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Fishermen's perspectives on climate variability ☆

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ABSTRACT

Understanding fishermen's perspectives and responses relating to climate variability is important for sustainable fisheries management. To this end, a survey of captains of commercial passenger fishing vessels (CPFVs) was conducted in San Diego. The survey demonstrates that fishermen have observed and adapted to changes in the environment and fish populations associated with climate variability. However, only 12.9% of respondents agreed that global climate change is a possibility. In order to explain fishermen's divergent beliefs on climate change, a semiparametric discrete choice model is used to identify the potential determinants. The empirical results highlight the importance of the following factors: fishermen's experience, observations of the phenomena that are associated with climate variability, and an interaction of fishermen's experience and their observations.

1. Introduction

Climate variability – short-term pulses, decadal-scale regime shifts, and long-term presses – is a constant challenge to sustainable fisheries management because of its profound effect on fish population and the fisheries [1]. It affects the spatial and temporal distribution, patterns of migration, reproduction and recruitment of economically important species [2–5]. In particular, prolonged warming caused by global climate change could exacerbate or ameliorate extinction threats, lead to user group conflicts, and strain international agreements about shared fish stocks [6]. Realizing the importance of the dynamics of climate variability, fisheries managers have already incorporated climate indices into managing marine resources such as the sardine fishery in California [7].

In order to improve fisheries management in a changing environment, fisheries managers not only require the knowledge of the exogenous shocks to the ecosystem such as climate change but also need to understand the endogenous changes such as fishermen's responses to climate variability [8]. Fisheries usually are embedded in highly dynamic ecosystems, which poses additional difficulties for the science community to provide accurate scientific data regarding the health of the California fisheries. Therefore, the question that arises is whether fishermen have perceived and responded to climate variability. Furthermore, it is also a concern whether fishermen accept the scientific consensus of global climate change. This is an important issue because their perspectives could impact their interaction with other interest groups, and consequently the institutions that manage the resource.

Fishermen's opinions on climate variability were investigated by our face-to-face interviews with fishing vessel captains. This approach is aligned with the convention in the academic literature that elicits public's views on climate change through survey methods. This research contributes to the literature by targeting a special group of fishermen, captains of the commercial passenger fishing vessels (CPFVs) in San Diego.[1] The reasons for choosing this survey population include: (1) fishermen can be substantially impacted by changes in climate and ocean conditions, (2) compared with the general public, fishermen have a deeper knowledge of climate variability, and (3) the commercial passenger fishing fleet is a small and homogeneous community, which enables our survey to reveal a relatively complete picture of this group with a limited budget.

The survey demonstrates that the respondents have observed changes in the environment and fish populations associated with climate variability. They adapted to these changes by targeting different species and fishing on different grounds. However, only 12.9% of respondents unambiguously agreed that climate change is a possibility. This is of particular interest since our finding is substantially different from those of surveys targeting the general public. A large majority of the American public is convinced that

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[1] CPFVs are also referred to as "for hire" industry or charter/party boat operators.

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global warming is happening (71%)—almost the exact opposite findings of the survey of the California CPFV captains.[2] The conclusion that fishermen are much less likely to believe in climate change might be due to the fact they are more exposed to the cyclical nature of climate variability than the general public. Their observations of periodic changes in temperature at various scales could confound their beliefs in a warming trend.

Our respondents are subject to the same pattern of variability, but why do they form divergent perspectives on climate change? To address this question, econometric models are used to identify potential determinants. A fisherman's belief in climate change can be described by a binary discrete choice model. Because the dependent variable is clustered at zero (disbelief in climate change), the parameter estimates and statistical inference are sensitive to model specifications [9,10]. In order to avoid mis-specifications, a semiparametric maximum likelihood estimator is used, which does not make assumptions on the probability distribution [11]. The empirical results show that the difference in fishermen's beliefs can be explained by the following factors: (1) fishermen's experience is an important determinant, (2) fishermen have different observations of phenomena that are associated with climate variability, and (3) the interpretation of these observations is dependent on experience. The robustness checks demonstrate that the semiparametric model and two parametric models predict the same signs on the marginal effects; however, their magnitudes differ substantially.

The rest of this paper is structured as follows: Section 2 describes the background of commercial passenger fishing vessels in San Diego and the data from the survey; Section 3 discusses the empirical strategy; Section 4 presents estimation results and discusses the significance of the results; and Section 5 concludes.

2. Background and data

The target population of this survey is the captains of commercial passenger fishing vessels in San Diego. The face-to-face interviews were implemented from April to July 2010. The survey was administered in three steps. First, a draft survey was developed and a focus group with CPFV captains, fisheries researchers, and fisheries managers was tested. According to the feedback from the focus group, the questionnaire was revised and then a limited pretest on site was conducted. With the information in the second round, the questionnaire was further revised and the final version was applied to CPFV captains at various fish landings. It took a captain about 15–20 min to complete a survey.

As for the population size, there were 106 CPFVs in San Diego as of 2009.[3] Seventy vessels were randomly selected from the population and approached one captain for each vessel. In the end, 62 captains accepted our interviews and all responses are effective. Most data were collected from two locations in San Diego: (1) Mission Bay Seaforth Sportfishing; and (2) multiple landings in Point Loma including H&M Landing, Fisherman's Landing, and Point Loma Sportfishing. Fig. 1 illustrates the location of our survey. In the following subsections, the background information and the data collected in the survey are presented.

2.1. Climate variability and commercial sport fishing

Our study is confined to the San Diego area because its concentration of commercial passenger fishing vessels is substantially higher than anywhere else in Southern California. This facilitated our surveying efforts. The target fishing grounds for San Diego CPFV fishermen typically lie south of San Clemente Island (33°N) extending southward up to 1000 mile into Mexican waters (18°N and 118°W). The fishing grounds are illustrated in Fig. 1. CPFVs that lie north of San Diego generally target different fishing grounds.

In the survey, captains are asked about their target species in the past decades if they had fished during those decades and still remembered the targeted species. All participants provided answers to this question. The number of fishermen and the shares of target species in each decade since 1970s are depicted in Fig. 2. Note that a fisherman can report multiple target species. Therefore, the *y*-axis represents the percentage of fishermen who identified a particular species as their target fish. Overall, albacore tuna and yellowtail are the most popular target species. Tuna species including bluefin, yellowfin, and bigeye are also the favored targets. Other main target species include barracuda, bass, bonito, dorado, and rockfish. The relative shares of target species are fairly stable over time, except that bluefin and yellowfin have gained significant popularity.

Although fishermen's targeted fish did not change significantly over the last four decades, they did respond to cyclical climate conditions by fishing different species as is shown in Fig. 3. El Niño and La Niña are associated with physical and biological changes in the ocean that affect fish abundance. As a result, in El Niño years, fishermen's primary targets include yellowfin, dorado, and yellowtail. While in La Niña years, albacore and bluefin become the primary targets. The alternate warming and cooling conditions illustrate the impact of climate on fisheries as well as fishermen's adaptations. In addition, the short-term events also shed light on the long-term changes such as global warming [12]. Fishermen's spontaneous adaptations to climate variability might help to reduce the cost of climate change to some degree.

The equipment and tools for catching fish proved homogeneous. The use of sonar, fathometers, water temperature gauges, binoculars, and electronic charts is standard throughout the fleet of charter vessels. Furthermore, captains use a host of Internet services to guide their fishing efforts. Websites such as Terrafin.com and Tempbreak.com provide seemingly reliable and easy access to satellite imagery of computer-enhanced sea surface temperature (SST), auxiliary chlorophyll concentration data, and the cleanliness of water. These bits of information are collected before fishing trips to determine ideal locations to find schools of the targeted fish.

Fishermen pay close attention to weather conditions for a couple reasons. First, environmental variability caused by climate dynamics determines the distribution, migration, and abundance of fish population. Second, captains rely on the SST to identify locations where temperature breaks are present. A temperature break is characterized by a distinct change in water temperature, which demarks a so-called "hard edge." This is where the cold water meets the warm. Fishermen identify the hard edge as optimal conditions in which to locate the target fish. Finally, weather at sea affects fishing amenity, which results in more or less customers for charter boats.

2.2. Key variables

The primary goal of the survey is to elicit fishermen's opinions about climate change. After introducing the definition of global warming, the respondent was asked: "do you think global

[2] American Opinions on Global Warming: Summary (A Yale University/Gallup/ClearVision Institute Poll) http://environment.yale.edu/news/5310. Retrieved on August 25, 2010. Other studies found similar numbers, for example, the Global Warming Poll by Stanford University researchers found 74% Americans think global warming probably has been happening. http://woods.stanford.edu/docs/surveys/Global-Warming-Survey-Selected-Results-June2010.pdf. Retrieved on August 25, 2010.

[3] Annual Report of Statewide Fish Landings by the Commercial Passenger Fishing Vessel Fleet, Department of Fish and Game, State of California. http://www.dfg.ca.gov/marine/landings09/cpfv1.pdf. Retrieved on September 15, 2010.

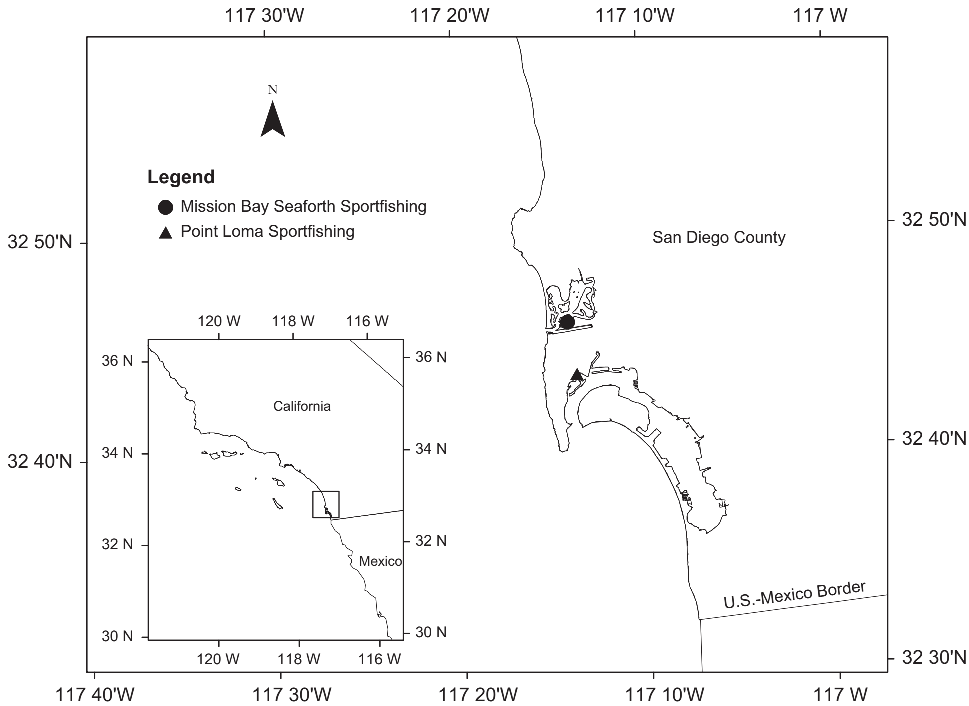

Fig. 1. Survey locations.

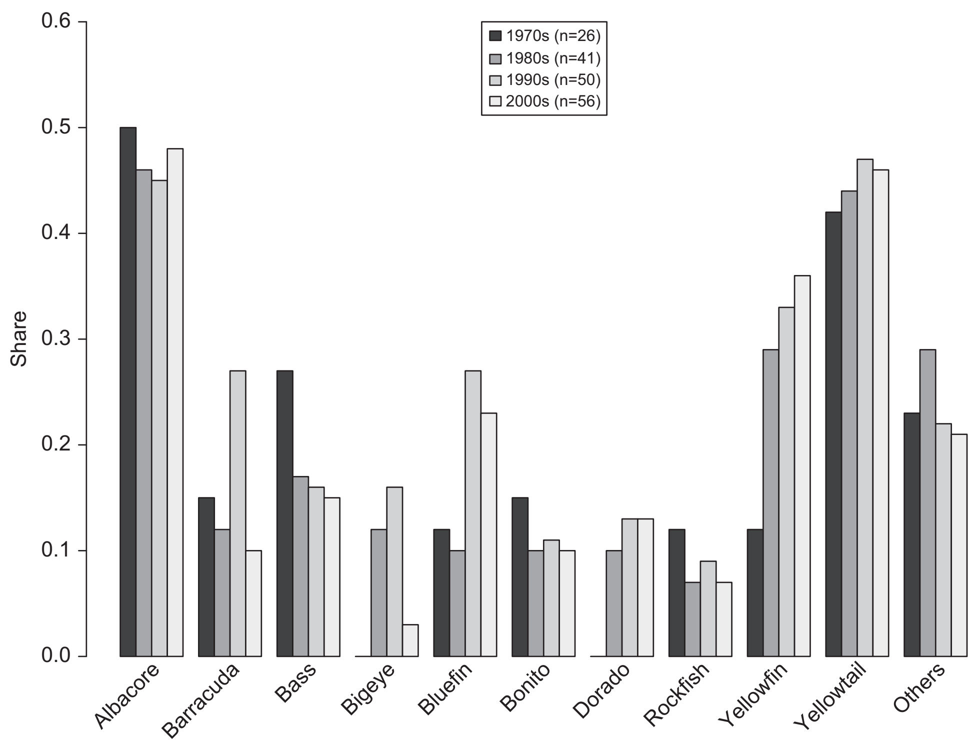

Fig. 2. Shares of target species during 1970–2000s.

warming is a possibility?"[4] To distinguish from cyclical climate patterns, our interviewer stressed that global warming is the upward trend in the average global temperature. The survey reveals that 12.9% of respondents unambiguously agreed that global warming is a possibility while other respondents were doubters or disbelievers. Many captains that responded to the question claimed with great conviction that the temperature change is cyclical.

The result that an extreme low percentage of respondents believe in climate change could be due to fishermen's deeply embedded perceptions about cyclical patterns of climate

[4] Climate change, global climate change, and global warming are used interchangeably. The choice of word does not affect public perceptions in most cases [13].

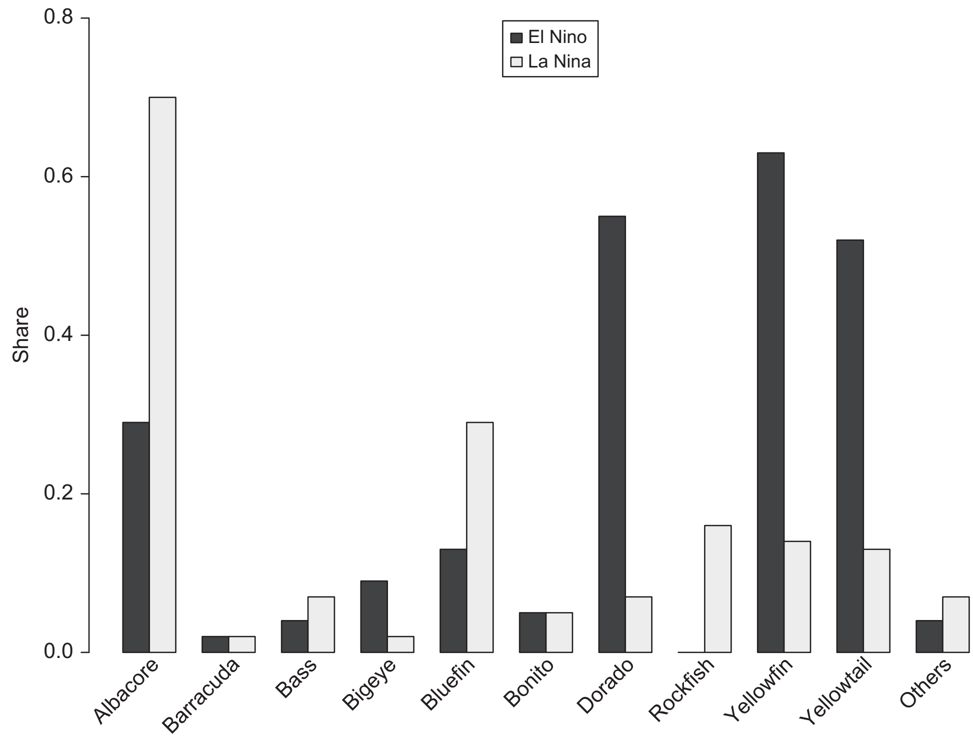

Fig. 3. Fishermen change target species under El Niño or La Niña.

variability. Besides intra-annual seasonality, science has demonstrated that there are patterns of Pacific climate variability that shifts phases on at various time scale: (1) El Niño/La Niña-Southern Oscillation (ENSO) causes quasi-periodic warming or cooling every 5 years on average [14]; and (2) the Pacific Decadal Oscillation (PDO) displays a long-lived pattern usually about 20 years [15]. Adding to the complexities of the periodicities, there is a global warming trend. The co-existence of cycles and trends may confuse fishermen, and thus disguise the overriding warming trend—the fishermen mistake the periodicities for global warming.

It is a concern whether fishing in warm-water conditions or El Niño years makes a fisherman better or worse off. About 72.5% of respondents think that warm weather makes them better off, and thus preferred the corresponding warm-water targeted species including yellowfin, dorado, and yellowtail. In addition, customers seem more hyped about fishing the target species during El Niño years. The other respondents claimed to be worse off during El Niño because it brings "stagnant sterile water" and the southern latitudes become too warm. What is more, the cold currents are good because they bring nutrient rich waters and the fishing is more consistent and the fish are bigger. Note that this conclusion is drawn from the CPFV captains in San Diego. It cannot be generalized to other fisheries because of the differences in climate variability, species, and locations.

Warming could affect the population and distribution of exotic warm-water species. These species are likely to expand to habitats that used to support cold or cool-water species [2]. If a fisherman observes an increasing trend of warm-water species, he might contribute it global warming. It is found that 40% of respondents claimed no increase in exotics, while the remaining 60% claimed that there has been an increase in exotics. This result shows that fishermen's observations of increasing warm-water species are pretty evenly distributed.

Based on the type of fishing trips, the CPFV industry is divided into two sub-categories: short-range trips (less than 1 day) and long-range trips (overnight, greater than 1 day). By this means, the fisheries are effectively differentiated by geographical size and target species. The short-range trips are constrained by the time allotted to reach the fishing grounds, limiting both the cruising radius and access to the offshore pelagic fishery. Resultantly, short-range half-day and three-quarter-day trips target the local fishery in La Jolla and the fisheries due south in Mexican waters. These local fisheries, especially in the kelp beds off the La Jolla coast, are home to barracuda, bass, bonito, rockfish, yellowtail, and occasionally tuna. On the contrary, the long-range trips, which vary from overnight to multi-day trips, are characterized by an expansive geographical scope and an explicit target species—namely, pelagic tuna. The target species include, but are not limited to, albacore, bigeye, bluefin, dorado, yellowfin, and yellowtail.

Respondents' individual information were also collected The average age is about 44 years old. The average length of working experience in fishing is 25 years. It shows that our respondents are mostly experienced fishermen. Individual attributes as well as observations of climate related phenomena will be used as explanatory variables for fishermen's beliefs in climate change. A summary of the statistics of the variables that are included in the regression analysis is reported in Table 1.

3. Empirical model

A discrete choice model is used to explain fishermen's divergent perceptions on climate change. Let i designate respondent, y designate a binary variable with one indicating that the respondent agrees with the assertion of climate change, x include all explanatory variables, and β is a vector of parameters to be estimated. Let F denote a cumulative distribution function (CDF). The probability of a respondent believing global warming is modeled by a single index function:

$$\Pr[y_i = 1 \,|\, x_i] = F(x_i'\beta)$$

Table 1
Summary statistics for the variables used in the regression.

Q1: Do you think global warming or climate change is a trend? (Y)		
	Yes (1): 12.9%	No (0): 87.1%
Q2: Age? (AGE)		
	Mean: 44	SD: 11
Q3: How long the fisher spends at sea and what is their potential radius? (RANGE)		
	>1 day trip (1): 82%	<1 day trip (0): 18%
Q4: Overall, are you better or worse off fishing in warm-water conditions? (WARM)		
	Better (1): 72.5%	Worse (0): 27.5%
Q5: How many years have you worked in fishing? (EXP)		
	Mean: 25	SD: 12
Q6: Have you seen any increase in exotic, warmer water species? (EXOTIC)		
	Yes (1): 40%	No (0): 60%

where

$$x_i'\beta = \beta_1 \mathrm{AGE}_i + \beta_2 \mathrm{AGE}_i^2 + \beta_3 \mathrm{RANGE}_i + \beta_4 \mathrm{WARM}_i + (\beta_5 + \beta_6 \mathrm{EXP}_i)\mathrm{EXOTIC}_i. \quad (1)$$

In this form, AGE is the respondent's age. A quadratic term is added to test the hypothesis that fishing captains might have different opinions in different periods.[5] RANGE designates the type of fishing trips. If the boat on which the respondent is working caters to trips longer than 1 day (long range), RANGE is one, otherwise it is zero. Different types of fishing trips involve different regions and species and consequently different information, which could affect a fisherman's perception on climate variability. WARM is a binary variable with one indicating that the respondent is better off fishing in warm-water conditions and zero otherwise. EXOTIC is also a binary variable with one indicating that there is an increase in exotic warm-water species. EXP is the number of years that the respondent has worked in fishing. The interaction term of EXP and EXOTIC assumes that a fisherman's experience might affect the use of information to form his beliefs.

With a random sample, the parameters of the single index model can be estimated by maximizing the following log likelihood function:

$$L = \sum_i \{y_i \log F(x_i'\beta) + (1-y_i) \log(1-F(x_i'\beta))\}. \quad (2)$$

The model can be identified under multiple specifications. The probit specification assumes a standard normal distribution which sets $F(x_i'\beta)=\Phi(x_i'\beta)$. The logit specification assumes a type-I extreme value distribution which sets $F(x_i'\beta)=\exp(x_i'\beta)/(1+\exp(x_i'\beta))$. Two models yield similar results if the conditional probability is not dominated by yes or no answers. However, for the event of low probability, the results could differ significantly for different specifications.

In our survey, the majority of the respondents do not believe in global warming. In this case, the choice of model specifications matters. In order to avoid misspecifications, the distributional assumptions on the CDF are avoided by using a flexible nonparametric estimate $\hat{F}()$ to replace $F()$ in Eq. (2). Because $\hat{F}()$ is completely unknown, β can only be identified up to a constant of proportionality. Since AGE is a continuous variable and its coefficient is nonzero (evidenced by the parametric models), β_1 is restricted to one for identification purposes. The transformed index becomes

$$x_i'\theta = \mathrm{AGE}_i + \theta_1 \mathrm{AGE}_i^2 + \theta_2 \mathrm{RANGE}_i + \theta_3 \mathrm{WARM}_i + (\theta_4 + \theta_5 \mathrm{EXP}_i)\mathrm{EXOTIC}_i, \quad (3)$$

where θ is a linear function of β in the original model. The semiparametric binary outcome model can be estimated by maximum score estimation, maximum rank correlation estimator, or semiparametric maximum likelihood estimation [9–11]. The Klein–Spady semiparametric maximum likelihood estimator is employed because of its efficiency. The semiparametric estimator is computed by iterative methods which nests a nonparametric kernel estimate $\hat{F}()$ with a maximum likelihood routine:

$$L = \sum_i \pi_i \{y_i \log \hat{F}(x_i'\theta) + (1-y_i) \log(1-\hat{F}(x_i'\theta))\}. \quad (4)$$

In this form, π_i is a trimming function that assigns zero weight to the observations with $x_i'\theta$ close to the lower and upper bound. The unknown CDF can be estimated by the following leave-one-out Nadaraya–Watson estimator

$$\hat{F}(x_i'\theta) = \frac{\sum_{j\neq i} K((x_j-x_i)'\theta)/h)y_j}{\sum_{j\neq i} K((x_j-x_i)'\theta)/h)}. \quad (5)$$

The Klein–Spady estimator is fully efficient in the sense that it attains the semiparametric efficiency bound.

The parameter in the semiparametric model θ has no natural interpretations because it is a linear function of the original parameter β. However, once all parameters are estimated, the marginal effects can be derived, which measure how the change in the response probability as a function of a change in explanatory variables. In order to compare the marginal effects predicted by three model specifications, the average partial effect (APE) for a continuous or discrete explanatory variable x_k is derived by

$$\frac{\Delta \Pr[y=1|x]}{\Delta x_k} = \frac{1}{n}\sum_{i=1}^{n} \frac{\Delta F(x_i'\hat{\beta})}{\Delta x_k}. \quad (6)$$

Note that $\Delta F(x_i'\hat{\beta})/\Delta x_k$ denotes a difference if x_k is discrete and a derivative if x_k is continuous. The partial derivative functions for probit and logit models are straightforward. For the semiparametric model, the following formula is used to numerically approximate the derivative:

$$\hat{F}'(x'\hat{\theta}) = \lim_{h\to 0} \frac{\hat{F}(x'\hat{\theta}+h) - \hat{F}(x'\hat{\theta}-h)}{2h}, \quad (7)$$

where $\hat{\theta}$ and $\hat{F}()$ have been estimated in the previous regression.

4. Results and discussion

Three econometric models are estimated to investigate fishermen's perspectives on climate change: two parametric models (logit and probit) and one semiparametric model. Examining the parameter estimates in Table 2, most parameters have statistically significant estimates. The semiparametric model produces quantitatively and even qualitatively different results from those of the parametric models. However, the difference should not be overstated because the parametric and semiparametric estimates are not directly comparable. The marginal effects should be used to predict how an explanatory variable affects opinions. The estimated average partial effects are reported in Table 3. It shows that the marginal effects only differ in magnitudes while they have the same signs. The results of the semiparametric model are preferred since it attains the minimum assumption on the functional form. The semiparametric model will be discussed in detail and other models are used as robustness checks.

The age of a particular fisherman is hypothesized the most significant indicator of whether or not he is more or less likely to

[5] Some surveys found that the young population tends to believe in global warming more than the older population. For example, see the survey conducted by the Pew Research Center for the People and the Press http://people-press.org/files/legacy-pdf/669.pdf and the one conducted by Cardiff University http://www.cf.ac.uk/psych/home2/docs/UnderstandingRiskFinalReport.pdf.

Table 2
Regression results: determinants that affect fishermen's belief on climate change.

	Logit	Probit	Semiparametric
AGE	−0.2548**	−0.1470**	
	(0.1132)	(0.0609)	
AGE^2	0.0048**	0.0028**	−0.0103***
	(0.0021)	(0.0011)	(0.0000)
RANGE	−3.7782**	−2.1426**	−0.4425***
	(1.6838)	(0.9162)	(0.1145)
WARM	0.7069	0.3305	0.0015
	(1.1487)	(0.6038)	(0.0898)
EXOTIC	5.7764*	3.4330**	0.3842*
	(2.9683)	(1.6301)	(0.2323)
EXP × EXOTIC	−0.1197	−0.0737*	0.0232**
	(0.0757)	(0.0413)	(0.0108)

The dependent variable is a binary variable with one indicating that the respondent believes that climate change is a trend. The total number of observations is 56. The coefficient of AGE for the semiparametric model is restricted to one for identification purposes. Standard errors in parentheses. Significance level: * 10%, ** 5%, and *** 1%.

Table 3
Average partial effects.

	Logit	Probit	Semiparametric
AGE	−0.0016	−0.0018	−0.0417
RANGE	−0.4342	−0.4256	−0.0725
WARM	0.0472	0.0407	0.0002
EXOTIC	0.1415	0.1377	0.0141

The average partial effects measure the impact of a change in an explanatory variable on the probability of believing climate change. AGE is continuous and other variables are discrete.

believe global warming. On the one hand, young fishermen might be more open to the emerging scientific consensus on climate change and hence more likely to accept that global warming is a trend. On the other hand, old fishermen have a better chance to observe multiple climate cycles and thus believe the temperature change is cyclical. If these hypotheses are true, the belief in climate change declines with growing age. The empirical result supports these hypotheses since the marginal effect of age is negative for all models. The estimated APE for the semiparametric model is −0.0417, which means that a 1-year increase in age reduces the probability of belief in global warming by 4.17% point. The logit and probit models predict the same sign but have a much smaller effect.

However, caution is needed to claim that senior fishermen are less likely to believe global warming. Note that a single cross-section of data is used to construct a "synthetic cohort," which assumes what a senior fisherman believes at a point in time can proxy for what a younger fisherman at that time might believe when they are old. This approach might be problematic if junior and senior fishermen's beliefs do not evolve in the same manner. When a senior fisherman started his fishing career decades ago, there were not a lot of discussions on the impact of climate change on fisheries. On the contrary, when a younger fisherman started his fishing career, there has been ample scientific evidence and public campaigns. The difference of information in their early career stages could affect their perceptions of climate change. If this holds true, the synthetic cohort approach cannot capture a fisherman's belief in his life cycle.

The type of fishing trips RANGE might also affect a fisherman's perspective. The rationale is that fishermen with different trip types receive distinct information because they fish in different locations and target different species. Therefore, their perceptions of climate variability may differ, which induces them to form divergent beliefs about climate change. However, there is no prior knowledge about the direction of this effect. The semiparametric model shows that a long-range fisherman (RANGE=1) is less likely to believe global warming than a short-range fisherman, other things being equal. The difference in probability is around 7.25% points. Two parametric models reach similar conclusions but with greater estimated marginal effects.

A vast majority of respondents prefer fishing in warm-water conditions (WARM=1). It is thus natural to question if their preferences will affect their answers. That is, whether a fisherman who prefers warm-water conditions is more likely to be a believer in global warming. The hypothesis is that a fisherman is willing to believe global warming because it makes him better off. There may be another hypothesis. The fishermen who evaluate the long-run effects of El Niño tended to be more sophisticated. This is because they knew that whatever short-term benefits El Niño brings in increased yellowfin, the long-term effects negatively impact the health of kelp beds. Therefore, the more sophisticated fishermen may also be believers of climate change whereas those who prefer El Niño would not believe in climate change. The regression reveals a positive relationship; however, all estimates in three models are not statistically significant from zero. Therefore, fishermen's preferences have no effect on their beliefs in climate change.

If a fisherman observes a trend of increasing exotic warm-water species (EXOTIC=1) during his fishing career, he might attribute it to global warming. Thus, it is expected that EXOTIC has a positive effect. However, how observations translate into beliefs hinges on a fisherman's experience. On the one hand, as a fisherman gains more experience working in the local fisheries, the more aware they become of the cyclical nature of the environment that is manifested through climatic phenomena such as El Niño and La Niña, as well as variations in pelagic fish landings. If this is true, more experienced fishermen are less likely to attribute increasing exotic species to global warming. On the other hand, the fisherman with a long fishing career is more certain to tell if the observed phenomenon is a trend or a cycle. In this case, experience will enhance the effect of EXOTIC. The estimated marginal effect of EXOTIC is a net effect. The empirical result shows that the fisherman that observed an increase in exotic species is 1.41% point more likely to believe global warming than those who did not observe the trend. Parametric models predict the same results but the effect is greater in magnitude.

The regression analysis has identified how fishermen's observations and experience affect their beliefs in climate change. However, there are caveats in the current study. Although the face-to-face interviews enable us to collect more accurate information, its cost is significantly higher than a mail or telephone survey. As a result of the budget constraint, the sample size is fairly small. It is expected that a larger sample size might lead to more convincing results. In addition, our survey population is a relatively homogeneous group with little variations in personal attributes. The advantage is that this group can be investigated exhaustively with a relative small sample size. While it is cost saving, this sampling strategy may not be informative about the opinions of fishermen in other fisheries. The problem becomes pronounced only if the conclusion is generalized to a larger population, which is clearly not the goal of this paper.

5. Conclusion

Fishermen's perspectives, preferences, and adaptations in response to climate variability are investigated by surveying captains of the commercial passenger fishing vessels in San Diego. Our respondents observed changes in fishing conditions relating to climate variability such as ocean temperature and fish species. They adapted to these changes by fishing in different zones and targeting different species. However, fishermen are divided in their belief about whether these changes are the result of warming trend or merely cyclical temperature variations. As a result, only 12.9% of respondents believe that global warming is a possibility while the remainder believe that the temperature change is cyclical. Of the determinants that affect a fisherman's belief, age and working on a long-range boat have negative effects, while observing more exotic species and preferring fishing in warm conditions have positive effects.

This study conjectures that the cyclical climatic phenomena such as El Niño and La Niña might influence fishermen's perceptions of climate change. If a long-run trend co-exists with periodic climate variability, it might be difficult to distinguish the trend from the cycles. Therefore, fishermen that are subject to substantial climatic cycles might be less likely to believe a warming trend. Unfortunately, our data cannot quantify this impact because our survey population is subject to the same climatic conditions. It might be interesting to survey fishermen in different locations with heterogeneous climate patterns. The effect of climatic cycles on the beliefs in climate change can then be identified by a cross-site analysis. This is left for future studies.

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