Long-term participation in collaborative fisheries research improves angler opinions on marine protected areas

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Recent marine spatial planning efforts, including the management and monitoring of marine protected areas (MPAs), increasingly focus on the importance of stakeholder engagement. For nearly 15 years, the California Collaborative Fisheries Research Program (CCFRP) has partnered volunteer anglers with researchers, the fishing industry, and resource managers to monitor groundfishes in California's network of MPAs. While the program has succeeded in generating sustained biological observations, we know little about volunteer angler demography or the impact of participation on their perceptions and opinions on fisheries data or MPAs. In this study we surveyed CCFRP volunteers to learn about (a) volunteer angler demographics and attitudes toward groundfish management and stock health, (b) volunteer angler motivations for joining and staying in the program, and (c) whether participation in the program influenced volunteer angler opinions on the quality of fisheries data used in resource management and the establishment of MPAs in California. CCFRP volunteers were older and had higher fishing avidity than average within the California recreational angling community. Many self-identified as more conservation-minded than their peers in the recreational fishing community and had positive views of California groundfish management and stock health. Participation in science and giving back to fisheries resources were major motivating factors in their decision to become and remain CCFRP volunteers. Angler opinions toward MPAs were more positive after volunteering with CCFRP. Those who had volunteered for seven or more years with CCFRP were more likely than not to gain a positive opinion of MPAs. Our survey results provide evidence that long-term engagement of stakeholders in collaborative research positively influences stakeholder opinions regarding marine resource management, and highlights CCFRP's success in engaging citizen science stakeholders in collaborative fisheries research.

2 **Long-term Participation in Collaborative Fisheries Research Improves Angler**

3 **Opinions on Marine Protected Areas**

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19 Abstract

20   Recent marine spatial planning efforts, including the management and monitoring of

21   marine protected areas (MPAs), increasingly focus on the importance of stakeholder

22   engagement. For nearly 15 years, the California Collaborative Fisheries Research Program

23   (CCFRP) has partnered volunteer anglers with researchers, the fishing industry, and resource

24   managers to monitor groundfishes in California's network of MPAs. While the program has

25   succeeded in generating sustained biological observations, we know little about volunteer angler

26   demography or the impact of participation on their perceptions and opinions on fisheries data or

27   MPAs. In this study we surveyed CCFRP volunteers to learn about (a) volunteer angler

28   demographics and attitudes toward groundfish management and stock health, (b) volunteer

29   angler motivations for joining and staying in the program, and (c) whether participation in the

30   program influenced volunteer angler opinions on the quality of fisheries data used in resource

31   management and the creation of MPAs in California. CCFRP volunteers were older and had

32   higher fishing avidity than average within the California recreational angling community. Many

33   self-identified as more conservation-minded than their peers in the recreational fishing

34   community and had positive views of California groundfish management and stock health.

35   Participation in science and giving back to fisheries resources were major motivating factors in

36   their decision to become and remain CCFRP volunteers. Angler opinions toward MPAs were

37   more positive after volunteering with CCFRP. Those who had volunteered for seven or more

38   years with CCFRP were more likely than not to gain a positive opinion of MPAs. Our survey

39   results provide evidence that long-term engagement of stakeholders in collaborative research

40   positively influences stakeholder opinions regarding marine resource management, and

41   highlights CCFRP's success in engaging citizen science stakeholders in collaborative fisheries

42   research.

44 Introduction

45   Stakeholder engagement is an important part of marine resource protection and

46   management (Pomeroy & Douvere, 2008). Benefits of such engagement include the

47   incorporation of local knowledge into policy, and the potential to build stakeholder trust in

48   management decisions (Yochum, Starr & Wendt, 2011). California's Marine Life Protection Act

49   (MLPA) of 1999 (Fish and Game Code § 2850-2863) directed the state to redesign California's

50   marine protection areas (MPAs) to function as a network and increase protection of the state's

51   marine habitats, wildlife, and cultural sites. Establishment of the statewide MPA network took 13

52   years and involved considerable effort to engage stakeholders (Gleason et al., 2010). Multiple

53   assessments of the MLPA stakeholder process found that it effectively achieved broad

54   participation of resource users and interest groups across the state (Fox et al., 2013; Gleason et

55   al., 2013; Kirlin et al., 2013). Since implementing the MPA network, the state (i.e. California

56   Department of Fish and Wildlife (CDFW), California Ocean Protection Council (OPC), and

57   California Fish and Game Commission (FGC)), in partnership with California Ocean Science

58   Trust (OST), has supported public engagement through continued scientific monitoring of fish

59   populations inside and outside MPA boundaries (OST, CDFW & OPC, 2012, 2017).

60   The California Collaborative Fisheries Research Program (CCFRP) was created in 2006

61   by a coalition of scientists, resource managers, commercial passenger fishing vessel (CPFV)

62   operators, and recreational anglers (Wendt & Starr, 2009). The program uses a hook-and-line

63   sampling design to monitor the abundance and size of groundfish species (e.g., rockfish, flatfish,

64   roundfish, and skates and rays); data are used to make long-term comparisons of species

65   diversity, catch rates, and length-frequency distributions within and among paired MPA and

66   reference sites (sites similar in character and location to the MPA, but without the protections

67   afforded the MPA). Between 2007 and 2016, CCFRP annually surveyed four sets of MPAs along

68   the central coast including Año Nuevo State Marine Reserve (SMR), Point Lobos SMR, Piedras

69   Blancas SMR, and Point Buchon SMR (Fig. 1). These MPAs were implemented in 2007 and are

70   located within the Central Coast MLPA planning region that extends from Pigeon Point to Point

71   Conception, CA.

72   CCFRP's volunteer saltwater recreational anglers are central to the program's

73   standardized hook-and-line survey. Once a fish is caught by a volunteer angler, it is processed by

74   scientists who identify, measure, tag (externally), and release the catch (Wendt & Starr, 2009).

75   Volunteering requires a commitment to early mornings and near constant fishing effort without

76   the benefit of keeping the day's catch. Nevertheless, volunteering gives participants the unique

77   opportunity to fish in MPAs designated as no-take zones where fishing is otherwise prohibited. It

78   also offers volunteer anglers the opportunity to interact with the science crew and make their

79   own observations on the similarities and differences between the catches in MPAs and reference

80   areas. This participation, and the direct observation of the scientific process, is thought to instill a

81 sense of ownership and trust among participants in the data being collected (Yochum, Starr &
82 Wendt, 2011).
83   The CCFRP program capitalizes on the expertise and knowledge of the fishing industry,
84 angling public, participating scientists, and managers; together, these constituents work toward a
85 common goal (e.g., measuring MPA effectiveness) that ultimately gives the group a shared
86 purpose (Wendt & Starr, 2009; Yochum, Starr & Wendt, 2011). CCFRP relies on relationship
87 building and transparency to create buy-in of MPA monitoring, evaluation, and management by
88 involving stakeholders in all aspects of the program, from study design to data collection and
89 sharing. An example of these efforts is the annual Volunteer Appreciation and Data Workshop
90 hosted by the coordinating staff from California Polytechnic University, San Luis Obispo (Cal
91 Poly) and Moss Landing Marine Labs (MLML), where survey results and trip highlights are
92 shared with volunteer participants and other partners. To date, the impact of these events on
93 angler opinions of MPAs has not been evaluated.
94   Human dimensions such as effective engagement, honesty, trust, and transparency can
95 impact the success of MPAs (Gall & Rodwell, 2016; Ordoñez-Gauger et al., 2018). However,
96 research on public knowledge, attitudes, and perceptions of California's MPA network is sparse,
97 and studies that do exist vary widely across geographic region and composition of study
98 populations (Baldassare et al., 2007, 2017; Loper, 2008; Ordoñez-Gauger et al., 2018). While the
99 success of CCFRP in generating valuable monitoring data is clear (Wendt & Starr, 2009; Starr et
100 al., 2015), the degree to which CCFRP participation has influenced volunteer perceptions of
101 California's MPAs is less clear. In addition, the essential context for understanding this influence
102 – (a) the demographics and characteristics of the CCFRP volunteer anglers and (b) their
103 perceptions on the health of groundfish stocks, the data quality used to manage those stocks, and
104 the effectiveness of MPAs relative to groundfish management measures (e.g. depth restrictions,
105 bag limits, size limits) -- has also not been assessed. Although California's network of MPAs
106 were not specifically designed as a fishery management tool, any beneficial fisheries impacts of
107 MPAs are important in the evaluation of overall MPA effectiveness. Thus, state resource
108 managers would be well served by learning about the volunteer anglers who help monitor
109 California's MPAs as well as their respective opinions on MPAs.
110   Given the longevity of CCFRP, and extensive volunteer participation, the program provides a
111 valuable opportunity to measure outcomes of long-term stakeholder engagement. We used an

112 online survey of current and former CCFRP volunteer anglers to learn about (a) volunteer angler

113 demographics and attitudes toward groundfish management and stock health, (b) volunteer

114 angler motivations for joining and staying in the program, and (c) whether participation in the

115 program influenced volunteer angler opinions on the quality of fisheries data used in resource

116 management and the creation of MPAs in California. By characterizing the population of CCFRP

117 angler volunteers and their perceptions in relation to their volunteer efforts, our intent is to

118 characterize the realized benefits of CCFRP as a collaborative research program, beyond the

119 fisheries data it yields.

120

121 **Materials & Methods**

122 Survey

123   We distributed an online survey to 722 volunteer anglers who participated in CCFRP

124 with Cal Poly and MLML between 2007 and 2018. This group represented a subgroup of the

125 entire volunteer population during that time period (N=901), as 179 volunteer anglers had

126 previously opted out of receiving communications from CCFRP and two other groups,

127 individuals without e-mail addresses and anglers under the age of 18 years, were not contacted.

128 We used Qualtrics, an online survey platform, to deliver the survey questionnaire. Respondents

129 provided written consent by agreeing to participate in the survey. The questionnaire consisted of

130 29 questions arranged into four sections: (a) CCFRP volunteering; (b) fisheries management and

131 health of California groundfish stocks; (c) MPAs; and (d) demographics and miscellaneous

132 questions (*Article S1*). We included multiple question types (yes/no, multiple-response, ordinal

133 scale, and free-response) and designed the survey so that respondents could complete their

134 responses in approximately 15 minutes. The University of California, San Diego Institutional

135 Review Board (IRB) certified this study of volunteer anglers as exempt from IRB review.

136   We distributed the survey via a series of e-mails sent to subjects over a two-week period

137 in Spring 2018. The first e-mail invited subjects to participate in the survey, and two subsequent

138 e-mails sent seven and 12 days into the study period reminded subjects to complete the survey.

139 Each e-mail contained a description of the study, a letter of consent, and a link to the online

140 questionnaire.

141   ## Acceptable survey response rate and margin of error

142   An acceptable survey response rate for categorical response surveys is dependent in part

143   on the confidence level and the maximum margin of error that the surveyor is willing to accept

144   (Bartlett, Kotrlik & Higgins, 2001). We calculated and report the acceptable minimum survey

145   response rates according to the minimum sample sizes needed for an allowance of 5% and 10%

146   margins of error (MOE_{95}) as described in Bartlett, Kotrlik & Higgins (2001). Five and 10%

147   MOE_{95} are equivalent to ± 0.25 and 0.5 points respectively, on a categorical ordinal response

148   scale from 1 to 5. With respect to the survey response rate and estimates, the MOE_{95}

149   corresponds to the $\pm$ percentage points defining the range of the 95% CI, where,

150        $$MOE_{95} \ = z * \sqrt{(\hat{p} \ \times \ (1 - \hat{p}))/n},$$

151        $z = z$-score for 95% CI,

152        $\hat{p} = $ sample proportion positive, and the second term in the equation is the standard error

153   of a binomial distribution.

154

155   ## Measures taken to address potential limitations with survey design

156   Potential limitations with the survey design included 1) the possibility a biased

157   population of CCFRP volunteer anglers responded to the survey (i.e. nonresponse bias) (Fisher et

158   al. 1996; Bartlett, Kotrlik & Higgins, 2001), 2) potential bias in respondent responses due to

159   surveyor association with the CCFRP program (i.e. response bias) and 3) reliance on a

160   respondent's ability to accurately recall the history and influence on their opinion change or lack

161   thereof (e.g., response bias due to the subjectivity of a reflexive counterfactual study design)

162   (Franks et al. 2014).

163   Steps taken to increase the survey response rate and aim for a large and representative

164   sample included providing respondents (a) assurance of confidentiality, (b) a short, well-

165   designed survey (e.g., ~ 15 minute completion time) (c) a seamless online submission format,

166   and (d) reminder emails (Fisher et al. 1996). Due to the anonymity of the survey we were unable

167   to test (or adjust) for nonresponse bias. However, the survey questions provided a means to

168   check whether respondents represented an unexpected demographic (e.g., mostly young anglers)

169   as well as to compare the distribution of MPA opinion change responses by age, angler avidity,

170   conservation-mindedness, level of engagement, etc.

171   With respect to potential surveyor influence on responses, the solicitation and reminder
172 emails were sent via CCFRP field technicians (to keep volunteer emails confidential), but
173 subjects were informed the survey itself was independently formulated by researchers at Scripps
174 Institution of Oceanography, UC San Diego.
175   Questions related to opinion change and volunteer participation were included in separate
176 sections of the survey so that these responses were made independent of each other. The longest
177 time frame for which a respondent was asked to recall their opinions was dependent on the
178 length of time since joining CFFRP, which at most, was 11 years (e.g., 2007 – 2017).
179

180 Angler demographics and characteristics

181   Age and gender comprised the survey's demographic categories; other characteristics
182 included years of fishing experience, frequency of fishing, degree of conservation-mindedness,
183 whether anglers had any prior work experience in marine resource management or the
184 recreational or commercial fishing industries, whether anglers had fished in MPA sites prior to
185 those areas being designated MPAs, and whether anglers had ever participated in the MLPA
186 planning process.
187   We categorized angling avidity (i.e. a relative measure of the enthusiasm an angler has
188 for the sport) into three avidity levels – low, medium, or high – based on the number of saltwater
189 angling trips they took per year, outside of CCFRP surveys, with low being <4 days, medium 4-
190 23 days, and high >23 days per year. Angler avidity ranges were based on the National
191 Oceanographic and Atmospheric Administration (NOAA) West Coast Fishing Avidity categories
192 (Rubio, Brinson & Wallmo, 2014).
193

194 Volunteer perceptions of groundfish management and stock health

195   In addition to characterizing the general opinion of anglers on the health of groundfish
196 stocks and the effectiveness of specific regulations, we also compared the percentage of
197 respondent opinions across related work experience categories to gauge the relative degree of
198 consensus in opinions among these groups. Work experience categories included marine
199 resource management, commercial or recreational fishing industry, and no experience.
200

201 ## Volunteer opinion change on fisheries data quality and MPAs

202  Questions regarding the quality of fisheries data were limited to whether volunteers had

203 an opinion of these data before CCFRP participation, and of those that did, whether their opinion

204 changed either positively or negatively after having volunteered with CCFRP.

205  Given that MPAs were expected to elicit strong opinions with the angling public we were

206 interested in (a) capturing the distribution of opinions on MPAs both before and after CCFRP

207 participation, (b) characterizing the extent of opinion change across the group, and (c) examining

208 whether opinion change is mediated by the extent of program participation. Respondents

209 answered questions on an ordinal scale. They could report an opinion of "Positive," "Somewhat

210 positive," "Somewhat negative," "Negative," or "No opinion." We coded the answers 1, 2, 3, 4,

211 and 5 respectively.

212  To capture the overall proportion of respondents having a change in opinion on MPAs

213 after volunteering with CCFRP, we subtracted the answer code corresponding to their opinion

214 after CCFRP participation from the answer code corresponding to their opinion before

215 volunteering with CCFRP. Results that were positive indicated a positive change in opinion of

216 MPAs, results that were negative indicated a negative change in opinion of MPAs, and results

217 that were "0" represented no change in opinion. We coded these differences numerically into a

218 single variable representing change in opinion, with positive change coded as "1", no change

219 coded as "2," and negative change coded as "3." We report the survey estimates $\pm MOE_{95}$ for the

220 proportions of positive MPA opinions *before* and *after* CCFRP participation. Confidence

221 intervals for which the calculated MOE_{95} was less than the minimum MOE_{95} for our reported

222 survey response rate were adjusted accordingly.

223

224 ## Volunteer opinion change relative to measures of participation

225  To evaluate volunteer opinion change relative to levels of volunteer participation, we

226 focused on three measures of CCFRP volunteer angler participation: (a) number of years since

227 becoming a volunteer angler; (b) the number of CCFRP Volunteer Angler Appreciation and Data

228 Workshops an angler had attended; and (c) approximate number of CCFRP sampling trips

229 attended. We calculated the number of years since an angler became a volunteer by subtracting

230 the year the respondent started volunteering from the year 2018 (the year we conducted the

231 survey). Given the survey was anonymous, we calculated the approximate number of sampling

232   trips a respondent went on throughout their time with CCFRP by multiplying the number of

233   years a volunteer participated in CCFRP by the average number of trips they went on per year.

234   We used the glm function within the stats package in R version 6.3.1 (R-Core-Team,

235   2019) to run a binomial logistic regression model and test the effect of each measure of volunteer

236   participation on respondents having either a positive opinion change or no opinion change on the

237   quality of data used in resource management. There were too few (n = 1) negative opinion

238   change responses to include this category within a multinomial logistic regression model (*Data*

239   *S1*).

240   We used the nnet, broom, scales, and car packages (Venables & Ripley, 2002; Fox &

241   Weisberg, 2019; Wickham & Seidel, 2019; Robinson & Hayes, 2020) in R version 6.3.1 (R-

242   Core-Team, 2019) to run a multinomial logistic regression model and test the effect of each

243   measure of volunteer participation on respondents having a positive, negative, or no opinion

244   change on the creation of MPAs (*Data S1*). We used the MNLpred package (Neumann, 2020) to

245   construct predicted probabilities and 95% confidence intervals for each opinion change category

246   over levels of participation (*Data S1*).

247   Demographics and characteristics of respondents were also compared across MPA

248   opinion change categories.

249

250   **Results**

251   Of the 722 current and former volunteer anglers contacted about the survey, one-hundred

252   and twelve (112) completed and submitted a survey (*Data S1*), for a response rate of 15%. One

253   respondent had not yet volunteered on sampling trips, leaving 111 surveys included in the

254   analysis. The acceptable minimum response rate, given a 10% MOE_{95} was 12% (n = 85); for a

255   5% MOE_{95}, the minimum response rate was 35% (n = 251). Given our survey response rate, the

256   minimum MOE_{95} for reporting was 9%. Excluding one outlier (24.7 hr), the average time

257   respondents took to complete and submit the survey was 12.4 min (± 6.4 *SD*).

258

259   Volunteer demographics and characteristics

260   The distribution of respondent age was skewed left, with nearly one third of respondents

261   being between 65 and 74 years of age, and the next largest age bracket being 55-64 years old

262   (17%, Table 1). Most respondents were male (86%); twelve percent (12%) were female. Two

263   percent (2%) of respondents chose the option "I prefer not to say." Respondents had medium to

264   high avidity for saltwater angling, with 40% taking between four and 23 trips a year and 35%

265   taking more than 23 trips a year. Eighteen percent (18%) of respondents said they participated in

266   the MLPA planning process. Of those participating in the MLPA planning process, 90% were

267   characterized as having high or medium angling avidity (45% each).

268   Seventy percent (70%) of volunteer anglers who responded to the survey considered

269   themselves to be more conservation minded than their peers in the recreational fishing

270   community, and an additional 25% thought they were similarly conservation minded with their

271   peers (Table 1). Sixty-five percent (65%) of respondents did not have any experience in marine

272   resource management, or the recreational or commercial fishing industries. Twenty-four percent

273   (24%) had experience working in the fishing industry sector, and 14% had some experience with

274   marine resource management (there was some overlap between these groups). Forty-five percent

275   (45%) of the respondents had previously fished in areas that are now MPAs. Seventy-four

276   percent (74%) of respondents participated in surveys of both MPA and reference areas during

277   their time as volunteers with CCFRP.

278

279   Volunteer perceptions of groundfish management and stock health

280   Many respondents (52%) believed California groundfish stocks were healthy, while 25%

281   thought they were somewhat unhealthy or very unhealthy; the distribution of responses was

282   similar across related work experience category (Fig. 2A). Nearly four out of five respondents

283   (79%) thought that California groundfish stocks were very well managed, well managed, or

284   adequately managed; 14% believed they were poorly managed, and 2% thought they were very

285   poorly managed. The distribution of responses regarding the management of stocks varied by

286   related work experience (Fig. 2B). Respondents having no related work experience and

287   respondents with marine resource management experience had a more positive response toward

288   the management of groundfish stocks than respondents having worked in the fishing industry

289   (Fig. 2B).

290   Eighty-five percent (85%) of respondents thought seasonal closures and bag limits were

291   effective fisheries management tools for groundfish stocks, while spatial closures and depth

292   restrictions were considered relatively less effective (Fig. 3A). Negative responses toward the

293   effectiveness of spatial closures and depth restrictions were comprised mostly of respondents

294   with experience working in the fishing industry (Fig. 3B). Respondents with no experience and

295   those with fishing industry experience were least certain about depth restrictions; this type of

296   regulation comprised the highest percentage of "Not sure" responses in these groups (Fig. 3C).

297

Motivations for volunteering with CCFRP

299   Nearly all respondents said they plan to continue volunteering with CCFRP (93%). Of those

300   who plan to continue volunteering (N=102), the reasons why they joined the program were the

301   same as the reasons why they continue volunteering with the program (Fig. 4). The most

302   frequently selected reason for continuing to volunteer with CCFRP was the opportunity to

303   participate in science (75%). Sixty-eight percent (68%) selected "giving back to fisheries

304   resources," and 58% selected "enjoying a day of fishing provided by CCFRP" as key reasons

305   why they both joined the program and why they stay involved (Fig. 4). Several respondents who

306   responded "Other" described desires to help fisheries or help marine resource managers gather

307   data to use in management. Three respondents replied that the opportunity to learn was important

308   to why they joined the program, and an additional three respondents cited learning new

309   information as a reason for continuing to volunteer.

310   Eight respondents (7%) said that they do not plan to continue volunteering with CCFRP.

311   Reasons included lack of available volunteer spots (n = 2), personal health (n = 2), seasickness (n

312   = 1), old age (n = 1), turned into a job (n = 1), and a lack of extra time to volunteer (n =1).

313

Opinion change on fisheries data quality and MPAs

315   Sixty-one percent (61%) reported having no opinion of the quality of fisheries data used

316   for resource management before volunteering with CCFRP; roughly equal portions reported

317   having either no change (18%) or a positive change in opinion (20%) after volunteering with

318   CCFRP; 1% reported a negative change in opinion (Fig. 5).

319   Sixty percent (60%) of volunteer anglers surveyed said that they had positive or

320   somewhat positive opinions of the creation of MPAs before they began volunteering (Fig. 6A).

321   The MOE_{95} for these responses was $\pm$ 9% (CI_{95} = 51 − 69%), which was within the MOE_{95} for

322   our survey. Twenty-eight percent (28%) said they had somewhat negative or negative opinions

323   of MPA creation in California before volunteering, while 15% of respondents said they did not

324   have any opinion of MPAs before joining the program (Fig. 6A). When volunteers were asked

325 what their opinions were after volunteering with CCFRP, 89% said they had a positive or

326 somewhat positive opinion of MPAs (Fig. 6A). The MOE_{95} for these responses was ± 6% (CI_{95}

327 = 83 – 95%); however, after adjusting for the minimum MOE_{95} (± 9%) for our survey response

328 rate, the CI_{95} becomes 80 – 98%. The proportion of respondents having no change of opinion on

329 the creation of MPAs after volunteering with CCFRP was 49%; these respondents comprised

330 95% of those having a positive or somewhat positive opinion before participating with CCFRP.

331 Of those respondents having a change of opinion (n = 57), 91% had a positive change and 9% of

332 respondents had a negative change in opinion of MPAs after volunteering with CCFRP (Fig.

333 6B).

334

335 ## Measures of volunteer participation

336   The number of years volunteers participated with CCFRP was nearly uniformly

337 distributed; volunteers who had been with the program since 2007 made up the highest

338 percentage (15%) and newly recruited volunteers (in 2017) followed behind at 12%. Fifty-four

339 percent (54%) of volunteers surveyed never attended an annual Volunteer Appreciation and Data

340 Workshop. Of the 46% who had, most attended one to four workshops. Six percent (6%) of

341 respondents attended five or more workshops. The estimated number of CCFRP trips attended

342 ranged from one trip to 154 trips (median = 8 trips, mean = 17 trips). Seventeen percent (17%) of

343 respondents attended one sampling trip.

344

345 ## Volunteer opinion change relative to measures of participation

346   The analysis on the quality of fisheries data used in resource management was limited to

347 only those anglers who stated they had an opinion before volunteering with CCFRP (n = 42).

348 This is because volunteers who did not have an opinion prior to volunteering were not asked

349 about their opinions after volunteering with CCFRP (see Methods). None of the measures of

350 volunteer participation were significantly related to having a positive change in opinion (versus

351 no change) on data quality (Table 2).

352   One hundred and seven (107) of the respondents answered all questions related to MPA

353 opinion change and the three calculated measures of participation (length of time since joining

354 the program, number of Volunteer Appreciation and Data Workshops attended, and total number

355 of trips attended). Length of time since joining CCFRP was the only significant predictor of

356   having a change in opinion regarding MPAs (Table 3). In general, as the time since joining

357   CCFRP increased, a volunteer angler was more likely to have a positive change in opinion on

358   MPAs than having no change in opinion (RRR = 0.82 (reference category = positive change in

359   opinion), 95% CI = 0.72, 0.92, z = -0.293, p = 0.003; Fig. 7).

360

361   MPA opinion change by volunteer characteristics

362   The distribution of respondents within different volunteer characteristics, including

363   angler avidity, conservation mindedness, and related work experience, were similar across MPA

364   opinion change categories (Table 4); however, respondents who expressed no opinion change of

365   MPAs tended to be younger than those who had a positive change in opinion of MPAs. Those

366   respondents who had previously worked in marine resource management were split between

367   having no change in (positive) opinion and having a positive change in opinion of MPAs.

368   The sample size for those who expressed a negative change of opinion toward MPAs

369   consisted of five respondents (Table 4). Of these, none participated in the MLPA planning

370   process or worked previously in marine resource management. Three had fished in both MPAs

371   and reference sites with CCFRP, but none had visited the same MPA sites with CCFRP that they

372   had fished in before the implementation of MPAs in 2007.

373

374   **Discussion**

375   Our results provide evidence that long-term engagement of stakeholders in collaborative

376   research can positively change angler opinions on MPAs. At the outset, the creators of CCFRP

377   postulated that collaborative research was a "potent mechanism" that could (among other listed

378   benefits) build trust in fisheries management and develop a more accurate consensus about

379   resource status (Wendt & Starr, 2009). These anticipated outcomes are directly linked to the

380   collaborative nature of the program, where participants are working together toward a shared

381   goal (Wendt & Starr, 2009; Yochum, Starr & Wendt, 2011). CCFRP straddles two modes of

382   public engagement in science: collaborative fisheries research and citizen science. In so doing, it

383   draws from a long history of scientists partnering with members of the fishing industry to study

384   fish populations or develop management tools (Hartley & Robertson, 2009; Mireles, Nakamura

385   & Wendt, 2012; Gleason, Iudicello & Caselle, 2017). Citizen science – also called community-

386   based or participatory science – involves members of the public who are not scientists by trade

387   (Mckinley et al., 2017), and it differs from collaborative fisheries research in that the volunteers

388   are not necessarily part of the fishing industry. While the partnership between CCFRP and

389   CPFVs follows a more traditional collaborative fisheries research model, the inclusion of the

390   angling public distinguishes CCFRP as having successfully integrated citizen science into

391   collaborative fisheries research.

392

393   ## CCFRP volunteers are mostly older, avid anglers

394   CCFRP volunteers who responded to our survey were representative of fresh and

395   saltwater anglers in California (mostly men); however, they were relatively older. Forty-nine

396   percent (49%) of the larger angling community are between 18 and 44 years old and less than

397   4% are 65 or older (US Fish and Wildlife Service, 2011). In contrast, 18 to 44-year-olds made up

398   less than a third of our angler respondents, and 40% were over the age of 65. CCFRP surveys

399   occur only on weekdays, of which older, retired adults are more likely to be free for volunteering

400   compared to younger anglers. This older demographic may have influenced the proportional

401   distributions of certain volunteer characteristics such as angler avidity (i.e. more time for fishing

402   opportunities) and perceptions that could be influenced by having a more historical perspective

403   (e.g., stock health). Our survey did not include questions regarding household income or

404   ethnicity.

405   Relative to saltwater recreational anglers on the West Coast of the United States (Rubio,

406   Brinson & Wallmo, 2014), CCFRP volunteer anglers surveyed in our study had higher fishing

407   avidity, having on average participated in a higher number of fishing trips (non CCFRP-related)

408   in the last year. Anglers with high fishing avidity have a greater stake in fisheries management

409   decisions. For instance, in a 2014 survey of saltwater recreational anglers, angler avidity was

410   positively correlated with perceived importance of ensuring "that the opinions of all recreational

411   fisheries stakeholders are considered in policy-making" (Rubio, Brinson & Wallmo, 2014).

412   While our volunteers were not asked to report their opinions on the importance of stakeholder

413   input in policy making, we found that avid CCFRP volunteer angler respondents were more

414   likely to have participated in the MLPA planning process.

415   Levels of public participation in the California MLPA planning process were very high,

416   with over 4,000 members of the public attending planning-related events and over 70,000 public

417   comments submitted during the process and environmental review (Gleason et al., 2013). Still,

418   with over 39 million residents in California ("United States Census Bureau QuickFacts:

419   California," 2017), this is a relatively small proportion of participants. In our study, one in five

420   CCFRP survey respondents participated in the MLPA in some form, making them more engaged

421   than the average resident. Perhaps not surprisingly, about one third of our respondents who

422   participated in the MLPA were marine resource managers, however not all of those who had

423   worked in marine resource management participated in the MLPA.

424   We found that CCFRP has successfully engaged members of the public, as two thirds of

425   respondents had no work experience related to either marine management or the fishing industry.

426   Although the general audience targeted for volunteer angler recruitment was recreational anglers

427   (Wendt & Starr, 2009), the experience of fishing side-by-side with people from different

428   professional backgrounds may aid in the relationship-building that is an important cornerstone of

429   the program.

430   Low survey response rates can introduce nonresponse bias in survey results if the

431   respondents are not characteristic of the overall survey population (Fisher 1996; Bartlett, Kotrlik

432   & Higgins, 2001). Due to the relatively low survey response rate in this study (15%), non-

433   response bias is not precluded from our results (Fisher 1996). Nevertheless, the dominant

434   characteristics of respondents (e.g., older men with high fishing avidity and no related work

435   experience), are not atypical of the general CCFRP volunteer population. Many volunteer

436   anglers reported being more conservation-minded than their peers in the recreational fishing

437   community. This characterization is also not entirely unexpected given that CCFRP volunteer

438   anglers are citizen scientists participating in collaborative fisheries research, of which

439   conservation is a common motivator.

440

441   CCFRP volunteer anglers are motivated by science and conservation

442   Part of CCFRP's success in relationship building is evidenced by the willingness of

443   anglers to want to continue to participate in the program year after year. Most respondents said

444   they plan to continue volunteering. The reasons respondents chose to stay with the program were

445   the same three reasons they cited for joining CCFRP in the first place: (a) to participate in

446   science; (b) to give back to fisheries resources; and (c) to enjoy a day of fishing provided by

447   CCFRP. These responses demonstrate that CCFRP anglers are not solely driven by the novelty

448   of fishing inside MPAs, but by their interest in being involved in fisheries research. A handful of

449 respondents were high school teachers who responded that learning was a motivator for why they

450 joined. Three other respondents listed learning as a motivator for why they stayed. Across marine

451 and coastal citizen science projects, increasing knowledge is often a frequent motivation for

452 volunteering (Thiel et al., 2014).

453

454 Volunteer angler consensus on groundfish health and management

455   A lack of transparency between fishery managers and the fishing community has often

456 led to angler distrust of fishery assessments and management measures (Yochum, Starr &

457 Wendt, 2011); thus, one goal of collaborative fisheries research is garnering accurate consensus

458 among the fishing community and fisheries scientists regarding resource health (i.e. everyone's

459 perception of stock health reflects reality). In this study, most CCFRP respondents, regardless of

460 their related work experience (including no related experience), believed groundfish stocks were

461 somewhat healthy. This is a relatively accurate assessment considering most species of fish

462 comprising the groundfish fishery in California are rockfishes, of which many stocks have rebuilt

463 or are rebuilding from an overfished status (NOAA Fisheries, 2019; Pacific Fishery Management

464 Council, 2008). The agreement that groundfish stocks are somewhat healthy, regardless of

465 related work experience, suggests that there is accurate consensus of resource status among these

466 groups. Although not explicitly addressed in our survey, it seems likely that CCFRP volunteer

467 participation influenced these angler perceptions over time. It is also possible CCFRP volunteer

468 perceptions regarding groundfish stock health are influenced by historical perspectives, as older

469 respondents are more likely to have participated in groundfish fishing prior to the collapse and

470 subsequent recovery of many rockfish stocks. In another survey of the iconic saltwater bass

471 fishery in southern California, fishermen with more years of experience (and typically older in

472 age) were more likely to have an accurate perception of stock health (Bellquist et al., 2017). In

473 our survey, the proportion of younger respondents who had a "neutral" opinion regarding

474 groundfish stocks was higher than that of the older respondents.

475   Most (79%) respondents thought groundfish stocks were well-managed. Many (65%)

476 believed spatial closures (including MPAs) were effective in ensuring healthy groundfish stocks

477 in California, though catch limits and season closures had higher support (85% each); 21% were

478 "unsure" and 14% believed spatial management to be "not effective." Most of the uncertainty

479 and negative opinion of spatial management was by respondents having worked in the fishing

480   industry. However, depth restrictions were least popular among all related work experience

481   categories and garnered the greatest amount of uncertainty. Depth restrictions for groundfish in

482   central California prohibit fishing in waters greater than 50 fathoms (91.4 m) and were intended

483   to assist in rebuilding overfished rockfish stocks such as Canary Rockfish (*Sebastes pinniger*)

484   and Yelloweye Rockfish (*Sebastes ruberrimus*). However, fishing these depths for other popular

485   recreational groundfishes in central California (e.g., Lingcod (*Ophiodon elongatus*), Cabezon

486   (*Scorpaenichthys marmoratus*), and Greenlings (Family Hexagrammidae)) is also precluded by

487   this regulation, and could be driving some of the uncertainty among respondents. In addition,

488   although Canary Rockfish was rebuilt in 2015 (Thorson & Wetzel, 2015), Yelloweye Rockfish

489   remains in rebuilding status (Gertseva & Cope, 2017). Interestingly, except for depth restrictions,

490   the relative proportion of respondents stating groundfish management measures are effective was

491   similar across regulations and related work experience categories.

492   The focus of CCFRP is not to educate anglers on groundfish management and

493   regulations. However, because groundfish regulations include mandatory release of overfished

494   rockfish species, CCFRP does actively work to increase angler awareness of the susceptibility of

495   rockfishes to pressure-related (i.e. depth-related) injuries associated with angling and the utility

496   of recompression (i.e. releasing fish back to depth). Generally, fishing deeper results in an

497   increased susceptibility to barotrauma and decreased survival rates of rockfishes; thus, CCFRP

498   protocol has always restricted captains to fish areas in depths less than 36.7 m (120 ft).

499   Additionally, CCFRP science crew release fish showing signs of barotrauma back to depth with

500   descending devices since recompression alleviates signs of barotrauma and significantly

501   increases release survival of many rockfishes (Jarvis & Lowe, 2008; Hannah, Rankin & Blume,

502   2012). These measures ultimately promote ethical rockfish angling practices.

503

504   Volunteers are less opiniated on fisheries data quality than MPAs

505   In addition to outreach, a typical day on the water provides CCFRP volunteers

506   opportunities to observe how data are collected. Important survey protocol details are relayed to

507   CCFRP volunteer anglers on each day's pre-survey briefing. At the end of the day, the science

508   crew debriefs the anglers on overall fish count, fish counts by angler, and biggest and smallest

509   fish caught, etc. Thus, although the anglers do not assist with recording data, the anglers are

510 immediately able to informally verify the data collected that day, based on their own

511 observations and recollections.

512   Unlike the topic of MPAs, most respondents (61%) stated they did not have an opinion of

513 the fisheries data used in resource management prior to volunteering for CCFRP. After

514 participation with CCFRP, opinion change was mostly positive, but it remains unclear the degree

515 to which this has to do with CCFRP. Although none of the metrics of angler participation were

516 significantly related to positive change (versus no change) in opinion of fisheries data quality,

517 our analysis was limited by a reduced sample size because (unlike the MPA analysis) only

518 anglers who stated they had an opinion before volunteering with CCFRP were asked about their

519 opinion change. Thus, we do not know whether anglers who had no opinion on data quality

520 before volunteering with CCFRP eventually gained a positive or negative opinion, or what the

521 opinions were of those not having an opinion change. Nevertheless, the mostly positive opinion

522 change suggests CCFRP participation may be a factor, regardless of the level of engagement.

523 Building trust in the quality of fisheries data used for management is an important step toward

524 increasing angler perceptions of groundfish management measures, including MPAs. It is also

525 worth noting that anglers with high avidity serve CCFRP by providing highly experienced

526 angling services, and likely relatively high consistency in angler skill levels, all positively

527 influencing data quality.

528

529 CCFRP positively influences opinions on MPAs

530   A significantly higher percentage of volunteer anglers surveyed had positive opinions of

531 the creation of MPAs after volunteering with CCFRP. We did not find that this response was

532 biased with respect to angler characteristics; the distribution of anglers across categories of

533 angler avidity, conservation-mindedness, and related work-experience were similar, regardless of

534 the direction of MPA opinion change. For example, although the majority of CCFRP volunteers

535 responding to our survey identified themselves as being more conservation-minded than their

536 peers in the recreational fishing community, about half of them gained a positive opinion of the

537 creation of MPAs after volunteering with CCFRP. Thus, even those considering themselves to be

538 conservation-minded did not necessarily have strong positive opinions of MPAs before

539 participating with CCFRP. We also found that respondents varied in their level of engagement

540 with CCFRP across all three different measures of participation; thus, survey respondents are not

541   likely to be more engaged than the overall population of CCFRP volunteers. In fact, the wide

542   range of engagement among respondents allowed us to test how different levels of participation

543   related or not to MPA opinion change.

544   Respondent subjectivity can be a disadvantage of reflexive counterfactual survey designs

545   (i.e. before and after opinions), in which there is no true control group and there is reliance on

546   respondents to recall changes in their beliefs and opinions (Smallhorn-West et al. 2019, Franks et

547   al. 2014). For example, we have no measure of how respondent opinions on MPAs would have

548   changed had volunteers never participated in CCFRP, nor do we have an indication of the

549   accuracy or legitimacy of subjective volunteer responses. However, the strength of our study

550   design is that it allowed us to test what aspect of participation and the extent to which that

551   volunteer participation was a factor in volunteer-stated opinion change. In other words, we did

552   not solely rely on respondent before and after opinions to evaluate CCFRP influence on MPA

553   opinions. In addition, we were interested in volunteer angler beliefs despite the potential for

554   subjectivity. Capturing volunteer beliefs and perceptions is also important for highlighting

555   opportunities for additional outreach and education (Franks et al. 2014).

556   The increase in positive perceptions of MPAs of CCFRP volunteers mirrors the

557   perceptions of California's public. In 2017, more than three in four Californians said that it was

558   very important that California have MPAs; a 20 point increase since 2006 (Baldassare et al.,

559   2007, 2017). While the overall increase in support for MPAs across the state in the last ten years

560   might be considered a counterfactual outcome suggesting no effect of CCFRP on volunteer

561   opinions of MPAs (Smallhorn-West et al. 2019), our study results indicate the time spent

562   volunteering for CCFRP was influential in volunteer opinion change.

563

564   Time with CCFRP influences positive change of opinion on MPAs

565   A positive change of opinion toward MPAs was directly related to the number of years

566   since respondents joined CCFRP. Other measures of participation, including the number of

567   Volunteer Appreciation and Data Workshops or the number of CCFRP trips attended, were not

568   significantly related to MPA opinion change, indicating that change in angler perceptions takes

569   time. In this study, the length of time necessary to achieve a greater than fifty percent (50%)

570   probability of having a positive change in opinion on MPAs was about seven years since joining

571   CCFRP. Long-term stakeholder engagement with CCFRP corresponds with a longer period

572 directly and indirectly gaining knowledge and awareness of MPAs through participation in

573 survey trips and through CCFRP communications, including e-mails, e-newsletters, and posts on

574 social media. Although Volunteer Appreciation and Data Workshops are arguably an important

575 part of CCFRP's relationship building and outreach tools, it is often lived experiences that are

576 more salient and have more impact on people's knowledge, attitudes, and perceptions.

577   Although not a stated goal of the study, we tested *a posteriori* whether any of the

578 different measures of volunteer participation were perhaps related to a volunteer's willingness to

579 continue participating (or not) with CCFRP (e.g., were volunteers who participated in more trips

580 more likely to state they would continue volunteering?). While volunteers were significantly

581 more likely to state they would continue volunteering with CCFRP than not continue (~ 13x

582 more likely), none of the measures of participation were significant predictors of their

583 willingness to continue with the program (*Data S1*). This would suggest that even newly

584 recruited and less engaged volunteer anglers are enthusiastic in their support of CCFRP.

585   In 2017, CCFRP was expanded statewide, and now includes a partnership of six

586 academic institutions that lead and organize surveys to actively monitor 14 MPAs in California

587 (Moss Landing Marine Laboraties, 2020). Between 2017 and 2019, eight-hundred and ninety-

588 eight (898) CCFRP volunteer anglers assisted science crew and CPFV captains/crew in

589 surveying 77,202 fish representing 94 species statewide (R Brooks, 2020, pers. comm.). This

590 large expansion of the program offers additional opportunity to learn about (a) demographics and

591 characteristics of the fishing industry sector of CCFRP (CFPV captains and crew), (b) how

592 demographics and characteristics compare by region within and among stakeholder groups, and

593 (c) whether CCFRP has had differential influence on MPA perceptions across stakeholder

594 groups. Bringing increased awareness of the human dimensions of stakeholders involved in

595 collaborative fisheries research can only serve to continue to build relationships, create buy-in on

596 management measures, and offer insights into areas of outreach that may need improvement.

597

598 **Conclusions**

599   Our survey highlights CCFRP as a model for incorporating citizen science into

600 collaborative fisheries research by capturing the realized benefits of collaborating with the

601 angling public. We have a clearer view of who CCFRP volunteers are as a group, and how

602 participation in the program has shaped their perspectives. CCFRP volunteers are older and have

603   a higher fishing avidity than the broader recreational angling community in California. Although

604   they represent a heterogeneous group in terms of experience with related industry sectors, their

605   perceptions of groundfish stock health and management are generally in agreement. Overall,

606   these volunteers have a positive view of the fisheries data collected for resource management and

607   the MPAs they help to monitor. This can be attributed, in part, to long-term participation in the

608   program. Most notably, a positive change in opinion on MPAs was more likely to occur only

609   after considerable time engaged with CCFRP (i.e. 7+ years). Future endeavors to develop new

610   citizen science partnerships with collaborative fisheries research programs, in which to achieve

611   similar benefits as CCFRP (e.g., building stewardship and advocacy), should focus not only on

612   recruiting as many volunteers as possible, but in retaining those volunteers for as long as

613   possible.

614

Acknowledgements

616   This manuscript is based on A. Kellum's Master of Advanced Studies (MAS) Capstone

617   Project at Scripps Institution of Oceanography, UC San Diego. E. Brazier assisted with survey

618   design and analysis. T. Courtney, L. Waterhouse, N. Rosen, A. Siddall, L. Bellquist, and L.

619   Oremland provided technical expertise and advice. The staff, captains, and crews of Central

620   Coast Sportfishing, Morro Bay Landing, Patriot Sportfishing, and Virg's Landing provided

621   research survey support to Cal Poly while those of Tigerfish Sportfishing, Huli Cat Sportfishing,

622   Kahuna Sportfishing, and J & M Sportfishing provided survey support to MLML. P. Smallhorn-

623   West and one anonymous reviewer provided comments that greatly enhanced the manuscript.

624   We are indebted to all the Central Coast CCFRP volunteer anglers, past and present, for their

625   dedication to CCFRP and to those respondents who took the time to participate in our survey.

626

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Figure 1

Marine Protected Areas in central California monitored by CCFRP between 2007 and 2016.

The base map shown, OpenStreetMap[®], is *open data*, licensed under the Open Data Commons Open Database License and released under a CC-BY-SA license. Esri, HERE, Garmin © OpenStreetMap contributors.

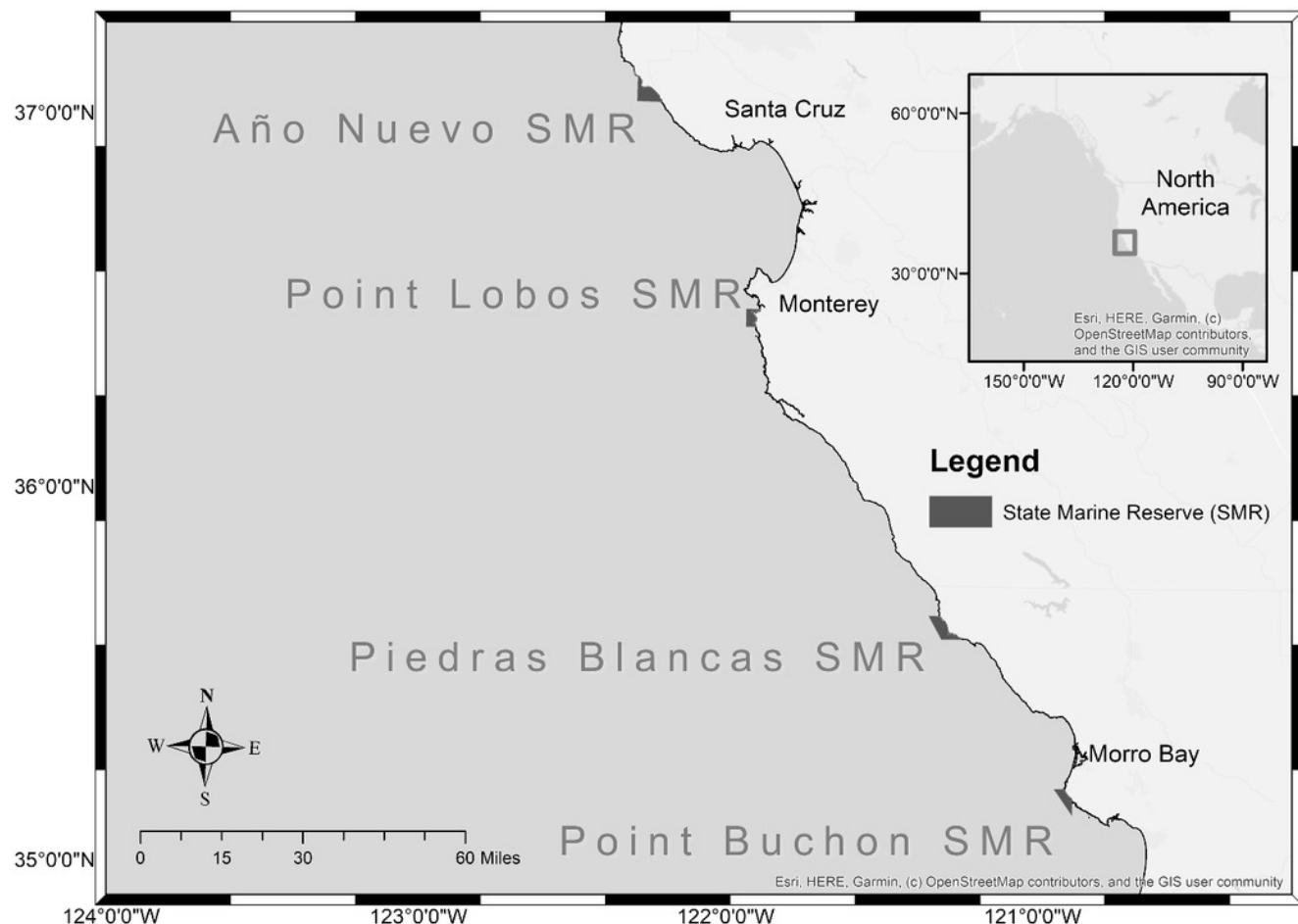



Figure 2

Comparison of CCFRP volunteer angler opinions on California groundfish health and management relative to volunteer related work experience.

(A) Percentage distribution of survey respondent opinions on the health of California groundfish stocks. (B) Percentage distribution of survey respondent opinions on California groundfish management. The distribution of angler responses (N = 102) is reported relative to their related work experience (fisheries management, fishing industry, no experience).

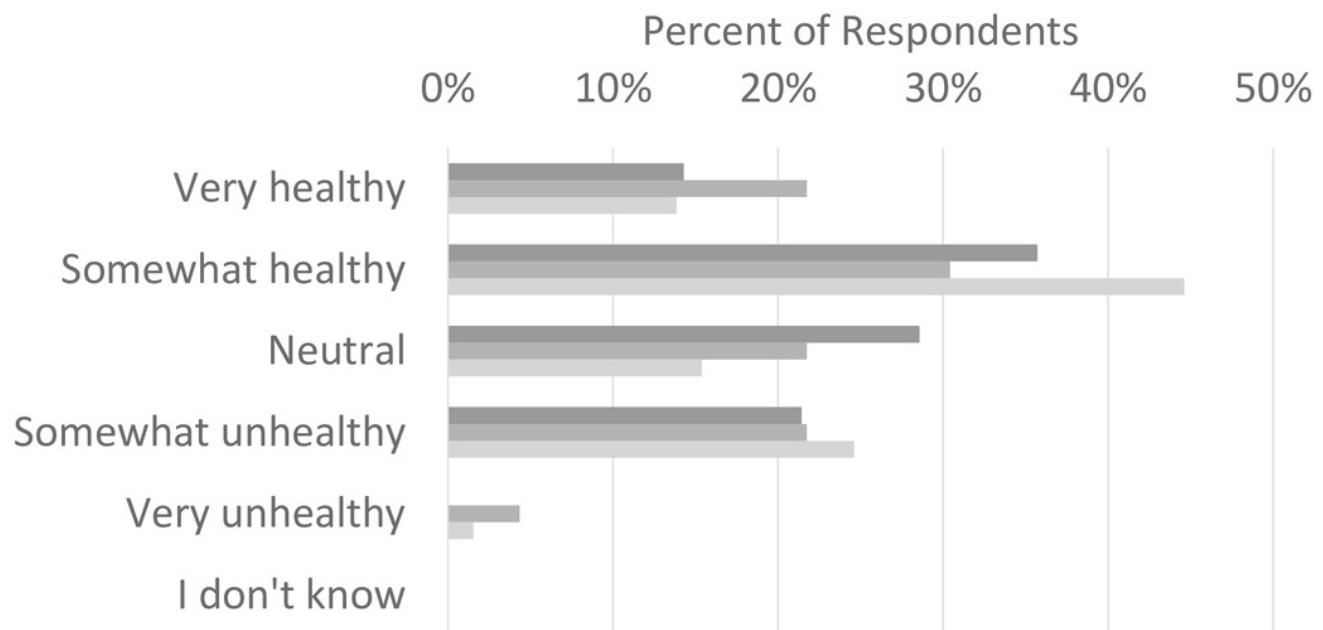
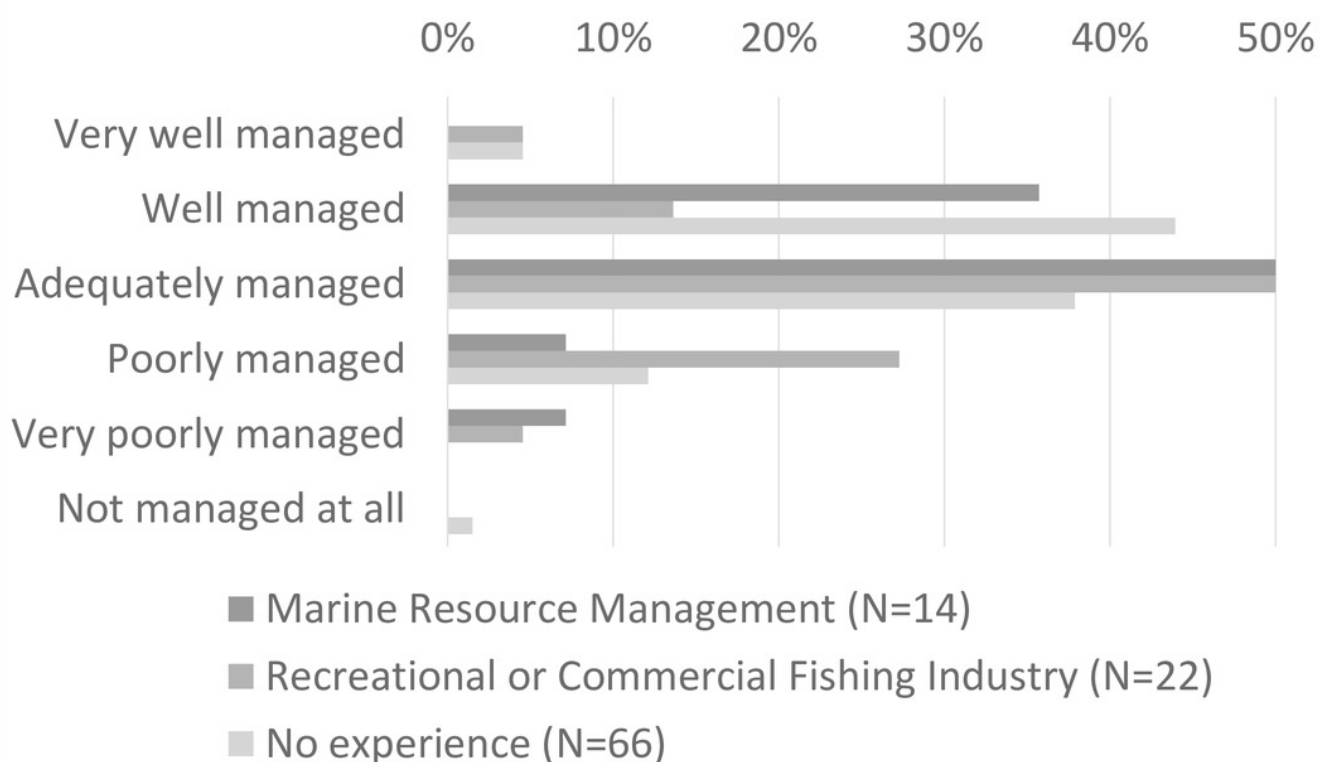



Figure 3

Comparison of CCFRP volunteer angler opinions on California groundfish management strategies relative to their related work experience.

(A) Percentage distribution of survey respondents who believe California groundfish management strategies to be "Effective". (B) Percentage distribution of those who believe them to be "Not effective". (C) Percentage distribution of those who responded "Not sure." The distribution of angler responses (N = 108) is reported relative to their related work experience (fisheries management, fishing industry, no experience).

A   *Effective*

■ Marine Resource Management (N=15)
■ Recreational or Commercial Fishing Industry (N=22)
■ No experience (N=71)

Percent of Respondents

B   *Not effective*

C   *Not sure*

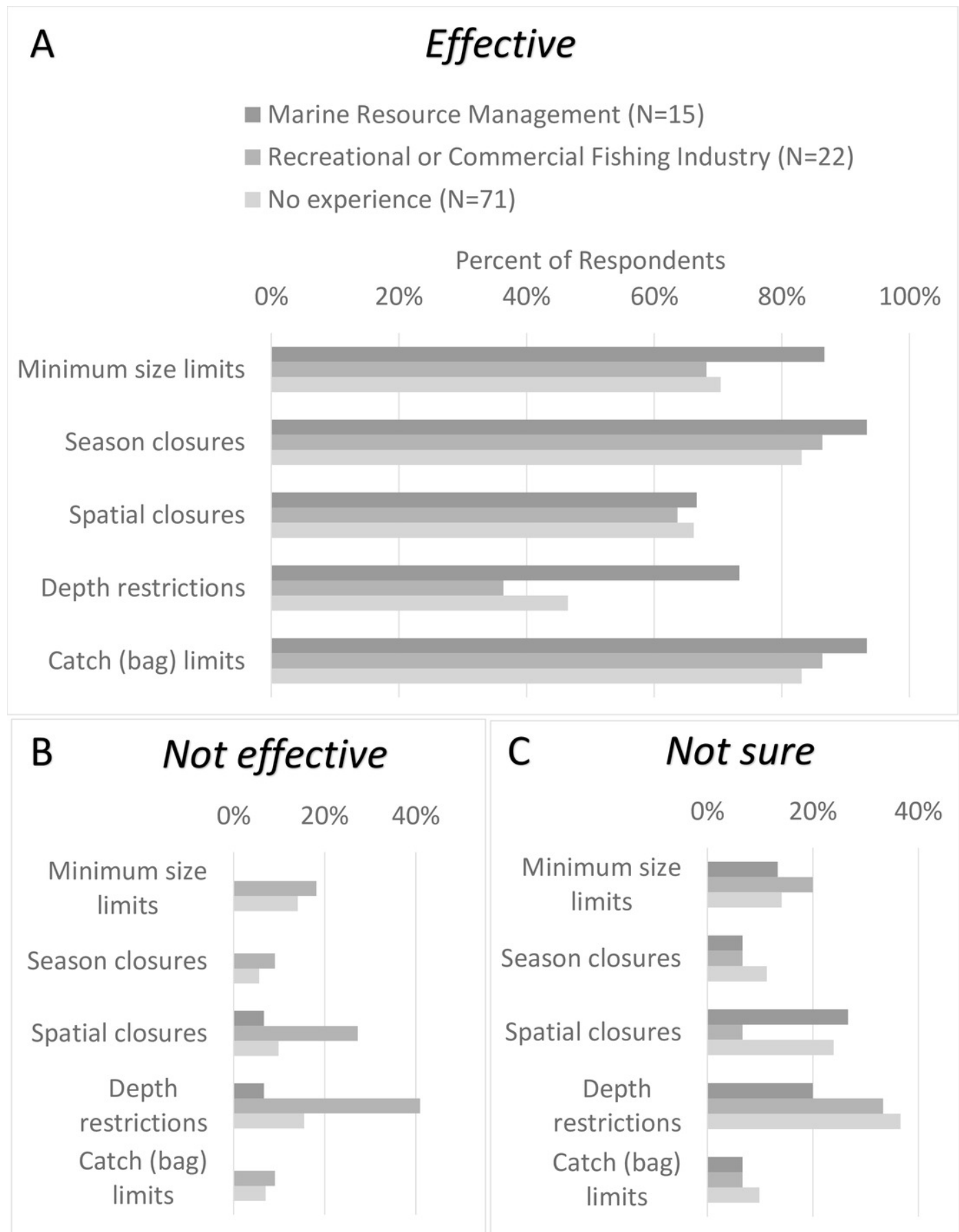



Figure 4

Volunteer angler motivations to join CCFRP and to continue volunteering with the program.

Percentage distribution of the reasons why survey respondents joined CCFRP and why they continue with the program (only showing responses of volunteers who plan to continue, N=102).

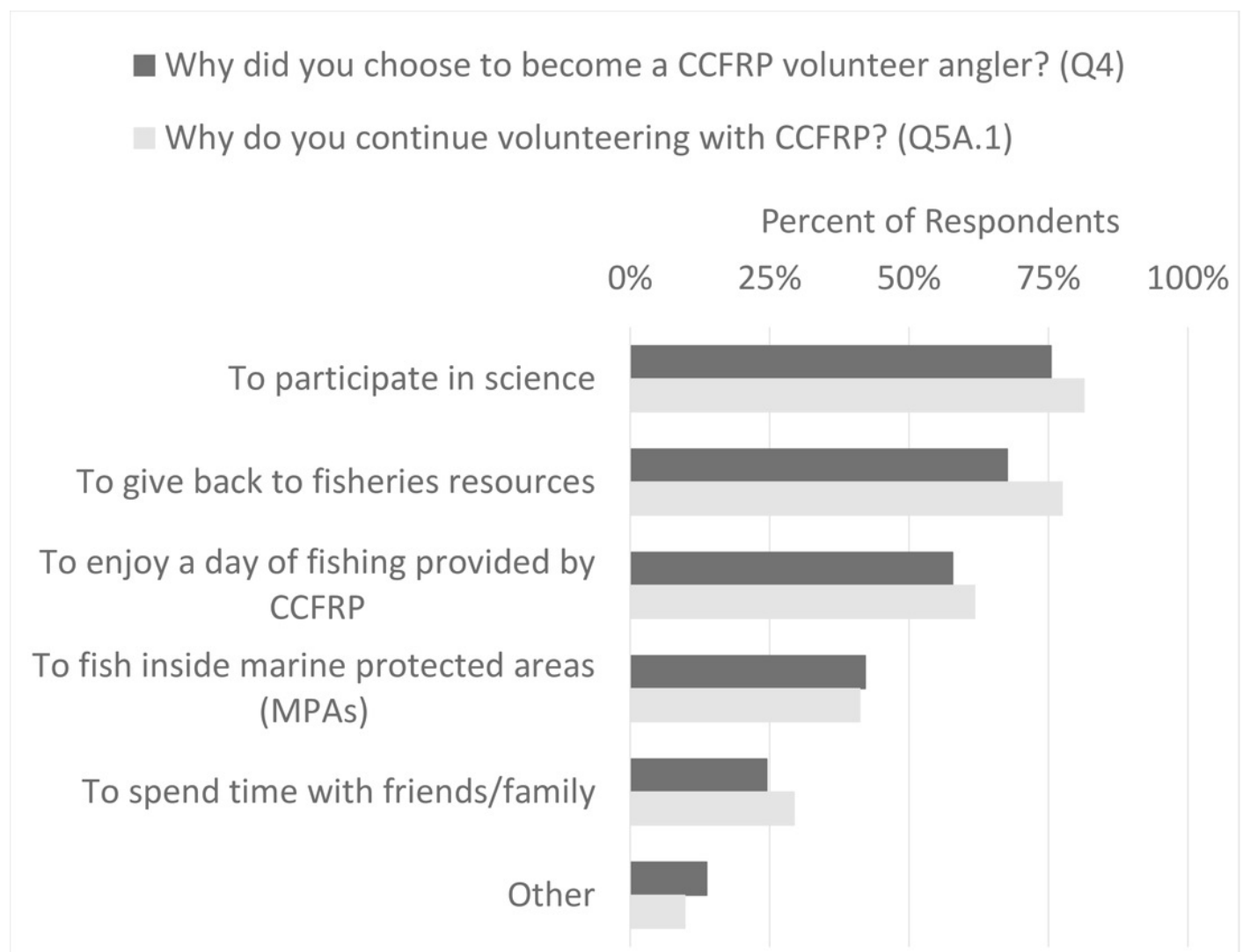



Figure 5

CCFRP volunteer angler opinion change on the quality of fisheries data.

Percent of CCFRP volunteer angler survey respondents (N = 110) who had no opinion on the quality of fisheries data used in resource management before becoming CCFRP volunteers, no change in opinion after volunteering with CCFRP, and either a positive or negative change in opinion after volunteering with CCFRP.

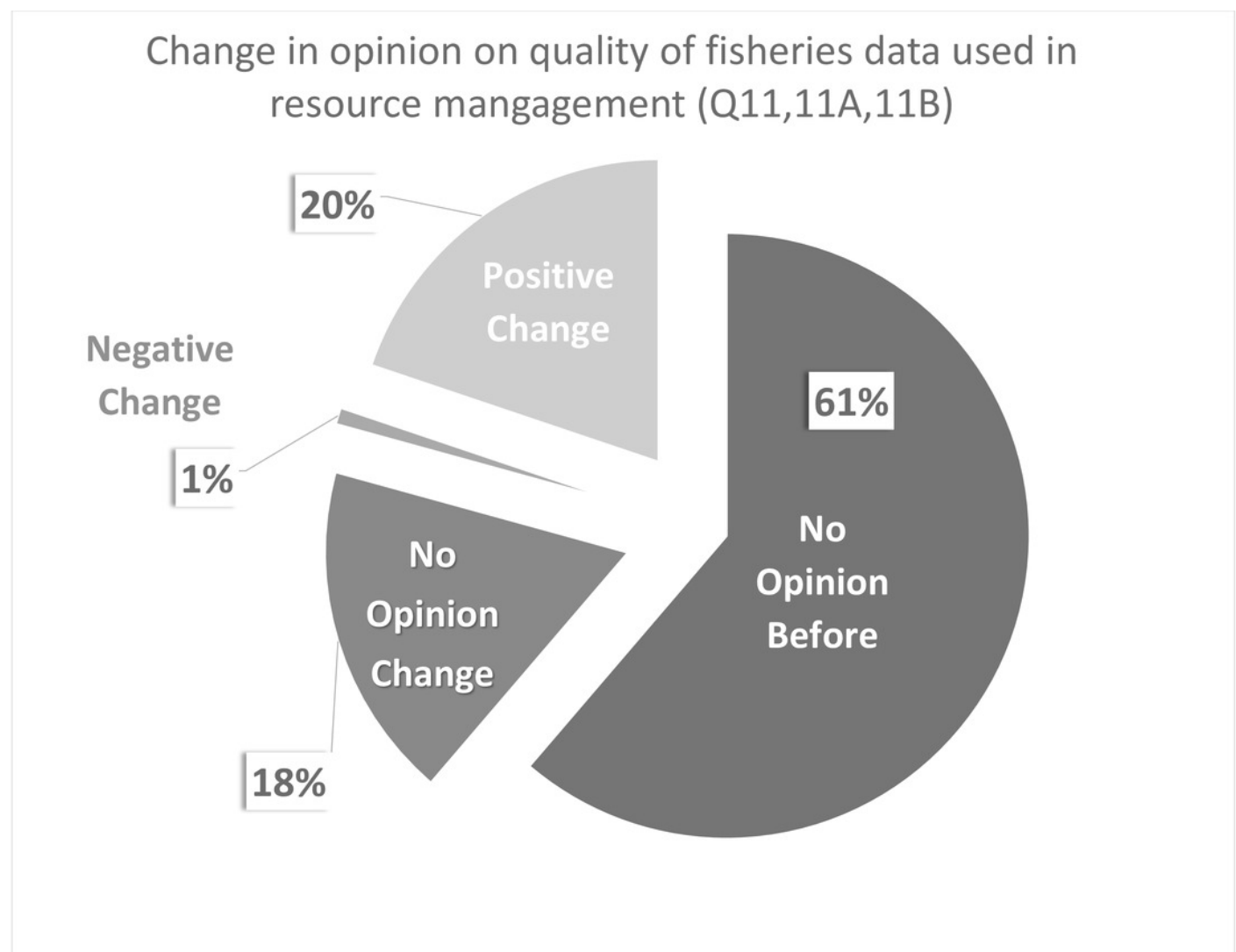



Figure 6

CCFRP volunteer angler opinions on MPAs.

(A) Percentage distribution of survey respondent opinions on MPAs before and after volunteering with CCFRP, N = 110. (B) Overall percent of survey respondents having a positive or negative change in opinion on MPAs after becoming CCFRP volunteers.

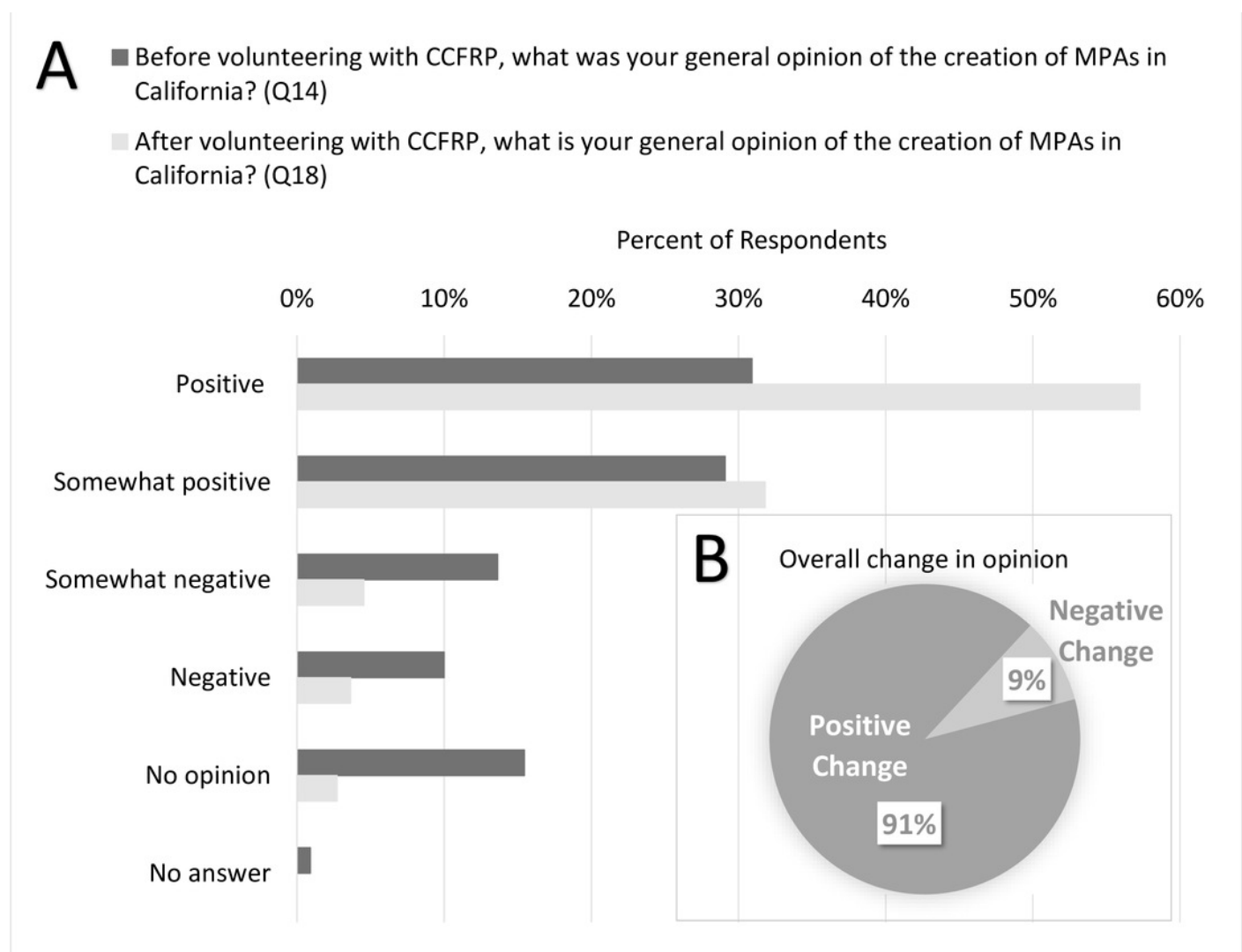
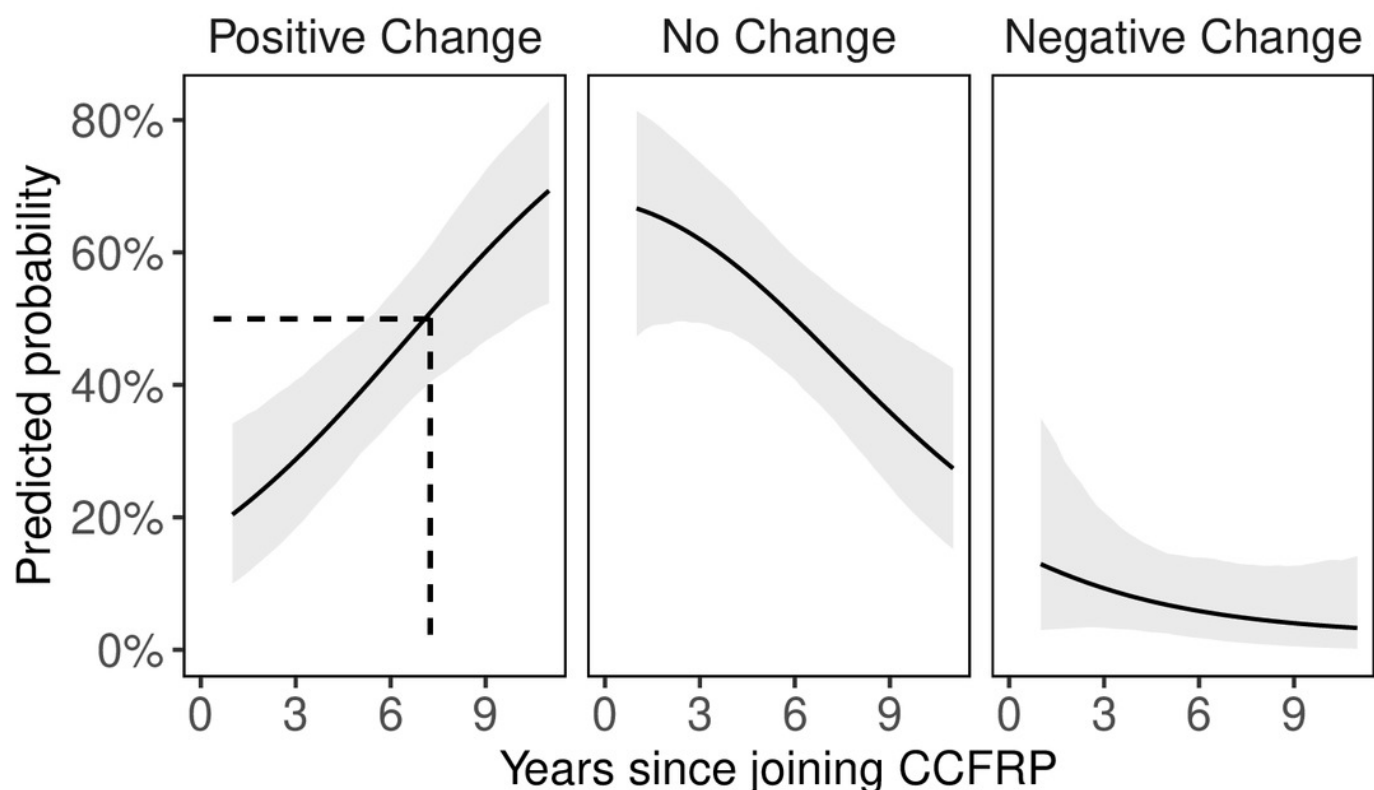



Figure 7

Predicted probability of CCFRP volunteer anglers having an opinion change on MPAs relative to time.

Predicted probability (± 95% CIs) of a CCFRP volunteer angler having a positive change in opinion, no change in opinion, and negative change in opinion on MPAs relative to the length of time (years) since joining CCFRP. The dashed line relates the length of time when the probability of having a positive change in opinion on MPAs becomes greater than or equal to 50% (= 7.25 years).

Demographics and characteristics of CCFRP volunteer angler survey respondents.

Category	Number of Respondents	Percent of Respondents
Age		
18-24	3	3%
25-34	16	15%
35-44	11	10%
45-54	17	15%
55-64	19	17%
65-74	35	32%
75+	9	8%
Gender		
Male	95	86%
Female	13	12%
Prefer not to state	2	2%
Angler avidity[a]		
Low	27	25%
Medium	44	40%
High	38	35%
Participated in the MLPA planning process		
Yes	20	18%
No	90	82%
Conservation Mindedness[b]		
More	77	70%
Similar	27	25%
Less	1	1%
Related work experience[c]		
Recreational fishing only	12	11%
Commercial fishing only	3	3%
Marine resource management only	11	10%
Management and Commercial	0	-
Management and Recreational	2	2%
Recreational and Commercial	7	6%
All three	2	2%
None	71	65%
Fished and sampled at CCFRP sites before and after MPA creation		
Yes	36	33%
No	74	67%
Total	110	100%

[a] The 1 respondent who did not answer this question was not included.
[b] The 5 respondents who did not answer this question were not included.
[c] The 2 respondents who had incomplete answers for these questions were not included.

Likelihood ratio tests of the binomial logistic regression model of change in opinion on the data quality used in resource management relative to measures of volunteer angler participation with CCFRP.

Predictors	Likelihood Ratio Tests		
	Chi-Square	df	p
Length of time since joining CCFRP	0.320	1	0.572
Number of Volunteer Appreciation and Data Workshops attended	0.713	1	0.340
Number of sampling trips with CCFRP	0.000	1	0.977

Likelihood ratio tests of the multinomial logistic regression model of change in opinion on MPAs relative to measures of volunteer angler participation with CCFRP.

Italics denote significant p-values.

Predictors	Likelihood Ratio Tests		
	Chi-Square	df	p
Length of time since joining CCFRP	12.8658	2	*0.002*
Number of Volunteer Appreciation and Data Workshops attended	0.951	2	0.622
Number of sampling trips with CCFRP	0.124	2	0.940

Distribution of CCFRP volunteer angler survey respondents by angler demographic within each MPA opinion change category.

2   .

Category	Positive change (N=51)	No change (N=53)	Negative change (N=5)
Age			
18-24	-	6%	-
25-34	14%	15%	20%
35-44	6%	11%	20%
45-54	12%	21%	-
55-64	18%	19%	-
65-74	41%	23%	40%
75+	10%	6%	20%
Angler avidity [a]			
Low	24%	26%	20%
Medium	41%	36%	60%
High	35%	38%	20%
Conservation Mindedness [b]			
More	63%	77%	60%
Similar	29%	21%	20%
Less	2%	-	-
Related work experience [c]			
Recreational fishing only	6%	15%	20%
Commercial fishing only	6%	-	-
Recreational and Commercial	12%	2%	-
Marine resource management only	14%	8%	-
Management and Recreational	-	4%	-
All three	-	4%	-
None	63%	66%	60%

[a] The 1 respondent who did not answer this question was not included.
[b] The 5 respondents who did not answer this question were not included.
[c] The 2 respondents who had incomplete answers for these questions were not included.