AN ECONOMIC ANALYSIS OF REBUILDING ARTISANAL FISHERIES: THE POTENTIAL FOR FISHERMEN-BASED ECOTOURISM IN THE GALAPAGOS MARINE RESERVE

By

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To Luis Alfredo, Juanita, Guillermo and Guillermo Jr.

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TABLE OF CONTENTS

LIST OF TABLES

Table page

LIST OF FIGURES

Abstract of Dissertation Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
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This study examined the diversification of artisanal fishermen into tourism as a strategy to recover resource stocks and rebuild fishermen livelihoods in the Galapagos Marine Reserve. Incorporating unique interdependence characteristics between individuals and fishing vessels, and using a combination of stated preference and stochastic production frontier methodologies, the study (1) assessed fishermen switching and tour choice behavior and socio-economic determinants, (2) examined the harvesting potential and technical efficiency of the fleet, and (3) assessed the demand potential for fishermen-operated tours.

Results indicate that vessel owners were more willing to switch than crew. Switching preferences also differed between boat size and geographical locations. Interestingly, capital malleability issues were compensated by the opportunity to transfer fishing capital outside the fishing sector. If switching, fishermen preferred bay and diving tours followed by the diving cruise option, and choices depended on vessel size, location, and access to bank funding.

The findings suggest that a reduction of fleet size would be less effective than policies managing variable inputs to reduce the harvesting potential of the fleet. Also, the fleet can still improve technical efficiency and increase harvests in the short run. As expected, interdependence

between boats influenced the production technology but the effect was negative. Smaller vessels, especially fiberglass boats, were less productive if they were towed by larger boats.

Standard tours had a higher demand potential in comparison to artisanal fishing trips. Standard tours had higher booking intentions if half-day excursions were offered and tourists preferred full-day fishing trips with a dining option. Expected conservation and local benefits increased the interest for fishermen-based tours, while wealthier tourists were more reluctant to book these trips.

Overall, the study found a promising market potential for fishermen-based ecotourism depending on the extent that fishermen are allowed into the standard tour market by the reserve managers. However, the potential for fishing effort reduction is limited and additional policies focusing on vessel efficiency and rights-based management will be needed to rebuild resource stocks. Future diversification strategies need to differentiate between vessel owners and crew and the specific realities of the fishing ports to entice fishermen to quit fishing.

CHAPTER 1
INTRODUCTION

Artisanal Fisheries

Artisanal fisheries represent a very complex and dynamic fishing sub-sector such that a universal definition for it does not exist (Berkes et al. 2001). They are usually described by a range of diverse characteristics (FAO/RAP 2004; Salas et al. 2007; Defeo and Castilla 2005, Berkes et al. 2001). First, artisanal fishing predominates in developing nations where coastal communities and fishing households are dependent on the marine resources for subsistence, in contrast to fisheries that are exploited by fishing firms (i.e., business ventures). Thus, artisanal fisheries are usually small-scale fisheries that rely on a large number of fishermen and vessels relative to industrial fishing.

Second, artisanal fishing fleets are often characterized by diverse vessel types that target multiple species, usually a large number of small stocks. Because of this, resource use is seasonal and vessels use multiple traditional gear types such as spears, lines, traps, or hand harvesting. That is, technological advancement is slower compared to industrial fleets since there is sufficient local labor. They operate mostly near shore, across multiple fishing grounds and landing sites, and on short trips of around one to two days. Therefore, there is a low level of capital investment. The harvesting, processing and distribution technologies are labor intensive.

According to a recent report from FAO/RAP (2004), artisanal fishing provides employment to more than 35 million people worldwide, contributes more than 50% of fish food in the world, and represents 19% of animal protein intake in developing nations. Therefore, this occupation plays a critical role in poverty alleviation, food security, and income generation for coastal communities in developing countries in Africa, Asia and Latin America. However, since these fisheries feed so many in local communities, what harvesters may receive from selling their catch is minimal compared to the size of the overall economy of their nations. Even the highest-value species in export markets do not translate into an important component of national product as profits are often earned by middlemen. Hence, fishermen have very limited power to influence the markets, and commercialization and credit access is highly-dependant on middlemen groups.

Despite the recognized importance of artisanal fisheries worldwide[1], management efforts for this sector have been met with limited success (where any exist) and many fishery resources have become overexploited. Most artisanal fisheries have operated under open access conditions, mainly to maximize employment and food supplies to local communities (Salas et al. 2007). Also, the prohibitive costs of monitoring and enforcement in extensive geographical areas prevent the collection of data that might be required to develop and manage a fishery successfully. Lastly, an increasing demand for high-valued species (e.g., lobster, scallops, shrimp) in international markets and the lack of alternative employment opportunities that characterizes many artisanal fisheries has often promoted the uncontrolled increase in fishing effort, which has reduced resource stocks, fishing income and food availability and generally worsened fishermen livelihoods in the long run (Defeo and Castilla, 2005).

Artisanal fisheries can be very diverse and so require unique approaches to manage them successfully. There are, however, a few different types of management that have been shown to work for this sector. The following section reviews those approaches, which include the use of a co- or joint- management structure and the use of territorial use rights (the two most common). Following this review, the unique case of managing overfished fisheries in the Galapagos Marine Reserve (GMR) is discussed. The final section outlines how this study will investigate the

[1] Although the terms artisanal and small scale fisheries are often used interchangeably in the literature, in this study artisanal fisheries refer to fishing communities that are heavily dependent on the marine resources for subsistence or sustainability of a localized culture or economy in addition to being small-scale.

potential success of a plan to manage an overfished artisanal fishery and to rebuild fishermen livelihoods using the GMR as a case study.

Approaches to Manage Artisanal Fisheries

Traditional approaches used in developed nations and industrial fisheries are recognized as not appropriate for the complexities of artisanal fisheries (Defeo and Castilla 2005). More suitable mechanisms need to consider fishing communities in decision making, emphasize participation of all stakeholders, and retain traditional knowledge in the resource management (Berkes et al. 2001). Such approaches include ecosystem-based management, integrated coastal management (fishing as part of a comprehensive coastal development policy), community-based and co-management (direct participation of local communities and shared responsibility for resource management between authorities and users), and spatially–based management (e.g., territorial use rights (TURFs), marine protected areas, and no-take zones) (FAO/RAP 2004).

Many communities in developing countries have adopted these management schemes. For instance, community quotas, TURFs and exclusive fishing zones have complemented regulated open access controls in some counties in Latin America, especially for benthic resources (Salas et al. 2007). No take zones and ban areas have performed successfully in reef fisheries in the Phillipines, the Caribbean and some countries in Africa (Martin-Smith et al. 2004) and on the demersal resources in the Gulf of Castellamare (Sicily) (Whitmarsh et al. 2003).

The most promising results in management of fisheries for community sustainability have been observed under appropriately designed and implemented co-management schemes, particularly when combined with spatial tools and access rights. For instance, the allocation of near shore management areas to local communities through well-established fishermen unions, associations or cooperatives has proven to be a stable and strong management system for some artisanal fisheries in Chile, Japan and Mexico. As documented by Cancino et. al. (2007) and

Defeo and Castilla (2005), in these initiatives the government sets general regulations such as quota and size limits for the species, gear restrictions and season length but transfers the authority and responsibility to manage, monitor and enforce the management areas to the users.

In Chile, the TURF system has been applied to benthic resources only. The federal government allocates 'Areas for Management and Exploitation of Benthic Resources' (AMERBs) for a given period subject to renewal based on performance and status of stocks. Fishermen associations are required to submit management and exploitation projects for evaluation prior to receive an exclusive management area, as well as periodic monitoring reports for renewal (Gonzalez 1996). In Japan, the allocation of areas with exclusive access rights is the prevalent management system and applies to a variety of fisheries (e.g., shellfish, shrimp, and mobile fish). Access rights have been managed and coordinated by Fishery Cooperative Associations traditionally attached to the coastal areas rather than based on management projects. The cooperatives in turn sub-allocate the area to groups of individuals, especially families, based on fishing tradition. Interestingly, in the two countries, fishermen as managers integrate efforts with biological consultants or extension scientists to monitor the status of the fisheries. Similarly, in the case of the spiny lobster of Punta Allen in Mexico, the government grants exclusive territorial access rights to cooperatives, which in turn sub-allocate the areas and rights to families based on tradition. Here, the system builds strongly on the family component of the organization by allowing the areas to be inheritable and transferable. In this way, the decentralization of management and the availability of exclusive access rights have transformed production areas and the resources into family assets.

The success of these TURF-based co-management approaches in artisanal fisheries has relied on the following main aspects:

- The existence of a clear and appropriate legal framework formalizing (a) the decentralization of management and decision making, (b) the implementation of exclusive territorial use rights and (c) the authority of local communities and cooperatives to manage and coordinate the access rights and area allocation among subgroups.
- The level of organization of communities and management cooperatives or associations, such that enforcement of internal rules and exclusive access may be ensured.
- The role of fishing tradition and family as productive units in the allocation of management responsibilities.

Despite the potential positive outcomes of co-management in artisanal fisheries, a sustainable use of resources and livelihood support has been difficult to accomplish or not realized at all in other cases (Defeo and Castilla 2005, Nasuchon and Charles 2010, Hearn 2008). A perfect example of limited success of a co-management structure is found in the case of the Galapagos Marine Reserve (GMR) in Ecuador.

Artisanal Fisheries in the Galapagos Marine Reserve

The GMR is one of the largest marine reserves in the world, covering the interior waters of the Galapagos Islands and those within 40 nautical miles measured from the baseline of the Archipelago. It is approximately 133,000 km2 in size and is managed as part of the Galapagos National Park (GNP). Fishing activities are restricted to small-scale levels by national law. The main income source for the fishing sector, which accounts for around 20% of the economy of the Islands (Taylor et. al. 2006), is provided by two fisheries: sea cucumber (Isotichopus fuscus) and spiny lobster (Panulirus penicillatus and P. gracilis). Both products have been primarily destined for exports, especially to Asian markets as delicacies. A third and smaller source of income comes from whitefish fisheries, which are harvested in the area all year long. These are destined mainly to local and mainland markets (Murillo 2002).

A co-management framework was formally established in the Special Law for the Conservation of the Province of Galapagos (SLG) in 2000. Under this legal framework the management of natural resources and the decision making process integrated for the first time all local user groups (i.e., scientists, small-scale fishermen, the governmental management agency, and tourism sector), changing from a top-down to a bottom up structure (Congreso Nacional del Ecuador 1998). Three instances of participatory democratic decision making and implementation define the co-management system (Heylings and Bravo, 2007). At the local level, stakeholders are represented on the Participatory Management Board (PMB). Participants of the PMB are representatives of the fishing, tourism (including naturalists guides), scientific and management sectors, which propose management actions and decide based on a consensus. At the national level, the Inter-institutional Management Authority (IMA) is the entity in charge of the final decisions about policies based on local-level proposals, including those that could not reach a consensus at the PMB. Decision makers at this level are representatives of national ministries and the environmental community, as well as representatives of the local user groups (i.e., fishing and tourism sectors). At this level, the scientific sector acts just as an advisor while the management agency, the Galapagos National Park Service (GNPS), serves as technical secretary. Finally, the GNPS is responsible for the implementation and enforcement of all resulting policies.

Under co-management the fisheries are regulated by limited access, total allowable quotas and traditional input-output controls such as gear restrictions, closed seasons and minimum sizes on landed product. Despite an explicit legal framework, management decentralization, and a clear institutional structure for decision making, the stocks of the most important and valuable species have continued declining and the profitability of fishing has worsened (Hearn 2008). For example, in 2006 the sea-cucumber fishery was considered to be severely overexploited and had to be closed temporarily, and the spiny lobster fishery showed strong indications of decreasing population abundance (Hearn et al. 2006). Also, illegal fishing from artisanal fishermen continues to be a concern (Viteri and Chavez 2007).

As noted by Heylings and Bravo (2007), one of the main challenges of the participatory decision making system is the low level of organization and fishermen representation. Fishing cooperatives are recently starting to be active as fishermen associations, and participants from the fishing sector at the PMB are not always considered good representatives of the whole group. In addition, the agreements reached at the local level are not always perceived as honored by the IAM which creates an issue of credibility. Lastly, but not least important, a critical limitation is the lack of a clear definition of access rights among users. Although a legal framework exists formalizing the co-management system, the resource is still managed as property of the government hindering the incentives for sustainable harvesting among fishermen (Hearn 2008).

Given the above mentioned challenges and fishery problems, alternative strategies to rebuild the fisheries are needed. The management authority (i.e., GNPS) has proposed the creation of alternative livelihood options for the sector in order to reduce the fishing effort (i.e., fishermen and fishing vessels). Specifically, the program proposes a change of activity from fishing to tourism through the concession of new tour operation permits to fishermen in permanent exchange for their fishing and vessel licenses (Servicio Parque Nacional Galapagos 2006, Murillo et al. 2006). The program is voluntary and competitive as the number of tour permits is strictly controlled. As such, this new program is expected to permanently reduce the size of the fishing fleet. If successful, fishermen leaving the fishing sector may engage in economically sustainable non extractive activity and the remaining fishermen should also anticipate more profitable fishing as spiny lobster and sea cucumber stocks rebuild in response to a smaller fleet size.

However, much remains unknown about the efficiency of this strategy as an instrument for fishing effort reduction and for future improvement of the fishing livelihoods. This informational gap becomes more relevant when considering the heterogeneity across vessels and individual fishermen (i.e., vessel owners and crew).

Approaches to Evaluate Preferences and Efficiency

Stated Preference Analysis for Fishery Entry and Exit

One useful approach to assess the entry-exit decisions of fishermen and to identify factors that may affect that choice is the stated preference method, particularly before the implementation of management strategies. With this technique, individuals (i.e., fishermen) indicate what their preference would be (i.e., stay or exit) based on a hypothetical management scenario. The preferred choices are assumed to be those that maximize their utility (Bennett and Blamey 2001).

The use of this approach has recently increased in comparison to other approaches commonly employed but which are based on past decisions and are not adequate to predict new behavior. For instance, Ikiara and Odink (2000) assessed the stated willingness to accept to quit fishing among small-scale Kenyan fishermen. They found that the main reason to stay was the lack of alternative fishing options, and that socioeconomic factors like opportunity costs, profitability of fishing, having more fishing experience and owning a fishing vessel increased the resistance to exit. Similarly, Cinner et al. (2008) also examined the willingness to quit fishing among nine Kenyan communities between Mombasa and Malindi and found that expected reduction in catch levels, and having additional occupations and higher income increased their likelihood to exit. They concluded that poorer households would be less likely to exit even when faced with declining fisheries and that the generation of employment opportunities directed to that sector may help reduce fishing effort.

Efficiency Analysis in Fisheries

Efficiency analysis has been widely applied in fisheries to evaluate the production technology of fleets under the inherent stochastic nature of fishing using stochastic frontier methods. With this approach, an economic production function is specified in terms of fixed (e.g., vessel size, engine power) and variable inputs (e.g., days at sea, fishing time, number of fishermen on board), measures of fish stock, environmental and technological factors that may affect the technology. Variations in catch are assumed to depend not only on random events but also on an inefficiency component for each vessel, which in turn is also dependent on fishermen and vessel characteristics (Pascoe et al. 2003).

The fisheries economics literature has used this type of analysis for a variety of production–related purposes, ranging from development implications to the effect of input controls on vessel economic performance. For instance, Squires et al. 2003 evaluated if development assistance directed to improve artisanal fishing vessels is effectively improving technical efficiency and the harvest potential of the fleet in the Malaysian gill net fishery. They concluded that focusing on 'developing' human capital factors would yield more efficiency improvements than technological and capital expansions of the fleet, and that development assistance for fishing communities would be better focused on aspects other than affecting harvesting capacity.

On the other hand, Fousekis and Klonaris (2003) found that variations on harvest depended mostly on random effects as opposed to technical efficiency, and that vessel characteristic were more important determinants of efficiency than skipper skills for trammel netters in Greece Their results allowed them to examine how existing and proposed structural policies might affect the harvesting potential of the fleet given specific input controls.

Problem Statement

The need to incorporate diversification options to rebuild artisanal livelihoods and stocks in artisanal fisheries management is recognized in the literature (Kuperan and Abdullah 1994; Teh et al. (2008), but it is scarcely documented (Salas et al. 2007). Salayo et al. (2008) and Teh et al. (2008) found that fishermen show strong support for the development of alternative livelihoods inside and outside the fishing sector as a management tool, especially in the tourism sector. As noted by Carvalho (2008), marine tourism jobs seem a natural option for relocated fishermen given their skills in boating and fishing.

To the author's best knowledge, only two studies have addressed the implications of ecotourism as an alternative employment opportunity for fishermen. Alban and Boncoeur (2004) assessed the potential demand, supply, institutional constraints and expected profitability of developing a pluri-activity for fishermen operating in the Iroise Sea. They indicated that despite a promising interest from tourists and fishermen, the fiscal and administrative framework and the low profitability of the new activity threatened to limit the potential of the initiative. More recently, Sarr et al. (2008) proposed a two-sector theoretical bioeconomic model to analyze the interaction between artisanal fishing and ecotourism and the effect on social welfare in the Saloum Delta, Senegal, in the context of an existing Marine National Park and a growing tourism sector. They concluded that creating a non-extractive activity in ecotourism may help integrate the need for long-term marine conservation and the immediate need of additional income in poor fishing communities.

Understanding fishermen behavior and potential demand is critical to the development and introduction of alternative livelihoods, especially when switching activities are considered as permanent decisions. However, it is also important to understand the implications of capital (i.e., vessel) reduction on the production performance of the remaining fleet to accurately evaluate the viability of such alternatives as a fishing effort reduction strategy. Moreover, in the context of artisanal fisheries, it is also relevant to consider the role of social ties in the dynamics of harvesting and fishermen behavior as such social networks are increasingly recognized as key components of economic processes and desirable outcomes (Sekhar 2007).

Goal and Objectives

The present study seeks to contribute to the artisanal fisheries management literature (especially when stocks need to be rebuilt) by expanding the assessment of alternative livelihood options as viable management tools by incorporating the role of production technology and of social ties that may be especially important in artisanal fisheries. Hopefully, knowledge of this information will help decision makers in the design of management strategies seeking to reduce extractive pressure on severely exploited resources, particularly when participatory management has had limited results.

The goal of this study is to assess the viability of fishing effort diversification into tourism as an alternative livelihood and effort reduction strategy for the artisanal fishing sector of the Galapagos Marine Reserve. The specific objectives are:

- To analyze fishermen stay/exit behavior and identify relevant socio-economic determinants.
- To assess the production frontier and technical efficiency of the artisanal fishing fleet.
- To ascertain the role of production interrelations proper of small scale fishing sectors on fishermen behavior and fleet production.
- To evaluate the market potential of fishermen-based operations in the local tourism industry.

Overview of Methods and Study

The objectives of this study are explored in each of the following chapters. Chapter 2 shows the assessment of stated preferences of fishermen to continue fishing or to exit using a discrete choice modeling framework. The stated behavior is based on the findings of personal interview surveys of individual fishermen. This primary data collection allowed for the examination of the effect of any interdependency in preferences based on social linkages between fishermen. Chapter 3 implements a stochastic production frontier model using trip-level catch data to determine the production structure of the sector and the role of technical inefficiency on harvesting potential and its determinants (including an examination of the linkages among harvesters). Chapter 4 explores the potential market demand for tour services provided by newcomers from the fishing sector using a probability modeling approach. The modeling is possible based on the primary data collection of stated preferences from past visitors to the islands. Finally, Chapter 5 summarizes the most salient findings of the analysis and presents the general conclusions and implications for artisanal fisheries management.

CHAPTER 2
EXITING PREFERENCES OF SMALL SCALE FISHERMEN: AN EXPLORATION OF INTERDEPENDECE EFFECTS

Introduction

Overcapacity in fisheries has been recognized as a leading cause of overexploitation of marine resources worldwide (Food and Agriculture Organization, FAO, 1998). Since the FAO published its Declaration of the Code of conduct for Responsible Fisheries in 1995, the managing of the extractive capacity of fishing fleets has received increased attention (Asche 2007). Many studies have explored the use of industry or government sponsored fleet size reduction programs (Guyader et al. 2004; Larkin et al. 2004; Funk et al. 2003; Kitts et al. 2001; Sun 1999) and recent efforts have focused specifically on the issue of stranded capital as it relates to changing management regimes (Wilen 2009). As noted by Ikiada and Odink (2000), the understanding of the behavior of individuals is as necessary as the understanding of the dynamics of the resource for any management plan. In the context of fishing fleet reduction, the identification and understanding of fishermen incentives to exit fisheries is crucial.

To date, the majority of behavioral analysis in fisheries has focused on spatial fishing effort allocation and fisheries selection (Smith and Zhang 2007; Smith 2005; Salas and Gaertner 2004; Smith and Wilen 2004; Smith and Wilen 2003; Wilen et al. 2002). This literature concludes that the behavior of individuals and the factors that drive decision making need to be incorporated into management decisions in order to avoid unwanted or unintended fishery outcomes. By comparison, less work has been conducted regarding the decision making process to exit fisheries. Given the state of many fisheries worldwide (Worm et al. 2006), the need for such information could not be more timely.

The majority of studies that have investigated fishery switching decisions, including the decision to forgo fishing in any given fishery, have utilized the profit maximizing assumption (either implicitly or explicitly) (Pascoe and Mardle 2005). Ward and Sutinen (1994) introduced the modeling of entry-exit behavior for vessels in the shrimp fishery of the Gulf of Mexico. They predicted the probability of a vessel to enter, and then stay or exit using revealed preference data. Their main findings are the expected positive effect of crowding externalities on the probability of exiting and supporting evidence that exit behavior is less sensitive to profitability variation than entry decisions. No evidence was found to support the role of opportunity costs, market variability, or stock variability on exiting behavior.

More recently, Pradhan and Leung (2004) extended the enter-stay-exit choice modeling approach to Hawaiian longline fisheries by also using revealed preference data. The study provides supporting evidence for many of Ward and Sutinen's (1994) findings – namely regarding the opportunity cost of fishing stock abundance, and crowding externalities – and they also found that individual characteristics such as residency and captainship also affected exiting preferences. These findings are important in identifying factors that have affected participation in the short run but they are based on past behavior and, therefore, cannot be used to accurately predict a new choice. Nor do they consider factors that might be unique to small-scale fisheries, especially in developing countries.

As vessel decommission schemes receive increased attention, so too has the modeling approaches to assess their outcomes. For example, Ikiara and Odink (2000) employed a contingent valuation approach to assess fishermen's resistance to exit small-scale Kenyan fisheries as measured by the stated willingness to accept to quit fishing. In this small scale-context, fishermen did not have alternative fishing options but were more interested in securing non-fishing sources of income to support their livelihoods. Drawing from the work of Ward and Sutinen (1994) and early models of fishing effort allocation, they explored the role of opportunity cost of exiting, imperfect capital malleability and indicators of opportunities outside the fishing sector. The effects of other variables describing individuals' utility function were also addressed such as alternative income sources, family tradition and vessel ownership. Their analysis supported the theoretical importance of opportunity costs and profitability in the resistance to exit, but no evidence was found to support the expected effect of imperfect capital malleability. Having more fishing experience and owning the vessel were, however, found to be significant factors in the resistance to exit.

Although previous studies have explored many and varied factors, most research has ignored specific transitions to alternative occupations and all models have assumed that individuals make decisions in a completely independent way. However, interdependencies of individual exiting decisions could be reasonably expected especially in highly interactive harvesting systems such as small-scale artisanal fisheries. In these types of fisheries, informal and fraternal linkages might be relevant to the decision making process of members of the same or interrelated production units (FAO 2004). The importance of interdependent preferences has been recognized in the fields of consumption economics, marketing and transportation research where it has been noted that ignoring such effects when they are likely to exist can yield biased estimates (Yang et al. 2006; Bhat and Pendyala 2005).

In fisheries, the issue of interdependence in spatial fishing decisions has been recognized (Hicks et al. 2004). Extending that idea, the relationships among individuals (captain, crew) and between vessels (changing captains, multi-vessel companies, mother boat arrangements) are likely to affect how any one participant will respond to an opportunity to forgo fishing rights in perpetuity. Excluding this information from the exit choice decision can, therefore, lead to inaccurate predictions of future fishing effort.

The objective of this chapter is to identify the factors that help to explain fishermen's stated preferences regarding whether they plan to switch from fishing to tourism and if they do, which type of tour activities they plan to provide. This information can help fishery managers facilitate and assess the success of a management program designed to reduce fleet size, fishing capacity, and fishing effort. In addition, the study will contribute to the existing literature by exploring the potential role of interdependence indicators in understanding exiting preferences at the individual (disaggregated) level. The analysis illustrates the case of the Galapagos small-scale fishing sector using a stated preference approach in the wake of an unprecedented management situation. The next section discusses the modeling methodology, which is followed by a section with details about the data. The last two sections discuss the estimation results and conclusions, respectively.

Methodology

Fishermen are assumed to maximize their utility when deciding whether to switch professions from fishing to tour operator and, if so, what type of tours they would prefer. An alternative methodology is to model choices by assuming decisions are based on the objective of maximizing profits. The more general utility approach is retained for this analysis since it is more appropriate within an artisanal fishing context.

In this study, fishermen are faced with multiple choices for each decision. The total utility for alternative j in the universal choice set C held by individual n can be specified by the construct:

$$U_{jn} = V_{jn} + \varepsilon_{jn} \quad \forall j \in C \tag{2-1}$$

where V_{jn} is the systematic, observable component of utility and ε_{jn} represents the random, unobservable part.

The observable component V_{jn} can be defined by the expression

$$V_{jn} = \sum_{i=1}^{I} \beta_j^i X_n^i \tag{2-2}$$

In Equation 2-2, i identifies the type of characteristics that are assumed to affect the choice (i.e., X^i variable vectors) and their measureable correlation with V (i.e.,β^i parameters). In particular, the variable groups include those directly or indirectly reflecting the benefits of fishing (i = 1), interdependence indicators (i = 2), and demographic characteristics (i = 3).

Fishermen opting to switch to tourism are also assumed to maximize their perceived utility when deciding among the new tour operations. Following the same theoretical framework, the systematic component of utility for the tour alternatives is just an expansion of the previous model to include variables that reflect an individual's ability to fund a switch into tourism (i = 4). In addition to the new X^4 variable, the set of regressors in X^1, X^2, and X^3 differs between tour choices since their nature are distinctly different.

While utility is unobservable, the stated preferences of each individual (Y_n) can be used to infer information about utility. Economically rational individuals are expected to prefer the alternative with the highest utility, so that the probability of choosing alternative j over all other available options l can be expressed as:

$$P(Y_n = j \mid j,l) = P\,[(V_{jn}+\varepsilon_{jn}) > (V_{ln}+\varepsilon_{ln})] \quad \forall l \in C, j \neq l \tag{2-3}$$

Given the computational complexity of multidimensional integrals related to the probability density functions of normally distributed error terms, the ε_{jn} are assumed to be identically and independently distributed Gumbell random variables. As such, choice probabilities for each individual n can be calculated as follows:

$$P(Y_n = j) = \frac{e^{Vjn}}{1 + \sum_{l \in C} e^{Vln}} \tag{2-4}$$

Since there are more than two choices, there is a reference category (e.g., j = 1) with the associated probability of:

$$P(Y_n = 1) = \frac{1}{1 + \sum_{l \in C} e^{Vln}} \tag{2-5}$$

Thus, there are J-1 equations to be estimated, one for each choice relative to the reference or base choice.

Data and Estimation

Small scale fishermen were interviewed from November 2007 through March 2008 about their preferred choices for switching permanently to tourism. If they indicated an intention to switch, they were then asked to identify their preferred type of tour permit. A total of 355 randomly selected fishery participants were interviewed (156 vessel owners and 199 crew members). This represents an overall response rate of 34.7% given there were 1,022 registered participants during the 2007-08 fishing season. Participants were selected across three strata each representing one of the three main islands. In addition to their choices, fishermen were asked about tourism-related factors and concerns, operational characteristics in the fishing sector and general socio-demographic questions.

Secondary data include vessel ownership records and trip-level landings records for the lobster and sea cucumber fisheries for the period 1997-2005. This information was obtained from the Galapagos National Park Service and the Charles Darwin Research Station. Vessel ownership records provided information on the number and type of vessels linked to the corresponding owner while the landing records allowed small vessels to be linked with mother boats in multi day trips. With these secondary data, it was also possible to relate fishermen to specific vessels and to identify historic inter-vessel harvesting relationships.

After excluding non-responses for the independent variables, the final dataset consisted of two samples, one for switching intentions (N = 299) and the other for the subsequent choice of tour activities only for those individuals planning to switch (N = 103). Exiting behavior is modeled in terms of the individual's stated response to a question asking them if they planned to relinquish their fishing rights (permits) in exchange for a tour operator permit. The response categories included "no", "do not know" and "yes". Those responding "yes" were then asked about their preferences for offering three distinct types of tours including: (1) standard cruises, (2) bay and diving tours, and (3) multi-day diving cruises. Table 2-1 shows the distribution of observed choice responses. Exiting choices are evenly distributed between the options to stay and switch with a slight preference for switching. Most respondents would prefer to offer bay and diving tours, followed by multiday diving cruises. This indicates a stronger preference for options involving some type of diving activities (85.4%) than for any other type of operation.

The X^i explanatory variables hypothesized to influence exit decisions are defined in Table 2-2. Two interdependence variables were created to control for relationships between captain and crew (i.e., intravessel linkages) and operations that involve 'mothership 'relationships. The 'mothership' system consists of smaller vessels offloading at sea onto larger vessels for multiday, multi-zone fishing trips, and it is not uncommon to observe a mother ship working with vessels related to the same family or social group. These variables provided the best approximations to account for the effect of social ties in fishermen exit behavior given the available information. Choice interdependence is addressed by introducing the variables into both models. In the absence of monetary variables for economic factors such as capital investment and alternative labor opportunities, this study is not able to include capital malleability or traditional opportunity cost measures. However, we were able to include six variables that related to the profitability of fishing and, thus, serve as proxies for opportunity costs. The capital malleability issue is less of a concern in this study since it is widely recognized that vessels operating in the Galapagos need to be moved into other uses or they will continue fishing, which is why they are being offered the chance to join the growing tourism sector.

Given the difference between the sets of explanatory factors assumed to affect the stated preference of each choice, the exiting and subsequent tour choices are modeled separately according to equation (4) using an unordered multinomial logit. The models are estimated using maximum likelihood techniques in NLOGIT. This software allows for differences in utility function specifications that can prove useful when analyzing limited sample sizes and distinct alternatives that are likely influenced by different set of factors, such as for our tour choice model. For comparison, a nested multinomial specification was used to correlate the two sets of choices since the choice responses were sequential. However, testing for correlation of the errors between tour choices and switching responses indicated a theoretically inconsistent structure and the model was rejected.

Results and Discussion

Exit Choice Model

Estimates are reported in Table 2-3, where the option to continue fishing (i.e., “no” response to switching alternative) was chosen as the base because identifying the factors contributing to the decision to switch to tourism is an objective of this study. Additional interaction variables were also evaluated using likelihood ratio tests, but they were statistically insignificant and are not presented in the final results. The overall model was statistically significant ($p < 0.0001$; LogL = -170.8) and the Adjusted R-squared indicated that the model was able to explain 41% of the variation in responses. In summary, only five of the 15 explanatory variables were significant at the 10% level or better in the equation explaining whether a fisherman was undecided with respect to switching from fishing to tourism versus someone who was planning to continue fishing. However, a total of 11 of the 15 variables were significant in explaining a fishermen's stated intention to switch into tourism versus someone who was not. The explanatory variables are discussed by type for each choice decision.

Profitability of fishing

Of the six variables representing the opportunity cost of fishing to a respondent, none explained undecided fishermen but nearly all were correlated with the decision to switch into tourism. Being a crew member (*CREW*) or using a fiberglass or small wooden boat to fish (*SBOAT*) reduced the likelihood that they were planning to exchange their fishing rights for tourism permits or, equivalently, they were more likely to want to continue fishing (the omitted alternative). Conversely, vessel owners or those working on larger boats were more likely to indicate they planned to switch their fishing effort from the fishing to the tourism sector. This result contradicts previous findings supporting the hypothesis that vessel owners are more resistant to exit than crew under the argument of a 'career' effect in fisheries (Ikiara and Odink 2000). Our result could reflect the perfect capital malleability in this case study since vessel owners will transfer their boat to the tourism sector and continue operating. Crew members, however, lack the capital asset required to immediately begin participating or they may lack the skills that could be required with the new tours. The finding that smaller boats are less likely to switch was expected since the requirements to enter the tourism sector are more stringent for vessels in the smallest size class (Servicio Parque Nacional Galapagos 2006). In addition, it's possible that this variable is also accounting for some of the concern over the need to meet new, more stringent, safety guidelines (*SAFEREG*, which was not significant) that would require significant investments in vessel upgrades.

Participation in high-value fisheries (*HIGHVAL*), having more years of fishing experience (*FISHYRS*), or being a diver (*DIVER*) also increased the probability that a fishermen has planned to exit the fishing sector and move into tourism. This result implies that fishermen who rely mostly on whitefish or open water stocks (versus the relatively high-valued spiny lobster or sea cucumber), have less fishing experience, or who do not dive are more likely to want to continue fishing. This result could reflect the decline in stock abundance of the traditional high-valued stocks, which is likely more noticeable by those who have been fishing longer.

The reduced abundance of the high-valued species also increases the relatively profitability of alternative species that do not require dive skills. Divers have an advantage in switching to marine tours in that diving tours in particular have been expanded creating more opportunities in the industry (Servicio Parque Nacional Galapagos 2009). Thus, training programs targeted to replace traditional fishing methods (i.e., free diving to dangerous depths) with more specialized scuba diving methods could be effective at enticing human capital from fishing into tourism.

Interdependence

An owner-crew relationship within a vessel (*ICLINK*) was not found to have any effect in explaining exiting intentions, however, a mother boat relationship between small and large vessels (*IMLINK*) increased the probability that the fishermen were undecided in their decision to switch. This implies that fishermen that were not associated with a mother boat were more likely to indicate they planned to continue fishing. This result may reflect the complex and subtle social and economic linkages that characterize small-scale fisheries, especially in the Galapagos (Baine et al. 2007). In this context, it is not uncommon to observe a mother boat providing storage and towing service to other vessels.

Demographics

The majority of demographic variables were significant in explaining the undecided responses, and only one of the seven variables did not have any explanatory power with respect to the "yes" responses, which indicated a plan to switch into tourism. Geographic differences in plans were evident as residents of San Cristobal and Isabela were less likely to switch into tourism (i.e., more likely to continue fishing) compared to residents of Santa Cruz who were more likely to switch to tourism. Residents of San Cristobal were also more likely to be undecided versus those who plan to continue fishing.

The probability that a fishermen intends to switch to tourism versus continue fishing was found to be directly correlated with the number of children in the house (*CHILD*) and total household income (*INC2* or *INC3*). Having an alternative source of income (*ALTINC*) in the household in addition to fishing income was also a factor that increased the probability of a switch versus remaining in the fishing sector. This result likely reflects the ability to pay for costs associated with switching into the tourism sector, or it could reflect the ability to access to formal funding sources. Issues related to access to investment (start-up) capital for small-scale food production in developing countries are not new (FAO 2005), especially as it relates to inherently risky resource-based products. For fisheries managers and policy makers who hope fishermen decide to abandon fishing and enter the tourism sector, it may be more important to identify those individuals who are undecided. In this study, it is fishermen that live in San Cristobal, have no (or fewer) children, or those with a monthly income of US$501-$1,000.

Lastly, having a college degree (*EDUC*) was not found to affect either the decision to exit or whether a fisherman was undecided[1]. Although a higher education level may represent more

[1] A college level education was examined in the model because the majority of participants had high school education.

opportunities outside fishing, there are not many other alternatives besides fishing and tourism in the Galapagos. Given that both fishing and tourism rely on skills associated with marine boating, the extra education was not a factor.

Probability simulations

Using the "yes" equation from Table 2-3, we calculated a base or benchmark probability level to explain how the decision to continue fishing or to switch into tourism varied between the vessels owners and crew members (*CREW*). The benchmarks were calculated with the sample means for the continuous variables (*FISHYRS, CHILD*) and assuming a value of zero for the discrete variables. The distinct effects of each significant variable are summarized in Table 2-4. This is a critical simulation as the decision to allocate equal and independent rights for crew is topic of much debate. Are they equally likely to want to switch professions? Do certain characteristics explain their reluctance to switch as opposed to vessel owners? The answers to these questions can help fishery managers devise the appropriate social programs that would have the best chance of achieving their fishing effort reduction goals.

The benchmark probabilities indicated that vessel owners had a much higher probability of switching from fishing to tourism compared to crew members (i.e., 55% versus 9%). The simulations show that both vessel owners and crew react in a similar way to all socioeconomic variables; however crew members are more sensitive to changes in those factors. This is best illustrated by the relative change in probability (percent change) rather than the nominal change (percentage points).

Owners and crew that had the highest level of income (*INC3*) or alternative sources of income (*ALTINC*) had the highest probability of switching from fishing to tourism (i.e., switching probabilities increased from 55.3% to 83.9% or 81.9% for owners and from 9.1% to 26.8% or 29.6% for crew, respectively), but crew were dramatically more sensitive to changes in these variables. Earning the highest income level increased the switching probability of crew in 233% as opposed to only a 51.6% increase for vessel owners. Similarly, crew members with access to alternative income were 193% more likely to switch, while vessel owners were just 48% more likely to do so.

The probability of switching from fishing to tourism was also found to be much more sensitive to the type of target fishery and diving practices for the crew than for vessel owners. Owners participating in high value fisheries had a probability of switching that was 40.6% lower than those targeting other fisheries compared to a 142% lower probability for crew. Being a diver increased the probability of a crew member switching in 188% while that of owners increased only in 47.3% in comparison to non-divers.

Finally, while the probabilities of switching are directly related to fishing experience (*FISHYRS*) and number of dependents (*CHILD*) for both owners and crew, the size and magnitude of these effects differed greatly (figure 1a and 1b). The number of dependents increased the probability that a crew member would switch at an increasing rate versus a constant rate for owners. The more years of fishing experience by the crew also increased the probability they would switch at an increasing rate. However, the probability of switching for vessel owners increases at a decreasing rate. These results underscore the importance of accounting for human capital in fishing since the crew are less likely to switch, especially those with less fishing experience. Although this result may seem counterintuitive (as we might expect the more experienced fishermen to have the comparative advantage to continue fishing), it is likely that those with more experience have a better understanding of the extent of overfishing and the potential for recovery. Training or funding programs to entice fishermen to leave the fishing sector would be more effective if they target recently active owners and crew (e.g., recent beneficiaries of parental fishing rights or boat investors who entered the sector during the fishing expansion in the late 1990s).

Tour Choice Model

Results for the multinomial logit models of tour choice operations are reported in Table 2-5 where the standard cruise operation was chosen as the base category since it is the most common type of tour that is already being offered.

While the models include an additional set of variables related to the tour choices (X^4), they include fewer explanatory opportunity cost, interdependence and demographic variables compared to the exit choice model. The reduction in explanatory variables increased the degrees of freedom available to the model but was also necessary to better match the distinct nature of each choice. For example, the bay and diving tour option is a single-day operation restricted to in-shore visits such that the size of boats and investment required are modest. Variables reflecting vessels size (*SBOAT*) and traditional financing options (*FBANK, FFAM*) are included in that model only. On the other hand, diving cruises are multi-day, off shore diving excursions which require high levels of capital and specialization. Hence, high investment needs (*INVHIGH*) and large funding sources (*FINV*) are hypothesized to affect this option only. Additional relevant factors such as owner-crew and owner-owner interdependence, diving skills (*DIVER*), geographical location and concern with safety regulations are included in both specifications. The overall model was significant ($p < 0.00001$; LogL = -60.81) and the adjusted R-squared indicated that the model explained 35.0% of the variation in the responses.

Five out of the nine explanatory variables significantly explained the choice of bay and diving tours; while only three of the eight covariates explained the diving cruise option at the 10% level at least. The probability of choosing bay and diving tours is higher for individuals working or owning small fishing vessels, or who are concerned with safety regulations in comparison to standard cruises. This reflects the fact that fishermen are not used to strict safety procedures and the costly implications of adapting small boats for traditional cruise operations. Safety aspects in tourism are critical and safety procedures, equipment and vessel upgrades for single-day excursions may seem more manageable than for other types of trips. Interestingly, there is no evidence supporting the significance of diving skills (*DIVER*) to explain the choice of tour options by fishermen in the study site. For this specific case, abilities to perform alternative occupations in recreational excursions are perhaps more relevant in their tour choice behavior.

Out of the two possible funding sources, only access to bank credits (*FBANK*) increases the probability of individuals engaging in bay and diving tours. This is expected as investment requirements for standard cruise activities may be more prohibitive for this type of funding. Fishermen from San Cristobal (*LOC_CR*) are also more likely to want to engage in bay and diving excursions, while individuals from Isabela (*LOC_IS*) are more reluctant to do so and also to engage in diving cruises. This is, individuals from this latter community have a higher probability of preferring standard cruise operations overall.

Fishermen with an identified owner–crew relation (*ICLINK*) are less willing to want a multi-day diving cruise permit in comparison to standard cruises. The result may reflect the highly specialized nature of a diving cruise and the informal ties among individuals working in the same vessel. A fishing vessel may be the workplace for members of the same family or social network, and the relocation of fishing crew into tourism may seem more difficult the higher the specialization and complexity of the tour excursion. However, interrelations between vessel owners (*IMLINK*) were not found to affect tour choice behavior.

Fishermen have a higher probability to choose multiday diving cruises when faced with higher investment than standard cruises (*INVHIGH*). Access to informal credit institutions

(*FFAM*) and third party investors (*FINV*) was not found to explain tour choice, which may reflect the lack of these types of investment opportunities in small-scale fishing communities.

Summary and Conclusions

The two main marine stocks that support the local small-scale artisanal fishery in the Galapagos Marine Reserve are near extinction. In an effort to reduce fishing effort, the managers have proposed an ambitious program to exchange permits to fish for tour operator permits permanently. The tour permits would be freely transferrable in the current market where the numbers of permits are tightly-controlled and have a relatively high market value. To assess the potential effectiveness of this program in terms of an effort reduction in the fishery, and to identify any factors that can be used to help the authorities devise training programs to increase the effort reduction, a stated preference survey was implemented. The data was used to estimate multinomial logit models of the exit decisions of both vessels owners and the crew, who would be eligible to obtain equal and autonomous rights. Those indicating they planned to exchange their fishing rights for tourism permits were then asked to indicate the type of tour they would prefer to offer.

Results support the relevance of accounting for interdependence between fishing participants in addition to traditional economic and demographic factors to explain exit choices and preferences for alternative tour occupations in the context of small scale fisheries. Consistent with economic theory and previous findings, opportunity cost indicators are significant explanatory factors of stated or revealed exit behavior. Vessel ownership, participation in high-value fisheries, longer fishing experience and possessing diving skills were found to increase the likelihood of a fisherman to switch to tourism, while working with small fishing boats reduced that probability. In contrast to previous studies, these results model the transition to a particular alternative occupation where capital malleability is not an issue. Geographical location, total household income, additional non-fishing occupations and household size were also statistically significant demographic variables that helped to explain differences in switch choices.

As hypothesized, interdependent relationships affected a fisherman's stated behavior. A mother boat relationship increased the probability that a fisherman remained undecided in their decision to exit the fishing industry. Thus, it is important to recognize that production relationships can prohibit independent decision making. Any program designed to transfer fishing effort may need to redefine a production unit to account for such relationships. Among those fishermen planning to switch into tourism, interdependence within a production unit with respect to human capital (i.e., owner and crew) was found to reduce the probability of planning to offer multi-day diving cruises. Because this variable will capture relatives, it could be that offering such a trip would not be possible due to the need to have some of these family member stay at home. It is important for fisheries managers that are devising effort reduction strategies to recognize the constraints on households in their ability to participate in every option.

The analysis found different reactions of crew and vessel owners especially to differences in income level, availability of alternative income, target fishery, diving practice, number of children and fishing experience, which could also be a proxy for age. Both groups, who often lack access to formal financial assistance, showed the highest dependency on their own income resources in order to exit the fisheries. Improved access to external funding or training is likely to play a role to facilitate the relocation of fishermen outside the fisheries. Furthermore, funding aspects such as access to bank loans and investment needs are critical determinants of the type of tour options fishermen choose besides geographical, safety and infrastructure considerations.

The findings of this study have important management implications. Future fishing capacity programs need to be tailored to the characteristic of each port, which can be accomplished through the local cooperative organizations. For instance, fishing cooperatives could institute savings and credit programs for their active members (to improve access to funding in the absence of formal credit offering for the sector). Second, plans aiming to entice fishermen to exit should include an effective description of the status of the stocks sea cucumber and lobster fisheries to emphasize the duration and difficulty of the rebuild. Traditional instruments such as closed seasons, taxes to landing values or innovative policies such as allocations of quotas to 'mother boat' structures in multiday fishing trips may prove effective in reducing fleet size while protecting endangered stocks.

The scope of these findings regarding stated fishermen exiting behavior is limited to the context of a fishing-tourism transition where the issue of capital malleability is overcome. However, the results provide further evidence about expected 'rational' behavior and social aspects relevant to small-scale fisheries. Given data availability and sample size considerations, this study used simple linkage indicators among individuals to identify possible interdependency in behavior. Further research that explores more refined scales of relationships, such as actual correlations between related fishermen choices, is needed. Another area beyond the scope of this paper is the role of vessel efficiency on exiting behavior. Further exploration of this topic is important to better understand observed differences among individuals related to different fleet segments and to help management authorities design fleet-targeted, and perhaps more efficient capacity reduction plans.

Table 2-1. Distribution of observed responses

Response	No. observations	Percent
Exit choice:		
No	120	40.10%
Do not know	51	17.10%
Yes	128	42.80%
Total	299	100.0%
Tour choice:		
Standard cruise	15	14.60%
Bay and diving tour	51	49.50%
Diving cruise	37	35.90%
Total	103	100.0%

Tour options with less than 10 observations were excluded from the model.

Table 2-2. Variable descriptions and statistics

Variable	Definition	Exit choice (N = 299) Mean	Std dev.	Tour choice (N = 103) Mean	Std dev.
Profitability of fishing (X^1):					
CREW	1 if crew; 0 if owner	0.552	0.497	0.165	0.372
SBOAT	1 if works with or is a small boat, 0 otherwise	0.866	0.341	0.864	0.343
HIGHVAL	1 if fishes lobster and sea cucumber, 0 otherwise	0.856	0.351	0.845	0.363
FISHYRS	Fishing experience (years, range: 0 - 60)	18.07	9.321	21.068	9.743
DIVER	1 if worked as diver, 0 otherwise	0.411	0.492	0.544	0.499
SAFEREG	1 if concerned with safety regulations, 0 otherwise	0.198	0.395	0.265	0.439
Interdependence (X^2):					
ICLINK	1 if crew-owner relation observed, 0 otherwise	0.528	0.499	0.417	0.494
IMLINK	1 if 'mother boat' relation observed, 0 otherwise	0.147	0.354	0.281	0.450
Demographics (X^3):					
LOC_CR	1 if resides in San Cristobal, 0 otherwise	0.475	0.499	0.330	0.471
LOC_IS	1 if resides in Isabela, 0 otherwise	0.298	0.448	0.233	0.423
CHILD	Children living in household (number, range: 0-4)	0.916	0.956	1.107	1.006
INC2	1 if monthly income: USD$501- 1,000, 0 otherwise	0.405	0.491	0.447	0.498
INC3	1 if monthly income >USD$1000, 0 otherwise	0.237	0.426	0.379	0.486
ALTINC	1 if have alternative income, 0 otherwise	0.472	0.499	0.612	0.488
EDUC	1 if college graduate, 0 otherwise	0.055	0.225	0.064	0.254
Funding to enter tourism (X^4):					
FBANK	1 if bank funding available, 0 otherwise	N/A	N/A	0.670	0.464
FFAM	1 if family funding available, 0 otherwise	N/A	N/A	0.304	0.458
FINV	1 if funding from third-party investors, 0 otherwise	N/A	N/A	0.320	0.467
INVHIGH	1 if high investment level needed, 0 otherwise	N/A	N/A	0.592	0.492

N/A indicates the variable was not applicable to the choice set.

Table 2-3. Multinomial logit estimates for exit choice

Variable	Do not know Estimate	t-value	Yes Estimate	t-value
Constant	-4.732	-2.742***	-1.125	-0.940
CREW	0.841	1.122	-2.501	-5.012***
SBOAT	0.559	0.936	-1.013	-1.726*
HIGHVAL	0.143	0.249	1.039	1.746*
FISHYRS	-0.049	-1.497	0.051	2.121**
DIVER	-0.346	-0.684	1.269	2.961***
SAFEREG	0.596	0.966	0.535	1.118
ICLINK	0.631	1.307	-0.068	-0.170
IMLINK	1.922	2.075**	0.634	0.944
LOC_CR	3.103	2.897***	-1.169	-2.291**
LOC_IS	-0.685	-0.459	-1.074	-1.927*
CHILD	-0.518	-1.911*	0.425	1.938*
INC2	1.147	2.135**	0.845	1.828*
INC3	1.243	1.830*	1.442	2.538**
ALTINC	0.402	0.873	1.296	3.022***
EDUC	1.387	1.377	-0.135	-0.151
LogL		-170.828		
Adj. R-Sq		0.415		
N		299		

*Significant at the 0.10 level; **Significant at the 0.05 level; ***Significant at the 0.01 level.

Table 2-4. Effects of discrete variables on the probability of switching by type of fishermen

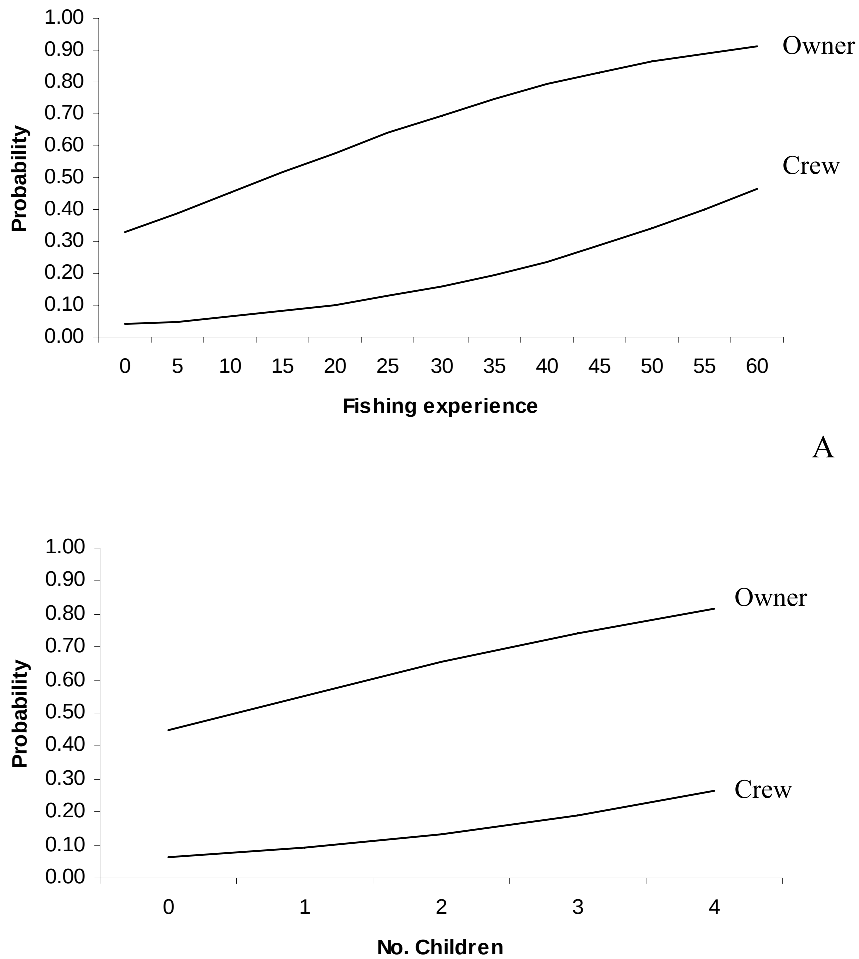
Variable	Owner (Base= 0.553)	Crew (Base = 0.091)
SBOAT	-0.240 (-43.9%)	-0.050 (-61.6%)
HIGHVAL	0.225 (40.6%)	0.130 (142.0%)
DIVER	0.262 (47.3%)	0.173 (188.2%)
LOC_CR	-0.284 (-51.4%)	-0.064 (-69.9%)
LOC_IS	-0.256 (-46.2%)	-0.058 (-63.5%)
INC2	0.188 (34.0%)	0.097 (105.7%)
INC3	0.286 (51.6%)	0.205 (223.4%)
ALTINC	0.266 (48.0%)	0.177 (193.2%)

Note: Results calculated using the “Yes” model from Table 2-3.

Table 2-5. Multinomial logit estimates for choice of tour operations

	Bay and diving tour		Diving cruise	
Variable	Estimate	t-value	Estimate	t-value
Constant	0.520	0.365	2.349	2.034**
SBOAT	1.364	1.645*	N/A	N/A
DIVER	-0.058	-0.066	0.989	1.123
SAFEREG	1.646	1.653*	0.490	0.481
ICLINK	-0.953	-0.989	-2.028	-2.096**
IMLINK	-0.993	-1.076	-1.075	-1.149
LOC_CR	3.114	3.856***	N/A	N/A
LOC_IS	-2.895	-2.799***	-3.940	-3.755***
FBANK	1.194	1.698*	N/A	N/A
FFAM	-0.038	-0.063	N/A	N/A
FINV	N/A	N/A	0.936	1.419
INVHIGH	N/A	N/A	1.316	2.122**
LogL		-60.811		
Adj. R-sq		0.350		
N		103		

*Significant at the 0.10 level; **Significant at the 0.05 level; ***Significant at the 0.01 level. N/A indicates the variable was not estimated. *LOC_CR* is not included in the diving cruise option because of lack of observation. *INVHIGH* is included in one option only given the limited to variation of the variable in the base category.



A

B

Figure 2-1. Probability of switching. (A) Probability by number of children. (B) Probability by fishing experience.

CHAPTER 3
ASSESING PRODUCTION TECHNOLOGY AND TECHNICAL EFFICIENCY IN SMALL SCALE FISHING FLEETS: DOES VESSEL INTERRELATION MATTER?

Introduction

The literature on production and technical efficiency analysis in large commercial fisheries has increasingly expanded in the last decade. Most empirical analyses usually focus on evaluating the effectiveness of capacity management programs, the effects of traditional input controls on harvest levels and vessel performance, and on the assessment of the role of fishing skills and vessel characteristics on explaining technical efficiency (Sharma and Leung 1999; Greenville et al. 2006; Pascoe and Coglan 2002; Tingley et al. 2005; Felthoven 2002; Kirkley et al. 1998).

However, fewer studies have addressed the specific production dynamics and technical efficiency of artisanal fishing fleets. In comparison to the industrial large commercial sector, artisanal fisheries are strongly influenced by socio-economic, technological and political factors. These distinctive characteristics in turn affect the appropriate type of management strategies (Berkes et al. 2001). Some studies explicitly mentioning the effect of production factors on efficient output levels indicate that harvests are more sensitive to variable inputs than to measures of vessel capital (e.g., size and capacity) (Fousekis and Klonaris 2003; Lokina 2008; Esmaeili 2006). Other studies have analyzed in more detail the technical efficiency of small scale fisheries in developing countries. There is evidence that the level of efficiency in input use is more relevant than random events or luck in explaining output variability (Esmaeli 2006, Jeon et al. 2006, Madau et al. 2009), although for the particular cases of artisanal trammel netters in Greece and gill netters in the east coast of Malaysia inefficiency was not critical in determining production performance (Fousekis and Klonaris 2003, Squires et al. 2003). In average, small scale fishing fleets seem to operate with moderate technical efficiency, suggesting a significant scope for output increases given the same input levels and resource conditions or input and costs reductions for the existing output levels.

The previous literature has addressed the productivity and efficiency of fishing vessels as independent production units, which decide autonomously how many inputs to use and what fishing grounds to operate in. Only Schnier et al. (2006) presented a descriptive analysis of paired trawling within and between producer segments using a latent class production model to explore the issue of unobserved heterogeneity in the Northeast Atlantic herring fishery. However, paired trawlers were excluded from the production modeling and efficiency estimation. In the context of artisanal fishing fleets and their limited infrastructure, vessel interaction in the production process may be a usual and customary practice to access different fishing grounds, especially those far from the home ports. This interaction is likely to be facilitated by the social ties prevalent on community-based production systems, where it is not uncommon to observe family and friends forming composite production units. Hence, accounting for vessel interdependence will help depict an appropriate production technology for small scale fleets that operate under that system and obtain accurate estimates of their productivity and technical efficiency. From a capacity management perspective for instance, this information would be helpful to better evaluate the potential impacts of fleet reduction programs that affect multi-vessel production units.

The objective of this chapter is to evaluate the production possibilities and technical efficiency of individual vessels and also the role of mothership-catcher vessel interrelations on boat performance with an application to the artisanal spiny lobster fishery in the Galapagos Marine Reserve. The next section describes the characteristic of the fishery, section three explains the stochastic frontier methodology employed, followed by the data description and model specification in section four. Finally, results and conclusions with recommendations about strategies to influence technical efficiency in the fleet are provided in section five.

The Artisanal Spiny Lobster Fishery

The spiny lobster fishery in the Galapagos Islands targets two species, Panulirus penicillatus and Panulirus gracilis, commonly known as red and green lobster respectively. It started in 1960 for subsistence purposes and expanded throughout the years with the introduction of fishermen and vessels from the mainland and the adoption of improved harvesting methods (Toral et al. 2002).

Since 1998, with the establishment of the special Law for the Galapagos and the creation of the Marine Reserve, the fishing fleet has been constrained to limited entry and small scale operations only. The fishery has become the second more important income-generation activity for the fishing sector (after sea cucumber) with landings of 31.40 MT and an ex-vessel value of USD$900,000 approximately in 2006 (Hearn et al. 2007).

The fishing fleet is comprised by a total of 446 registered vessels grouped in three fleet segments. Small wooden boats (WB) have a length between 3-8 mts. and the most limited storage capacity and propulsion power, medium fiberglass (FG) vessels are 5 to 9.5 mts. long and large boats (LB) are vessels of up to 18 mts., with the highest registered tonnage and engine power measures (Table 3-1). Overall, fiberglass vessels account for the majority of the fleet (i.e., 51%), while large boats represent only 14% (Table 3-2).

The fleet is distributed among the three main inhabited islands: San Cristobal, Santa Cruz and Isabela. Most vessels are located in San Cristobal and, contrary to the other ports; wooden boats represent most of the island fleet. By 2005, only sixty percent of the overall fleet was active, with 88% of fiberglass boats, 46% of wooden boats and 43% of large boats actually fishing (Hearn et al. 2006). Vessels usually operate independently for single-day fishing trips, which are mostly near shore. For multi-day offshore fishing trips, however, vessels work within the 'mother boat' system. In this system, larger or 'mother' boats tow smaller vessels to distant fishing grounds and provide storage for their catches until landing at the home port (Baine et al. 2007). Compensation is given as a fixed fee or share of total harvests. The mother boat system can be considered as a joint production unit where the harvesting performance of subunits (i.e., smaller vessels) is related to the corresponding mother boat. Only fiberglass and wooden boats are considered fishing units in this fishery (Castrejon 2007)[1].

The fishery is managed by limited entry and traditional input and output controls. The fishing season is limited to 4-5 months a year, generally from September to December. The product is collected exclusively by diving (i.e., scuba, hookah and snorkel), using Hawaiian fishing spears with a trident length not exceeding 40 cm or just hand picking. Output controls include minimum sizes of 26 and 15 cm for whole individuals and tails respectively, restrictions to spawning stocks and total allowable catch measures per year. For 2009, the total catch quota was set in 30 MT, which will be adjusted to the stock condition every season (Comisión Técnica Pesquera de la Junta de Manejo Participativo 2009).

Despite the innovative participatory management framework and fishing controls, lobster stock abundance has decreased during the last years raising concerns about the sustainability of the resource and the local fishing community. From 2000 to 2005, total harvests decreased in about 59% from an estimate of 85 MT to less than 35 MT per year with total revenues declining in 53% (from almost USD$ 2 million to $900.000) (Hearn et al. 2006). As with other open access fisheries worlwide, the need to rebuild these stocks and to limit the fishing capacity of the fleet has become a priority for this resource.

[1] Large boats are considered fishing units only for year round pelagic and demersal fisheries, specifically, whitefish.

Methodology

Production frontier methods provide a framework to identify the 'best practices' in an industry, creating boundaries or frontiers against which the inefficiency of firms is assessed. Firms on the frontier operate efficiently while those below the boundary are considered inefficient. From an output perspective, the 'best practice' frontier refers to the maximum possible output attainable by a firm at observed input combinations and given technology (Kumbhakar and Lovell 2000).This paper uses the Stochastic Production Frontier (SPF) methodology to assess the production technology and technical efficiency of the Galapagos artisanal fishing fleet. This method is considered particularly appropriate in fisheries production analysis, given the stochasticity related to the environmental and biological aspects of the activity (Kirkley, Squires and Strand 1995).

Following the Battese and Coelli (1995) approach for panel data, a stochastic frontier production function is defined as

$$\ln Y_{jt} = f(\ln X_{jt};\beta) + \varepsilon_{jt} \ , \qquad \text{with } \varepsilon_{jt} = v_{jt} - u_{jt} \tag{3-1}$$

Y_{jt} represents the level of output for firm j in period t, X_{jt} is the vector of production factors[2] used by firm j in period t, β is a vector of coefficients to be estimated and ε_{jt} is a composite error term where v_{jt} represents a traditional random noise and u_{jt} is an additional non-negative one-sided error component capturing technical inefficiency of firm j[3].

To obtain estimates of technical efficiency it is necessary to make distributional assumptions regarding the error components v^{jt} and u^{jt}. Both terms are assumed to be

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[2] In fisheries, production factors are usually represented by a vector of capital stock or fixed inputs, variable inputs, non-discretionary stocks out of the producer's control, and a vector of temporal, environmental or technological conditions (Kirkley et al 2002).

[3] This composite error definition allows impacts of random events or unmeasured inputs on final output not to be confused or combined with inefficiency deviations (Kirkley et al 2002).

independently distributed from each other, with v_{jt} ~iid $N(0,\sigma_v^2)$ and u_{jt} ~id $N^*(\mu,\sigma_u^2)$ where N* indicates the normal distribution truncated at zero[4].

In order to estimate inefficiency effects, u_{jt} is specified as a function of relevant variables, z_{jt}, hypothesized to influence firms' efficiency such that

$$u_{jt} = \delta_0 + z_{jt}\delta + w_{jt} \;\; ; \quad j_{it} \sim N^*(0, \sigma_u^2) \;\; and \; u_{jt} \sim \text{id } N^*(z_{jt}\delta, \sigma_u^2) \qquad (3\text{-}2)$$

where z_{jt} is a vector of exogenous firm and operator specific factors. These factors differ from those in the production frontier as they are more related to influencing the ability of vessels to locate and catch fish than to determining the production technology. δ is the set of parameters to be estimated and w_{jt} is a random variable not required to be independently and identically distributed, assumed to follow a normal distribution truncated at $-z_{jt}\delta$ to satisfy the non-negativity condition of u_{jt}. Equations 3-1 and 3-2 are estimated jointly using maximum likelihood techniques[5]. Details on the likelihood function and variance parameters and transformations are provided by Battese and Coelli 1993.

The technical efficiency (TE) score for the individual firm j in period t is defined in a logged-based functional form as:

$$TE_{jt} = \exp(-u_{jt}) = \exp(-z_{jt}\delta - w_{jt}) \qquad (3\text{-}3)$$

As the SPF model (Equations 3-1 and 3-2) is estimated given the joint density function of the composite error term ε_{jt}, the estimator of technical efficiency, TE, is based on the conditional

[4] Additional distributional assumptions for u_{it} used in the literature include (a) a half-normal, (b) exponential and (c) 2-parameter Gamma distributions. The truncated normal distribution allows a more flexible specification for the one-sided efficiency error (Kumbhakar and Lovell 2000).

[5] Joint estimation of the frontier and technical efficiency effects avoids inconsistencies between the distributional assumptions of the inefficiency term arising when Equations 3-1 and 3-2 are estimated using a 2-step approach. In that case, estimation of the stochastic frontier in the first step assumes identically and independently distributed inefficiencies (u_{it}). In the second stage, the predicted TE scores are assumed to be a function of firm specific variables, meaning that the u_{it}'s are not identically distributed (Battese and Coelli 1995).

expectation of u_{jt} and TE_{jt}. As shown in Kumbhakar and Lovell (2000), the TE for individual firm j is predicted by the following expression:

$$E[\exp(-u_j) \mid \varepsilon_j] = \{\exp[-\mu_j * + 1/2\sigma^2 *]\} * \{\Phi[(\mu_j * / \sigma *) - \sigma *] / \Phi(\mu_j * / \sigma *)\} \qquad (3\text{-}4)$$

where μ_i* and $\sigma*$ are transformations of the variances of the error components u_j and v_j.

Estimation of technical efficiency effects (Equation 3-2) is plausible provided that technical efficiency exists and that it is stochastic. The validity of these assumptions can be tested using standard generalized likelihood ratio tests. To test whether or not inefficiency effects are absent, the null hypothesis is expressed by γ =δ=0, where $\gamma = \sigma_u^2 / (\sigma_v^2 + \sigma_u^2)$. If technical inefficiency indeed applies to the model, it is necessary to test if they are stochastic through the null hypothesis γ =0.[6]. Finally, the null hypothesis δ =0 is used to test if technical inefficiency is a linear function of the hypothesized Z_{jt} factors. As noted by Battese and Coelli (1995), if the hypothesis that all δ are zero can not be rejected (excluding the intercept δ_0), the u_{it} would have a truncated normal distribution with mean δ_0.

A flexible functional form such as the translog production specification is recommended for econometric estimation since it avoids imposing too restrictive assumptions on returns to scale and elasticities of substitutions in the technology. The translog production function is given by:

$$\ln Y_{jt} = \beta_0 + \sum_n \beta_n \ln X_{njt} + 1/2 \sum_n \sum_k \beta_{nk} \ln X_{njt} * \ln X_{kjt} + \sum_{m=2}^{m} \beta_m d_{mjt} + v_{jt} - u_{jt} \qquad (3\text{-}5)$$

[6] If technical inefficiency is absent, the production frontier would reduce to the standard OLS mean production function with only the input variables X_{jt} included. In this case the degrees of freedom (number of parameter restrictions) equal 1 for γ and the number of δ coefficients, including δo. If technical efficiency is not stochastic (i.e., deterministic), the frontier reduces to a mean production function with the z_{jt} variables added to the input (X_{jt}) variables in the specification. In this case, the number of degrees if freedom equals 1 for γ plus the number of non-identified δ parameters, in some cases being just δo. For these two hypotheses, the likelihood ratio statistic has an asymptotic mixed chi-squared distribution as γ=0 is on the boundary of the parameter space (Battese and Broca 1997). The appropriate critical values can be found in Table 1 of Kodde and Palm 1986.

where Y_{jt} and X_{njt} rpresent output and production inputs respectively, d_{mjt} are additional technology indicators, such as time, resource stocks, etc. However, this approach is likely to create problems of multicollinearity and degrees of freedom (Coelli 1995). An alternative functional form such as the Cobb-Douglas production function can also be tested as a special case of the translog function where all the β_{nk} equal zero in order to validate the assumption of a more restrictive production technology (Pascoe et al. 2003)[7].

Data and Model Specification

The data used in this study are pooled cross sections of trip-level catch and fishing effort from a total of 316 individual vessels during the period 1997-2006. The total dataset consisted of 8746 trip observations and it was obtained from the Charles Darwin Research Station monitoring program[8]. The information included landing volume, fishing effort, fishing sites, vessel names, departure and landing ports and an indicator of whether the vessel was towed or not in the specific trip. Data on physical boat characteristics such as length, engine power, gross registered tonnage and construction year was provided by the Galapagos National Park Service.

The estimation sample was limited to fiberglass and wooden vessels only because reported output from large boats (i.e., motherships) corresponds to the catch of the smaller vessels they tow (Castrejon 2007). Vessels with less than 5 trips were excluded in order to reduce the number of missing time series. Also, catch data with values of zero or more than 500 MT and gross registered tonnage (GRT) of more than 5.68 tons were considered outliers and were not included

[7] Specifically, the Cobb-Douglas specification restricts output elasticities to be constant at all input levels and returns to scale to be equal across all firms.

[8] Information was collected from almost all active fishing vessels during each season though either on-board observers or field assistants filling record sheets at the docks (Hearn et al 2006). Vessels were required to report their landings in order to obtain a monitoring certificate from the Galapagos National Park to be able to sell their product. Landings that were not monitored are considered illegal catch.

in the final sample[9]. Missing information for towing accounted for 21% of the sample and it was dropped from the sample to avoid bias from any missing data adjustment method as this is a fundamental variable in the analysis. Therefore, the analysis was conditional on towing information. Most missing data for control variables such as capital characteristics and fishing effort accounted for less than 6% of the sample and were replaced using the dummy adjustment method[10,11]. The final sample included 201 fishing boats and 6381 observations. A detailed description of the variables, summary statistics and *a priori* expected effects are presented in Table 3-3. In comparison to a sample that is not conditional on observing towing data, boats in the final sample had higher average catch and storage capacity levels (Table 3-4). The absence of towing information caused only a moderate underrepresentation of fishing units departing from or fishing in San Cristobal, of those operating during the first two years in the analysis (1997-1998) and those fishing by hand picking. Conversely, boats operating around the other fishing ports, during the period 1999-2001 and which used mechanized gear were overrepresented. The rest of the variables remained considerably similar.

The analysis follows the approach suggested by Battesse and Coelli (1995) given its ability to identify factors influencing technical inefficiency in a panel data context. A full Translog specification was not allowed by the data as several interaction terms had a linear correlation

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[9] GRT outliers represented only 1% of the sample and consisted of 60 observations from 3 fiberglass boats. They differed substantially from the rest of the sample as a measure of capital, and were likely to introduce biases in the model, as indicated by preliminary analysis.

[10] The dummy adjustment method replaces missing values with the mean of the corresponding variable and additionally creates a dummy variable indicating that the observation was missing, which must be included in the model (Allison 2002).This approach allows retaining non missing information from the same cross sectional unit with missing data, and it is better justified if applied to a small percentage of the sample.

[11] Preliminary regression analysis was used to compare the effect of listwise deletion vs. dummy adjustment for missing data. Coefficients remained relatively stable for most factors across methods, but listwise deletion of missing data on boat age (14% sample) created stability and converging problems. For that reason dummy adjustment was considered a justified approach.

greater than 0.99 and caused stability and convergence problems. Hence, the frontier model for the Galapagos spiny lobster fishery is specified as a Cobb-Douglas production function[12]:

$$\ln WEIGHT_{jt} = \beta_0 + \beta_1 \ln GRT_j + \beta_2 \ln SEADAYS_{jt} + \beta_3 \ln NDIVERS_{jt} + \sum_{k=1}^{19} \alpha_k DZONE_{kjt} + \sum_{m=2}^{10} \phi_m DYEAR_m + \phi_{11} DWBOAT_j + \phi_{12} DTOW_{jt} + \phi_{13} DTOW_{jt} * DWBOAT_j + v_{jt} - u_{jt} \tag{3-6}$$

$WEIGHT_{jt}$ represents catch volume in kilograms for vessel j in trip t[13]; GRT_j is the gross registered tonnage of vessel j capturing the capital stock measure[14], and variable inputs are denoted by $SEADAYS_{jt}$ and $NDIVERS_{jt}$, the number of days at sea and number of divers observed for vessel j in trip t respectively.

$DZONE_{kjt}$ is a vector of dummy variables indicating if vessel j fished in zone k and it is intended to control for high and low productivity areas capturing the effect of resource stock availability[15]. The next variables are dummy indicators used to control for temporal and technological conditions. $DYEAR_m$ represents a vector of M-1 year binary variables which are intended to capture non linear technical change in time, and $DWBOAT_j$ indicates if vessel j is a wooden boat. The term $DTOW_{jt}$ is introduced to control for vessel interrelations in the production process, taking the value of one if vessel j was towed in trip t. This variable was

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[12] Generalized likelihood ratio tests of joint significance did not support the inclusion of cross product input terms in a translog specification context.

[13] Catch is expressed in kilograms to avoid negative values after logarithmic transformations and it is treated as a single-output measure since there are not price differentials between the two target species. In addition, lobster output is modeled separately from other fisheries also open during lobster season since participation in different fisheries requires completely separate fishing trips given the differences in gear use, technology and the spatial distribution among resources.

[14] An additional fixed input, horse power, was also considered in preliminary models, but the inclusion of a second factor did not improve the performance of the model as indicated by likelihood ratio tests. The inclusion of GRT over horse power was supported by AIC and BIC criteria.

[15]In the absence of independent measures of stock biomass, using area-based dummy variables as proxies for stock abundance allows to control for spatial differences in resource abundance, fishing practices and socio-economic conditions (Squires et. al. 2003). In this case, all fishing zones are included in the model because they are not mutually exclusive; vessels can fish in more than one site in the same trip, especially during multi-day trips.

introduced in the frontier function as opposed to the inefficiency model because the towing system reflects a technological component likely to affect input use and maximum possible output. It allows vessels to spend more days at sea and to go to more and different fishing sites increasing their exposure to different levels of resource abundance. Finally, the interaction term $DTOW_{jt}*DWBOAT_j$ captures possible differential effects of the towing system between fiberglass and wooden boats[16].

The inefficiency measure for vessel j in trip t, u_{jt}, is specified as:

$$u_{jt} = \delta_0 + \delta_1 DPORT1_{jt} + \delta_2 DPORT3_{jt} + \delta_3 DPORT4_{jt} + \delta_4 DFDIVE_{jt} + \delta_5 DGEAR_{jt} + \delta_6 BAGE_j + v_{jt} - u_{jt} \tag{3-7}$$

The first five explanatory variables are dummy indicators taking the value of one if the vessel homeport is Puerto Baquerizo Moreno (San Cristobal) ($DPORT1_{jt}$), Puerto Villamil (Isabela) ($DPORT\ 3_{jt}$) or others ($DPORT4_{jt}$), if divers practiced free diving as opposed to hookah methods ($DFDIVE_j$), and hand-picked the catch ($DGEAR_{jt}$); while $BAGE_j$ measures the age of the boat in years. These variables intend to capture the effect of social and vessel-specific practices and characteristics on the observed efficiency of input use.

According to economic theory, fixed and variable inputs (*GRT, SEADAYS* and *NDIVERS*) are expected to have a positive effect on the catch frontier and the year indicators for 2005 and 2006 (*DYEAR9* and *DYEAR10*) are hypothesized to show a negative effect given the reduction in resource biomass observed in those years. The coefficients for *DPORT1*, *DPORT3*, and *DPORT4* are expected to have a negative effect on technical inefficiency as they represent ports with higher fishing activity in comparison to the tourism-based economy of the base port

[16] A model with interactions between WBOAT and DTOW with inputs was also explored to check for differential impacts on inputs main effects but they were jointly non-significant as indicated by likelihood ratio test statistics.

(*DPORT2*) and they may presumably be more efficient in their input use given their fishing specialization. The practice of free diving (*DFDIVE*) and the use of non-mechanized gear (*DGEAR*) are likely to limit the full use of the existing technology increasing technical inefficiency (reducing technical efficiency). Older vessels may be in worse maintenance conditions or constructed with outdated materials and designs, which is also expected to limit the optimal use of available inputs and boat efficiency (Pascoe and Coglan 2002; Squires et al 2003).

Vessel interrelation (*DTOW*) may have different effects on the production frontier. On one hand, it could show a positive effect on output as being towed increases the number of days that individual vessels can spend fishing and the number of sites they can reach, simulating an expansion of fishing technology. On the other hand, towed boats function just as a part of a bigger fishing unit (i.e., mothership) and they may need to adjust their catch considering the rest of vessels in the mothership and the available storage space. Consequently, their catch per day may be more limited than for independent boats. Additionally, controlling explicitly for the towing factor in the frontier model might capture part of what might be considered inefficiency in the absence of that control. These are empirical questions to be answered by the analysis. The rest of the variables have unknown a priori expectations.

Characteristics of the sample differed between towed and independent boats in a given fishing trip (Table 3-5). On average, towed vessels were smaller (i.e., lower *GRT*), spent more days at sea and had higher catches per trip than autonomous boats (25,980 vs. 11,448 kgs. respectively).The majority of towed boats in the sample (68%) operated in the north and west section of Isabela Island and around two other zones father north in the archipelago in comparison to 91% of independent boats which fished closer to the main ports (Santa Cruz, San Cristobal and the southern part of Isabela Island). In order to assess the implications of controlling for the effect of vessel interrelation (i.e., towing effects) on production and technical efficiency, the complete (base) model presented in Equation 3-6 and Equation 3-7 is compared to a restricted version without those controls (i.e., restricted model). The production frontier and the inefficiency effects models are estimated simultaneously using maximum likelihood routines in FRONTIER 4.1 (Coelli 1996).

Results

Frontier Model

The coefficient estimates for the complete (base) and restricted models are reported in Table 3-6. Generalized likelihood ratio tests for the validity of a stochastic frontier specification, inefficiency determinants and interrelation effects for both models are reported in Table 3-7.

Results show that the stochastic frontier framework is more appropriate than the mean production function for the sample data ($\gamma = \delta = 0$ strongly rejected), technical inefficiency is stochastic ($\gamma = 0$ strongly rejected), and that inefficiency effects are a linear function of the proposed social and vessel specific factors ($\delta_1 = \ldots \delta_5 = 0$ strongly rejected). The inclusion of vessel interrelation (DTOW and interaction term) significantly improved the final model specification as supported by the result of the first hypothesis for the complete model. Result interpretations will be based on the complete model and comparisons with the restricted specification will be introduced later to assess any differences.

Input variables were statistically significant, had the expected signs, and since the model was expressed in logarithmic form, the significant input coefficients represent output elasticities. Given the assumption of a Cobb-Douglas technology, trip productivity depended mostly on the number of days spent at sea as a proxy of fishing time (0.97 elasticity), followed by labor (0.50 elasticity) and capital (0.017), although only the variable inputs had significant effects. This finding is not surprising since the fiberglass and wooden vessel segments are relatively homogenous in terms of capital and by nature, the lobster fishery is a diving intensive activity. The fishing technology exhibited increasing returns to scale even if excluding the non-significant elasticity of capital (i.e., an expansion of 1% in all inputs yielded more than 1% output increase). In fisheries, there are a priori reasons to expect variable returns to scale (Pascoe et al. 2003), specially decreasing returns, given the incentives for overcapitalization in open access fisheries. However, this result reflects the artisanal nature of the Galapagos fishing fleet, and it is consistent to the findings of previous studies. For instance, returns to scale for the trammel net inshore fleet in Northeastern Greece and for the gillnet artisanal fleet operating in the Hormozgan Province (Iran) were estimated at 1.26 and 1.42 respectively (Fousekis and Klonaris 2003; Esmaeili 2006). Similarly to our study, higher harvest responses for these artisanal fleets were associated primarily to changes in variable inputs such as the amount of gear used or number of days at sea. Interestingly, in theses cases, capital inputs significantly affected output levels.

Some of the disaggregated zone indicators capturing the spatial distribution of stocks are statistically significant. Vessels fishing around San Cristobal South and East, Isabela West, Marchena and Genovesa Islands had significantly larger catches, while harvests were lower in Santa Cruz grounds. This finding indicates particularly unfavorable stock conditions in Santa Cruz, which is consistent with the historical lower abundance levels reported for that area in comparison to other zones (Hearn et al. 2006). Additionally, trip productivity was significantly lower for vessels operating during the 2004 and 2006 seasons. These temporal effects are most likely attributed to the observed drop in resource stocks after 2004 rather than to any technical change effect in the fleet. As hypothesized, the vessel interrelation variable (*DTOW*) and the corresponding interaction term (*DWBOAT*DTOW*) were highly significant. Results showed that in fact, towed vessels were less productive than autonomous boats despite the expansion of days at sea and fishing zones available. This indicates that the towing system (mothership) limits the harvesting potential of small vessels, but the negative effect was lower for small wooden boats in comparison to fiberglass units as indicated by the positive sign of the interaction term. The finding supports the relevance of accounting for vessel interrelations in the production technology of small scale fisheries.

Technical Efficiency Model

Port of origin, gear type and vessel age were significant determinants of the fleet's technical efficiency (Table 3-6). The positive signs indicate an increase in technical inefficiency or alternatively, a decrease in technical efficiency. Vessels departing from Isabela (*DPORT3*) were more inefficient than vessels from Santa Cruz, the main tourism hub, and there was no evidence of higher efficiency for vessels originating in the main fishing port, San Cristobal (*DPORT1*). Only vessels related to other, occasional, departure ports showed higher technical efficiency (i.e., lower technical inefficiency) relative to the base. A possible explanation may arise from the lack of active cooperative organization in the fishing communities, which limits the development of fishermen attributes that may be applied to increase their fishing efficiency (e.g., training and specialization options). Although these results did not support the hypothesis of better performance for vessels from fishing-based communities relative to the tourism-based port, they suggested that technical efficiency varies across geographically distributed vessel groups.

Hand picking (*DGEAR*) and free diving (*DFDIVE*) increased technical inefficiency (i.e., reduced efficiency) relative to the use of Hawaiian spears or hooks and more advanced methods like hookah diving. Surprisingly, older vessels (*BAGE*) were less inefficient (more efficient) than younger boats[17]. However, a similar effect was also observed by Squires et al. (2003) in artisanal fisheries. They argued that vessel performance may respond to a learning period, and that older vessels are more likely to be mastered to the fullest, increasing their efficiency. Alternatively, older vessels may have taken corrective measures such as updating their propulsion power in order to compensate for the limitations of older capital vintage (e.g., dated construction materials and hull design), actually increasing their efficiency in reaching fishing grounds faster.

As indicated by the γ (Gamma) coefficient, deviations from the output frontier depended mostly on technical inefficiency rather than on random shocks as the variance of u_{jt} (σ^2_u) represented 96.6% of total error variance, $\sigma^2_u + \sigma^2_v$. There is also considerable scope for technical efficiency improvement in the fishery. Fleet performance varied widely, with scores ranging from a lowest of 0.01 to a maximum of 0.92 and a mean technical efficiency of 0.65. The distribution of the scores was slightly skewed to the right (Figure 3-1A), the majority of trips (57%) were between 60%-80% efficient, and only around 15% were more than 80% efficient. These results support the findings of previous studies in small scale fishing fleets; however, the average performance and scores distribution are somewhat lower than those previously reported in the literature. For instance, Fousekis and Klonaris (2003) reported and average technical efficiency of about 72% for the inshore fleet of artisanal trammel netters in Greece with most vessel units performing above 80% efficiency. Similarly, the small scale gillnet fleet of the Hormozgan Province in Iran, which targets demersal and pelagic multispecies like tuna and mackerel, was found to operate at around an average of 78% efficiency (Esmaeili 2006).

Using the estimated coefficients from the restricted model (Table 3-6), technical efficiency scores for the fleet were also estimated for comparison with the complete model. Interestingly,

[17] Non linear effects for boat age (BAGE) were also explored but results did not show any difference from the linear specification.

there is no evidence of overrepresentation of technical efficiency when failing to control for vessel interrelation (*DTOW*) as the extent of technical inefficiency and the distribution of efficiency scores between both models are similar (Figure 3-1A). The result may reflect the particular fleet under study and further exploration of this effect on technical efficiency estimation in other empirical applications is needed to test the validity of this conclusion.

Finally, technical efficiency of towed vessels was lower than for autonomous boats (Figure 3-1B).[18] Fishing trips from towed units tended to concentrate more in the lower efficiency ranges, with only 67% of towed trips operating at more than 80% efficiency in comparison to 72% of independent units performing at the same efficiency level. It is important to note that in order to assess technical efficiency differences between the towing and autonomous technologies, it will be necessary to analyze the performance of the motherships and towed boats in a trip as a whole and comparing it to that of independent trips, which is beyond the scope of this study.

Summary and Conclusions

This paper analyzed the production technology and technical efficiency of the artisanal lobster fishing fleet in the Galapagos Marine Reserve during the period 1997-2006, accounting for vessel interrelations into the production framework.

Given the assumed production technology, harvests were not significantly affected by vessel capital. Instead, they were more sensitive to variable fishing effort. The fleet operated at increasing returns to scale, which corresponds to the findings of previous studies also applied to the small scale fisheries.

[18]Frontier and inefficiency effects models were explored for the towed and autonomous subsamples separately, but the increased lack of balance in the panel for the towed group created model instability and the pooled model was preferred.

The analysis revealed that considering vessel interrelation structures between large motherships and smaller catcher boats in the modeling of the production technology matters, but it did not affect the extent of the technical efficiency found in the fleet. Being towed limited the harvesting frontier of individual catcher vessels, but the extent of the impact varied between wooden and fiberglass boats. In addition, trips where individual vessels are towed also tended to be less technically efficient than when they operate autonomously.

Results indicated a considerable potential for technical efficiency improvement in the fleet. Technical inefficiency accounted for most of the variation in catches and, on average, vessels were only 65% efficient in their input use. These findings contribute to the evidence of moderate-to-high technical efficiency observed in small scale fishing fleets.

Geographical location, diving methods, gear type and vessel age had significant impacts on technical efficiency levels. Policies promoting and enforcing the use of more advanced diving methods and collection gear, as well as targeting the crew of younger vessels with training programs will likely increase the technical efficiency of the boats. Locally-based governance efforts to strengthen fishermen cooperatives might also prove useful to improve the technical efficiency of vessels in San Cristobal and Isabela. Active fishermen organizations are likely to have the incentives to conduct a more organized and monitored fishing activity. They may also facilitate appropriate training of members through partnerships with the management authority or development NGOs working in the area.

Technical efficiency increase in fisheries may be an undesirable objective in the absence of appropriately defined property rights, especially in stock declining fisheries (Jeon et al. 2006). However, policies that promote input savings while maintaining the observed output levels will help increase the profitability of the fleet, improving their economic performance without expanding the fishing pressure on the stocks in the short run.

From a capacity management point of view, the results suggest that capital reduction policies (e.g., vessel decommissioning programs) in the small scale fiberglass and small wooden fleet segments will have little effect on the efficient harvesting potential in the Galapagos spiny lobster fishery. Instead, controls targeting variable fishing effort (e.g., fishing time and labor) will be more useful to affect catch at the trip level[19]. However, the potential for technical efficiency improvements in the fleet are a latent limitation for the success of capacity reduction policies in the absence of strategies that complementarily address the lack of property rights.

Given multicollinearity limitations to estimate a flexible functional form of technology, this paper assumed a Cobb-Douglas production function and focused on the effect of vessel interrelation on fiberglass and small wooden vessels as individual production units. Additional research addressing multi-vessel structures as composite fishing units and the influence of vessel interrelation in technical efficiency measurement in other empirical applications is recommended to complement the present analysis. Finally, the results of this study are conditional on observing towing information. Future work needs to address the issue of sample selection due to missing information for towing status.

[19] Limitations on days at sea will likely be compensated with increases in labor effort, but the output effect of increased labor will be lower than that caused by changes in days at sea as indicated by the estimated output elasticities.

Table 3-1. Average fleet characteristics

	Boat	Fiberglass	Wooden boat
Length (mts)	11.14	6.94	4.81
GRT (tonnes)	20.62	2.85	1.71
Engine power (hp)	109.35	75.68	46.78
Crew capacity (individuals)	6.60	3.00	3.00

Source: Fishing Registry 2008, Galapagos National Park Service.

Table 3-2. Geographical distribution of the fleet

Type	Total	San Cristobal	Santa Cruz	Isabela
Boat	14.35%	16.51%	18.75%	6.61%
Fiberglass	51.57%	36.79%	64.29%	66.12%
Wooden boat	34.08%	46.70%	16.96%	27.27%
Total Fleet	100.00%	47.53%	25.34%	27.13%

Source: Fishing Registry 2008, Galapagos National Park Service.

Table 3-3. Variable definition and descriptive statistics

Variable	Description	Mean	Std. Dev.	Min	Max	Expected effect
WEIGHT	Catch weight in kilograms per trip	13165.83	21664.99	40	343637	
Frontier:						
GRT	Gross registered tonnage in tons	2.195	0.822	1	5.68	(+)
SEADAYS	Number of days at sea per trip	1.740	2.000	1	23	(+)
NDIVERS	Mean number of divers per trip	1.300	0.468	1	4	(+)
DZONE1	1 if fishing zone Isabela Sur, 0 otherwise	0.486	0.499	0	1	(- / +)
DZONE2	1 if fishing zone Santa Cruz, 0 otherwise	0.245	0.429	0	1	(- / +)
DZONE3	1 if fishing zone San Cristobal South and East, 0 otherwise	0.114	0.317	0	1	(- / +)
DZONE4	1 if fishing zone Isabela West, 0 otherwise	0.042	0.199	0	1	(- / +)
DZONE5	1 if fishing zone Isabela North , 0 otherwise	0.029	0.168	0	1	(- / +)
DZONE6	1 if fishing zone San Cristobal North and West, 0 otherwise	0.023	0.148	0	1	(- / +)
DZONE7	1 if fishing zone Santiago, 0 otherwise	0.019	0.136	0	1	(- / +)
DZONE8	1 if fishing zone Floreana, 0 otherwise	0.011	0.103	0	1	(- / +)
DZONE9	1 if fishing zone Pinta, 0 otherwise	0.013	0.112	0	1	(- / +)
DZONE10	1 if fishing zone Marchena, 0 otherwise	0.013	0.111	0	1	(- / +)
DZONE11	1 if fishing zone Espanola, 0 otherwise	0.004	0.059	0	1	(- / +)
DZONE12	1 if fishing zone Wolf, 0 otherwise	0.006	0.075	0	1	(- / +)
DZONE13	1 if fishing zone Santa Fe, 0 otherwise	0.005	0.072	0	1	(- / +)
DZONE14	1 if fishing zone Darwin, 0 otherwise	0.005	0.067	0	1	(- / +)
DZONE15	1 if fishing zone Genovesa, 0 otherwise	0.006	0.076	0	1	(- / +)
DZONE17	1 if fishing zone Rabida, 0 otherwise	0.002	0.043	0	1	(- / +)
DZONE18	1 if fishing zone Pinzon, 0 otherwise	0.002	0.042	0	1	(- / +)
DYEAR2	1 if 1998, 0 otherwise	0.003	0.052	0	1	(- / +)
DYEAR3	1 if 1999, 0 otherwise	0.136	0.343	0	1	(- / +)
DYEAR4	1 if 2000, 0 otherwise	0.175	0.380	0	1	(- / +)
DYEAR5	1 if 2001, 0 otherwise	0.267	0.442	0	1	(- / +)
DYEAR6	1 if 2002, 0 otherwise	0.169	0.375	0	1	(- / +)
DYEAR7	1 if 2003, 0 otherwise	0.139	0.346	0	1	(- / +)
DYEAR8	1 if 2004, 0 otherwise	0.059	0.236	0	1	(- / +)

Table 3-3. Continued

DYEAR9	1 if 2005, 0 otherwise	0.049	0.215	0	1	(-)
DYEAR10	1 if 2006, 0 otherwise	0.003	0.048	0	1	(-)
DWBOAT	1 if wooden boat, 0 otherwise	0.400	0.490	0	1	(- / +)
DTOW	1 if towed, 0 otherwise	0.118	0.323	0	1	(- / +)
Inefficiency						
DPORT1	1 if home port Baquerizo Moreno, 0 otherwise	0.185	0.388	0	1	(-)
DPORT3	1 if home port Puerto Villamil, 0 otherwise	0.519	0.499	0	1	(-)
DPORT4	1 if home port Other, 0 otherwise	0.003	0.053	0	1	(-)
DFDIVE	1 if free diving, 0 otherwise	0.014	0.119	0	1	(-)
DGEAR	1 if hand gear , 0 otherwise	0.167	0.373	0	1	(+)
BAGE	Vessel age in years	4.763	4.465	0	21	(+)

Dummy base categories: 1997, hookah diving, fiberglass, autonomous vessels, mechanized gear (spear and hook), and Puerto Ayora home port (Santa Cuz Island, tourism hub).

Table 3-4. Sample differences based on observation of towing information (DTOW)

	Final sample (N=6381)		Not based on observing DTOW (N=8101)	
Variable	Mean	Std. Dev.	Mean	Std. Dev.
WEIGHT	13165.83	21664.99	12615.39	20290.47
Frontier:				
GRT	2.195	0.822	2.136	0.808
SEADAYS	1.740	2.000	1.677	1.852
NDIVERS	1.300	0.468	1.328	0.476
DZONE1	0.486	0.499	0.454	0.497
DZONE2	0.245	0.429	0.199	0.398
DZONE3	0.114	0.317	0.182	0.385
DZONE4	0.042	0.199	0.036	0.185
DZONE5	0.029	0.168	0.024	0.153
DZONE6	0.023	0.148	0.036	0.186
DZONE7	0.019	0.136	0.017	0.129
DZONE8	0.011	0.103	0.017	0.131
DZONE9	0.013	0.112	0.011	0.105
DZONE10	0.013	0.111	0.012	0.107
DZONE11	0.004	0.059	0.006	0.008
DZONE12	0.006	0.075	0.005	0.067
DZONE13	0.005	0.072	0.005	0.072
DZONE14	0.005	0.067	0.004	0.062
DZONE15	0.006	0.076	0.005	0.070
DZONE17	0.002	0.043	0.002	0.044
DZONE18	0.002	0.042	0.002	0.044
DYEAR2	0.003	0.052	0.068	0.252
DYEAR3	0.136	0.343	0.108	0.310
DYEAR4	0.175	0.380	0.139	0.347
DYEAR5	0.267	0.442	0.212	0.409
DYEAR6	0.169	0.375	0.168	0.374
DYEAR7	0.139	0.346	0.134	0.341
DYEAR8	0.059	0.236	0.059	0.236
DYEAR9	0.049	0.215	0.046	0.210
DYEAR10	0.003	0.048	0.002	0.046
DWBOAT	0.400	0.490	0.441	0.496
DTOW	0.118	0.323	0.118	0.323
Inefficiency				
DPORT1	0.185	0.388	0.278	0.448
DPORT3	0.519	0.499	0.482	0.499
DPORT4	0.003	0.053	0.005	0.067
DFDIVE	0.014	0.119	0.016	0.126
DGEAR	0.167	0.373	0.240	0.427
BAGE	4.763	4.465	5.003	4.439

Table 3-5. Sample statistics by towing status

	DTOW=0 (N=5627)				DTOW=1 (N=754)			
Variable	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
WEIGHT	11448.72	15225.21	200	268409	25980.35	45370.50	40	343636.10
Frontier								
GRT	2.230	0.821	1	5.68	1.940	0.785	1	4.35
SEADAYS	1.549	1.287	1	17	3.167	4.383	1	23
NDIVERS	1.270	0.454	1	4	1.548	0.498	1	2
DZONE1	0.525	0.499	0	1	0.203	0.399	0	1
DZONE2	0.271	0.444	0	1	0.051	0.217	0	1
DZONE3	0.127	0.332	0	1	0.015	0.116	0	1
DZONE4	0.016	0.126	0	1	0.231	0.421	0	1
DZONE5	0.009	0.096	0	1	0.178	0.382	0	1
DZONE6	0.026	0.157	0	1	0.000	0.000	0	0
DZONE7	0.007	0.084	0	1	0.108	0.310	0	1
DZONE8	0.007	0.082	0	1	0.041	0.199	0	1
DZONE9	0.002	0.044	0	1	0.093	0.290	0	1
DZONE10	0.002	0.042	0	1	0.093	0.290	0	1
DZONE11	0.004	0.064	0	1	0.000	0.000	0	
DZONE12	0.000	0.013	0	1	0.046	0.211	0	1
DZONE13	0.004	0.062	0	1	0.015	0.120	0	1
DZONE14	0.000	0.019	0	1	0.036	0.186	0	1
DZONE15	0.003	0.050	0	1	0.031	0.172	0	1
DZONE17	0.000	0.013	0	1	0.015	0.120	0	1
DZONE18	0.001	0.030	0	1	0.008	0.089	0	1
DYEAR2	0.003	0.055	0	1	0.000	0.000	0	0
DYEAR3	0.154	0.361	0	1	0.004	0.063	0	1
DYEAR4	0.176	0.381	0	1	0.167	0.373	0	1
DYEAR5	0.242	0.428	0	1	0.454	0.498	0	1
DYEAR6	0.164	0.370	0	1	0.211	0.408	0	1
DYEAR7	0.150	0.357	0	1	0.058	0.235	0	1
DYEAR8	0.063	0.243	0	1	0.032	0.176	0	1
DYEAR9	0.045	0.208	0	1	0.074	0.262	0	1

Table 3-5. Continued

DYEAR10	0.003	0.052	0	1	0.000	0.000	0	0
DWBOAT	0.383	0.486	0	1	0.529	0.499	0	1
Inefficiency								
DPORT1	0.167	0.373	0	1	0.317	0.466	0	1
DPORT3	0.544	0.498	0	1	0.338	0.473	0	1
DPORT4	0.002	0.044	0	1	0.009	0.096	0	1
DFDIVE	0.016	0.126	0	1	0.000	0.000	0	0
DGEAR	0.156	0.363	0		0.267	0.442	0	1
BAGE	4.797	4.436	0	21	4.513	4.664	0	20

Table 3-6. Parameter estimates

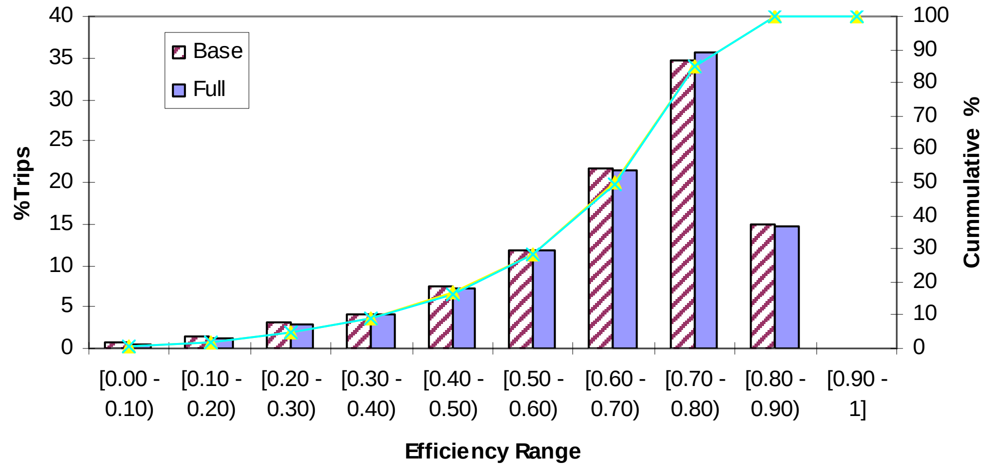
Variable	Restricted model Estimate	t-value	Complete model Estimate	t-value
Stochastic Frontier Model				
Constant	9.336	29.621***	9.373	29.906***
GRT	0.014	0.531	0.016	0.581
SEADAYS	0.970	57.577***	0.972	57.239***
NDIVERS	0.497	17.484***	0.499	17.457***
DZONE1	-0.035	-0.646	-0.066	-1.223
DZONE2	-0.184	-3.367***	-0.224	-3.868***
DZONE3	0.229	3.830***	0.194	3.179***
DZONE4	0.128	2.097**	0.162	2.625**
DZONE5	-0.051	-0.824	-0.019	-0.294
DZONE6	0.139	1.776*	0.103	1.294
DZONE7	-0.083	-1.138	-0.065	-0.872
DZONE8	0.161	1.700*	0.141	1.469
DZONE9	-0.079	-0.920	-0.041	-0.459
DZONE10	0.250	2.850***	0.277	3.054***
DZONE11	0.150	1.051	0.112	0.783
DZONE12	0.045	0.325	0.127	0.919
DZONE13	-0.071	-0.539	-0.101	-0.752
DZONE14	0.100	0.634	0.143	0.925
DZONE15	0.355	3.071***	0.353	3.023***
DZONE17	0.001	0.000	0.038	0.193
DZONE18	-0.051	-0.238	-0.073	-0.348
DYEAR2	-0.025	-0.073	-0.021	-0.061
DYEAR3	-0.069	-0.224	-0.075	-0.244
DYEAR4	-0.061	-0.198	-0.065	-0.209
DYEAR5	-0.240	-0.776	-0.236	-0.766
DYEAR6	-0.336	-1.086	-0.329	-1.064
DYEAR7	-0.297	-0.959	-0.301	-0.975
DYEAR8	-0.629	-2.024**	-0.633	-2.039**
DYEAR9	-0.427	-1.375	-0.424	-1.368
DYEAR10	-0.921	-2.612***	-0.921	-2.602***
DTOW			-0.181	-3.911***
DWBOAT	-0.018	-0.833	-0.028	-1.195
*DTOW*DWBOAT*			0.135	2.459**
Inefficiency Model				
Constant	-16.510	-2.829***	-14.437	-3.316***
DPORT1	-0.282	-2.058**	-0.143	-1.022
DPORT3	0.766	3.391***	0.853	3.628***
DPORT4	-6.786	-2.421**	-7.266	-4.240***
DFDIVE	5.288	3.918***	4.818	4.119***
DGEAR	3.502	3.072***	3.113	3.403***
BAGE	-0.079	-6.647***	-0.069	-8.132***
Sigma-squared	9.146	3.135***	7.959	3.738***
Gamma	0.970	97.967***	0.966	102.283***
Log likelihood	-6869.523		-6862.642	
N	6381		6381	

*Significant at the 0.10 level; **Significant at the 0.05 level; ***Significant at the 0.01 level.

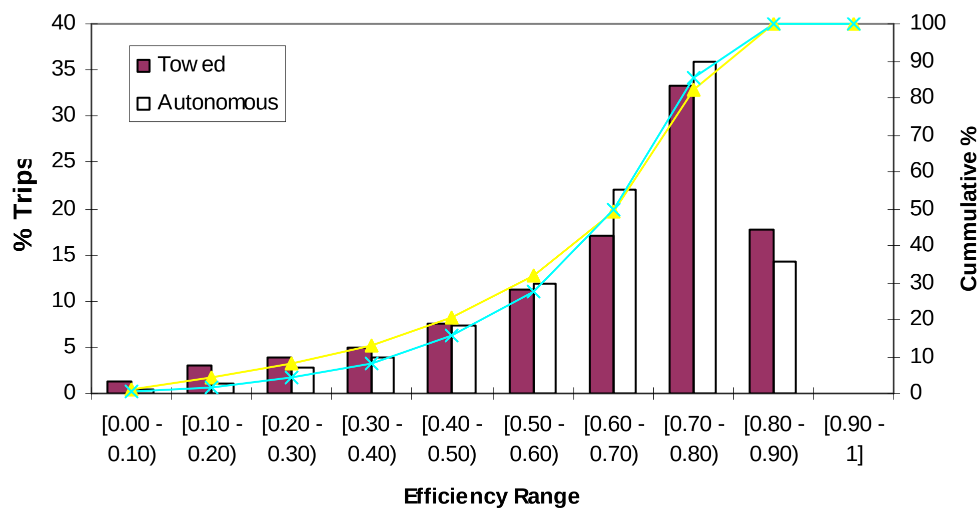
Table 3-7. Hypotheses testing for parameters of the frontier and inefficiency models

Null Hypothesis	Log-likelihood value	Likelihood ratio statistic	Critical[a] value	No. restrictions
Restricted model				
1. No TE ($\gamma = \delta = 0$)	-7089.982	440.92	19.05	11
2. Deterministic TE ($\gamma = 0$)	-7065.588	392.13	5.14	2
3. Z factors do not affect TE ($\delta 1 = \ldots = \delta 9 = 0$)	-6890.976	42.91	16.92	9
Complete model				
1. No tow effects ($\beta_{DTOW} = \beta_{DTOW*DWBOAT} = 0$)	-6869.523	14.68	5.99	2
2. No TE ($\gamma = \delta = 0$)	-7075.244	425.20	19.05	11
3. Deterministic TE ($\gamma = 0$)	-7049.550	373.82	5.14	2
4. Z factors do not affect TE ($\delta 1 = \ldots = \delta 9 = 0$)	-6884.505	43.73	16.92	9

[a] Critical values for hypotheses about γ correspond to a mixed chi-squared distribution and were obtained from Table 1 in Kodde and Palm(1986).



A



B

Figure 3-1. Distribution of efficiency scores. (A) Comparison between restricted and complete models. (B) Comparison between towed and autonomous boats.

CHAPTER 4
TOURISTS PREFERENCES FOR FISHERMEN-OPERATED EXCURSIONS

Introduction

In the wake of collapsing fisheries worldwide, fisheries managers have begun to consider new and creative ways to reduce fishing effort while at the same time continuing to support fishing communities. Recent strategies include vessel decommissioning programs or a change in management system such as toward rights-based program. These programs can be effective, but are costly to the public and time consuming and may not be possible in isolated areas. For example, artisanal fishing communities do not have alternative sources of employment or the infrastructure to disable fishing vessels.

One creative alternative to reduce commercial fishing effort but take advantage of the available capital (vessels and fishing expertise) is to transition fishermen into marine-based recreation (Kusakawa 1992; DiarioC 2003; Estrategia and Negocios 2009). In order for this type of strategy to work, managers need to consider the potential demand for marine or boat-based recreational activities offered by these new operators prior to promoting and implementing a strategy that is new, different, and, therefore, risky.

In order to assess the potential for new products, researchers have relied on stated preference analysis. With respect to new marine-based tours, and fishing-related tours in particular, the existing literature has focused on such factors as changes in catch rates and fishing conditions to understand consumer behavior (Alberini et al. 2007; Rolfe and Prayaga 2007; Paulrud 2006; Prayaga et al. 2010; Stoll and Ditton 2006). Much of this literature has relied on the contingent valuation approach to estimate the non-market value of regulatory changes that affect recreational fishing.

To our knowledge, the only study specifically addressing the market potential of new boat-based tours in the context of the transition of commercial fishers to tourism was presented by Alban and Boncoeur (2004). They analyzed the general interest and potential demand for guided fishing and non-fishing tours offered by commercial fishermen in the Iroise Sea, France. Using personal interviews, they explored the role of demographics and tour-related attitudes on preferences for the new trips. Their results suggested considerable general interest on tours offered in commercial fishing boats, especially for non-fishing activities in comparison to fishing-only tours. Preferences significantly differed between gender, age and social origin. Females, participants between 20 to 55 years old and seniors or white collar workers were more likely to prefer these tours. In summary, the transition of fishermen to the tourism industry was expected to be a promising alterative due to the potential demand for the new tours.

The Galapagos Marine Reserve (GMR) provides a recent example of a similar initiative to transfer existing fishing effort to local tourism in an attempt to rebuild declining fish stocks and ensure sustainability of the local community. After appropriate training and vessel renovations, selected fishermen will be allowed to provide the same type of tours provided by traditional operators (standard tours like bay and diving trips, interisland and diving cruises), as well as new artisanal fishing trips where consumers will be exposed to the local fishing culture and practices. This latter option will offer fishermen the opportunity to continue applying their fishing and boating skills and generate revenue for the local economy[1]. To assess the potential success of the program, information about the market potential for fishermen as tour operators and for the proposed new services is of critical importance.

[1] While all tours generate revenue, those booked through large foreign tour-operators can often result in leakage of funds outside of the local community (either to mainland Ecuador or to foreign companies).

The objective of this chapter is to assess the interest in and potential demand for standard tours and new artisanal fishing trips provided by fishermen in the GMR. The analysis uses stated preference methods and probability models as the tour services are new options in the market. Identifying the level of interest in the new operations provides a first indicator of market potential. The level of interest is expected to depend primarily on consumers' attitudes regarding the characteristics of the tour providers, the quality of services, and the appeal of new tour experiences (e.g., fishing in small boats) compared to current operations. This information will help identify the type of consumers to target and the most relevant factors to increase the demand for the new fishermen-based operations. This is especially important since fishermen have to compete with well-established traditional operators. In addition, the potential demand can be assessed for specific tours by examining what characteristics would increase the likelihood of tourists including them in their itineraries (Roehl et al. 1993).

To examine the potential for new marine-based recreational boating tours offered by the new tour operators (i.e., ex-commercial fishermen), I conducted a survey of past visitors. The selection of past visitors as the sample frame was considered necessary due to the uniqueness of the destination and, thus, the relatively small target population. In addition to standard socio-demographic information, past visitors were asked about their trip, the benefits and concerns of new tours, their general level of support for the program and level of interest for two different types of tours, and the characteristics of each type of trip they would most prefer. The following section describes the methodology that was used to quantitatively analyze interest and willingness to book two specific types of new tours. Then, we describe the data and empirical specifications of the models. Following a discussion of the results, we conclude with a brief summary of the potential success of this program based on the reported consumer preferences.

Methodology

This study uses stated preference methods and a probability modelling framework to analyze past visitors interest ratings and willingness to book fishermen-operated tours (both in general and for a specific type of fishing tour). In summary, a higher level of interest in or willingness to book a tour is assumed to generate a higher level of utility to the respondent.

Following Liao (1994), the latent indirect utility function for individual *n* generated by fishermen-based tours can be modeled linearly as:

$$V_n{}^* = \sum_{i=1}^{I} \beta^i x_n{}^i + \varepsilon_n \quad (4\text{-}1)$$

where *i* identifies the type of characteristics that are assumed to influence visitors' interest and willingness to include tours in their itineraries (i.e., x^i variable vectors) and estimated parameters. The types of variables assumed to affect either their interest or willingness to have booked one of these new tours on their last trip include traditional demographic characteristics, information about their last trip (duration and purpose, for example), the benefits and concerns of booking with new operators, and for a specific tour, the characteristics of the trip that would be most appealing to them.

Since utility is unobservable, and what is observed is the individuals' stated interest for or likeliness to book a tour, we can use the observed information to define a new variable, Y_n, to specify the preferences. For a multinomial ordered response model:

$Y_n = 1$ If $V_n{}^* \leq \mu_1$ ($\mu_1 = 0$)

$Y_n = 2$ If $\mu_1 < V_n{}^* \leq \mu_2$

$Y_n = 3$ If $\mu_2 < V_n{}^* < \mu_3$

$Y_n = J$ If $\mu_{J-1} < V_n{}^*$

where the μ_J are unknown cutoff or threshold parameters differentiating each response category and μ_1 is normalized to zero so that only J-2 threshold values are to be estimated. With this specification, the probability of observing the different outcomes (such as successively higher interest ratings) is given by (Borooah 2002):

$$\Pr(Y_n = 1) = \Pr\left(\sum_{i=1}^{I} \beta^i x_n{}^i + \varepsilon_n < 0\right) = \Pr\left(\varepsilon_n < -\sum_{i=1}^{I} \beta^i x_n{}^i\right) = F\left(-\sum_{i=1}^{I} \beta^i x_n{}^i\right)$$

$$\Pr(Y_n = 2) = \Pr\left(0 < \sum_{i=1}^{I} \beta^i x_n{}^i + \varepsilon_n < \mu_2\right) = \Pr\left(-\sum_{i=1}^{I} \beta^i x_n{}^i < \varepsilon_n < \mu_2 - \sum_{i=1}^{I} \beta^i x_n{}^i\right) =$$

$$= F\left(\mu_2 - \sum_{i=1}^{I} \beta^i x_n{}^i\right) - F\left(-\sum_{i=1}^{I} \beta^i x_n{}^i\right) \qquad \text{4-2}$$

$$\Pr(Y_n = 3) = \Pr\left(\mu_2 < \sum_{i=1}^{I} \beta^i x_n{}^i + \varepsilon_n < \mu_3\right) = \Pr\left(\mu_2 - \sum_{i=1}^{I} \beta^i x_n{}^i < \varepsilon_n < \mu_3 - \sum_{i=1}^{I} \beta^i x_n{}^i\right) =$$

$$= F\left(\mu_3 - \sum_{i=1}^{I} \beta^i x_n{}^i\right) - F\left(\mu_2 - \sum_{i=1}^{I} \beta^i x_n{}^i\right)$$

$$\Pr(Y_n = J) = 1 - F\left(\mu_{J-2} - \sum_{i=1}^{I} \beta^i x_n{}^i\right)$$

where F represents the cumulative density function of the error term ε_n. The errors are assumed to follow a standard logistic distribution since the outcomes from other distributional assumptions are similar and the results are easier to interpret (Liao, 1994). Response probabilities for each individual n can then be calculated with a logit model as follows:

$$\Pr(Y_n \le J) = \frac{e^{\mu_j - \sum_{i=1}^{I} \beta^i x_n{}^i}}{1 + e^{\mu_J - \sum_{i=1}^{I} \beta^i x_n{}^i}} \quad . \qquad \text{4-3}$$

To facilitate interpretation of the estimated parameters, it is common to try to isolate the effects of each variable by looking at the change in probability at the variable means. The effect of a continuous covariate on the response variable is given by the partial derivative of a particular probability with respect to the explanatory variable of interest. In general notation, it can be defined as follows where f represents the probability density function of the logistic distribution:

$$\frac{\partial \Pr(Y_n = j)}{\partial x_i} = \left\{ f\left[\mu_{j-1} - \sum_{i=1}^{I} \beta^i x_n{}^i \right] - f\left[\mu_j - \sum_{i=1}^{I} \beta^i x_n{}^i \right] \right\} \beta^i \tag{4-4}$$

Partial derivatives are not; however, appropriate to capture the effect of discrete covariates. In this case, the appropriate marginal effect is better estimated by taking the difference between estimated probabilities when the discrete explanatory variable $\tilde{x}^i$ takes the value of 0 and 1 holding all other variables constant, usually at their means, using equation 4-3 such that:

$$\frac{\Delta \Pr(Y_n = j)}{\Delta \tilde{x}^i} = \Pr(Y_n = j \mid \tilde{x}^i = 1) - \Pr(Y_n = j \mid \tilde{x}^i = 0)\,. \tag{4-5}$$

Binomial processes follow the same logic of the general ordered framework described above, without the need of specifying separating thresholds as there is just one response category. In this case, the binary outcome Y^*_n (such as whether or not the respondent would have been willing to book a tour) is generated by the following relation:

$Y^*_n = 1$ if $V_n^* > 0$

$Y^*_n = 0$ otherwise

The probability of observing $Y^*_n = 1$ is now given by:

$$\Pr(Y^*_n = 1) = \Pr\left(\sum_{i=1}^{I} \beta^i x_n{}^i + \varepsilon_n > 0 \right) = \Pr\left(\varepsilon_n > -\sum_{i=1}^{I} \beta^i x_n{}^i \right) = 1 - F\left(-\sum_{i=1}^{I} \beta^i x_n{}^i \right) \tag{4-6}$$

Again, assuming a logistic distribution for the error term ε_n, this probability may be estimated using the following equation:

$$\Pr(Y*_n = 1) = \frac{e^{\sum_{i=1}^{I} \beta^i x_n^i}}{1 + e^{\sum_{i=1}^{I} \beta^i x_n^i}} \quad \text{4-7}$$

Lastly, following Long (1997), the marginal and discrete effects on the probability of binary response variables are computed as:

$$\frac{\partial \Pr(Y*_n = 1)}{\partial x^i} = \Pr(Y_n = 1 \mid x^i)[1 - \Pr(Y_n = 1 \mid x^i)\beta^i \quad \text{4-8}$$

$$\frac{\Delta \Pr(Y*_n = 1)}{\Delta \tilde{x}^i} = \Pr(Y_n = 1 \mid \tilde{x}^i) - \Pr(Y_n = 0 \mid \tilde{x}^i) \quad \text{4-9}$$

Under this framework the interest ratings and the subsequent willingness to book are modeled independently. This is because respondents were directed to identify the characteristics of their ideal tour and their willingness to book that tour only if they had an interest in the general concept. Thus, the decision to answer the willingness to book questions were made independently by each respondent and not determined by a pre-specified response to the interest question. As a result, a range of interest ratings could respond to those answering the willingness to book questions but those answering the latter were self-selected based on their own level of perceived interest.

Data

The data used for this study was collected from a sample of past visitors to the Galapagos Marine Reserve (GMR). Tourist information was obtained from the tourist arrival/departure record forms collected in 2007 by the tourism monitoring department at the Galapagos National Park Service. Of the total of 97,390 international visitors recorded in 2006, 46% were from the United States. Given their documented importance among the group of international tourists (Kerr 2005) and, in order to reduce survey costs, the focus of the study was limited to U.S. visitors. A random sample of 2,500 households was selected and sent a letter to respond to an

Internet survey in August 2009. A total of 229 letters were returned as undeliverable. By September 15, 2009, 282 completed responses (12.4% response rate) had been submitted and were used for the analysis.

The survey instrument had five components. The first section obtained information on the visitors' last trip. The second section discussed the entry fee (every foreign visitor pays a $100 entry fee of which $5 goes to the GMR) and their willingness to pay an additional $5 fee directly to the GMR (which nearly everyone agreed). The third section described the state of the fishery and the plan to move vessels from fishing to tourism. Participants were asked to individually rate several distinct benefits and concerns associated with the proposal. In the fourth section, respondents were asked to state their level of interest in booking two different types of tours: standard excursions and artisanal fishing trips on a five-point qualitative scale ranging from "not at all" interested to "very" interested. At this point, respondents were directed to specify their preferred trip characteristics (using a closed-ended framework) if they had any interest at all in a tour offered by ex-artisanal fishermen. The trip characteristics included trip length, boat size, and activity options. Then, respondents were asked to consider their itinerary on their last trip and, if their ideal tour would have been offered, would they have added the tour to their itinerary, replaced another tour with this one, or would not have taken the tour. The final questions in this section asked respondents to provide their maximum willingness to pay for the ideal tour they specified as an open-ended question; however, a low response to this question and the high variability of responses precluded further analysis.[2] In the last section respondents were asked a series of demographic questions.

[2] Respondents were not required to answer any question. The high variability of responses was expected following traditional findings of open-ended contingent valuation models, although surveying past visitors was expected to partially solve the anchoring problem. Voluntary comments at the end of the survey indicated that the majority of

The dependent and explanatory variables are defined in Table 4-1 and the corresponding summary statistics for each model are presented in Table 4-2. Four dependent variables are defined for analysis: interest level in tours offered by ex-fishermen – both traditional tours that are currently being offered and tours that would provide an artisanal fishing experience – and whether they would have been willing to book one of these tours by ex-fishermen. Interest variables were defined as categorical ratings on a scale of 1 (not interested at all) to 5 (very interested). Potential demand is based on their stated willingness to have booked (added or replaced) one of the tours during their last visit had they been available. Assessing to what extent these new tours would negatively affect the demand for existing tours is important to evaluate the overall effectiveness of the program to the economy as a whole. Unfortunately, insufficient responses for the "replace" alternatives precluded the estimation of a multinomial logit specification that would have formally analyzed the options independently[3]. Thus, these discrete dependent variables reflect the willingness to book one of the tours regardless of whether the tour would be added to an itinerary or replace an identical tour operated by a traditional tour agency.

Figure 4-1 shows the distribution of responses for the interest response variables. Interest for standard tours (*INT1*) is normally distributed with the majority of respondents being somewhat interested. Of the subset of those reporting some level of interest (i.e., 69% of sample), 59% of those would have been willing to book the standard tour they constructed (*D1*). On the other hand, the distribution of responses for interest on artisanal fishing (*INT2*) was skewed to the left, with most of the respondents being not interested at all in this tour option. Of

respondents had pre-purchased a set number of tours such that they could not recall pricing of individual components.

[3] Of course this is only unfortunate for our analysis, but the fact that the majority of respondents stated they would add a tour instead of replace one is an encouraging result for the managers.

those that did have some level of interest in an artisanal fishing tour (48%), 64% would have been willing to include the fishing excursion of their design in their itineraries (*D2*). A detailed comparison of willingness to book responses with respect to the level of interest for each type of tour is shown in Table 4-3. Due to the self selection characteristic of the willingness to book questions, the above mentioned percentages apply to the group of visitors who were particularly interested in these tours and not to the overall sample of visitors. This is especially true of the artisanal fishing tours which are hypothesized to apply to only a subset of visitors. However, the characteristics of this sample were not dramatically different from those of a sample including the self excluded respondents (Table 4-4).

The explanatory variables (X^i) were classified into four groups. The first group (X^1) represented relevant characteristics of the respondents' last trip to the site, which were hypothesized to influence demand intentions. These were very similar between samples, and indicated that most visitors went to the islands for vacation as opposed to study or business, most arranged their trips exclusively with travel agencies and stayed for six days on average.

The second group of explanatory variables (X^2) included the potential benefits and shortcomings associated with fishermen-operated tours. Most respondents, ranging from 78% to 88% across models, considered fish conservation as a highly important benefit of the switching program; while only 37% to 40% considered the attraction of small boat amenities highly compelling. The most important concern among visitors was the lack of experience of fishermen as tour operators, which accounted for around half the visitors across samples, and the least important concern was the lack of language skills as only 33% to 36% considered this a highly important limitation associated to the new tours.

The third group of covariates (X^3) included the trip characteristics for standard tours and artisanal fishing trips operated by fishermen that will affect whether they would be willing to book a tour. Most respondents preferred standard tour trips in at least medium size boats and boating activities instead of snorkeling and diving specially (only 15% chose this last option), but they showed similar preferences for different trip lengths. When deciding for an artisanal fishing tour, half day trips were preferred to full day excursions (accounted for only 28%), catching finfish using hook and lines or nets was preferred to a diving-based lobster fishing trip (36%), and more than half respondents were compelled by the option of eating their catch at the end of the trip.

Finally, the fourth group of explanatory variables (X^4)included the demographic characteristics of the respondent that are assumed to affect both whether they were interested in or were willing to book either the traditional or new fishing tours offered by the ex-fishermen Across models, respondents were relatively similar by gender, geographic origin and membership to environmental and development organizations. The average respondent was between 48 to 53 years old and had a relatively high household income level[4] (USD$100,000-USD$150,000).Most participants were white and highly educated, as 91%of them had at least a college degree and 54% had a graduate education.

Results and Discussion

All models were estimated in Limdep 4.0 using maximum likelihood estimation (MLE) techniques. Interest models were estimated using ordered logit specifications and potential

[4] Income categories were specified as continuous instead of dummy variables as preliminary model runs suggested a positive and increasing correlation between interests and income across binary indicators. This also retained degrees of freedom, which is important with limited sample sizes. *LOGINC* was considered as an explanatory variable in order to explore non-linear effects of income. Preliminary model runs, likelihood ratio tests and information criteria for model selection did not support the inclusion of the linear income term for any of the artisanal fishing models, and only the logged term was retained for explaining interest and demand of fishing excursions.

demand models, as indicated by the willingness to book any type of tour, assumed binary logit specifications. Coefficient estimates and marginal effects are discussed below for each type of tour and policy implications are discussed at the end of the section.

Interest Models

Parameter estimates for the ordered multinomial logit models of the level of interest expressed for the standard and artisanal fishing tours are shown in Table 4-5. All models were superior to constant only specifications ($p < 0.001$) and statistically significant coefficients are indicated at the 10% level or lower.

All threshold parameters (μ_1, μ_2 and μ_3) were statistically significant confirming that the response categories of both models are indeed ordered. Ten out of the nineteen explanatory variables were significant determinants of interest for standard tours, while only five out of eighteen covariates significantly explained the interest for artisanal fishing excursions. For standard tours, of the four benefits considered in the model, fish stock conservation (*FISHCONS*), exposure to the local culture (*CULTURE*) and small boat experiences (*SBOAT*) explained interest level, while only one of the four concerns considered, namely the lack of affiliation with a known company (*AFFIL*), was statistically significant. Gender, age, higher education and income were also relevant factors explaining interest for this type of tour.

Expected benefits were less relevant in explaining the interest for artisanal fishing tours in comparison to standard trips, and concerns were not significant at all. Only direct support to the local community (*LSUPPORT*) influenced visitors' interest for a fishing excursion. Gender, age, and geographical location also influenced interest for this type of tour, but in contrast to standard trips, education and income were not found to explain differences in the general interest for fishing trips.

As the sign and magnitude of the estimated coefficients for ordered response models are not directly interpretable, the direction and extent of the impact for each variable is better illustrated by their marginal effects. These effects were computed at the means of the covariates and the 'marginal' effects of binary variables were calculated as the difference between the predicted probabilities when the variable take the values of zero (i.e., reflects the base category) and one (i.e., reflects the included category). Table 4-6 and Table 4-7 report the marginal effects on the probability of interest for the variables that were found significant in the standard tour and artisanal fishing models.

For standard tours, the variation in responses for the 'somewhat interested' middle category could not be significantly explained by the variables in the model (Table 4-6). Thus, the trade-offs in probability changes are observed between the two lowest and highest interest levels only. Individuals very compelled by fish conservation increased their probability of being highly interested by 21 percentage points. High interest for exposure to the local culture and in supporting operators of the smallest boats raised the probability of being highly interested (providing a 4 or 5 interest rating) by 6 and 25 percentage points, respectively. Interest in smaller boats had the highest positive impact on the interest for traditional tours. The lack of affiliation with a known company reduced the probability of being highly interested by 10 percentage points.

Gender and age had opposite effects on the interest probability for standard tours. Men were about 10 percentage points more likely than women to be highly interested in this type of tour, while a 10 year increase in average age reduced the probability of being very interested by 4 percentage points. Higher levels of education and income[5] also reduced the interest in standard

[5] This observation refers to the full effect of income shown in Table 4-6.

excursions. College graduates were 19 percentage points less likely to be in the highest response categories and as average income increases one category, the probability of being highly interested decreases by 23 percentage points.

In comparison to standard tours, significant trade-offs in the interest probabilities for artisanal fishing were observed between the lowest (INT_I=1) and the three top response categories (INT_I=3,4,5) with the marginal effects evenly distributed among each of the upper categories (Table 4-7). Being highly compelled by the opportunity to contribute directly to the local community reduced the probability of being not interested at all in fishing tours by 16 percentage points but increased the probability of being at least somewhat interested by 17 percentage points. Men and individuals from the southern and north central regions of the U.S. were more likely to be at least somewhat interested in fishing tours by 14 and 22 percentage points, respectively, as compared to women and residents of the Pacific coast. Age was the only demographic variable indicating a decrease in interest for artisanal fishing. A ten-year increase of average age reduced the probability of being at least somewhat interested by 0.7 percentage points. Conversely, the probability of being not interested at all increased by around 0.6 percentage points.

Willingness to Book Models

The binary logit estimates for the willingness to book fishermen-based standard tours and artisanal fishing trips are presented in Table 4-8. The models were significantly better than constant-only specifications ($p<0.05$) and correctly predicted 80% and 77 % of the responses, respectively. Seven of the twenty nine explanatory variables for the standard tour model significantly explained the willingness to book such a tour, while five out the twenty five covariates explained the likelihood to book an artisanal fishing excursion.

From the characteristics of their last trip, only independent travel arrangements had a significant effect on the intention to book standard tours. Of all benefits, concerns and specific trip characteristics considered, only a high interest for exposure to the local culture, high concern for the lack of affiliation with known tour operators, and preferences for multi-day operations played a role in explaining the decision to book a traditional tour. Geographical location and income were the two demographic factors influencing the booking intentions for this type of trips. The sign of the estimates in a binary logit model indicates the direction of the effects, suggesting that only individuals highly compelled by the local culture and residing in the northeastern region were more likely to book standard trips.

Contrary to standard tours, booking preferences for artisanal fishing were not significantly explained by any benefits or concerns. A combination of independent and agency–based travel arrangements and the length and dining characteristics of the trip significantly affected the demand intentions for this tour. Individuals looking for full-day trips and those interested in dining their catch at the end of the day were more likely to book a fishing excursion. Interestingly, the type of target species was not a significant factor. Gender, graduate education and income significantly influenced individuals' booking intentions for an artisanal fishing tour and, of the three, only men were more likely to book this option.

As in the interest models, the extent of the effects of the significant explanatory variables on the probability of booking standard and artisanal fishing excursions is better illustrated by marginal effects. Marginal effects of significant variables for both models are presented in Table 4-9, and were calculated similarly to the effects shown in the previous section.

Regarding the demand for standard tour operations, visitors who arranged their last trip on their own were 30 percentage points less likely to book standard tours than those who had a travel agency arrange their trip. This is not surprising as visitors arranging their excursions are able to better discriminate among trips than those who had to choose from a pre-established set of options offered by travel agencies. The negative effect of the lack of known affiliation concern was higher than the positive effect of the culture-associated benefit on the probability of booking a standard tour (i.e., an increase of 26 percentage points versus a reduction of 34 percentage points). Visitors who preferred multiday excursions were 52 percentage points less likely to include a traditional tour in their itineraries. This implies that those interested in half day trips were more likely to try this tour. Residents of the northeast increased their likelihood to demand this tour by 23 percentage points in comparison to residents of the pacific coast, while having higher income dramatically reduced the booking probability of standard tours provided by fishermen by 83 percentage points[6].

For artisanal fishing trips, having a wider scope of tour planning resources (i.e., own planning and agency assistance) reduced the booking probability by 37 percentage points in comparison to those who arranged their trip exclusively with travel agencies. This outcome suggests that tourists were more likely to choose this type of tour if offered as part of their pre-arranged package rather than to search specifically for it, especially when having more resources to design their itineraries. From the trip characteristics, the opportunity to eat the day's catch had the highest positive impact. Individuals preferring full day trips and the dining option were 31 and 35 percentage points more likely to book a fishing trip, respectively. The reduction in booking intentions was higher for individuals with graduate education than for those with higher income (43 versus 27 percentage points), while being male raised the probability of including a fishing excursion in their itineraries by 40 percentage points in comparison to women.

[6] This observation refers to the full effect of income shown in Table 4-9.

These results have important planning implications. The analysis indicates that of the total number of respondents, 40% and 31% would be willing to add or replace a traditional trip with a new standard and artisanal fishing tour respectively. Considering the share of U.S. visitors to the Galapagos in 2007 (i.e.44,312 tourists) and the limited number of fishing boats that could be included in the tourism sector, an approximate extrapolation of the number of fishermen–operated trips that are likely to be booked suggests a promising demand (17,325 and 13,427 tours approximately). Campaigns to inform tourists about the expected conservation benefits, small scale recreational attractions such as unique small-boat amenities and access to the local culture, as well as the legitimacy and professionalism of fishermen-based tour companies will be useful to increase U.S. tourists' interest and potential demand for fishermen operated excursions, especially for standard tours. At the same time, financing and training efforts to ensure the optimal condition of small vessel infrastructure, service quality and learning of tour-specific skills will be needed to complement advertising campaigns. Marketing efforts must also address the significant differences in preferences for the new fishermen-based tours across gender, education and income, focusing on raising the interest of women, highly educated and wealthier individuals.

Also, fishermen interested in providing standard tours will have higher demand potential by focusing on half-day operations rather than on multiday trips. To entice the demand for artisanal fishing tours, operators should offer a full day of activities and the unique experience of dining the catch at the end of the day. A full day of activities may entail visitations to several fishing sites or different fishing targets during the day. Authorities need to consider the viability of these aspects into the normative for new tours. Additionally, building relationships with traditional tour operators and travel agencies to negotiate the inclusion of the new standard and artisanal tours as part of pre-arranged packages may prove very useful for the new providers to introduce their tours in the market with a level of legitimacy.

Conclusions

As a strategy to reduce fishing effort in the Galapagos Marine Reserve, managers have offered small scale fishermen the opportunity to become marine tour operators in permanent exchange of their fishing permits. They will be allowed to offer standard excursions such as those currently offered by traditional operators (single-day bay and diving tours and multiday interisland and diving cruises) as well as new artisanal fishing tours where visitors will be exposed to traditional fishing culture and practices.

Using a stated preference approach, this study investigated tourists' support for the new program of fishermen-based tour operations and identified relevant factors that explain general interest and booking intentions (i.e., demand) for two types of tour excursions: standard torus and artisanal fishing trips. Similarly to the findings of Alban and Boncoeur (2004), the potential demand for fishermen-based excursions is promising, especially for standard tours. Conservation benefits, small scale tour attractions and affiliation concerns associated to the inclusion of fishermen into tourism, trip length, dining attractions, type of trip arrangement, as well as individual characteristics such as gender, education and income were the most important factors explaining tourists preferences.

The scope of these findings is limited to the U.S market in general and past visitors in particular. Visitors from other countries are likely to have different preferences although it's reasonable to expect that there would be some positive level of demand such that the projections in this paper are conservative. Also, this study used simple main effects to explore the role of individual characteristics on tour interest and demand and additional research is needed to identify relevant market niches in order to better target marketing efforts. The next step of this analysis is to identify clusters of visitors and incorporate that information into the modeling of interests and booking intentions. Additionally, given the self-selection characteristic of the willingness to book questions, the modeling could be extended to consider sample selection issues to identify possible biases in the results. Despite the mentioned imitations, this study provides valuable insights for small-scale fisheries managers about the potential market support for diversification of fishermen into tourism and about relevant determinants of potential demand for the new fishermen-based tour operations that may help planning similar fishing diversification programs in other artisanal fishing communities.

Table 4-1. Variable description

Variable	Description
Response variables:	
INT1	Interest rating for standard tours (1= not to 5=very)
INT2	Interest rating for artisanal fishing tours (1= not to 5= very)
D1	1 if willing to book standard tours, 0 otherwise
D2	1 if willing to book artisanal fishing, 0 otherwise
Last visit (X^1):	
VACATION	1 if purpose of visit was vacation, 0 otherwise
ARRANGEI	1 if trip arranged independently only, 0 otherwise
ARRANGEIA	1 if trip arranged independently and with agency, 0 otherwise
LENGTH	Length of trip (days)
Benefits and Concerns (X^2):	
FISHCONS	1 if highly compelled by fish conservation, 0 otherwise
LSUPPORT	1 if highly compelled by local support, 0 otherwise
CULTURE	1 if highly compelled by local culture, 0 otherwise
SBOAT	1 if highly compelled by small boats, 0 otherwise
EXP	1 if highly concerned with limited experience, 0 otherwise
LANG	1 if highly concerned with language skills, 0 otherwise
AFFIL	1 if highly concerned by lack of known affiliation, 0 otherwise
VSIZE	1 if highly concerned with small vessel amenities, 0 otherwise
Trip characteristics (X^3):	
BMED	1 if medium boat size, 0 otherwise
BLARGE	1 if large boat size, 0 otherwise
FULLD	1 if full day trip, 0 otherwise
MULTD	1 if multiday trip, 0 otherwise
SNKL	1 if snorkel, 0 otherwise
BTOUR	1 if boat tour, 0 otherwise
LOBSTER	1 if lobster target, 0 otherwise
DINING	1 if dining option, 0 otherwise
Demographics (X^4):	
MEMBER	1 if environmental or development organization, 0 otherwise
MALE	1 if men, 0 otherwise
AGE	Visitor's age (years)
SOUTH	1 if resides in Southwest or Southeast, 0 otherwise
NCENTRAL	1 if resides in Great Lakes and Mountain Prairie, 0 otherwise
NEAST	1 if resides in Northeast, 0 otherwise
COLLEGE	1 if college graduate, 0 otherwise
GRADS	1 if graduate school, 0 otherwise

Table 4-1. Continued

INC	Household income levels:1=less than USD$50,000; 2=USD$50,000-USD$ 99,000; 3=USD$100,000-USD$149,000; 4=USD$150,000-USD$199,000; 5=USD$200,000-USD$499,000; 6=more than USD$500,000
LOGINC	Natural logarithm of income level
WHITE	1 if white race, 0 otherwise

Dummy base categories: study/other visit purpose, travel agency exclusive arrangement, small boat, half day trip, diving, finfish target, no dining, Pacific coast residence, less than college degree.

Table 4-2. Summary statistics

	Standard tours				Artisanal fishing			
	Interest (N = 218)		Demand (N = 196)		Interest (N = 220)		Demand (N = 100)	
Variable	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.	Mean	Std dev.
INT1	2.954	1.202	N/A	N/A	N/A	N/A	N/A	N/A
D1	N/A	N/A	0.587	0.494	N/A	N/A	N/A	N/A
INT2	N/A	N/A	N/A	N/A	2.395	1.365	N/A	N/A
D2	N/A	N/A	N/A	N/A	N/A	N/A	0.640	0.482
Last visit (X^1):								
VACATION	N/A	N/A	0.918	0.274	N/A	N/A	0.910	0.287
ARRANGEI	N/A	N/A	0.163	0.370	N/A	N/A	0.170	0.377
ARRANGEIA	N/A	N/A	0.102	0.303	N/A	N/A	0.140	0.348
LENGTH	N/A	N/A	6.535	1.662	N/A	N/A	6.420	1.706
Benefits and Concerns (X^2):								
FISHCONS	0.775	0.418	0.806	0.396	0.782	0.414	0.880	0.326
LSUPPORT	0.660	0.474	0.668	0.472	0.664	0.473	0.780	0.416
CULTURE	0.693	0.462	0.688	0.464	0.690	0.463	0.800	0.402
SBOAT	0.404	0.492	0.387	0.488	0.400	0.491	0.370	0.485
EXP	0.532	0.500	0.500	0.501	0.536	0.499	0.530	0.502
LANG	0.357	0.480	0.331	0.472	0.364	0.482	0.330	0.472
AFFIL	0.417	0.494	0.403	0.492	0.423	0.495	0.400	0.492
VSIZE	0.408	0.492	0.408	0.493	0.409	0.492	0.410	0.494
Trip characteristics (X^3):								
BMED	N/A	N/A	0.469	0.500	N/A	N/A	N/A	N/A
BLARGE	N/A	N/A	0.438	0.497	N/A	N/A	N/A	N/A
FULLD	N/A	N/A	0.326	0.470	N/A	N/A	0.280	0.451
MULTD	N/A	N/A	0.357	0.480	N/A	N/A	N/A	N/A
SNKL	N/A	N/A	0.367	0.483	N/A	N/A	N/A	N/A
BTOUR	N/A	N/A	0.495	0.501	N/A	N/A	N/A	N/A
LOBSTER	N/A	N/A	N/A	N/A	N/A	N/A	0.360	0.482

Table 4-2. Continued

DINING	N/A	N/A	N/A	N/A	N/A	N/A	0.530	0.502
Demographics (X^4):								
MEMBER	0.472	0.500	0.459	0.499	0.468	0.500	0.500	0.502
MALE	0.504	0.501	0.500	0.501	0.504	0.501	0.480	0.502
AGE	53.300	15.740	51.830	15.390	53.540	15.620	48.280	16.240
SOUTH	0.303	0.460	0.311	0.464	0.300	0.459	0.370	0.485
NCENTRAL	0.206	0.405	0.194	0.396	0.204	0.404	0.210	0.409
NEAST	0.234	0.424	0.229	0.422	0.240	0.428	0.180	0.386
COLLEGE	0.376	0.485	0.372	0.485	0.373	0.485	0.370	0.485
GRADS	0.536	0.499	0.540	0.499	0.540	0.499	0.540	0.500
INC	3.261	1.430	N/A	N/A	3.277	1.430	N/A	N/A
LOGINC	1.069	0.503	1.069	0.513	1.074	0.503	1.051	0.539
WHITE	0.922	0.268	0.923	0.266	0.927	0.260	0.900	0.301

N/A indicates the variable was not applicable to the model.

Table 4-3. Willingness to book responses by interest level

	Standard tour			Artisanal fishing		
Interest	Add	Replace	No	Add	Replace	No
1	4	2	20	1	0	15
2	5	4	23	5	2	7
3	28	12	30	13	9	11
4	27	14	3	15	4	3
5	14	4	3	12	3	0

Table 4-4. Comparison of covariates based on participant self selection for booking an artisanal fishing tour

	Final sample (N=100)		Not based on self selection (N=207)	
Variable	Mean	Std. Dev	Mean	Std. dev
VACATION	0.910	0.287	0.928	0.259
ARRANGEI	0.170	0.377	0.164	0.371
ARRANGEIA	0.140	0.348	0.101	0.303
LENGTH	6.420	1.706	6.522	1.639
FISHCONS	0.880	0.326	0.783	0.413
LSUPPORT	0.780	0.416	0.657	0.476
CULTURE	0.800	0.402	0.700	0.459
SBOAT	0.370	0.485	0.386	0.488
EXP	0.530	0.502	0.536	0.499
LANG	0.330	0.472	0.357	0.480
AFFIL	0.400	0.492	0.402	0.495
VSIZE	0.410	0.494	0.406	0.492
FULLD	0.280	0.451	0.324	0.469
LOBSTER	0.360	0.482	0.346	0.478
DINING	0.530	0.502	0.479	0.501
MEMBER	0.500	0.502	0.464	0.499
MALE	0.480	0.502	0.502	0.501
AGE	48.280	16.24	52.899	15.631
SOUTH	0.370	0.485	0.309	0.463
NCENTRAL	0.210	0.409	0.198	0.399
NEAST	0.180	0.386	0.237	0.426
COLLEGE	0.370	0.485	0.367	0.483
GRADS	0.540	0.500	0.546	0.499
INC	N/A	N/A	N/A	N/A
LOGINC	1.051	0.539	1.078	0.508
WHITE	0.900	0.301	0.923	0.267

Table 4-5. Ordered logit estimates for tour interest

	Standard tours		Artisanal fishing	
Variable	Estimate	t-value	Estimate	t-value
Constant	2.781	3.308***	0.795	1.001
FISHCONS	1.389	3.779***	0.171	0.461
LSUPPORT	0.370	1.012	0.679	1.905*
CULTURE	0.715	2.031**	0.148	0.428
SBOAT	1.328	4.450***	0.343	1.191
EXP	-0.474	-1.571	0.055	0.181
LANG	0.055	0.162	0.073	0.218
AFFIL	-0.590	-1.950*	-.354	-1.168
VSIZE	0.217	0.710	0.322	1.031
MEMBER	0.063	0.233	-0.153	-0.572
MALE	0.573	2.084**	0.897	3.270***
AGE	-0.024	-2.676***	-0.027	-2.960***
SOUTH	-0.102	-0.281	0.602	1.668*
NCENTRAL	0.445	1.199	0.819	2.160**
NEAST	0.113	0.303	0.205	0.557
COLLEGE	-1.339	-2.653***	-0.587	-1.171
GRADS	-1.030	-2.069**	-0.288	-0.576
INC	0.587	1.662*	N/A	N/A
LOGINC	-1.835	-1.829*	-0.320	-1.162
WHITE	-0.397	-0.783	0.201	0.392
u_1	1.359	8.526***	0.565	5.908***
u_2	3.482	19.710***	1.850	11.785***
u_3	5.325	21.328***	3.029	12.738***
LogL		-275.80		-302.85
$LogL_0$		-333.69		-321.25
p-value		<0.001		0.005
N		218		220

* Significant at 10%; ** Significant at 5%; *** Significant at 1%.

Table 4-6. Effects of significant variables on the interest probability for standard tours

	Standard tours				
Variable	1	2	3	4	5
FISHCONS	-0.149[a]	-0.156[c]	0.093[a]	0.162[c]	0.050[c]
LSUPPORT	-0.030	-0.044	0.006	0.051	0.017
CULTURE	-0.062[a]	-0.084[b]	0.022	0.094[b]	0.031[b]
SBOAT	-0.096[c]	-0.144[c]	-0.022	0.187[c]	0.075[c]
AFFIL	0.048[a]	0.069[b]	-0.008	-0.081[a]	-0.027[a]
MALE	-0.044[b]	-0.066[b]	0.003	0.080[b]	0.028[a]
AGE	0.002[b]	0.003[c]	0.000	-0.003[b]	-0.001[b]
SOUTH	0.008	0.012	-0.001	-0.014	-0.005
NCENTRA	-0.031	-0.050	-0.008	0.065	0.024
COLLEGE	0.122[b]	0.152[c]	-0.044	-0.172[c]	-0.058[b]
GRADS	0.079[b]	0.116[b]	0.001	-0.144[b]	-0.053[a]
INC	-0.045[a]	-0.069[a]	0.003	0.082[a]	0.028[a]
LOGINC	0.141[a]	0.215[a]	-0.010	-0.257[a]	-0.088[a]
*INC**	0.096	0.146	-0.007	-0.175	-0.060

[a] Significant at 10%; [b] Significant at 5%; [c] Significant at 1%

*INC** denotes the full effect of income. It was calculated as the sum of the individual marginal effects of INC and LOGINC. This sum is equivalent to calculating the full marginal effect as the product $f(X^*\beta) * (\beta_{INC} + \beta_{LOGINC})$ where f represents the probability density function of the logistic distribution, X^* is the vector of mean values of explanatory variables, β is the complete set of estimated coefficients, β_{INC} is the estimated coefficient on linear income and β_{LOGINC} is the coefficient on the log of income (Borooah 2002).

Table 4-7. Effects of significant variables on the interest probability for fishing tours

	Artisanal fishing				
Variable	1	2	3	4	5
FISHCONS	-0.041	-0.002	0.016	0.016	0.011
LSUPPORT	-0.163[a]	-0.003	0.065[a]	0.060[a]	0.042[a]
CULTURE	-0.035	-0.002	0.014	0.014	0.010
SBOAT	-0.081	-0.005	0.029	0.033	0.024
AFFIL	0.084	0.004	-0.032	-0.033	-0.023
MALE	-0.210[c]	-0.011	0.076[c]	0.083[c]	0.061[c]
AGE	0.006[c]	0.000	-0.002[c]	-0.003[c]	-0.002[c]
SOUTH	-0.137[a]	-0.012	0.046[a]	0.059	0.045
NCENTRA	-0.179[b]	-0.022	0.051[c]	0.082[b]	0.068[a]
COLLEGE	0.140	0.004	-0.055	-0.053	-0.037
GRADS	0.068	0.004	-0.025	-0.027	-0.019
LOGINC	0.076	0.004	-0.029	-0.030	-0.021

[a] Significant at 10%; [b] Significant at 5%; [c] Significant at 1%.

Table 4-8. Binary logit estimates for willingness to book a tour

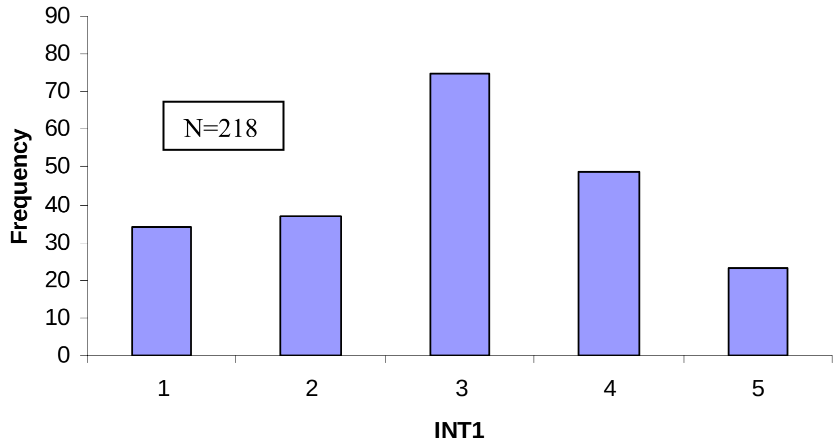
	Standard tours		Artisanal fishing	
Variable	Estimate	t-value	Estimate	t-value
Constant	1.940	0.954	3.753	1.211
VACATION	-0.465	-0.595	-1.622	-1.269
ARRANGEI	-1.224	-2.032**	-1.247	-1.294
ARRANGEIA	-0.962	-1.207	-1.570	-1.689*
LENGTH	0.160	1.120	-0.182	-0.944
FISHCONS	0.558	0.916	0.462	0.405
LSUPPORT	0.552	0.979	0.708	0.727
CULTURE	1.101	2049**	0.161	0.172
SBOAT	0.479	1.015	0.702	1.034
EXP	0.464	0.911	-0.237	-0.335
LANG	-0.632	-1.213	-0.467	-0.619
AFFIL	-1.492	-3.147***	0.562	0.806
VSIZE	-0.046	-0.095	0.217	0.273
BMED	-0.352	-0.511	N/A	N/A
BLARGE	-0.315	-0.430	N/A	N/A
SNKL	-0.820	-1.276	N/A	N/A
BTOUR	-0.245	-0.391	N/A	N/A
MULTD	-2.358	-3.650***	N/A	N/A
FULLD	-0.299	-0.549	1.818	2.192**
LOBSTER	N/A	N/A	-0.736	-1.026
DINING	N/A	N/A	1.727	2.534**
MEMBER	-0.2126	-0.497	0.449	0.716
MALE	-0.137	-0.318	2.044	2.804***
AGE	0.004	0.258	0.018	0.759
SOUTH	0.614	1.108	0.076	0.103
NCENTRAL	0.477	0.819	-0.916	-0.947
NEAST	1.102	1.906*	-0.214	-0.217
COLLEGE	-1.399	-1.365	-1.270	-1.650
GRADS	-1.555	-1.524	-1.324	-1.906*
INC	2.039	3.303***	N/A	N/A
LOGINC	-5.640	-3.101***	-1.324	-1.906*
WHITE	-1.137	-1.241	-1.283	-1.073
LogL		-89.06		-44.49
p-value		<0.001		0.019
% correct predictions		80.10%		77.00%
N		196		100

* Significant at 10%; ** Significant at 5%; *** Significant at 1%.

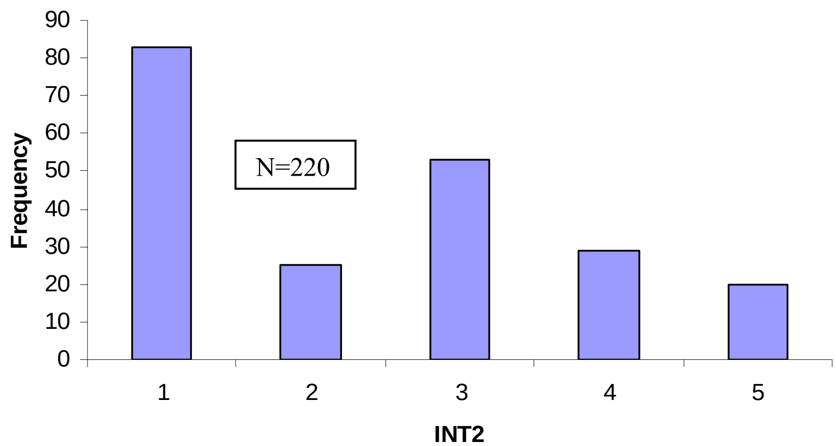
Table 4-9. Effects on the probability of booking a tour

Variable	Standard tours	Artisanal fishing
ARRANGEI	-0.295**	-0.288
ARRANGEIA	-0.234	-0.366*
CULTURE	0.260**	0.034
AFFIL	-0.343***	0.114
MULTD	-0.525***	N/A
FULLD	-0.069	0.310***
DINING	N/A	0.355***
MALE	-0.032	0.402***
NEAST	0.227**	-0.046
GRADS	-0.340	-0.434*
INC	0.470***	N/A
LOGINC	-1.303***	-0.276*
*INC**	0.833	N/A

* Significant at 10%; ** Significant at 5%; *** Significant at 1%.
*INC** denotes the full effect of income on interest probabilities for standard tours. It was calculated as the sum of the individual marginal effects of INC and LOGINC. This sum is equivalent to calculating the full marginal effect as the product $f(X^*\beta) * (\beta_{INC} + \beta_{LOGINC})$ where f represents the probability density function of the logistic distribution, X^* is the vector of mean values of explanatory variables, β is the complete set of estimated coefficients, β_{INC} is the estimated coefficient on linear income and β_{LOGINC} is the coefficient on the log of income (Borooah 2002).



A



B

Figure 4-1. Distribution of interest responses. (A) Interest for standard tours. (B) Interest for artisanal fishing tours.

CHAPTER 5
CONCLUSIONS

This study presents a socio-economic analysis of the potential of transferring fishing effort (i.e., vessels and fishermen) to the tourism industry as a successful strategy to rebuild small scale fisheries illustrating the case of the Galapagos Marine Reserve. The evaluation combined three different areas: individual fishing preferences, fleet production and efficiency and tourists' interest and potential demand. The main findings are summarized below.

- Fishermen were almost as likely to stay as to exit, and a considerable number of individuals were undecided. Vessel owners were more likely to switch to tourism than crew and both groups had different sensitivities to changes in demographics and fishing related factors. Preferences also differed between geographical locations. Fishermen from Santa Cruz, the tourism hub for the Archipelago, were more enticed to switch than other individuals. These findings indicate the need to devise diversification strategies that differentiate between vessel owners and crew and the specific realities of the fishing ports. Participants in high value but depleted fisheries (higher opportunity costs) or who dived were also more likely to exit. Higher availability of income (funding) also encouraged fishers to switch. Capital malleability issues were compensated by the opportunity to transfer fishing capital investments outside the fishing sector. This particular feature of the diversification strategy provided vessel owners with stronger incentives to exit the fisheries, in contrast to previous findings in the literature suggesting a negative effect of ownership on exiting decisions.

- From the existing standard tour operations, fishermen were more likely to engage in bay and diving tours (single–day) followed by the diving cruise option. Mostly fishermen from Isabela were interested in standard cruise operations. Individuals preferred bay and diving tours if they own small vessels, had concerns about safety implications, were from San Cristobal or had access to bank funding. Individuals willing to make great investments preferred diving cruises to standard cruise operations.

- Vessel lobster catch depended mostly on the level of variable inputs used, especially days at sea, and not on the fleet's capital. Also, the fleet shows a considerable level of technical inefficiency (around 35%), which is the prevalent factor influencing per-trip harvest variation. Technical efficiency differed between geographical locations, and it could be increased by the use of more sophisticated diving methods and gear types.

- Interrelations between vessels and fishermen played a role on fishermen decisions and the production structure of the small scale fishing fleet. Results suggested that linkages between owners and crew in the same fishing vessel influenced their choices for diving cruise operations in the local tourism industry. Also, the per-trip harvesting potential and technical efficiency of individual vessels was limited when they participated in mothership operations (i.e., composite fishing units) in comparison to independent boats. This limiting effect was higher for fiberglass than for wooden vessels.

- Results suggested a promising market potential for fishermen-based ecotourism considering the limited number of fishing vessels in the Islands in contrast to the number of visitors per year. Standard tours had a higher interest and demand potential in comparison to artisanal fishing trips. Conservation benefits, exposure to the local culture and specially preference for small boats increased the general interest for standard tours, while the direct contribution to the local community made fishing trips more appealing. Only the lack of affiliation with a known company had a negative effect on tourist preferences, specifically for standard tours. The demand potential for artisanal fishing trips was higher for full-day fishing with a dining option, and standard tours had higher booking intentions if half-day excursions are offered. High income individuals were more reluctant to book any type of tours offered by fishermen.

These findings have important implications about the success of the switching program. Fishermen and visitors are willing to engage in standard tours, especially in half day operations (e.g., bay and diving tours). From the supply and demand perspective, this suggests a promising potential for the program as a viable economic alternative for fishermen outside the fishing sector to the extent that they are allowed to participate in standard tour market by the management authority. However, the level of interest from tourists still needs to be increased to realize a full potential. Management authorities or fishermen groups need to develop informational campaigns or advertising for actual and potential visitors about the expected fish conservation and local community benefits related to the transition of fishermen into tourism in order to increase the appealing of the plan. In this sense, the promotion of artisanal fishing trips needs special attention as the activity is completely new, visitors are more unfamiliar with its characteristics and it still has limited potential. Efforts to create a legitimate image of fishermen as tour providers are also critical, and these may include the formal organization of the new providers in companies or associations, as well as service quality and technical training. Partnerships or collaborations with local restaurants to offer the unique option of dining the catch and with travel agencies to make fishermen-based tours known are also needed.

From a production perspective, the program has a more limited scope for controlling the harvesting potential of the fleet in the lobster fishery. As the results suggest, per-trip harvests depend mostly on variable inputs, participation in mothership structures and technical efficiency. Since the program is likely to be more successful among owners of larger boats, its impact is expected to be higher on the capitalization of the motherboat segment than on the other vessel groups. Provided that fish stocks and other production factors remain stable in the short run, a reduction in the number of mother ships will also reduce the harvest limitations observed among towed vessels in comparison to independent boats, actually improving harvest rates per day of trip. In the long run, and in the absence of alternative strategies to rebuild resource populations, stocks will be reduced. In addition, the catch potential of the remaining fishing units may also increase if technical efficiency is improved.

In order to restore fishery stocks in the GMR, additional policies controlling input use and technical efficiency are needed (e.g., limiting the number of days at sea per trip or restricting the use of mechanized gear and diving methods). Contrary to agriculture, increasing the efficiency of fishing fleets is not a desirable outcome given the problem of open access in fisheries and declining stocks. On the other hand, inefficient fishing vessels are not a desirable economic outcome either. In the long run, managers will need to direct their attention to alternative management schemes, such as rights based policies. This regime will help control the race for catch while promoting an efficient allocation of fishing effort in order to achieve more promising outcomes in fisheries conservation.

This study contributes to the fisheries management literature in several ways. First, as emphasized by the modern approach to artisanal fisheries management focused on poverty reduction and livelihood improvement, management policies must include the generation of alternative employment opportunities while promoting reduction of harvesting effort. This study suggests a promising potential for fishermen and fishing vessels diversification into ecotourism as an alternative livelihood strategy, but it also illustrates the possible limitations of such plan as a mechanism to reduce the production capacity of artisanal fishing fleets when catch is not dependent on vessel capital. It also identifies factors that can be useful to the design of similar programs in other artisanal fishing communities. Second, this analysis contributes to the understanding of artisanal fishermen incentives to stay or exit when faced by the opportunity to switch into alternative occupations. Knowledge of this behavior is critical to design better informed fishing management strategies. Lastly, the study demonstrated the relevance of explicitly considering the unique characteristics of artisanal fishing systems, namely vessel interrelations, into the assessment of fleet harvesting potential. This is particularly important for the design of more appropriate capacity management programs targeted to small scale fishing fleets, which consider the socioeconomic ties influencing the operations of this sector.

The conclusions of this study are subject to some limitations. Limited linkage information for all the fishermen in the sample precluded a richer analysis of the role of interdependence in fishermen's switching (exiting) decisions and choice of tour operations. Hence, those results should be interpreted only as preliminary indicators of relevance of individual linkages rather than as exact effects. Similarly, results about linkage effects on the production technology of the fleet are dependent on observations of responses regarding vessels' towing status. Also, findings about input elasticities and returns to scale are assumed to be the same for all firms regardless of the level of input use as a flexible functional form of technology could not be analyzed given high collinearity issues in the data. Results about tourists' preferences are limited to the market of U.S visitors. Therefore, the demand potential suggested by the analysis may be considered as conservative as it is reasonable to expect some interest for fishermen-operated tours from other visitor markets. Lastly, the analysis of potential demand is dependent on the assumption of complete independence between interest and demand preferences for fishermen-based tours.

The next steps to address some of the above mentioned limitations include the exploration of alternative measures of interdependence among fishermen for switching preferences analysis. To the possible extent allowed by the survey data, a reduced sample with only vessel owners and crew members from the same fishing units (i.e., vessels, motherships) may be defined and new indicators will reflect a relationship with a 'yes' response from another individual in the same production unit .Also, this study will be extended by examining sample selection implications on the modeling of interdependence effects on harvesting technology and on tourists preferences. Finally, further research that addresses (1) the role of technical efficiency on exiting behavior, (2) fishermen incentives to stay or exit fishing regarding other diversification opportunities, (3) clear market niches for fishermen-based tours, and (4) the demand potential for fishermen-based ecotourism in other markets will be very useful to complement the contributions of the present study to the understanding of artisanal fishing and the improvement of its management.

APPENDIX A
FACE TO FACE SURVEY INSTRUMENT FOR FISHERMEN EXITING BEHAVIOR IN SPANISH

PARTE 1: El primer grupo de preguntas que le haré se relacionan con su interés y preocupaciones como armador pesquero respecto al cambio de actividad de pesca hacia turismo que seria posible a través del programa de concesión de nuevos cupos de operación turística.

Q1. Está interesado en cambiar su cupo de pesca por un nuevo cupo de operación turística en la Reserva Marina de Galápagos?

Encuestador ENCIERRE solo UNA respuesta
(1) Si (0) No (8) NS/talvez (9) NR

Si respuesta es SI: Continúe
Si respuesta es NO, NO SE, NO RESPONDE: Pase a la pregunta Q2.

Q1.A En que modalidad turística preferiría participar? Escoja SOLO UNA opcion por favor.

Encuestador ENCIERRE solo UNA respuesta:

(1) bahía	**(2) bahía y buceo con puertos**
(3) bahía y buceo sin puertos	**(4) Puerto a puerto**
(5) Buceo navegable	**(8) NS/ Inseguro**
(9) NR	**(77) Otros**

Cualquier respuesta: Continúe.

Q1.B De las siguientes actividades que le mostrare, por favor seleccione TODAS las que usted ofrecería en su negocio turístico:

Encuestador ENCIERRE TODAS las que apliquen:

(1) Snorkel	**(5) Surf**
(2) Paseo panga	**(6) Kayak**
(3) Caminatas	**(8) NS**
(4) Buceo	**(9) NR**

Cualquier respuesta: Continúe.

Q1.C Cuenta con la embarcación y equipos ADECUADOS para iniciar la operación de esta modalidad turística?

Encuestador ENCIERRE solo UNA respuesta
(1) Si (0) No (9) NR

Cualquier respuesta: Continúe.

Q1.D Su negocio sería SOLO propio o en sociedad? Por favor escoja SOLO UNA opción.

Encuestador ENCIERRE solo UNA respuesta
(1) Propio (2) Sociedad
(8) NS (9) NR

Cualquier respuesta: Continúe.

Q1.E Cuánto dinero aproximadamente necesita invertir para cambiarse a la actividad turística?:

Encuestador ENCIERRE solo UNA opción:
(1) Menos de $10,000
(2) $10,001-$50,000
(3) $50,001-$100,000
(4) $100,001-$200,000
(5) Mas de $200,000
(8) NS (9) NR

Cualquier respuesta: Continúe.

Q1.F Por favor responda Si , No, NR a las siguientes preguntas. Para financiar el cambio de actividad, ud. contaría con:

a. Con préstamo bancario?
b. Con inversión de socio-operador turístico?
c. Con inversión de socio- armador pesquero?
d. Con préstamos de familia o amigos?
e. Con préstamos de chulqueros?
f. Con otra fuente de recursos?_____________

Cualquier respuesta: Continúe.

Q1.G. Le interesaría alquilar su cupo de operación turística?

Encuestador ENCIERRE solo UNA:
(1) Si (0) No (8) NS/talvez (9) NR

Cualquier respuesta: Continúe.

Q1.H Cuenta con los conocimientos administrativos para manejar su negocio turístico?

Encuestador ENCIERRE solo UNA:
(1) Si (0) No (8) NS/inseguro (9) NR

Cualquier respuesta: Continúe.

Q2. Le mencionare 6 aspectos relacionados con el cambio de actividad de pesca a turismo. Por favor dígame que tan preocupado esta ud. por cada aspecto usando una escala del 1 al 3 donde 1 representa NADA PREOCUPADO, 2 significa UN POCO PREOCUPADO y 3 MUY PREOCUPADO.

	Nada	Poco	Mucho	NS	NR
Que tan preocupado esta ud ….	1	2	3	8	9
A) Por el costo de cambiarse al turismo?	1	2	3	8	9
B) Por la cantidad de nuevos cupos a otorgarse?	1	2	3	8	9
C) Por las medidas de seguridad requeridas?	1	2	3	8	9
D) Por el compromiso con horarios fijos?	1	2	3	8	9
E) Por encontrar tripulación apta para su barco?	1	2	3	8	9
F) Por la necesidad de un traductor de idiomas?	1	2	3	8	9
G) Otra preocupación? ________________________					

Cualquier respuesta: Continúe

PARTE DOS: Ahora le haré unas preguntas sobre su experiencia en el sector pesquero, la necesidad por otras fuentes de empleo y condiciones socioeconómicas en general.

Q3. Por cuantos años ha estado involucrado en el sector pesquero de Galápagos?

Encuestador ESCRIBA NUMERO o NR si no responde: ______ años

Cualquier respuesta: Continúe

Q4. Durante el último año, ha trabajado usted como patrón o capitán de alguna embarcación pesquera?

Encuestador ENCIERRE respuesta:
(1) Si (0) No (9) NR

Si respuesta es SI: Continúe.
Si respuesta NO o NO RESPONDE: pase a la pregunta Q5

Q4.A Cuantos años de experiencia tiene como capitán?

Encuestador ESCRIBA NÚMERO o NR si no responde: _______ años

Cualquier respuesta: Continúe

Q4.B Alguna de las embarcaciones pesqueras en las que ha sido capitán tiene sistema de identificación de coordenadas geográficas?

Encuestador ENCIERRE respuesta:
(1) Si (0) No (8) NS (9) NR

Cualquier respuesta: Continúe

Q4.C. Tomando en cuenta las pesquerías en las que ud. ha participado durante el ultimo año, aproximadamente cuantas empresas del continente le compraron su captura en el 2007?

ESCRIBA NÚMERO incluido 0 si respuesta es 'ninguna' o NR si no responde:
_____ empresas

Cualquier respuesta: Continúe

Q4.D Ha obtenido un precio más alto por los animales más grandes de la captura de cualquier pesquería?

Encuestador ENCIERRE respuesta:
(1) Si (0) No (9) NR

Cualquier respuesta: Continúe

Q5. Durante los últimos 12 meses, ha trabajado usted como tripulante de alguna embarcación pesquera?

Encuestador ENCIERRE respuesta:
(1) Si (0) No (9) NR

Cualquier respuesta: Continúe

Q6. Durante los últimos 12 meses, ha trabajado usted como buzo?

Encuestador ENCIERRE respuesta:
(1) Si (0) No (9) NR

Si respuesta es SI continúe.
Si respuesta NO, NO RESPONDE pase a la pregunta Q7

Q6.A Que método de buceo prefiere: con hookah o buceo libre?

Encuestador ENCIERRE respuesta:
(1) Hookah (2) Libre (9) NR

Cualquier respuesta: Continúe

Q7. En cualquiera de los TRES últimos años, ha participado ud. en:

	1	0	9
a. Pesquería de langosta?	Si	No	NR
b. Pesquería de pepino?	Si	No	NR
c. Pesca blanca?	Si	No	NR
d. Pesca de altura?	Si	No	NR

Cualquier respuesta: Continúe

Q8. Trabaja en otras actividades además de la pesca?

Encuestador ENCIERRE respuesta: **(1) Si (0) No (9) NR**

Si la respuesta es SI: Continúe.
Si respuesta NO, NO RESPONDE pase a la pregunta Q9

Q8.A Le mostrare una lista de otros sectores económicos. Por favor dígame en cuales de ellos ud. también trabaja.

Encuestador ENCIERRE TODAS las que digan:	
(1) Turismo	**(5) Transporte**
(2) Agricultura	**(6) ONGs**
(3) Comercio	**(77) Otro ___________**
(4) Empleo de gobierno	**(9) NR**

Cualquier respuesta: Continúe

Q8.B Que le genera mayor ingreso: la pesca o sus otras actividades?

Encuestador ENCIERRE solo UNA: **(1) Pesca (2) Otra (9) NR**

Cualquier respuesta: Continúe

PARTE TRES: Las siguientes preguntas que le haré tratan sobre sus características sociales generales:

Q9. En que año nació?

ESCRIBA ANO (ej: 1954) o NR si no responde: Año ______

Cualquier respuesta: Continúe

Q10. Terminó la escuela primaria?

Encuestador ENCIERRE respuesta: **(1) Si (0) No (9) NR**

Cualquier respuesta: Continúe

Q11. Es ud. originario de Galápagos o de Ecuador continental?

Encuestador ENCIERRE solo UNA respuesta:	
(1) Galápagos	**(2) Continente**
(9) NR	**(77) Otro __________**

Cualquier respuesta: Continué

Q12. Cuantas personas viven en su casa, incluido ud.?

ESCRIBA NÚMERO o NR si no responde: ______ personas

Cualquier respuesta: Continúe

Q13. De aquellos que viven con ud., cuantas personas son menores de 12 años?

ESCRIBA NÚMERO (incluido 0 =ninguno) o NR si no responde: ____ personas

Cualquier respuesta: Continúe

Q14. Además de usted, cuantos miembros de su casa ayudan a mantener el hogar?

ESCRIBA NÚMERO (incluido 0 =ninguno) o NR si no responde: _____ personas

Cualquier respuesta: Continúe

Q15. Cual de las siguientes categorías que le mostrare representa el ingreso *mensual aproximado de su hogar*, proveniente de todas las actividades laborales en su casa durante el 2007?:

Encuestador ENCIERRE solo UNA opción:

(1) Menor $500	**(4) $1501-$2000**
(2) $501-$1000	**(5) Mayor $2000**
(3) $1001-$1500	**(9) NR**

Esto termina nuestra conversación. Muchas gracias por su tiempo y participación. Tiene preguntas adicionales sobre esta encuesta o sugerencias sobre los nuevos cupos de turismo u otras estrategias que la autoridad debería considerar para promover una pesca sostenible?

APPENDIX B
ONLINE SURVEY INSTRUMENT OF PREFERENCES OF U.S. VISITORS FOR FISHERMEN-OPERATED TOURS

Section I: Your last Galapagos visit

Q1. In your opinion, what was the quality of the environment in the Galapagos Islands at the time of your visit?

Very poor (conservation efforts are not working) 1	Poor 2	Okay 3	Good 4	Very good (conservation efforts are working well) 5
☐	☐	☐	☐	☐

Q2. How important was it for you to visit the Galapagos Islands someday in your life?

Not at all 1	2	Somewhat 3	4	Very 5
☐	☐	☐	☐	☐

Q3. Which of the following sources of information did you use to learn about the Galapagos prior to your visit? [Please check all that you remember using]

☐	a) Ecuadorian Ministry of Tourism webpage
☐	b) Galapagos Chamber of Tourism webpage
☐	c) Charles Darwin Research Station webpage
☐	d) Galapagos National Park Service webpage
☐	e) Ecotourism webpage
☐	f) Environmental organization webpage
☐	g) Specialized travel books/pamphlets/magazines
☐	h) AAA
☐	i) Past visitors

Q4a. Were the Galapagos Islands the main destination of this trip?

Yes	No
☐	☐

Q4b. What was the main purpose of this visit to the Galapagos Islands? [Select one...]

Q5. In what year was this trip? [Select one...]

Q6. Including you, how many people traveled in your party? [Select one...] persons

Q7. How long did you stay in the Islands? [Select one...] days

Q8. How did you arrange this visit to the Galapagos Islands? [Select one...]

Q9. How did you arrive in the Galapagos Islands? [Select one...]

Q10. What recreational activities did you do during this visit? [check all that apply]

☐ a) Snorkeling	☐ b) Surfing	☐ c) Camping
☐ d) Scuba diving	☐ e) Kayaking	☐ f) Horse riding
☐ g) Mountain biking	☐ h) Trekking/hiking	☐ i) Flora/wildlife watching
☐ j) Shopping	☐ k) Boat tour of islands	☐ l) Other

Q11. Please complete the table about any excursions (either land or water-based) you might have taken on this trip.

Length	Number taken	Average cost per person per trip
Half-day	Select one...	USD$
Full-day	Select one...	USD$
Multi-day	Select one...	USD$

Section IIA: Park entry fee

The Galapagos National Park (GNP) was established in 1959 and includes over 1.7 million acres of the Galapagos Islands or 90% of the total land area. The GNP collects an entry fee from every visitor. The current base fee is USD$100 for adult foreign tourists. This money goes to the Ecuadorian Government but USD$40 (40%) is returned to the park for operating expenses.

Management of the Galapagos Marine Reserve (GMR) began when it was added to the GNP in 1988. The GMR extended 40 nautical miles from the Islands for an area of nearly 33 million acres; it is the largest marine reserve in a developing country and the second largest in the world. The Ecuadorian Government returns USD$5 (5%) from each visitor fee to the GMR.

Q12a. How did you pay your entry fee on your last trip?

Separately ☐	Included in package ☐	Don't recall ☐

Small scale commercial fishing - also known as artisanal fishing since the monies earned stay in the local community and support the sustainability of locals - is the second most important economic activity in the GMR after tourism. However, stocks of the main commercial fisheries (i.e., sea cucumber and spiny lobster) have dramatically declined during the past few years due to overharvesting to supply strong demand in overseas markets. *To rebuild the populations, fisheries, and ensure sustainability of local communities (as fishing revenue stays in the local economy), the management authority (i.e., Galapagos National Park Service) plans to permanently exchange fishing licenses for tourism permits, which are tightly controlled.*

The fishermen selected as new tour operators will be authorized to operate tours similar to those currently offered. They will be subject to the <u>same</u> training and procedural regulations as for 'traditional' tour operators. Likewise, the fishing boats will have to be appropriately equipped before obtaining final <u>authorization</u> and will be subject to the same itinerary and safety policies. As standard practice in the industry, these boats will also have a <u>licensed naturalist guide</u> on board.

Q12b. If an Artisanal Fisherman's Trust Fund were established to support the rebuilding of stocks (e.g., cost to determine sustainable yields and increased enforcement) and the transition of fishermen to tour operators, how support would you have been to have to pay an additional $5 on your entry fee for this fund?

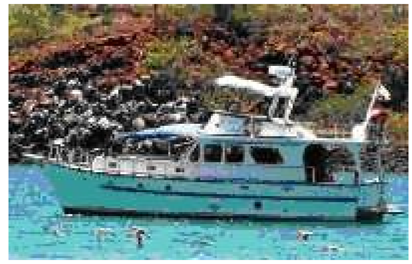
0% Not at all (not willing to pay) ☐	50% don't know (somewhat willing to pay) ☐	100% supportive (very willing to pay) ☐

Section IIB: Opinions on new tours and operators

Artisanal fishing boats have been classified in the following 3 groups:

Small
Material: wood
Length: 3.8 - 8.3 meters
Engine: 10 - 85 HP
Passengers: 5

Medium
Material: fiberglass
Length: 5 - 8.6 meters
Engine: 25 - 200 HP
Passengers: 8



Large
Material: wood
Length: 8 - 18 meters
Engine: 30 - 219 HP
Passengers: 16

Q13. We want to assess whether tourists like you would be willing to book excursions with fishermen as new tour operators. The main expected benefits associated with the new providers are listed below. How compelling is each aspect to you? *[Note: we recognize that a trip to the Galapagos may be a once in a lifetime experience. Please try to consider these questions as if you were planning another trip]*.

	Not 1	2	Somewhat 3	4	Very 5
a) Aids in conservation of marine fisheries stocks	☐	☐	☐	☐	☐
b) Direct financial support to local residents	☐	☐	☐	☐	☐
c) Direct exposure to local culture	☐	☐	☐	☐	☐
d) Trips on smaller boats	☐	☐	☐	☐	☐

Q14. Some areas of concern related to fishermen as new tour operators are also listed below. How concerned are you with each of these aspects?

	Not at all 1	2	Somewhat 3	4	Very 5
a) Lack of crew experience with tourism	☐	☐	☐	☐	☐
b) Poor English language skills of crew (other than guide)	☐	☐	☐	☐	☐

c) Not affiliated with known company	☐	☐	☐	☐	☐
d) Lack of amenities available on larger vessels	☐	☐	☐	☐	☐

Section IIC: Evaluating two alternative types of excursions

Alternative 1:

Q15a. Considering the potential benefits and concerns of excursions operated by new providers that you just indicated, how <u>interested</u> are you in booking one of these excursions? *[Note: As before, please try to think back to when you were planning your trip when answering the following questions]*.

Not at all 1	2	Somewhat 3	4	Very 5
☐	☐	☐	☐	☐

Q15b. If you would have been interested in these new tour operators, which type of excursion would you have been most likely to try? Please construct this tour by selecting your preferred boat size, trip length, and main activity of the choices offered.

Boat size:	Small ☐	Medium ☐	Large ☐
Trip length:	Half day ☐	Full day ☐	Multi-day ☐
Main activity:	Scuba diving ☐	Snorkeling ☐	Inter-island Transportation ☐

Q15c. Would the availability of such an excursion have changed your itinerary during your previous visit? If you booked an all-inclusive package, assume this was one of the options
.

YES I would have <u>added</u> an excursion by one of these new operators ☐	YES I would have <u>replaced</u> an excursion I took with one from these new operators ☐	NO I would not have taken this excursion ☐

Alternative 2: Besides the same tour activities offered by traditional operators, fishermen will also offer a unique opportunity for fishing trips with them in medium to large boats. Known as "Artisanal Fishing Tours," this will be the first time that visitors have been allowed the opportunity for recreational fishing. Visitors will experience the local fishing culture and will learn about day-to-day fishing practices. They could even end their fishing experience by eating their fresh catch in a local restaurant.

Q16a. Considering the same potential benefits and concerns of excursions operated by new providers that you evaluated on the previous page, but ignoring the previous alternative (Q15), how interested would you have been (if at all) in booking a new Artisanal Fishing Tour?

Not at all 1	2	Somewhat 3	4	Very 5
☐	☐	☐	☐	☐

Q16b. If you would have been interested in an Artisanal Fishing Tour, which type of excursion would you have been most likely to try? Please construct this tour by selecting your preferred trip length, fishing trip, and whether you would like the dining option.

Trip length:	Half Day ☐	Full day ☐
Fishing options & method:	Lobster (scuba diving)  ☐	Finfish (hook & line, nets)  ☐
Dining option (eat caught seafood at local restaurant after trip):	Yes (retain catch) ☐	No (release catch) ☐

Q16c. Would the availability of such an excursion, if priced reasonably or was available as an option, have changed your itinerary during your previous visit?

YES I would have added an excursion by one of these new operators ☐	YES I would have replaced an excursion I took with one of these new operators ☐	NO I would not have taken this excursion ☐

Q16d. How much would you have been willing to pay for this tour? Please consider your individual selections, the average cost of tours during your last visit, and the uniqueness of this opportunity.

The most I would pay for this tour is: USD$ ________

Section III: Information about the sample of respondents

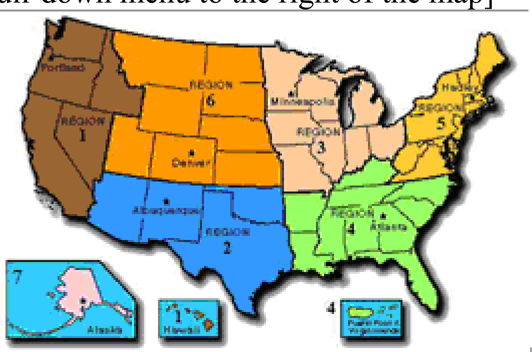
Q17. Are you or was anyone in your party…

	Yes	No
a) a member of any conservation organization?	☐	☐
b) a member of a development/aid organization?	☐	☐
c) employed in any aspect of the tourism industry?	☐	☐

Q18. What is your gender? [Select one...]

Q19. In what year were you born? [Select one...]

Q20. In what region do you consider your primary home to be located? [Please select from the pull-down menu to the right of the map]



U.S. Fish & Wildlife Service Regions

[Select one...]

Q21. What is the highest level of education you have completed?
[Select one...]

Q22. In what range – approximately – was your total household income before taxes in 2008?
[Select one...]

Q23. And, just to see if we have a representative sample, would you please share your race?
[Select one...]

Q24. Would you say that you are of Hispanic ancestry? Select one...

Section IV: Comments and finish

Thank you for your information, which will be used to estimate the potential use and value of this new tourism sector.

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BIOGRAPHICAL SKETCH

Liliana Alencastro was born in Guayaquil, Ecuador. She obtained her undergraduate degree in Economics with a minor in Finance in 2000 at the Escuela Superior Politécnica del Litoral (ESPOL) in her home country. After working as a research assistant in the Center for Economic Research at ESPOL, she continued her graduate education and obtained her Master of Science degree in the Food and Resource Economics Department at the University of Florida in 2004. In the same year, she started the doctoral program in the same department and received her Ph.D. degree in May of 2010. Her research interests are focused on natural resource economics, especially on the human dimensions of artisanal fisheries management. She has studied the preferences of hobbyists for marine ornamental fish, and more recently, the socioeconomic and efficiency implications of fishing capacity management in small scale commercial fisheries.