The Economic Benefits of the Red Abalone Fishery in Northern California

DISCUSSION PAPER

Nº 15 January 2016

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January 2016 / №15

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Photo: California Department of Fish and Wildlife

We would like to thank the Resources Legacy Fund for financial support for this project, and Mike Weber in particular for his insights and advice throughout. Thanks also to the entire group of professionals who work with red abalone at the Department of Fish and Wildlife for all their support with data, guidance for the study and feedback on preliminary results. Finally, thanks to Kim Bonine, project leader of the broader partnership between CDFW and CSF.

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Executive Summary

This study presents an analysis of the economic importance of the recreational red abalone fishery to both fishermen and the two coastal California counties, Mendocino and Sonoma, where most of the catch is taken. We address three key economic features of the fishery:

1. Recreational value of the fishery to participants
2. Positive economic impact on Sonoma and Mendocino county businesses and
3. Potential for a fee increase in the abalone report card

The report was prepared by Conservation Strategy Fund (CSF) for the California Department of Fish and Wildlife (CDFW) as essential economic information to inform the fishery management plan. Red abalone, *Haliotis rufescens,* is the last of California's seven abalone species sufficiently abundant to support a fishery. Various species once supported both commercial and recreational fisheries. It is critical that economic considerations be taking into account while sustainably managing the fishery, which vulnerable to overfishing and to environmental factors.

Based on data from 2013, we found that the approximately 31,000 abalone harvesters derived a total of between $25 and 44 million dollars per year of recreational benefit from the fishery. The figures refer to enjoyment people get from the leisure activity of collecting and eating abalone. The value is calculated with the widely used "travel-cost method," a technique for estimating non-market values based on the time and money people spend to enjoy recreational sites.

The study also examined factors other than travel costs that influence the choice of sites among the 50-plus fishing locations along the North Coast. The data are from after the 2011 harmful algal bloom (HAB) that decreased stocks in Sonoma County by 60 percent, but did not impct Mendocino County sites. Our data showed that that event was a major driver in fishers' (by "fishers" we mean both divers and "rock-pickers," people who wade in shallow water to collect abalone at low tide) site selection. Other key determinants of where people go were the degree of protection from prevailing northwest swells and the presence of boat launch and restroom facilities. These preferences were quantified in terms of the lost value per trip that would result from hypothetical loss of a given site. The five most valuable sites in this post-HAB season we studied were all located on the Mendocino Coast (in order): Arena Cove, Moat Creek, Albion Cove, Russian Gulch and van Damme.

The second component of the study measured the economic impact on Mendocino and Sonoma Counties from abalone divers' spending on a variety of local services, such as food, lodging, gas and incidentals. We looked at direct spending, plus the indirect and induced spending by the county residents who sold goods and services to the abalone divers. The economic impact in Mendocino County was $15 million in direct spending and $22 million in overall impact. The corresponding figures in Sonoma were $3 million and $5 million. We estimated tax revenue at $1,137,830 in Mendocino and $235,900 in Sonoma.

In Mendocino 208 jobs were directly connected to abalone recreation with 260 total jobs, when considering indirect and induced employment. Job totals in Sonoma were 44 direct and 57 overall. Mendocino's roughly 80 percent share of impact corresponds to the approximate share of abalone harvested in that county.

A third part of the study examined fishers' willingness to pay higher abalone card (permit) fees to generate more funds for management and enforcement. Based on information gathered in an online survey of 1,521 fishers, we found an average willingness to pay $34, which would represent a $12 increase over the current $22.17 sum it cost people to obtain their abalone "report card" in 2013. This fee is in addition to the standard fishing license, which cost $45.93 that year. Because some fishermen may choose not to participate at higher prices, a fee increase could decrease total revenues to CDFW. We note that the survey may be subject to "strategic bias," which causes respondents to understate their willingness to pay.

Safeguarding the abalone resource is an important mandate outlined in the Marine Life Management Act for sustainability, cultural, biological and ethical reasons. The data presented here suggest that there are *also* compelling economic reasons to invest in the species' management and conservation. Abalone generates tens of millions of dollars in net recreational benefits to tens of thousands of Californians who inject millions of dollars annually into the local economies of remote areas of the state's coastline where few other economic opportunities are present.

The model used for this analysis can now be applied for specific management purposes. Comparisons can be made across years to detect changes in economic value over time in response to natural and regulatory factors. CDFW can simulate management changes, upgrades to facilities and closures of specific sites or groups of sites. Also, user groups can be identified to discover divergences in site preferences and behavior, information that can guide management pertaining to specific sites or fishing modes. These might include analyzing local fishers versus those who travel more than 50 miles, fishers focused on different seasons or divers compared to rock-pickers.

Finally, we make recommendations for future economic work, including: 1) modifications to current data collection to enable analyses repeated yearly to track the economic productivity and health of the fishery; 2) economic analysis of specific stressors at specific sites within the fishery; 3) more precise assessment of the likely impact of fee increases on participation in the fishery; and 4) rigorous comparison of the economic values of the fishery in different years since 2000.

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1. Introduction

Abalone has been extensively fished[1] along the California coastline for decades. The resource has long been important as food, as the basis for recreation enjoyed by tens of thousands of Californians, and as a driver of economic activity in remote areas of the state's coastline. Recently, however, the decline in populations of all varieties of abalone has led to increased regulation. Red abalone is currently the only species that may be legally fished, and they may only be taken north of San Francisco Bay. Commercial fishing is prohibited.

The species is vulnerable to overfishing because it matures slowly, requires high densities for successful reproduction, and has no mechanism for clotting the blood (so undersized abalone put back often perish from wounds inflicted by the tools used to pry them from the rocks). The fragile state of the species was made more acute in 2011 when the abalone population of Sonoma County experienced the effects of a red tide, a toxic algae bloom that sharply diminished its numbers. In the aftermath of that event, the California Department of Fish and Wildlife (CDFW) added further restrictions to the already existing Abalone Recovery and Management Plan (ARMP), including a later daily start time of 8:00 a.m. (excluding July), during the season, which runs from April to November. The annual limit is 18 abalone per year, down from 24. No more than nine of that total may be fished in Sonoma and Marin counties. The most popular site in the fishery had such low densities that the site was closed in 2014, as per guidance in the ARMP. There is also a daily bag limit of three. Two additional measures remain important regulations for the fishery: no scuba gear is allowed and there is a 7-inch minimum legal size. Fishermen must fill out a report card, which details where and when each abalone was caught. There are around 31,000 individual report card holders in the CDFW database, who took an estimated 256,000 abalone legally in 2013. Over 95 percent of the legal take comes from Sonoma and Mendocino counties.

The purpose of this study is to determine the economic benefits of abalone fishing for fishermen and the positive economic impact of the fishery on the coastal communities in Sonoma and Mendocino counties where the fishermen spend money. This information is intended to help managers better understand the economic implications of choices they face as CDFW writes a new Fishery Management Plan (FMP) for the species. The results from this valuation and impact study will help inform decision-making processes aimed at preserving the species as well as the economic benefits it provides to fishermen and coastal communities.

It should be noted that the year examined in detail in this study, 2013, was in some ways atypical. The 2011 harmful algae bloom had a catastrophic impact on populations of the species in the southern part of its range. Fort Ross was closed in response. That event

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[1] Abalone are fished by both divers and "rock pickers," people who wade into the water at low tide. In this paper we refer to fishers, anglers, divers and collectors interchangeably to denote all the people who fish abalone. We will be explicit when distinguishing between rock pickers and people who use fins to dive for the abalone.

and resulting regulatory measures mentioned above most likely led to a lower overall value for the fishery than during periods unaffected by this environmental impact and shifted fishing activity to Mendocino County. The anticipated shirt in fishing effort was a major driver in the need to reduce the annual limit from 24 to 18 in the non-HAB impacted region of the fishery. The data we present are broadly indicative of the economic importance of abalone to anglers and communities alike in this post-HAB period.

Three methods were used in this study. The travel cost method (TCM) was used to calculate the recreational value of the resource based on the expenses people incur traveling to the sites. The method doesn't estimate the value of abalone as food but of the overall experience of gathering them from the wild. We complement this analysis with a look at the value anglers place on having stronger management and enforcement in the fishery. That calculation was done using the contingent valuation method (CVM), based on responses to an online survey of fishery participants. The third method is economic impact analysis, which tallies up the spending, employment and tax revenue generated by abalone diving in the coastal locales where the resources is found. This part of the study used the IMPLAN model.

Before we dive into the analysis we note that, as with most wild species, there are many non-economic considerations in abalone management, and there are legal and ethical rationales for preserving it quite independent of its economic uses. The information in this study merely offers insights regarding the species' economic dimensions, and hopefully provides a tool that will help managers preserve the species while enabling it to sustainably generate economic benefits.

The report is organized as follows. The next section looks at the recreational value of abalone fishing to divers. Section 3 examines the economic impact of abalone fishing on Sonoma and Mendocino counties. Section 4 presents the analysis of fishermen's willingness to pay for more active management and enforcement. We conclude with a synthesis and discussion of the results, including recommendations for future data collection and analysis.

2: Recreation Value

2.1 Methods

The travel cost method is an economic approach that is used to assign monetary value to non-market goods such as recreational activities or resources. The TCM takes into account the costs paid by a participant to engage in the activity. These include direct costs such as fees, and other costs such as the opportunity cost of time and fuel. The method also considers the factors that influence the choice of the given site as opposed to other possible sites for the same or comparable activities. Using this information, a travel cost function and demand curve can be estimated where the consumer surplus is representative of the economic value of the resource to the recreational users. Parsons (2003) provides a detailed overview of the method.

Travel-cost studies follow one of two basic approaches: single-site models and multi-site models. Single-site models construct a demand curve based on the relationship between the cost of visiting a site to the frequency of visits. Multi-site models add in the element of choice from among a set of alternative sites for the same recreational purpose, and tease out the impact of site characteristics on the choice of sites, while also providing the overall value of recreation. Given that abalone is taken at some 50 different sites along the coast, a multi-site model was adopted for this study.

TCM is used rather than a market-based method because abalone may only be fished recreationally; there is no legal market for the species. This is the first study of which we are aware that applies the TCM to this fishery. Indeed, no comprehensive valuation of abalone has been done to date. The value of recreational fishing in coastal California in general has been investigated using TCM (Pendleton & Rooke, 2006) and using both TCM and CVM (Huppert, 1989), but literature examining the economic impact and value of abalone in particular is lacking.

Travel-cost analysis is usually performed based on a questionnaire designed for the express purpose of the study. Due to the existence of large datasets on abalone fishing and a short time frame for this assessment, we elected to work with information already collected by wildlife managers. We worked with the CDFW database of 30,768 abalone report card holders, which represents the population of legal harvesters, and a telephone survey of a sample of this population. CDFW conducted the random telephone survey of this group in 2014, with 516 responses regarding the 2013 fishing season. Respondents to the telephone survey provided demographic information and data on their fishing histories and habits. Of these 516 responses, 392 respondents also provided detailed catch information to the CDFW via its reporting system. Because we had demographic and catch data from these 392 respondents, they were used as our sample for the travel-cost analysis. There is a risk that this group is not representative of the overall population; those reporting may collect more or less than the average number of abalone, prefer certain kinds of sites or be demographically distinct from the population. Since the telephone sample is random, we are comfortable that the sample used will provide an acceptable representation of the population.

For TCM, the unit of analysis is an abalone-fishing trip, of which the typical diver takes several in a season, so the data was rearranged according to trips taken. Each diver had recorded the number of abalone caught per site visited and the number of abalone caught on each day of the fishing season. This information was then used to approximate the number of trips undertaken by each diver and, for each trip, the dive site destination, number of abalone caught and the date. The distance from origin location to dive site was calculated for each trip based on the diver's city of residence. The number of trips was confirmed with information on total trips in the season, as reported in the telephone survey.

Sorting the data by trip rather than angler allowed for a calculation of costs incurred for each trip. To participate in the fishery, an individual incurs the cost of the recreational fishing license and the cost of the report card. Standard licenses for state residents are $47.01 per year and for non-residents are $126.36. The abalone report card costs an additional $22.17. These fees are the same for all divers and minimal in the context of overall expenditures so they were excluded from the analysis. We also excluded food and lodging costs because specific data were not available at the trip level.

In consultation with CDFW staff (personal communication, J. Kashiwada, L. Rogers-Bennett, C. Catton and C. Juhasz), site attributes were identified that might influence an angler's decision of where to fish. Values for each attribute were assigned to each location where abalone is taken. Please see Table 1. Some attributes were "category" variables ranked on a scale from 1-3 with 1 being the most desirable and included accessibility of entry points into the water, availability of parking and protection from ocean swell (considering the prevailing northwest swell). "Dichotomous" variables are yes-no attributes, either present or not, and included presence of a boat launch, presence of bathrooms and whether the harmful algal bloom of 2011 affected the site.

Table 1 - Site attributes

Attributes	Variable name	Description	Type
Access	ACC	Difficulty of access to the water from parking area, often determined by steep terrain.	Category: 1-3 1 = easy, safe access 3 = most difficult or dangerous access
Boat launch	BL	Existence of a boat launch.	Dichotomous: 0 = no 1 = yes
Parking	Parking	The availability of parking.	Category: 1-3 1 = abundant parking 3 = very limited parking

Bathrooms	Bath	Existence of public bathrooms.	Dichotomous: 0 = no 1 = yes
Exposure to ocean swell	PROTEC	The degree of protection afforded by geographic features to prevailing NW swells.	Category: 1-3 1 = least exposed 3 = most exposed
Harmful algae bloom	HAB	Site affected by 2011 harmful algae bloom.	Dichotomous: 0 = no 1 = yes
Pay for parking	PAY	Whether parking requires payment of a fee.	Dichotomous: 0 = no 1 = yes

Model specification

We assume that the welfare obtained by an individual i from a trip to the site j on occasion t is given by the following utility function:

$$U_{ijt} = \beta_1 TC_{ij} + \beta_2 ACC_j + \beta_3 BL_j + \beta_4 Parking_j + \beta_5 Bath_j + \beta_6 PROTEC_j + \beta_7 HAB_j + \beta_8 PAY_j + \mu_{ijt} \quad [8]$$

In this equation TCij is the travel cost from each i-th individual´s origin to the destination j.

Travel cost includes the cost of operating a vehicle, for which we used the federally specified rate of $0.565 per mile for 2013. To this we added the opportunity cost of time traveling and spent at the recreation site. Common practice is to use a fraction, which we set at 0.5, of the person's wage. We encountered a gap in the data because many of the respondents to the telephone survey declined to provide income information and no income data is contained in the report card database. The model was therefore estimated with two variants on the definition of travel cost. For those respondents without income data, we used the average income for their zip code of residence. We ran one regression using only the driving cost, TC1, in order to use the whole sample with consistent data for every trip. This approach obviously underestimates the travel cost and, consequently, recreational value, representing therefore a lower bound. TC2 uses income data (both individual and zip code) and adds four hours spent at the dive site (in and out of the water) to calculate the travel cost.

Welfare measures

Calculating willingness to pay (WTP) is complex with this kind of model and ours is especially involved since there are over 50 alternative choices for sites to collect abalone. The generic formula for WTP is known as the "log-sum" formula and is given by:

$$WTP = \frac{1}{\theta}\left[\ln \sum_{j=0}^{J} e^{V_j^1} - \ln \sum_{j=0}^{J} e^{V_j^0}\right]$$

Where j represents the recreation site, j=1, 2, ..., J, and superscripts 0,1 represent the initial and final situations, respectively. θ is the coefficient on travel cost (in absolute value). The final situation is characterized by whatever policy (or, generically, change) we are evaluating, which could include a change in a site's attributes, that is, in elements of every Vj, or elimination of one or more sites. In this latter case, the site(s) in question simply disappear from the sum of values of all the sites.2

On the other hand, if the quality of an attribute changes for all sites, the WTP is:

$$WTP = \frac{\beta_1 \Delta X}{\theta}$$

The coefficients βi capture preferences for various levels of the attribute. A positive and significant coefficient (βi > 0) means that the increase in in the attribute results in a higher likelihood that the site is selected. The other relevant coefficient for calculating the WTP is θ, which captures the reduction in an individual's utility as the travel cost rises.

Regressions were run in the Stata software package. We present results from a conditional logit model using TC1 and TC2 and a mixed logit model using TC1. The mixed logit regression is provides a useful comparison because it more effectively accounts for "unobserved" heterogeneity among users, that is, the variation in characteristics of abalone users that may affect their site choice but are not specifically included as variables in the model due to data constraints.

2.2 Results

In Table 2 we present the results of three regressions using alternative econometric models and treatments of the travel cost, as discussed above.

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[2] In other words, we replace $\sum_{j=0}^{J} e^{V_j^1}$ with $\sum_{j=0}^{J_k} e^{V_j^1}$ in which $J_k < J$.

Table 2 - Travel cost regression results

	Model 1	Model 2	Model 3
	TC1	TC2	TC1 mixed logit
TC1	-0.0173***		-0.0221***
	(-18.73)		(-19.93)
TC2		-0.00919***	
		(-18.56)	
Access	0.114*	0.105*	-0.0815
	(2.41)	(2.23)	(-0.99)
Boat launch	0.574***	0.575***	0.692***
	(7.94)	(7.95)	(4.18)
Parking	0.0764	0.0847	0.0679
	(1.40)	(1.55)	(0.87)
Bathrooms	0.627***	0.626***	0.817***
	(7.40)	(7.38)	(6.47)
Exposure to ocean swell	-0.377***	-0.373***	-0.374***
	(-8.03)	(-7.99)	(-4.54)
Harmful algal bloom	-1.470***	-1.421***	-2.932***
	(-15.90)	(-15.58)	(-10.30)
Pay for parking	0.0758	0.0755	-0.516**
	(1.08)	(1.08)	(-2.85)
SD			
Access			1.098***
			(9.16)
Boat launch			2.677***
			(9.57)
Parking			1.061***
			(8.82)
Bathrooms			1.336***
			(6.33)
Exposure to ocean swell			1.533***
			(13.86)
Harmful algae bloom			3.051***
			(9.78)
Pay for parking			3.820***
			(10.11)
N	77520	77163	77163

t statistics in parentheses * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Travel cost coefficients are significant and negative all models. Boat launch, bathrooms, exposure to ocean swell and HAB are highly statistically significant (99.9 percent confidence level) with the expected sign. Paying to park is significant only in the mixed logit model and accessibility is significant at the 95 percent level in the TC1 and TC2 conditional logit models. HAB has the largest coefficient (impact on site choice), which is perhaps unsurprising because the 2011 algae bloom along the Sonoma coast has caused closure of some sites and severly diminished the abundance of abalone at those sites still open.

The lower section of the table shows the standard deviations of the parameters for the mean of each variable, which are shown in the top part of the table. The important thing to take away is that these standard deviation numbers are large and significant, which means that there is a great deal of variation in the importance of attributes to different people, indeed that there may be groups of distinct users who diverge dramatically in whether they value a given attribute. If those categories of users can be identified, the analysis can be repeated to study the value of attibutes by group.

The model presented here can also be used to determine the value of increasing the level of an attribute for one site of a group of sites. For example, if planners wish to determine the value of adding bathrooms to a handful of sites that currently lack them, we can switch the value of that attibute from 0 to 1 for those sites and show the economic benefit to divers. Likewise if trail work is considered to improve access to certain sites, the economic benefit of the change can be estimated with this model.

Table 3 - Value of access to each site and the activity of abalone recreation overall

		Model 1: TC1				Model 2: TC2			
COUNTY	**SITE**	mean	SD	min	max	mean	SD	min	max
Del Norte	Crescent City	-0.33	2.83	-41.23	-0.02	-0.54	3.44	-49.27	0.00
Del Norte	Other Del Norte County	-0.25	0.88	-7.28	-0.03	-0.53	1.91	-17.00	-0.01
Humboldt	Trinidad	-0.54	1.93	-17.03	-0.06	-1.22	4.73	-45.08	-0.03
Humboldt	Punta Gorda	-0.20	0.37	-2.88	-0.06	-0.43	0.70	-6.53	-0.04
Humboldt	Shelter Cove	-0.88	1.07	-9.96	-0.34	-1.75	1.74	-16.78	-0.31
Humboldt	Other Humboldt County	-1.07	1.41	-14.39	-0.41	-2.14	2.28	-23.80	-0.34
Mendocino	Usal	-0.94	0.49	-3.97	-0.58	-1.86	0.88	-6.00	-0.54
Mendocino	Hardy Creek	-0.79	0.31	-2.70	-0.49	-1.51	0.56	-4.32	-0.54
Mendocino	Abalone Point	-1.03	0.38	-3.57	-0.56	-1.99	0.70	-5.73	-0.75
Mendocino	Westport	-0.73	0.27	-2.49	-0.38	-1.39	0.50	-3.98	-0.52
Mendocino	Bruhel Point	-0.27	0.10	-0.84	-0.13	-0.52	0.18	-1.36	-0.20
Mendocino	MacKerricher State Park	-1.37	0.45	-3.02	-0.46	-2.61	0.84	-6.08	-1.16
Mendocino	Glass Beach	-1.47	0.48	-3.05	-0.44	-2.78	0.89	-6.83	-1.30
Mendocino	Georgia Pacific Mill	-1.68	0.54	-3.40	-0.48	-3.14	0.99	-7.52	-1.43
Mendocino	Todd's Point	-1.30	0.41	-2.54	-0.36	-2.41	0.74	-5.51	-1.05
Mendocino	Hare Creek	-1.62	0.51	-3.18	-0.45	-3.06	0.95	-7.02	-1.33
Mendocino	Mitchell Creek	-0.64	0.15	-1.11	-0.16	-1.21	0.27	-2.41	-0.47

Mendocino	Jughandle State Reserve	-1.05	0.21	-1.73	-0.25	-1.95	0.39	-3.63	-0.70
Mendocino	Caspar Cove	-1.52	0.29	-2.48	-0.35	-2.88	0.55	-5.16	-0.99
Mendocino	Russian Gulch State Park	-2.70	0.49	-4.56	-0.59	-5.04	0.89	-8.57	-1.62
Mendocino	Jack Peters Gulch	-0.75	0.13	-1.27	-0.16	-1.41	0.23	-2.29	-0.44
Mendocino	Mendocino Headlands	-2.31	0.40	-4.03	-0.49	-4.29	0.73	-7.12	-1.31
Mendocino	Gordon Lane (Spring Ranch)	-0.46	0.07	-0.76	-0.09	-0.88	0.14	-1.38	-0.25
Mendocino	Van Damme State Park	-2.61	0.41	-4.16	-0.50	-4.86	0.77	-7.45	-1.32
Mendocino	Dark Gulch	-1.05	0.16	-1.53	-0.19	-1.97	0.29	-2.75	-0.48
Mendocino	Albion Cove	-2.99	0.45	-4.41	-0.50	-5.54	0.82	-7.62	-1.27
Mendocino	Salmon Creek	-0.83	0.12	-1.21	-0.14	-1.53	0.22	-2.10	-0.34
Mendocino	Navarro River	-1.98	0.30	-2.92	-0.30	-3.67	0.53	-5.16	-0.74
Mendocino	Elk	-2.45	0.42	-4.63	-0.36	-4.53	0.73	-7.41	-0.80
Mendocino	Point Arena Lighthouse	-0.90	0.19	-1.54	-0.08	-1.68	0.33	-2.63	-0.16
Mendocino	Point Arena (Arena Cove)	-3.60	0.84	-5.32	-0.26	-6.58	1.44	-9.03	-0.48
Mendocino	Moat Creek	-3.14	0.76	-4.64	-0.21	-5.74	1.32	-7.94	-0.39
Mendocino	Schooner Gulch	-1.03	0.26	-1.52	-0.07	-1.89	0.46	-2.64	-0.12
Mendocino	Anchor Bay	-1.14	0.33	-1.72	-0.06	-2.18	0.62	-3.16	-0.10
Mendocino	Robinson Point	-0.21	0.07	-0.32	-0.01	-0.40	0.12	-0.59	-0.02
Sonoma	Gualala Point	-0.34	0.11	-0.48	-0.01	-0.63	0.20	-0.94	-0.02
Sonoma	Sea Ranch	-0.58	0.19	-0.82	-0.02	-1.09	0.36	-1.67	-0.03
Sonoma	Black Point	-0.42	0.14	-0.60	-0.01	-0.79	0.27	-1.28	-0.02
Sonoma	Stewart's Point	-0.49	0.17	-0.71	-0.01	-0.93	0.33	-1.54	-0.02
Sonoma	Rocky Point	-0.22	0.08	-0.32	0.00	-0.42	0.15	-0.72	-0.01
Sonoma	Horseshoe Cove	-0.60	0.21	-0.86	-0.01	-1.13	0.42	-1.98	-0.02
Sonoma	Fisk Mill Cove	-1.10	0.42	-1.60	-0.01	-2.07	0.81	-3.76	-0.04
Sonoma	Salt Point State Park	-1.07	0.41	-1.56	-0.01	-2.00	0.81	-3.76	-0.03
Sonoma	Ocean Cove	-1.11	0.43	-1.63	-0.01	-2.09	0.86	-4.04	-0.03
Sonoma	Stillwater Cove	-1.53	0.61	-2.25	-0.01	-2.87	1.20	-5.66	-0.04
Sonoma	Timber Cove	-0.99	0.39	-1.45	-0.01	-1.86	0.79	-3.77	-0.02
Sonoma	Fort Ross	-0.99	0.40	-1.46	-0.01	-1.85	0.80	-3.83	-0.01
Sonoma	Reef Campground (Pedotti)	-0.79	0.32	-1.17	-0.01	-1.47	0.65	-3.12	-0.01
Sonoma	Jenner	-0.41	0.17	-0.60	0.00	-0.76	0.35	-1.79	0.00
Sonoma	Bodega Head	-1.57	0.68	-2.37	0.00	-2.92	1.47	-7.82	-0.01
Marin	Tomales Point	-0.92	0.41	-1.56	0.00	-1.69	0.91	-5.44	-0.01
Sum EC per site		-58.97	0.85	-70.83	-58.77	-110.64	1.04	-120.52	-110.31
Total WTP for closure of all visited sites		-218.71	24.12	-256.81	-29.35	-405.84	43.36	-486.41	-86.94

Table 3 presents the absolute economic values, which we simulate as the loss in wellbeing per trip that would result from closing each abalone site individually while the rest of the sites remain open. The sites for which the losses are greatest are largely clustered between Albion and Fort Bragg on the Mendocino coast, with losses in the range of $2.50-$5.00 per trip.

The modest figures are explained by the fact that divers can simply opt for another of the long list of sites if only one is closed.

In the last line of the table we present the overall recreational value of the fishery, calculated as the economic loss associated with simultaneously closing all the sites, which is larger than the sum of losses of all the sites individually (shown in the second-to-last line) because it implies the total closure of the fishery. The loss is $219-406 per trip, depending on the model chosen. The 2013 telephone survey reports 30,678 fishers take on average 3.6 trips per year. Based on this data, the total net recreational value of the red abalone fishery in 2013 was between $24 based on the driving cost alone and $44 million when consider both driving cost and the time spent driving and on site.

Figure 1 - Total recreational value and report cards sold

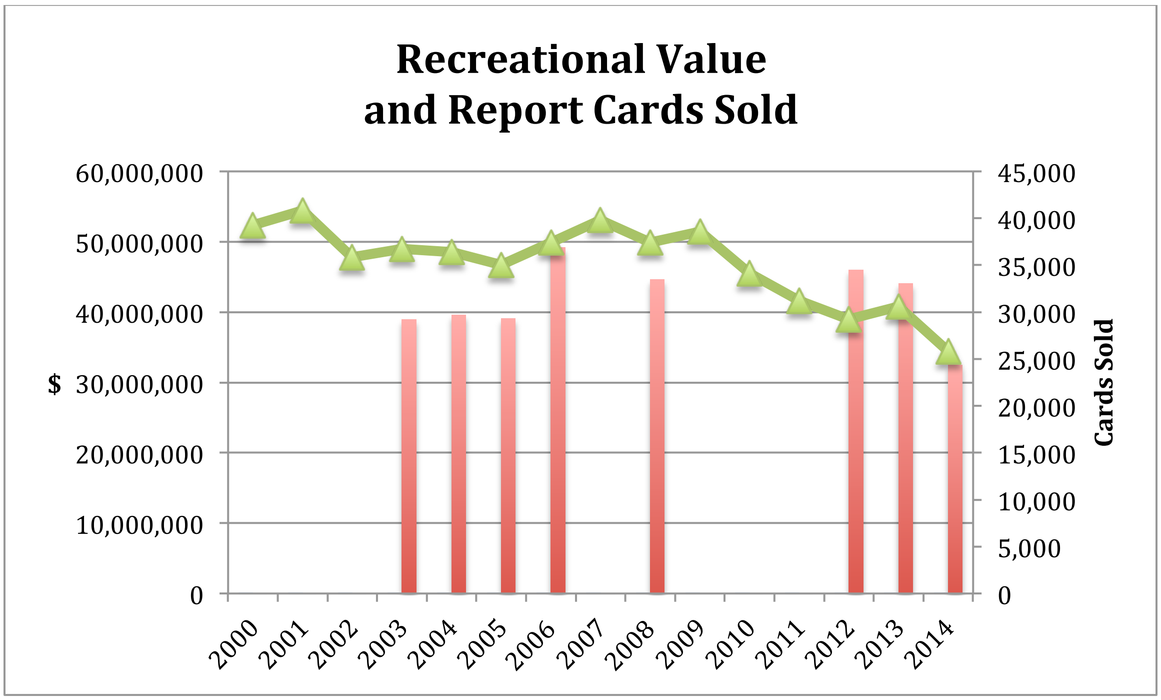


Figure 1 shows the recreation value for other years for which data on numbers of trips exists, extrapolating the per-trip values from 2013 to other years. The value of an individual trip should be expected to vary somewhat in response to year-to-year changes in economic, regulatory and environmental conditions, but the estimates in Figure 1 are a reasonble approximation. Total values in the early 2000s were slightly lower than for 2012-2013 due to a lower average number of trips taken per report-card holder. The steady decline in report card sales since 2009 accelerated in 2014, the first year for which data reflect the full impact of the HAB, including additional regulation and the closure of the Fort Ross site.

We consider the value estimates to be conservative because, due to data constraints, they are calculated based on driving cost alone (TC1), or the driving and time cost (TC2), excluding the money spent on other items during the trip in both cases and the value of time in the first. The data that do exist from the 2013 telephone survey, while not usable in the model indicate that other expenditures average around $349 per year, which, divided by an average of 3.6 trips adds $98 per trip. To put this figure into perspective, it is 52 percent as large at the $189 average driving cost for each trip.

3. Economic Impact

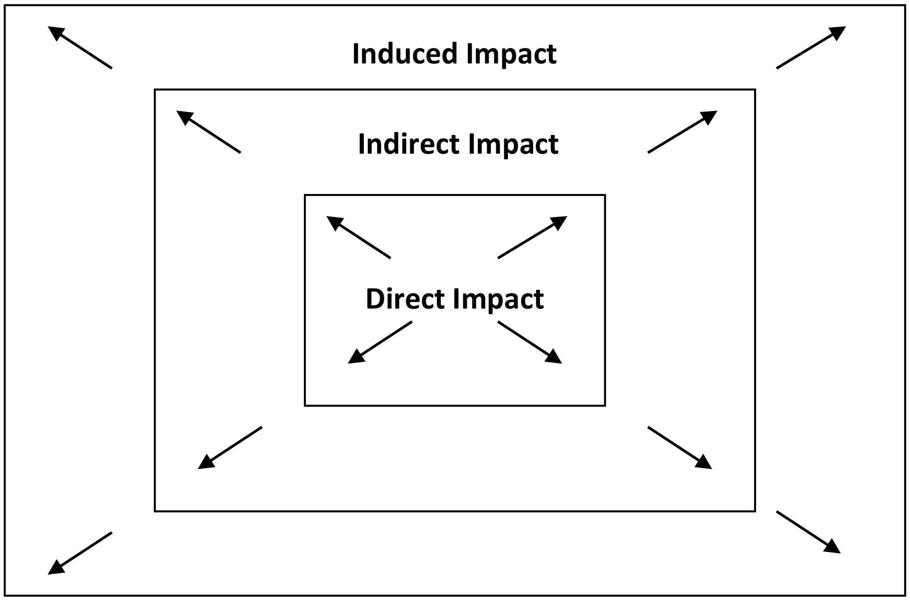
3.1. Methods

An industry's existence or expansion has ripple effects on a local economy and beyond, as a result of new incomes, jobs, and tax revenues supported and created. The IMPLAN model used here, which stands for IMpact analysis for PLANning (see www.implan.com for more), is used by municipalities and other organizations to analyze employment, revenue, wage, and tax effects of economic events. In our scenario, abalone fishing along the northern coast of California is the economic event of interest; we are trying to understand its economic connections to other industries throughout Mendocino and Sonoma counties. IMPLAN was used by Leeworthy and Schwartzmann (2015) to assess the economic impact of recreational fishing in marine sanctuaries along the California coast. While covering a broader area and range of fisheries, that study omits part of the area in Mendocino key for the abalone fishery.

This model has three impact classifications, summing to a total effect. The direct effects are those specific to the event or industry in question. For example, spending on travel, overnight stays, meals, fuel, and other related expenses incurred while traveling to the fishing locations and gathering abalone, generates an initial economic effect on local employment, tax and business revenues. Indirect effects originate with the direct incomes earned because hotel workers, gas station employees, grocery clerks, and other workers now have incomes supported by the abalone fishermen. These businesses and individuals spend a portion of their incomes from abalone fishing on yet other businesses' goods and services. More revenue, from business or employee spending, flows to even more businesses and leads to more employment, wages, revenue and taxes for merchants in the two counties. These additional jobs and revenues then represent induced effects.

The induced effects are similar to the indirect effects, but come from indirectly affected workers and firms and their economic gains, as well as new households that spend on a variety of businesses. For example, a new linen-service worker, hired due to a restaurant's expansion during the construction phases, may go to the grocery store, dry cleaners, or the doctor's office more often, which induces growth in local business revenues, employment and taxes.

Figure 2 - Economic impact concept



The sum of these effects is the total economic impact. The tables below are split into impact categories, where the top ten industries affected are shown explicitly, beyond the directly-affected industries. The new jobs and income are shown by the top industries affected; new receipts for the counties in question are shown by specific categories. Figure 2 shows the ripple effect idea of the multiplier process.

A telephone survey was conducted during the summer months of 2015 to generate a sample of economic and demographic information from holders of abalone licenses with the California Department of Fish and Wildlife. Respondents were asked to provide spending information in three ways:

- Total spending while on the trip;
- The proportions of spending by multiple counties visited (where most of the spending was in Mendocino and Sonoma counties);
- The proportion of spending on specific industries, including
    - Camping;
    - Hotel/Motel;
    - Food (grocery and restaurant);
    - Non-abalone fishing;
    - Fuel costs; and
    - Other entertainment while on the abalone trip.

3.2 Results

Average spending during abalone trips was approximately $599 annually per license holder. For the population of license holders, total spending was approximately $18,526,425. The survey results suggest that 82.7 percent of the spending is in Mendocino and 17.3 percent of the spending is in Sonoma County:

- Mendocino County = $15,368,400; and
- Sonoma County = $3,218,025.

These are the direct effects, spread across the six "industry" areas mentioned above. Notice that the industries affected beyond the direct industries (indirect and induced) in both counties are similar. This is due to similar spending patterns among workers and a similar mix of industries in the two counties. The spending patterns of people employed in the business patronized by divers have the largest proportions of their spending in medical, banking, retail, and other services industries.

Table 4 - Employment impacts in Mendocino County (number of full-time equivalent workers).

Industry	Direct	Indirect	Induced	Total
Bars and restaurants	75.1	1.9	3.9	80.9
Overnight accommodations	78.6	0.3	0.3	79.2
Other entertainment	40.5	0	0	40.5
Commercial fishing	9.5	0	0	9.5
Real estate	0	3.4	1.2	4.6
Retail - gasoline stores	4	0.1	0.1	4.2
Wholesale trade	0	1.1	0.7	1.8
Services to buildings	0	1.3	0.3	1.6
Individual and family services	0	0	1.6	1.6
Dry-cleaning and laundry services	0	1.3	0.2	1.5
Accounting and payroll services	0	1.3	0.2	1.5
Hospitals	0	0	1.4	1.4
Retail - general merchandise stores	0	0.6	0.7	1.3
Investment Banking	0	0.8	0.3	1.1
All Others	0	13.2	15.5	28.7
Totals	207.7	25.3	26.4	259.4

Businesses affected in Mendocino County include real estate, wholesale, accounting and bookkeeping businesses, health care, investment banking, banks and credit unions. Other retail beyond gas stations and grocery stores are also affected as local workers are supported and businesses generate more revenue. In addition, apartment rental and rental home incomes are influenced. Many of the industries where jobs are supported also experience revenue support from these abalone fishermen.

Table 5 - New business revenues in Mendocino County (1000s of 2015 dollars)

Industry	Direct	Indirect	Induced	Total
Bars and Restaurants	$5,827,000	$128,000	$230,300	$6,185,300
Overnight Accommodations	5,590,600	23,500	31,200	5,645,300
Other Entertainment	2,328,600	1,700	2,500	2,332,800
Commercial fishing	922,800	300	-	923,100
Real estate	-	621,500	214,600	836,100
Retail - Gasoline stores	646,000	12,700	19,800	678,500
Rental Income for Property Owners	-	-	547,900	547,900
Wholesale trade	-	230,100	140,200	370,300
Hospitals	-	-	203,700	203,700
Other local government enterprises	-	119,200	82,800	202,000
Maintenance and repair construction, commercial	-	162,200	25,600	187,800
Management of companies and enterprises	-	167,900	16,000	183,900
Banks and Credit Unions	-	67,400	95,300	162,700
Lessors of nonfinancial intangible assets	-	102,500	6,000	108,500
All Others	200	1,531,200	1,516,500	3,047,900
Totals	$15,315,200	$3,168,200	$3,132,400	$21,615,800

Table 6 - Local tax impact for Mendocino County, annualized 2013 dollars.

Type of Tax Receipts	Amount
Employment Taxes	28,000
Sales taxes – State	478,000
Sales Taxes – Local	82,700
TOT	564,530
Property taxes	490,600
Personal Income	252,300
Other Taxes and Fees	168,200
Total State and Local taxes	$2,064,330

The sales tax rate in Mendocino County ranges from 7.625 percent (unincorporated Mendocino County) to 8.125 percent (e.g., Ukiah). The state base begins at 6.5 percent and adds another one percent to get to 7.5 percent, where the one percent is for local governments. Hence, the local portion of the sales tax ranges from 1.125 percent to 1.625 percent. We will use 1.125 percent to break out the local sales tax estimate from the total, and add property taxes. There is an additional, local tax based on hotel stays, the transient occupancy tax (TOT). This estimate is based on 10 percent of hotel and accommodations revenue, as we assume all revenue there is room-related (restaurants in hotels would be under "Bars and restaurants"). Property taxes are assumed to be one percent of the current assessed value of land in Mendocino County. Additional property taxes are associated with both new construction and improvements to existing structures, as well as any reassessments allowed under Proposition 13.

Table 7 - Employment impacts in Sonoma County. Number of full-time equivalent workers.

Industry	Direct	Indirect	Induced	Total
Other Entertainment	18.2	0	0	18.3
Bars and Restaurants	16	0.5	1	17.5
Overnight Accommodations	7	0	0.1	7.1
Retail Stores - Gasoline stations	1.7	0	0	1.8
Real estate establishments	0	0.4	0.3	0.7
Commercial Fishing	0.6	0	0	0.6
Employment services	0	0.5	0.1	0.6
Services to buildings and dwellings	0	0.4	0.1	0.5
Wholesale trade businesses	0	0.2	0.3	0.5
Medical and Dental Offices	0	0	0.5	0.5
Accounting and payroll services	0	0.3	0.1	0.4
Maintenance and repair construction	0	0.3	0.1	0.3
Retail Stores - Grocery	0	0	0.3	0.3
Private hospitals	0	0	0.3	0.3
Nursing and residential care facilities	0	0	0.3	0.3
Investment Banking	0	0.1	0.2	0.2
Advertising and related services	0	0.2	0	0.2
All Others	0	2.8	4.3	7.1
Totals	43.5	5.7	8	57.2

Table 8 - New business revenues in Sonoma County. 1000s of 2015 dollars.

Industry	Direct	Indirect	Induced	Total
Other Entertainment	$1,132,900	$400	$2,600	$1,135,900
Bars and Restaurants	1,020,500	32,200	63,800	1,116,500
Overnight Accommodations	864,300	5,500	9,800	879,600
Retail Stores - Gasoline stations	179,200	400	5,200	184,800
Rental Income for Property Owners	-	-	161,200	161,200
Real estate establishments	-	76,000	48,900	124,900
Wholesale trade businesses	-	43,400	59,400	102,800
Commercial Fishing	74,300	-	-	74,300
Bank and Credit Unions	-	22,500	41,100	63,600
Medical and Dental Offices	-	-	59,400	59,400
Private hospitals	-	-	50,100	50,100
Management of companies and enterprises	-	36,000	6,200	42,200
Telecommunications	-	21,700	16,900	38,600
Maintenance and repair construction, commercial	-	31,400	5,900	37,300
Advertising and related services	-	30,300	4,500	34,800
Accounting and payroll services	-	27,000	6,800	33,800
Services to buildings and dwellings	-	26,400	6,600	33,000
All Others	-	428,200	489,900	918,100
Totals	$3,271,200	$781,400	$1,038,300	$5,090,900

The data on Sonoma County are similar to those in Mendocino County. Advertising, telecommunications, and other building services are slightly more important in Sonoma than in Mendocino, likely because the former has larger and more numerous advertising and telecommunications businesses. Also, Mendocino County residents likely patronize some of these Sonoma County businesses.

Table 9 - Local tax impact in Sonoma County. Annualized 2013 dollars.

Type of Tax Receipts	Amount
Employment Taxes	$6,550
Sales taxes - State	115,100
Sales Taxes – Local	31,000
TOT	88,100
Property taxes	116,900
Personal Income	58,500
Other Taxes and Fees	29,200
Total State and Local taxes	$445,350

For Sonoma County, sales and TOT rates are more complex than in Mendocino County. TOT rates range from 10 to 12 percent depending on the municipality where a visitor stays. While we assume that the abalone fisherman generally stays in a coastal setting where room and TOT rates are higher, we will use 10 percent again here as the default rate to generate a conservative estimate. Sales tax rates range from 8.25 percent to 9.25 percent, where 8.25 percent is 1.75 percent more than the state base rate not committed to local areas. Property taxes, as a state tax assessed locally, are considered the same in Sonoma County as in Mendocino (though in both counties there are parcel taxes added in some municipalities to the base of 1 percent).

These data show that abalone fishermen in Mendocino and Sonoma counties have an economic effect and connections to many industries. If we divide the total business revenue figures by the number of report card holders we see that in Mendocino County divers generate around $599 directly and $843 in total, plus $44 in tax revenue. In Sonoma the figures are similar: $609 direct, $948 total and $44 in taxes. The number of jobs supported per fisherman is negligible. The total impacts are modest compared to the overall size of the counties' economies, particularly the diversified economy of Sonoma. But the positive impact of this activity is disproportionately concentrated in the relatively remote coastal areas of the two counties and therefore has a greater relative importance than the raw numbers suggest. Data on the size of the economies of the coastal areas, some of which are unincorporated, are not available.

Table 10 - Summary economic impact data

	Direct Mendocino	Total Mendocino	Direct Sonoma	Total Sonoma
Business Income Supported	$15,315,200	$21,615,800	$3,271,200	$5,090,900
Jobs Supported	207.8	259.5	43.6	57.2
Local Tax		$1,137,830		$235,900

Revenues				
Per Fisherman				
Business Income Supported	$599.00	$843.28	$609.50	$948.56
Local Tax Revenues		$44.39		$43.95

4. Value of Increased Management

4.1 Methods

To determine willingness to pay for an increase in management and enforcement effort, a contingent valuation (CVM) analysis was performed. Whereas the TCM values the recreational experience itself at a particular moment in time based on actual behavior of visitors, a CVM estimates the value placed on a change in the resource or management of the resource based on something akin to an opinion survey. Together, the two can provide insight into the value of the activity and the impact of changes to the current regulations. The methods have been used together in various studies, such as Huppert (1989), that analyzed the value of recreational activities. CVM analyses can also provide insight into reactions to possible future situations (Lee & Han, 2002).

A CVM uses participants' responses to questions concerning their WTP to maintain or improve a certain resource, or asks what compensation they would have to be offered to willingly see the resource diminished. After determining the influence of demographic variables upon these responses an approximate WTP for the hypothetical market situation can be assigned to the resource or activity.

The CVM used data from an online survey of abalone report card holders. Of 1637 responses a sample of 1521 valid observations was used. Because they were not sampled randomly the results cannot be treated as a completely reliable reflection of the population of abalone fishermen. Nonetheless the data is considered relevant enough by CDFW to use as an input to management decisions. In order to determine the maximum WTP for "more active management and increased enforcement to reduce poaching" respondents were asked the maximum price of an abalone report card they would be willing to pay. The choices included $30, $40, $50 and an open ended "no more than" question with a blank space for participants to write their maximum price.

The survey's presentation of the current and various higher prices simultaneously, plus an open-ended option may have helped counter anchoring bias, wherein an answer is influenced by the respondent's being exposed to a potential price before formulating their own answer. A similar attempt to minimize this bias in a recreational CVM context was used by Greiner & Rolfe (2003), who informed survey participants of the current price, gave them the option of determining their own WTP with the open-ended question, and also gave them a variety of potential increases to serve as reference points and help counteract implausibly high stated WTP in the open-ended response.

When participants both selected a given value and entered a value in the open-ended question, the maximum stated price for each respondent was the value used for the analysis. Participants who stated $0 as their maximum were assumed to have a maximum WTP of $22.17, the current price for a report card, as they had shown they were willing to pay at least that amount. "Protest" responses were removed from the sample. These are responses where a $0 value is motivated by something other than WTP, such as a general distrust of government or lack of confidence in the payment mechanism. Protest responses were identified by respondent comments associated with this question.

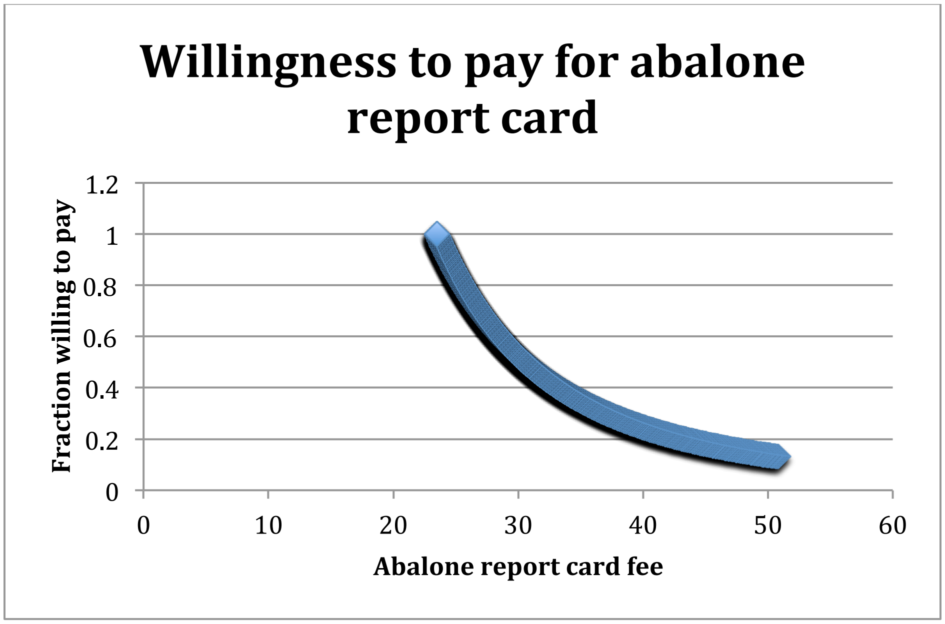
For an income variable, we used average income by zip code. These values, along with number of years fishing were identified as possible influences on WTP. We took the natural log of the willingness to pay value, rank ordered them and created another log-transformed variable for rank. The final regression, predicted log of willingness to pay based on log of rank, income, and years of fishing experience and had an $R^2 = 0.78$, indicating a strong explanatory power. We reversed the logarithmic transformation to obtain absolute monetary values and create a demand curve.

4.2. Results

The average willingness to pay for more active management and enforcement to reduce poaching was found to be $34.30 (median of $33.82). The results suggest that the average permit holder would be willing to pay something like $12 more for their abalone report card if it meant that more resources would be dedicated to combatting abalone poaching. The personal characteristics included in the regression, income (by zip code) and years fishing were statistically significant but not strong predictors of willingness to pay. The coefficients of influence were 1.29e-06 and .0001046 for income and years fishing respectively.

If mean WTP value were applied to the entire population of some 31,000 anglers, $372,000 in additional revenue would be raised. However we should expect that an increased fee would result in some decrease in participation in the fishery. In theory, about half of the current participants would quit fishing if the fee increase is equal to the average additional willingness to pay. The net loss in permit revenue from that reduction in participation would be at least $158,000, before considering that some anglers would opt not to purchase the general fishing license needed in addition to the abalone report card. At an increase half as large, $6, for a total fee of $28.17, our analysis predicts participation would decline by 37 percent. The net decline in CDFW revenue would be around $140,000.

Figure 3 - Willingness to pay for more management and enforcement



Our intuition is that the reaction to higher prices would not be as dramatic as suggested by these calculations, based on the way people answer survey questions and other evidence we have about the value of abalone recreation. For example, there are two key forms of respondent bias at play here that may skew results. One is *hypothetical bias*, which affects respondents' answers when the scenario presented isn't real, likely, plausible or understandable. If the scenario is not something they really think is going to happen, responses may be wildly different from their demonstrated willingness to pay for an abalone permit. Divers may overbid if they really want the state to spend more to stop poaching and don't think they will actually have to pay for it. *Strategic bias* would work the opposite way in this case. A respondent gives a value in an attempt to drive an outcome that benefits him. If he thinks the state really *will* raise the price of a permit based on the survey, he may state a value much lower than that which he's prepared to pay. We expect strategic bias is more likely to be at play in this very real and plausible scenario, which will tend to have depressed the stated willingness to pay.

Further, given the substantial expenditures made by people to acquire the necessary gear and travel to abalone sites, a substantial majority of those whose bids fell under the $34 mean/median would still pay for the permits at that price. As noted above, the average non-travel expenditures for participants in 2013 were around $98 per trip and average vehicle costs were $189. And, abalone diving tends to be a lifelong activity. The average age is 45 and average years diving is 20; people have shown that they will continue diving though years of regulatory, fee and environmental changes.

5. Discussion and Conclusions

The analyses carried out here show that tens of thousands of Californians derive hundreds of dollars – some over $1000 – each in enjoyment every year from recreational abalone fishing in the waters along the state's North Coast. Sustaining this fishery is worth, at a minimum, $24-44 million annually to the people who engage in it. These figures are very likely an underestimate of the total value because they are calculated based on a partial accounting of costs incurred by abalone fishers. We found that the choice of sites is strongly driven by natural protection from swells and avoiding areas affected by the 2011 harmful algae bloom, as well as the availability of facilities such as restrooms and boat launches. It's worth noting that abalone density data were for each of the 50+ specific sites and that algae bloom is the only variable actually linked to abalone abundance.

Despite the fact that abalone collectors have favorite sites to which they are strongly attached, our results suggest that the impact on the average harvester is minimal from the closure of any single site. Where the impact of losing the entire fishery is $219-$406 per trip, the maximum loss from closing any individual site in isolation is around $5 per trip, and much less than that for most sites. This finding is driven by the sheer profusion of sites from which users can choose to substitute for a site that's no longer available.

The tremendous value people get from the resource is not strongly reflected in the stated willingness to pay higher fees to fund its management and protection. Only half of those surveyed stated a willingness to pay an increase of $12 to improve management. We speculate that this finding is a result of "strategic bias" and to a perception on the part of legal fishers that they are already contributing their share to conserving the resource, which is also being used illegally by poachers. In other words, the underlying willingness to pay for increased health of the abalone population may well be higher and the results obtained here may say more about attitudes regarding permit fees and poachers than about protecting the fishery. If our conjecture is correct that the WTP is larger than predicted, modestly higher fees would not be a significant deterrent to participation in the fishery.

The economic impact analysis showed that abalone collecting contributes millions of dollars annually to the local economies of coastal Mendocino and Sonoma Counties. Some $22 million—over 80 percent of the impact—is in Mendocino, with the remaining $5 million in Sonoma. This proportion roughly matches the number of abalone taken from the two counties in 2013, suggesting that spending patterns are roughly similar in the two areas. Given the much smaller size of Mendocino's economy and the current concentration of abalone activity there, we expect that its impact is far more noticeable in the more northern county.

Our findings suggest that abalone is a key economic engine in some coastal areas and that sustaining the species' population has substantial economic return in terms of recreational value for over tens of thousands of Californians. Along with non-economic conservation rationales, these figures justify a significant level of management effort to curb the main threats to the species, notably poaching and overfishing. Finally, with respect to the legal fishery, we see scope for CDFW to continue to test regulations and incentives to reduce pressure on the species, while minimizing negative impacts of regulation on recreational values and the positive role this fishery plays in Northern California communities.

We would like to point to several future directions for economic analysis of the fishery. First, to enable quick and inexpensive replication of the travel-cost analysis of recreational benefits, we recommend that CDFW collect data on fishermen's trips explicitly, either in the reporting mechanism of the report card database, or in the annual telephone survey, or both (See Appendix 2). Second, if closing groups of sites is considered a potential management option, the economic consequences of such closures should be analyzed within the travel-cost model, which is well-suited for the purpose. Third, if fee increases to are contemplated to fund an expansion of anti-poaching and other management efforts, the response of fishers to fee changes should be more rigorously examined, using historical data on fees and possibly applying an adjusted willingness to pay question in a user survey. Fourth, the values for past years should be more precisely calculated based on detailed analysis of trips taken during those years. Finally, application of economic valuation techniques to other fisheries could yield useful information at CDFW decides how to allocate management effort across the range of resources under its care.

Appendix 1: Travel-cost model estimation

Discrete choice models have been widely used in fields of environmental economics research including tourism and recreational studies (Adamowicz, Louviere, & Swait, 1998); (Louviere, Hensher, & Swait, 2000). Based on the choice of the preferred alternatives, it is possible to obtain the underlying preference structure using statistical tools. The main advantage of this approach over other methods, such as contingent valuation, is its ability to characterize an asset or service as a function of its attributes, based on actual behavior. Thus, it is possible to assess the relative relevance of each attribute for the consumer, or, in our case, participant in a recreational activity (Louviere, Hensher, & Swait, 2000) (Train, 2009) (Train, 1998).

In a discrete choice model where people face several decision occasions, the utility level obtained by an individual n selecting site j in the choice occasion t is given by:

$$U_{njt} = V_{njt} + \varepsilon_{njt} \quad [1]$$

where V_{njt} represents a function of attributes observed for site j, individual characteristics n, and occasion decision t. The variable ε_{njt} is the analyst-unobserved random component that varies among individuals, alternatives and occasions. The individual will choose the site providing the maximum utility, so that (Train, 2009):

$$U_{njt} \geq U_{nkt} \Leftrightarrow V_{njt} - V_{nkt} \geq \varepsilon_{nkt} - \varepsilon_{njt} \;\; \forall k \neq j \quad [2]$$

The observed decision reveals the alternative that provides the largest utility but not its utility level because the random component is not known. Although we cannot determine whether inequality [2] is met with certainty, we can describe the probabilistic structure of the problem by specifying a distribution function for the random component. The probability that individual n chooses site i in occasion decision t is given by:

$$\mathrm{Prob}(Y_{nt} = j) = P_{ijt} = \mathrm{Prob}\left(\varepsilon_{nkt} \geq \varepsilon_{njt} + \left(V_{njt} - V_{nkt}\right)\right) \forall k \neq j \quad [3]$$

The assumptions on the random component distribution determine the probabilistic models adopted. The travel cost discrete choice model applications commonly use the conditional logit model specification, which assumes an identical and independent Gumbel-distributed stochastic component, among individuals and alternatives (Train, 2009). The conditional Logit model does not allow the random error to be correlated among alternatives and observations. This lack of correlation prevents considering different substitution patterns among pairs of alternatives and the common effect of unobserved individual factors in a sequence of independent decisions. The mixed Logit model can overcome both limitations. The probability that an individual makes a sequence of independent choices conditioned to coefficients α_{ni} and β_n is the product of the logit expressions established by equation [4]:

$$L_{ni}(\alpha_{ni}, \beta_n) = \prod_{t=1}^{T} \left[\frac{e^{\alpha_{ni} + \beta_n' x_{ni_t}}}{\sum_j e^{\alpha_{nj} + \beta_n' x_{n_j t}}} \right] \quad [4]$$

where x_{njt} are the observed attributes of the sites, which correspond to attribute levels and the characteristics of individuals; α_{ni} is a coefficient independent of attribute levels, but it varies among alternatives; and β is a vector of coefficients associated with the attribute levels and characteristics of individuals. To determine the unconditional probability, it is necessary to know the distribution function for those coefficients considered random among individuals. Most mixed logit model applications consider this distribution—called the mixing distribution—to be continuous and normal (Train 2009 p. 136). We can represent the normal mixing distribution as $f(\beta \mid b,W)$, where β is a vector containing all of the coefficients assumed to be random including those of alternative intercepts, b corresponds to the vector of the means, and W indicates the covariance matrix. Because an analytical expression for the choice probability (unconditional) cannot be obtained, simulation methods have been developed that allow assessing the integral of the probability for given values of β and W. Values for β are generated from the distribution $f(\beta \mid b,W)$ called β^r, which in turn allows calculating the value according to the expression of the logit probability $L_{ni}(\beta^r)$. The simulated unconditioned probability of choosing alternative i, $\breve{P}_{ni}$, is obtained as the average of the results obtained in R simulations. Since mixed logit models are more general than conditional logit models and have come to dominate the literature, we estimated both.

Appendix 2: Data for Future Analyses

In order to quickly replicate the recreational valuation for future years CDFW should strive to compile in a single dataset the trips taken by a random sample of ~500 individual abalone collectors. Information would include:

[In brackets we indicate whether the data is now collected in the telephone survey (TS) or report card database (RC), or both].

- Individual information:
- ID number [TS, RC]
- Origin city or zip code [RC]
- Income (as a range category) [TS]
- Characteristic that defines preferences (use of boat; rockpicker; etc.) [TS]
- Number of trips [TS]
- Information for each trip
    - Number of abalone fishermen traveling in same vehicle
    - Destination site visited [RC, reported for # of abalone, not trip]
    - Date [RC, reported for # of abalone, not trip]
    - Time spent per trip
    - Non-vehicle expenditures [TS]
- Site attributes
- Include question about attributes in future TS to adjust attributes used in regressions.
- Data on abalone abundance

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