Small Boat Fishing in Hawaii: Choice and Economic Values

Kenneth E. McConnell & Timothy C. Haab

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1. Introduction

The purpose of this report is to investigate the economic dimensions of small boat fishing, as well as describe the basic characteristics of fishermen who take part in the fishery. It is a complex fishery. Small boat fishermen[1] are not strictly commercial, though many sell their catch. The fishery is not completely recreational, although many anglers fish for the fun of it, often releasing their catch. Eating the fish they catch motivates many other small boat fishermen. Further there is a cultural component to the fishing. Fishermen learn from one another about what's running and where, and the act of giving fish away is an important part of fishing and a traditional communal activity. The small boat fishery is worth studying for its own sake because of its role in the daily lives of many in Hawaii. But the evolution of commerical fishing and the policies that have been developed in response to changes in commercial fisheries make it even more important to study the small boat fishery.

The report is written to help understand the economic dimensions of the small boat fishery. It does not attempt to estimate landings for the fishery. Although this is an important aspect of the fishery, it takes a special type of survey, one that intercepts fishermen when they have just completed their trips or during their fishing. Occasionally a survey can serve the purposes of both economic and biological research. But in this economic study, a phone survey proved to the best method of gathering data, and such a survey is not a good means of gathering catch data.

Fishing is a way of life for many people in Hawaii. In times when the technical means of harvesting were limited and stable, and the harvests were bound for limited local consumption, harvesting could stay in equilibrium with the natural productive capacities of the ocean. When temporary declines in the natural productive capacity or improvements in harvesting abilities threatened this equilibrium, local and informal institutions evolved to help allocate scarce resources. The historical development of fisheries not only induced equilibrium in the harvesting of fisheries resources, but cemented fishing as a way of life in Hawaii.

The introduction of mechanized means of harvesting fish, the growth of interstate and international trade in fisheries products, and the development of more complex governing institutions have banished for good most informal arrange-

[1]In referring to all people as fishermen, rather than fishermen or fisherwomen or even fishers, I have followed the precedent of Linda Greenlaw, captain of the longline vessel Hanna Boden and author of "The Hungry Ocean" who insists on being called a fisherman.

ments for allocating fisheries resources, in Hawaii and elsewhere. These informal arrangements were initially overwhelmed by open access to fisheries. The larger-scale fishing vessels can quickly overexploit fisheries that were harvested by more traditional means.

The initial gains by larger, more mechanized sectors, and consequent losses by the small boat fishery, have led to fishery policy measures to reserve some resources for the small scale sectors. For example, the restriction on long-lining in the near-shore fishing areas of Hawaii represents an attempt to allocate fish away from the strictly commercial sector to the small boat sector. The small boat sector differs from the strictly commerical sector in more than scale. In addition to the scale of the vessels, the chief distinction between the informal small boat sector and the commercial sector is the influence of profit maximization. In the small boat sector, market forces and prices may influence behavior, but decisions to enter and exit the fisheries that characterize commercial fisheries are generally absent.

Distinguishing between recreational and commercial fishing takes on a greater importance when regulations are designed to allocate between the two sectors. The distinction between the two sectors is often blurred. Many fishermen who sell their catch fish mainly for the enjoyment. Hence sales of catch is not a good discriminant. Many captains of large commercial vessels not only earn income but also enjoy the enterprise. In Hawaii, selling catch is common among many who would otherwise be considered recreational. For purposes of this report, we take large-scale ommercial fishing to be the activity undertaken for the main source of earned income of the individual. This discriminates between the commercial sector and the small boat sector imperfectly, because some fishermen in this sector do earn most of their incomes from fishing.

Fishery policy is made for many reasons–for fairness in allocation, to satisfy major political forces, and for good and efficient uses of scarce resources. Fairness and political motives work themselves out through lobbying. But in the long run it is wise to avoid undue wasteful or inefficient use of scarce resources. For the efficient allocation of scarce fish stocks, harvests should provide the same economic values in different harvesting sectors and the additional economic value of fish harvested from increased fishing in different sectors should be equal. The marginal (that is, incremental) value of landing a fish equals the gross extra value of having the fish, less the full cost of landing it. In the commercial sector, the self-interest of fishermen working in the market tends to equate the economic value of increased fishing across activities. In the commercial sector, the marginal

value equals the price less the full marginal cost of harvesting the fish. In the small boat sector, the marginal value of catching the fish may be the price for those who sell, the consumption value for those who consume, and the aesthetic value of pure recreation. When the marginal values of catching fish are equal in different sectors, and they account for the future value of scarce fish, then fish stocks are allocated efficiently. Hence implementing policies that induce efficient use of resources requires that we know the value of catching fish in the small boat sector.

Estimating the marginal values of catch fish in the small boat fishery is one of the chief goals of this research. Marginal values can be discovered by finding the economic value of access to different fishing areas. The discovery of the value of fishing areas is not straightforward, however. Compare it with the market for vacant lots in a real estate market. In a market-driven system, lots would go to the use with the highest value, some as parking lots, others as building sites. Both a fishery and a vacant lot are valuable natural resources, but similarities end there.

The allocation of fish stocks and fishing locations is naturally quite different from the allocation of land. Property rights on fish and locations to fish are for the most part not assigned and cannot be bought and sold. Instead, these fishery resources are allocated informally, by individual arrangements, by competition, by political means, and on a first-come, first-served basis. Economic values play a role in these allocations. Large commercial enterprises are able to invest in lobbying efforts to secure access to fishery resources from regulators[2] If the returns to fishing were small, the enterprises would be less willing to lobby for access. In the small boat sector, the economic value is measured by the amount of income that is equivalent to the opportunity to fish. Economic values may also be high for small boat fisheries, but they lack visibility compared with the commercial sector. In commercial fisheries, it is easy to see economic value, because the product is sold. For the small boat fishery, fishing activity also generates economic value, even when there is little market activity. This report measures some parts of the economic value for the small boat fishery and estimates central tendencies of important economic components of the fishery. For a view of what the fishery is like from a social perspective, see Glazier 1999b[3].

[2]Numbers of votes count too. This helps explain why the small boat fishery can lobby successfully.

[3]The report by Glazier (Social Aspects of Hawaii's Small Vessel Troll Fishery) provides a great deal of information about how the small boat fishery actually works. And anyone wanting to

The report measures the economic value of the small boat fishery. The research is based on a phone survey of small boat owners whose boats are registered with the state of Hawaii. The survey, conducted in 1997-1998 and 1999, provides the basis for two approaches to estimating economic value: a random utility model, based on the behavior of anglers as revealed in the survey, and a contingent valuation model, which stems from direct questions to the anglers about their preferences under hypothetical circumstances.

To be useful, economic values must be comparable across sectors. This is critical for the small boat fishery, where much of the output is not destined for the market. Economics has a logically consistent and unambiguous definition of economic value: it is the amount of additional income that is equivalent to (or compensates for) changes in circumstances. The key word in this definition is income. For an improvement in circumstances, economic value is the amount of income that would be equivalent to the improvement. That is the minimum amount of income an individual would accept in lieu of the improved circumstances. For diminished circumstances, economic value is the amount of money that would compensate an individual for the change–that is, make him indifferent between accepting the monetary compensation and the diminished circumstances. Economic value can be attached to commodities, rights, services and opportunities. In the case of fishing, economic value can be attached to the broad notion of the opportunity to fish in a particular area for a given length of time, or narrowly to the catching of a particular fish. In the commercial sector, economic value to the producer is straightforward: the net monetary gains, equal to revenues from harvest less costs from harvest. In the elementary case of one fish, the economic value to producers is the price of the fish less the cost of harvesting the fish.

Aggregate measures of income or equivalent income have one important drawback: they typically tell us little about how the income changes are distributed. The same dollar value of a change in equivalent income can be distributed in many different ways. For example, a policy that brings an increase of $1 million distributed evenly among 10,000 households would probably be viewed as more desirable than an increase of $1 million where 10,000 households get an increase of $200 and 10,000 households suffer a loss equivalent to $100. While distributional issues are not always important, it is worthwhile to bear in mind that aggregate measures do not tell us anything about how the income changes are distributed. In this report, we estimate measures of central tendency–i.e., means and medians

know the difference between a model and the real world should compare the present report and the report of Glazier

of economic values for representative anglers. In the case of the small boat fishery, we will estimate aggregate economic values but not how the values would be distributed.

1.1. What Are Good Measures of 'Economic Importance'?

Measures of the size and contribution of an industry's, or sector's, proposed activity to a region's or state's economy are often sought as a means of justifying government support in the form of subsidies or tax breaks. This is true in Hawaii, where state resources are especially scarce, and the geographical isolation of the economy exacerbates its vulnerability. And in the case of fisheries, different sectors compete not only for state support, but for the resource itself. Many kinds of economic measures are constructed and used to justify state support or resource allocation. Not all measures are equally valid in making allocation decisions.

Economic value can be defined as *the amount of income for an individual that is equivalent to (or compensates for) specified changes in circumstances.* Consequently a good measure of economic importance of a project, policy or proposed change is the aggregate amount of the equivalent income change induced by the policy or project. The most efficient use of resources is the one that increases income or income-equivalent the most for the relevant population. In decisions that involve only residents of Hawaii, judging resource allocation would entail measurement of the changes in real income or its equivalent for residents of Hawaii.

Two issues arise in recognizing equivalent real income increases. The first is that some dollar measures such as total spending or total economic impact induced by projects overestimate equivalent real income because they include payment for the costs of goods and services in addition to income. This is true of measures of economic impact, which typically overstate equivalent real income increases. The second is that resource allocation decisions can often improve or reduce equivalent real income without causing a discernible change in spending or other monetary aggregates. This is especially true when non-market resources such as fisheries are concerned. Consequently, it is critical to recognize the dimensions of economic value.

The definition of economic value has three critical qualifications:

Focus on change in economic value. Governmental policies make changes in resource allocations, and the relevant evaluation is of the increases or decreases in equivalent income, not total income. Measures of total economic value are typically not relevant to the immediate policy questions because they do not

provide information on how incomes of individuals change. Rather, a sensible approach would look for policies that increase income, or attempt to avoid policies that decrease income.

Income as a basis of evaluation. Measures of economic value should help sort good projects and policies from bad or wasteful ones by identifying circumstances that improve well-being. The economic measure that is least likely to lead to the misuse of resources is real income. Other measures, such as sales revenue, expenditures, or costs, may be composed in part of income, but typically overstate income increases, and do not reflect increases that are valued by individuals. Consider two projects: one brings $1 million worth of goods into Hawaii and resells them for $1.1 million; another reduces the cost of doing business by $200,000. The latter project would provide the greater improvement in the well-being of residents of Hawaii.

Equivalent income. Occasionally changes in resource allocations can change equivalent income or economic welfare without changes in monetary aggregates. This is especially true when non-market activities such as recreation or subsistence are concerned. For example, consider a fishery where local anglers make their own gear, catch their own bait and consume their catch. Hence most activity is outside the market. A policy that constrained their access to the fishery could easily go unrecorded in monetary aggregates but would most certainly reduce the well-being of local anglers. To be complete, economic value includes the income equivalent of the change in the conditions of access for local anglers. The trick is to find circumstances that allow one to infer the equivalent income changes that would compensate anglers for changes in fishing circumstances.

In summary, good measures of economic value should represent the equivalent of changes in real income for policies or projects.

The measures of economic value estimated in this report are equivalent income measures for small boat fishermen in Hawaii. These measures are typically called willingness to pay. They represent estimates of the changes in income that anglers would give up for the specified improvements in circumstances. We estimate willingness to pay for various aspects of small boat fishing, including geographical restrictions, improvements in catch, and a variety of other circumstances. In this report there is no research on the economic impact of small boat fishing on the state's economy per se.

1.2. Past Research on Small Boat Fishing in Hawaii

The research in this report builds on a series of studies on recreational fishing in Hawaii. These studies provide three sorts of estimates: economic value, economic impact, and aggregate catch and effort for recreational fishing. Research from the 1970s to the present has been motivated by the same concerns of the present report: to determine the economic and biological significance of small boat fishing in Hawaii. A larger survey of this literature can be found in the report by Glazier[4].

Studies by Karl Samples and associates in the 1980s are the most complete on the economics of small boat fishing in Hawaii. Samples' work focused on the charterboat industry. Given the definition of commercial fishing proposed above—that the activity of fishing is the main source of income for the participants—one may wish to designate charterboat fishing as a commercial activity. Their work focused not only on the economic impact of charterboat fishing, but also on the willingness to pay by patrons of charterboats, the latter being relevant to the present research. Willingness to pay is another expression meaning equivalent income. It is synonymous with economic value. When economists measure willingness to pay, as Samples and associates did and is done throughout this report, they measure households' willingness to give up income in exchange for specified alternatives. The charterboat research on patrons estimated the willingness to pay for two kinds of services: a charter trip and harvesting a marlin on a charter trip. In Samples and Schug, the estimates of these values are $57 per trip and $23 for an extra marlin. That is, a charterboat patron would pay an extra $57, above the ordinary costs of the trip, rather than forego the trip. And a patron would give up an additional $23 in income to obtain an additional marlin. (In 2000 prices these values would be about $94 for a trip and $38 for an extra marlin per trip.)

The values estimated by Samples and Schug are similar to the kinds of values the present report estimates for the small boat fishery. Further, the techniques exploited by Samples and in this report have in common the use of discrete choice contingent valuation. The chief difference is the study population. The charter patrons are principally visitors to Hawaii. Hence economic values for the charter patrons, while important for the continued health of the charter fleet, are not values enjoyed by residents of Hawaii. The key difference between Samples and Schug's work and the present report is the target population. In dealing with the small boat fishery, this report explicitly excludes charter boats. Implicitly charter

[4] This document gives an excellent coverage of the relevant literature.

patrons are also excluded, except to the extent that they own and operate a small boat.

A study by Meyer Resources Inc. focused on the small boat fishery group, with some of the same goals in mind. The Meyer report sought to estimate the economic value of time spent fishing. It proceeded by informal interviews with members of boat clubs in Hawaii. Meyer used some unconventional techniques to arrive at an aggregate value of small boat fishing in the neighborhood of $240 million (equivalent to $355 million in 2000 prices). This is total value that was arrived at by finding a 'fair' value per hour of non-market activity, and then multiplying by an estimate of the aggregate number of hours of the activity. While it may be comforting for proponents of the small boat fishery to believe that it provides services of such prodigious value, the method by which the services were measured has not been exposed to the usual scrutiny given to non-market valuation. Further, other than the possibility of the complete loss of the recreational fishery, this aggregate value does not address any obvious issues in fisheries policy. That is, it does not estimate the change in equivalent income from any proposed change in policy.

The studies concerned with sampling to estimate aggregate catch and effort, while not directed at economic values, are useful for the present report. Efforts to estimate aggregate catch for Hawaii extend back at least to the National Marine Fisheries Service (NMFS) marine recreational fishing surveys of 1979 to 1981. NMFS has supported recreational fishing surveys on most of the mainland on an annual basis since 1979. The survey was conducted in Hawaii during the period 1979 to 1981 but aggregate estimates were never published from survey results. Several proposals to sample boat fishing for the purpose of estimating aggregate catch and effort were made during the 1980s (Omnitrak Research and Marketing Group, 1988; Sen, Sampling Methodology for a Boat Fishing Survey Design for Hawaii, unpublished report) but were never undertaken. A test study conducted by the state of Hawaii on small boat fishing on Oahu provides valuable information on the level of activity at eight ramps or harbors (Hamm and Lum). In the survey, approximately 1,350 interviews were conducted at the ramps with returning fishermen. These completed interviews give critical information on the nature of fishing, such as gear, method, and sales activity. It also provides good estimates of the relative activity at different ramps. This information can be compared with survey information in the present study.

1.3. Outline of the Report

This report is composed of three sections. The first section explains the survey and provides descriptive statistics for the survey participants. The descriptive statistics have no immediate economic content but help explain the survey and the characteristics of respondents. The second section reports on a random utility model of small boat fishing in Oahu. It is based on reported behavior of survey respondents. The third section reports the analysis of contingent valuation questions. For some important questions relevant for fisheries policy, such as the willingness to pay to catch particular species, behavioral models may provide little evidence. In those cases, a contingent valuation study is preferred. In addition, in one important respect, random utility models cannot reveal what anglers would be willing to pay to fish for a single trip. In these cases, contingent valuation, the use of hypothetical responses to direct questions, is a suitable and commonly employed alternative.

2. The Survey of Hawaii Small Boat Anglers

The empirical analysis in this report is based on a systematic phone survey of Hawaii small boat anglers in 1997 and 1998. The sample survey was conducted by SMS, Inc., a professional survey firm in Honolulu.. The basis for the sampling is the list of registered boats in Hawaii. Any boat over six feet long and not documented through the Coast Guard must be registered with the state of Hawaii—the Division of Boating and Ocean Recreation in the Department of Land and Natural Resources (DLNR). From this list the types of vessels that are typically not used in fishing—sailing, thrill craft, and motor vessels more than 65 feet in length—were eliminated. This created a population of about 6,600 boat owners in Hawaii. The list also contained names and addresses of boat owners, which allowed the recovery of phone numbers.

The year-long survey was divided into six 2-month sampling periods. While the basic survey was a phone survey, it was initiated by a letter that was mailed to potential respondents.[5] Sampling periods were two months in length. Every sampling period, SMS drew 300 names from the population of boat owners. These

[5]The letter was sent on the University of Hawaii's Joint Institute of Marine and Atmospheric Research (JIMAR) stationery in an effort to convince respondents that the survey was motivated by scientific concerns. The letter also offered the respondent the opportunity of declining to participate in the survey.

names were matched with phone numbers. SMS mailed out letters to the 300 boat owners. From the initial mailout, some respondents no longer had boats, and some did no fishing. Eliminating those respondents created the phone list from which respondents would be called. The disposition of the phone list is described in Table 1.

Table 1: Disposition of Attempts to Call from the Phone List.

Refusals	3%
No boating or fishing	17%
Not able to reach	49%
Completed survey 1008 Respondents	31%
Phone list	100%

Those who did not boat or fish (even though they may have owned a boat) were legitimately out of the survey. The refusals were quite low at 3 percent, well below refusal rates for other surveys, which are often as high as 50 percent The largest proportion of non-contacts came from the boat owners who could not be contacted for one reason or another. The great majority of calls in the 'Not able to reach' category were due to respondents not being home. The 'Not able to reach' category can potentially cause non-representative sampling in the survey.[6]

To test the representativeness of the sample when compared with the 'Not able to reach' category, we designed a special survey that was carried out in February and March 1999. In this survey, SMS resampled respondents who originally fell in the 'Not able to reach' category. Much greater effort was made to reach each respondent, with the number of callbacks increased from 3 to 10. This testing survey resulted in 182 interviews with respondents who initially fell in the 'Not able to reach' category. Table 2 shows a comparison of several relevant variables across the two samples. (Not all of the attempts to reach this group were successful. SMS, Inc. attempted 243 callbacks, of which 182 were completed.) None of the differences in the means reported in this table are significantly different from zero. A comparison of the means of many more variables leads to a similar conclusion: there is no systematic difference between the respondents who were interviewed for the main survey and those who could not be reached on the main survey.

[6]The initial rate of attempted callback was three calls.

Table 2: Comparison of Original Sample with Sample of Non-Respondents

	Original Survey[a]		Sample of Non-Respondents[b]	
Variable	Mean	S.E.[c]	Mean	S.E.
Trips:				
Last Two Months	4.37	.22	3.55	.89
Last Six Months	13.23	3.37	13.86	.68
Next Two Months	6.47	.26	5.67	1.05
% Catching Something	22.0	1.31	19.8	3.0
% Retake Last Trip	85.2	1.1	87.1	2.5
Household Size	3.31	.05	3.37	.11

[a]Based on the original survey of 1008 respondents.
[b]Based on the 182 observations of the followup survey.
[c]S.E.. is the standard error of the mean.

2.1. Descriptive Survey Results

The basic purpose of this report is the economic analysis of fishing decisions made by the sampled anglers. The economic models are estimated for Oahu and for all of the islands combined. There is additionally a wealth of information on anglers. This section reviews several types of information about anglers. This information will be provided on all of the anglers interviewed. Two kinds of data will be analyzed: data on the anglers and their characteristics and data on the anglers' choices.

The survey commenced in March 1997 and was completed in February 1998. The survey design called for 1,000 completed interviews. The total of completed interviews was 1,008. The survey was conducted to cover six 2-month periods, with the number of completed interviews distributed evenly across the year. The distribution across islands should reflect the distribution of registered boats, not the distribution of population. The distribution of interviews over periods and across islands is given in Figure 1. The variation across interview period is minor. The numbers change little from one period to the next.

Although it cannot be discerned from Figure 1, the interviews are distributed differently from Hawaii's population. This is principally due to the distribution of registered boats by island. Table 3 shows the distribution of interviews compared to the distribution of registered boats and population. Oahu has a greater proportion of population and smaller proportion of registered boats and interviews,

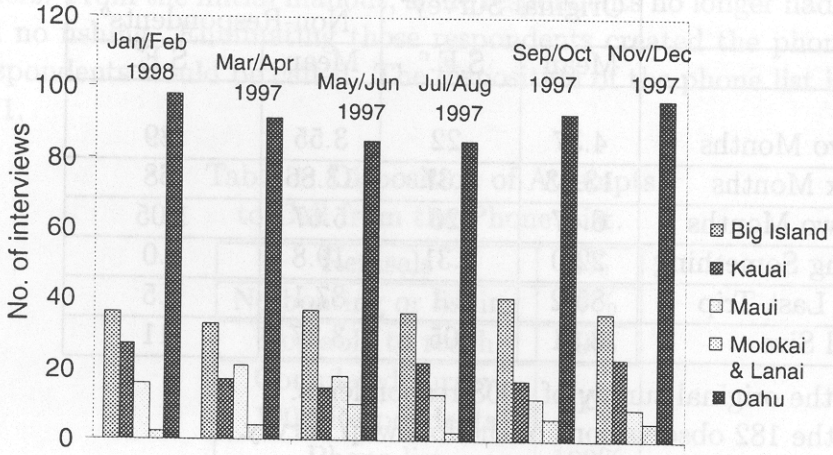

Figure 1: Number and dates of angler interviews.

principally because of the urban nature of Honolulu.

The survey gathered various forms of information about the respondents. Here we show the most basic demographics: income, age, ethnic identification, and place of birth. These demographics can serve two roles. First, if we had independent information on the population of boat owners, a comparison of demographics could help us assess whether the sample of boat owners is representative of the population of boat owners. Independent information on the population of boat owners typically is not available. So under the assumption that the sample is representative, we can compare the sample of boat owners with the population of Hawaii. Table 4 gives the income class of respondents. Income here is best construed as before-tax income for the household. Table 5 gives the age distribution of respondents. There are no published statistics that correspond with these tables, because the tables refer to the select population of boat owners. So the real value of these demographics is simply that they help understand the population that has been surveyed. Almost 35 percent have incomes below $50,000, and a small proportion, 5.6 percent, have incomes above $150,000. Comparing the dis-

Table 3: Percent of Interviews, Registered Boats and Population, by Island

Island	Interviews[a]	Registered Boats[c] (1993)	Population (1992)
Big Island	21.9%	14.4%	11.3%
Kauai	12.0	10.7	4.7
Maui	11.6[b]	9.7	9.3
Oahu	54.5	63.6	74.7

[a]Based on the original 1008 set of interviews.
[b]Includes Molokai and Lanai, about 3% of interviews.
[c]Includes all vessels, not just fishing vessels.
Source for 3rd and 4th columns: The State of Hawaii Data Book 1993-1994.

Table 4: Income Distribution of Respondents Compared with Population of Hawaii

Income ($1000s)	< 15	15-25	25-35	35-50	50-75	75-100	100-150	> 150
Survey Responses[a]	1.7%	4.3%	11%	19.1%	26.8%	21.5%	10.0%	5.6%
Households in Hawaii[b]	15.0%	14.9%	14.6%	19.1%	20.6%	8.7%	4.9%	2.2%

[a]Non-responses to this question were 17.4% of sample of 1,008 respondents. [b]Source: The State of Hawaii Data Book 1993-1994.

Table 5: Age Classification of Sample[a]

Age	<18	18-24	25-34	35-39	40-44	45-49	50-54	55-64	65-69	>69
Percent	0.2%	0.8%	9.3%	12%	15.6%	17%	15%	18.4%	5.7%	5.4%

[a]Non-responses were .8% of the sample of 1,008 respondents.

tribution of income among households in Hawaii with the boat owners' income, we see that boat owners tend to have a greater proportion of households with higher incomes. The non-response rate is the highest for any item in the survey, as is usually the case for income data. While the data reveal that the population of boat owners is not exclusively wealthy or uniformly low income, they have higher incomes than the general population.

Table 5 gives the age distribution of the sample. As in the case of income, comparing this distribution with the population distribution is not informative, because we have no independent information on the age distribution of the population of boat owners. The age distribution of boat owners tends to be skewed, for financial reasons, to the older age groups. It takes time to accumulate the capital required to own a boat, and it takes some income to operate and maintain boats. Two additional pieces of information round out the summary of the socioeconomic characteristics: the self-described ethnic group and the place of birth. In Figure 2, we have the self-reported ethnic group. Respondents were allowed to describe themselves as belonging to one of several ethnic groups. The predominant group is of Japanese origin, with Caucasian being second. About 150, roughly 15 percent of the sample, describe themselves as Hawaiian or part Hawaiian. Figure 3 shows the frequency of small boat owners by place of birth. Almost 75 percent were born in Hawaii.

Naturally most of the survey deals with fishing. Here we summarize the fishing activity in terms of species caught and sought, as well as providing some data on gear used. Each respondent is asked the primary species targeted during the last trip. The results are summarized in Figures 4 and 5. In Figure 4, the target information is given by island. There are six groups of target species plus a catchall group labeled 'other.' The catchall group can include a variety of reef fish as well as non-fin fish. There are some general patterns across islands. Between 5 and 10 percent seek aku (skipjack tuna). The percent seeking tuna, excluding aku, is much higher on the Big Island, though for all islands it is in the range of 15 to 30 percent. The percent who target billfish is uniformly quite small, less than 5 percent. The percent not classified, that is, those who target other species, is quite high on Oahu and the rest of the islands. The differences in targeting suggest care in generalizing inferences from one island to the others.

The species actually caught tend to follow the same pattern as the species targeted. The species caught by island are given in Figure 5. Here we see that tuna and ono are more important for the Big Island than for the other islands. The success rate for billfish and bottomfish reflects the low percent of respondents

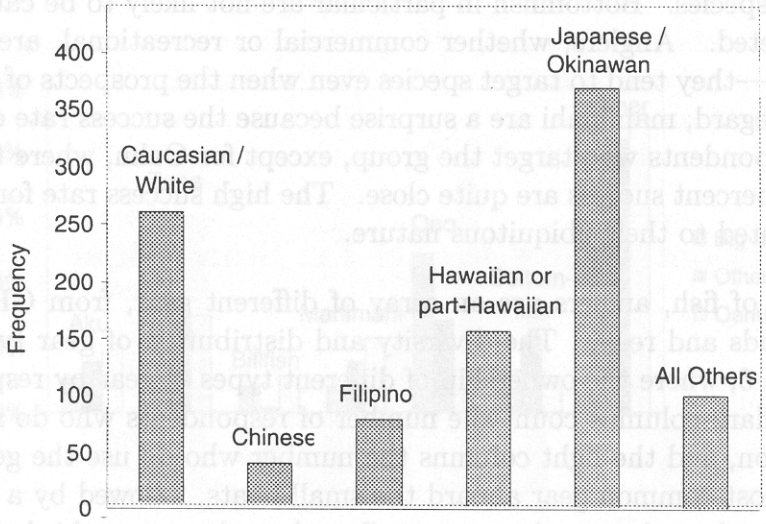

Figure 2: Primary ethnic group of respondents.

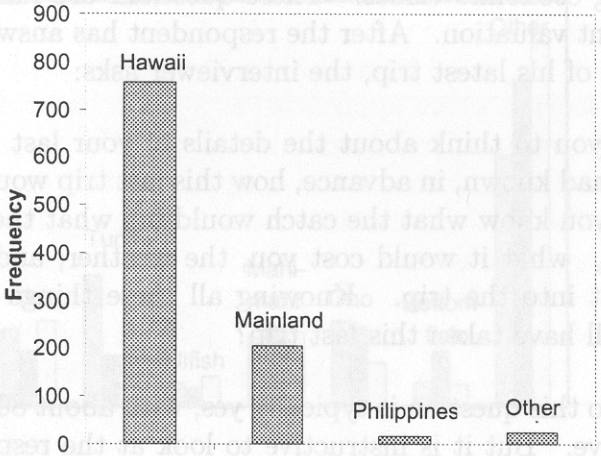

Figure 3: Birthplace of respondents.

seeking these species. Bottomfish in particular are not likely to be caught unless they are targeted. Anglers, whether commercial or recreational, are nothing if not optimistic—they tend to target species even when the prospects of success are low. In this regard, mahimahi are a surprise because the success rate exceeds the percent of respondents who target the group, except for Oahu, where the percent targeted and percent success are quite close. The high success rate for mahimahi can be attributed to their ubiquitous nature.

In pursuit of fish, anglers use an array of different gear, from GPS units to a variety of rods and reels. The diversity and distribution of gear types can be seen in Figure 6, where the ownership of different types of gear by respondents is shown. The dark columns count the number of respondents who do not use the gear in question, and the light columns the number who do use the gear. A CB radio is the most common gear aboard the small boats, followed by a cell phone. Very few respondents have radar or autopilots, but about two-thirds have depth finders. Line haulers are used principally by respondents who target bottomfish. Hence the distribution of this gear type is limited.

The importance of catching fish will be explored in the two sections on economic models that follow. But a crude understanding of the importance of catching fish can be gleaned from responses to a series of hypothetical questions aimed at measuring economic values. These questions are fully explored in the section on contingent valuation. After the respondent has answered questions on the costs and catch of his latest trip, the interviewer asks:

> Now, I want you to think about the details of your last fishing trip. Suppose you had known, in advance, how this last trip would turn out. For example you know what the catch would be, what the experience would be like, what it would cost you, the weather, and everything else that went into the trip. Knowing all these things in advance, would you still have taken this last trip?

The response to this question is typically yes, with about 80 percent responding in the affirmative. But it is instructive to look at the responses conditional on whether any fish were caught on the trip in question. This is given in Figure 7. Here we have the percent yes and no by whether the respondent caught fish. In the first two columns, the figure gives the percent yes and no given that the respondent caught one or more fish. When fish are caught on the trip, the percent yes to the question above is slightly more than 80 percent. When no

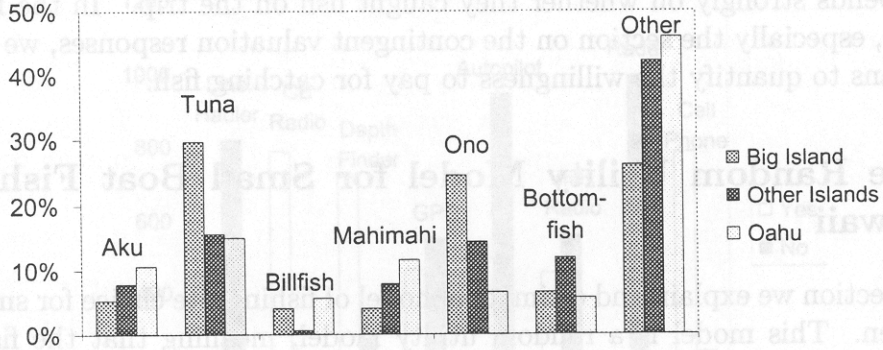

Figure 4: Primary fish species targeted.

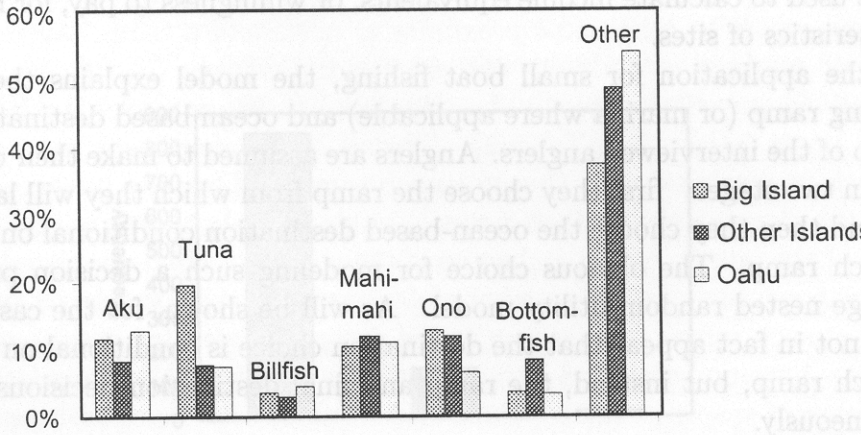

Figure 5: Primary fish species caught.

fish are caught, the percent yes falls to about slightly less than 20 percent while the percent no is about 45 percent. Whether respondents are willing to repeat a trip depends strongly on whether they caught fish on the trip. In the following sections, especially the section on the contingent valuation responses, we will find the means to quantify the willingness to pay for catching fish.

3. The Random Utility Model for Small Boat Fishing in Hawaii

In this section we explain and estimate a model of fishing site choice for small boat fishermen. This model is a random utility model, meaning that the fisherman chooses a fishing destination based on the utility it brings him, and that part of the utility involves factors that cannot be observed by the researcher. Hence the utility is random. Utility depends on characteristics of alternatives, such as cost, probability of catching different fish and other variables. The randomness of utility means that a researcher can only make probability statements about fishermen's choices. The essence of the random utility model is that it leads to a model of the probability of choosing a destination, and the estimation of this model gives parameters of fishermen's preferences. The estimated model can then be used to calculate income equivalents, or willingness to pay, for measurable characteristics of sites.

In the application for small boat fishing, the model explains the choice of launching ramp (or marina where applicable) and ocean based destination for the last trip of the interviewed anglers. Anglers are assumed to make their destination choice in two stages: first they choose the ramp from which they will launch their boat, and then they choose the ocean-based destination conditional on the choice of launch ramp. The obvious choice for modeling such a decision process is a two-stage nested random utility model. As will be shown, for the case of Oahu, it does not in fact appear that the destination choice is conditional on the choice of launch ramp, but instead, the ramp and final destination decisions are made simultaneously.

3.1. Description of the Data

The assembly of data in support of the conditional random utility models is substantial. Further, choice among alternatives is quite different among the islands. Hence the estimated model is limited to choices made by anglers on Oahu. Data

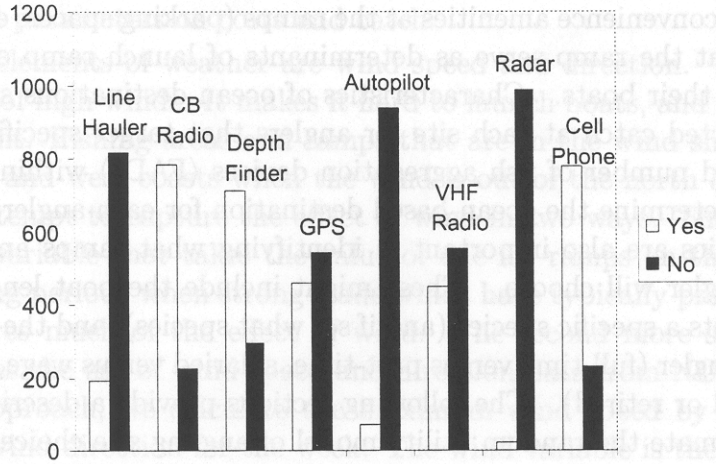

Figure 6: Frequency of gear type use.

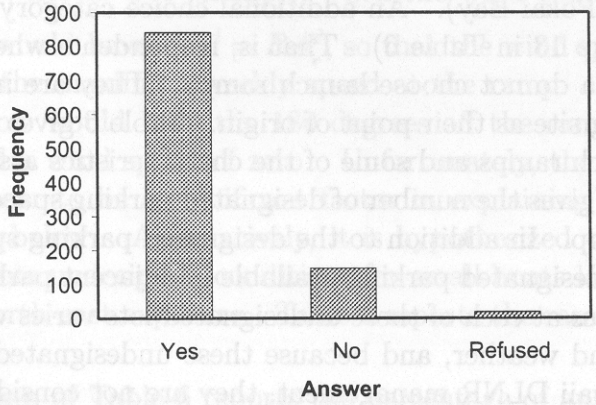

Figure 7: Would you take this trip again?

must be collected on angler choices of launch ramp and ocean-based destination. Ramp-specific characteristics, such as the travel expenditures and travel time to each ramp, convenience amenities at the ramps (parking spaces, etc.) and weather conditions at the ramp serve as determinants of launch ramp choice for anglers that trailer their boats. Characteristics of ocean destinations such as the travel costs, expected catch at each site for anglers that target specific species, size of the site, and number of fish aggregation devices (FADs) within each geographic boundary determine the ocean-based destination for each angler. Angler-specific characteristics are also important in identifying what ramps and ocean destinations an angler will choose. These might include the boat length, whether the angler targets a specific species (and if so, what species), and the employment status of the angler (full-time versus part-time, salaried versus wage, employed versus unemployed or retired). The following sections provide a description of the data used to estimate the random utility model of angling site choice on Oahu.

Characteristics of the Launch Ramps on Oahu

Based on angler interviews and personal communication with officials knowledgable of boating conditions on Oahu, a total of 12 ramps were identified as viable public ramps for launching a trailered boat on Oahu (see Table 6). In two cases, due either to geographic proximity or closure of a ramp, ramps were combined into a single ramp for model estimation purposes (Hawaii Kai/Maunalua Bay and Waianae/Pokai Bay). An additional choice category is considered: for moored boats (ramp 13 in Table 6). That is, respondents who moor their boats at a dock or marina do not choose launch ramps. They are instead assumed to choose the mooring site as their point of origin. Table 6 gives a brief description of each of the launch ramps and some of the characteristics associated with each. The fourth column gives the number of designated parking spaces for vehicles with trailers at each ramp. In addition to the designated parking spaces, a number of the ramps have undesignated parking available in adjacent parking lots. Because the number of spaces at each of these undesignated lots varies with tourist traffic, shopping traffic, and weather, and because these undesignated lots are typically not subject to Hawaii DLNR management, they are not considered here.

For several reasons, the modeling of seasonal weather is of value. If weather variables are omitted from the model but correlated with included variables, such as catch data, coefficients on the included variables will be inconsistent. Further, weather variables may be useful for policy analysis when seasonal policy measures

are considered. Finally it is clear that weather patterns influence choices, and explaining the choices better increases the precision of parameter estimates for the more critical parameters on costs and catch.

The critical elements of weather are wind speed and direction. There are at least two effects of high winds. It makes it hard to launch boats, and it makes the fishing unpleasant. Fishing areas and ramps that are in the wind shadow would be on the south and west coasts when the wind is out of the north and east, for example. We attempt to capture the effect of wind in two ways. The simplest is with a dummy variable that takes the value of one for ramps on the north and east shores during periods when strong trade winds have typically prevailed. This approach captures much of the effect of wind. The second more sophisticated approach involves the use of wind speed and direction data from NOAA weather sites. In this approach, we calculate the maximum wind speed by week, along with the mean wind direction for the week. The wind variable is then calculated as follows:

$$WS_r = \text{Maxspeed} \cdot (180 - (WI^d - RA_r^d))/180$$

where

Maxspeed = maximum of wind speed for the week;

WI^d= the angle of the wind in degrees deviation from north;

RA_r^d= the angle of a perpendicular to a line parallel to the shore, in degrees deviation from the north. For example, when the wind comes out of the east a ramp facing east would have $WI^d = RA_r^d$, so that the wind speed variable would equal Maxspeed, the maximum weekly speed at the ramp. A ramp completely in the wind shadow would have the 180 degrees off the ramp direction, and so would be assigned a wind speed of zero. Unfortunately, the wind direction and speed do not appear to be a significant factor in explaining ramp choice in the models estimated below. Alternatively, it is hypothesized that the presence of trade winds presents undesirable conditions for small boats launched from ramps with north and north-east exposure. Table 6 reports the ramps exposed to trade winds.

The final column of Table 6 reports the percentage of anglers reporting each ramp as their launch site on their last trip. Almost half of the anglers launched from either Waianae or Heeia-Kea on their most recent trips. Hickam Harbor, Marine Corps Air Station, and Rainbow Bay are located on military bases or installations and as such are restricted to military personnel only. Of the 413

Table 6: Ramps and Their Characteristics

Ramp Number	Ramp Name	Comments	Parking Spaces	% Recorded Visits
1	Ala Wai		19	3%
2	Haleiwa[a]		60	9%
3	Heeia-Kea[a]		65	22%
4	Hickam Harbor	Military Ramp	12	2%
5	Kahana[a]	Launch Difficult	28	1%
6	Kailua[a]	Launch Difficult	25	2%
7	Kaneohe	Private	130	1%
8	Keehi		59	15%
9	Marine Corps Air Station[a]	Military Ramp	30	1%
10	Rainbow Bay	Military Ramp	60	.5%
11	Hawaii Kai/ Maunalua Bay		65	8%
12	Waianae/ Pokai Bay		180	24%
13	Moored[b]			12%

[a]These ramps are assumed to be exposed to strong trade winds during the period January through April.
[b]This ramp is an artificial designation for all respondents whose boat was moored.

anglers reported to trailer their boats, only 15 reported an occupational status that can be classified as military (either the interviewee or spouse reporting their occupation as military). Twelve of these 15 anglers reported launching from one of the three military sites.

Description of Destination Sites

The thirty-four ocean sites visited by sampled anglers are defined by the Hawaii Division of Aquatic Resources (HDAR). The sites are often well known by the anglers, but vary greatly in size. For estimation purposes, this exogenous differ-

ence in size of the destination sites will be captured by including a measure of the water surface area of each HDAR site (in square-kilometers). Figure 8 shows the HDAR sites. Around Oahu, HDAR 400-409 represent what will be termed coastal HDARs. The distinction between coastal and non-coastal HDAR sites is important as it is expected that anglers with smaller boats (boat length <20 feet) tend to choose to fish in coastal HDAR sites, while anglers with larger boats (boat length $\geq$ 20 feet) will be more willing to venture into non-coastal HDAR sites. As stated above, the choice of HDAR is assumed to be joint with the choice of launch ramp. As such there are 442 possible ramp-HDAR combinations for each angler to choose from (13 ramps x 34 HDARs).

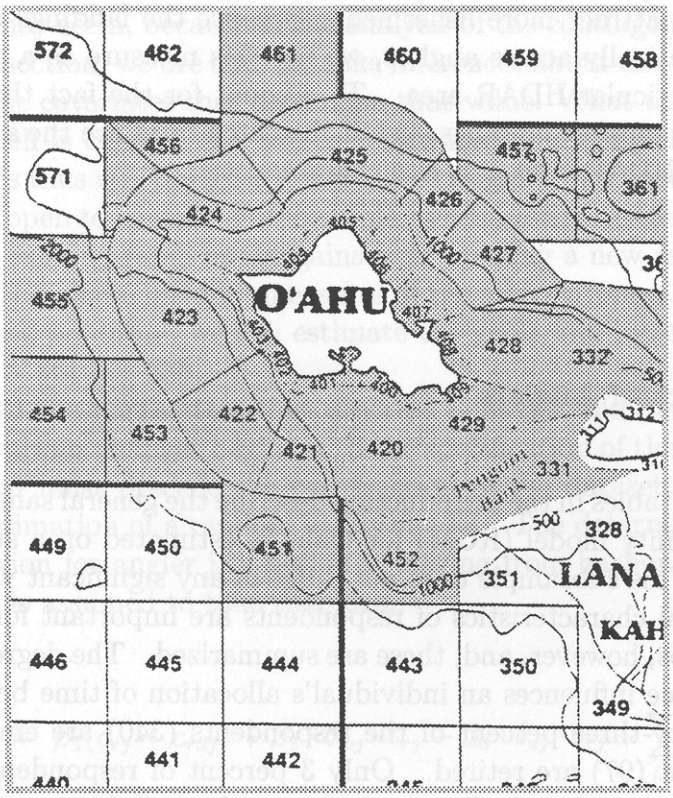

Figure 8: Destination sites; 400-409 are coastal HDRs.

Data on sales by species from vessels that sell their catch are recorded by the HDAR areas and date. The pounds of fish sold is strictly speaking not a measure

of or proxy for expected catch at an HDAR area. Only if the anglers that sell a portion of their catch is a random subsample of the general population of anglers would fish pounds sold per angler at auction represent an estimate of expected catch at an HDAR area. Because the sale of fish is expected to vary systematically across anglers, we use catch sold simply as a proxy for fishing quality at a particular HDAR area. Small boat anglers want to catch fish. An ideal measure of the potential for catching fish would be a measure of stock abundance or density. A good proxy would be the catch rate (or catch per unit effort) for different species. If the anglers who sell a portion of their catch are a representative sample of the general population of anglers, then landings sold per angler at auction represent an estimate of expected catch at an HDAR area. Nevertheless, the higher HDAR landings should attract more fishermen. Because the landings can be expected to vary systematically across anglers, we use this measure as a proxy for fishing quality at a particular HDAR area. To account for the fact that larger HDAR areas would have higher landings even if the catch rates are the same, we also use the area of the HDAR sites as a site characteristic.

Characteristics of Anglers

The figures and tables in the introduction describe the general sample of fishermen. The random utility model (RUM) for Oahu is estimated on a subsample of 468 respondents. This subsample does not differ in any significant way from the full sample. Several characteristics of respondents are important for modeling their behavior on trips, however, and, these are summarized. The degree of attachment to the labor force influences an individual's allocation of time between work and leisure. Seventy-three percent of the respondents (340) are employed full time while 21 percent (97) are retired. Only 3 percent of respondents (14) reported being currently unemployed. Some ramps are only available to military personnel, but only 20 of the 468 respondents (4 percent) either are in the military or have a spouse in the military. Boat length also influences ramp choice. The average length of boats owned by the respondent is 18.3 feet, with a minimum length of 7 feet and a maximum length of 42 feet. The average boat length is 17.6 feet for those who trailer their boat, but moored boats average 23.7 feet.

3.2. Specification of Model and Variables

The Model

The model that we estimate, a random utility model, is described in detail below. It is important to understand the kind of information that can be inferred from the observed choices. The empirical analysis is based on the last trip taken by the interviewed angler. Because we do not observe a sample of anglers in which some take trips and some do not, we cannot make inferences about the decision to take a trip (although we will estimate the economic values for changes in several trip attributes). Consequently, we cannot infer the economic value of taking a trip, regardless of destination, from the random utility model. This shortcoming is not as serious as it may seem, because in the analysis of the contingent valuation data in the following section, we are able to make inferences about the value of taking a trip as well as the covariates that determine that value. What the random utility model can do well is capture the way in which individual anglers choose among alternatives. It is thus well designed to measure the gains and losses from changing the alternatives open to anglers. For example, we can estimate the economic losses from closing an existing ramp or the gains from opening a new ramp. Further, to the extent that the model includes measures of the attractiveness of sites based on their fish-catching potential, we can estimate the gains and losses from changing the availability of various fish.

Estimation of the parameters that describe behavior and determine the economic value of various changes begins with the specification of the utility function. The specification must precede the construction of the dataset, a major undertaking in the estimation of a random utility model. The deterministic portion of the utility function for angler j in period s, leaving from harbor or ramp r going to ocean site a, is assumed to take this form:

$$\begin{aligned} v_{ra}(j,s) &= \beta_1(c_{rj} + c_{raj}) + \beta_2 \cdot \delta_{wj} \cdot t_{rj} + \beta_3 \cdot \delta_{sj} \cdot t_{rj} + \sum_{f=1}^{4} \beta_{4f} q_{af} \delta_{fj} \\ &\quad + \sum_{f=1}^{4} \beta_{5f} q_{af} \delta_{nj} + \beta_6 \cdot KM_a^2 + \beta_7 \cdot WS_r + \beta_8 \cdot F_a \\ &\quad + \beta_9 \cdot P_r + \beta_{10} \cdot \delta_{bj} \cdot \delta_{ca} + \beta_{11} \cdot (1 - \delta_{bj}) \cdot \delta_{ca} \end{aligned} \tag{1}$$

where

c_{rj} = travel cost from home to ramp or harbor r for angler j;
c_{raj} = travel cost by boat from ramp or harbor r to HDAR area a for angler j;
t_{rj} = travel time from home to ramp r for angler j;
q_{af} = pounds sales from area a of species group f;
f = 1 for billfish, 2 for bottomfish, 3 for other pelagics, and 4 for tuna;
δ_{wj} = 1 if the angler does not work flexible hours;[7]
δ_{sj} = 1 if the angler j is retired;
δ_{fj} = 1 if angler j targets species f;
δ_{nj} = 1 if angler j targets no species;
δ_{bj} = 1 if angler j has a boat of length greater than or equal to 20 feet;
δ_{ca} = 1 if HDAR a is a coastal HDAR;
F_a = number of fish aggregating devices (FADs) in area a;
KM_a^2 = surface area of HDAR site a in kilometers squared;
WS_r is a ramp specific weather variable that will be calculated from wind speed and direction or a dummy variable that equals 1 if the ramp has a northern or eastern exposure during trade wind months (January-April);
P_r = number of designated parking spaces at ramp r.

With the exception of wind speed and variables that do not change temporally, the variables are defined for the specific two-month period during which the angler took the trip. Wind speed is defined as the weekly average wind speed for the week in which the trip was taken.

The model structured this way has two nests: ramp or harbor r, and area a. The ramps are the well-known sites on Oahu where anglers can launch their boats. The areas are the HDAR fishing areas. There are four species groups aggregated across the major fisheries in Hawaii: Billfish, Bottomfish, Other Pelagic, and Tuna. The terms $\sum_{f=1}^{4} \beta_{4f} q_{af} \delta_{fj}$ and $\delta_{nj} \sum_{f=1}^{4} \beta_{5f} q_{af}$ are the sums of the recorded sales of each of the four species groups for those that target particular species and those that do not target any particular species. If an angler seeks a species group, then one of the indicator variables will equal one, and one term from the first sum will be picked out for the angler. For example, if angler j seeks Billfish, f = 1, then δ_{1j} =1, with δ_{nj} = 0 and δ_{fj} =0 for f >1. If an angler does not seek a species, then δ_{nj} =1 and the second sum will appear in the angler's utility function. The coefficients β_{4f} and β_{5f}, f = 1,..,4, capture the attraction of q_{af},which is the mean

[7] All of the indicator variables are equal to zero if the statements are not true.

sale of species group f from area a for the period in which the trip took place. The choice of ramp will depend on time and travel costs of hauling the angler's boat from home to ramp, as well as weather-related variables.

When a stochastic element is added to the deterministic utility described in equation (1), the utility per trip becomes

$$\begin{aligned} u_{ra}(j,s) &= \beta_1(c_{rj}+c_{raj}) + \beta_2 \cdot \delta_{wj} \cdot t_{rj} + \beta_3 \cdot \delta_{sj} \cdot t_{rj} + \sum_{f=1}^{4} \beta_{4f} q_{af} \delta_{fj} \\ &+ \sum_{f=1}^{4} \beta_{5f} q_{af} \delta_{nj} + \beta_6 \cdot KM_a^2 + \beta_7 \cdot WS_r + \beta_8 \cdot F_a \\ &+ \beta_9 \cdot P_r + \beta_{10} \cdot \delta_{bj} \cdot \delta_{ca} + \beta_{11} \cdot (1-\delta_{bj}) \cdot \delta_{ca} + \varepsilon_{ra} \end{aligned} \tag{2}$$

If the unobservable error term ε_{ra} is distributed as a generalized extreme value random variable, the choices of ramp and HDAR can have a nested interpretation. If the choice of ramp and HDAR are not independent, then the probability of choosing a ramp-HDAR area combination can be written as product of the probability of choosing the area, given the ramp, and the probability of choosing the ramp:

$$\Pr(r,a) = \Pr(a|r) \cdot \Pr(r). \tag{3}$$

Intuitively, the second stage, the probability of choosing an area, would be estimated first, and at that stage the parameters associated with the area choice would be recovered. The ramp probability would be estimated second, with the remaining parameters to be recovered from the first stage. Given the generalized extreme value error assumption, the probability that angler j chooses HDAR area 'a' given that he launched from ramp 'r' is

$$\Pr_j(a|r) = \frac{\exp(\beta_1(c_{raj}) + \sum_{f=1}^{4} \beta_{4f} q_{af} \delta_{fj} + \delta_{nj} \sum_{f=1}^{4} \beta_{5f} q_{af} + \beta_6 \cdot KM_a^2 + \beta_8 \cdot F_a + \beta_{10} \cdot \delta_{bj} \cdot \delta_{ca} + \beta_{11} \cdot (1-\delta_{bj}) \cdot \delta_{ca})/\theta}{\sum_{a'=1}^{M_s} \exp(\beta_1(c_{ra'j}) + \sum_{f=1}^{4} \beta_{4f} q_{a'f} \delta_{fj} + \delta_{nj} \sum_{f=1}^{4} \beta_{5f} q_{a'f} + \beta_6 \cdot KM_{a'}^2 + \beta_8 \cdot F_{a'} + \beta_{10} \cdot \delta_{bj} \cdot \delta_{ca'} + \beta_{11} \cdot (1-\delta_{bj}) \cdot \delta_{ca'})/\theta}$$

where the sum is over all HDAR areas that are in the individual set of choices (M_s). In this probability, only the HDAR areas for the given ramp are part of