)	2 (3.17%)
Occasionally	63 (24.05%)	45 (71.43%)
Never	195 (74.43%)	12 (19.05%)
Frequency of dolphin interference with fishing		
Every time	2 (0.68%)	0 (0%)
Most of the time	2 (0.68%)	1 (1.56%)
Occasionally	18 (6.08%)	29 (45.31%)
Never	274 (92.57%)	34 (53.13%)
Dolphins feel pain		
Yes	269 (90.27%)	56 (87.50%)
No	18 (6.04%)	8 (12.50%)
Not sure	11 (3.69%)	0 (0%)

<sup>a</sup> Multiple response question.

accuracy of their responses. The fishing platforms surveyed, especially CPFVs, have been popular in Southern California since the 1920s [39,40,53], and as a result have had a long-term association with the local fisheries. Based on the surveyed anglers, results of this study suggest that summer had the highest fishing effort reported, and winter the lowest. These data are in accordance with the arrival of migratory target species in summer and the yearly fishing closure in winter [14]. Hook and line was the method used by almost all anglers surveyed (100% of CPFV crew and 99% of recreational anglers). This seems to be the most common method in the area according to the anglers interviewed during our study, but other methods (spearfishing, netting, trawling, etc.) may be underrepresented due to difficulty in intercepting anglers using these methods.

#### 4.2. Knowledge (and opinions) on California sea lions

The majority of all anglers surveyed reported that sea lions are abundant in Southern California, and that their population has increased in the past decade. Almost half of interviewed recreational anglers reported seeing California sea lions every time they were fishing (46.98%) along with the majority of CPFV crew (84.38%). These results are in accordance with studies showing that the California sea lion population has been growing consistently since the implementation of the MMPA of 1972 and have reached carrying capacity [9]. The majority of surveyed CPFV crew reported “variable” group sizes (70.31%) while recreational anglers were split between variable (28.42%), single animals (31.93%), and 2–5 animals (28.77%). These responses are not in accordance with Bearzi et al. [3], who observed 1–2 California sea lions as the most common group size. This could be due to a difference in the size of the areas covered in the two studies, as this investigation encompassed all of Southern California instead of focusing only on Santa Monica Bay. Further, this study used data from angler observations instead of directly collecting data at sea. Anglers are not focused on finding sea lions, so they

**Table 6**  
Opinions on current marine policy and conservation.

Angler N (%)	CPFV N (%)
CSL are protected by law	
Yes	214 (71.33%) 64 (100%)
No	21 (7%) 0 (0%)
Not sure	65 (21.67%) 0 (0%)
CSL should be protected by law	
Yes	229 (76.33%) 18 (28.13%)
No	53 (17.67%) 41 (64.06%)
No opinion	18 (6%) 5 (7.81%)
Awareness of Marine Mammal Protection Act	
Yes	126 (42%) 63 (98.44%)
No	174 (58%) 1 (1.56%)
Awareness of marine protected areas	
Yes	194 (64.67%) 64 (100%)
No	106 (35.33%) 0 (0%)
MPAs help to repopulate fish stocks	
Yes	137 (45.67%) 28 (43.75%)
No	35 (11.67%) 14 (21.88%)
Not sure	33 (11%) 22 (34.38%)
Increase or decrease in fish catch	
Increase	35 (11.71%) 0 (0%)
Decrease	140 (46.82%) 35 (59.32%)
No change	72 (24.08%) 23 (38.98%)
Not sure	52 (17.39%) 1 (1.69%)
Increase or decrease in fish size	
Increase	22 (7.38%) 1 (1.72%)
Decrease	116 (38.93%) 25 (43.10%)
No change	111 (37.25%) 32 (55.17%)
Not sure	49 (16.44%) 0 (0%)
Most effective method to replenish fish stocks	
MPAs	51 (19.39%) 1 (1.67%)
Regulate fishing effort	118 (44.87%) 47 (78.33%)
Restore nursery habitat	23 (8.75%) 4 (6.67%)
Stock enhancement	59 (22.43%) 7 (11.67%)
All	8 (3.04%) 0 (0%)
None	4 (1.52%) 1 (1.67%)
Conflict between angler and conservation interests	
Yes	172 (57.33%) 58 (90.63%)
No	92 (30.67%) 4 (6.25%)
Maybe	28 (9.33%) 1 (1.56%)
Don't care	8 (2.67%) 1 (1.56%)

may have been more likely to notice only larger groups, leading to a report biased toward larger group numbers.

#### 4.3. California sea lion depredation

The majority of anglers interviewed during this study reported that depredation by California sea lions impacts fishing in Southern California, and that sea lion depredation has increased over the past decade. This is consistent with studies showing sea lion depredation rates in California have increased proportionately with the population, especially since the implementation of the MMPA ([13,24,4,27]). Anglers from this study reported that the damage from depredation occurs mostly from sea lions stealing hooked target fish off of their lines, damaging the catch as they reeled it up or damaging the gear itself. This result is similar to the findings of DeMaster et al. [13] and Scordino [49]. An unexpected type of interference observed by a large number of anglers (especially CPFV crew) was sea lions stealing their bait from hooks before they had a chance to catch a larger fish. As a consequence, anglers found themselves forced to reel up their line and re-bait the hooks, depleting their limited bait supply. This type of depredation has not before been addressed, but may be of future concern as the bait fish populations, such as sardine (*Sardinops sagax*) and anchovy (*Engraulis mordax*), in Southern California tend to fluctuate dramatically and are vulnerable to crashing [31].

#### 4.4. Current opinions on deterrent devices

Our results show that the angler community is split on the issue of depredation control. The majority of CPFV crew included in this study (95.31%) supported implementing some sort of control for sea lion depredation, while less than half of recreational anglers supported sea lion control. The recreational anglers surveyed who did support depredation control tended to fish mostly offshore (private boats or CPFVs).

Anglers replying to this survey were generally dismissive of current deterrent methods, and complained of their ineffectiveness. These responses by anglers are in accordance with several studies showing that sea lions readily habituate to deterrents and often use them as a “dinner bell” [41,49,22,46]. Scordino [49] reported that active pursuit and harassment of sea lions in a boat was the only deterrent method that seemed to be effective in the long term. This study, however, took place in a relatively small area of a river mouth (Gold Beach, Oregon), whereas in Southern California the area affected by sea lions is too large to be effectively patrolled this way.

Predictably, surveyed anglers with a higher monetary investment in fishing (by owning a boat or earning a living) felt much more negatively toward sea lions and had more interest in buying deterrents. This follows the pattern found by Engel et al. [17] in a Brazilian MPA, where anglers were the only stakeholder group to have a negative view of sea lions.

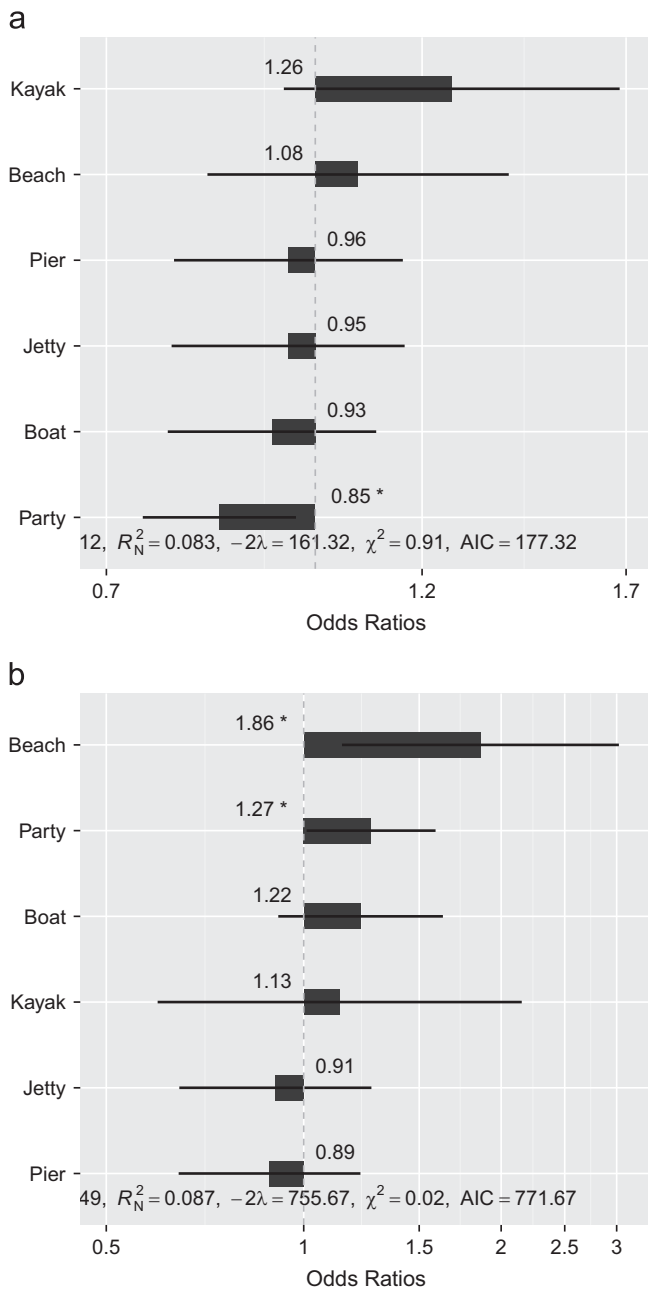
Interviewed CPFV crew were strongly in support of a lethal control program for sea lions. However, culling programs for marine mammals rarely have the desired effect (stock increase) on the target fish species, and instead often have unintended consequences on the marine food chain in question [8]. The fact that there is still strong support for lethal programs among surveyed CPFV crew reveals either an antagonism toward California sea lions or potential unawareness of the inefficacy of culling programs, both of which could likely be changed through educational campaigns.

#### 4.5. Knowledge and opinions on other marine mammals and their impact on Southern California fishing

This survey supports the finding that other marine mammals are not a major source of depredation in Southern California, as also reported by DeMaster et al. [13] as well as Navarro and Bearzi [35]. Almost all anglers surveyed (88.74%) in this study reported seeing dolphins at least occasionally while fishing, but not often associated with sea lions. This differs from the findings of Bearzi [2], who reported sea lions often following dolphins in order to find food. The dissimilarity in these results could be attributed to difficulty in observing sea lions when in the presence of a large dolphin school, especially for anglers focused on fishing rather than observation. These results could also indicate that when in the presence of fishing boats, sea lions do not follow dolphins and instead choose to associate with the fishing boat.

When asked whether dolphins and sea lions feel pain, surveyed anglers answered “yes” overwhelmingly for both species with no discernible difference between the two. This attitude toward sea lions, however, did not affect whether the same anglers supported using potentially painful non-lethal or lethal deterrent methods against sea lions. This suggests that the negative perception due to depredation overrides any positive emotion produced by the charismatic “flagship” nature of sea lions [25,54]. The apparent lack of “sympathy” corresponds with the findings of Edgell and Nowell [16], who reported that anglers were the only group to display a negative attitude toward marine mammals in the context of the “new environmental paradigm” scale, defined by Dunlap et al. [15] as a measure of pro-environmental orientation. A study by Barney





**Fig. 5.** (a) Belief that MPAs help repopulate fish stocks analyzed by fishing platform. (b) Perception of conflict between angler and conservation interests analyzed by fishing platform.

et al. [1] found that the more education an individual has, the less likely they are to have a negative attitude toward marine mammals or participate in harassment toward these animals. This indicates that increasing education programs regarding sea lions may change angler attitudes toward these animals.

#### 4.6. Opinions on marine policy and conservation

Anglers surveyed in Southern California, especially CPFV crew, had a distinctly negative view of marine legislation regarding fishing and conservation. CPFV crew from this study were in support of reversing the protection given to sea lions under the MMPA, and did not think MPAs are effective in replenishing fish stocks. This is a problem, as MPA networks have been shown to be more effective with greater angler support [29]. Recreational

anglers were found to encroach upon the Southern California MPAs more than commercial anglers [19]. Angler compliance is key for the success of MPAs [29]; therefore, steps should be taken to address angler concerns in order to encourage compliance.

A large percentage of both surveyed recreational anglers and CPFV crew reported a general decrease in the quantity and size of fish caught over the last decade. It has been shown that anglers accurately report fish population declines [33], and a similar decline has been found with the CPFV fleet in Monterey Bay, California [32]. The decline in fish size is of concern, as an old growth age structure (indicated by the presence of large fish) is important for fish reproduction and recruitment [5]. Despite this negative trend, most of the interviewed anglers still believe that there is a conflict between conservation interests and angler interests. Their answers revealed a general distrust of conservationists' motives and qualifications. Anglers suggested meetings or forums between both parties as a way of bridging this gap, as well as increasing education and having conservationists spend more time on the water, similar to the suggestions proposed by Cowx et al. [11] to reconcile anglers with conservation goals.

Some interviewees mentioned that commercial anglers, and not recreational anglers, are causing fish depletions so regulations should only focus on commercial fishing. Studies, however, have shown that recreational fishing has a significant impact on fish populations [48,12,30]. Educational programs aimed toward recreational anglers could increase awareness of their impact on the fisheries they interact with, and therefore increase support and participate in conservation programs, as demonstrated by Granek et al. [23].

## 5. Trends and future directions

Overall, the results of our surveys suggest that California sea lion depredation is impacting offshore fishing in Southern California, with CPFVs and private boaters hit the hardest. Surveyed anglers fishing onshore from piers and jetties seem, so far, to be relatively unaffected. Respondents from San Diego County had the highest number of sea lion sightings as well as the highest instance of depredation, suggesting mitigation efforts should be targeted to this area, primarily toward offshore anglers. Currently, most non-lethal deterrents are seen as ineffective, demonstrating the need for the development of new technologies, as also shown by Schakner and Blumstein [46]. As an angler's monetary investment in fishing increases (through earning a livelihood on a CPFV or owning a private boat), their support for relaxing sea lion protection and interest in an effective deterrent device also increases. These anglers represent the target demographic for marketing future deterrents. New devices should follow guidelines set by Schakner and Blumstein [46] to "take advantage of the sea lion sensory and behavioral repertoire while maintaining long-term efficacy".

CPFV crew interviewed during our study supported a lethal culling program for California sea lions, although Bowen and Lidgard [8] have shown that culling marine mammals does not increase stocks of target fish. Evidence of this should be circulated through the angler community through an educational campaign, to steer the discussion toward more productive solutions. Jacobs and Harms [26] found that interpretation (in the context of naturalists on a whale watching boat), can increase conservation intentions toward marine mammals. Perhaps a similar education program could improve attitudes toward California sea lions and lead to effective non-lethal depredation solutions. Our results, in accordance with DeMaster et al. [13] and Navarro and Bearzi [35], indicate that dolphins are not major culprits of depredation in Southern California therefore any future deterrents will need to be

**Table 7**  
Opinions on where the conflict between angler and conservation interest comes from, and angler suggestions on how to improve the conflict and bridge the gap. Responses were categorized based on similarity, and a category was only included if at least 10 anglers responded in a similar way.

Conflict	N	Suggested solutions	N
Disagreement over MPAs and regulations	36	Compromises	17
Opposing goals: anglers want to fish, conservationists want to stop all fishing	66	Increased education	24
Anglers have monetary and livelihood interest in fishing	13	Meetings and forums between two sides	30
Lack of education	10	Increase online resources	11
Conservationists do not spend time at sea	14	Provide more information—nonspecific	22
Commercial anglers are causing the problems	10	Have conservationists spend more time on the water	28
Overfishing	11	Better science	14
Conservationists are ignorant	14		

sea lion specific in order to avoid potential harmful consequences (hearing damage or exclusion from habitat) for dolphins and other marine mammals in the area [38,22,46]. Results from our study also revealed a distressing trend of fish stock decline and dissatisfaction with current conservation efforts, alongside a distrust of conservationists by the angler community. This is a sentiment that needs to be overcome in order to have productive compromises and solutions. As long as this divide persists, it will be difficult to make management decisions that benefit angler stakeholders and preserve recreational fisheries for future use. Angler responses to this survey indicated that meetings or forums between the two parties will help accomplish this goal, as well as having conservationists log more hours on the water to increase their credibility in the eyes of the anglers.

This project was designed to promote the use of anglers' knowledge to aid in the assessment and implementation of marine policy. Angler surveys are a viable tool and ally for marine conservation [51], and these findings support further use of this method. Collaborative efforts need to be made on both sides to facilitate the spread of scientific information and observations, and to include angler expertise and input in ongoing conservation efforts. Educational meetings and campaigns are the likeliest place to begin this process. This will result in more effective conservation as well as greater stakeholder satisfaction, a mutually beneficial outcome.

## Acknowledgements

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## Appendix A. Supplementary Information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.marpol.2014.09.020>.

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