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# The Non-Market Value of Private Recreational Boating in the Channel Islands National Marine Sanctuary

A 2012-2013 Group Project

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## Abstract

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The Channel Islands National Marine Sanctuary provides environmental, economic, and social value to a variety of users. A lack of information on private recreational boaters (PRBs) limits the ability of managers to integrate the comprehensive socioeconomic value of the Sanctuary into policy. A particular gap exists in the understanding of non-consumptive PRB use of the Sanctuary. To address this need, our project analyzes data on spatial use patterns of PRBs through a multinomial logit Random Utility Model. The model estimates that non-consumptive PRBs receive a consumer surplus of \$53.25 per trip. Taking into account the average number of boat trips per year, the total non-market value of non-consumptive private recreational boating is conservatively estimated to be \$86,325 annually. The model demonstrates that boaters have a preference for sites with greater species richness and abundance. Furthermore, PRBs were shown to associate a positive monetary value with this biological quality. Our findings advance the understanding of how an underrepresented stakeholder group associates value with the Sanctuary and confirms the socioeconomic importance of biological quality. This project demonstrates the feasibility of applying a Random Utility Model to recreational use of a National Marine Sanctuary and presents recommendations on future research of this nature. Additionally, our study is relevant to the non-market valuation of coastal and marine recreation worldwide. The results can be used in management decisions that affect marine resources and the stakeholders who value them.

### **Disclaimer:**

*The views and recommendations in this report represent those of the authors and are not necessarily endorsed by the Channel Islands National Marine Sanctuary or NOAA.*

## Commonly Used Acronyms

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<i>CDFW</i>	California Department of Fish and Wildlife (formerly Department of Fish and Game)
<i>CINMS</i>	Channel Islands National Marine Sanctuary
<i>MPA</i>	Marine Protected Area
<i>NOAA</i>	National Oceanic and Atmospheric Administration
<i>PRB</i>	Private Recreational Boater
<i>PISCO</i>	Partnership for Interdisciplinary Studies of Coastal Oceans
<i>RUM</i>	Random Utility Model
<i>SAC</i>	Channel Islands National Marine Sanctuary Advisory Council

## Executive Summary

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The Channel Islands National Marine Sanctuary (CINMS or Sanctuary) encompasses an area of 1,470 square miles around five of the eight Channel Islands in California: Anacapa, Santa Cruz, Santa Rosa, San Miguel, and Santa Barbara (Channel Islands National Marine Sanctuary Management Plan, 2008). Accessible by a boat ride from the heavily populated Southern California Bight, it is an ideal location for many commercial uses, research interests, and recreational pastimes. Within the Sanctuary is a network of eleven no-take marine reserves and two limited-take marine conservation areas (“Marine Reserves Network Map”, 2012). With nationally significant cultural and biological resources, the Sanctuary is responsible for maintaining the natural biological communities and, where appropriate, restoring and enhancing the natural habitats, populations and ecological processes (National Marine Sanctuary Act, 2000). A federal advisory body known as the Sanctuary Advisory Council (SAC) provides advice to the Sanctuary Superintendent on a variety of sanctuary management issues. Management decisions regarding where to focus limited resources are based on knowledge of how stakeholders value the Sanctuary.

In general, the benefits that users gain from engaging in private boat-based recreational activities, such as kayaking, sport fishing, or diving are not well understood. Research on this user group is identified as a priority in the Social Science Plan (Channel Islands National Marine Sanctuary Social Science Plan, 2007). In particular, information is lacking on a subgroup of these stakeholders, non-consumptive users, who participate in activities that involve no “take” of marine resources (e.g. snorkeling, wildlife viewing, and kayaking). In contrast to other uses of the Sanctuary, such as recreational charter operations or commercial fishing, private recreational boating is not associated with a direct monetary value because these activities do not take place within a market. As a result, the interests of PRBs have the potential to be underrepresented in policy, and the resources on which they depend may be at risk of being undervalued.

Using non-market valuation techniques, this project provides CINMS managers with monetary values for private recreational boating and reports the value these stakeholders associate with the Sanctuary’s resources. To do this, we used an empirically-driven economic model that translates the choices of PRBs into direct monetary value. Data from a survey collected in 2006 and 2007 on PRBs’ utilization of the CINMS indicated which sites and activities individuals chose for recreation (LaFranchi and Pendleton, 2008). These individual choices were then correlated with site-specific biological and physical characteristics using a Random Utility Model (RUM) in order to evaluate which characteristics influence boaters’ site choice. By integrating travel cost into this analysis, the value of a trip to the Sanctuary was monetized. The marginal value of site characteristics was also obtained using travel cost data and represents what boaters would be willing to pay for a particular characteristic. The analysis considered variation in behavior and value estimates associated with four PRB activity categories: underwater non-consumptive, surface non-consumptive, consumptive, and land-based. Non-consumptive underwater activities were prioritized for the analysis.

The model suggests PRBs receive a positive monetary benefit from trips to the Sanctuary ranging from \$34.72 to \$53.69. The value of a trip did not vary significantly across different activity categories, suggesting that all PRBs value the sanctuary similarly. The total non-market value for non-consumptive

PRBs was estimated to be at least \$86,325 annually. Regardless of activity category, all boaters were found to be positively influenced by biological characteristics and negatively affected by site exposure. Biological characteristics were considered as a composite index of fish species richness and abundance with invertebrate species richness and abundance. The marginal willingness to pay for one unit of this biological index (range of 16) varied from \$10.11 to \$16.78. Site exposure, which was measured as the angle between the predominant winds and the coastline (range of 165), was associated with a negative marginal cost between \$ - 1.32 and \$ - 0.91.

Our results advance the understanding of a poorly understood stakeholder group by providing a monetary, non-market value of private recreational boating within the Sanctuary. This number may be used when evaluating policies that affect this stakeholder group. However, due to limitations of the model, \$86,325 should be considered a conservative lower bound estimate. PRB values per trip are consistent with similar recreational activities in coastal and marine environments (Leeworthy et al., 2005, Leeworthy and Wiley, 2003; Kaval and Loomis 2003). The model also indicates that PRBs receive a positive monetary benefit from visiting the Sanctuary, and that biological resources and exposure of the site to wind/weather are significant factors that affect where PRBs chose to recreate. Our model suggests that management actions that improve the biological quality within the CINMS, such as water quality and resource protection, prohibition of habitat alteration, fisheries management, or MPAs all have the potential to increase the Sanctuary's value to the non-consumptive private recreational boating community. This report supplies a methodology for calculating how changes in biological quality (as measured by fish and invertebrate richness and abundance) can be translated into changes in the total non-market value of private recreational boating. Our data may be used in other Sanctuaries or similar marine recreation areas worldwide using benefits transfer methods to quantify how changes in biological characteristics affect values held by similar user groups.

As the first such model generated for a National Marine Sanctuary, the project validates the feasibility and relevance of socioeconomic modeling for the purpose of informing Sanctuary management. Additionally, this report highlights data gaps that can inform the design of future studies of this stakeholder group in addition to advancing the efficacy of other valuation projects within coastal and marine recreation. Our findings indicate that PRBs benefit from their interaction with the marine resources of the Sanctuary. This result contributes to the discussion of policies that impact this stakeholder group and the biological resources they value.

## Objectives

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The main objective of this project is to inform CINMS managers of the value that the Sanctuary provides to private recreational boaters. Non-consumptive users, which are underrepresented in Sanctuary literature and research, are prioritized in the analysis. To address the need for understanding these stakeholders, our project aims to:

- 1) Quantify both the value of a PRB trip to the Sanctuary and the annual non-market value of private recreational boating within the Sanctuary.
- 2) Determine the effect of biological and physical attributes on PRB site choice and quantify the marginal value of these attributes.

## Significance

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The most effective and informed management decisions involve the consideration of all stakeholders (Papadopoulos and Warin, 2007). The National Marine Sanctuaries Act guides the Sanctuary program, “to facilitate to the extent compatible with the primary objective of resource protection, all public and private uses of the resources of these marine areas not prohibited pursuant to other authorities” (National Marine Sanctuary Act, 2000). This implies a need for comprehensive information on how different stakeholder groups benefit from and interact with marine resources. The CINMS Social Science Plan (2007-2010) details a methodology to answer this need in the Channel Islands, but full implementation is constrained due to budget limitations. Research on recreational use is identified as a priority in the Social Science Plan. This project addresses this need (CINMS Social Science Plan, 2007). It also provides a profile of the behavior of non-consumptive PRBs, which is lacking within the literature and research. With a large subset of PRBs (47%) participating in only non-consumptive activities, our study supports efforts to incorporate a more comprehensive socioeconomic value of the Sanctuary into policy discussion (LaFranchi and Pendleton, 2008).

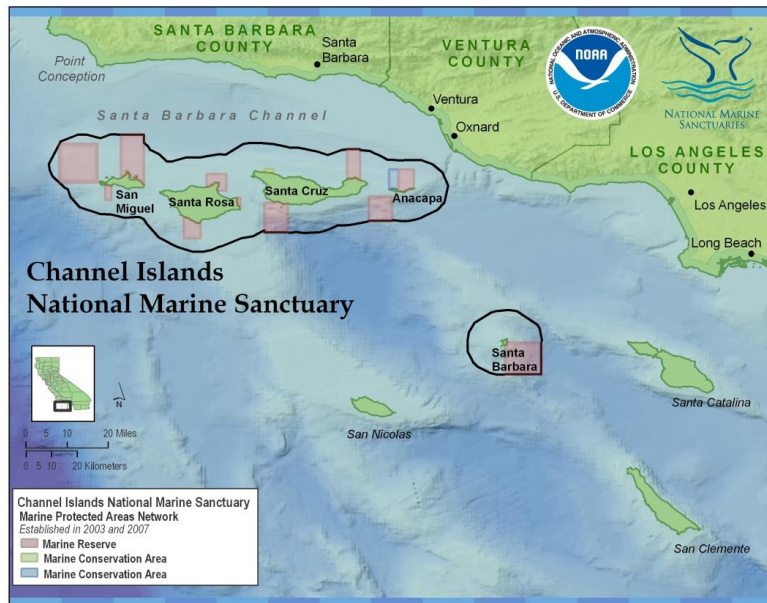
The lack of quantitative analysis on the factors influencing non-consumptive spatial behavior limits the ability of marine resource managers to incorporate those factors into management decisions (Channel Islands NMS Social Science Plan, 2007). Identifying site characteristics around the Sanctuary that are important to PRBs supports policy discussions about these characteristics. The results of our study may be used to determine how changes in biological aspects of the Sanctuary affect the total non-market value of private recreation boating. Furthermore, our research provides a procedure for quantifying how changes in site-specific biological attributes result in changes in value.

Quantifying the socioeconomic value of the Sanctuary to PRBs requires the use of non-market valuation techniques, which have not previously been employed for this user group. Although the value some user groups receive from the Sanctuary may be easily quantifiable, such as revenue from commercial fisheries, quantifying the value that PRBs receive from recreation is not as straightforward. As the first of its kind, our project demonstrates the feasibility of applying a RUM to non-consumptive PRBs within a National Marine Sanctuary and communicates valuable lessons learned for future research. We identify data gaps that will inform the design of future studies of this stakeholder group within the Sanctuary in addition to informing other valuation projects within coastal and marine recreation.

# Background

## The Channel Islands National Marine Sanctuary (CINMS)

The Channel Islands National Marine Sanctuary encompasses the waters around five islands 12 to 70 miles off the coast of Southern California. Their unique ecosystems are important both economically and ecologically, and have been subject to considerable preservation efforts starting in the early twentieth century (Davis, 2005). In 1938, select islands were first set aside as a National Monument. Since that time, the designation and protection of the area has evolved; in 1980 all five islands (San Miguel, Santa Rosa, Santa Cruz, Anacapa, and Santa Barbara) were designated a National Park and the waters surrounding them became the Channel Islands National Marine Sanctuary. As of 2007, the Sanctuary encompasses an area of 1,470 square miles extending from the mean high tide line to six nautical miles off the coast around each island (See Figure 1) (Channel Islands National Marine Sanctuary Management Plan, 2008).



**Figure 1:** The Channel Islands National Marine Sanctuary (Channel Islands National Marine Sanctuary Management Plan, 2008)

The Sanctuary lies within the Southern California Bight, an area of east-west running coastline that stretches from Point Conception to Punta Eugenia, Mexico. On the western side of the islands the California Current travels south year round, bringing colder, nutrient-rich water to the region.

As this current reaches the U.S.-Mexico border, it turns east and begins to flow northward along the coastline, bringing warmer water into the Santa Barbara Channel and along the eastern and southern sides of the Sanctuary. This ultimately creates a temperature gradient along the island chain, which supports an array of habitats and species (U.S. Department of Commerce, 2009). These habitats include kelp forests, seagrass beds, intertidal and subtidal zones, as well as benthic and pelagic habitats. High levels of productivity from nutrient rich waters sustain numerous species of invertebrates and fish. At least 26 different species of marine mammals have been recorded in the Sanctuary, and it serves as a breeding or feeding ground for many different species of seabirds (U.S. Department of Commerce,

2009). This productive and unique ecosystem is significant to the communities along the Southern California coast because it provides many opportunities for economic and social engagement.

## **Management of the Sanctuary**

The objective of the Sanctuary is to maintain this unique ecosystem. Specifically, the CINMS Management Plans aims to, “conserve, protect, and enhance the biodiversity, ecological integrity, and cultural legacy of marine resources surrounding the Channel Islands for current and future generations” (Channel Islands National Marine Sanctuary Management Plan, 2008) and “to create models of, and incentives for, ways to conserve and manage these areas, including the application of innovative management techniques” (16 U.S.C. 1431 et. seq.). To address the ecological elements of this goal, the Sanctuary and its partners use several marine conservation strategies. For example, managers can set regulations on activities allowed within the Sanctuary (16 U.S.C. 1434 (e)). Currently, dredging of the sea floor and further oil and gas exploration are prohibited. Another example of marine resource management within the CINMS is the restriction of extraction of marine organisms in select areas through Marine Protected Areas (MPAs). In addition to regulation, the Sanctuary is also charged with facilitating or promoting the anthropogenic uses of its resources as long as those uses are consistent with the primary goal of resource protection (Channel Islands National Marine Sanctuary Management Plan, 2008).

## **The Socioeconomic Uses of Sanctuary**

Biodiversity and ecological resources in the CINMS provide a range of socioeconomic values to the heavily populated counties of Southern California. Stakeholders derive benefit from the Sanctuary through a variety of avenues including recreation, fisheries, cultural heritage, research, and education. The discussion of these uses and their relevance to policy is complicated by the fact that more easily quantified uses are better understood, while uses that are difficult to quantify have remained poorly understood. This study focuses on private recreational boating in order to provide managers with data on how this stakeholder group values their recreational experience in the Sanctuary, and how their decisions are affected by characteristics within the Sanctuary. This project will offer insight on a stakeholder group that is not well represented by previous research.

### *Private Recreational Boating*

Private recreational boaters (PRBs) represent a significant portion of the Sanctuary’s stakeholders. Each year there are over 30,000 visitors to the islands, with another 60,000 exclusively utilizing the waters around them (Engle, 2006). In 1999, an estimated total visitation of 437,908 person-days\* was recorded within the CINMS (Leeworthy and Wiley, 2003). Many visitors are recreational users who access the CINMS via private boat. In 2007, about 1,621 private non-consumptive boat trips were observed (Leeworthy, 2013). PRBs operate under a unique set of motivations and resource use patterns. For example, there is a preference among PRBs for anchorages within the eastern portion of the Sanctuary. In particular, a postcard survey in 2006-2007 showed that over 50% of boating is concentrated in the

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\* A person-day is defined as the number of people visiting the Sanctuary times the number of days. For example, five people visiting the sanctuary on one day would equate to 5 person-days. Likewise, one person visiting for five days would also be 5 person-days.



following areas: North Santa Cruz, South Santa Cruz, and Anacapa Island (LaFranchi and Pendleton, 2008). This trend is likely a result of anchorage proximity to cities such as Ventura and Santa Barbara, but may also be due to protection from prevailing winds and swell.

PRBs engage in a range of activities, both consumptive and non-consumptive. Activities that involve a “take” of marine species are defined as consumptive: for example, hook and line fishing, spearfishing, or lobster diving. Conversely, non-consumptive activities such as SCUBA diving, kayaking, and surfing interact with the ecosystem without removing species from their environment (for a complete list of PRB activities see Table 1). A survey conducted in 2006-2007 by postcard (henceforth referred to as the Postcard Survey) found that 47% of boaters engaged in only non-consumptive activities (Lafranchi and Pendleton, 2008) and 51% of users from the Postcard Survey participated in both non-consumptive and consumptive activities. About 16% of users described consumptive activities as the most important factor when choosing an anchorage site, while the remaining users (84%) named environmental factors or non-consumptive activities (LaFranchi and Pendleton, 2008).

PRBs contribute to the local economy by spending money on food, gas, lodging, and other expenses associated with their trips. Consumptive and non-consumptive PRBs in 2006 reported spending an average of \$140.35 per trip on such items. These expenditures imply a larger benefit to the local economy because these categories are known to have greater multiplier effects. (LaFranchi and Pendleton, 2008).

#### *Non-Consumptive PRB Uses*

Non-consumptive users are one subcategory of PRBs. The Sanctuary is a renowned destination for non-consumptive recreation (Engle, 2006). Its numerous anchorage sites and proximity to Santa Barbara and Ventura harbors allow easy access for boaters. The diversity of the marine ecosystem and presence of maritime heritage resources (such as historic shipwrecks) draw recreational divers from all over the world. Surfers, snorkelers, and kayakers also enjoy the use of the Islands’ protected coves and inlets. The vast majority (84%) of PRBs surveyed refer to non-consumptive activities or environmental factors as their primary motivation for visiting the Sanctuary. Slightly less than half of PRBs (47%) participate in only non-consumptive activities (LaFranchi and Pendleton, 2008).

#### *Additional Sanctuary Uses*

In addition to PRBs, the Sanctuary provides socioeconomic value to many other stakeholder groups. These values range from direct economic revenues attributed to specific industries to indirect “existence” values. The latter is defined as measure of the intrinsic or non-use significance that individuals attribute to the Sanctuary without directly interacting with its resources. This value is difficult to quantify but research suggests that it can be applied to large, well-known marine ecosystems in addition to regional areas of interest (Farrow, 1996). In contrast, direct economic values of the Sanctuary are best understood: in particular, charter boat operations and commercial fisheries.

The Sanctuary supports numerous charter operations within its waters. In 2002, charter vessels that engaged in fishing or consumptive diving tallied 186,859 person-days, representing a total of \$9.5 million in revenue over the course of a year. Conversely, charter vessels that promoted non-consumptive activities accounted for 42,000 person days, representing \$2.6 million in revenue. The “for

hire” industry, which includes guiding outfits, accounts for almost 46.7 percent of all the person-days of recreational activity within the CINMS (Leeworthy and Wiley, 2005).

The Channel Islands contain rich fishing grounds that support sizeable commercial and recreational fisheries. Species harvested in these waters include squid, sea urchin, spiny lobster, prawn, rock crab, rockfish, flatfish, and pelagic species. The squid fishery is the largest commercial fishery of the Channel Islands while sea urchin landings from the CINMS are the highest in California (California Department of Fish and Wildlife, 2008). In 2003, there were around 450 commercial boats and 3,300 jobs generated as a result of this activity. In 2002, consumptive activities contributed over \$100 million to the local economies in the 6 counties that participated in the fisheries (Monterey, San Luis Obispo, Santa Barbara, Ventura, Los Angeles, Orange and San Diego). Of the total fishery revenue, \$71 million originated from commercial fisheries and \$26 million resulted from consumptive recreational activities. More than 4,000 recreational fishing trips, targeting both bottom and pelagic species, were also recorded in the CINMS during the same year (Leeworthy et al., 2005).

### **Market and Non-Market Valuation**

Unlike charter boat operations and fisheries, most recreational activities do not have a direct monetary value associated with them. PRBs assume a travel cost associated with their activities, but do not pay a fee in a marketplace as do people who use charter boats. However, they still associate a value with their recreational activities. These values can be difficult to quantify, and can sometimes be underestimated. This can complicate the policy discussion because it makes it difficult to evaluate how policy affects different stakeholder groups. One way to overcome this challenge is to use non-market valuation techniques to monetize the benefit people receive from visiting the Sanctuary.

Quantifying the value that a National Marine Sanctuary provides to the local and national community presents a unique challenge as benefits can range from direct monetary input into an industry, such as a commercial fishery, to an “intrinsic value of existence” held by local or global stakeholders. Market valuation is based on the price people are willing to pay for a product or service in a market system and, as such is easy to quantify. However, goods and services not traded in markets (such as many environmental goods) tend to be implicitly undervalued, resulting in ineffective management. Non-market valuation seeks to assign monetary value to these goods. Non-market valuation methodologies are frequently used in cost-benefit analyses where projects have an environmental dimension in order to account for benefits that are not represented using purely market-based tools. The application of non-market valuation can greatly improve the ability of managers make economically informed decisions in order to increase user benefit (Mathis et al., 2003).

The literature on the non-market value of marine services is limited, especially within our study area. The National Ocean Economics Program (NOEP) seeks to provide more of such information and inform policy makers on the value of our coastal ecosystems and their contribution to recreational fishing, marine and wildlife viewing, snorkeling, and other non-consumptive activities (“Environmental & Recreational (Non-Market) Values”, 2008). Within this program, Leeworthy and Wiley (2003) conducted a study using benefits transfer methods to look at the socioeconomic impacts of multiple management scenarios of marine reserves in the Sanctuary. The authors were able to derive estimates of the

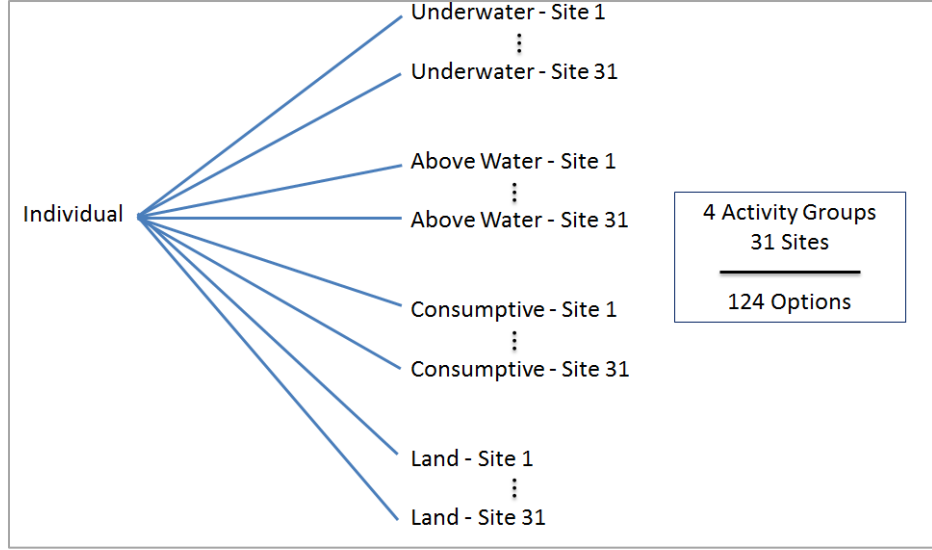
aggregated monetary benefits that consumers receive from a range of recreational activities, including whale-watching, kayaking, diving, and sailing.

Similar to past studies on recreational activities, our study aims to monetize the benefits received by each boater. This value takes into account certain costs associated with visitation and is reported as consumer surplus. Consumer surplus is defined as the difference between the maximum price that consumers are willing to pay for a good and the market price that they actually pay for a good (Kolstad, 2000). In other words, our research identifies the extra benefit PRBs receive from their experience over and above what they actually pay to get to the Sanctuary.

### **Describing PRB Behavior through a Random Utility Model**

A commonly used non-market valuation technique is the Random Utility Model (RUM). The RUM is used in travel cost recreational demand analysis to quantify the value of recreation site characteristics, along with quantifying the value of recreation activities as a whole (Parsons, 2001). This type of model is appropriate when individuals are choosing between a discrete choice set of alternative recreation sites and activities, where each site has a number of unique and quantifiable attributes (Hoehn et al., 1996). Choice behavior is modeled such that individuals choose sites to visit based on attributes of that site and the total travel cost to access to that site. The relative importance of site attributes and travel cost may be dependent on the specific activity that the individual chooses to do. For example, an individual may be interested in SCUBA diving in the Sanctuary. Certain attributes, such as a biological index, kelp cover, and wind exposure may affect their site selection choice. However, these attributes may affect their choice differently than it would affect an individual who recreates above water. The RUM can be used to quantify how individuals value different site characteristics and express how individuals value their choices in general. Furthermore, it can show how changes in resource attributes affect the value individuals receive from recreating in the Sanctuary (Parsons, 2001).

In this study of recreational boater use of the Sanctuary, a model was created in which each individual chose to recreate at one of 31 possible site choices (around Anacapa, Santa Cruz, and Santa Rosa Islands) and 4 possible activity group choices at each site. This represents a discrete choice set of 124 unique site-activity alternatives. In this model, individuals base their decision on four attributes: kelp cover percentage, a biological index, wind exposure, and travel cost. Descriptions of how the sites and activity groups were chosen are given in the Methods section. Figure 2 shows a theoretical tree for this decision making process.



**Figure 2:** Individual Choice Decision Tree. Each individual chooses from a combination of 4 activity groups and 31 sites, for a total of 124 choice options

Each activity-site choice is assumed to give an individual a specific utility, which is a function of the travel cost and site attributes. This model has the following utility function (modified from Thomas and Stratis, 2002):

$$U_{ij} = V_{ij}(TC_{ij}, Z_j) + e_{ij} \quad (\text{Equation 1})$$

Where  $U_{ij}$  is the utility of individual  $i$  selecting activity-site choice  $j$ ;  $TC_{ij}$  is the total travel cost for person  $i$  to the activity site  $j$ ;  $Z_j$  is a vector of attributes at site  $j$ ;  $V_{ij}$  is a vector of coefficients of choice observable to the analyst (which could also be described as  $dU/dTC$  and  $dU/dZ$ ); and  $e_{ij}$  are other factors considered by the individual in the decision making process, but unknown to everyone else. This last term encompasses personal taste in the decision making process which is unobservable to the analyst. Based on this utility function, the probability that individual  $i$  will choose activity-site  $j$  is given as:

$$P_{ij} = \frac{\exp(V_{ij})}{\sum_i^m \sum_j^n \exp(V_{ij})} \quad (\text{Equation 2})$$

In our study, the vector  $V_{ij}$  includes coefficients for biological index (bio), kelp cover (kelp), wind exposure (exposure), and travel cost (TC) for four different activity categories, yielding a total of 16 coefficients.

In action, the RUM is estimated using logistic-based regression models. These models solve a series of equations that maximizes the utility for all individuals by optimizing the coefficients for site attributes and travel cost. The multinomial logit model (MNL) is perhaps the most commonly used regression-based RUM for nominal outcomes and is employed when there are a large number of alternative choices. In the MNL model, random components of the utilities of the different alternatives are independent and identically distributed (Bhat, 2003). Other types of less common RUM models, such as probit models, use other types of distributions. One assumption implicit in the multinomial logit model

is the Independence of Irrelevant Alternatives (IIA), which assumes that an individual’s relative probability of choosing between two options is not dependent on the presence or absence of another “irrelevant” option. In our study, each individual is equally willing to choose amongst the 124 activity-site choices, and no single activity-site choice serves as a substitute for another. Under this assumption, activity-sites are chosen merely based on the attributes of that option (Kaoru, 1994).

Although this type of analysis has not been used for a National Marine Sanctuary before, it is a common technique in the literature. A RUM was used in Southern California to quantify the value of beach attributes, including site-specific water quality, for beach goers in the region and predict the change in value associated with decreased water quality (Leeworthy et al., 2007). Researchers in Florida also used this method to predict how non-consumptive recreational boaters would be affected by a new policy decision of imposing speed limits in certain waterways to protect endangered manatees (Thomas and Stratis, 2002).

In this particular study, the RUM is appropriate and provides consumer surplus and choice probability functions for PRBs in the Sanctuary. The model, and implicit assumptions, realistically reflects how individuals choose sites based on their activity of choice and certain attributes. The results could help to inform managers on how different attributes affect boaters’ behavior and how this user group values the Sanctuary, therefore addressing the two main objectives of this project.

### Quantifying Non-Market Value

Once a multinomial logit model has been used to estimate the coefficients of the RUM, consumer surplus is next calculated based on these coefficients. The total consumer surplus of a single activity-site trip is calculated using the following equation (Small and Rosen, 1982):

$$\text{Trip Consumer Surplus} = \frac{1}{dU/dTC} \quad (\text{Equation 3})$$

Where  $dU/dTC$  is the travel cost coefficient for a particular activity group. In this equation, trip consumer surplus is essentially equal to how much an individual is willing to pay above and beyond the actual travel cost for a proportional increase in their utility. Since travel cost is calculated based on boat expenses and only the operator’s opportunity cost, this is the trip value for one individual visiting the Sanctuary.

Additionally, the monetary value of specific attributes can also be calculated. The marginal willingness to pay for a 1-unit change in a particular attribute is given by the following equation:

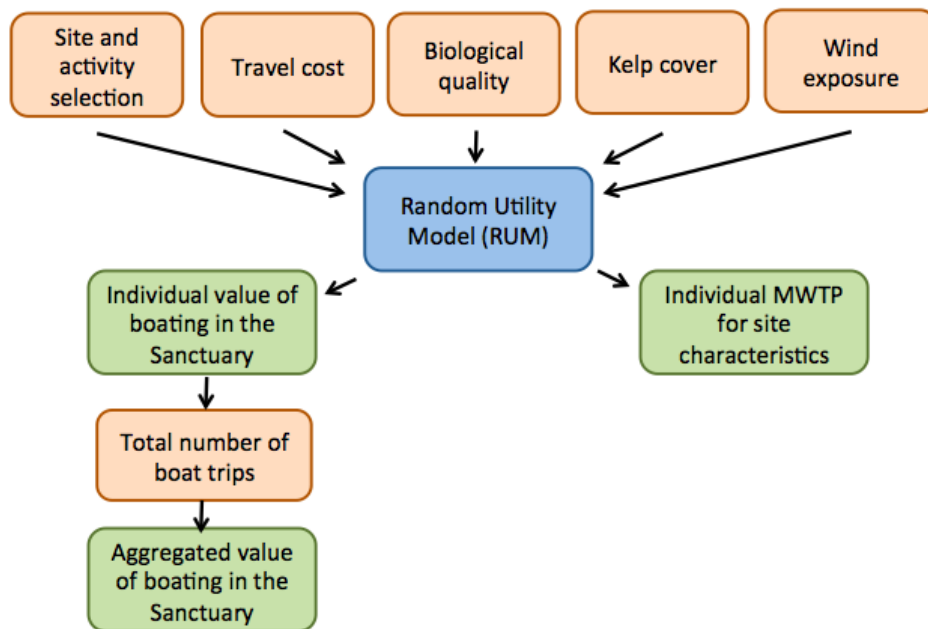
$$MWTTP = \frac{dU/dZ}{dU/dTC} \quad (\text{Equation 4})$$

Where  $dU/dZ$  is the attribute coefficient for a particular activity group and  $dU/dTC$  is the travel cost coefficient for a particular activity group. This ratio describes how a change in utility with respect to a particular attribute is proportional to a change in utility with respect to travel cost. This quantifies the marginal value of the attribute. This methodology is consistent with the literature (Sillano and Ortuzar, 2004; Leeworthy et al., 2007; Banfi et al., 2008).

Individuals partaking in different activity groups may value each attribute differently, and may be willing to pay differing amounts to enjoy improvements in each attribute. Each activity group therefore may have a different marginal willingness to pay for a unit change in a particular attribute. The higher this willingness to pay, the more the activity group values the attribute and the more utility they can be expected to gain from improvements in that attribute. For example, individuals who recreate underwater may have a different marginal willingness to pay for changes in the biological index versus individuals who recreate above water (Banfi et al., 2008).

## Materials and Methods

We used a multinomial logit RUM to quantify the value that private recreational boaters place on the Sanctuary and its attributes. This model takes several inputs, the first of which is individual site and activity choice. This data comes from an intercept survey done at the Sanctuary that describes what sites 110 individual boaters chose to visit, and what activities they did at these sites. This survey also collected data that could be used to calculate the travel cost of each individual, which acted as another input to the model. Additionally, site-specific attributes were used as inputs, including a biological index, kelp cover, and wind exposure. With these inputs, the model is able to monetize the value that an individual boater associates with a boat trip to the Sanctuary and their marginal willingness to pay for the specified site attributes. The boat trip value is the consumer surplus, and is the amount of economic benefit these individuals gain over and above what they spent on their trip. These individual values can then be extrapolated using the total number of recreational boat trips to the Sanctuary to arrive at aggregated numbers for the total value of private recreational boating to the Sanctuary. A flowchart for this analytical process is shown in Figure 3.



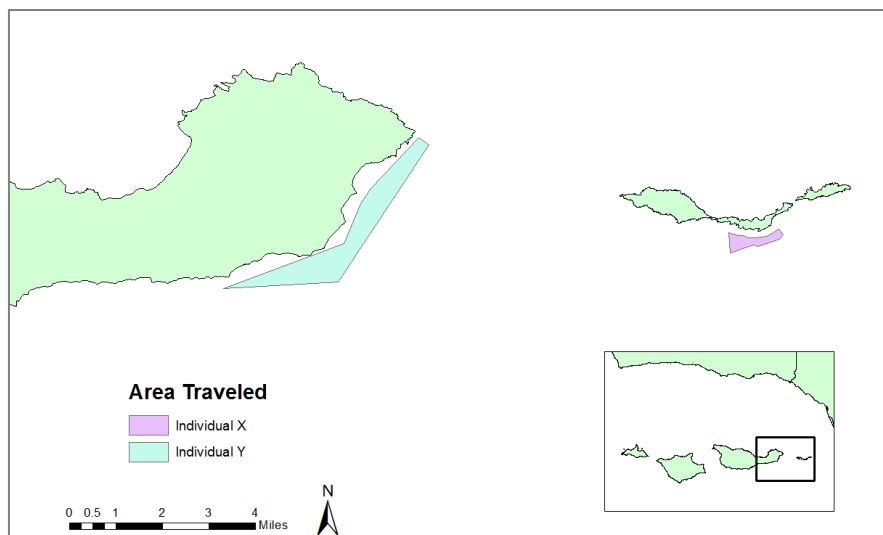
**Figure 3:** A Random Utility Model used for obtaining aggregated values of boating in the Sanctuary and Marginal Willingness To Pay (MWTP) for site attributes. Model inputs are shown in orange, model outputs are shown in green, and the model is shown in blue.

This section will first describe the site and activity selection data and how this data was used to calculate travel cost for each individual. As discussed below, in order to use this data in the model, a discrete set of sites was defined, and activities were placed into hierarchical groups. Next, the site-specific attribute data will be described with a discussion on why these particular attributes were chosen for this analysis. Finally, the aerial survey data will be discussed that was used to extrapolate individual values to the aggregated community of private recreational boaters visiting the Sanctuary.

### Individual Choice Behavior - Intercept Survey

As part of a series of studies on PRBs, an Intercept Survey was conducted in 2006 and 2007 by Sanctuary staff and contracted researchers (LaFranchi and Pendleton, 2008). The intercept survey took place in waters surrounding Santa Cruz Island, although respondents reported visits at three islands: Anacapa, Santa Cruz and Santa Rosa. As no respondents reported visits to San Miguel and Santa Barbara Islands, these locations were omitted from our analysis. The survey was conducted between the months of May through October to reflect the greatest frequency of recreational visitation, which was determined from the Sanctuary Aerial Monitoring Spatial Analysis Program (LaFranchi and Pendleton, 2008). A survey of 43 questions was distributed to the operator of each approached vessel that was willing to participate. Respondents were invited aboard the Sanctuary Research Vessel *Shearwater* in order to complete the survey. Survey questions included, but were not limited to, port of departure, activities, income, demographic information, and vessel type. Income information was elicited by having respondents select the income interval that best represents them (LaFranchi and Pendleton, 2008).

In addition to the survey questions, they were asked to draw polygons of the areas where they participated in activities. This was done using an interactive GIS-based survey tool called Oceanmap. For each polygon drawn, an activity was assigned from a list of 15 activity choices (listed in Table 1). An example of these polygons is given in Figure 4. After accounting for missed responses or collection errors, the full dataset comprised 110 respondents who participated in 15 activities and drew a total of 323 polygons.



**Figure 4:** A screenshot of two example activity polygons drawn in the Intercept Survey. Individual Y indicated an activity at Santa Cruz Island, while individual X indicated an activity at Anacapa Island (LaFranchi and Pendleton 2008).

## Hierarchy Approach

In order to run the RUM, only one activity-site selection could be used from each individual. The majority of survey respondents participated in more than one activity at multiple sites. These repeated decisions complicate the analysis because they require an unreasonable assumption: that each respondent's choice of activity and site is independent of any previous choices. Due to this complication of modeling multiple decisions made by the same person (Parsons, 2001), our analysis considered only one activity choice at one site for each boater (defined as an “activity-site”).

First, we categorized the fifteen activities reported in the Intercept Survey into five activity groups based on similar preference for Sanctuary attributes. These categories include: underwater non-consumptive, surface non-consumptive, consumptive, land-based, and wave-based activities (Table 1). Next, selecting single activity-sites required creating a hierarchy of activities (see Hanneman et al., 2007). As the large majority (84%) of users cite environmental factors or non-consumptive activities as their main reasons for visiting the islands (Lafranchi and Pendleton, 2008), we prioritized non-consumptive activities as the top two activity groups in our hierarchy. Non-consumptive users were also a previously misunderstood and underrepresented stakeholder group, and were a focus of this study. Underwater non-consumptive activities were prioritized above surface non-consumptive activities for two reasons: 1) the majority of the attribute data available were related to underwater qualities of the sites, and 2) manager’s decisions have the potential to affect underwater qualities such as water quality, habitat preservation or alteration, and biological quality. Therefore, the first level in our hierarchy included non-consumptive underwater activities, followed by non-consumptive surface activities, consumptive activities, land-based activities, and lastly, wave-based activities (Table 1). Although six respondents chose wave-based activities, all six of these people also participated in other activities choices higher in the hierarchy. Therefore, wave-based activities were omitted from the analysis. It should be noted that this is not the only way to prioritize the hierarchy, and prioritizing different categories could be a focus of future studies with this model.

**Table 1:** Activity Hierarchy

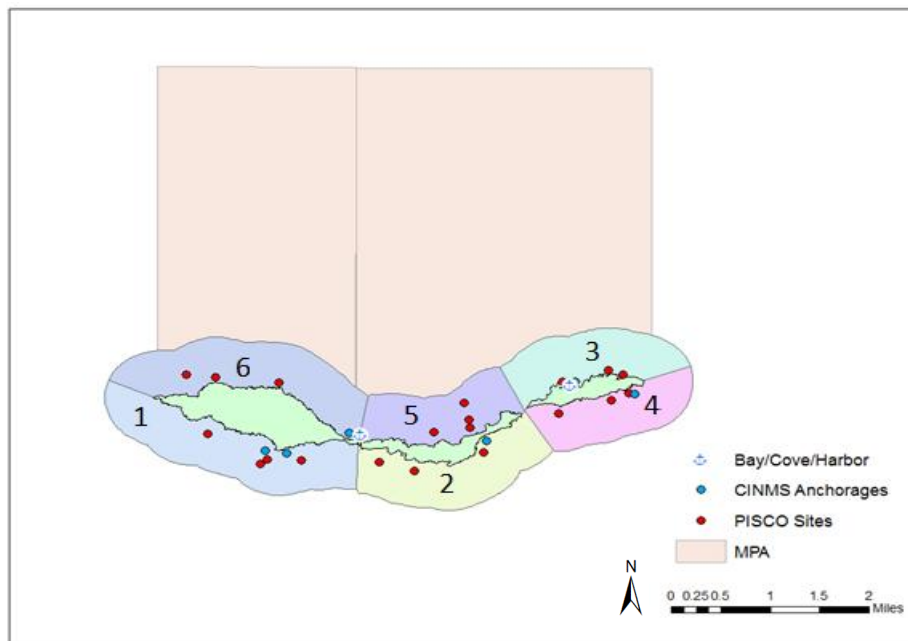
Activity Category	Activity
1 – Underwater non-consumptive	Snorkeling/freediving SCUBA Diving
2 – Surface water non-consumptive	Exploring by dinghy Kayaking Marine mammal watching Bird watching
3 – Consumptive	Hook and line fishing Spearfishing Lobster diving Hoop netting Collection of rock scallops
4 – Land-based	Beach going and exploring Tidepooling Hiking
5 – Wave-based	Surfing



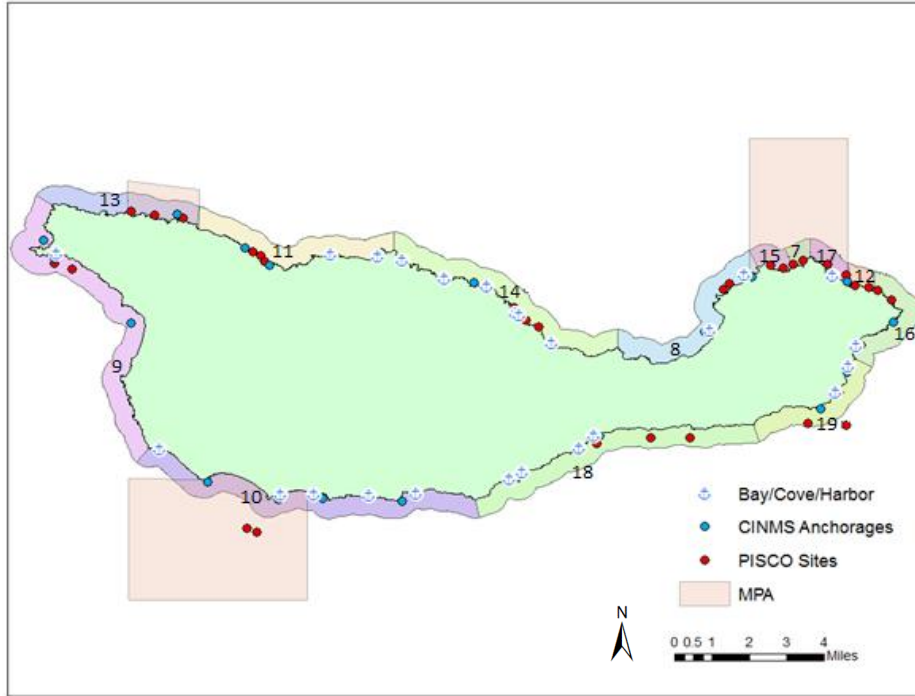
## Site Definition

In order to run a random utility model, there must be a discrete set of choices available to each individual. To create this set, the coastlines of Anacapa, Santa Cruz, and Santa Rosa islands were split up into 31 unique sites (see Appendix A). The 110 activity polygons that individuals drew were therefore overlaid with this list of discrete sites, such that each activity corresponds to one of 31 sites.

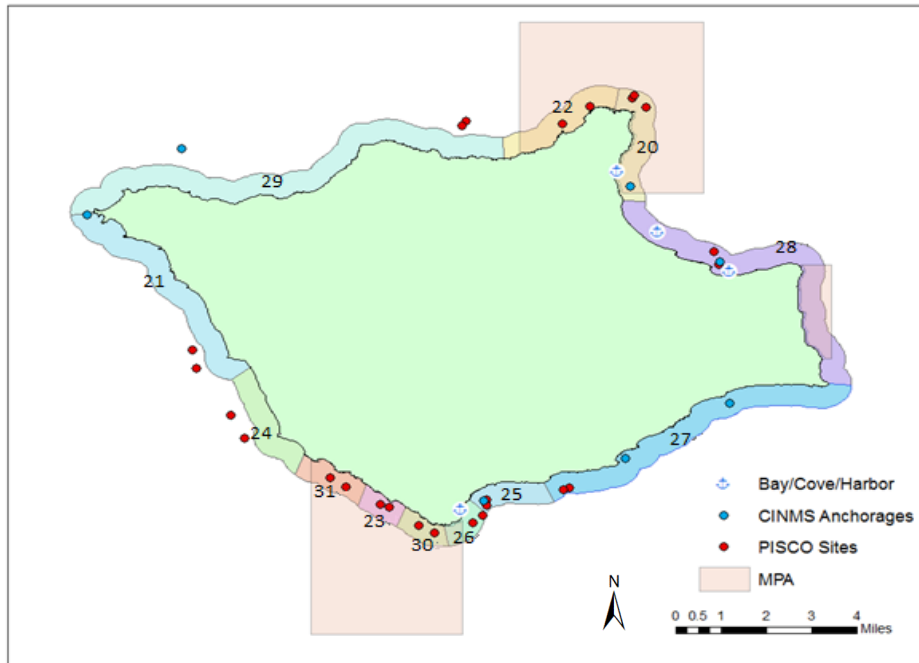
Several criteria were used to delineate the sites. Each site name corresponds to a study site from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) that was surveyed from 1999 to 2010. PISCO works on a number different research goals and are particularly interested in species distributions and marine ecosystems responses to management (PISCO Research, 2009). In addition to using PISCO sites as a framework for creating site boundaries, we included MPA boundaries and anchorages known to the boating community. These data were provided by the California Department of Fish and Wildlife and the CINMS. In order to help define shapefile borders, physical island landmarks such as points or coves were also considered. Each shapefile/site extends 800m from the shoreline around the entire island. When PISCO sites fell outside this range (such as Gull Island on Santa Cruz), attributes were assigned to the closest shapefile. The 800m offset was kept constant for all sites so that kelp percentage cover would be consistent and comparable between sites. Figure 5 shows the division of sites at Anacapa Island. Due to Anacapa's natural division between three isles, sites were drawn for the frontside and backside of each isle, resulting in a total of six sites. Figures 6 and 7 show the created sites around Santa Cruz and Santa Rosa (See Appendix A for site names corresponding to ID numbers). It is important to note that sites were not created for Santa Barbara and San Miguel islands due to a lack of activity shapefiles corresponding to these islands.



**Figure 5:** Defined sites at Anacapa Island. Colored areas bordering the island represent defined sites.



**Figure 6:** Sites at Santa Cruz Island. Colored areas bordering the island represent defined sites.



**Figure 7:** Sites at Santa Rosa Island. Colored areas bordering the island represent defined sites.

## Attribute Selection

For our model to be accurate, the site attributes in the model need to capture boaters' decisions as closely as possible. In our model, these attributes consist of biological quality, kelp percent cover, and exposure of the site from prevailing wind. These attributes were selected because there was robust, accessible data, and because these attributes were described as being potentially important when the study was originally designed (LaFranchi and Pendleton, 2008). Although the model can describe how these attributes affect boater behavior, it cannot describe why. The ways listed below are examples of how these attributes might affect user decisions.

Many visitors are attracted to the Sanctuary by its ecological resources, and this biological quality may be an important attribute to PRBs in the Channel Islands (Engle, 2006). Biological quality is expressed in our model as a function of fish and invertebrate species richness and abundance, and stood out as an important consideration for underwater non-consumptive users (e.g. SCUBA divers, snorkelers) and consumptive users (e.g. fishermen and spear fishermen). High species richness and abundance provide SCUBA divers and snorkelers with greater enjoyment as they have more to see; likewise, high fish species richness and abundance translates directly into a larger range of fish species and higher frequency of bites for fishermen. Other user groups (eg. birdwatchers, tidepoolers) may also gain utility from underwater biological quality, albeit perhaps to a lesser degree. Surface non-consumptive and land-based users might also indirectly benefit from areas with high biological diversity. For example, bird and marine-mammal watchers would conceivably see larger numbers of seabirds or mammals from a wider range of species at sites with high underwater biological quality. Biological quality is also notable in that it is one of the attributes Sanctuary decisions may have the greatest effect on.

Separated from biological quality, we also looked at kelp percent cover. Kelp forests are phylogenetically diverse, structurally complex and highly productive, and the kelp forests of the Southern California Bight hold the most diverse kelp flora in the world (Steneck et al., 2002). As kelp is also easily visible from the ocean surface, some boaters interested in biological quality may use kelp cover as a measure of biological quality, and preferentially select sites with high kelp percent cover. On the other hand, the presence of kelp might also deter certain user groups: some kayakers, for example, might not enjoy having their paddles entangled in kelp fronds. As the presence kelp affects different user groups' site selection processes in varied ways, we selected it as one of the attributes to include in our model.

Finally, wind and swell conditions out at sea affect both the accessibility and suitability of recreation sites to users. This varies with the activity type as well as the boat type and size. The suitability of a site for certain activities, notably surface non-consumptive (kayaking, exploring by dinghy), is reliant on how exposed the site is to the predominant direction of the wind and swell. Exposure also affects the accessibility of sites: for example, a site with attractive biological quality and kelp cover, but with high exposure, might be accessible to a large powerboat, but not to a smaller sailboat. As exposure heavily affects user activity-site choice, we included it as the third attribute in our model.

## Description of Site Attributes

### *Biological Index*

The model incorporates four biological measures including fish richness, fish abundance, invertebrate richness, and invertebrate abundance. These data were obtained from PISCO subtidal community surveys. These surveys take place at various sites around the islands. A number of transects are run at each site and pass through important kelp and rocky reef habitats. Each site may have transects at several sides (East, Central, and West) and also at several depth profiles (inner and outer reefs). In order to reach a single representative value for each site, species richness was calculated by summing the total number of species represented across all site transects. A representative abundance value was taken from the transect with the maximum abundance within the site. This transect represents the best possible viewing or fishing experience for users within the site.

These data were also averaged over time. Although the intercept survey was done in 2006/2007, data for biological attributes were aggregated for several years before this time frame (2003-2007). Since there is no way for boaters to check the “biological status” of sites, we assumed that PRBs form an opinion of the biological quality of each site through word of mouth or repeated visitation. Therefore, the biology of a site before 2006/2007 would affect the choices of those who participated in the survey during those years. We included data for years after 2006/2007 because they provide more data points on the overall biological characteristics of a site. Four sites presented data gaps for invertebrate richness and abundance. In order to fill those data gaps the program Amelia II was used. This program performs multiple imputations, a general approach to data with missing values. Multiple imputations are shown to reduce bias and increase efficiency when filling data gaps (Honaker and King, 2010).

A biological index was created to represent the biological quality of sites. This index was developed due to the high correlation observed between all biological attributes (see Appendix E). Multinomial logit models are more robust when attributes are not highly correlated, resulting in coefficients that more accurately predict choice decisions. The following equation combines fish abundance, fish richness, invertebrate abundance, and invertebrate richness into one site-specific biological index:

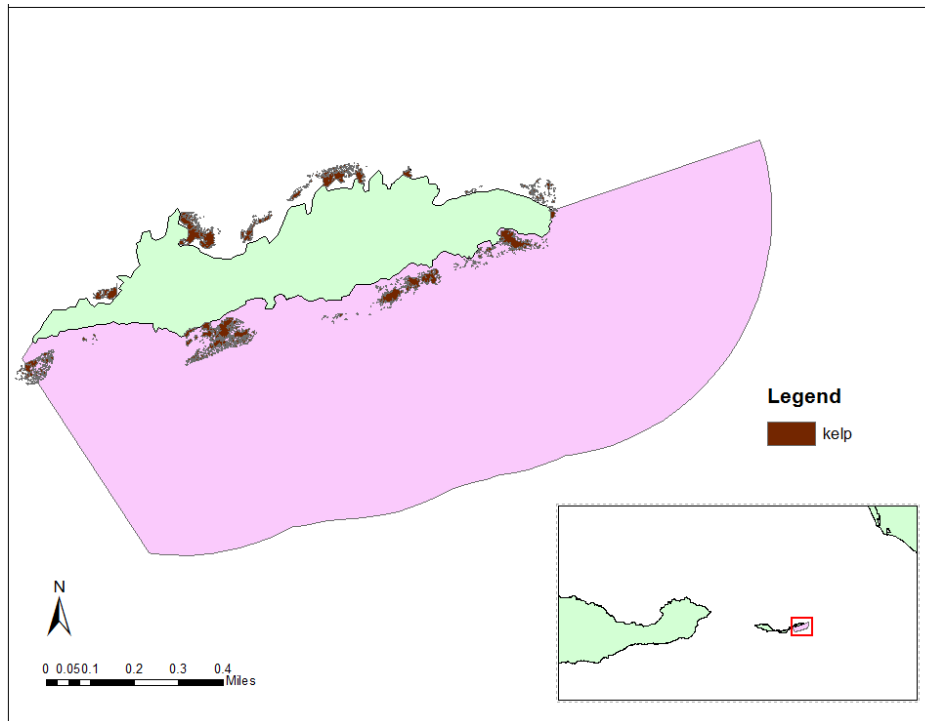
$$B_j = \left( \frac{FA_j}{FA_{max}} + \frac{FR_j}{FR_{max}} + \frac{IA_j}{IA_{max}} + \frac{IR_j}{IR_{max}} \right) * 10 \quad (\text{Equation 5})$$

Where  $B$  is the biological index,  $j$  is the site,  $FA$  is the fish abundance,  $FR$  is the fish richness,  $IA$  is the invertebrate abundance, and  $IR$  is the invertebrate richness. See appendix B for detailed biological index values for each site.

### *Kelp*

Kelp data was collected from California Department of Fish and Wildlife (CDFW) aerial surveys. CDFW collects these data as part of the California Coastal Kelp Resources Survey with ECOSCAN Resources. Aerial surveys were taken July through October in 1989, 1999, 2002, and 2003, and 2006. Due to the dynamic nature of kelp, our analysis included values for 2006 only, as this sample best represents the conditions present during the time of the survey (LaFranchi and Pendleton, 2008). Kelp percent cover was found for each site using a GIS model (Figure 8). Note again that sites extend 800m from the shore.

By keeping this distance consistent, percent covers can be compared relative to one another between sites. See appendix B for kelp percent cover values for each site.



**Figure 8:** Example of kelp cover at Anacapa Lighthouse Reef.

### *Wind Exposure*

Our model incorporates a metric of coastline exposure to represent the effect of weather factors on user site selection. The angle of each coastline was measured and assigned a value relative to the predominant NW (315°) winds. The exposure metric is expressed continuously from 0-180, where 0 represents a site with a coastline that is completely protected from the predominant winds (coastline facing SE) and 180 represents a site where the coastline has no wind protection (coastline facing NW). See appendix B for wind exposure values for each site.

### *Travel Cost*

A travel cost analysis was conducted in order to determine how much each individual valued a particular trip to the Sanctuary. Total travel cost to recreation sites within the Sanctuary consists of two components: the actual monetary cost of traveling to and from the site (including on-land and on-water expenses) and the opportunity cost of time associated with this travel.

Our external advisor, Dr. Bob Leeworthy from the Office of National Marine Sanctuaries, used PC Miler software to compute the on-land distance traveled between respondents' homes and their access points where they launched their boats into the water. An average fuel cost of \$0.2128 per mile was obtained using data from the Automobile Association of America (AAA) and the US Department of Energy that reflects 2006/2007 costs. This number incorporates fuel and maintenance costs. The on-

land cost per mile was then multiplied by round trip on-land distances traveled by each respondent to obtain the total monetary cost of travel on land.

To calculate the cost of traveling on water, we multiplied the distances each of the boaters traveled with the fuel cost they incurred with each mile traveled. On-water fuel costs per mile vary according to boat type (sail, motor-sail, power boats) and boat size. We derived figures for the fuel consumption of boats of different sizes (on-water gallons per mile) from a study on recreational boating in Florida, which compiled data from several boating magazines, interviews with marinas, and other boating experts (Thomas and Stratis, 2002). These per-mile boating costs were divided by the per gallon cost of gasoline in Florida in 1998, which generated fuel consumption per mile for the different boat classes. We then multiplied these figures with the gasoline cost per mile in California in 2006-2007 to calculate the fuel cost per mile for each boat category during our study period. The total monetary cost of travel on water for each boater was obtained by multiplying the travel cost per mile by the round-trip distance between the access point and recreation site.

To calculate the distance from the water access point to the recreation site for each boater, we measured the distance from each harbor to the centroid of each created site using GIS. Boaters launched from a total of 7 harbors: Santa Barbara, Ventura, Channel Islands, Morro Bay, Marina Del Rey, San Diego, and San Pedro Point. Distances were calculated based on the shortest possible travel path. When possible, we used direct straight lines (e.g. trips from Channel Islands Harbor to Anacapa). For PRBs traveling from San Diego, San Pedro Point, and Mission Bay, we assumed that boats traveled between the coast and Catalina Island before cutting over to Anacapa, Santa Cruz, or Santa Rosa. In all cases, if direct straight lines were not possible, boaters were assumed to travel in a straight line to the island of choice, and then follow the edge of the island along a border 800m from shore until reaching their destination site.

Opportunity cost is the cost of any activity measured in terms of the value of the next best and not be chosen alternative. In our study, the opportunity cost of time is the sacrifice PRBs make when they choose to spend time travelling to the Channel Islands instead of spending time doing something else. The opportunity cost of time spent while travelling over land was calculated for each respondent, and was a function of the individual's income. Since time spent boating (i.e. the on-water travel component) is considered a part of the recreational experience, only on-land driving time was assigned a marginal cost. This method is accepted in the scientific literature (Thomas and Stratis, 2002). Respondents were assumed to work 2000 hours a year, a figure obtained by multiplying average working hours of 40 hours/week by 52 weeks/year, and deducting 2 weeks of leave. The hourly wage of each respondent was then calculated by dividing their annual income values by 2000.

As income data was collected in ranges, we used averages for this calculation. For example, an individual who reported an income between \$30,000 and \$60,000 a year received an income value of \$45,000 (see Appendix C). For the uppermost income bracket (greater than \$210,000 a year), we used a figure of \$3 million, which is the median of this income level in California (Hanemann, 2007). We then computed the opportunity cost of time using 50% of the hourly wages of the respondents. A sensitivity analysis was conducted to determine if 50% was a reasonable percentage of wage to be used. By adjusting the

percentage of wage and observing how the value of a trip changed. It was concluded that the results were not sensitive to this percentage (see Appendix F). Therefore, we assumed that the opportunity cost was valued at 50% of the hourly wages of the respondents' wage.

## Implementing the Random Utility Model in R

With the inputs collected and collated, the RUM was implemented using R statistical software. Equation 1 was used to formulate the RUM, and was represented in R using the multinomial logit package "mlogit." This function was used to estimate coefficients for kelp cover percentage, biological index, wind exposure, and travel cost for all four user groups, for a total of 16 coefficients (Figure 9). This code calculates each coefficient based on the site-activity choice data obtained from the intercept survey, along with attribute and travel cost data for all sites and individuals. By using MNL regression, the coefficients are optimized in order to reflect the assumption that individuals are choosing sites with attributes that maximize their utility. The model also provides the statistical significance of each coefficient, along with statistical goodness-of-fit metrics in the form of AIC and log-likelihood. Note that the first line of code is necessary for data formation. Table 2 describes the variables used in the model.

```
data.logit =
mlogit.data(data.raw, shape="long", choice="choice", alt.var="site_activity")

results=mlogit(formula=choice~V_bio_1+V_bio_2+V_bio_3+V_bio_4+V_kelp_1+V_k
elp_2+V_kelp_3+V_kelp_4+V_exposure_1+V_exposure_2+V_exposure_3+V_exposure_
4+TC_1+TC_2+TC_3+TC_4|0, data=data.logit)
```

**Figure 9:** Coding used in the statistical package R to estimate the multinomial logit model

**Table 2:** Variable Descriptions

Variable	Description
total_TC_water_land_1	Underwater non-consumptive travel cost
total_TC_water_land_2	Surface water non-consumptive travel cost
total_TC_water_land_3	Consumptive travel cost
total_TC_water_land_4	Land-based travel cost
bio_1	Underwater non-consumptive biological index
bio_2	Surface water non-consumptive biological index
bio_3	Consumptive biological index
bio_4	Land-based biological index
kelp_1	Underwater non-consumptive kelp cover
kelp_2	Surface water non-consumptive kelp cover
kelp_3	Consumptive kelp cover
kelp_4	Land-based kelp cover
exposure_1	Underwater non-consumptive exposure
exposure_2	Surface water non-consumptive exposure
exposure_3	Consumptive exposure
exposure_4	Land-based exposure

Once this function was able to calculate all 16 coefficients, trip value for each user group was calculated using Equation 3, and the marginal willingness to pay of each attribute for each user group was calculated using Equation 4. The results of the model are given in the following section.

Multiple iterations of the model were run with and without various attributes, and with and without separate coefficients for each activity category. This was done in a manual and deliberate fashion. We used log-likelihood estimates and AIC values to check for model fitness. The log-likelihood test is an indicator of how well the model is actually predicting reality in relative to pure chance. The AIC test (Akaike Information Criterion) is a relative measure of how much information is lost when the model attempts to describe reality. The final model used represents the model with the best level of fitness for both of these tests.

### **The Total Non-market Value**

In order to obtain a total value of the Sanctuary to private recreational boaters, and a willingness to pay for site attributes, the results from the RUM could be aggregated to the total number of private boat trips to the Sanctuary. This number comes from data collected by the Sanctuary Aerial Monitoring and Spatial Analysis Program (SAMSAP). This program conducted aerial surveys of the Sanctuary, which can later be analyzed to determine how many boats are in the Sanctuary during a given period of time, and what activities the boats are participating in. For boats that are determined to be private, the survey data is able to differentiate boats engaged in consumptive versus non-consumptive activities based on the visible presence of fishing gear. A study determined that in 2007, there were 1,621 non-consumptive private recreational boat trips to the Sanctuary (Leeworthy, 2013). Although there were additional boat trips by consumptive recreational users, the data is not able to differentiate between private consumptive boats and charter consumptive boats – both types of vessels are visibly identical. Therefore, when aggregating to the total number of boaters in the Sanctuary, only non-consumptive private boaters can be included in the study.



# Results

## Model Results

The results of the model are given in Table 3. This table summarizes all of the variable coefficients that were estimated, along with the standard error and statistical significance of each coefficient. The log-likelihood for this model was found to be -400.85, and the AIC was found to be 833.7094. The results demonstrate the following trends:

- For all activity groups, travel cost had a significantly negative effect on respondents’ choices. This was slightly more pronounced for consumptive users, who had a higher negative coefficient than all of the other activity categories.
- The biological index had a significantly positive effect on all activity categories, and had the highest impact on underwater and surface non-consumptive users.
- Exposure had a significantly negative effect on respondents’ choices for all activity categories.
- Kelp had no effect on boaters’ decisions.
- Across all attributes, coefficients from consumptive users were less statistically significant than attribute coefficients of other activity categories. This is a function of the small number of users who only participated in consumptive activities, and were therefore not included in more highly prioritized activity groups.

**Table 3:** RUM output listing. Coefficients, standard errors, significance level, and relationship.

Variable	Estimated Coefficients	Std. dev	Significance	Relationship
total_TC_water_land_1	-0.0188	0.0049	***	
total_TC_water_land_2	-0.0186	0.0049	***	
total_TC_water_land_3	-0.0288	0.0100	**	(-)
total_TC_water_land_4	-0.0189	0.0050	***	
bio_1	0.3153	0.0362	***	
bio_2	0.2908	0.0358	***	
bio_3	0.2912	0.0567	***	(+)
bio_4	0.2834	0.0421	***	
kelp_1	-0.0110	0.0214		
kelp_2	-0.0117	0.0253		
kelp_3	-0.1104	0.1458		Not significant
kelp_4	-0.1547	0.1290		
exposure_1	-0.0240	0.0041	***	
exposure_2	-0.0170	0.0040	***	
exposure_3	-0.0297	0.0131	*	(-)
exposure_4	-0.0250	0.0078	**	
Log-Likelihood:	-400.85			
AIC	833.7094			
Sample Size	110			

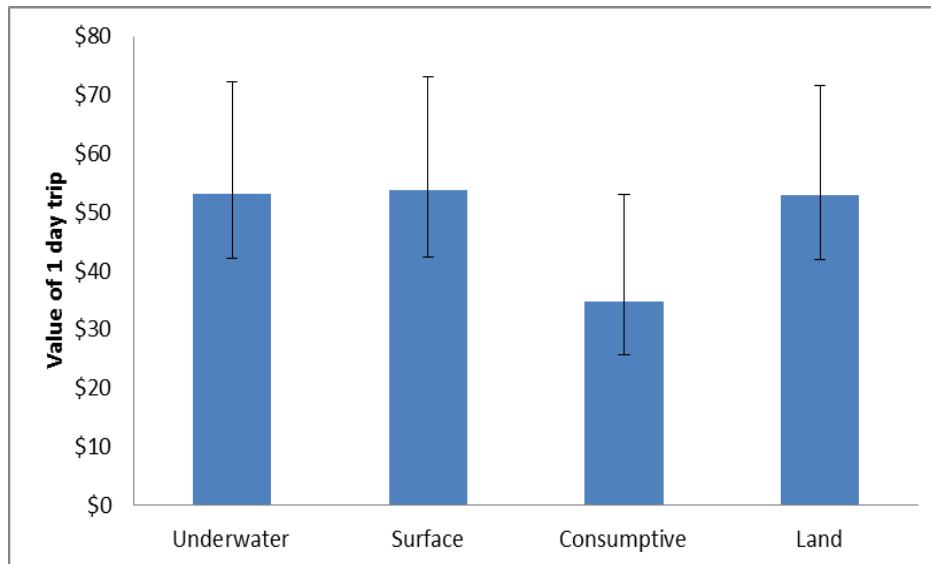
Note: \*, \*\* and \*\*\* denote significant at the 90%, 95% and 99% confidence levels, respectively

## Value of Trips and Attributes

Using the model coefficients from travel cost and the various attributes, we were able to determine the value of a trip to the Channel Islands for each activity category (Table 4). This value ranged from \$34.72 to \$53.69. It was highest for surface non-consumptive and underwater non-consumptive users (\$53.69 and \$53.21 respectively), and lowest for consumptive users (\$34.72). However, there is no significant variation between these values when considering a 95% confidence interval. These results are also shown in a bar graph in Figure 10.

**Table 4:** Trip value for one day in the Sanctuary for all four activity groups

Activity Group	Value of 1 Day Trip	95% Confidence Intervals
Underwater	\$53.21	[42.14, 72.17]
Surface	\$53.69	[42.44, 73.06]
Consumptive	\$34.72	[25.79, 53.10]
Land	\$52.86	[41.89, 71.61]

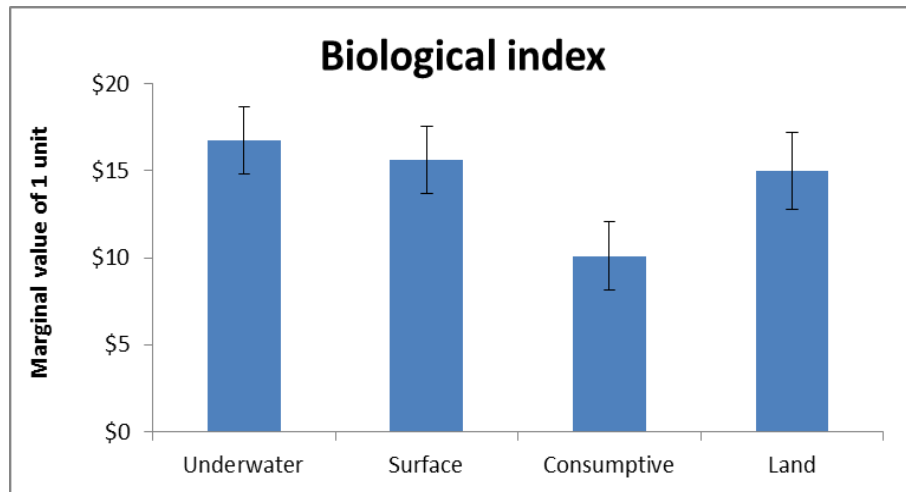


**Figure 10:** Bar graph showing trip value for one day in the Sanctuary for all 4 activity groups, along with 95% confidence intervals.

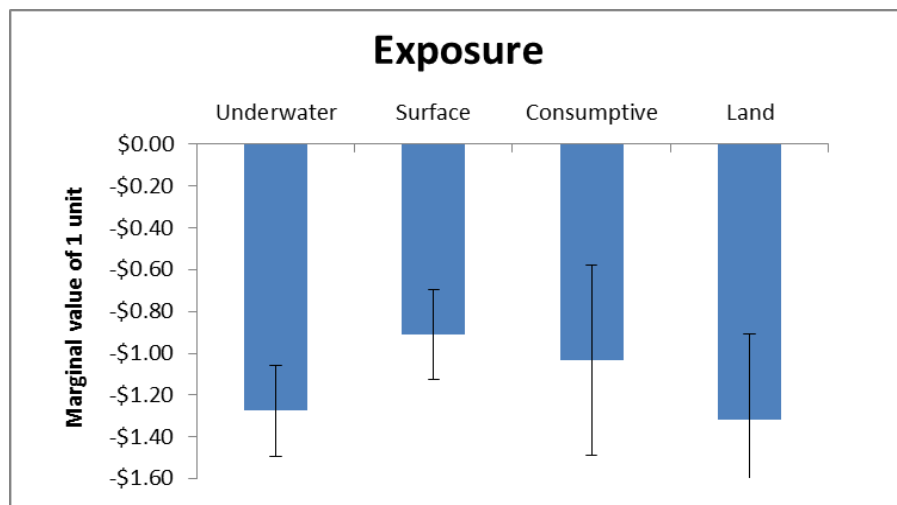
The marginal value of significant attributes for each activity category is shown in Table 5. The marginal value of one biological index unit ranged from \$10.11 to \$16.78. Underwater non-consumptive, surface non-consumptive, and land-based groups had statistically similar values, while the consumptive group had a statistically significant lower value. The marginal value of exposure to predominant wind and swell ranged from -\$0.91 to -\$1.32, with no statistically significant difference among user groups. These results are shown as a bar graph in Figures 11 and 12.

**Table 5:** Marginal willingness to pay for units of the biological index and wind exposure for all four activity groups.

Activity Group	Activity Group	Marginal value of 1 unit	95% Confidence interval
Biological Index	Underwater	\$16.78	[14.85, 18.70]
	Surface	\$15.62	[13.70, 17.54]
	Consumptive	\$10.11	[8.14, 12.08]
	Land	\$14.98	[12.75, 17.21]
Exposure	Underwater	-\$1.28	[-1.49, -1.06]
	Surface	-\$0.91	[-1.13, -0.69]
	Consumptive	-\$1.03	[-1.49, -0.58]
	Land	-\$1.32	[-1.73, -0.91]



**Figure 11:** Bar graph showing marginal values of the biological index for all 4 activity groups, along with 95% confidence intervals.



**Figure 12:** Bar graph showing marginal values of the wind exposure attribute for all 4 activity groups, along with 95% confidence intervals.

## The Total Non-market Value

The individual value of the Sanctuary described above can be extrapolated to the entire user group of non-consumptive private recreational boaters visiting the Sanctuary. Since the SAMSAP aerial survey data described in the methods section could only differentiate non-consumptive PRBs, this was the only user group that could be aggregated. Consumptive PRBs, therefore, could not be included in this aggregate value, meaning that this value is an underestimate of the value the entire community of PRBs associates with the Sanctuary.

To extrapolate the total value of non-consumptive PRB use of the Sanctuary, the value of an individual trip for non-consumptive underwater, non-consumptive surface, and land-based activities was first averaged to arrive at a value of \$53.45. This was next multiplied by 1,621, the total estimated number of private non-consumptive boat trips to the Sanctuary in 2007. This gives a value of \$86,642, which represents the total annual consumer surplus gained by private recreational non-consumptive boaters in the Sanctuary. As will be described in the Discussions section, this should be considered a conservative value and likely an underestimate.

## Example Application of Results

In order to illustrate how managers can translate an increase in any factor of the biological index in a monetary value, we performed a small theoretical experiment. If fish abundance were to double in one popular site of the Sanctuary (e.g. SCI\_PELICAN), as has occurred as a result of management decisions elsewhere (Dugan and Davis, 1993; Lester et al., 2010), we would observe a corresponding increase of 4.45 units in the biological index (see Equation 5). By multiplying this difference by the marginal willingness to pay and the predicted proportion of visitors to this particular site within a year, we arrive at an estimate of \$33,011 for the total value gained (Table 6). This number can be considered an underestimate because it does not account for any additional boater who may choose to visit that site now that the biological attributes have improved.

**Table 6:** Effect of doubling abundance within one popular site

	Invertebrate Abundance	Fish Abundance	Invertebrate Richness	Fish Richness	Biological Index
<b>Current State</b>	329.75	721	22.5	25	22.524
<b>Doubled Fish Abundance</b>	329.75	1442	22.5	25	26.977

This increase in value is substantial in comparison to the total non-market value for private recreational boaters in the Sanctuary (\$86,259). This finding implies that a relatively small increase in any of the factors comprising the biological index in only a few popular sites would have a positive and sizable impact on the total non-market value of the Sanctuary for PRBs. Conversely, if the biological index decreases it is reasonable to assume that the value of the Sanctuary will be reduced.

## Discussion

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Our results show that PRBs gain a measurable monetary benefit from visiting the Sanctuary, and that Sanctuary attributes significantly guide their decisions on which sites to recreate at when they visit. In general, boaters prefer sites with high biological quality, low exposure, and low travel cost. While the multinomial logit model we used in this study has limitations, it is the best model to use given the available data and it demonstrates reliability by capturing realistic trends. Finally, the values reported in our results represent very conservative estimates; true values are expected to be greater.

### Discussion of Results

The results of our model are consistent with the literature and with expectations of private recreational boater behavior. Given that PRBs are investing considerable time and money into their activities, it is logical that they are receiving a measurable benefit from the experience. A value of between \$35 to \$54 per trip represents a reasonable consumer surplus for PRBs. Using data from a 1984 study on private boaters, Leeworthy et al. (2005) found a per trip value of \$43.25, adjusted to the survey time period of 2007 (Consumer Price Index, 2013). Additional studies of per trip value include \$45.60 in 2007 dollars for non-consumptive SCUBA divers within the Channel Islands (Leeworthy and Wiley, 2003) and \$33.53 per trip for pacific coast snorkelers (Kaval and Loomis, 2003). The comparable per trip values generated by the model illustrate its ability to accurately capture the respondents' economic tradeoffs.

Our results demonstrate that travel cost and attributes of the Sanctuary can influence boater behavior. The negative correlation between travel cost and site choice in our model validates the assumption that users consider cost and distance when choosing places to recreate. The positive coefficient for the biological index suggests that PRBs consider some measure of underwater biological quality in their site choice. Land-based non-consumptive users are not directly affected by underwater biological quality. However, it is possible that PRBs are making their choices based on attributes omitted from analysis that are correlated with underwater biodiversity; for example, seabird diversity and abundance may be dependent upon fish abundance as a prey resource. Given that our index is a compilation of fish and invertebrate species richness and abundance, the model suggests that improved biodiversity and productivity of marine ecosystems contribute to better recreational experiences.

While our model does suggest that boaters who engage in underwater non-consumptive activities are willing to pay the most for biological attributes (\$16.78), the differences in willingness to pay between this group, the surface non-consumptive, and land-based user groups are not statistically significant at the 95% confidence level (\$15.62 and \$14.98, respectively). Only consumptive PRBs, with a willingness to pay of \$10.11, are statistically different from the other three activity categories. However, given the small number of respondents (N=5) in this activity group, we cannot report confidence in this difference. The other three activity groups have much larger sample sizes ranging from 15 to 49, indicating that more research on consumptive PRBs is required to arrive at a reliable estimate of this user group's willingness to pay.

The results suggest that PRBs consider the exposure of the coastline when choosing activity-sites, with increased exposure serving as a deterrent. This is logical because improved protection from the

predominant wind and swell in sites with lower exposure is likely to result in a safer and more pleasant experience of the activities considered in the study. The statistical insignificance of percent kelp cover in our model suggests that PRBs do not consider the presence of kelp at the surface in their decision process. However, this result may also be due to the fact that kelp cover is highly dynamic (Dayton et al., 1992), and therefore aerial survey of kelp data taken in October of 2006 might not accurately reflect kelp coverage patterns at the time of the survey (May-Oct 2006/2007). The fact that kelp percent cover at our sites is not correlated with alternative measures of kelp (PISCO's underwater survey of kelp stipes,  $R^2 = -0.06$ ) further reduces our confidence in this dataset as a reliable measure of kelp at the time of study.

The annual consumer surplus of \$86,259 represents only non-consumptive PRBs, and does not consider the additional consumer surplus that consumptive PRBs receive. This is because the SAMSAP data, from which the total number of trips was collected, is unable to make a distinction between a large private fishing boat and a small charter fishing boat (Leeworthy, 2013). Therefore, all consumptive boats were excluded in the final count.

## Discussion of the Model

This study successfully uses a multinomial logit RUM to quantify how private recreational boaters value the Sanctuary and its attributes. This type of model was chosen based on its ability to address the objectives of the project, which were to 1) determine the value of private recreational boater trips to the Sanctuary, and 2) identify which biological and physical attributes influence boater behavior, and quantify how boaters value these attributes. A multinomial logit model calculates the relative importance of both travel cost and site-specific attributes to an individual's decision process. It thus indicates how much individuals value their choice as well as how much individuals value these different attributes.

This type of model was selected as the best possible method for describing behavior based on the existing data. Multinomial models are used when the dependent variable is nominal, meaning that it falls into a discrete set of choices. In this case, the dependent variable is the activity-site that an individual chooses for recreation. There are a finite number of activity choices (4), and a finite number of sites (31), meaning there are 124 possible discrete choices (Figure 2). Multinomial logit models examine how independent variables affect the dependent variable of choice. In this case, there are four independent variables, which are different for each site: a biological index, kelp cover percentage, wind exposure, and the travel cost to the site. In this particular model, it is assumed that the relative importance of each of these independent variables depends on the activity group of the individual. Therefore, this model appropriately predicts what activity-site an individual will choose based on attributes that are important for their chosen activity.

Although the random utility model is commonly used when analyzing demand for access to recreation sites (Thomas and Stratis, 2002), it has its limitations and assumptions that should be recognized and considered. These caveats are summarized below.

First, the RUM is centered on the choices of an individual and assumes decisions are made independent of any other decision maker or social interaction (Ben-Akiva et al., 2002). It is possible that some respondents in our study were traveling alone, but it is most likely that there were groups of people traveling to the Sanctuary together. There is no way to account for joint decisions, site recommendations from friends, or other social sources in our model.

Second, multinomial logit models assume that independent variables (attributes) have relatively low collinearity. This was initially confirmed for exposure and kelp, but not for the biological attributes (fish abundance, fish richness, invertebrate abundance, and invertebrate richness). As a result, these biological attributes were combined into one biological index. After running regressions between the independent variables and the new biological index, we verified that all attributes had low levels of correlation with each other (see Appendix G). Although creating an index was necessary to satisfy non-collinearity assumptions, it reduces the ability of the model to distinguish between the effects of different biological measures.

Third, a potential source of bias arises from the assumption that all activities are possible at all sites. Although certain activities like SCUBA diving or snorkeling may be theoretically possible at almost every location, it is not realistic to assume that boaters have an equal probability of participating in every activity at every site. This would especially be true for land-based and consumptive activities, since not every anchorage offers access to land, and some sites are no-take reserves.

Fourth, the RUM model is unable to deal with multiple site visits (Parsons, 2001). We used the activity hierarchy approach in order to assign one activity-site choice to each individual. By doing so, a portion of our dataset could not be used. The original Intercept Survey data contained all activity and site choices for each individual. Of the 110 individuals that participated in the survey, 62% recorded multiple site visits. One respondent went to as many as 16 different sites. While using a hierarchy approach to organize the data best represents our interest in underwater, non-consumptive users, it shrinks the sample sizes of those who participated in consumptive and land-based activities, and thus limits our ability to speak to the behavior of those users. Additionally, using only one activity-site per individual may lead to an underestimation of the value of that individual's trip (see Section below on "Conservative Estimates of Value").

Fifth, this model was unable to calculate site-specific intercepts that would otherwise account for unrepresented attributes affecting site choice decisions. Only a portion of the total available site choices was represented in boaters' decisions. Most individuals chose to recreate at a handful of sites at Santa Cruz Island. This reduces the relevance of attribute coefficients to sites that were not visited by individuals during the survey, and makes it impossible to determine the intercepts for those sites. Without intercepts, we make the assumption that the attributes included in our model account for all site-related characteristics affecting boater choice. Examples of other attributes influencing boater behavior could include measurable attributes such as seafloor substrate, the number of other boats at a site (congestion), the availability of a safe anchorage, or the proximity to beach access.

Finally, boaters may also be influenced by factors that are more difficult to measure, such as the aesthetic value of a site. Some characteristics may not be linked to certain sites but instead influence a PRB's decision to go the Sanctuary in the first place. For example, dynamic attributes linked to weather are highly variable and are likely to play a significant role in boater behavior. Our model was not able to incorporate these attributes due to limitations in the 2006/2007 survey design. Overall, the robustness of the model could be improved with the inclusion of additional attributes, given more time and resources.

Despite shortcomings associated with the multinomial logit RUM, it is one of the most extensively used methods when estimating recreation choice among multiple substitute sites with different characteristics (Bockstael, 1989). Given the data limitations, it is also the best possible form of RUM for this research effort. Its application in this study demonstrates its ability to realistically model private recreational boater choice decisions within the Sanctuary. Until current non-market valuation methods can relax these limitations and assumptions, no single model will be able to take into account the entire suite of complex, interconnected factors that go into making a decision or valuing a place. Nevertheless, this approach still offers valuable insight to the patterns of decisions made by boaters and the amount they are willing to pay to visit the Sanctuary and enjoy its amenities.

### **Conservative Estimates of Value**

It is important to note that the consumer surplus and willingness to pay values obtained in this project should be considered conservative estimates of the true values. Data limitations and the inherent assumptions of the multinomial logit model (as discussed previously) suggest that the results model may be underestimates, and the value of \$86,259 should be considered a lower bound. These reasons are listed below:

- 1) We assume that each boat carried a single individual because the survey provided demographic data on only the boat's captain. In reality, it is highly likely that most boats carried multiple passengers. Assuming a single travel cost per boat may undervalue a trip with multiple individuals because it ignores the on-land travel and opportunity cost of all of the passengers that are not the captain.
- 2) The multinomial logit model only captures the utility PRBs receive from participating in a single activity in one location. In reality, most boaters did many activities in multiple sites. Any additional utility PRBs may derive from these extra activities and/or sites is ignored. It is expected boaters are receiving utility from these additional activities, so by not including them, we are underestimating their total utility.
- 3) We were unable to address additional expenditures, including but not restricted to food/beverage costs, gear, slip fees (for those boats that are kept in harbors), and the actual costs of owning and maintaining a boat. The true amount a PRB pays to visit the CINMS is likely to be substantially greater than the cost of fuel, vehicle maintenance, and opportunity cost alone.
- 4) Finally, as stated in the discussion of our results, the annual consumer surplus of \$86,259 we obtained only considers non-consumptive PRBs. We could only consider non-consumptive PRBs



because we did not have data on the number of consumptive PRBs visiting the Sanctuary. If we could include these individuals in our aggregation, the consumer surplus for all private recreational boaters would increase.

## Management Implications

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### Management of the Sanctuary

Effective management of the CINMS requires consideration of the value that the Sanctuary provides to a wide range of stakeholder groups (Papadopoulos and Warin, 2007). While we cannot speak to the integrated management of the Sanctuary, the result of our study do pose a few policy implications for PRBs that management may consider.

Based on the results of our model, managers may incorporate the benefits PRBs receive from a single trip to the Sanctuary (i.e. about \$54) in any quantitative or qualitative analysis of future policy. To improve the value that recreational boaters gain from access to the CINMS, managers may also consider management actions that protect or restore the biological quality of the Sanctuary. Our research suggests that these types of actions are especially relevant for non-consumptive PRBs. Water quality improvements, limits on oil and gas development, fishing restrictions and MPAs are examples of management actions that are linked to proportional increases in fish biomass and invertebrate density for species targeted by fishing (Lester et al., 2010; Airamé et al., 2003).

MPAs were examined as an individual attribute (separate from the biological index) in the model; however, when MPAs were included, the statistical power of the model was reduced. This suggests that based on the intercept data from 2006, the presence of MPAs at that time was not a reliable indicator of boater site choice. Since the model demonstrates that biological index more accurately explained boater behavior overall, it would be expected that management actions that increase fish and invertebrate abundance and richness would add value to the Sanctuary. For example, our results suggest that as the network of MPAs matures and fish and invertebrate abundance and richness increase for a variety of species (Hamilton et al., 2010), we would expect an increase in the value of the Sanctuary to private recreational boaters.

As our model indicates, distance from port is a substantial deterrent for PRBs in choosing sites; thus it is logical that recreational boating is most often concentrated to closer Islands from port such as Anacapa and Santa Cruz. This finding is consistent with other research efforts, which report a spatial concentration of boaters within the eastern portion of the Sanctuary (LaFranchi and Pendleton 2008). The trend suggests that management efforts that impact these highly frequented regions are likely to disproportionately affect PRB activities positively. Directing policy to maintain the quality and value of eastern sites may therefore be an effective use of limited management resources.

By quantifying the total non-market value for private recreational boating (i.e. a lower bound of \$86,259), we are supporting managers' ability to consider the economic tradeoffs of the various uses of the Sanctuary. Before this study, PRBs did not have a total value associated with their activities.

Therefore, our estimate can be used in the discussion of management actions that affect this stakeholder group.

## Application of Results

Managers from the CINMS and other parts of the world can use the marginal willingness to pay for one unit of the biological index (i.e. \$16.78) that we have derived to represent the changes in value associated with fluctuations in the biological quality of marine ecosystems. This essentially transforms the effects of management action on biological quality into a monetary value. To do this, the researcher calculates the biological index at the site of interest from the monitoring data of fish and invertebrate abundance and richness. The change in biological index can next be multiplied by the marginal willingness to pay for a unit of index and by the annual predicted number of visitors to the site, yielding a change in the total PRB value of the region of interest. This may make it possible for managers to speak to how both policies and natural fluctuation affects marine resources and the stakeholders who value them.

## Future Research

We advocate the use of Random Utility Models as a methodology for exploring the non-market value of recreational activities and for defining the factors that influence the behavior of individuals who engage in these activities. However, there are several ways to build on the results of this study. Future research could examine different hierarchies in which different activity groups are prioritized. In addition, our research process has highlighted several data gaps that, if addressed, will improve the relevance of our results.

Given more time and resources, additional iterations of the model may provide greater resolution between our activity categories as well as increase the robustness of the model. We recommend running the model with several alternative hierarchies, where other activity categories, such as consumptive PRBs, are prioritized. This research may reveal differences in willingness to pay per attribute or consumer surplus per trip that is not apparent in our current model. As a robustness check, we also recommend performing a Monte Carlo analysis. Building several iterations of the model without the hierarchy by randomly selecting the activity that represents the single visit per individual will provide a distribution of attribute coefficients and values. Comparing the results of the Monte Carlo analysis to the hierarchical model would provide a quantitative measure of how the hierarchy affected results.

The presence of several data gaps required some assumptions that, if relaxed, might further the understanding of PRBs. Future research that eliminates these data gaps can improve the accuracy of our results and therefore contribute to the literature on this stakeholder group. If remedied, the following data gaps could improve our results:

- 1) Collect additional information on the number of private boats that visit the CINMS annually. The SAMSAP data, which was used for the annual total of boat trips, is limited by the fact that it is unable to differentiate between privately owned boats and charter or rental operations. If we had this data, our estimates for overall value of the Sanctuary to PRBs may be both larger and more accurate.

- 2) Finer temporal scale data on kelp percent cover could more accurately capture what PRBs experienced when they visited their recreation sites. This would allow for a better understanding of how kelp percent cover affects PRBs' choices.
- 3) Develop a list of the activities that can be done at each site. The full list of activities may not be practical at each site, and this data will allow us to more closely model PRBs' decision trees.
- 4) Other attributes that may influence boaters' decision that were not included in our model could also be explored. Site characteristics such as scenic view, presence of coves, and abundance of marine mammals are examples of attributes that can also drive boaters' decision on site choice. Also, congestion of boats might play an important role on site selection since if there is no extra space for the boat to anchor the boaters will be obligated to choose a different location. For refinement of the model in future studies all these attributes should be considered in order to develop a more complete picture of PRBs' behavior.

A further improvement on our research efforts would account for a boater participation tier with a nested RUM (Leeworthy et al., 2007). This would capture the boater decision process involved in initiating a trip to the Sanctuary. By using this approach it is possible to predict how the number of private recreational boaters in the Sanctuary would change as a function of variations in site attributes or travel cost. For example, if biological quality increases, a greater number of non-consumptive recreational boaters are expected to visit the islands. In contrast, if fuel costs increase it follows that fewer boaters would visit the Sanctuary.

Given the limitations of the RUM and the data, we suggest that future studies of this kind build upon the analytical process through the use of stated preference conjoint approaches (Williams, 1994). These approaches allow for the estimation of correlated attributes separately, as opposed to dropping attributes or combining them into indices. In some cases, this method has the ability to model interactions between attributes. Therefore, it can predict the importance of individual characteristics within a location as well as the intrinsic value of the location itself (Johnson, 2008).

In order for this or similar models to be applicable to other studies of recreational behavior, we recommend several improvements for survey design including:

- 1) Pre-define the sites for consistency before survey implementation, based on the attributes of interest. This action facilitates the estimation of the model and is likely to more clearly define the relative significance of attributes.
- 2) Survey a large sample of the recreational area (based on time and resources). The data in our study was biased due to the fact that only one Island was studied.
- 3) Design surveys that directly ask for boaters' reasoning behind their site and activity choices. This would help determine if factors such as the aesthetic value of a site or congestion are important in the decision-making process. In addition, it may identify which activity to use in hierarchical approaches.
- 4) Edit the survey questionnaire for ease in calculating travel costs more accurately, including:
  - a. Data on the number of individuals per boat, as well as individual demographic data

- b. Data on other attendant costs besides travel costs, including cost of food, gear and equipment costs, and boat purchase costs.
- 5) Edit the survey questionnaire to elicit fine-scale temporal details, including:
- a. Data on time spent at each activity. This aids in data reduction techniques as it may reveal a preference for certain activities.
  - b. Information on the time of trip departure. This supports the use of nested models, as it allows for the inclusion of dynamic, weather-based attributes.
  - c. Activity-specific attributes, such as activity cost or effort. This also aids in designing a nested model. Nested models are increasingly advocated in the literature (Hanemann et al., 2007; Hoehn et al., 1996; Morey, 1994; Thomas and Stratis, 2002), and therefore designing surveys carefully for this purpose is advisable.

Finally, further research that describes the significance of recreational boating to the local economy is recommended. Such a study could use the total non-market value of private recreational boating identified in this report. By applying an Impact Analysis and Planning Software model, it is possible to determine how PRB expenditures interact with the nearby economies of coastal Southern California through multiplier effects.

## Conclusion

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Our research demonstrates the challenges and complexity of quantifying the value of stakeholder activities that operate outside of conventional economic markets. Nevertheless, the process of non-market valuation is necessary to demonstrate that resources have monetary significance in a market-driven society. Without this research, managers are at risk of undervaluing natural resources. To date, random utility models are one of the most effective methodologies for assessing the importance of marine resources to recreational users. Our study applies this technique to an underrepresented stakeholder group, the non-consumptive private recreational boater, and demonstrates that specific characteristics of the Sanctuary are valuable to these stakeholders. We are confident in the results and recommendations of our study and hope they will contribute to the effectiveness of Sanctuary management.

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## Appendices

**Appendix A:** Created sites and attributes for each site in the analysis. 31 shapefiles were created to represent sites around Anacapa, Santa Cruz, and Santa Rosa Islands. Site IDs range from 1 to 31. See table below for ID names.

**Site Attributes:** Table represents values for all attributes in each site. Kelp cover is given in percentage, biological index is unitless, and wind exposure is given in degrees from the predominant wind direction (northwest).

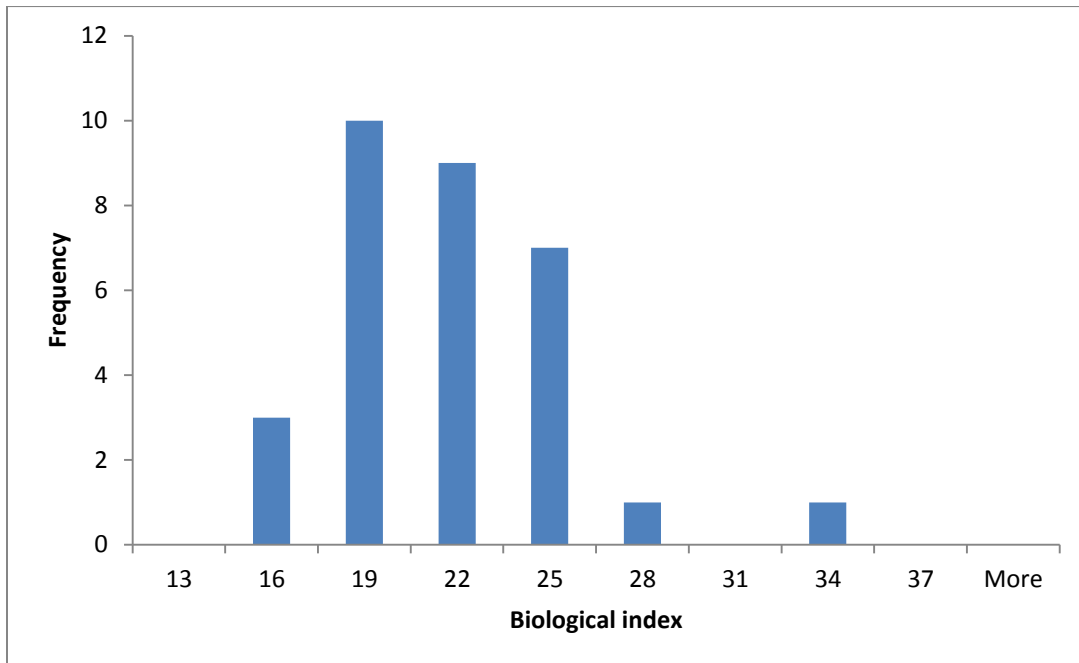
Site	Site ID	Kelp Cover (%)	Biological Index	Wind Exposure (deg)
ANACAPA_ADMIRALS	1	0.84	21.95	58
ANACAPA_FISH_CAMP	2	0.62	21.53	34
ANACAPA_EAST_ISLE	3	0.75	20.73	150
ANACAPA_LIGHTHOUSE_REEF	4	1.21	24.04	30
ANACAPA_MIDDLE_ISLE	5	0.12	18.67	146
ANACAPA_WEST_ISLE	6	0.08	19.03	123
SCI_CAVERN_POINT	7	0	20.21	160
SCI_COCHE_PONIT	8	0.55	18.66	165
SCI_FORNEY	9	1.77	20.37	113
SCI_GULL	10	0.88	22.59	54
SCI_HAZARDS	11	0.24	22.51	127
SCI_LITTLE_SCORPION	12	0.25	18.41	125
SCI_PAINTED_CAVE	13	0.028	31.26	125
SCI_PELICAN	14	0.05	27.90	111
SCI_POTATO_PASTURE	15	0.72	16.49	140
SCI_SAN_PEDRO	16	0.88	20.76	30
SCI_SCORPION	17	1.13	23.80	99
SCI_VALLEY	18	3.61	22.52	0
SCI_YELLOWBANKS	19	25.43	22.33	13
SRI_BEACON_REEF	20	6.27	15.90	50
SRI_BEE_ROCK	21	26.63	16.76	102
SRI_CARRINGTON	22	0.03	18.98	159
SRI_CHICKASAW	23	2.18	19.11	67
SRI_CLUSTERPOINT	24	12.04	17.67	105
SRI_JOHNSONSLEE_NORTH	25	7.67	18.27	31
SRI_JOHNSONSLEE_SOUTH	26	6.99	23.01	3
SRI_JOLLA_VIEJA	27	5.16	18.33	53
SRI_MONACOS	28	1.63	18.24	91
SRI_RODES_REEF	29	14.92	14.54	144
SRI_SOUTH_POINT	30	4.25	15.89	67
SRI_TRANCIONCANYON	31	8.82	19.33	67

## Appendix B: Attribute Profile

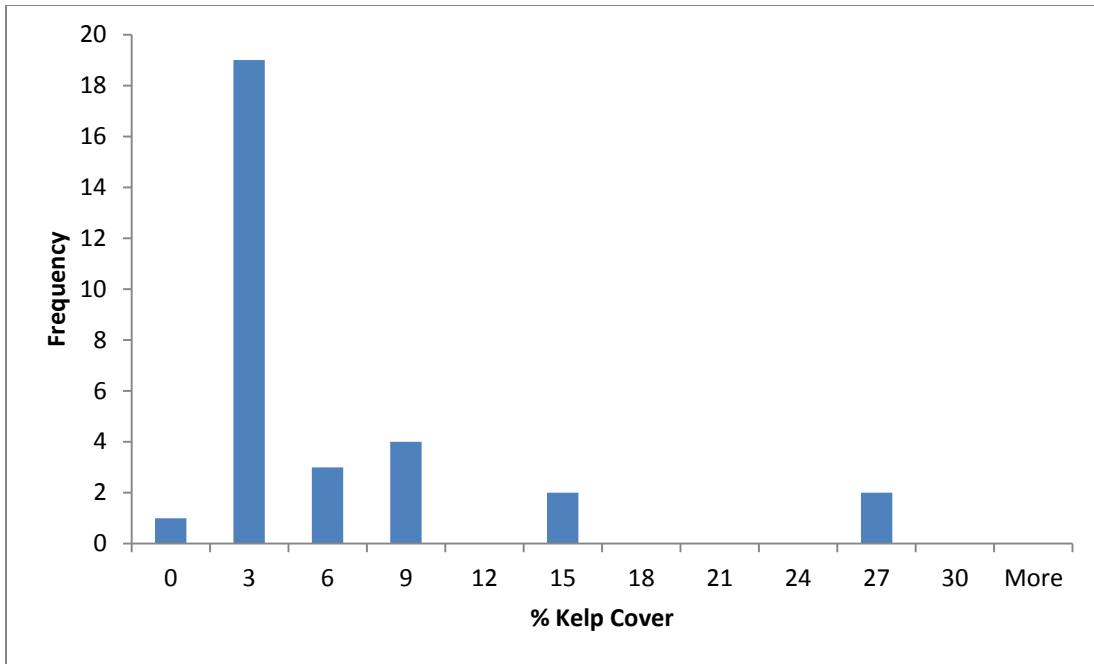
The profile of our attributes reveals considerable variation across sites (Table 3 and Figures 13-15). The biological index follows a normal distribution, which shows that most sites have similar levels of fish and invertebrate abundance and richness without extreme values. The percent cover of kelp seems to show a right skew, with most sites containing lower percentages of kelp cover. The exposure index did not display any distribution pattern. However, most values seem to be represented in the data set.

**Table 3:** Distribution of attribute values

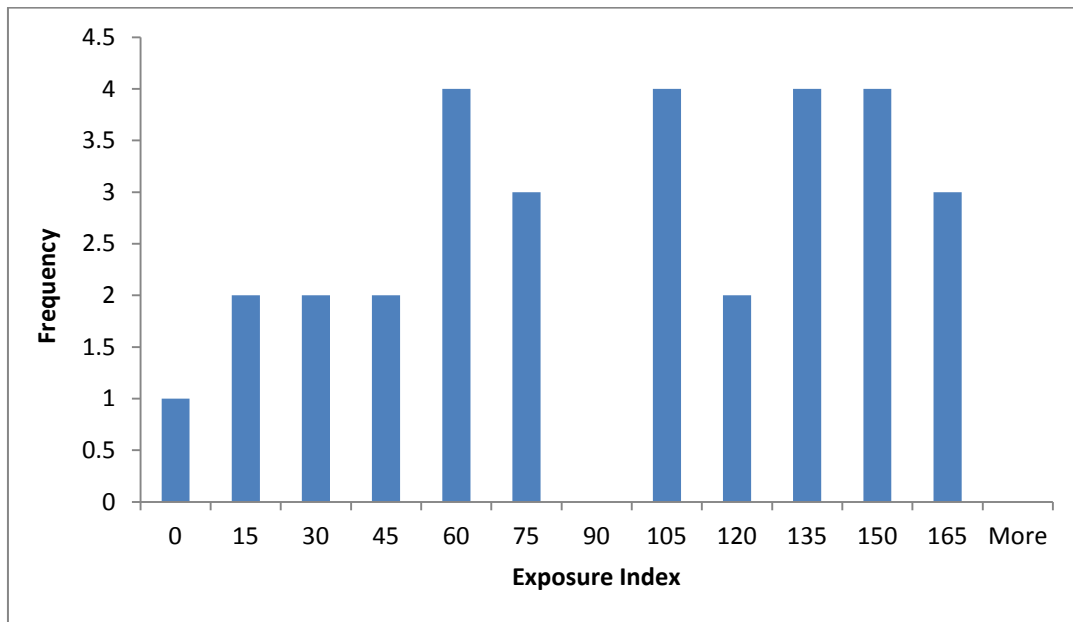
Attribute	Min	Max	Mean	Std. dev
Biological index	14.54	31.27	20.32	3.5
Kelp percent cover (%)	0	26.63	4.38	6.9
Exposure index	0	165	88.45	50.33



**Figure 13:** Frequency distribution of biological index



**Figure 14:** Frequency distribution of kelp cover percentage



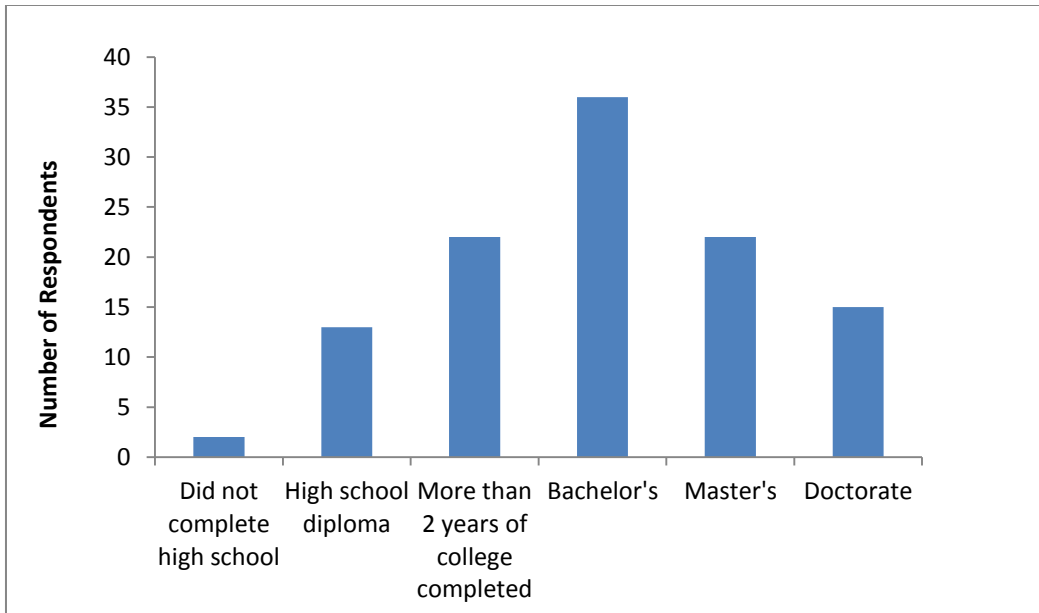
**Figure 15:** Frequency distribution of wind exposure. 0 signifies a completely protected coastline and 180 signifies completely exposed.

### Appendix C: Demographic Profile of Respondents

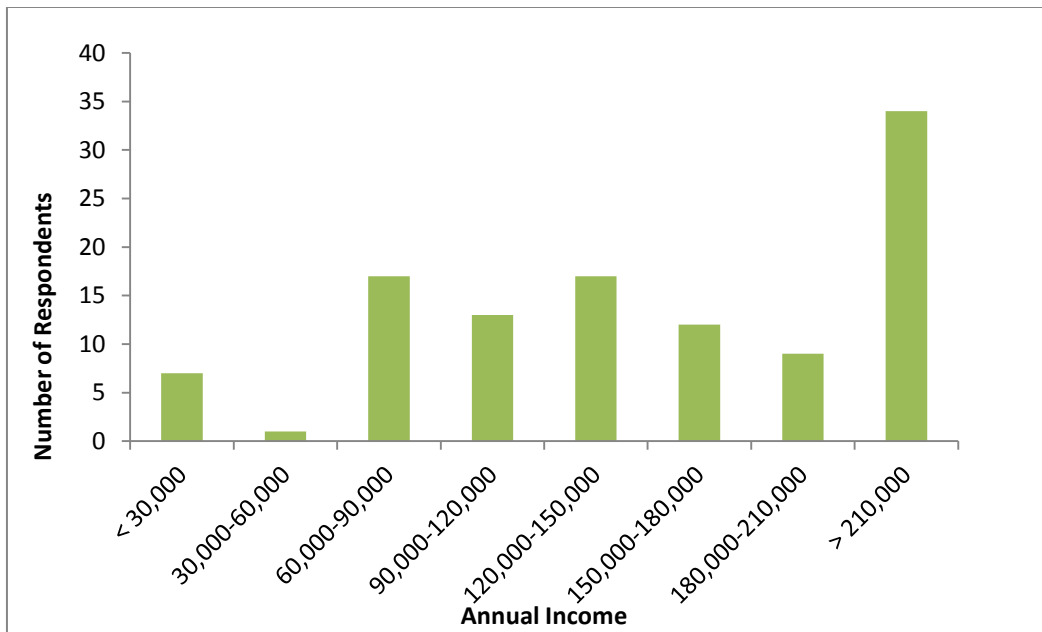
The majority of private recreational boaters in the Intercept Survey are male, over fifty years of age, relatively well educated, and in possession of an income over \$60,000. However, there is some variation in the demographic profiles of these users (Figures 16-18). The usable data from the Intercept Survey represents 110 respondents, 109 of which were male. The age and education of the respondents follows a roughly normal distribution. The mode for age is 51-55 years, and the most common level of education is a Bachelor's degree. The distribution of annual income is more evenly distributed with the exception of individuals who make over \$210,000 per year.



Figure 16: Age distribution of respondents. N=110



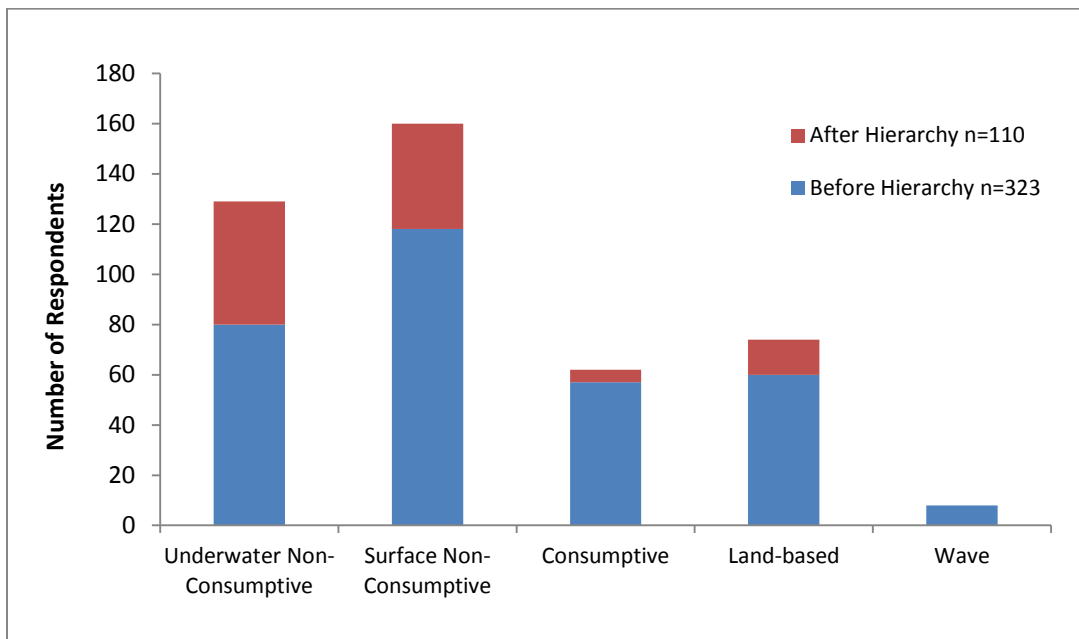
**Figure 17:** Education distribution of respondents. N=110



**Figure 18:** Income distribution of respondents. N=110

## Appendix D: Choice Profile of Respondents

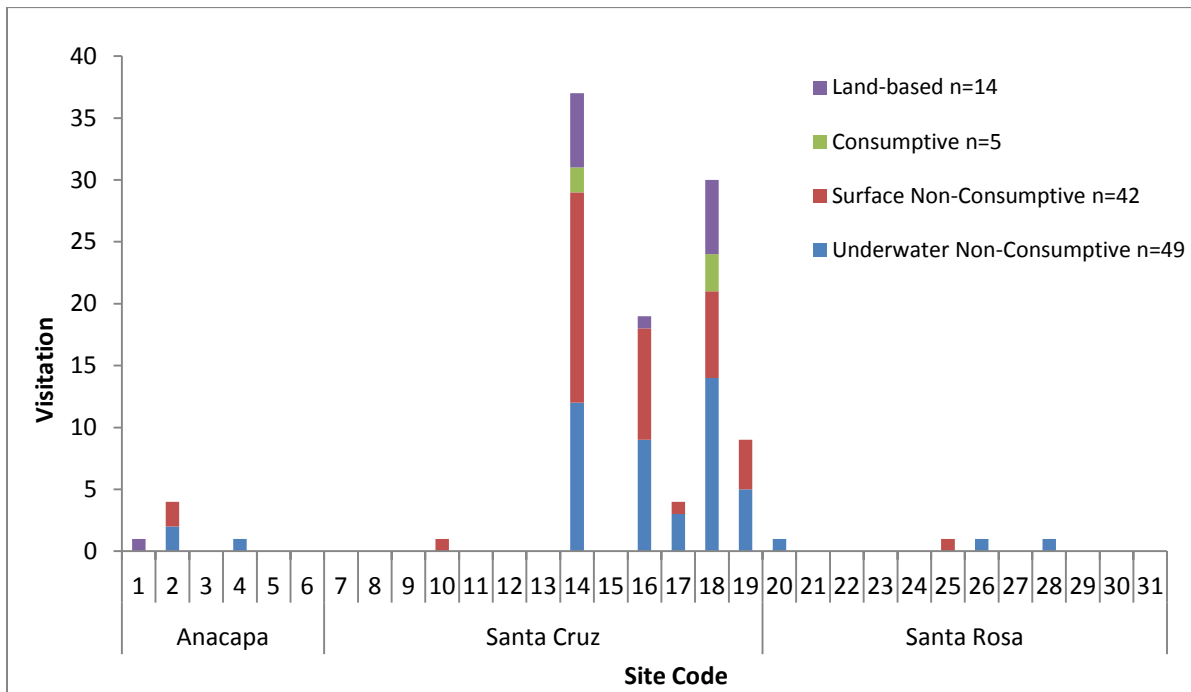
**Activity Choice:** The application of the study’s hierarchy altered the distribution of respondent participation in activity categories. Prior to the elimination of multiple visits, survey respondents drew from polygons in OceanMap, representing their participation in an activity at a unique time. The total number of 323 unique “activity shapes” was reduced to 110 after the single-visit hierarchy was applied. Figure 12 demonstrates the change in activity category participation with the hierarchy. The most common activity category in the original dataset of N=323 was surface non-consumptive (37%), which includes exploring by dinghy and kayaking, while the second most frequent was underwater non-consumptive (25%). In the N=110 dataset, underwater non-consumptive activities are the most represented (45%), followed by surface non-consumptive activities (38%). Participation in consumptive activities changed from 18% to 5% after the implementation of the hierarchy. Land-based activities, however, maintained a relatively consistent percentage after the elimination of multiple visits (19% to 13%). The wave activity category was removed completely due to lack of participation.



**Figure 19:** Number of visits per activity category before and after data reduction

**Site Choice:** The site choices in the hierarchical dataset demonstrate an uneven spatial distribution across sites and islands. They reported visiting just 13 of the 31 defined sites, or 42% (Figure 20). Results show that site visitation for all activity categories was highly concentrated around Santa Cruz Island, which may be a result of conducting the survey around Santa Cruz Island. The following trends are noted:

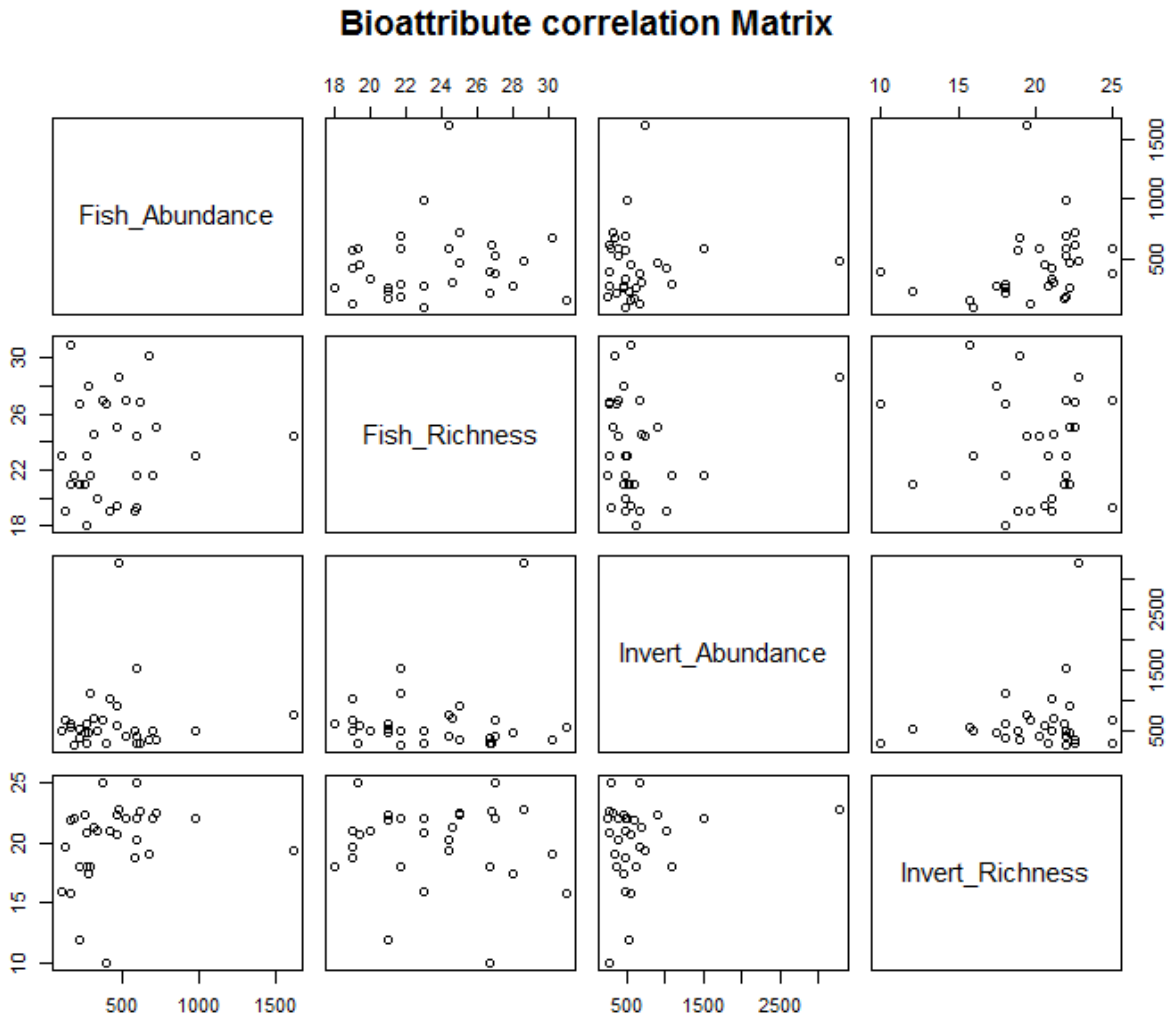
- 78% of respondents visited just 3 sites around Santa Cruz Island while 90% visited the 6 sites on Santa Cruz.
- The remaining 10% of respondents visited 7 sites around Anacapa and Santa Rosa.
- Underwater and surface non-consumptive users reported visiting all three islands, while land-based users visited Santa Cruz and Anacapa, and consumptive users only visited Santa Cruz.



**Figure 20:** Distribution of site visits by private recreational boater activity category.

**Appendix E: Correlation of Biological Attributes before creating the Biological Index**

**1: Biological Attribute Correlation Matrix**



**2: Biological Attribute Correlation Matrix showing R<sup>2</sup> values**

	Fish_Abundance	Fish_Richness	Invert_Abundance	Invert_Richness
Fish_Abundance	1	0.107	0.044	0.242
Fish_Richness	0.107	1	0.114	-0.124
Invert_Abundance	0.044	0.114	1	0.175
Invert_Richness	0.242	-0.124	0.175	1



**Appendix F: Sensitivity analysis of trip value versus wage percentage used in opportunity cost**

Opportunity Cost of Time	Value of One Trip
33% of Wage	\$52.79
50% of Wage	\$52.79
100% of Wage	\$52.79

**Appendix G: Collinearity of different independent variables used in the multinomial logit model**

Attribute 1	Attribute 2	R <sup>2</sup>
Biological Index	Kelp Cover	-0.2922
Biological Index	Exposure	-0.1603
Biological Index	Travel Cost	-0.0039
Kelp Cover	Exposure	-0.2527
Kelp Cover	Travel Cost	0.0048
Exposure	Travel Cost	-0.0044