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Conservation of vaquita marina in the Northern Gulf of California

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ABSTRACT

Vaquita marina, a small species of porpoise endemic to the Northern Gulf of California in Mexico, is the world's most endangered cetacean species. With the purpose of preserving vaquita, the Mexican government launched PACE-Vaquita in 2008. This voluntary program offers an innovative schedule of compensations: as in a payment-for-conservation program, PACE-Vaquita compensates for temporary reductions in fishing effort; as in a program to accelerate technology adoption, PACE-Vaquita compensates for switching to vaquita-safe fishing methods; and as in a buyback program, PACE-Vaquita compensates fishermen for a permanent exit from fisheries. This paper seeks the factors explaining fishermen's participation in PACE-Vaquita during its first year of operation. Analysis is carried out through a multinomial logit specification on a data set collected one week after the enrollment deadline. This paper shows that fishermen with skills in alternative economic activities more likely quit fishing, and fishermen with relatively less productive vessels more likely switched to vaquita-safe fishing methods. Discussion of public policy implications is provided.

1. Introduction

Marine mammals are threatened to extinction by fisheries all around the world. A non-exhaustive list of the most endangered marine mammals includes the Mediterranean monk seal in northwestern Africa; the North Atlantic right whales; the Burmeister's porpoises in Peru; and the vaquita marina in Mexico [1]. Despite recognition of this problem since the 1980s, little governmental efforts have been made to implement conservation measures [2]. The seriousness of this threat became evident when the Baiji, a fresh water dolphin endemic to the Yangtze River in China, was declared functionally extinct in 2007 [3]. After the Baiji's extinction, vaquita marina became the world's most critically endangered cetacean species [4].

PACE-Vaquita represents the first worldwide governmental effort to prevent a marine mammal's extinction. This program was launched by the Mexican government in 2008. PACE-Vaquita seeks to preserve vaquita marina by compensating fishermen for voluntarily switching to vaquita-safe fishing methods, or temporarily reducing fishing effort, or permanently quitting fishing. After 3 years of operation, the Mexican Minister of Environment has announced that vaquita is on the path to recovery [5].[2] Arguably, this promising declaration will encourage other governments with a similar problem to follow suit. Thus public policy makers will benefit from understanding the factors driving voluntary participation in PACE-Vaquita. This paper seeks factors driving fishermen enrollment in PACE-Vaquita during its first year of operation.

1.1. Vaquita marina

Vaquita marina (*Phocoena sinus*) is a small species of porpoise, endemic to the Northern Gulf of California, Mexico [7]. Currently, the main threat to vaquita comes from artisanal fisheries, in the form of incidental mortality. During the 1940s, vaquita was caught in the artisanal gillnet fishery for totoaba and shark and in the commercial trawl fishery for shrimp [8]. As the totoaba resources declined in the late 1940s, shrimp trawlers overtook totoaba gillnets in economic importance. Then artisanal gillnetting and commercial trawling for shrimp became the biggest threats for vaquita [4]. During the 1980s, commercial trawling for shrimp faced a decline in catch rates and most fishermen turned to artisanal fisheries [9]. Since 1993 only artisanal boats are allowed to fish in the Biosphere Reserve of the Upper Gulf of

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[2] This declaration seems supported by the unusual sighting of nine vaquitas, including one newborn and three juveniles, in September 2011. Vaquitas are usually seen in groups of only two adult members [6].

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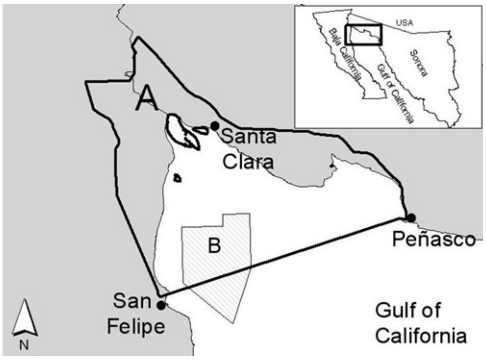

Fig. 1. Biosphere reserve of the Upper Gulf of California and delta of the Colorado River (A), and Vaquita refuge area (B).

California which comprises around 85% of vaquita's known habitat (see Fig. 1). In 2007, the total number of artisanal boats with gillnets was 2070—41% in San Felipe, 32% in Peñasco, and 27% in Santa Clara [10].

According to the Convention on International Trade in Endangered Species, vaquita is listed as fully protected in Appendix 1 since 1979. In 1999, vaquita's population was estimated to be 567 [11], but estimated decline of 8.7% per year implies that only 150 vaquitas remained in 2007 [12]. Total annual catch is estimated in the range of 78–168 [13]. Comparisons of catch rate and population made experts call for immediate action in 2007 [12].

1.2. Socioeconomics in Northern Gulf of California

Artisanal fishermen from three villages – Peñasco, San Felipe and Santa Clara – constitute most of the fisheries in the Northern Gulf of California. Fishermen catch shrimp from mid-September to mid-February, and fin fish when the shrimp fishery is closed. Six major fin fish are caught: chano, curvina, golfina, manta, sierra, shark and guitarra.[3]

Most fishermen are members of cooperatives. By 2005,[4] only 22 out of 2440 permit-holder fishermen were not members of a cooperative [17]. Almost half of the cooperative members (48%) lived in Peñasco, 35% in San Felipe, and 17% in Santa Clara. By 2007, 40% of the 62 cooperatives were registered in Santa Clara, 31% in Peñasco, and 29% in San Felipe [10].

Access to credit and lower transaction costs are the two major advantages of being affiliated to a cooperative. Cooperatives facilitate access to credit by borrowing money and equipment from large buyers to finance loans for cooperative members.[5] Individual fisherman's future catch often serves as collateral [19]. Cooperative members face lower transaction costs because cooperative representatives have specialized knowledge of the bureaucratic nuances in obtaining fishing permits. Obtaining a fishing permit is difficult and time-consuming for independent fishermen [20].

Fishing permits are granted to each cooperative depending on the number of members and boats. Allocation of permits within cooperatives depends on the rules of each cooperative. Three types of cooperatives can be distinguished: regular cooperatives, family-owned cooperatives, and sole-owner cooperatives.[6] A sole-owner cooperative is the result of an owner of multiple boats registering his employees as cooperative members. Accordingly, the owner decides how to allocate the fishing permits. A family-owned cooperative is mostly integrated by fishermen with a family relationship. Allocation of permits is decided by family members even if non-relative fishermen are formally registered as cooperative members. In a regular cooperative, every member participates in the allocation process.

Around 63,000 people lived in the three villages by 2005—71% in Peñasco, 24% in San Felipe, and 5% in Santa Clara [17]. In two out of the three villages, tourism employs most of the working population. In Santa Clara, 50% of the working population was engaged in fishing, and 30% in tourism. In contrast, 59% (10%) and 64% (15%) worked in tourism (fishing) in Peñasco and San Felipe, respectively. However, experts' perception is that fishermen have no real economic alternatives due to lack of training, education, and willingness to move into alternative activities [4].

Fisheries in Santa Clara contribute the most to the fishing industry in the region. With only 5% of the population, 9% of affiliated fishermen and 27% of the artisanal boats, revenues from fisheries in Santa Clara represent 51% of the total revenues, with profits representing 56% (Table 1). Fisheries annually generate revenues equivalent to million US$16.17, with the shrimp fishery contributing 62.5% of this value (Table 1).

1.3. Vaquita conservation plan

In 2008, the Mexican government launched PACE-Vaquita, a program aimed to preserve vaquita.[7] During its first year of operation, PACE-Vaquita compensated fishermen voluntarily choosing one of three alternatives: rent-out, switch-out or buy-out.

The rent-out option resembles a payment-for-conservation program in the sense that fishermen acquire temporal contractual obligations to carry out conservation activities. Specifically, fishermen are compensated if they agree to suspend all gillnet fishing inside what is known as the Vaquita Refuge Area (see Fig. 1). If fishermen breach the contract, their vessels are confiscated. The rent-out option is associated with a maximum decline of 10% in total catch.[8]

The switch-out option follows the spirit of a subsidy-based program to accelerate technological adoption by compensating fishermen for permanently switching to vaquita-safe harvesting technologies.[9] Experimental settings suggest that a vaquita-safe net catches 34% of what is caught with gillnets [23].[10]

As in a buyback program,[11] the buy-out option compensates fishermen for permanently turning in fishing permits and their respective boat, engine and gear.

Two modifications were introduced in the program's rules in 2009 and 2010. Starting in 2010, the compensation structure was changed to make the buy-out alternative relatively less appealing

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[3] A thorough list including scientific and popular names of 241 species is provided by [14].

[4] Most studies in the region have focused on vaquita's abundance (e.g. [15,12,16]). Fewer studies have described the socioeconomic situation. A detailed description is provided by [17], although relatively dated. More recent but less detailed description is provided by [4,10].

[5] Personal communication with fishermen and Catalina Sagastegui, Secretariat of Noroeste Sustentable, an NGO working in the region since 2001. Also, previous studies have documented the relevance of the middlemen, i.e., fish buyers in the role of providers of credit and access to markets in the context of artisanal fisheries (e.g. [18]).

[6] Description of cooperatives is based on personal communication with fishermen.

[7] A pilot program was implemented in 2007 to test acceptance and compensations. This pilot involved 68 transactions [21].

[8] Personal communication with Enrique Sanjurjo, WWF consultant, and Miguel A. Cisneros Mata, fisheries expert.

[9] As pointed out by [22], due to international pressures to reduce any type of subsidies in fisheries, the use of subsidies to reduce bycatch is limited in fisheries. This type of subsidies are more common in the agricultural sector where adoption of efficient irrigation technologies is encouraged.

[10] Details on the vaquita-safe net can be found in [23].

[11] A buyback program buys one or several of the following items: fishing vessels, licenses, access, use or other rights, and gear. Fishermen permanently give up their opportunity of using the item that has been sold. Detailed description is provided in [24].

Table 1
Estimated profits from fisheries, 2007.
Source: [4].

Fishery	Units	San Felipe	Santa Clara	Peñasco
Shrimp				
Total landings[a]	Metric tons	342	280	100
Average landings[b]	Metric tons	0.70	0.63	0.72
Total revenues[a,c]	Million US$	4.78	3.92	1.40
Average revenues[b]	Thousand US$	9.73	8.84	10.07
Labor costs[b]	Thousand US$	2.30	2.10	2.50
Other expenditures[b]	Thousand US$	4.60	4.60	4.60
Net profits[b]	Thousand US$	2.83	2.14	2.97
Total profits from legal fishing[a] (A)	Thousand US$	908	520	204
Total profits from illegal fishing[a] (B)	Thousand US$	481	428	208
Total profits ($A+B$)[a]	Million US$	1.39	0.95	0.41
Fin fish[d]				
Total landings[a]	Metric tons	1469	3946	168
Average landings[b]	Metric tons	2.99	8.90	1.20
Total revenues[a]	Million US$	1.60	4.29	0.18
Average revenues[b,e]	Thousand US$	3.25	9.68	1.29
Labor costs[b]	Thousand US$	0.70	1.70	0.20
Other expenditures[b]	Thousand US$	1.50	3.30	0.40
Net profits[b]	Thousand US$	1.05	4.68	0.69
Total profits from legal fishing[a] (A)	Thousand US$	337	1137	48
Total profits from illegal fishing[a] (B)	Thousand US$	179	936	48
Total profits ($A+B$)[a]	Million US$	0.51	2.07	0.10

[a] Per season.
[b] Per season per panga.
[c] Average price: US$14/kg.
[d] Includes chano, curvina golfina, manta, sierra, shark, and guitarra.
[e] Average price: US$1.09/kg.

Table 2
Compensations offered by PACE-Vaquita, 2008–2010.
Source: [36–38].

Option	Number of permits, location	Compensation (thousand US$)		
		2008	2009	2010
Buy-out				
Permanently quiting fishing	1, anywhere	40.0	40.0	30.0
	2, anywhere	50.0	50.0	35.0
	3+, anywhere	60.0	60.0	40.0
Permanent switch-out				
Permanent use of vaquita-safe net	1, anywhere	30.0	30.0	30.0
Temporal switch-out				
Use of vaquita-safe net for one year				
(a) Fisher buys vaquita-safe net[a]	1, anywhere	–	17.0	17.0
(b) Fisher rents vaquita-safe net[b]	1, anywhere	–	–	9.0
(c) Use of prototype net[c] for one year[b]	1, anywhere	–	–	12.0
Rent-out				
Suspension of fishing activities in no-fishing zone for one year	1, San Felipe	4.5	4.5	6.0
	1, Santa Clara	3.5	4.5	6.0
	1, Peñasco	3.5	4.5	6.0

[a] Available since 2009.
[b] Available since 2010.
[c] Potentially more vaquita-friendly than suripera net but still in testing stage.

and the rent-out option relatively more appealing. The different compensation schemes are shown in Table 2.

The other modification was directed towards the switch-out option. Due to the low enrollment rate in the switch-out option in 2008, PACE-Vaquita added a short-term gear switching alternative for those fishermen who switched to the vaquita-safe net for a year at a time. Compensation for the short-term switching of technologies is smaller than the permanent switch-out—17 thousand US$ versus 30 thousand US$, respectively (see Table 2). By 2010, the temporary switch-out option was further broken down into two alternatives: whether or not to buy the vaquita-safe net. When fishermen decide not to buy the net, they borrow the net for a year but receive less compensation—nine thousand US$. Also in 2010, fishermen had the option of temporarily using a potentially more vaquita-friendly net. This net is called prototype net because it is in a testing stage.

Table 3 presents the allocation of compensations by year, village and option. Peñasco had the lowest participation rate over the 3 year period of the program. Participation in buy-out decreases over time in the three villages—153, 18 and 0 boats were turned in during 2008, 2009 and 2010, respectively. The 171 and 154 artisanal boats enrolled in buy-out and switch-out options represent 8.2% and 7.4% of the estimated fleet in 2007, respectively. This means that 15.6% of the artisanal boats have permanently been transformed to vaquita-safe options. Total compensation decreases through the years—15.5

Table 3
Allocation of resources in PACE-Vaquita, 2008–2010.
Source: [36–38].

Option	2008				2009				2010			
	San Felipe	Santa Clara	Peñasco	Total	San Felipe	Santa Clara	Peñasco	Total	San Felipe	Santa Clara	Peñasco	Total
Artisanal boats												
Buy-out	50	71	32	153	8	10	0	18	0	0	0	0
Permanent switch-out	38	9	4	51	43	10	1	54	10	26	13	49
Temporal switch-out												
(a) Fisher buys vaquita-safe net[a]	–	–	–	–	18	19	1	38	45	23	1	69
(b) Fisher rents vaquita-safe net[b]	–	–	–	–	–	–	–	–	14	2	1	17
(c) Use of prototype[c] net[b]	–	–	–	–	–	–	–	–	34	6	0	40
Rent-out	157	384	1	542	81	133	0	214	148	360	0	508
Total	245	464	37	746	150	172	2	324	251	417	15	683
Compensation (million US$)												
Buy-out	3.900	4.130	2.450	10.480	0.340	0.480	0.000	0.820	0.000	0.000	0.000	0.000
Switch-out	2.310	0.270	0.270	2.850	1.750	0.630	0.070	2.450	0.300	0.780	0.420	1.500
Temporal switch-out												
(a) Fisher buys vaquita-safe net[a]	–	–	–	–	0.374	0.340	0.017	0.731	0.765	0.391	0.017	1.173
(b) Fisher rents vaquita-safe net[b]	–	–	–	–	–	–	–	–	0.126	0.018	0.009	0.153
(c) Use of prototype[c] net[b]	–	–	–	–	–	–	–	–	0.333	0.066	0.000	0.399
Rent-out	0.707	1.344	0.004	2.055	0.675	1.494	0.000	2.169	0.888	2.160	0.000	3.048
Total	6.917	5.744	2.724	15.538	3.139	2.944	0.087	6.170	2.412	3.415	0.446	6.273

[a] Available since 2009.
[b] Available since 2010.
[c] Potentially more vaquita-friendly than suripera net but still in testing stage.

million US$, 6.1 million US$ and 6.2 million US$ for 2008, 2009 and 2010, respectively.

2. Materials and methods

2.1. Econometric model

The econometric analysis seeks factors explaining a fisherman's participation in either option offered by PACE-Vaquita. The Random Utility Model (RUM) provides both theoretical and empirical frameworks to analyze a fisherman's decision [25].

According to the RUM, a fisherman chooses the option that provides the highest utility. In this application, a fisherman chooses among four alternatives: non-participation in PACE-Vaquita, participation in the buy-out, participation in the switch-out, or participation in the rent-out. The model assumes that a fisherman's utility can be expressed as the sum of a deterministic component and a random component. The deterministic component incorporates the observed factors that potentially explain a fisherman's decision. This model becomes an econometric model when a specific distribution for the random component is assumed. In this application, the type 1 extreme value distribution is assumed. Thus a multinomial logit model (MNL) is estimated.[12]

In a MNL, the dependent variable is dichotomous—it takes value one for the alternative chosen and zero for the alternatives that are not chosen. Explanatory variables may vary across alternatives. In the case explanatory variables are individual-specific, variation across alternatives is induced by interacting the explanatory variables and alternative-specific dichotomous variables. A MNL yields parameter estimates required in calculations of the marginal effect of each explanatory variable on the probability of a fisherman choosing each alternative.

2.2. Data

Data are obtained from a survey and official records regarding number of boats owned by each fisherman. Artisanal fishermen from the three villages were randomly selected to take part in the survey. This survey included questions to describe the socioeconomic profile of the interviewed and his attitudes towards the governmental efforts to encourage conservation. In addition, the survey includes questions to infer the type of cooperative and the position of the fisherman in the cooperative. These questions are open questions about the fisherman's opinion on how the cooperative works and how well the cooperative represents his interests.[13]

The survey gathers information to estimate net profits per season, i.e., catch weight, price per unit, and both variable and fixed costs. However, in order to estimate profits per season per boat, number of boats per fisherman were obtained from the 2007 official records regarding number of boats per fisherman.

The survey was gathered through personal interviews carried out by personnel from the National Institute of Ecology and the Autonomous University of Baja California. Interviews were carried out the first week of October 2008—1 week after the enrollment deadline. A total of 306 usable surveys were gathered. Because the econometric analysis focuses only on fishermen who can take the decision of enrollment in the program, observations from employees are discarded. Also, 13 independent fishermen – i.e., fishermen not affiliated to a cooperative – are discarded from analysis. Thus analysis is carried out on 210 observations—46% from Santa Clara, 31% from San Felipe, and 23% from Penãsco.

2.3. Data description

Descriptive statistics of variables used in the econometric specification are presented in Table 4. These variables account

[12] See [26] for further details.

[13] Open questions are used because neither family-owned cooperatives nor sole-owner cooperatives are legally recognized, and fishermen may not truly answer a question on whether their cooperative is a regular cooperative or not. Inference from open questions is feasible because, for instance, employees tend to answer their cooperative does not represent their interests because they are only employees. Owners tend to answer their cooperative represents very well their interests because most members are relatives who look for the common benefit. Fishermen in representative positions tend to answer they are well represented because they are (or recently were) in a leadership position. Regular members may or may not feel represented and their reasons vary from pointing out the representatives do not work well enough to highlighting the cooperative is actually a democratic body where they actively participate.

Table 4
Data summary.

Variable	No participation		Rent-out		Switch-out		Buy-out		Sample	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
Fisherman's characteristics										
AGE	41.51	(1.30)	40.76	(1.47)	50.47	(3.47)	51.82	(2.20)	44.12	(0.93)
EDUCATION	7.99	(0.43)	7.23	(0.38)	7.20	(1.10)	8.80	(0.61)	7.87	(0.26)
CHILDREN	0.96	(0.14)	1.08	(0.13)	0.67	(0.26)	0.91	(0.17)	0.97	(0.08)
HOUSEHOLD	4.79	(0.21)	4.80	(0.24)	4.93	(0.31)	5.42	(0.36)	4.94	(0.14)
PEÑASCO	0.23	(0.05)	0.00	(0.00)	0.13	(0.09)	0.60	(0.07)	0.23	(0.03)
FELIPE	0.43	(0.05)	0.18	(0.05)	0.67	(0.12)	0.18	(0.06)	0.31	(0.03)
CLARA	0.35	(0.05)	0.82	(0.05)	0.20	(0.10)	0.22	(0.06)	0.46	(0.03)
OWNER	0.15	(0.04)	0.38	(0.06)	0.27	(0.11)	0.27	(0.07)	0.26	(0.03)
LEADER	0.17	(0.04)	0.09	(0.04)	0.20	(0.10)	0.16	(0.05)	0.14	(0.02)
MEMBER	0.68	(0.05)	0.53	(0.06)	0.53	(0.13)	0.58	(0.07)	0.60	(0.03)
Fisherman's attitudes										
GOVERNMENT	0.44	(0.05)	0.23	(0.05)	0.60	(0.13)	0.31	(0.07)	0.36	(0.03)
Fisherman's alternative sources of income										
TOURISTIC F	0.06	(0.03)	0.09	(0.04)	0.07	(0.06)	0.13	(0.05)	0.09	(0.02)
TOURISTIC NF	0.11	(0.03)	0.05	(0.03)	0.20	(0.10)	0.44	(0.07)	0.17	(0.03)
NONTOURISTIC	0.11	(0.03)	0.11	(0.04)	0.20	(0.10)	0.29	(0.07)	0.15	(0.02)
Fisherman's wealth										
SAVINGS	0.23	(0.05)	0.39	(0.06)	0.27	(0.11)	0.31	(0.07)	0.30	(0.03)
WORK	0.06	(0.03)	0.08	(0.03)	0.13	(0.09)	0.16	(0.05)	0.09	(0.02)
Fisherman's financial liabilities										
LOAN	0.52	(0.05)	0.64	(0.06)	0.27	(0.11)	0.27	(0.07)	0.49	(0.03)
STUDY	0.14	(0.04)	0.11	(0.04)	0.13	(0.09)	0.18	(0.06)	0.14	(0.02)
Fishing-related variables										
BOATS	2.26	(0.30)	1.77	(0.23)	5.33	(1.17)	7.76	(1.14)	3.50	(0.34)
PROFITS	12.10	(4.29)	10.47	(1.74)	1.67	(0.54)	4.82	(1.29)	9.28	(1.84)
LNPROFITS	1.10	(0.21)	1.46	(0.19)	−0.47	(0.42)	0.34	(0.25)	0.94	(0.13)
NPV	130.88	(46.39)	113.24	(18.85)	18.08	(5.84)	52.14	(13.95)	100.41	(19.88)
LNNPV	3.48	(0.21)	3.84	(0.19)	1.91	(0.42)	2.72	(0.25)	3.32	(0.13)
Observations	84		66		15		45		210	

for fisherman's characteristics, fisherman's attitudes towards government conservation programs, fisherman's alternative sources of income, fisherman's wealth, fisherman's financial liabilities, and fishing-related factors.

A fisherman's characteristics include age (AGE); number of years of education (EDUCATION); number of children younger than 13 (CHILDREN); number of people living in the house (HOUSEHOLD); dichotomous variables for location of the house (PEÑASCO, FELIPE or CLARA)[14]; and dichotomous variables assigning a fisherman to one of three exclusive categories: OWNER, LEADER or MEMBER. OWNER takes value one if the fisherman is owner, in the case of the sole-owner cooperatives, or co-owner, in the case of family-owned cooperatives. LEADER takes value one if the fisherman is representative of a regular cooperative. MEMBER takes value one if the fisherman is member of a regular cooperative and is not in a leadership position.

Favorable attitudes towards conservation efforts are expected to positively impact the likelihood of enrollment. A fisherman's attitudes towards PACE-Vaquita are captured by a dichotomous variable (GOVERNMENT). If the fisherman thinks conservation-related government policies restricting fisheries are a major risk for the future of artisanal fisheries, then GOVERNMENT takes value one, and zero otherwise.[15]

Fishermen more likely shift from fishing if they can perform non-fishing activities [27,28]. Thus fishermen with skills in non-fishing activities are expected to enroll in PACE-Vaquita. TOURISTIC F, TOURISTIC NF, and NONTOURISTIC stand for the fisherman's alternative economic activities. TOURISTIC F stands for touristic, fishing dependent activities such as owning or working in a restaurant. TOURISTIC NF stands for touristic, non-fishing dependent activities such as renting recreational items on the beach, teaching scuba diving, driving a taxi, etc. NONTOURISTIC stands for non-touristic activities such as repairman, mechanic, construction worker, etc.

Wealthier fishermen are expected to be more likely to enroll in PACE-Vaquita because, according to the literature on poverty traps, wealthier fishermen are more able to take risks associated to shifting from fishing activities [29]. A fisherman's wealth includes savings (SAVINGS) and possible remittances from relatives working abroad (WORK). SAVINGS takes value one if the fisherman has savings. WORK takes value one if the fisherman has at least one child that has migrated to work in USA or elsewhere.

A fisherman's financial liabilities are captured by two dichotomous variables (LOAN and STUDY). LOAN takes value one if the fisherman has pending loans obtained through his cooperative. Because future catch, the collateral, is expected to be smaller if he enrolls in PACE-Vaquita, a fisherman with a pending loan is less likely to enroll in PACE-Vaquita. STUDY takes value one if the fisherman has at least one child that has migrated to study in USA or elsewhere. Having a child studying elsewhere may imply planned expenses, deterring a fisherman from enrolling in a program that implies at least a temporary change in income.

Fishing-related variables are number of boats owned by the fisherman (BOATS); logarithm of 2007 net profits per boat in thousand US$ (LNPROFITS); and logarithm of net present value of

[14] Econometric specifications use PEÑASCO and CLARA as reference categories. This strategy is followed because no fishermen from PEÑASCO are observed for the rent-out option (see Table 4).

[15] Fishermen were asked which factor out of four alternatives poses the largest risk for the future of artisanal fisheries. Alternatives were decrease in prices, decline in catch rates, increase in illegal fishing, and conservation-related government policies restricting fisheries. If a fisherman listed government policies as the number one factor, then GOVERNMENT takes value one.

Table 5
Results from multinomial logit specifications. Reference alternative: no participation. 210 observations.

Variable	Specification I (LNPROFITS)						Specification II (LNNPV)					
	Rent-out		Switch-out		Buy-out		Rent-out		Switch-out		Buy-out	
	Coeff	*t*-Test	Coeff	*t*-Test	Coeff	*t*-Test	Coeff	*t*-Test	Coeff	*t*-Test	Coeff	*t*-Test
Fisherman's characteristics												
AGE	0.00	0.18	0.04	1.15	0.16[a]	3.59	0.00	0.22	0.05	1.29	0.17[c]	3.69
EDUCATION	−0.07	−1.16	−0.04	−0.39	0.15[b]	1.73	−0.07	−1.11	−0.02	−0.20	0.17[a]	1.85
CHILDREN	−0.02	−0.11	0.20	0.47	0.99[c]	2.59	−0.02	−0.10	0.23	0.54	0.98[b]	2.55
HOUSEHOLD	0.07	0.70	0.12	0.61	0.42[b]	2.35	0.07	0.71	0.14	0.70	0.45[b]	2.46
FELIPE	−0.52	−0.92	0.46	0.47	−1.62[b]	−1.96	−0.52	−0.90	0.42	0.43	−1.55[a]	−1.86
OWNER	1.15[b]	2.41	1.79[b]	2.01	1.00	1.31	1.13[b]	2.35	1.75[a]	1.93	0.96	1.26
LEADER	−0.45	−0.71	0.52	0.58	−0.96	−0.94	−0.46	−0.72	0.44	0.49	−0.83	−0.81
Fisherman's attitudes												
GOVERNMENT	−0.46	−0.89	0.44	0.50	−0.04	−0.06	−0.46	−0.89	0.68	0.75	−0.02	−0.03
Fisherman's alternative sources of income												
TOURISTIC F	0.69	0.89	0.75	0.51	3.77[c]	3.10	0.72	0.93	1.04	0.72	3.82[c]	3.12
TOURISTIC NF	−0.96	−1.27	1.15	1.20	4.37[c]	4.31	−0.97	−1.28	1.07	1.13	4.26[c]	4.26
NONTOURISTIC	−0.63	−0.98	1.88[b]	2.02	3.82[c]	3.88	−0.67	−1.03	1.80[a]	1.93	3.77[c]	3.87
Fisherman's wealth												
SAVINGS	1.44[c]	3.15	−0.52	−0.70	−0.11	−0.15	1.46[c]	3.17	−0.29	−0.39	0.00	0.00
WORK	0.27	0.35	0.67	0.60	1.40	1.40	0.23	0.30	0.59	0.51	1.22	1.22
Fisherman's financial liabilities												
LOAN	0.32	0.82	−0.95	−1.30	−0.89	−1.34	0.31	0.77	−1.10	−1.47	−0.98	−1.47
STUDY	−0.39	−0.57	−0.42	−0.38	−1.92[a]	−1.65	−0.39	−0.57	−0.42	−0.39	−1.99[a]	−1.72
Fishing-related variables												
BOATS	−0.10	−1.14	0.21[b]	2.45	0.36[c]	3.77	−0.10	−1.17	0.19[b]	2.16	0.35[c]	3.82
LNPROFITS	0.10	0.87	−0.36[a]	−1.77	−0.03	−0.16	–	–	–	–	–	–
LNNPV	–	–	–	–	–	–	−0.18	−0.43	−3.14[a]	−1.84	−1.27	−0.94
Constant	−0.59	−0.49	−5.84[b]	−2.43	−15.63[c]	−4.43	−0.21	−0.11	4.71	0.69	−11.74[b]	−2.05
Log-likelihood	−164.43						−163.41					
Pseudo-R^2	0.43						0.43					

[a] Coefficient significant at 1%.
[b] Coefficient significant at 10%.
[c] Coefficient significant at 5%.

net profits under each alternative (LNNPV). Calculations of net profits are based on interviewee's answers to questions on last season average fish prices, total catch, fixed costs – maintenance and capital depreciation – and variable costs—fuel, ice, and labor costs.

Calculations of net present value (NPV) are based on three assumptions: fishermen adhere to the alternative they first chose until the end of their careers, profits in future years are identical to 2007s net profits, and end of career occurs at the age of 86.[16] Following [4], who calculate the economic value of artisanal fisheries in the Northern Gulf of California, a discount rate of 10% is used. Thus NPV under no participation is calculated assuming fishermen generate net profits identical to 2007s every year until the end of their career. NPV under rent-out scenario is calculated as the net present value of the annual sum of the respective compensation and 90% of 2007 net profits, every year until the end of their career. NPV under permanent switch-out scenario is calculated as the sum of an one-time compensation and the net present value of 34% of 2007 net profits every year until retirement.[17] NPV under buy-out scenario is identical to the compensation received in 2008.

[16] The oldest active fisherman in the survey is 86 years old. Calculations assuming 70 and 75 as the age at the end of the career were also performed without impacting the final results.

[17] An implicit assumption is that fishermen will not change their fishing effort.

3. Results

Table 5 presents results from two multinomial logit specifications.[18] Specification I includes LNPROFITS but not LNNPV. Specification II includes LNNPV but not LNPROFITS. Specifications including both LNPROFITS and LNNPV were estimated as well[19] but did not yield a significant improvement in fit,[20] and faced collinearity problems—correlation between LNPROFITS and LNNPV is 0.69. Therefore specifications including both LNPROFITS and LNNPV are not shown.

Calculation, interpretation and discussion of marginal effects are based on specification I. There are three reasons to use specification I. First, coefficients from both specifications have the same sign and similar magnitude. Second, statistical significance of NPV in

[18] Nested logit models may also be an econometric option in this context. However, a set of Hausman tests (not shown) cannot reject the independence of irrelevant alternatives assumption.

[19] Three specifications including both LNPROFITS and LNNPV were estimated. When impact from both variables were allowed to vary by alternative, both sets of coefficients were insignificant. When only impact from LNPROFITS varies, LNNPV is insignificant and results are similar to those in specification I in Table 5. The third specification consisted of a random parameter model where impact from LNNPV is normally distributed and the rest of coefficients are fixed. Mean impact from LNNPV is not different from zero and results are similar to those in specification I.

[20] Both Akaike and Bayesian criteria (not shown) yield no significant improvement in likelihood values.

Table 6
Significant average marginal effects.[a]

Variable	No participation			Rent-out			Switch-out			Buy-out		
	Average marginal effect	90% confidence interval[b]		Average marginal effect	90% confidence interval[b]		Average marginal effect	90% confidence interval[b]		Average marginal effect	90% confidence interval[b]	
Fisherman's characteristics												
AGE	−0.006	−0.011	−0.001	–	–	–	–	–	–	0.010	0.006	0.013
EDUCATION	–	–	–	–	–	–	–	–	–	0.012	0.003	0.021
CHILDREN	–	–	–	–	–	–	–	–	–	0.061	0.023	0.098
HOUSEHOLD	–	–	–	–	–	–	–	–	–	0.023	0.006	0.041
FELIPE	–	–	–	–	–	–	–	–	–	−0.102	−0.179	−0.022
OWNER	−0.203	−0.317	−0.084	0.121	0.017	0.220	–	–	–	–	–	–
Fisherman's alternative sources of income												
TOURISTIC F	−0.203[c]	−0.392	−0.012	–	–	–	–	–	–	0.218	0.103	0.331
TOURISTIC NF	–	–	—	–	–	–	–	–	–	0.278	0.202	0.350
NONTOURISTIC	–	–	–	–	–	–	–	–	–	0.224	0.144	0.303
Fisherman's wealth												
SAVINGS	−0.141	−0.242	−0.034	0.215	0.117	0.307	–	–	–	–	–	–
Fishing-related variables												
BOATS	–	–	–	–	–	–	0.007[c]	0.001	0.014	0.021	0.014	0.028
LNPROFITS	–	–	–	–	–	–	−0.022[c]	−0.042	−0.004	–	–	–
Constant	0.663	0.368	0.955	–	–	–	–	–	–	−0.892	−1.161	−0.614

[a] From specification I in Table 5.
[b] Krinsky–Robb method, 20,000 repetitions.
[c] Nonsignificant at 5%.

specification II may only be reflecting the significance of profits in specification I because calculation of NPV is based on profit estimates. Third, inclusion of LNNPV in specification II relies on assumptions that cannot be tested with the available data. For instance, calculation of NPV assumes participation in rent-out is permanent. However, some fishermen choosing the rent-out option in 2008 may have quit participation in subsequent years or may have shifted to other alternative.

Table 6 presents significant average marginal effects from variables in specification I on each alternative.[21] According to Table 6, likelihood of no participation declines with age and is smaller for owners of cooperatives, fishermen with savings, and fishermen with skills in touristic, fishing dependent activities. Likelihood of enrollment in the rent-out option is larger for owners of cooperatives, and for fishermen with savings. Likelihood of participation in the switch-out option increases with the boats owned by the fisherman, and decreases with the profits per boat. Likelihood of participation in the buy-out option increases with age, years of education, number of children younger than 13, number of people living in the house, skills in any type of alternative activities, and number of boats owned by the fisherman. Likelihood of enrollment in the buy-out option is smaller for the fishermen living in San Felipe village.

Discussion of results with public policy implications is provided in the next section.

4. Discussion

4.1. Fisherman's attitudes

Attitudes towards government policies do not significantly impact a fisherman's decision (see Table 5). This result contrasts to previous findings according to which attitudes towards government policies and resources use are relevant when fishermen decide enrolling in conservation programs (e.g. [30–32]).

[21] For details on calculation of marginal effects, see [26].

4.2. Fisherman's alternative sources of income

Average marginal effects from variables reflecting alternative sources of income confirm that fishermen more likely shift from fishing if they can perform non-fishing activities, as suggested by [27,28]. According to the average marginal effects in Table 6, having skills on any type of non-fishing activity increases the probability of participating in the buy-out option.

4.3. Fisherman's wealth

Average marginal effects from SAVINGS, a variable capturing a fisherman's wealth, show that wealthier fishermen more likely participate in the rent-out option. This result is consistent with previous findings from the literature on poverty traps which argues that wealthier fishermen are more able to take the risk associated with shifting from fishing [29].

The lack of impact of savings on participation in the switch-out and the buy-out options suggest that there is a limit to the risk a wealthy fisherman is willing to take. The risk involved in participating in either the switch-out or the buy-out options is bigger than the risk of participating in the rent-out option because both the switch-out and the buy-out options imply more changes in fishing methods. Thus, a wealthy fisherman is only willing to choose the option with the smallest risk.

4.4. Probability of participation across fishermen

In comparison to non-representative members of regular cooperatives, owners of sole-owner and family-owned cooperatives have a larger probability of participation in the rent-out option. This larger probability is not the consequence of owners having more boats because the effect from boats (BOATS) has already been taken into account. A plausible factor such as owners being able to take greater risks because they are wealthier has already been included through SAVINGS. Also, the possibility of owners' participation due to their better understanding of the program's rules and implications has already been controlled for through education. Owners, as

Table 7
Comparison of average values of selected variables across chosen option.[a]

Difference[b]	95% confidence interval	
	Lower bound	Upper bound
Age		
$Age_b - Age_r$	4.37	17.75
$Age_b - Age_{np}$	3.92	16.70
$Age_b - Age_s$	−8.96	11.66
$Age_s - Age_r$	−0.18	19.60
$Age_s - Age_{np}$	−0.74	18.66
$Age_{np} - Age_r$	−4.94	6.44
Profits		
$Profits_{np} - Profits_s$	−8.75	29.61
$Profits_{np} - Profits_b$	−5.36	19.92
$Profits_{np} - Profits_r$	−9.63	12.89
$Profits_r - Profits_s$	−10.78	28.38
$Profits_r - Profits_b$	−7.58	18.88
$Profits_b - Profits_s$	−17.26	23.56
Felipe		
$Felipe_s - Felipe_r$	0.17	0.81
$Felipe_s - Felipe_b$	0.16	0.82
$Felipe_s - Felipe_{np}$	−0.07	0.55
$Felipe_{np} - Felipe_r$	0.07	0.43
$Felipe_{np} - Felipe_b$	0.04	0.46
$Felipe_b - Felipe_r$	−0.22	0.22

[a] Based on Tukey–Kramer method for multiple comparisons.
[b] Subscripts stand for buy-out (b), switch-out (s), rent-out (r), and no participation (np).

officially registered as cooperative representatives, usually receive first-hand information on the governmental programs. Thus better access to information may explain both the smaller probability of no participation and the larger probability of participation in the rent-out option. However, if this was the case, the variable LEADER should have similar impacts than OWNER. Hence the lack of significant impact from LEADER let us dismiss better information as a possible explanation for the impact from OWNER.

4.5. The lemons

Lemons are older or in need of repair vessels, less productive at catching fish, and their owners are often older and reaching the end of their careers [24]. Buyback programs have been found to only accelerate the exit of lemons [24]. In contrast to those findings, econometric results in this study suggest the buyback program embedded in PACE-Vaquita through the buy-out option did not retire the most unproductive vessels. Fishermen with unprofitable vessels chose the switch-out option. Discussion of this result focuses on the effect from the age of a fisherman and profits per boat.

4.5.1. Age of a fisherman

Consistently with previous analyses of conventional buyback programs, older fishermen chose the buy out option in 2008. Table 7 shows that fishermen choosing the buy-out option are older (51.8 years old) than both non-participants (41.5) and fishermen choosing the rent-out option (40.7).[22] Table 6 shows that the age of a fisherman impacts negatively the likelihood of no participation and positively the likelihood of participation in the buy-out option.

4.5.2. Profitability

Fishermen choosing the buy-out option are the oldest but not the most unprofitable ones. Table 7 shows no statistical differences among profits generated by fishermen choosing the buy-out option and profits generated by fishermen choosing any other option. Profitability is a significant factor only when deciding to enroll in the switch-out option. According to Table 6, an increase of 1% in profits decreases the probability of participation in the switch-out option by 0.022. This effect implies that the less profitable a vessel is, the more likely this vessel is enrolled in the switch-out option. Thus, in 2008, the lemons switched to vaquita-safe techniques rather than retiring from fishing.

4.5.3. Why were some lemons switched out?

Had fishermen faced the decision of participating in a conventional buyback program, fishermen who chose the switch-out option would have decided to participate in the conventional buyback program because they are as old as the fishermen who chose the buy-out option and no difference in average profitability seems to exist (Table 7). Then why did not those fishermen choose the buy-out option?

Comparing fishermen choosing the switch-out option and fishermen choosing the buy-out option provides some clues on why some lemons were enrolled in the switch-out option. In comparison to fishermen participating in the buy-out option, a larger proportion of fishermen switching out live in San Felipe and a lower proportion of fishermen switching out have skills in touristic, non-fishing dependent activities. Table 7 shows that the proportion of fishermen from San Felipe is statistically larger for the switch-out option in comparison to the buy-out option.[23] In fact, most of the fishermen participating in the switch-out option live in San Felipe (68%). In addition, a *t*-test on the proportion of fishermen with skills in touristic, non-fishing dependent activities cannot reject the hypothesis that this proportion is larger for the buy-out option in comparison to the switch-out option at 95% of confidence.[24]

Thus the lemons enrolled in the switch-out option in 2008 were mostly owned by fishermen who live in San Felipe. These fishermen have fewer skills in alternative economic activities. Because these fishermen have fewer alternative sources of income, they prefer to keep fishing.

4.5.4. Is the buy-out option being used to upgrade the fleet and re-enter the fishery?

As pointed out by [24], fishermen may use the funds obtained through the buyback program to purchase an upgraded or new vessel, and re-enter the fishery. If this was the case for PACE-Vaquita in 2008, then there is the chance that fishermen enrolled in the buy-out option with the goal of re-entering once an upgraded vessel has been obtained. However, neither documented nor anecdotal evidence suggest fishermen have re-entered the fishery. Local newspapers have reported cases where the environmental attorney agency has succeeded in confiscating boats from fishermen attempting re-entry (e.g. [34,35]). As a general perception, re-entry seems to be under control.[25]

[22] Multiple comparisons of means were carried out for each variable through the Tukey–Kramer method. This method takes into account the increase in probability of making a type I error when doing multiple comparisons (see [33]). Table 7 shows the results for variables relevant in Discussion section.

[23] Consistently, comparison of proportions of fishermen from Peñasco enrolling in the buy-out option and the switch-out option shows that the former proportion is larger than the latter.

[24] A multiple comparison test rejects the same hypothesis.

[25] Personal communication with Catalina Sagastegui, Secretariat of Noroeste Sustentable.

5. What do these results tell us about conservation of vaquita?

The buy-out alternative is preferred by older fishermen. Therefore, participation in the buy-out option will stop as soon as every close-to-retirement fisherman has given up fishing. Not surprisingly, enrollment in the buy-out option has declined to the point where no fisherman participated in 2010. For this reason, the buy-out option will not be a reasonable option to encourage vaquita's conservation in the near future.

In order to induce additional participation in the buy-out option, policy makers have two options: to increase the buy-out payment or to invest in human capital. The current buy-out payment has already removed the marginal fishermen out of the fishery, leaving those whose vessels and permits are worth more in terms of expected value. Thus additional fishermen could be removed by offering a larger payment. Investment in programs providing fishermen with skills in alternative economic activities may also increase participation in the buy-out alternative. However, this strategy may be less efficient than increasing the buy-out payment.

Making the switch-out option more appealing is a priority to increase conservation efforts because the switch-out option implies more conservation than the rent-out option. Increasing the switch-out payment could induce more participation in the switch-out option.

In contrast to the public policy recommendations offered in this study, the buy-out payment has been reduced during the subsequent years PACE-Vaquita has operated, and the switch-out payment has remained the same. In addition, the compensation offered by the rent-out option has increased. Under these circumstances, it is not surprising that most fishermen who participated in PACE-Vaquita enrolled in the rent-out option.

Since 2009, fishermen can choose among temporal switch-out options as well. A description of the profile of fishermen choosing temporal switch-out is not feasible because the data set was gathered in 2008, the first year PACE-Vaquita operated. Thus no specific recommendations can be provided with respect to temporal switch-out.

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