RESISTING EXTINCTION: THE VALUE OF LOCAL ECOLOGICAL KNOWLEDGE FOR SMALL-SCALE FISHERS IN SOUTHEASTERN PUERTO RICO

by

CARLOS GERÓNIMO GARCÍA-QUIJANO

(Under the Direction of O. Brent Berlin)

ABSTRACT

I used a qualitative-quantitative approach to explore the adaptive value of Local Ecological Knowledge for a population of small-scale fishers in Southeastern Puerto Rico. Through interviewing and participant observation with 20 expert fishers, I gathered data on: 1) ecological knowledge of local ecosystems held by fishers, 2) culturally-relevant models of success (i.e. what does it mean to be a successful fisher by local standards), and 3) In what ways local ecological knowledge is used to be more successful. I found that knowledge about important target species' biology is complemented by knowledge of the continuity and change in species' populations over space and time. Thinking about the ecosystem in terms of ecological-parameters (e.g. species assemblages, trophic structures, bottom composition, salinity, seasonality, depth, changes of parameters over time) is of paramount importance for fishers dealing with the complex multi-species fishery. Many fishers make sense of complex ecological information by thinking about underwater landscapes and about what kinds of fish they might find in a given scenario. I also found that social recognition as a member of the community of 'true fishers', as well as making enough profits to ensure reproduction of the domestic unit, are the most widely shared goals of a fisher. This finding goes against a common assumption in fishery bio-economic models: that small-scale fishers operate towards profit maximization, like firms. I also found that due to an historical subsistence strategy of combining agricultural work and fishing on a part-time basis, being a full-time fisher was not necessary for being a knowledgeable and successful fisher.

Based on ethnographic work, I conducted structured interviews to test: 1) intracultural variability in ecological knowledge, through consensus analysis and 2) intra-group variability in culturally-relevant success measures. After conducting structured interviews with a stratified random sample of 41 additional fishers I investigated the relationships between ecological knowledge and success in the population. I found that there is a significant correlation between ecological knowledge and measures of success.

This study serves to underscore the value of indigenous/traditional/local ecological knowledge for small-scale societies. By drawing parallels with the theory of ecosystems ecology, it also points to possible avenues of collaboration in the management of complex tropical fisheries.

INDEX WORDS: Anthropology, Ethnoecology, Maritime Anthropology, Human Ecology, Caribbean, Fisheries, Tropical Fisheries, Puerto Rico, Cultural Models, Local Ecological Knowledge, Peasant Studies, Complex Ecosystems, Fisheries Management, Cultural Consensus

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CARLOS GERONIMO GARCIA-QUIJANO

B.S., University of Puerto Rico-Mayagüez, 1996

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CARLOS GERONIMO GARCIA-QUIJANO

Major Professor:	O.Brent Berlin
Committee:	Benjamin G. Blount Theodore L.Gragson

Electronic Version Approved:

Maureen Grasso
Dean of the Graduate School
The University of Georgia
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DEDICATION

A mi familia, la mejor familia que se pueda tener, por el apoyo y amor sin límites que me han dado, y por ser todos para uno y uno para todos, siempre.

A la memoria de Don Héctor Oliveras Cummings, amigo, pescador, y gente de bien, quien por primera vez me llevó a conocer el mar del Sureste de Puerto Rico.

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CHAPTER 1

INTRODUCTION[1]

"¡El buen pesca'o, el buen pesca'o! ¡Fresquecito, escamaíto! ¡El buen pesca'o!"
(The good fish! The good fish! Fresh! Scaled! The good fish!)

-- A street fish vendor's sales pitch, yelled through a bullhorn, from a pick-up truck, at 7 o'clock in the morning. These words greeted me on the first morning I woke up in the house I had rented in Guayama, Puerto Rico.

'*Yo tengo el título para tu libro:* *Pescadores en Peligro de Extinción'*. (I have the title for your book: "Endangered Fishers"). Those were the first words that Don Teófilo[1] ever spoke to me, right after his brother introduced us and when I finished explaining to him the work I had hoped to do with his help, if he agreed to participate in my study. Don Teófilo, an expert fisher from the village of Aguirre, Puerto Rico, was among my first informants and later became a main collaborator, a teacher, and a friend.

It was March of 2003, and fishers throughout Puerto Rico were preparing to go to battle. Puerto Rico's Department of Natural and Environmental Resources (DRNA from Spanish name hereafter) had just distributed a draft of the newest Puerto Rico Fishing Regulations Code, which was tentatively scheduled to take effect on early 2004.

Following the distribution of the proposed regulations code was a collective uproar throughout Puerto Rico's coasts (Saavedra 2005; Pinto 2004a; 2004b). The new fishing regulations code was referred to by fishers as *"El Reglamento"* (The Code). The ominous sound of this moniker did little to hide the fear and contempt that fishers held for this latest attempt by

[1] To protect the identity of field informants, all fishers and other field collaborators who do not belong to universities and/or government institutions are identified by assumed names.

the state government to increase control over the use of fishery resources in Puerto Rico. Among the changes that the new code attempted to implement were 1) a revamping of the commercial and recreational fishing licensing system that would result in many of the most experienced fishers receiving a 'novice fisherman' license, 2) new sets of size-limit regulations, and 3) a complex scheme of closed seasons and separate license fees for some of the most important economic fishery species in the island. The most widely-vocalized criticism of the "The Code" by fishers is that in trying to exert excessive control over the use of fishery resources, "The Code" was robbing fishers of their most important survival weapon: the flexibility to take advantage of resources that varied in quality (e.g. different resource species) and in quantity over space and time (See Griffith, Valdés-Pizzini and García-Quijano 2006). In essence, this highly-detailed regulation was negating the utility of their local ecological knowledge.

Don Teófilo's wordplay in proposing a title for my work was very interesting because in assigning an "endangered" status to a labor group, commercial small-scale fishers, he was suggesting that this group of people was vulnerable and should be protected. In essence, he was using a technical term that in the past had been used to regulate highly lucrative fishery species (sea turtles and big groupers, among others). Only this time the 'endangered species', who needed help to avoid extinction, were the fishers themselves. Later in my work, during meetings, public hearings, and manifestations concerning "The Code", I heard the "Endangered Fishers" chanted during protests and saw "Endangered Fishers" written on signs during manifestations, until it became clear that this wordplay with the Endangered Species Act had become a war-cry of sorts for the movement of fishers against the implementation of "The Code". Wordplay and clever improvisation is a national pastime in Puerto Rico, a close second to talking about politics, and fishers were showing fine form in this pastime in appropriating the Endangered Species Act discourse for the purpose of resistance to a resource management scheme.

I had come to Puerto Rico to study the value of Local Ecological Knowledge (LEK) for fishing communities in southeastern Puerto Rico. The ink describing my hypotheses and research plan in my proposal was still wet, and I had arrived to the coast of Puerto Rico to find out that the most important thing happening for fishers was a serious struggle against the state, in which the fishers were defending what they perceived was their capacity to make a living from fishing. I considered briefly, but strongly, throwing out my original research project and dedicating my energies to document the conflict over "The Code". How could I interest them in talking extensively about fish and marine ecosystems, when their livelihood was a stake? Why should I occupy their time with questions about LEK when there were maybe other things I could document that would be of more help in their struggle?

Don Teófilo himself, later during that same conversation, gave me the answer to my rethorical questions. He told me, while pointing to the ocean from his water-facing porch: "*Ellos hacen sus leyes allá en el aire acondicionado, pero acá afuera es que nosotros conocemos y aquí es que nosotros nos defendemos*" (They make their laws in their air-conditioned offices, but out here (in the ocean) it is what we know, and here is where we defend ourselves). I asked him if he meant that the fishers' strength resided in being the ones who really knew what was going on under the water's surface. '*Exactamente. Eso mismito te estoy diciendo*'. (Exactly. That is exactly what I am saying to you) was Don Teófilo's reply.

The conversation with Don Teófilo that I am describing above was crucial in my decision to stay with my proposed topic of study, the value of LEK. Surely, LEK's primary value for fishers must be to help them find and catch fish, but LEK about local marine ecosystems is also their credential and their expertise, the body of knowledge that sets them apart from other labor groups, and which helps them make informed decisions over their short-term and long-term courses of action. LEK also enables Puerto Rican fishers to engage in discussions with relatively more powerful groups such as state management agencies and coastal developers. David C. Griffith wrote in a document that we co-authored that fishers in Puerto Rico faced the many obstacles of their daily life while "*armed with ecological knowledge*" (Griffith,Valdés-Pizzini and García-Quijano 2006). Griffith's insight resonates strongly with this work.

Figure 1.1. From an informant's sea-facing porch, we watched a local fisher give a young apprentice a lesson on the intricacies of casting a hand-line. The recipient of the lesson (on the right) watches attentively. Photo by H. Lloréns, 2005.

This dissertation is based on two simple but very important questions: 1) what do small-scale fishers want to achieve from their enterprise?, and 2) how does their knowledge of local ecosystems help them achieve it? These two questions (which drive the research objectives and hypotheses detailed in Chapter 3) are of importance for natural resource, and especially fisheries, management for a variety of reasons:

First of all, in any resource management scheme that intends to even marginally take into account the behavior of human resource users, some idea of what the goals of the resource users are (e.g. what do the resource users consider to be 'success' in their activity) will be needed. Second, is the intrinsic value of documenting Local Ecological Knowledge for maybe using it in resource management. LEK has been the focus of a growing body of literature that points to the importance of studying ecological knowledge held by small-scale natural resource users (e.g. fishers, farmers, hunters-gatherers) and further including this knowledge in resource management programs (Agrawal 1995; Aswani and Hamilton 2004; Berkes 1999; DeWalt 1994; Gadgil *et al*. 2003; Hamilton and Walter 1999; Hunn *et al*. 2003; Johannes 1978; 1981; 1998; 2001, Posey, Frenchione and Eddins 1984; Ruddle 1994). The continued experience of fishers with coastal environments, coupled with their LEK and the diachronic depth that their knowledge reaches through intergenerational communication make them an important, but largely untapped, source of information about continuity and change in coastal ecosystems (Folke 1991, Johannes 1981; Ruddle 1994). Recent research stresses that local knowledge can be a powerful tool for dealing with complexity and uncertainty in ecosystems for effective resource management (Acheson and Wilson 1996; Aswani and Hamilton 2004; Aswani and Lauer 2006;

Berkes, Colding, and Folke 2003; Gadgil *et al*. 2003; Kinzig 2001; Levin 1998, Olsson, Folke, and Berkes 2004).

Third is the focus on the adaptive value of LEK achieved by combining the two research questions above. LEK can be useful for the human groups who hold it in a variety of ways. It can serve to maintain group cohesion and identity in times of uncertainty and change (Posey , Frenchione and Eddins 1984), to illuminate the ever-challenging issues of allocating local resources (DeWalt 1994; Johannes 1981; Gadgil and Berkes 1991), and as a tool for traditional groups attempting to maintain control over their traditional territories and resources (Brush 1993; Nietschmann 1989; Peluso 1995; Orlove 1991; Ruddle 1994). Bodies of LEK, such as that of Puerto Rican fishers, result from the continued interaction of a highly specialized group of subsistence resource users with the ecosystems they depend on. LEK, then, is a product of ecosystem functioning and cultural/socioeconomic diversity, two factors that are currently endangered by degradation, modernization, and globalization (Blount 2001, Brosius 1997; Costanza *et al*. 2001, Folke 1991; Maffi 2001; McGoodwin 1990). Speaking about LEK in terms of its value for local communities and for resource management will be essential in order to make convincing arguments to protect local ecosystems and cultural diversity.

Theoretical Framework

Because of the interdisciplinary nature of this dissertation, the topics covered are broad, and most relevant literature is discussed in appropriate chapters. There are, however, some overarching themes that are relevant throughout this document, and they will be introduced in this section.

Intracultural variation in knowledge

Arguably the most important recent finding in the study of intracultural variation in knowledge is that agreement among individuals -cultural consensus- is a function of shared knowledge (Boster 1986; Romney *et al*. 1986; Weller 1987). Research on intracultural variation of ecological knowledge in human societies has found that the cultural information related to important natural resources (which affects patterns of use of the resources) is not only manifested in the overall presence or lack of consensus, but also in the patterns of agreement/disagreement in the population (Boster, 1985; 1986b; Boster and D'Andrade 1989; Boster and Johnson 1989; Medin *et al*. 1997; Romney 1997; Ross 2002).

The distribution of knowledge is affected by a variety of factors related to the social and personal characteristics of individuals (Boster 1985; 1986; 1996; Ross 2002). Another important source of variation in cultural knowledge is related to the domain of knowledge itself. Boster (1991) makes an important distinction between two kinds of domains that constitute endpoints of a continuum: On the one end, there are domains in which information is freely available and exhibits high coherence and redundancy (such as morphological types of plants and animals (e.g. Berlin 1992, Hunn 1977), or types of ceramic vessels (Kempton 1981) and thus one would expect novices to recognize the same underlying patterns as experts. On the other end, there are domains in which information is of poor quality or difficult to obtain, incoherent, or inconsistent (such as knowledge about the factors that affect blood pressure (Garro 1986), or knowledge about quantum mechanics). Local ecological knowledge about the underwater environment clearly falls within this second type of domain. In these cases one would expect for experts to agree considerably more than novices and thus agreement would constitute a good measure of cultural competence for that domain (Boster 1991; Garro 1986)

Knowledge and success in small-scale fisheries

Knowing where, when, and how to fish is the principal driver of decision-making for small-scale fishers (Ruddle 1994). Resource users' ecological knowledge is an important factor influencing compliance and further informing marine resource governance, thus there is a need for the study of the distribution of that knowledge (Pollnac 1998b).

Fishing is a hunting-gathering activity that relies heavily on the knowledge held by the individuals performing it (Acheson, 1981; Andersen and Wadel 1972; Breton and Estrada 1989; McCay, 1978; Ruddle, 1994; Smith, 1977). Fishers pursue a resource that is often mobile, and exists in a medium (sub-aquatic) in which the targeted resource cannot be easily seen. Therefore, fishers must constantly make inferences about the location, abundance, quality, and distribution of the resource. These inferences are derived from indirect observation and sampling. Every time a fisher sets out a net, hook, or trap, he/she is sampling the water for the resource, which can then be related to proxies such as water conditions, underwater environments and topography, weather, and catch characteristics (Acheson and Wilson 1996; Johannes 1981; Pollnac 1998, Ruddle 1994). Acheson (1981:290-91) states that among the skills needed by fishers are a detailed knowledge of the variety of species of fish/shellfish captured and about the physical characteristics of the marine environment, such as depths, currents, habitats, underwater topography, and zonation.

Success in small-scale fisheries

In a series of studies, John Poggie, Richard Pollnac, and colleagues (Poggie 1978; 1979; Pollnac and Poggie 1978; Pollnac, Gersuny, and Poggie 1975; Pollnac and Ruiz-Stout 1977), explored the relationships between culturally relevant traits of individuals and their success as small-scale fishers in Puerto Rico, Panama, and New England. Success was found to be related to traits such as deferred economic gratification orientation, entrepreneurial activities of the fishers, fishing effort, access to technology and means of production, boat sizes, experience, wealth, and political contacts. In Poggie's (1979) study, key informant success rankings of fellow fishers in Puerto Rico were correlated with traits widely believed to be related to success. The findings of Poggie's (1979) study suggest that: 1) using *emic* measures of success, (specifically, he used key informant rankings), is the most reliable way of determining success in a small-scale fishery, and 2) that success is a multidimensional phenomenon, thus it is affected by several cultural variables, including those forming part of the fishers' folk models of success.

Poggie (1979) was able to empirically investigate co-variation between success rankings and some of the identified determinants of success that were easily quantifiable (such as years of fishing experience, boat size, ownership of fishing equipment, fishing effort, and kin relationships to other fishers. The explanatory model of success, however, remained incomplete. Knowledge (labeled as *understanding* in the original) was widely believed to be an important determinant of success but, possibly because of the difficulties involved in obtaining quantifiable measures of knowledge, the actual relationship between knowledge and success remained only as an untested suggestion (this was also noted by Valdés-Pizzini (1985). This research will help resolve this problem by applying the more recent methodological approach of Cultural

Consensus Analysis (Romney, Weller and Batchelder 1986) to the task of differentially measuring cultural knowledge between individuals, and thus empirically test the relationships between knowledge and success.

This research is also closely related to a still-unresolved debate in maritime anthropology and marine resource management: the effect that individual fishers' characteristics have on fishing success, exclusive of all other factors (the "skippers' effect") (Durrenberger 1993; Gatewood 1984; Russell and Alexander 1996). This debate has been approached in the past by 1) assessing whether a skipper's skill has a statistically significant effect in catch rates (Palsson and Durrenberger 1990, Palsson and Helgason 1999), or 2) exploring and documenting folk models of fishers' skill and its effects in catch rates (Palsson 1988; Russell and Alexander 1996). Most of the research on this subject has focused on large, industrialized fisheries (e.g. Durrenberger 1993; Durrenberger and Palsson 1983; 1986; Palsson and Durrenberger 1982; 1983; 1990; Palsson and Helgason 1999; White 1989; 1992), where factors such as vessel size, capital investment, technology, and crew selection might obscure the effect of fishers' competence (Russell and Alexander 1996). Studies of the skippers' effect done on small-scale, non-industrialized fisheries have focused on competitive strategies and tactics, village leadership, and social status rather than directly on the knowledge of the fishers' themselves (e.g. Russell 1997; Russell and Alexander 1998). The debate over the skipper effect has mostly been about technology, social capital, and an obscure, monolithic cognitive body called 'knowledge' or 'understanding'. To the best of my knowledge, this is the first study placing fishing success in the context of distributed cognition of ecological knowledge about marine ecosystems.

The value of local ecological knowledge

A major development in ecological sustainability studies is the increasing recognition of the extent to which Natural Capital and Ecosystem Services contribute to human development and well-being. Natural Capital and Ecosystem Services are the services provided by functioning ecosystems (e.g. water purification, seed dispersion, disease control, carbon storage, etc.); therefore there is a concrete practical, economic value in preserving ecosystems and their functions (Costanza *et al.* 1997; 2001; Prugh *et al.* 1999).

Because local ecological knowledge is a product of the prolonged functioning of human ecosystems, local ecological knowledge is both *natural capital* (Costanza *et al.* 1997) and also *social/cultural capital* (Berkes and Folke 1992). Local ecological knowledge is *Ethnoecological capital* because it depends on 1) the continued interaction of a group of people with the ecosystems they depend on, 2) ecosystem functioning, and 3) cultural and socioeconomic diversity. The services provided by this form of capital (food, shelter, medicine, spirituality, independence, adaptability and many others!) go beyond the services provided by any of the other two forms of capital by themselves, bridging social and biological/ecological systems. *Ethnoecological capital* is at once resilient and vulnerable, because while its value and usefulness grow over time and thrives in change (within certain parameters), its continued existence depends on the continued interaction of cultural and biological diversity and the functioning of ecosystems, factors that are subject to many changes by inside-and outside forces (Maffi 2001; Blount 2001).

Tropical reef and estuarine fisheries such as those in PR are ideal for this study because they could benefit directly from including local ecological knowledge as a management tool.

This is because current biological and economic models are based on temperate fisheries that have strikingly different population dynamics from tropical ones. Achieving knowledge on the ecology and population dynamics of tropical fisheries by temperate population and economic models is difficult because: 1) the sheer numbers of harvested species; 100+ in this study's region (Johannes 1981; 2001; Roberts and Polunin 1996; Suarez Caabro 1979, 2) the ecological complexity of tropical reefs and estuaries (Aswani and Hamilton 2004; Johannes 1998, Roberts and Polunin 1996; Roberts 1997), 3) the lack of knowledge about continuity and change in fisheries over time (Gadgil *et al*. 2003; Jackson *et al*. 2001; Ruddle 1993; 1996; 1996b, Pandolfi *et al*. 2003; 2005), 4) the large variety of fishing gears and techniques used (Johannes 2001; Ruddle 1996b), and 5) Limited research, assessment, and enforcement funding for state management agencies (Johannes 1998; 2001), among other factors. Thus, tropical fisheries management can directly benefit from fishers' extensive knowledge of local trends of abundance and scarcity in fish species.

Throughout this dissertation, using a variety of methods and lines of evidence, I will explore some of the ways in which LEK about coastal/marine ecosystems is valuable for fishers in Southeastern Puerto Rico. The remaining chapters of this dissertation will be organized as follows:

Chapter 2 presents the ethnographic and ecological context of this study by defining and describing the study region. Coastal subsistence patterns that include fishing are explored, with an emphasis on socioeconomic and ecological complexity and how small-scale fishing is adaptive in those contexts. A description of the municipalities and coastal communities in the study region is included.

Chapter 3 presents the research design and methodology used in this study. I include an explanation of exploratory-explanatory (Johnson 1998) research, the synergistic utilization of combined qualitative, ethnographic methods with quantitative methods for testing hypothesis about culture.

Chapter 4 presents the exploration and analysis of cultural models of success in fishing. I provide a discussion of how ethnographic inquiry and a focus on human institutions can be a valuable tool for fishery management.

In Chapter 5 I explain the content and distribution of local ecological knowledge that is important for fishing in the tropical reef-estuarine ecosystems that surround southeastern Puerto Rico. I emphasize how ecological, parameter-based thinking about ecosystems helps fishers find fish among ecological complexity, habitat heterogeneity, and constant change.

In Chapter 6 I detail the value of local ecological knowledge for small-scale fishers and for fisheries management. In the first section of this chapter I test the hypothesis that fishers that possess more ecological knowledge will tend to be more successful according to local, culturally valid measures of success. In the second section of this chapter I illustrate a way in which fishers' knowledge can be useful for fishery management, by detailing fishers' opinions and recommendations about the recovery of the fishery for an important food fish species (the spotted goatfish, *Pseudupeneus maculatus*).

In Chapter 7 I conclude with a summary of the findings of this dissertation, followed by an explanation of the implications of this research for several fields of anthropological and interdisciplinary inquiry. I end the chapter with a discussion of the limitations of this research and the associated opportunities for further research.

CHAPTER 2

ETHNOGRAPHIC AND ECOLOGICAL CONTEXT

The study region

As is evident from the title of this dissertation, my study of the value of LEK for fishing communities has a geographic delimitation beyond a single specific political unit, a village, or a place-based community in the strict sense. The Southeast of Puerto Rico can be most accurately referred to as a region.

Regions may be classified according to their perceived common geographic, cultural, economic, and ecological characteristics (Cruz-Torres 2005). Much like a thematic map, a region can be defined by almost any variable or characteristic tied to a geographic area (De Blij and Mueller 2005). Van Young (1992:3, originally quoted in Cruz-Torres 2005) accurately observed that "*regions are like love- they are difficult to describe*, *but we know them when we see them*".

A number of anthropologists and/or political economists, most notably (Wolf 1982;1959), Wallerstein (1979), Fish and Kowalewski (1990), among others have used the geographical unit of a region as a basis for their analysis of economic, social, and/or ecological studies. As Stockton (1999) noted, relatively few ecological anthropologists have used an explicitly regional approach for their studies. Many ecological anthropologists, however, have used what could be termed a region as a unit of analysis without perhaps using the specific geographic term. Some examples of this that specifically refer to fisheries and/or watersheds are Nietchsmann's (1973) work on fishing along the Miskito Coast of Nicaragua, Griffith's (1999) cultural biography of the United States Atlantic Coast, Blount's (1999; 2002) and Cooley's

(2002) work on coastal fishing on the Georgia Coast, Rhoades (1998) work on using watersheds as social/ecological research units, among others. Moreover, many recent ecological research initiatives, most notably Long-Term Ecological Research (LTER) plans, use ‘regions’ as their unit of analysis (Gozs 1999). In the remainder of this chapter, I will briefly describe the physical, ecological, and ethnographic context of small-scale fisheries along my region of study, the coast of southeastern Puerto Rico.

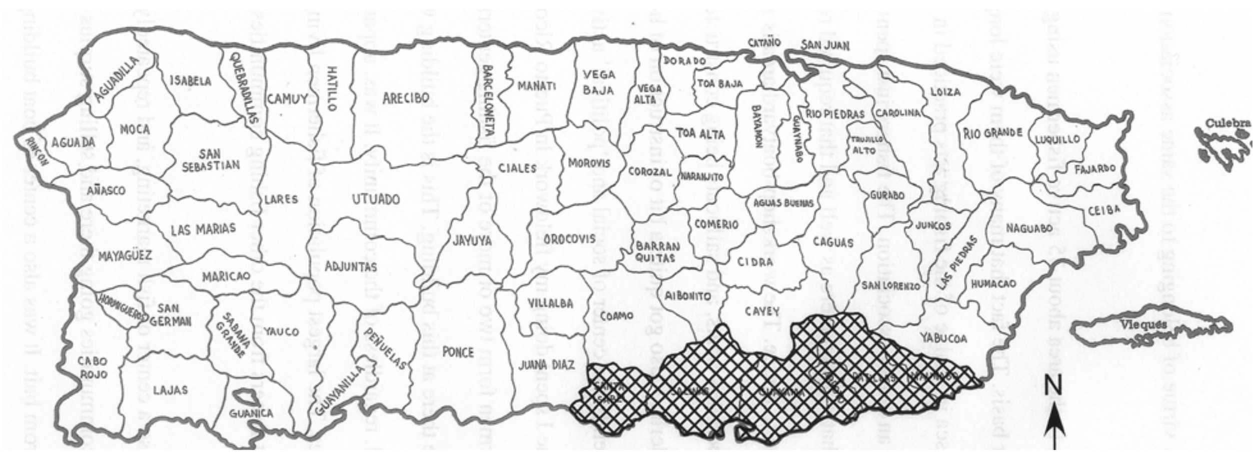


Figure 2.1 . Map of Puerto Rico with study region marked by pattern.

Physical and political geography

Puerto Rico is about 60 by 165 km, with an area of 9,104 km^2 and 501 km of coastline (Cadilla 1988) With a population of almost four million people, Puerto Rico has 418 people per square kilometer. Most people in Puerto Rico reside along the coastal plains. The region in which I have based my study of small-scale fishing is composed of the municipalities of (from East to West along the southern Coast of Puerto Rico) Maunabo, Patillas, Arroyo, Guayama, Salinas, and Santa Isabel, to which I will collectively refer to as Southeastern Puerto Rico or ‘the Southeast’ hereafter. Growing up in San Juan, Puerto Rico, it was intuitively clear to me that, “*El Sureste*” (the Southeast) is one of the regions of Puerto Rico, one defined by a rugged coast of mountains interspersed with coastal agricultural plains and which, relative to San Juan and other places in the island, was still visibly close to Puerto Rico’s sugarcane-based past economy.

Guayama, a relatively large city of 44,300 people (United States Census 2000), dominates the social and economic landscape by having concentrated administrative functions and opportunities for employment. Regional boundaries tend to be fuzzy: towards the Eastern and Western ends of this range, Guayama begins to share some of the economic dominance with the cities of Humacao and Ponce, respectively. It could be also argued that the region of Southeastern Puerto Rico also includes the municipalities to the east of Maunabo all the way to Humacao. In terms of Senate Administrative Districts of Puerto Rico, two of the municipalities (Patillas and Maunabo) are part Humacao District (PR Senate District #7) jurisdiction and the other four under the jurisdiction of the Guayama District (PR Senate District #6).

Patillas and Maunabo are, however, more closely related historically and socially to their neighbors to the West than to Humacao. Patillas used to be part of Guayama’s territory until 1811, when it was segregated into an independent municipality. Maunabo, while never an official part of Guayama, was founded in the early 1800’s by *Guayamenses* migrating east (Toro-Sugrañes 1995). Furthermore, Maunabo and Patillas are separated from their counterparts further to the East by the southeasternmost extension of the largest mountain range in Puerto Rico. Arroyo, located along the coast between Patillas and Guayama, was part of Guayama’s territory until recently. Arroyo became an independent municipality in 1855 (Lloréns 2005; Toro-Sugrañes 1995).

The eastern tip of the *Cordillera Central*, a range of mountains that traverses Puerto Rico along its east-west axis,'dives' dramatically towards the Caribbean Sea between Maunabo and its neighbor to the East, Yabucoa, shortly after bending south as a small mountain chain known as *La Sierra de Cayey* and an extension of *La Sierra de Cayey* called la *Cuchilla de la Pandura*. (Cadilla 1988; JOBANERR 2000). This geographic layout means that Maunabo and Patillas share the eastern part of Puerto Rico's Southern Coastal Plain with Arroyo, Guayama, Salinas and Santa Isabel.

To the west of Guayama, Salinas and Santa Isabel occupy the Southern Coastal Plain as it widens towards the mid-southern coast of the island, near the city of Ponce. Like Patillas and Arroyo, Salinas was a part of Guayama, although it also at other times formed part of it's neighbor to the north, Coamo (Toro-Sugrañes 1995). Santa Isabel is the westernmost town in this study area, and occupies an intermediate position between the southeast and the Ponce Metropolitan Area (Ponce and Juana Díaz) to the west. However, in terms of fishing and coastal subsistence, Santa Isabel is more similar and socially closer to Salinas to its east than to Juana Díaz to its West (Griffith, Valdés-Pizzini and García-Quijano 2006).

Coastal Geomorphology and Local Ecosystems

The coastal geomorphology of this region reflects Puerto Rico's complex geological past of episodic vertical and horizontal movements and alternating deposition of volcanic and carbonate rocks near the coastline. For more than 40 million years, Puerto Rico has been at the leading edge of the Caribbean Tectonic Plate (Krushensky and Schellekens 2001). The geological history has resulted in a coastline in which patchiness and discontinuity, rather than uniformity, dominate the landscape. Morelock, Ramírez and Barreto (2002:2) state that:

> Unlike the shorelines of many major continents, there are no long interrupted stretches of basically similar beach. The beaches are relatively short and are divided into separate and distinct beach systems that have restricted communication with one another. Each is a closed or semi-closed unit receiving its supply of sediment from limited local sources and transmitting little of its sand to another beach system (ibid.).

The geomorphological and topographical complexity of this coast is also reflected in marine ecosystems, which in turn shape the bodies of local ecological knowledge needed for coastal subsistence.

The southeastern part of Puerto Rico's Southern Coastal Plain coast is "*a low-lying alluvial plain with a coastline either of beach plain or of mangrove, and wave erosion where alluvial cliffs form the coast eastward*" (Morelock, Ramírez and Barreto 2002:5). The plain was formed by an extensive alluvial fan that extends from the mountain ranges to the north (Morelock, Ramírez and Barreto 2002). The plain extends from West to East until volcanic rocks from the *Cuchilla de la Pandura* mountain range reach the coastline. As with most coastal plains around Puerto Rico, much of the original flora has been removed to make room for coastal agriculture (specially sugarcane) and coastal development. More than 50% of this coast is suffering erosion (Morelock, Ramírez and Barreto 2002; JOBANERR 2002). This erosion is a major cause of marine ecosystem degradation through sedimentation of estuaries and coral reefs (Cambers 1998).

This coastal region (and especially its estuaries) depends on precipitation that falls on the southern slopes of the *Cordillera Central* and eventually makes its way to the Caribbean Sea. The three principal types of coastline that are found in Puerto Rico: rocky cliff and headlands, mangrove shoreline, and sand/gravel beaches are found interspersed throughout the study region. Going East, the coastline between Santa Isabel and Salinas fluctuates between beaches, rivermouths, and mangrove shoreline (Morelock 1998). Between Salinas and Guayama there are extensive mangrove forests, including the Bay of Jobos, site of the JOBANERR National Estuarine Research Reserve (NOAA). Small mangrove islands, called *Cayos* (Keys), with associated fringing and patch reefs are found close to shore from Santa Isabel to Guayama. Some of these small mangrove islands, specially the *Cayo Caribe, Cayo Barca, Cayo Cabuzazo and Cayo Berberia*, constitute prime fishing and recreation areas.

From *Punta Las Mareas* in Guayama eastward the coast is dominantly the result of wave erosion of the relatively unconsolidated alluvial plain material that lies south of the central mountains (Morelock 1978). Betweeen Arroyo and Punta Viento in Patillas, the coastline is predominantly beach-associated alluvial plain interspersed with mangrove shoreline and small estuaries. Between Cabo Malapascua in Patillas and Maunabo, rocky headlands divide sandy beaches as the *Cuchillas de Pandura* mountains come near the coast.

Estuaries, areas of sea- and freshwater mixing, occur throughout the region, along the mouths of multiple rivers and creeks, as well as in coastal mangrove forests. The second-largest estuary in Puerto Rico, the Bay of Jobos, occupies a central place in the marine ecology of the southeast, both geographically and ecologically. The estuarine zones of the region are important sources of nutrients for local marine life. They are also important nurseries and refuges for marine fish, mollusks, crustaceans, reptiles, birds, and mammals (Aguilar-Perera 2004; Delgado and Steadman 2004; JOBANERR 2000; Smith and Berkes 1993). Some of the most highly-regarded nearshore fishing areas in this study region, such as Media Luna Reef near Salinas, are patch reefs associated with estuarine bays.

Fringing reefs, patch reefs, and small barrier reefs occur at varied distances from the shore and throughout the area (JOBANERR 2002). These coral reefs, along with the *Cayos*, or mangrove islands, *Thallassia sp.* and *Syrygodium sp*. seagrass prairies, sand flats and muddy bottom areas make up an incredibly complex underwater environment where patchiness, rather than uniformity, seems to dominate ecosystem processes. The continental shelf (where most small-scale fishing in Puerto Rico occurs) is fairly wide by Puerto Rico standards (between 11-13 miles) south of Santa Isabel, Salinas, and Guayama, narrowing down from West to East until it gets as close as 1 mile to the shore near the coast of Maunabo (Morelock 1978). The change in width of the continental shelf from West to East has an effect on the local availability of different resource species and also on the time and effort that fishers from different locations throughout the study region have to spend in order to get to fishing grounds.

Table 2.1. Landings and revenues from fishing in region of study based on reports to fishery statistics program. Adapted from Griffith, Valdés-Pizzini and García-Quijano (2006)

Municipality	Landings 1999-03 (pounds)	avg. price (US$)	revenues (US$)	rank (Puerto Rico)	rank (in study region)
Arroyo	219,462	2.233	490,059	21	**4**
Guayama	464,378	2.283	1,060,075	11	**1**
Maunabo	124,104	2.245	278,613	31	**6**
Patillas	132,164	3.092	408,651	27	**5**
Salinas	319,765	2.408	769,994	17	**2**
Santa Isabel	220,437	2.776	611,933	20	**3**
Totals	**1,480,310**	**Avg. 2.506**	**3,619,325**		

Fish and fishing

Fishing in the study region is mostly small-scale, tropical reef-estuarine fishing. Reef-estuarine takes place in the immediate vicinity of coral reefs and/or in the various shallow-water and estuarine environments associated with tropical coastal regions, such as seagrass, mangrove forests, sand patches and mudflats. Tropical reef-estuarine fisheries represent a special case of humans interacting with an extremely complex, poorly understood environment (Polunin and

Roberts 1996). The following characteristics of reef-estuarine fishing apply to fisheries I the study region: 1) Reef-estuarine fisheries tend to be multi-species, multi-gear, and multi-habitat (Ruddle 1996; Pollnac 1998; 1998b), 2) Conditions in these fisheries tend to change at a very rapid rate (Ruddle 1996), 3) Because of the complexity of tropical marine ecosystems, reef-estuarine fisheries are specially vulnerable to mismanagement and overexploitation (McManus 1996; Polunin and Roberts 1996), 4) The overwhelming majority of reef-estuarine fishing takes place at the subsistence or small-scale commercial level (Pollnac 1988; Munro 1996), and 5) Successful reef fishing often relies on sophisticated bodies of local knowledge (Ruddle 1994; 1996a; Johannes 1981).

Puerto Rican fisheries are small-scale (McGoodwin 1990:8-11). This means that Puerto Rican fisheries are predominantly operator-owned, have low capital investment, are managed at the household level and are oriented towards petty commodity, informally marketed production (Griffith, Valdés-Pizzini and Johnson 1992; Pérez 2005; Valdés-Pizzini 1985; 1987; 1990). Puerto Rican fisheries have remained as small-scale despite periodic episodes of moderate to heavy investment by the Puerto Rican government to promote fisheries modernization (Pérez 2000; 2005).

Resource species

More than two hundred coastal, reef, and estuarine species of fish, crustaceans, and mollusks are routinely fished in Puerto Rico (Griffith, Valdés-Pizzini and García-Quijano 2005; Matos Caraballo 2002, Suarez Caabro 1979). At least one hundred of them are routinely fished in the study region (Riesco and Cepeda 1996; Suarez Caabro 1979). All species, however, are not equally important. Only 11 species account for over 50% of reported landings in Puerto Rico, and most species landed account for less than 1% of the landings (Griffith, Valdés-Pizzini and García-Quijano 2006, Matos-Caraballo 2002).

Economic importance is closely, but not perfectly, tied with locally-perceived importance and patterns in ecological knowledge. During the beginning stages of this research project I conducted freelisting interviews with 17 expert fishers from around the study region. I asked "please list all of the species that are important for fishing in this area". The 17 fishers mentioned a total of 101 species, with only 7 being mentioned by 10 or more fishers and only 29 being mentioned by 4 or more fishers. Analysis of both importance in reported landings and in perceived importance patterns suggest that while Puerto Rican fishers pursue- and thus need to have ecological knowledge pertaining to a wide variety of fishes, some species of fish are more economically and culturally important than others. One should, therefore, expect fishers' ecological knowledge to be more concentrated around the biology and ecology of those species.

As with other tropical fisheries in the Caribbean, most of the economically important fish species belong to the snapper (Lutjanidae), grouper (Serranidae), grunt (Haemulidae), mackerels and tunas (Scombroidae), jack (Carangidae), and parrotfishes (Scaridae) families. Mollusks such as the Queen Conch (*Strombus giga*), the common octopus (*Octopus vulgaris*) are also economically important, as well as crustaceans like the spiny lobster (*Panulirus argus*). Also important and routinely captured are bait species such as mullets (Mugilidae), anchovies (Engraulidae), sardines and herring (Clupeidae), and half-beaks (Hemiramphidae) (Suarez Caabro 1979; Riesco and Cepeda 1996). Bait species are very important for fishers through the study area. Most fishers report using live- or just-captured bait to fish. Very few, if any, studies have given attention to the cultural, economic and ecological importance of local bait species.

Some species of fish are not of major commercial importance, but, according to ethnographic data, are very important food fish for local consumption. This is the case of fishes such as the snook (*Centropomus undecimalis*), and the spotted goatfish (*Pseudupeneus maculatus).* Yet other species are regarded by fishers as important indicators of ecosytem health, such as the white mullet (*Mugil curema*), the black mullet (Mugil lisa), and *Penaeus sp*. Shrimp. The land crab (*Cardisoma guanhumi*) is a very important (and delicious!) food and commercial species, but the *jueyeros* (land crab hunters) are not widely considered fishers in a strict sense, and thus, in terms of social networks, fall outside of the scope of this study.

Table 2.2. Principal gear types and species landed through study region, based in reports to fishery statistics program (1999-2003). Adapted from Griffith, Valdés-Pizzini and García-Quijano (2006)

	gear1	**gear2**	**gear3**	**Species1 Landings (1999-2003)**	**Species2 Landings (1999-2003)**	**Species3 Landings (1999-2003)**
Arroyo	Gill net	Fish trap	Scuba	Parrotfishes (Scaridae)	Lobster (*Panulirus argus*)	Halfbeaks (*Hemyramphidae*)
Guayama	Fish trap	Gill net	Bottom Line	Lobster (*Panulirus argus*)	White Grunt (*Haemulon plumierii*)	Lane Snapper (*Lutjanus synagris*)
Maunabo	Gill net	Fish trap	Bottom Line	Lane snapper (*Lutjanus synagris*)	White Grunt (*Haemulon plumierii*)	Lobster (*Panulirus argus*)
Patillas	Fish trap	Scuba	Bottom Line	Lobster (*Panulirus argus*)	Lane snapper (*Lutjanus synagris*)	Parrotfishes (*Scaridae*)
Salinas	Fish trap	Gill net	Bottom Line	Lane snapper (*Lutjanus synagris*)	Yellowtail Snapper (*Ocyurus chrysurus*) Mutton Snapper (*Lutjanus analis*)	White grunt (*Haemulon plumierii*) Lobster (*Panulirus argus*)
Sta. Isabel	Fish trap	Gill net	Long Line Scuba	Lane snapper (*Lutjanus synagris*)	Lobster (*Panulirus argus*)	Yellowtail snapper (*Ocyurus chrysurus*) Mutton snapper (*Lutjanus analis*)

Fishing vessels

Yolas are by far the most widely-used small-scale fishing vessels in Puerto Rico. A *yola* is a generic term for locally-made flat-bottom wood or wood-and-fiberglass boats that typically range in size from 10-25 feet long. Many *yolas* have a built-in fish tank, called *vivero*, used to keep catch alive and fresh as long as possible. *Yolas* are typically operated with a small outboard engine. The use of *yolas* spread after the 1970's, when state-sponsored programs to develop fisheries in the island engaged in promoting and subsidizing the use of small outboard engines (Pérez 2005; Valdes-Pizzini 1987). Nowadays virtually all fishers around Puerto Rico routinely use outboard engines to go out to sea.

Yolas can be made of locally harvested wood, but most *yolas* nowadays are made from a combination of local wood and treated planks bought at hardware stores and/or woodlots in the area. Four of my key informants were expert *yola* builders and several times I had the opportunity to see how a *yola* was built. While each of those fishers was a specialist in a different type of *yola*, they all agreed that treated wood planks were only good for building the floor and the sides of the *yola*. The structural features of the yola (keel and ribs) had to be built out of carefully-selected branches and trunk sections from one of several species of trees that have very light and flexible, yet strong and non-porous, wood. Some of the locally-abundant trees that the *yola*-builders mentioned were: *Frescura or Emajaguilla* (*Thespia populnea*), *Uva Playera* (*Coccoloba uvifera*) and the red mangrove (*Rhizopora mangle*). Red Mangrove harvesting has been highly restricted during the last decade, so most of the tree harvesting for boats has fallen on the other two species.

As with any wooden vessel, *yolas* need to be water sealed before being launched into the water. The process of caulking (*calafatear*) every crevice or space between pieces of wood is extremely laborious and, according to my observations, can account for at least half of the effort involved in building a *yola*. Caulking is done by using a *calafate*, a small steel mallet, to insert pieces of *estopa* (burlap) between every crevice and empty space along the hull. After the burlap is snugly inserted, the *masilla,* a filler-glue made of flour and water, is applied to seal the spaces. The process of inserting the burlap is called *calafatear*. The process of applying the filler-glue is called *amasillar*. After letting it dry, the yola is painted. After the vessel is finished, a Department of Natural Resources representative comes to inspect and declare the boat safe for navigation. Only then a vessel identification number is painted on the *yola* and it is ready to be launched. Using a combination of wood and fiberglass to coat the outer hull and to add structural durability to high-use areas such as the engine transom or the sides is a very common practice. According to fishers, a wood-only *yola* has to be grounded for maintenance every 3-4 months. A wood and fiberglass *yola* has to be grounded once a year.

Size and hull design of *yolas* is diverse. *Yolas* are built to suit particular types of gear, navigation distances, the kinds of seas (open or inshore, rough or calm) the boat has to face, and whether the *yola* will be launched from a high surf or low surf beach, a dock, or a trailer. Some of the variation in design also follows the individual preferences of builders that can also become regional trends through the builder's apprentices and sharing/copying of designs. For example, according to some fishers a sturdy, large-sized (21 feet plus) *yola* with a wide flat area towards the front of the vessel is ideal for carrying fish traps and anchoring trap-lifting winches, while a small (12 feet long) skiff-like *yola* that can be either engine-propelled or oar-maneuvered by one person is ideal for setting drifting nets inside a bay or along the land-facing edge of reefs. A fast, responsive medium-sized (15-21 feet) *yola* with straight lines is ideal for setting longlines and for taking quick trips to the deepwater snapper fishing grounds away from shore (figure 2.2). A highly skilled operator can, of course, use almost any *yola* (except for the more extreme designs) for a variety of purposes. *Yolas* and locally-made fiberglass boats owned by the 61 fishers I collaborated with during this study ranged between 14 and 29 feet long, with a mean of 18 feet long (Std. Error .451). The outboard engines used by the 61 fishers ranged between 350 and 10 horsepower (HP), with a mean of 55HP (Std. Error 10.26).

Figure 2.2. A longliner's yola, ready to fish, in Santa Isabel, Puerto Rico.

Before the spread of outboard engines, most fishing in Puerto Rico was done by sail (Suarez Caabro 1979). Most of the building and waterproofing techniques used today to build *yolas* were developed to build the once-ubiquitous sailboats, alternatively called *chalanas, veleros nativos*, or *chalupas*. These names can be used interchangeably but can also reflect differences in hull design, such as size and keel-shape. The sailboats were also diverse in size, sturdiness, and purpose, in a similar fashion to today's *yolas.* Most of the fishers over 50 years old whom I met during my fieldwork started out as sailboat fishers and two of them are widely known traditional sailboat builders and navigators. The traditional sailboats are no longer used as fishing vessels, but are still built around the coast, especially in Salinas and Santa Isabel. A very popular traditional sailboat regatta series is held annually at various locations from Salinas to Arroyo. Most of the participants in the regatta are fishers as well.

Figure 2.3. *Chalanas*, local sailboats, in the community of Playa Cortada. The tree to the left, behind the boats is a *Frescura* (Emajaguilla) tree (*Thespia populnea*), a common tree used to build boats in the area.

A few fishers through the study region used imported fiberglass-hulled, open-fisher powerboats or large multi-day trip working boats for fishing. The open fisher boats (such as the SeaHawk 21' boats assigned to various fishers associations in Puerto Rico through the

Department of Agriculture) are essentially faster, and much more expensive versions of a *yola:* A *yola* can be built with a couple of thousand dollars, with the most significant investment being the outboard engine. A 21’ SeaHawk can sell for more than 15 thousand dollars and repairs are much more expensive.

The larger working boats (35+ feet) are usually used for deepwater hook-and-line or trap fishing for deepwater snappers. Buying one of these boats is a very large investment, and the few that I saw were owned by fishing associations, rather than individuals, and were bought with the help of state subsidies. According to fishers, many of these large boats were bought during the 1970’s and 1980’s, during the period of state investments in fisheries modernization described by Pérez (2005). Some individual fishers achieved great success as large boat owners, until the advent of Exclusive Economic Zones in the early 1990’s that rendered productive fishing grounds in the British Virgin Islands and the Dominican Republic off-limits for Puerto Rican fishers. Deep-water snapper fishing never reached in this region the level of investment seen in the municipalities of Lajas and Cabo Rojo in southwestern Puerto Rico (Valdés-Pizzini 1985).

Fishing gear

Similar to other multi-species tropical fisheries (Ruddle 1996), a wide variety of fishing gears are used to capture fish in Puerto Rico (Ojeda 2000, Riesco and Cepeda 1996, Suarez Caabro 1979). Fishing gear in Puerto Rico is generally locally-made and inexpensive, and it probably is the single best material indicator of the small-scale nature of Puerto Rican fisheries. Fishery landings data for 1999-2003 for Puerto Rico lists 20 different fishing gear varieties, with five gear varieties accounting for over 90% of the landings (Griffith, Valdés-Pizzini and García-Quijano 2006). Please see Table 2.3 for a summary of the gear types. All of the gear varieties used around Puerto Rico are used in the Southeast, but there is considerable variation in dominance of fishing gear types from one community to the next. For example, Guayama fishers are widely known for being prolific *nasa* (fish trap) fishers. Six of the 10 fishers with the largest number of fish traps in Puerto Rico hail from Guayama (Valdés-Pizzini, pers. comm., 2003). Santa Isabel, on the other hand, is a stronghold of *palangre* (long line) fishing in Puerto Rico, while in Arroyo, most fishers use drift nets or dive for conch and reef fish.

Table 2.3. Types of gear used in Puerto Rican small-scale fisheries, adapted from Griffith, Valdés-Pizzini and García-Quijano (2006). Translation of gear names is mine.

Gear (English)	*Gear (Spanish)*	*Percent reported*
Bottom line	*Línea de fondo*	*29.2*
Fish trap	*Nasa*	*26.8*
Scuba diving	*Buceo con tanque*	*16.7*
Gill net	*Filete/Chinchorro*	*13.9*
Troll line	*Silga*	*5.1*
Trammel net	*Trasmallo/Mallorquín*	*2.1*
Skin diving	*Buceo a Pulmón*	*1.7*
Long line	*Palangre*	*1.2*
Beach seine	*Chinchorro de arrastre/playa*	*1.1*
Lobster trap	*Cajón/nasa de langosta*	*1.0*
Cast net	*Atarraya*	*0.9*
Rod & reel	*Caña*	*0.2*
Land crab trap	*Trampa de jueyes*	*0.1*

Suarez Caabro (1979) classifies the fishing gears of Puerto Rico using 5 general categories (translation mine): 1) hook-and-line gear, 2) net gear, 3) fish trap/trap gear, 4) search-and-capture gear, and 5) auxiliary gear. The technology used to build and prepare the various fishing arts is constantly evolving as fishers interact with the larger regional and global economies. Many raw materials that in the past had to be fabricated are now catalog-ordered from mainland United States marine suppliers. Two of the most dramatic developments in fishing gear in the past two decades have been: 1) the advent of monofilament net material, which largely displaced cotton woven nets, and 2) the shift in materials used for the construction of fish traps, from mangrove and sea grape wood to welded steel rods (Suarez Caabro 1979).

Figure 2.4. A fisher repairs his gillnet in Aguirre, Puerto Rico

Fishers Associations

A widespread characteristic of small-scale fisheries around the world is the existence of associations, cooperatives or unions of fishers. These common-interest organizations come together to protect labor group interests, pool or share information, resources and equipment, or simply to help each other during sea emergencies (Breton *et al.* 1985; Breton y Lopez-Estrada 1989; Comitas 1962, Valdés-Pizzini 1990).

In Puerto Rico, the most common form of labor-group organization by fishers is the Fishers Association, an organization that enjoys recognition from the state as a public-interest group and is thus eligible for subsidies and tax breaks. According to Valdés-Pizzini (1990: 167) a fishers association is different from a cooperative in that generally, "*the fishers belonging to an association own their boats and are responsible for their production and revenues. That is, they remain petty commodity producers with individual ownership over the means of production*".

Fishers Associations around Puerto Rico are very diverse institutions. Fishers Associations differ form one another in their level of organization, membership exclusivity, involvement in fish marketing and engagement in political activities (Griffith, Valdés-Pizzini and García-Quijano 2006). Fishers Associations are usually named after the municipality or coastal community in which they are based. Membership may or may not be restricted to fishers living in that community. Some associations are involved in all realms of their members activities, from providing equipment to the processing and marketing of fish. In other cases, a Fishers Association might only provide a physical space to use and might only engage in organized action over specific issues or economic/political threats to its members (Griffih, Valdés-Pizzini and García-Quijano 2006; Valdés-Pizzini 1990). In some coastal communities, most fishers belong to a Fishers Association, while in other communities very few or none do.

Coastal subsistence in southeastern Puerto Rico

Politically, geomorphologically, ecologically, and historically, the coastal municipalities between Santa Isabel and Maunabo in Puerto Rico can be said to comprise a region. This study, however, is primarily about fishing. The commonalities related to fishing and coastal subsistence are what make the southeastern coast of Puerto Rico an ethnographically coherent unit for this study.

Figure 2.5. A Fishers Association in Maunabo, Puerto Rico

I have used the term ‘fishing and coastal subsistence’ instead of just ‘fishing’ in the preceding pages because fishing is not the only activity tying this coastal region together in profound ways. Rather, it is ‘coastal subsistence’, a lifestyle that partly depends on fishing but also on coastal agriculture and other jobs such as work in local industries. The fishers with whom I collaborated throughout this study held jobs as varied as farmer, boat builder, master welder, policeman, mechanic, fireman, leather worker, truck driver, carpenter, and agronomist. Griffith and Valdés-Pizzini (2002) have compellingly shown that in Puerto Rico fishing is part of a complex coastal household economy of episodic ‘*labor* (in the proletarian sense of agricultural and industrial laborers) and subsequent *refuge* (in fishing and interaction with coastal ecosystems)'. Less than one generation ago, this repeated journey between fishing and land-based labor happened mainly between the sea and the sugarcane field.

Fishing and sugarcane labor have historically coexisted very closely along Puerto Rico's Coastal Plains. All of the fishers that I interviewed for this study had been dependent (either directly or through their parents while they were growing up) on seasonal sugarcane agriculture labor together with fishing. This phenomena of dual coastal subsistence in Puerto Rico's coastal plains has been documented over time by authors such as Griffith and Valdés-Pizzini (2002), Mintz (1956: 1974; 1960), Steward (1956), Giutsi-Cordero (1994) and others. Mintz' iconic '*worker in the cane*', who lived in the 1950's in Santa Isabel's coast, was a sugarcane worker and a fisher (Mintz 1960).

It comes as no surprise that a subsistence activity like fishing, which is associated mostly with rural coastal living in this area, has close ties with sugarcane growing. All aspects of life in the Southern Coastal Plain of Puerto Rico are closely tied to sugarcane. The following quote in a book about the history of Guayama illustrates this more eloquently: "For more than a century and a half since about 1820 the predominant agricultural use of this plain was the growing and grinding of sugarcane to produce raw sugar to be refined in the United States and to a lesser extent in Europe. As Rafael Picó put it in 1938, "Everything from Ponce to Patillas is connected with sugar'" (Figueroa 1991:94, in Lloréns 2005).

Fishing was very important to the subsistence of the people who were seasonally employed and laid off, only to be employed and laid off again the following year. As was repeated to me throughout this study, fishing historically provided the poor communities of sugarcane laborers with what was sometimes the only quality protein they would consume for the duration of *El invernazo*, the dead season, which lasted for up to 7 months of each year. The fact that fishers were such important providers of food for coastal communities in the study region is closely related to fishers' cultural models of social and economic success in fishing.

In the words of Don Gero, an elderly fisher from Aguirre: "*Por toda ésta area se practicaba la pesca de invernazo*" (Dead season fishing was common practice throughout this area). *Pesca de invernazo (*dead-season fishing), was fishing that mostly took place during the dead seasons or winter closures of sugarcane mill operations. These closures could last anywhere from four to seven months of the year. The situation during the dead season was very difficult for communities dependent on sugarcane employment. According to the elder among my informants, periods of widespread hunger were not uncommon until as recently as the 1960's. Fish caught locally could be the only protein (and one of the few food items) that people in these communities had access to for a good part of each year. A number of people in each area took to fishing as a dead season activity. In many ways, the nutrition of people in these communities rested on the shoulders of fishers. The words of Don Ricardo, describing the typical diet of sugarcane laborers during the dead season, illustrate this point perhaps more poignantly:

> *En las mañanas, comíamos funche con café. Al medio día, café con funche. En la noche, funche con café de nuevo. Y asi por meses, a menos que hubiera pesca'o*
> (In the mornings, we ate cornmeal with coffee. At lunchtime, coffee with cornmeal. At night, cornmeal with coffee again. It went on like that for months, unless we had any fish).

The material remains of the historical link between fishing and sugarcane labor are still visible today. Abandoned sugarcane fields surround many of the coastal communities, and the ubiquitous tower of one of the region's abandoned sugarcane processing mills (the "rotting corpses of history" (Lloréns 2005)) can be seen from almost any coastal community in the area.

In a collaborative study related to this research, I was in charge of ethnographically assessing fishery dependence in the southwestern coastal town of Guánica, Puerto Rico (not included in this study, but which was similarly historically dependent on sugarcane growing and fishing). The following excerpt, which I wrote describing the landscape as I entered a coastal community in Guánica, southwestern Puerto Rico, could be used to describe an entrance to many of the coastal communities included in this study:

> "As one approaches Guánica going on route 16 from east to west, towards *Guaypao/Caña Gorda*, one can see the abandoned remains of the old Central Azucarera right between the road and the coast. The main building looks like a cross between a old hangar and an oversized barn. There are some smaller replicas of that building besides it and two large chimney towers a little farther towards the coast. Right on the coast there are two large docks, now abandoned. One is your regular large, low-lying cement dock, the kind of dock used for embarking or disembarking miscellaneous goods and/or people. The other dock doesn't have a low-lying cement platform, but a scaffolding-like construction consisting of aerial ramps, conveyor belts, and tubes used to fill the holds of outgoing vessels with sugar…All this is now abandoned but when you look around it you see coastal settlements where people now live. When you approach one if these settlements you start to see the unequivocal signs of a community that is dependent on fishing to some degree: *yolas* on the water or on the yards of houses, nets or fish traps piled up on a driveway, "*hay pescado*" (fish for sale) signs, etc.." (Griffith, Valdés-Pizzini and García-Quijano, 2006).

My ethnographic observations indicate that fish caught locally still is an important source of high-quality protein, even though fishers comprise a small portion of the population and face stiff competition from imported fish sold in supermarkets (also see Pérez 2005). In those ways, fishing binds this region together.

Regional and global economic integration

The last sugarcane mill to close operations in southeastern Puerto Rico was Central Aguirre in 1990 (Vázquez-Orlandi 1998; JOBANERR 1997). Even before then, most other sugarcane operations had long been closed and Central Aguirre was operating at only a fraction of its capacity (JAPR 1988:65). Although the historical dependence on sugarcane still shapes coastal communities in the study region, sugarcane labor is no longer an option for coastal residents looking for employment. In the post-sugarcane coastal landscape of the southeast, a series of industrial developments in the area (especially in the municipal territory of Guayama) have taken over as major providers of employment. Most notable among these are pharmaceutical developments, two petroleum refineries, and two power plants that generate electricity for much of the rest of Puerto Rico (see table 2.4).

Fishers and other coastal residents have a conflicted relationship with these industrial developments. On one hand, the developments provide much-needed employment. On the other hand, local residents, because of their rural background and lack of formal education, are often employed only at the lowest levels of salary and power within the companies that operate these developments. Entire communities, such as the coastal community of Barrancas in Guayama, have been relocated to make space for coastal industries. Local residents also have to deal directly with the extensive impact that these industries have on local ecosystems. Respiratory health problems are common and at least some of the incidence is attributable to industrial emissions from local factories (Seguinot 2000; Umpierre 2003).

Wetlands and locations along the shore are preferred locations for industrial complexes because of the extensive flat areas, because it eases delivery and shipment of materials by cargo ships, and because water from local estuaries is used for the cooling systems of industrial machinery. Industrial activities along the coast increase the opportunities for episodes of pollution and degradation. As with cases around the coastal plains of Puerto Rico (such as Pérez 2005), the promise of jobs and modernization has come at the cost of disproportionate environmental burdens shouldered by coastal communities. Fishers and their families suffer the most, since vast expanses of critical habitat and nursery grounds for fishery species have become degraded by coastal industries. Several of the fishers with whom I talked during this study, found themselves needing a coastal industry as a source of employment for the fisher and/or his/her family, while at the same time fighting and hating it because of the industry's destruction of local ecosystems.

Levels of Engagement in Fishing

Very few fishers in Puerto Rico have been only full-time fishers all of their lives, and there is no coastal community in Puerto Rico that depends only on fishing for its survival (Griffith and Valdés-Pizzini 2002, Griffith, Valdés-Pizzini and García-Quijano 2006). An average of two thousand people depend on fishing as an economic activity in Puerto Rico, since the state began taking a census of fishers in 1971 (Perez 2005).

These numbers by themselves tell very little about the true nature of fishery dependence in Puerto Rico. A series of works over the last 20 years have greatly advanced the understanding of the varied ways in which coastal Puerto Ricans engage in fishing and related activities. Valdés-Pizzini (1985) spearheaded these studies by examining how social networks structure economic relationships between fishers in southwestern Puerto Rico. Griffith, Valdés-Pizzini and Johnson (1992) applied peasant labor theory to Puerto Rican fisheries and described the status of fishers in Puerto Rico vis-à-vis the rest of the labor economy as a status of 'semi-proletarianization'. Fishers are proletarian laborers, but only partially: by engaging in fishing they allow themselves the opportunity to be strategic about their involvement in the labor economy. Griffith and Valdés-Pizzini (2002) expanded upon these results and further showed that fishing is the common thread that holds the economic lives of many coastal Puerto Ricans together as they bob and weave through repeated employment and joblessness, displacement, emigrations (to the capital city of San Juan and/or the United States) and returns home.

Table 2.4. Large Coastal Industries in the study area. Data compiled from Enviromapper Server, United States Environmental Protection Agency, 2005.

Company name	**Type of Activity**	**Location**
Johnson & Johnson	Pharmaceutical	Arroyo
Stryker	Biomedical	Arroyo
AES Jobos Steam Power Plant	Electric Power Generation	Guayama
Ayerst-Wyeth	Pharmaceutical	Guayama
Baxter	Pharmaceutical	Guayama
Chemsource, Inc.	Pharmaceutical	Guayama
Colgate-Palmolive	Pharmaceutical	Guayama
ICI	Pharmaceutical	Guayama
IPR	Pharmaceutical	Guayama
Phillips Puerto Rico Core	Petroleum Refinery	Guayama
Smithkline-Beechamn	Pharmaceutical	Guayama
Squibb	Pharmaceutical	Guayama
General Electric	Manufacture	Maunabo
AEE Aguirre Power Generation Complex	Electric Power Generation	Salinas
Steri-Tech Inc.	Biomedical	Salinas
Allergan	Biomedical	Santa Isabel

Pérez (2000; 2005) examined the relationship between the state and fisheries in Guayanilla, Puerto Rico in the context of attempts to modernize fishing and coastal subsistence. Pérez found that fisheries were at the same time resistant and highly vulnerable to top-down modernization attempts: Fishers and their communities in Puerto Rico resist the loss of economic adaptability and flexibility brought about by modernization, but at the same time are highly vulnerable to the streamlining of the economy and the local resource degradation that often accompany modern development.

Figure 2.6. Coastal industrial complexes along the estuary. Guayama, Puerto Rico

More recently, Griffith, Valdés-Pizzini, and García-Quijano (2006) have attempted to understand fishers and their communities in Puerto Rico in terms of: 1) their economic dependence on fishing, and 2) the levels of entanglement of the fishing activity in other aspects of coastal subsistence and in the context of the larger economies that surround it. Among other things, they have found that despite very diverse approaches to the problem of economic survival, most fishers share the belief that their subsistence activities are a moral enterprise, an ecologically-sound, productive, and socially-just use of marine resources. This is based on fishers' understanding of ecological and social contexts, and they report being willing to resist and struggle to have access to the resources.

Fishers' recent struggles for access to coastal and marine resources

As I explained in the introduction to this work, the most talked about topic in fishers' social circles when I started my fieldwork in Puerto Rico was the recent publication of a new fisheries code (DRNA 2004) by the Department of Natural Resources. Fishers almost-universally regarded the new code as a heavy burden on their ability to make a living from fishing. It was also perceived as the latest in a series of state policy developments that put the burden of marine and coastal conservation on small-scale fishers, while comparatively rich and powerful coastal industries and tourism developments had a *carte blanche* to engage in activities that were very harmful to the environment. A fisher in Salinas told me:

> The mangrove swamps and sea bottom areas that the *Termoeléctrica* (The Aguirre Powerplant, which is widely held responsible for degrading the Bay of Jobos estuary) kills in one year represent much more damage than the entire population of fishers in this area could cause in a 100 years of fishing

Resistance and organizing against the new fisheries code reached a recent peak in May 17th, 2004, when hundreds of fishers from around Puerto Rico marched towards the Department of Natural Resources office in San Juan to protest the fishery code. I attended this demonstration along with my research assistant Taína Rivera, a student of Marine Biology at the University of Puerto Rico. Many of the fishers whom I had met with during my work in the previous year were at the demonstration, and their presence allowed me to join them and observe from within and ask questions, even though I was clearly not a fisher.

From the slogans chanted and the signs wielded during the march, it was clear that the fishers deeply believed that they had a moral imperative to protect their livelihood. It was also apparent that fishers held the ecological and field expertise of the DRNA officials in very low esteem, as evident from the several signs that read "*No hagan leyes desde el aire acondicionado*"

("Do not attempt to make laws from your air-conditioned offices"). At nearly 2 O'clock in the afternoon, the DRNA Secretary sent an emissary out of an air-conditioned office to announce to the fishers that the implementation of the new fishery code would be suspended indefinitely upon further review of the code's content. The emissary also invited fishers to the nearby House of Representatives to witness proceedings as a representative declared a moratorium of the fishery code implementation until further notice. Many fishers, and I along with them, entered the House of Representatives and sat as the proceedings went on. From my conversations with fishers upon exit, it appeared that neither them (nor I) had fully understood what had just gone on during the proceedings. The halls of government were clearly not a friendly place for them (or me, for that matter).

Conflict between fishers and the state is not uncommon either in Puerto Rico or in many fisheries around the world. As access to coastal space and resource is negotiated, many instances of conflict and semi-resolution will inevitably result in more conflict. Fishers have a greater chance do better in these conflicts when they are fought on their familiar territories, along the coast or in the installations of their fisher associations. Some groups of fishers have become very adept at enrolling public support through the newsmedia or through lobbying with local politicians who might need their and their families' votes in the future (Valdés-Pizzini 1990; Griffith and Valdés-Pizzini 2002). However, once the storm generated by a particular conflict passes, they have to deal with their powerful adversaries during the course of everyday life.

Description of the fishing communities included in this study

In the previous sections of this chapter, I have argued that the six coastal municipalities included in this study comprise an ethnographically- and ecologically coherent region for a study of small-scale fishing. This is not to say that the different municipalities, nor the communities of fishers that live in the different municipalities, are uniform. In the next section of this chapter, I will briefly describe the general demographic characteristics of each of the coastal municipalities included in this study and some key characteristics of fishers and fishing communities in each municipality. I wrote the municipality and fishing community descriptions below partly as a result of my collaboration with David Griffith and Manuel Valdés-Pizzini in a large-scale research project studying fishery dependence in Puerto Rico Rico (Griffith, Valdés-Pizzini and García-Quijano 2006). My collaborators in that study have kindly allowed me to include these descriptions in this dissertation, and many of the ideas that guide these descriptions of fishing communities are attributable to our collaboration.

Table 2.5 . Population and number of fishers for the municipalities in the study region.

	Population (2000 United States Census)	Number of fishers (PR fishers census)	Number of of fishers (field assessment)
Arroyo	19117	21	45-50
Guayama	44300	31	60-70
Maunabo	12741	10	20-25
Patillas	20150	10	45-50
Salinas	31113	23	70-80
Santa Isabel	21665	32	55-60

Arroyo

Arroyo was part of Guayama until 1855 (Toro-Sugrañes 1995). Arroyo’s Population is 19,117 (2000 United States Census) and there are 21 registered fishers (Matos-Caraballo 2002). My personal observations and conversations with fishers reveal that the number of fishers in Arroyo is close to 50. Arroyo’s fishers landed approximately 45 thousand pounds of fish in between 2002-2003, worth more than 100 thousand dollars (Griffith, Valdés-Pizzini and García-

Quijano 2006; NOAA Fisheries). Employment and poverty levels are relatively high compared to the rest of the island. Arroyo was the most important seaport in the Southeast Coast until the early 20th century. Central Lafayette was a sugarcane mill that, along with the port of Arroyo dominated economic life in this municipality (Lloréns 2005).

The port of Arroyo is adjacent to the waterfront, and consists of a small embayment protected by a breakwater, about 30 small-boat slots used mostly by fishers. On the entrance to the embayment, to the western side, are the Arroyo Fishing Association (Coral Marine Inc.) grounds. Fishers in Arroyo have better than average facilities and Arroyo's fishing association has managed to maintain access to impressive and well-kept facilities that include freezers for storing catch, around 25 docking slips along Arroyo's downtown waterfront, and a large and well-equipped shop area. The association's members (about 40) have their own boats, but the association also has 6 SeaHawk 21-feet powerboats with v-hulls and Yamaha 85HP outboard engines. An association official reported that the association got the powerboats from the Department of Agriculture in 2001. These boats and other political successes have kept membership in the association high.

The fishing association is very active in local politics and Arroyo fishers have been very successful in enlisting local politicians level as benefactors. In a small, very strongly ocean-oriented town like Arroyo, the fishers association officials can use the possible electoral numbers of association members, members' families and friends, to use as leverage to secure the mayor's and local representatives' attention. Similar strategies by fisher associations were documented in southwestern Puerto Rico by Valdés-Pizzini (1990).

Fishers in Arroyo are currently atempting to find funds to dredge the bay where the fishing association sits. This bay was dredged 20 years ago as part of a project to revitalize

Arroyo's waterfront, but due to faulty design of the breakwater, sediment from a nearby rivermouth has filled the bay with sediments, making the entrance to the bay treacherous and impossible for any boat larger than a small *yola.*

All age groups and most types of fishing gear are represented in Arroyo, but Arroyanos are widely perceived to be a younger group of fishers than fishers in some neighboring municipalities. Related to this age perception is that scuba diving (viewed as a young person's activity) is a relatively popular fishing activity compared to other fishing strategies, with 57.1% of fishers reporting scuba diving as an important activity (Griffith, Valdés-Pizzini and García-Quijano 2006). Fishers from Arroyo routinely fish a wide area along the southeastern coast, but the extensive seagrass shallows and some fringing reefs located 2-3 miles offshore between Guayama and Arroyo appear to be a preferred area.

Guayama

Guayama has long been the center of economic activity in the Southeast. This city has a population of 44,300 (2000 United States Census) and there are 31 registered fishers (Matos-Caraballo 2002). From my observations and conversations with fishers, I would place this number at around 60-70 fishers. Through its former port of Arroyo, and the coastal barrios of Las Mareas, Machete and Pozuelo, Guayama has historically dominated seagoing activity in the area. Because it is a medical, commercial, and administrative center, most people in the southeast have to pass through Guayama at one time or the other. The sea-facing *Barrio Machete* of Guayama is where I lived during the time of my fieldwork.

Central Machete was Guayama's sugarcane mill and it occupied a strategic location between *Central Lafayette* to the East and Central Aguirre to the west, which put *Guayamenses* in a good position in the sugarcane economy. It was, however, after the bust of the sugarcane industry, with the development of the section 936 tax-relief petrochemical, pharmaceutical, medical, and energy industry sectors (Dietz 1986, 2003) and the establishment of 16 industrial complexes in Guayama, when Guayama truly developed a stronghold in the economy of the region (Dietz 1986; 2003; Griffith, Valdés-Pizzini and García-Quijano 2006). Since these industries were mostly established along low-lying coastal areas, coastal communities (and especially fishers) have suffered from marginalization and coastal degradation.

The two coastal communities where most fishing occurs in Guayama are called *Barrancas* and *Pozuelo*. A third traditional fishing community, *Puente de Jobos*, seems to have declined as a commercial fishery center. Guayama is the focal point for *nasa* (fish trap) activity in the Southeast. Of the 13 fishers in Puerto Rico that are registered as having more than 100 traps, six come from Guayama: three from Barrancas and three from Pozuelo (Schärer *et al.* 2004). Many others have between 40 and 100 traps (Schärer *et al.* 2004). My ethnographic observations conflict with landings data, which show net and hand-line arts to be dominant in Guayama, but I suspect this discrepancy is due to the fact that many fishers utilize more than one art. For example, some of my informants who were trap fishers from Guayama told me that they used nets to fish for bait and that they routinely used a hand-line to troll for pelagic species (this is called *correr la silga)* while they were traveling to and from the locations where they would set their traps. The boats that I observed in Guayama were sturdy fiberglass and wood *yolas*, as well as some imported powerboats, all obviously designed and built for hauling fish traps, and most wereequipped with electric winches for bringing the traps aboard.

Barrancas and Pozuelo are similar in their approach to fishing, and they also have close social ties. Many fishers from Barrrancas visit Pozuelo frequently and viceversa. Fishers from both communities repeatedly said that "*Pozuelo and Barrancas are friends*". One of the things these two communites share is their emphasis on independence. A fisher from Barrancas told me: "*In Barrancas fishers are independent people, we are similar to Pozuelo in that, too*".

Pozuelo

Pozuelo is Guayama's best known fishing community. Pozuelo is located on a peninsula that stretches into the sea from the Bay of Jobos. The boating, and fishing landing facilities, as well as several private docks, are on the calm bay side of the Peninsula. On the seaward side, are the public swimming beach and the surfing beaches. Although mired by problems related to pollution, mangrove destruction, and dramatic socioeconomic differences between full-time, traditional residents, and those who own marina boats/vacation homes, Pozuelo is a beautiful spot on the Southeastern coast of Puerto Rico.

At least 10 full-time restaurants, all dedicated to seafood vending, operate in the area. There are at least the same amount or more temporary seafood-vending facilities. There are also two fishing associations (*Barrio* Pozuelo Fishers Association and the *Barrio* Pozuelo Independent Fishers Association, which have, according to locals, at least 50 fishers between the two). Pozuelo is also a focus of recreational fishing and boating (of the luxury boat sort), since the *Club Náutico de Guayama* (Guayama Yatch Club) is located on territory taken from mangrove flats in Pozuelo. Pozuelo also has Guayama's premier surfing beach and only good place to take a swim, although the waters on Pozuelo's seaward coast are notorious for drowning unsuspecting visitors. The maritime police and the FURA (*Fuerzas Unidas de Rápida Acción*, Puerto Rican police's elite anti drug-smuggling unit, equipped with high-speed motor boats and helicopters) are also located in Pozuelo, near the Club Náutico.

The most obvious link between fishing and other economic activities in Pozuelo is the seafood restaurant business, with seafood restaurants ranging from small to large and from humble to very luxurious and pricey. According to informants many of the most luxurious restaurants do not belong to Pozuelo natives, but the smaller ones do belong to locals. Also, one of the fishers associations in Pozuelo has branched into a restaurant itself. To the best of my knowledge, that restaurant sells exclusively local catch, although from what I heard, and due to the fact that many of the most prominent fishers in Pozuelo do not belong to that association, they buy a considerable amount of the food they sell from non-members.

Pozuelo's fishers association branched into two separate associations after a dispute over management (also see Griffith and Valdés-Pizzini 2002). The new group, the *Asociación de Pescadores Independientes de Pozuelo* (Independent Fishers Association of Pozuelo) formed after disagreement with the original group over the use of resources and boats belonging to the association. In a visit to Pozuelo one observes 3-4 large abandoned fishing boats of the type used for multi-day deepwater snapper fishing trips. They seem to have been abandoned for quite a while. A fisher from Pozuelo told me that those boats are a good example of a communal activity gone wrong: people wanted to use them, but nobody wanted to fix them when they were broke. To me, they looked like the abandoned remains of another failed attempt at fisheries modernization led by the state (Pérez 2000; 2005).

There are two docking facilities in Pozuelo, one used by the *Independiente*s, (Independent Fishers Association), and the other used by the original association. Other fishers tie their *yolas* to mangroves in the channels or pull them in a trailer. The *Independientes* dock, however, doesn't appear to have strict ownership, and most Pozuelo fishers can use the dock and the fish cleaning table there. Docking overnight in the communal dock seems to be more restricted.

Barrancas

There is no doubt that Barrancas is a fishing community. Barrancas is a coastal barrio consisting of six streets lined with houses, located right next to the water to the east of the Phillips Puerto Rico petroleum refinery, which dominates the landscape. When driving around Barrancas one can see commercial *yolas* and powerboats in trailers, and the community is dotted with small fishers workshops, consisting of a shed (sometimes just a palm frond roof), a few tools, a workbench, and fishing traps in various stages of construction and/or repair. Barrancas amateur baseball team is named the "Marlins". There are two small seafood restaurants close to two fish markets. There is a small high-surf beach from which some small *yolas* can be launched to sea, but the larger *yolas* and powerboatscannot launch from there.

Barrancas is a rural community that was made to fit into a couple of streets of shoreside property. The original coastal community was called *Las Mareas*, and it was divided into two sectors: *Matuyas* and *Las Barrancas*. According to local informants, *Matuyas* residents were forced to relocate because developers decided that *Matuyas* was the ideal place to build a Petroleum Refinery, the Phillips Puerto Rico complex. *Matuyas* was a fishing/sugarcane workers community located in the mangrove tidal flats, and it had flourished there, in part, because the mangrove-protected inlet was a good place to launch and tie fishing boats. *Las Barrancas* was the beach, high surf area to the east of *Matuyas.*

When Phillips developers, assisted by the local government, expropriated the low-lying tidal flat areas in *Matuyas*, the whole community was relocated to prefabricated houses where Barrancas is presently located. People in Barrancas, specially fishers, are still bitter by this move, which happened 20 years ago. Not only were they uprooted and moved away, but also they also were relocated from a mangrove-protected inlet to the high-surf zone, where the larger boats cannot be launched without considerable danger to property and body alike. Due to this relocation, a community of fishers who were able to go from the landing area to their homes fairly easily, and who could almost always leave their boats in the water, now have to trail their boats over one mile of rough terrain to the mangroves, where they can launch their boats. Every night they have to bring their boats back home, for fear of burglary and vandalism. As a result, their workdays are much longer, more expensive, and more difficult now. This means investment in trailers, gasoline, increased wear and tear in vehicles and equipment, and a general feeling of displacement.

The destruction of mangrove flats, coupled with the relocation, caused the people of Barrancas to loose access to land crabs, which where an important source of protein as well as an occasional source of supplementary income. Barrancas current location is vulnerable to flashfloods from the creek that separates the community from the main road. While I was doing fieldwork, Barrancas was twice stranded by storms which washed away the bridge. The last time I went to Barrancas, in 2005, Guayama municipal workers were finishing a more modern bridge, which promises to withstand storms and rains during the hurricane season.

According to Barrancas fishers, there are 15-20 boat owners who fish in Barrancas, and about the same number of *proeles* (strikers). According to my observations, the families of these fishers also work selling fish or helping out with cleaning and marketing. The two local fish markets buy fish from fishers in Barrancas, but there is no formal association. Most fishers personally market part of their catch to restaurants and to private buyers. A conservative estimate is that 100 people in Barrancas (about a fourth of the population (Seguinot 2000) depend at least partially on fishing as a source of income.

Maunabo

Maunabo is a town of 12,741 people (2000 United States Census), located close to the sea on the southwestern flanks of the *Cuchillas de Panduras* mountain range. Maunabo is the easternmost coastal municipality in the study region. Fishers in Maunabo are concentrated in the coastal community of *Emajagua/Punta Tuna.* Access to the ocean in other areas in Maunabo is difficult due to rugged terrain and ocean-facing cliffs. This coastal landscape is rugged and spectacular, specially where the *Pandura* mountains dive towards the sea. Maunabo's economy was, until the third-quarter of the 20th century, based mostly on sugarcane and tobacco agriculture (Toro-Sugrañes 1995). After the collapse of these industries, Maunabo has suffered from chronically high unemployment hovering between 26 and 29 percent (Census 2002). Fishing is one of the few available economic activities in Maunabo (Griffith, Valdés-Pizzini and García-Quijano 2006). I observed considerable fishing activity given the size of the municipality. Again, my observations about the extent of the fishing activity conflict with the number of registered fishers reported by the Puerto Rico Fishers Census (Matos-Caraballo 2002). The census reports about 10 active fishers in Maunabo, while my observations and conversations with locals indicate about 20 active fishers.

A few restaurants surround the Maunabo Fishers Association (*Asociación de Pescadores de Punta Tuna)* grounds. The fishers association has good installations and access to a cement dock, but it was not being fully used during the time when I was in the field. The grounds were partially used by some local fishers to store their gear and sell cooked seafood. The six fishers from Maunabo that I talked to during this project marketed most of their catches from their own homes. Fishers from Maunabo told me that the association disbanded due to a bad management scandal in the early 1990's and has struggled to form again. A middle-aged fisher from

Maunabo told me: "*from that point* (the scandal) *on*, *everything went downhill for Maunabo fishers*". Some of the most pressing problems faced by *Maunabeño* fishers today, according to the fishers themselves, are related to the disbandment of the association. Because of the rugged coast, the association's dock and boat ramp are crucial for fishers attempting sea access. These facilities are deteriorating since the association disbanded because they are not being maintained by anybody. Fishers claim that the degradation of these facilities is making accessing the water hazardous to equipment and body alike.

Many fishers in Maunabo use gill nets. Most of the young fishers scuba-dive for conch, lobster and reef fish. A few of them fish a good number of fish traps (40 or more), and two fishers whom I met were fish trap builders and sold pots around the coast. Some older fishers from Maunabo are widely considered expert fishers throughout the coast. Maunabo is also regionally famous for its large populations of land crabs which served as an important source of food. The land crab populations are not what they used to be, but Maunabeños are still called *jueyeros* (land crab hunters) due to their historical prowess as land crab hunters and marketers.

Patillas

Patillas is a coastal town with a tradition of dependence on the sea. Patillas has long been a moderately used port and the coastal parts of the municipality dealt with piracy and invasion attempts during the years of the colonial wars in the Caribbean (Toro-Sugrañes 1995; Randall and Mount 1998). The population of Patillas is 20,150 (2000 United States Census). As with Arroyo and Maunabo, its two coastal neighbors, Patillas suffers from high unemployment (28.51% in 2000). Again, the number of fishemen reported by the state census for Patillas conflicts with my field assessment: the census only reports 10 fishers from Patillas, while my observations and conversations with fishers indicate that there are between 35-40 fishers in El Bajo and between 10-15 in Guardarraya.

The changing topography between the two main coastal barrios of Patillas , ‘El Bajo’ and ‘Guardarraya’, divides and differentiates them. *El Bajo de Patillas* is located close to Arroyo, and near the Patillas River floodplain. It is also located near the Former Central Lafayette, and has a strong history of dependence on sugarcane work. In many ways, El Bajo de Patillas is closer to Arroyo than to the other coastal barrio of Patillas, even socially (Griffith, Valdés-Pizzini and García-Quijano 2006).

The largest group of fishers in Patillas operates out of El Bajo (The Shallows). As the name implies, their coastal barrio fronts the extensive shallows that were formed by the combined action of a rivermouth, the coastal mangroves, and the fringing coral reefs. These factors enhance biological productivity of coastal waters, and thus, historically, fishers from El Bajo have been able to fish relatively close to shore. The public beach of Patillas is located in el Bajo, as well as the only bay suitable for overnight anchorage of boats and sailboats in the region to the east of Guayama. El Bajo is one of the most important traditional ports in the native sailboat regatta circuit. In late July, when the yearly El Bajo regatta takes place, the colorful *chalanas* with their large sails, racing up and down the beautiful bay is truly a sight to behold. The seafood restaurant scene of Patillas is also concentrated in El Bajo, and one of the most famous restaurants in the Southeast, “El Mar de la Tranquilidad’, is located there.

The Asociación de Pescadores de El Bajo de Patillas (Fishers Association of *El Bajo*) has about 35-40 members. It is located right next to the Maritime Police Station and the Public Balneario of Patillas, as well as very near the large vacation houses of rich people from San Juan which are usually only occupied during the Holidays. It is dramatic how all the different and sometimes strongly competing stakeholders come together within meters of each other in a short length of coast. *Arroyana* anthropologist Hilda Loréns (pers.comm. 2005), who grew up nearby to El Bajo, reports that the establishment of vacation homes by rich *sanjuaneros* in El Bajo is a recent phenomenon dating only to the last 15 years or so.

Many of the members of the El Bajo Fishers ssociation actually live in Arroyo and during the 18 months that I lived in the area, several of the fishers that I saw hanging out in the Arroyo docks would also hang out and out and even land catches in El Bajo de Patillas. They readily accept this, that the two associations are close, and even engage in cooperative activities: for example, El Bajo divers routinely go to the Arroyo Association to get their scuba tanks filled up. Recently, the siltation problem in the Arroyo port has made it difficult for *Arroyanos* to keep some of their larger boats in their area, so the El Bajo fishers have been taking care of the larger boats that belong to the Arroyo Association. Although I heard some grumblings from El Bajo fishers about '*until when are we going to have to keep those boats here in our beach*', they were for the most part good-natured grumblings made in jest, right in front of a meekly amused Arroyo fishers who were visiting.

Guardarraya

The coast of Guardarraya, especially the *Cape Malapascua* sector, is comprised of a narrow strip of land between the tall mountains of the eastern end of the Cordillera Central of Puerto Rico, and the sea. People in Guardarraya, and this includes fishers, tend to be independent of other coastal areas, and in many occasions they expressed to me that they are proud of it.

Guardarraya has a small but active group of fishers. Some of them, besides regular commercial fishing, run small-scale charter fishing as well. The Guardarraya coastline differs from El Bajo to the West and Maunabo to the east in that the coral reefs are much closer to the shore in front of Guardarraya, and specially in the Malapascua sector. This gives locals access to reef fish without having to deal with open-water long-distance navigation. The reefs' proximity to the shore make them vulnerable to siltation and runoff pollution, but the coastline is rugged and rocky, as well as relatively unpopulated and undeveloped, so the reefs keep in decent health, as I was able to observe during some snorkeling trips I undertook in the area.

Salinas

Fishing, internal coastal tourism, and recreational boating are important activities in Salinas. The population of Salinas is 31,113 and, like many other municipalities along this coast, unemployment is high at 27.81% (2000 United States Census). My interviews and observations indicate that there are around 80 fishers in Salinas, but the 2002 census only reports 23 fishers (Matos-Caraballo 2002). Salinas has four beautiful bays surrounded by mangroves, plus hundreds of mangrove channels, locally called *Caños*, that zig-zag between and around the bays. Whenever there is a hurricane approaching the area, boaters from nearby coasts flock to the mangrove channels of Salinas to tie their boats under the protection of mangroves. Ironically, those same mangroves that give Salinas its charm for tourism also have been the recipients of a continued assault by all kinds of actors, including Public Health agents fighting malaria, developers, marina builders, and a city Mayor who in the 1980's designated a coastal lagoon as a landfill (interviews with Salinas fishers, 2003-04).

The coastal plain of Salinas was a major area of cane cultivation, with Central Aguirre being the largest sugarcane operation in this municipality. Similar to other southeastern municipalities, the coastal communities of Salinas are remnants of the sugarcane past. These coastal communities are *Playa, Playita,* and *Aguirre*. Each of these communities has its own embayment. That is, each community has a bay that is associated with it. Playa has the Bay of

Salinas, Playita has an associated smaller bay to the east, and Aguirre has the deep sector of the bay of Jobos.

Playita and Playa

The communities of Playa and Playita are continuous to one another on land, but when approached from the sea, they are separated by coastal topography (they each have their own bay). Hence, each community has its own Fishers Association: Playa has the *Asociación de Pescadores de la Playa de Salinas* (Also known as *Pescadería Don Piche*), and Playita has the *Asociación de Pescadores de La Playita de Salinas*). Fishers associations in Playa and Playita apparently have a conflict-ridden history. Fishers repeatedly told me how conflicts over management have driven them from the associations. Association membership data analyzed by Grifftih, Valdés-Pizzini and García-Quijano (2006) seem to confirm that membership in associations in these communities has dropped over time.

The communities of Playita and Playa are a focal point of the seafood restaurant 'scene' in the area, and many people travel to Playa and Playita to visit the restaurants there. Land crabs are an important resource in the area, and many of the restaurants specialize in them. Boating and recreational fishing are very important as well, and many of the fishers in Playa and Playita double as captains, boat mechanics and charter operators for the recreational sector. My interviews indicate that the majority of the fishers in Playita and Playa are fish trap and lobsterpot fishers. Due to diving's popularity with younger fishers, however, diving is becoming common,.

Playa and Playita's engagement with the tourism and recreational boating sectors allows them to enjoy economic opportunities in the form of abundant buyers for their fish and jobs as guides and charter captains. The opportuinities, however, come at an environmental cost. Most fishers from these two communities whom I talked to mentioned that recreational boating has greatly damaged their bays and mangrove channels. The fishers claim that noise pollution from jet-skis scares baitfish species out of the bay, while pollution coming from recreational yatchs anchored inside the bays is an important source of environmental degradation. Some ways in which these yatchs pollute are by dumping used water and human waste and by the leaking of engine oil, gasoline, transmission fluid, and other substances from boats that have been left there anchored (semi-abandoned) for long periods of time. Shiny floating spots resulting from gas and diesel spills are frequently seen in the area where recreational vessels anchor inside the bays of Salinas.

Aguirre

If there is one community in Puerto Rico that is a testament to the coastal sugarcane past, that community has to be Aguirre. In a way, Aguirre constituted the focal point of this dissertation research, because one of the grants that supported this research came from my collaboration with the National Estuarine Research Reserve (JOBANERR) located in Aguirre.

Aguirre is different from other former sugarcane-dependent communities in that instead of being a former satellite colony of a sugar mill, Aguirre was in fact located inside the area owned by a sugar mill. To enter Aguirre one has to go through the former gates of the Central Aguirre, the same gates outside of which, until the near past, any employee that fell out of grace with the administration would find themselves, together with their families and all of their belongings, under rain or shine.

Aguirre occupies the deep end of the Bay of Jobos. There are three principal groups of human dwellings associated with Aguirre: 1) A group of houses just outside of the gates called Barrio El Coqui, 2) a group of houses that used to belong to Central Aguirre (now they belong to their tenants) and which share the plantation house architecture that one sees in the southeastern United States (Wooden construction, high ceilings, and a wrap-around porch), and 3) a group of newer but more modest houses in and around the Aguirre's plaza called Montesoría I and II. A related group of houses called Urbanización Eugene Rice, was built for laborers on the East side of Aguirre.

The Aguirre Central installations in Aguirre are very close to water in the Bay of Jobos and thus very close to where the old Fishers Association is. The Fishers Association does not operate at present times. According to fishers in Aguirre, this resulted from rivalries over control of the installations. The small stretch of beach located there in Aguirre, however, always has a number of yolas that are evidently being used. There are about 10-12 active fishers that are from Aguirre, and according to three elder fishers who were among my key informants for this study, this number is on the decline. I, however, observed a lot of fishing activity during the time I spent in Aguirre. I observed that life in Aguirre is still oriented towards the sea, and the elder fishers are very well respected, and stand as pillars of the community.

Aguirre is located in the deepest part of the Bay of Jobos, and the area where the fishers head out to sea is located right in front of the three islets called *Cayos Caribe*. The very dangerous channel between two of the Cayos Caribe, *Boca Infierno* (Mouth of Hell), is where *Aguirreño* fishers head out to sea in their small *yolas*.

Fishers from Aguirre routinely fish outside of the bay, but they still practice a lot of estuarine fishing. In fact, I would say that of all the communities that I worked with during this research project, Aguirre is the most estuarine. While fishers from Pozuelo and Barrancas in Guayama, located on the outside of the bay, are in great position to go out to the continental shelf dropoff, *Aguirreños* are deep in the bay, surrounded by mangroves. It takes some time to even get out of the estuarine area. However, this is not so much a disadvantage because, like a fisher from Aguirre told me: "*the bay provides*". According to fishers, throughout the year the bay attracts large schools of high-priced fish (mainly mackerels and jacks) that come inside the bay to feed on estuarine species such as mullet, sardines, small clupeids, and shrimp. Besides the migratory species, fish such as snook, tarpon, lane snapper, yellowtail snapper, and other snappers and groupers live inside the bay.

I noticed from the first time I went to Aguirre that *yolas* were much smaller (12-14 feet) than the *yolas* I had observed in surrounding areas. These *yolas* were small, but wide. When I asked about this I learned that this was due to the fact that fishing with drift nets is easier from these small, maneuverable yolas. Aguirreños use driftnets for catching aggregations of migratory pelagic fish, such as mackerels and jacks, which come into the bay to feed on baitfish. This was for a long time the main fishing strategy for Aguirreños. Aguirre today, however, faces estuarine habitat degradation that has greatly affected the quantity of bait species found in the Bay. Since, as an elder fisher told me "*The fish go where the food is*", the schools of mackerels and jacks that used to provide ample catch for Aguirreños are smaller and farther between with every passing year.

Aguirre is one of those places in which the past and the future of coastal resource use, sugarcane and modern coastal industry, come dramatically close to each other. *Don* Teófilo, an expert *Aguirreño* fisher with whom I spent a lot of time during my fieldwork, has a house located right at the water edge, with a seaward facing deck. Standing in *Don* Teófilo's deck, facing South towards the ocean: if one looks East one can see the remains of the gigantic Central Aguirre. If one looks West, even closer, one sees the *Central Termoeléctrica de Aguirre* (Thermoelectric Power Plant of Aguirre), one of two twin thermoelectric powerplants that provide electricity to much of Puerto Rico. The Termoeléctrica is huge, and it brings to Aguirre some jobs, but it also brings air pollution, water pollution and constant deafening noise. The plant has a cool water intake and a hot water outtake inside the Bay, used for its cooling system. Ships carrying fuel for the plant come in regularly, creating leak hazards, and disturbing the soft bottoms with the powerful tugboats' propellers. Air pollution from the power plant has been the subject of many controversies between Aguireños and the Puerto Rico Power Authority, and while some advance has been made with the help of the JOBANERR reserve officials, Aguirreños whom I talked with still claim that their air quality is sub-par thanks to the power plant. The sugarcane mill was also responsible for some environmental damage. Fishers in Aguirre report that, over the years, several instances of molasses spills into the bay resulted in episodes of massive fish and shellfish mortalities.

As I became more informed about the situation in Aguirre it became clear that the aquatic environment has been greatly impacted by agriculture and industry in Aguirre. Just from looking at the landscape one suspects that a fair amount of abuse to the estuary has taken place there over the years. My interviews with fishers in Aguirre, all took place under the shadow of those two coastal monsters, on one side the *Central Aguirre* and the *Termoelectrica* to the other side. A long-standing controversy regarding the impact of the hot-water outtake on the Jobos Bay ecosystems is a major point of contention between fishers in the study region and the government.

Santa Isabel

Santa Isabel is the westernmost municipality included in this study. *Central Cortada,* another of the large sugarcane mills of the southern coastal plain, was located in Santa Isabel, the fishing communities of Santa Isabel are remnants of sugarcane dependent communities. As with the other municipalities, after the sugarcane operations ceased, unemployment became very high and in Santa Isabel, a municipality of 21,665 people, unemployment has hovered between 23 and 25% from the 1990's on (2000 United States Census). Fishing in Santa Isabel remains an important activity and Santa Isabel is a stronghold of *palangre* (longline) fishing in Puerto Rico. In Santa Isabel, again, the number of fishers reported by the state fishers census seems to be an undercount: my interviews and observations indicate about 60 fishers in Santa Isabel, and the census reports 32 fishers (Matos-Caraballo 2002).

The principal fishing grounds of Santa Isabel fishers are the extensive shallows south of its coast. Staple species include lane snapper, mutton snapper, yellowtail snappers, mackerels, lobsters, conch, and octopus. According to one of my informants, parrotfishes are also regularly caught by divers and some specialized netters. Santa Isabel is a regional stronghold of *palangre* lonline fishing, a very time-consuming and laborious (but potentially productive) type of fishing. Compared to other fishers, *Palangreros* spend a lot of time at sea. Fishers in Santa Isabel are concentrated in the communities of *Playa-Malecón, Playa Cortada, and Jauca*.

Playa-Malecón

The center of fishing activity in Santa Isabel is the Pueblo-Playa-Malecón area. The fishers association in Santa Isabel is named *Asociación de Pescadores Cheo Tejero* in honor of Don Jose "Cheo' Tejero, a highly respected older fisher who was a very important collaborator for this research. The association is located in a two-story building. It has about 20 lockers for fishers. There was a rather large gas-pumping station by the water, which was obviously not in use and a t-shaped cement dock. A rather large workshop area for boat building and three smaller wooden docks completed the installations. I later learned that the three wooden docks were semi-communal. That is, technically they belonged to a couple of private fishers who lived on the coastline right next to the building, but they as a rule allowed other fishers to use their docks by virtue of belonging to the same association, being friends, or merely being fellow fishers.

According to fishers in the area about 35 active fishers use the installations to various degrees on a regular basis. The first few times I visited the association's grounds, it seemed empty and underused. I later learned that it was being very much used and that I had to go there in the very early morning or right after dusk to meet fishers. The fact that many of them were longliners, arguably the most work intensive and time-at-sea intensive of the fishing arts practiced in the study region, accounts for my initial impression of an empty association. The fishers just spent a lot of time at sea. But there is also a lot other activity that goes on there that required repeated visits and just a lot of participant observation to notice. The workshop-boatyard area is an important center of activity. I saw *yolas*, fiberglass boats, and sailboats being built there during my visits. I also got quite a bit of instruction on how to build a *yola* there.

The Fishers Association building was evidently the center of social and political activity related to fisheries in Santa Isabel. During the time I spent doing my fieldwork in Puerto Rico, if there was any sort of meeting that involved Santa Isabel fishers, it was probably going to take place there at this building. This is the building where I met most of the fishers from Santa Isabel, regardless of the community. It was a shared space between fishing communities.

The Fishers Association was also a center of fish marketing, and repeatedly, I saw fishers both from Playa-Malecón and from other communities selling surplus fish and buying ballyhoo and sardines for bait. It was also a center of boat building and repairing. I repeatedly saw fishers from other communities engaged in boat repairing and building on its grounds. The building, and docks area around it, was also a communal recreational space, with kids and families repeatedly diving and swimming of the cement dock. I observed repeated instances of some of the older fishers teaching little kids how to fish, and while at first it looked like just some recreational, fun-time fishing, after a while I started to appreciate that both the teachers and the students were quite serious.

Playa Cortada

As many other coastal villages in this area (e.g. Aguirre, Jauca) Barrio Playa Cortada still bears the name of the sugarcane mill that operated near it. Because fo the lack of other economic opportunities after the closing of the sugarcane mill, it appeared to me that Playa Cortada was the sector most obviously dependent on fishing in Santa Isabel. According to the people I interviewed, around 20-25 fishers live in Playa Cortada. I asked them if that included all people that fish, and they said no, that those numbers only pointed to boat owners/captains and strikers who go out on a consistent basis.

What stood out the most for me about Playita Cortada was the large degree of youth involvement in fishing and/or other traditional sea-oriented activities. In many other fishing areas one might get the impression that young people have moved away from fishing, leaving it as a middle-to-old age activity. In my visits to Playa Cortada, however, I always saw a a lot of young people (between 10-17) coming up and down the street next to the coast with fish, fishing gear, or boat-building materials. Young people in Playa Cortada are specially involved in native sailboat building and racing. I suspect that this link between sports and seafaring work has helped keep more young people associated with fishing activity.

Playa Cortada is the westernmost coastal community of Santa Isabel, the closest to the large fishing communities of Juana Diaz and Ponce, but still closer to Playa, Jauca and the other fishing centers in Santa Isabel. A climate of self-reliance is definitely in the air in Playa Cortada. I learned over the course of fieldwork, that Playa Cortada is a foci of resistance against governmental control of fishing. Playa Cortada is home to a group of fishers that are promoting union organizing for fishers in Puerto Rico.

Playa Cortada is highly dependent on fishing, and one sees *yolas* (between 15-20 depending on the day) being used and in good working condition throughout the coastline and in people's backyards, plus the ones going out to sea. In all of my visits to Playa Cortada, however, I never saw a "*Hay pescado*" (Fish for sale) sign. This obviously did not mean that fish was not being sold. There are two fishmarkets in Playa Cortada, and most fishers have freezers in their homes from which they sell their catch. To find fishers, all one has to do is to go and ask the first person one sees where one can buy fish. When I did this, I was provided with three choices, two of which later became informants. People know where to go to find fish in Playa Cortada, and most fishers have clients that go to them for fish and whom they call when they come in with a good catch. To the best of my knowledge, there was no fishers association operating in Playa Cortada, and they held meetings in the installations of the association in Playa-Malecón. Playa Cortada is unique in that while fishers operate very independently, they do maintain close ties with an organized association, as friends-neighbors more than regular members.

Jauca

Jauca is the sector of Santa Isabel where Mintz's "Worker in the Cane" (Mintz 1968) lived, and was also a place of research for the "People of Puerto Rico" (Steward 1956; 1972). In general, I sensed that this community of fishers is much more independent of the other fishing communities than the others between them. My sense, after a few conversations and visits, is that Jauca is, in general, a more remote coastal area not geographically, but in relation to the main road (#3) of the area. It takes a while to get from road #3 to the coastal area of Jauca, and even when one gets there, the extensive mangroves/tidal flats separate the houses located closer to the water from the rest of the houses.

Many people report going to Jauca to buy fish, however, it was very hard to find where the fish was being sold. Jauca's coast is divided into two separate bays. The larger bay is where most of Jauca's fishers land, and at various times during my fieldwork I saw moderate activity there, with usually between 10-12 yolas that looked like they were being used regularly, a couple of houses hidden between mangrove stands where I saw signs of fishing gear being made or repaired, plus a few abandoned or stranded *yolas*. According to my other contacts in Santa Isabel, Jauca fishers tend to be highly specialized in net fishing, and my few observations of *yolas* supported this: they were usually loaded with seemingly very large nets. I did observe (this is where my only conversation with a fisher from Jauca took place) a few fish cleaning and boat working areas at various points along between mangrove stands. They appeared to be maintained communally and the local fisher confirmed this. To the west of the main bay in Jauca, a smaller bay between mangroves had about a dozen houses very close to the water's edge. About half of them looked like seasonal vacation homes, the other half looked like fishing people's homes. *Yolas* were mostly in the water, at the end of long and narrow docks in the shallow water. This bay has a seabathing area, and every time I visited I saw some families enjoying the tranquil water.

In 2004 I was talking to one of the fishers in Santa Isabel Playa-Malecón about my frustration with Jauca: I could never find anybody to talk to there. His response was: '*I am not surprised. Jauca is another world*'. Jauca's fishers are not in the census records. The only fisher from Jauca I was able to contact told me to come later, and only once in repeated visits I was able to find him. Jauca was the community that I could never reach.

Conclusion

Fishers in southeastern Puerto Rico live, fish, and struggle to support their families in extremely complex historical, economic, social, and ecological landscapes. Fishers' ability to find fresh fish and thus provide high quality protein to their communities and beyond is what determines if they will be able to thrive amidst such complexity, or if they, their families, and their way of life will undergo extinction. For a long time until the not-so-distant past, coastal communities along the southeastern coasts of Puerto Rico depended, for much of the year, on the ecological knowledge of fishers for survival. Now it is the fishers themselves who face great odds against their survival. During the remainder of this dissertation, I will explore the ways in which fishers' local ecological knowledge helps them fishers and their families to stay alive in their complex and often-hostile world.

CHAPTER 3

RESEARCH DESIGN AND METHODOLOGY

The main goal of this work is to explore the value of Local Ecological Knowledge for small-scale fishers and their communities in the region of study. Two principal lines of inquiry delimited my exploration of this topic. The first line of inquiry consisted of studying the value of LEK for fishers at the individual level. I attempted to illuminate the relationship between patterned variation in knowledge about fish and ecosystems and *emic* (culturally-relevant) measures of success in fishing. The second line of inquiry entailed an exploration of the value of LEK for fishers as a labor group, for coastal communities, and for fishery management and conservation.

The information I obtained using these two lines of inquiry, however, was not separate or mutually exclusive. Rather, open-ended ethnography and participant observation were necessary for systematically documenting important local knowledge and local models of success in fishing. The information gathered this way served as the basis for measuring variation in ecological knowledge and success. Conversely, the patterns in variation of knowledge and success which I measured illuminated my thinking about the implications of the complexity of fishers' knowledge of their local environments.

This research results from fieldwork conducted over 18 months, between February 2003 and September 2004. During those 18 months I lived in coastal *Barrio Machete*, in Guayama, Puerto Rico. Thereafter, I have made several short (between 5-10 days) visits during which I conducted follow-up interviews and visited the friends I made during my work. These short visits took place in December 2004, March 2005, and June 2005.

Most of my field activities consisted of interviewing fishers in the study region, but I also spent considerable time going out to fish as a participant observer and attending fishers' political meetings and rallies whenever I was invited. During meetings I participated little and spent much of the time observing and note-taking. Many of my insights about the political value of LEK for fishers, however, came from my attendance to those meetings. The Bay of Jobos National Estuarine Research Reserve, located in the coastal community of Aguirre in Salinas, partially funded this study and was a second field home of sorts. I spent many hours undertaking archival research in the reserve's collection. I was also fortunate to have the help and assistance of Manuel Valdés-Pizzini and his colleagues at the University of Puerto Rico-Mayagüez Sea Grant, located one and a half hours away, by car, from the study region. Many of my field materials and interview instruments were developed at the Sea Grant installations.

Research Design

Aside from the main objective of exploring the value of Local Ecological Knowledge of small-scale fishers in the study region, this research had four specific objectives:

1) To systematically document ecological knowledge held by reef fishers in southeastern Puerto Rico, with an emphasis on the kinds of knowledge that are directly important for the fishing activity.

2) To systematically document fishers' folk models of success, with an emphasis on what it means to '*be a successful fisher*' in the study region and what constitute the perceived determinants and indicators of success.
3) Based on results form the previous two objectives, I intended to measure intra-group variation in knowledge and in success among fishers.
4) Finally, I intended to empirically describe co-variation between fishers' knowledge and success.

I worked on these four objectives successively over two research phases. First, I conducted an exploratory phase in which I sought to gain a firm understanding of the context, content, and richness of fisher's LEK and folk models of success through participant observation, conversations and open-ended interviewing with widely-recognized expert fishers. The exploratory phase addressed objectives 1 and 2.

Based on what I learned during the exploratory phase, I embarked on the second phase, the explanatory phase, in which I measured intracultural variation in ecological knowledge and success. I empirically tested the correlations between ecological knowledge and success in a random sample of the fishers' population (objectives 3 and 4). The task of developing the interviewing instrument linked the two research phases together. I constructed the interviews for the explanatory phase based on the information gathered during the exploratory phase. Figure 3.1 summarizes some characteristics of the two phases of this research.

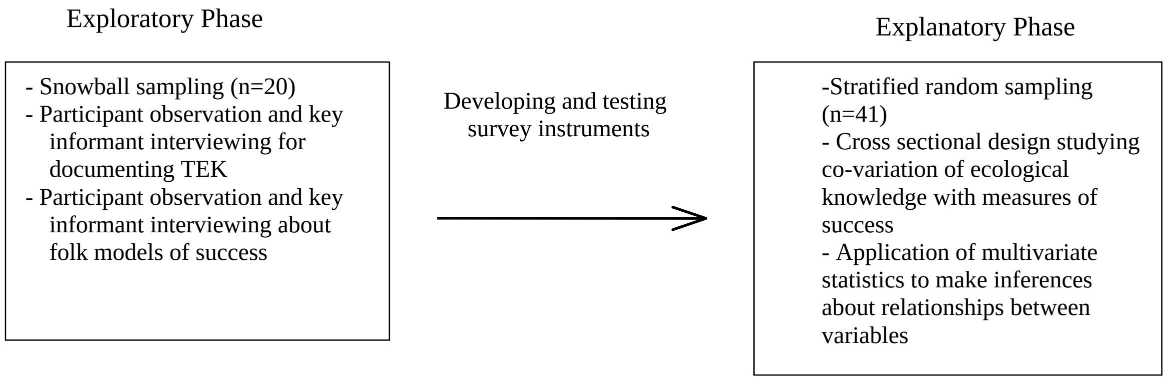


Figure 3.1 Overview of research design for this study. (modified from Johnson 1998)

Many researchers have encountered the dilemma of balancing the context-richness and attention to detail achievable with open-ended ethnographic methods against the predictive power and comparability of results acquired by exposing respondents to comparable stimuli (for example Kempton, Boster, and Hartley 1995; Ross 2004, Boster 1986; Garro 1986; 2000; Johnson 2000; Johnson and Griffith 1998; Ross and Medin 2003; Ross *et al*. 2003; Strauss and Quinn 1997). A number of these researchers, such as Kempton, Boster and Hartley (1995) and Boster and Johnson (1989), have successfully sequenced open-ended ethnography and structured questionnaire research to draw on the strengths of both approaches.

Johnson (2000; 1998) used the term ‘*exploratory-explanatory approach’* to describe the sequencing of open-ended and structured methods for testing hypotheses about LEK and other cultural beliefs and value systems. The two phases of this research project are thus named after Johnson’s nomenclature. The two phases of research pursue different but complementary goals. Therefore, the two have different information-eliciting methods and different sampling strategies (see figure 3.1).

The dilemma between context-rich ethnographic detail and comparative, predictive power results from the apparent contradiction between two theoretical approaches in the study of culture. One theoretical approach emphasizes that cultural knowledge and cultural meanings are inextricable from context and are constantly negotiated (for example Geertz (1973), Rosaldo (1989)). The other emphasizes that individuals in a culture vary in their knowledge and in their level of sharing of cultural meanings (For example. Boster (1986); (1991); Romney, Weller, and Batchelder (1986)). Both approaches seem intuitively and logically correct. On the one hand, cultural knowledge is only meaningful under the appropriate context. It would be misleading to describe the marine ecological knowledge achieved by small-scale fishers merely as a set of propositions regarding prey species distribution, habitat variation, and trophic webs. This description would be incomplete without a detailed understanding of the socioeconomic context of fishers' knowledge, such as the technology used to fish, the time fishers spend at sea, the extent that children growing up in fishing households are involved in the activity, etc. It would likewise be unwise to assume that cultural knowledge regarding fish is a static entity that is not renegotiated as fishers share experiences and observations about the changing marine environment or as new technologies expand the ways in which fishers experience fishing.

It would be conversely difficult to deny that some people have a more detailed understanding of some domains of knowledge than others, and that individual levels of competence in a domain can change over time. For example, a fisher who is in the process of teaching his/her children how to fish will at the time of the instruction have a much more detailed understanding of fish and fishing than his children. Over time those children could theoretically attain or even surpass the level of understanding that their teachers had. The differences in cultural knowledge between fishing teachers and apprentices are not attributable to belonging to different cultural milieus but to varying degrees of expertise (cf. Boster and Johnson 1989; D'Andrade 1987; Ross 2004; Ross and Medin 2003).

I wanted to learn what kinds of ecological knowledge the fishers in my study region needed to be able to fish successfully and what were some of the ways in which ecological knowledge helped the fishers to be successful. If my *a priori* assumptions about 'what was ecological knowledge' and 'what was success in fishing' were too strong, I would have probably missed important insights about both topics. For example, I could have missed that 'success in fishing' had an important dimension related to social status of fisher vis-à-vis other fishers, and that sharing and cooperation were important components of a fisher's social status. I could also have missed that an important component of 'ecological knowledge' is to keep track of local patterns in degradation and recovery of marine ecosystems to avoid wasting time visiting degraded, unproductive areas. I only gained this last insight after learning, by participant observation, that comparing notes about environmental degradation patterns is an important topic of conversation for fishers (also see St. Martin 2000).

An important goal of this research, however, was to compare agreement patterns in ecological knowledge and differences in fishing success. Comparing agreement patterns and differences would have been very difficult without systematically asking a set of questions about these topics to a group of fishers who had a range of variation in both knowledge and success (also see Kempton, Boster and Hartley 1995: 17-24). Sampling was also an important part of the research design since different sampling strategies are optimal for either maximizing contextual information or comparing between informants.

Figure 3.2. Underwater participant observation. I participated in many activities related to fishing, including skin diving for Queen Conch (*Strombus gigas*), in seagrass prairies 3 miles from Arroyo's shore. That I was able to keep up with the divers gained me some credibility with fishers, accustomed to university and government people that would not risk going into the water. In this photo, a fisher in SCUBA gear hands out captured conch for his son to take back to the boat while he continues to scan the bottom for more conch.

Exploratory phase

Choosing key informants

The exploratory phase of this research had the overall objective of maximizing the amount of information I could gather about fishing activities, fisher's ecological knowledge about local marine environments, and about the goals, determinants, and indicators of success for fishers. I used snowball sampling to identify 20 expert fishers in the study area in order to maximize my access to expert knowledge about fishing. Snowball sampling is a useful technique for finding informants who meet specific criteria and who, by following social networks, can be found as reasonably expected (Johnson 1990).

The main criteria for selecting key informants was that their peers consider them highly knowledgeable about the fishing activity. If a fisher was pointed out by two or more of his/her peers as a highly knowledgeable fisher, I would attempt to contact him/her to find out if they were willing to collaborate in my study. The number of widely regarded expert fishers in the area exceeded the number of key informants that would have been practical to recruit. Thus, due to time constraints, I used other criteria for choosing the final group of key informants. My other criteria were to pursue as balanced a representation of coastal communities and fishing gears as possible. Also, because relatively few women fish in the study area, in the two occasions in which a woman was mentioned as a knowledgeable fisher I made an extra effort to contact and request her collaboration.

I made a total of 17 snowball lists, from two starting points. First, Dr. Manuel Valdés-Pizzini, an established researcher of fisheries anthropology in Puerto Rico, recommended I talk to two widely known fishers from the southeast. Secondly, the local Department of Natural

Resources fishery outreach official recommended I talk to several fishers, including the two fishers recommended by Valdés-Pizzini. Later, other fishers confirmed that the first fishers whom I contacted were, in fact, widely regarded expert fishers. All of the fishers I recruited as key informants were mentioned by at least two other fishers as experts.

My final list of key informants included 20 fishers, representing most of the different coastal communities in Southeastern Puerto Rico, and several types of fishing gears. One of the key informants was a woman (see table 3.1). Five of the fishers whom I initially contacted to collaborate declined to participate, citing their (understandable) distrust of outsiders who claimed to be doing research. The fishers who declined to participate also cited the pervasive political tension between fishers and state agencies. Refusals due to political tensions were also a problem for recruiting informants during the subsequent phases of this research.

I approached each of the fishers listed in table 3.1, explained the purpose of my research, and asked if they were willing to collaborate in this project, explaining that their collaboration would include multiple visits on my part over a period or a few months. I expected difficulties in justifying the great time and effort that my collaborators would spend with me, but after I explained to them that I wanted to understand fishing and fishers' knowledge from their perspective, they were mostly happy to spend time with me. I have seldom met people so generous with their time as these fishers and their families.

Table 3.1. Selected characteristics of expert fishers who participated in exploratory phase. Fishing gear Types: N-Nets, Sk-Skindiving, Sc-Scubadiving, Fp-fishpot, Lp-Lobsterpot, Ll-Longline, Bl-BottomLine, Tr-Troll line. Exp- Years of Experience fishing.

ID#	Municipality	Community	Gender	Age	Exp	Typeboat	Fulltime	Parentsfished	Gear
1	Santa Isabel	Playa-Malecon	m	50	35	yola	no	yes	N, Sk,Tr
2	Salinas	Playita	m	76	75	yola	yes	yes	N,Fp,Lp,Ll
3	Arroyo	Pueblo	m	57	43	yola	yes	no	N,Sc
4	Salinas	Playa	m	57	52	powerboat	yes	yes	N,Lp,LL
5	Guayama	Barrancas	m	64	59	powerboat	yes	yes	Fp
6	Salinas	Playa	m	59	51	powerboat	yes	yes	Fp,Lp,Tr
7	Guayama	Pozuelo	m	54	53	powerboat	yes	yes	Fp
8	Salinas	Aguirre	m	63	62	yola	yes	yes	Fp,N,Tr
9	Salinas	Aguirre	m	72	64	yola	no	yes	Fp,N,Tr
10	Maunabo	Emajagua	m	33	21	yola	yes	yes	N,Fp,Bl
11	Arroyo	Pueblo	m	73	62	yola	yes	yes	N,Fp
12	Santa Isabel	Playa-Malecon	m	69	57	yola	no	yes	Fp,Lp,N
13	Santa Isabel	Playa-Malecon	m	56	41	yola	yes	yes	Fp
14	Salinas	Aguirre	m	83	79	yola	no	yes	Fp,Bl,N
15	Santa Isabel	Playa Cortada	m	70	66	yola	yes	no	Ll,Sk,
16	Patillas	Bajo	m	57	43	yola	yes	yes	Fp,N,Bl
17	Santa Isabel	Playa-Malecon	m	67	58	yola	yes	yes	N,Bl,Sc
18	Santa Isabel	Playa Cortada	m	58	43	yola	yes	no	Sc,Ll,Tr,N
19	Guayama	Pozuelo	f	63	33	yola	no	yes	N,Bl,Fp
20	Salinas	Playa	m	65	50	workboat	no	no	Bl,Tr

Over the first 12 months of this research I conducted 4 formal interviews with each fisher. I also conducted one extra interview with 6 of the fishers where I asked them to match fish species names with fish photographic specimens, for a total of 86 interviews. The interviews were mostly semi-structured, consisting of open-ended questions with free-listing and matching exercises. Interview times ranged from one to three hours. Of the 86 interviews, 71 were tape-recorded. With the help of student-workers from the University of Puerto Rico Sea Grant, I transcribed the interviews as I collected them. In addition to the formal interviews, I spent many hours visiting and conversing with fishers (not limited to my key informants), and, when they allowed or invited me I went out to fish with them (see figure 3.2). I describe these 10 months comprising the exploratory phase as a time of total immersion in learning about fishing.

The four (five for some fishers) interviews I conducted with each fisher were designed to cover a range of subjects, from informants' characteristics, current issues in fishing and fishers' relationships with other coastal stakeholders, to the ecological knowledge needed to fish and folk models of success. Parts of the interview protocols had been tested before by Valdés-Pizzini in his work with Puerto Rican fishers. I was lucky to have a very good platform to build the thematic sequence of my interviews. Table 3.2 lists the four interviews with a brief description of the themes covered in each interview. The Spanish version of the key informant interview protocols can be found in Appendix II.

The transcript of my conversations, experiences, notes, and observations related to fishers and fishing was the most basic type of data collected during this study. This text was also the basis of subsequent analysis. Careful textual analysis is necessary in order to maximize the gains in construct validity pursued by following a exploratory-explanatory research design (Bernard and Ryan 1998; Johnson 1998).

The questions asked to key informants in the semi-structured interviews were geared towards eliciting detailed information on a series of topics, including: 1) Fishers' attitudes and values towards fishing and the coastal environments, 2) Fishers' knowledge about coastal ecosystems and the species captured, 3) What constitutes 'success' for a small-scale fisher in the study region, and 4) Fishers' folk models of determinants and indicators of success in fishing, with an emphasis on the role of LEK in determining success. The answers to these questions constituted the main source of textual data. My observations and conversations with fishers and their families, however, proved to be very important for my understanding of these issues. In some cases, the previous literature on subjects relating to my topic of interest was illuminating in my writing of notes.

Table 3.2. Summary of characteristics of five successive interviews in exploratory phase, themes covered and types of questions asked.

Interview #	Protocol Title	Themes covered	Types of questions
I	Initial Interview and basic information about key informants	Demographic information, types of fishing practiced, labor history, social networks, problems and issues of fishing in area, history of fishing in area	Demographics, open-ended questions, freelisting of locally-important fish species, snowball list of other expert fishers
II	Interview on Ecological Knowledge I	Ecological knowledge need to fish successfully, fishing season, environmental variables and fishing, changes in marine environments, habitat-species matching	Open-ended questions, ecological narratives, multiple freelisting exercise on species found on different habitats
III	Interview on Ecological Knowledge II	Prospects for conservation, degradation patterns, practical knowledge, navigational knowledge	Open ended-questions
IV	Local models of success in fishing	What are the goals of fishers, what does it mean to be successful in fishing, personal and social indicators and determinants of fishing success	Open-ended questions
V	Interview with photographic fish specimens	Eliciting local names of 104 fish, crustacean and mollusk species fished locally, using laminated photographic specimens,	In addition to identification, fishers commented on each species in open-ended fashion

Using Atlas.ti (Muhr 2004)[1] as a qualitative analysis platform, I analyzed the different types of textual data together and treated them as potential sources of information for describing the cultural models that I would be testing in the exploratory phase of this research. During this process I was careful in weighing primary interview data, as the most important source of information.

In the analysis pertaining exclusively to LEK and to fishers' folk models of success, my main purpose was to understand the 'cultural models' held by fishers about these two subjects. Cultural models constitute the more or less widely shared information and insights about a subject(s), which helps a group of people make sense of the world around them (Strauss and Quinn 1987; D'Andrade 1984). Cultural models are a cognitive structure, an extension of culturally-defined, cognitive schemata, or even multiple interrelated schemata, and they are often described by detailing internal logical relationships (D'Andrade 1984; 1995; Keesing 1987). D'Andrade and Strauss (1992) theorized that cultural models could be powerful motivators of human behavior, especially when they are high-level, hierarchically broad cultural models. For example, the idea that 'the natural environment is worth conserving' is a high-level cultural model, one that has the ability to significantly drive a wide range of everyday human behaviors (see also Kempton, Boster, and Hartley1995). Cultural models have been successfully used to study cultural knowledge pertaining to the natural world, such as fisheries and marine environments (Blount 2002a, 2002b; Cooley 2003; Paolisso and Chambers 2001). Although the systematic study of cultural models in human discourse is an expanding and exciting field of research, relatively few researchers have attempted to test the degree of sharedness of cultural models by combining qualitative-quantitative analysis (Johnson 1998; 2000; Ross 2004).

To describe cultural models inscribed in textual data, I systematically searched for keywords or key concepts that were widely repeated in interviews (see Blount 2002; Cooley 2003). After identifying those concepts, I searched for the relationships between key concepts and the questions asked. The most widely shared, high-level concepts and relationships between concepts were considered important cultural models and I further analyzed them using quantitative methods.

Fish Species Freelists and Assessments of Local Importance

I conducted freelisting exercises with 17 of the 20 fishers interviewed in this phase of research. The freelists were elicited in response to the question: "Can you please mention, in the form of a list, all of the species that in your opinion are important for fishing in this area?" More than 100 fish species are routinely fished in Puerto Rico, and most of these are fished on the southeast coast of the island (Suarez-Caabro, 1979, Riesco and Cepeda, 1996). When studying LEK, the species diversity of the fisheries poses the problem of knowing what species to ask/talk about. Asking about each one of the species would result in too long and superficial interviews and questionnaires. Previous studies in Puerto Rico and in similar fisheries in the Dominican Republic suggested that fishers' thinking about the ecosystems was structured around a core group of 20-25 important species (Valdés-Pizzini *et al*. 1996; 2004; García-Quijano 2001). I used ANTHROPAC X (Borgatti 2001) to analyze the freelists for frequency of appearance in lists, average rank, and Smith's S salience (a composite parameter from frequency and average rank). Smith's S was used as the principal criterion for ranking the species.

The main purpose of the freelisting exercise was to construct a list of locally-important species to ask about during the course of subsequent interviewing. Salience in the freelists was the main criterion for including fish species in questionnaires, but I also supplemented the list with species that I learned, through ethnographic interviewing and participant observation, were important. The list of species used in subsequent interviews was comprised of 16 species. Later in this chapter I will briefly discuss the ways in which different species of fish and shellfish are important for fishers in the study region.

Figure 3.3. Fish captured, cleaned, and ready to be marketed. Photo by H.Lloréns 2005.

Underwater landscapes

I used multiple, habitat-centered freelisting exercises to explore the kinds of fishes that fishers in my study associated with particular aquatic environments. An important endeavor during this study was uncovering the cognitive mechanisms by which fishers made sense of the enormous amount of information involved in fishing many species, using many kinds of gear, in multiple aquatic environments. During the first round of interviews fishers repeatedly told me that they used two general modes of thinking to find fish. One mode was to think about a given species and then about what kinds of aquatic environments and environmental parameters were, in their experience, associated with that species. The other was to think about a particular aquatic environment and then make a mental list of the different fish and shellfish species that might be found there under a given set of environmental parameters. Previous studies of southwestern Puerto Rican fishers' folk fish taxonomies also suggest that species-habitat matching is an important force in shaping folk taxonomis of fish and shellfish species (Valdés-Pizzini et. al 1996; 2004).

I asked the 20 key informants, and later, the 41 participants of the structured questionnaire to list the species of fish and shellfish that they associated with 8 broad types of coastal/marine environments, which include: 1) mangroves, 2) inside bays, 3) coral reefs, 4) seagrasses, 5) mudflats, 6) sandflats, 7) deep waters, and 8) pelagic (open) waters. I analyzed the lists for each type of environment separately and chose the most salient species for characterizing fishers' constructions of imagined underwater landscapes. In Chapter 5, I detail the results of this exercise, which constitute a useful representation of fishers' thinking about local ecosystems.

Using photographic specimens to elicit knowledge about fish

As is the case with many multi-species fisheries, considerable confusion can result from variations in the names given to species of fish. In previous studies in Puerto Rico and the

Dominican Republic, I had noted that the common names that fishers use to refer to fish vary according to location and that referring to a single species by different names is common. Moreover, the common fish names that fishery officials and biologists use can also differ from the folk names used by fishers. A fisher and a fishery official might think they are talking about the same species of fish, while they in fact might be talking about two separate species. The potential for confusion between common fish names has obvious implications for cooperative management and communication among stakeholders, as well as for the accuracy of fishery landings statistics.

I assembled a set of 104 photographic specimens of resources species to ensure that the information I collected could in the future be referenced by stakeholder groups, as well as to make certain that I knew what kinds of fish the informants were describing during interviews. These specimens were presented as photographs of fish that were laminated for durability and numbered in the backside (see figure 3.4). I assembled the photos from a variety of sources, including scientific field guides, and the FISHBASE web database (Froese and Pauly 2003). The 104 photographic specimens were compiled, verified, and laminated with the help of UPR-Sea Grant personnel.

As I stated previously, I conducted 6 interviews with key informants wherein I asked them to tell me the local common name for the particular fish portrayed in a photographic specimen. The process entailed that fishers examine the ordered photographic specimen and tell me the local names of the fish presented in the photo, I would then write down the names reported to me. The result of this exercise was a list of 104 fishery species and the common name(s) used for each species in southeastern Puerto Rico. The photographic specimens were also a very useful "photographic- or visual-elicitation" technique (Collier 1967; Johnson and Griffith 1998). The photographic specimens were additionally useful to keep track of interviews about LEK. References to specific fish were commonly made when discussing ecosystems' change, degradation, and pollution.

Figure 3.4. Photographic specimens assembled on the floor of the author's house in Guayama.

Explanatory phase

In the explanatory phase I followed a correlational research design, utilizing a cross-sectional approach in choosing respondents (Johnson 1990; Babbie 1990). The purpose of this design was to investigate co-variation in patterns of agreement in ecological knowledge with social and material measures of success. The structured questionnaires comprising the principal research instrument during this phase were developed based on the findings of the exploratory phase. The questionnaires were administered in pre-arranged, face-to-face interviews with fishers in the study region. As it happens with many rural, working class populations, a mail survey was not an adequate option for the collection of data because many of the fishers are not comfortable with written instruments (key informants repeatedly told me that many older fishers did not read or write well), while the structured interview was just too specific and/or too long for a telephone conversation.

Choosing Respondents

In the exploratory phase my intention in choosing respondents was to maximize my access to expert knowledge of fishing. During the second phase I aimed to maximize the variation in ecological knowledge, success, and other variables in the population of respondents. At the same time, I strived to pursue a balanced representation of coastal communities in my study area. I thus chose random sampling, stratified by coastal communities, as my sampling strategy. Below I explain some of the factors that affected my sampling strategy.

I drew this sample from a list of fishers I compiled during the first 12 months of field research. I compiled this list of fishers from two principal sources. The first source was the list of licensed fishers in Puerto Rico from the 2002 Puerto Rican Fishers Census (Matos-Caraballo 2002) obtained from NOAA Fisheries. The second was a list of fishers informally gathered from my conversations with fishers in the study area. Building a list of possible respondents from these two sources was the best approach available under the circumstances, but it was by no means perfect. The Fishers' Census suffers from undercounting because it only includes fishers who submit reports to the fishery statistics program. Some fishers, however, do not submit reports on purpose due to strained relationship between them and state agencies (Griffith, Valdés-Pizzini and García-Quijano 2006). The names submitted by other fishers, on the other hand, only included fishers who were known by my key informants.

Compounding the sources of error in sampling was that again, due to the political situation, some fishers did not agree to participate in any interviews with me and/or my field assistants. Other fishers from the list had moved and/or could not be located. Of 100 fishers who comprised the list of possible respondents for interviewing, only 41agreed to do both participate and meet with me and/or my research assistants for an interview. My key informants were not included in the explanatory phase sample, mainly because they had already given me a great deal of their time. Furthermore, most of them had collaborated with me in testing and refining my survey instrument, making their responses not comparable with the responses of fishers who had never seen the instrument.

Out of 100 fishers that comprised my original list of possible respondents, my final list of structured questionnaire respondents included 41 fishers. I calculated that the total number of fishers in the study area is close to 200. All of the coastal communities, except for *Barrio Jauca* in Santa Isabel, were represented in my final sample. Strictly speaking, this survey can only be said to represent the fishers included in this study, that is, fishers who were in the original list of possible respondents, whom my research assistants and I were able to contact, and whom agreed to participate in this study. There does not, seem to exist, however, any systematic error related to ecological knowledge and/or success associated with the reasons I was not able to reach informants. The use of specialized network techniques for reaching hidden ethnographic populations (see Kilworth *et al*. 1998; 2003) was not possible due to time constraints and available funding. It can, however, be an excellent option for future research.

Tables 3.3 and 3.4 comparisons of age (in 2004) and of self-reports of hours spent fishing each week for my sample of 41 fishers and for 139 fishers reported in the Puerto Rico Fishers Census for the study region and two nearby municipalities. These two numerical variables were measured by both my structured questionnaire and the census. It can be assumed that these variables are normally distributed in the general fisher population (within the range of possible values). By controlling experience and effort, age and hours spent fishing are variables that can affect success in fishing. The descriptive statistics for the two samples in the two parameters are very similar, and supports the assertion that my sample can be interpreted to represent the larger population.

Table 3.3 Comparison of descriptive statistics of age values for the exploratory phase sample and 139 fishers reported by the census in or near the study region.

Age of fishers in census (2004)		**Age of fishers in sample (2004)**	
Mean	48.49	Mean	49.34
Standard Error	1.18	Standard Error	2.12
Median	47	Median	47
Mode	58	Mode	62
Standard Deviation	13.87	Standard Deviation	13.59
Sample Variance	192.35	Sample Variance	184.58
Range	57	Range	45
Minimum	20	Minimum	25
Maximum	77	Maximum	70
Count	139	Count	41

Table 3.4. Comparison of descriptive statistics of weekly hours spent fishing values for the exploratory phase sample and 139 fishers reported by the census in or near the study region.

Weekly hours fish census		Weekly hours fish sample	
Mean	29.04	Mean	28
Standard Error	0.97	Standard Error	2.01
Median	30	Median	27
Mode	40	Mode	40
Standard Deviation	11.41	Standard Deviation	12.90
Sample Variance	130.09	Sample Variance	166.45
Range	50	Range	50
Minimum	0	Minimum	0
Maximum	50	Maximum	50
Count	139	Count	41

Developing and testing structured questionnaires

The structured questionnaire instruments were developed based on the results of the exploratory phase. They were thus informed by 12 months of intensive ethnography. The questionnaires consisted of four parts. Part one, included a set of questions about the respondents' personal and demographic characteristics and about the respondents' extent of involvement in fishing. The second part, asked a set of questions measuring variation in determinants and indicators of success in fishing from the exploratory phase, as well as applicable parameters from previous literature. Part three involved a set of ecological knowledge assessment tasks. This part was built according to the information my key informants provided about ecological knowledge important for fishing. Finally, in part four I asked respondents to rate fellow fishers in the sample in terms of their perceived success in fishing.

Local importance of fish and shellfish species

An important component of developing the structured interview questionnaire was choosing a set of locally important fish and shellfish species to include in the questions about ecological knowledge. An important tool in choosing these species was the analysis of freelisting exercises already described. Table 3.5 lists the 20 most salient species mentioned in the freelisting exercises. Sixteen of those species were included in four questions about general ecological knowledge. Included in the instrument was a question that verified the importance of these species for respondents in the sample. All of the species were considered as ‘very important’ by the majority of the respondents. Additional fish species were included in questions regarding specific habitats or characteristics. For example, I added various estuarine species to the list in a question about distribution of fish according to salinity. Fish species that are believed to cause *ciguatera* fish poisoning were included in a question about *ciguatera.*

The five most salient species in the list were important for different reasons. These species are, the mutton snapper (*Lutjanus analis*), lane snapper (*Lutjanus synagris*), yellowtail snapper (*Ocyurus chrysurus*), mackerel (Scomberomorus *maculatus*) and red hind (*Epinephelus guttatus*). The mackerel and the red hind are ‘*de primera*’ (first class) species, commanding high prizes in the market and are highly sought after by restaurants and private buyers throughout Puerto Rico (Suarez Caabro 1979; Griffith, Valdés-Pizzini and García-Quijano 2006). The yellowtail snapper is not regarded as a first class species, but it is one of the more abundant and most frequently fished schooling species around Puerto Rico and other parts of the Caribbean. One would expect these three species to appear on any ‘important species’ list throughout fisheries in Puerto Rico.

The mutton snapper and the lane snapper are very important locally, although they are not the highest prized species. In my interviews with fishers, these two '*peces colorao's* (a local category meaning 'red fish') were repeatedly called the "most important food species", and "the fishes that feed this coast". A local legend, repeated by several key informants throughout this study, illustrates just how important these two species are in terms of historical nutritional value for coastal communities in southeastern Puerto Rico. These two fish species, both belonging to the snapper (*Lutjanidae*) family, both thrive in mixed seagrass, mud and fringing reef underwater ecosystems, such as the extensive shallows near southeastern Puerto Rico. The two species are anatomically distinguished by having black spots on both sides of the body on the upper back just above the lateral line and below the anterior dorsal fin rays (Froese and Pauly, 2005). According to local legend, one repeated by several informants, these two black spots represent the markings left by Jesus Christ's fingers when he used specimens of those two species for the 'multiplication of the fishes and the loaves' miracle (Holy Bible, John 6:11-14; Luke 9:13-17). The mutton snapper and the lane snapper have thus become part of the religious lore of southeastern Puerto Rico's coastal communities, highlighting both their ecological and economic importance for these communities (see Berkes 1993; 1999). Their importance dates back to the time when fish was often the only protein these communities would consume for up to 7 months out of the year.

The *boquicolora'o* (White grunt, *Haemulon plumierii*) illustrates a case where freelisting exercises and the use of photographs in interviews helped avoid confusion of resource species names that vary according to local or regional naming differences. This fish species, a grunt (*Haemulidae*), is known locally by the names *chicata*, *cachicata*, and *boquicolora'o*. Fishers (this happened in several interviews) used these names interchangeably during different parts of the interview. When working on the important species freelist exercise, fishers used one of the three names (in the list) and as a result I had three separate fishes of relatively low salience.

Table 3.5. Top 20 species by Smith's S salience in the freelists.

PR common name	rank	Scientific name	English common name
sama	1	*Lutjanus analis*	mutton snapper
arraya'o	2	*Lutjanus synagris*	lane snapper
colirrubia	3	*Ocyurus chrysurus*	yellowtail snapper
sierra	4	*Scomberomorus maculatus*	Spanish mackerel
cabrilla	5	*Epinephelus guttatus*	red hind
langosta	6	*Panulirus argus*	Caribbean spiny lobster
boquicolora'o	7	*Haemulon plumierii*	white grunt
mero	8	*Epinephelus morio*	red grouper
carrucho	9	*Strombus gigas*	queen conch
pulpo	10	*Octopus vulgaris*	common octopus
chillo	11	*Lutjanus vivanus*	silk Snapper
salmonete	12	*Pseudupeneus maculatus*	spotted goatfish
peje puerco	13	*Balistes vetula*	queen triggerfish
loro	14	*Scarus and Sparisoma sp*	parrotfishes
picúa	15	*Sphyraena barracuda*	Atlantic barracuda
jurel	16	*Carans hippos*	Crevalle jack
capitán	17	*Lachnolaimus maximus*	hogfish
pargo	18	*Lutjanus apodus*	schoolmaster snapper
cartucho	19	*Etelis oculatus*	queen snapper
dorado	20	*Coryphaena hippurus*	mahi-mahi
balajú	21	*Hemiramphus brasiliensis*	halfbeak, ballyhoo
peto	22	*Acanthocybium solanderi*	wahoo
jarea	23	*Mugil curema*	white mullet
cojinúa	24	*Carangoides ruber*	bar jack
juey	25	*Cardisoma guanhumi*	land crab

Figure 3.5. Graph showing the distribution of frequency (% respondents mentioned) and average ranks for important species mentioned in the freelists.

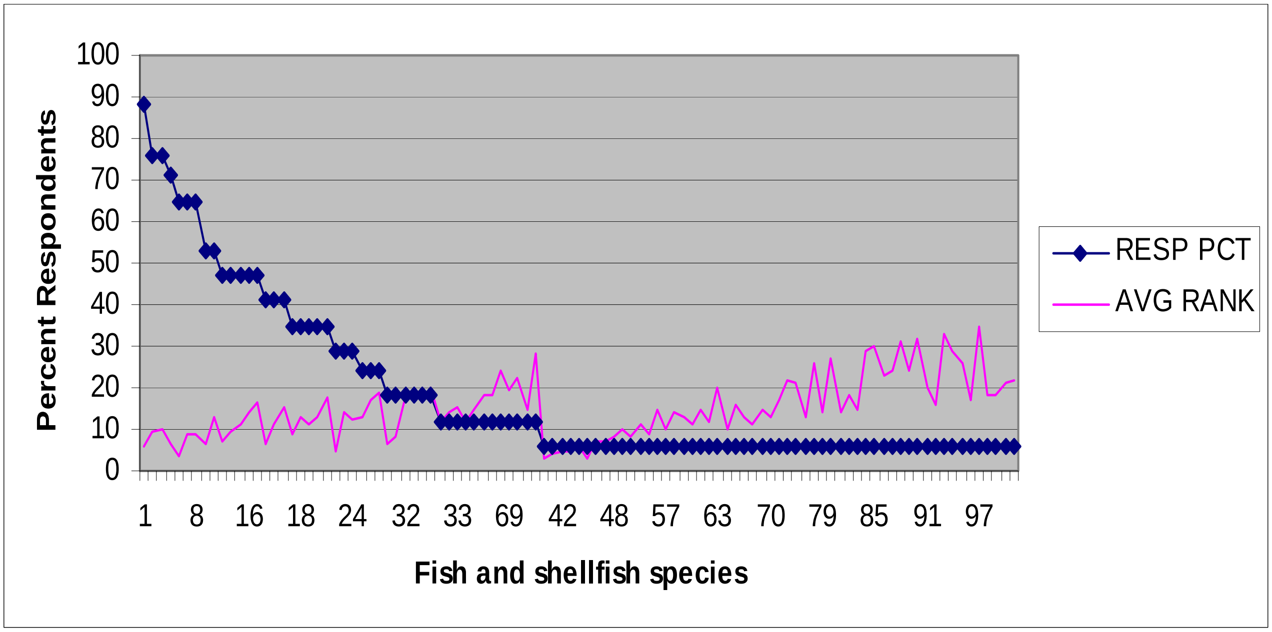
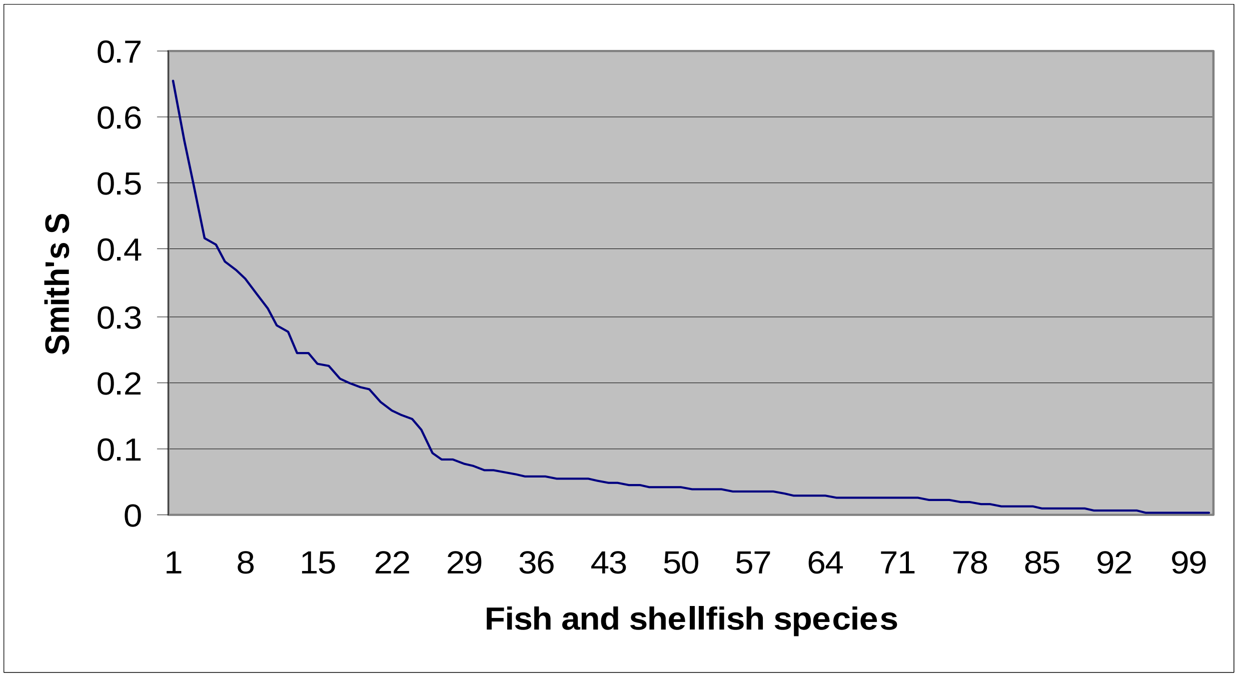


Figure 3.6. The distribution of Smith's S salience for important fish and shellfish species in the freelists. Smith's S was calculated with ANTHROPAC X (Borgatti 2001).



I would not have included the grunt (an important food species) if Don Teófilo, one of my key informants, had not pointed out to me in a conversation about trophic relationships, that *boquicolora'o, cachicata,* and *chicata* refer to, in fact, the same species of fish. Later during my fish identification interviews using photographic specimens I confirmed this. All fishers agreed that the three names referred to the same fish. More specifically, *boquicolora'o* is the most widespread name used around the island (my father, an enthusiast of sport spearfishing who learned how to fish 40 years ago in the Northern Coast of Puerto Rico, later told me that this is the name he knows). *Cachicata* is widely used through the southeast, and *chicata* is used more often in the Aguirre, Salinas and Santa Isabel areas. All of the fishers in my study knew the three names.

After I become aware of the multiple names given to the white grunt, I created '*boquichicata*' a new fish entry for my freelists. All instances of the three names for the same fish on the freelists were substituted with '*boquichicata*'. *Boquichicata* then became the 7th most salient species on the list, a more accurate reflection of the importance of this fish for local fishers. Had I not taken the extra steps to verify fish names, this wouldn't have become apparent, and I might have not included this fish species in the questionnaires in later stages of the research.

The rest of the species in the list are there for various reasons. Some, like the queen conch and the common octopus, are important commercial species. Others, such as the spotted goatfish, parrotfish, and the white grunt are important food species. The importance of other species in this list seems to be either cultural and/or ecological. For example, the white mullet is not an important food or commercial fish, but, according to several fishers, this herbivore/detritivore is an important food source for more commercially important fish species. For local fishers, the white mullet is also regarded as an important indicator of ecosystem health. This point fits the definition of a keystone species (Mills, Soule and Doak 1993; Paine, 1969). A key stone species refers to species who hold an important position in the trophic network and can serve as an indicator of ecosystem health. The white mullet is an example of a bottom-up keystone species (Schulze and Mooney, 1993), whereas other fishes on the list, such as the barracuda, are top-down keystone species, dominant predators who are also indicators of ecosystem health.

Some species, such as the schoolmaster snapper and the barracuda, used to be important species for commerce and local nutrition, but increased awareness of the species' responsibility in *ciguatera* poisoning cases may render them only as ecologically/culturally important species at present times. The determinants of a fish's salience are their commercial value, ecological, and local importance for nutrition.

Assessing variation in 'success in fishing'

In the structured interview questionnaire I measured variation in several domains that were widely considered as determinants or indicators of success. The main purpose of the questions was to assess variations in success within the group of respondents. I also tested the cultural models of success constructed from my analysis of key informant interviews. I included several variables that have been found by other researchers to affect success in fishing in similar fisheries. In chapter 4, I explain in detail the cultural model of success in fishing, constructed based on my interviews with expert fishers.

Why not use individual landings a measure of success?

At the beginning stages of this research**,** I had hoped to obtain records of individual fishers' landings (fish caught over time or per trip) and use them as a measure of success. Based on exploratory ethnographic work, I found that individual fishery landings from state agencies' records, if they were obtainable, were unreliable. Fishers throughout this study repeated to me that a widespread method of resistance against regulations was to report more or less landings to the Puerto Rico Fishery Statistics program, or not to report any landings whatsoever. Summarizing what fishers who I interviewed told me, some fishers would report their landings very exactly, and others would not. Other fishers would not report their landings at all, while some people who had fishing licenses but are not fishing reportedly make up landing reports following a hurricane or flood event to participate in the government's fishing equipment replacement program (also see Griffith, Valdés-Pizzini and García-Quijano 2006). The misreporting of yields, profits, and activities is a common method of resistance used by small-scale resource users to resist unilateral regulation from outside agencies (Scott 1985; 1998). Essentially, a 'legible' (numerically described and categorized) population is more easily controlled by the state (Scott 1998:11-70). By making participation unpredictable and therefore increasing the error inherent in statistics collected by the state, fishers decrease their legibility to the state apparatus.

With this discussion I do not wish to call into question the value of the state's Fishery Statistics Program. The data gathered by this program can be very useful to discuss large-scale trends in fishing, as well as comparison between regional and municipal populations (Griffith, Valdés-Pizzini and García-Quijano 2006). The combination of the Fishery Statistics Program undercounting of fishers, and the variability in reporting practices between fishers make the data resulting from fishers' reports to the program unfit for comparisons between individual fishers. Many fishers interviewed during this study believed that the better the relationship between fishers and state agencies (that is, the more participation the fishers perceive to have), the more faithful landing-reporting practices will be.

Local cultural models of success appear to be driven by a labor-group subsistence ethic model (see Chayanov 1966; Scott 1976), rather than by profit maximization. This is another reason why I did not use individual landings as a measure of success. According to many of my key informants, the actual magnitude of landings and profits that a fisher obtains is only a minor component of the cultural models of success that drives fishers' behavior. Because the ultimate goal of many small-scale fishers in this area is to ensure reproduction and economic survival of the fishers' extended household, the predictability and sustainability of access to moderate amounts of fish might be more important that the magnitude of landings themselves. Also, a fisher who fishes too much or too carelessly may impact the resource and thus face disapproval from other fishers in the community. This might be deleterious to success by decreasing the support network available to a fisher. Like one of the key informants told me: "*En el mar, tu mejor seguro son los demas pescadores, por eso es importante mantener buena relación*" (At sea, your best insurance is your fellow fishers, this is why it is important to maintain good relationships).

Measuring variability in ecological knowledge

One of the principal insights I gained from my interviews with key informants is that in order to find multiple species of fish in an environment characterized by patchiness of resource availability and which undergoes episodes of localized degradation and regeneration, small-scale fishers tend to think about local ecosystems in terms of ecological parameters. For example, given a set of parameters such as season, weather, time of day or night, salinity, bottom type, depth, water turbidity, distance from shore, and availability of food, a fisher might expect to catch ***x***,***y***, or ***z*** species of fish, or a combination of species. These fish species might be caught using one or more strategies and gears depending on the fish species and on fishers' preferences. By using their historical experience and by sharing knowledge, fishers learn precise localities within territories where different sets of conditions might come together to produce reasonably predictable catches of fish. Fishers call these places '*las areas de pesca*' (fishery areas). I will explain these concepts in more detail in chapter 5.

Using the list of 16 important fishery species described early in this chapter, I asked the fishers who participated in the structured questionnaire to tell me in what kinds of underwater habitats the species would be most likely found, during which seasons of the year the species is caught, whether individuals of this species are mostly found alone, with co-specifics or in multi-species assemblages, and what are the fishing gear types used to capture these species.

Using modified lists of fish species, I asked the fishers several additional questions. Using a list of estuarine-associated species, I asked the fishers where in a range of underwater habitats, ranging from freshwater to saltwater, each species could be found. Similarly, I used a list of fishery species that are believed to be associated with *ciguatera* fish poisoning to ask whether each species was always, very frequently, sometimes, very infrequently, or never poisonous. Lastly, I used a list of fishery species that are associated with deep fishing (the local category is called '*pejes de fondo*', bottom fish) to ask about the range of depths at which each species could be found. Questions about depths were asked in *brazas*, a depth unit used by Puerto Rican fishers, which is similar in magnitude to a fathom. Finally, I asked the informants a series of questions designed to measure their attitudes and values regarding environmental conservation, other fishers and cooperation with other fishers.

Analysis of explanatory phase data

The principal goal was assessing the direction and strength of correlations between a series of variables related to success in fishing and local ecological knowledge. After the structured questionnaire was administered to all of the respondents, I entered the results in a SPSS 12.0 (SPSS 2004) database. I conducted statistical and descriptive analysis of the structured questionnaire answers in S-Plus 7.0 (Insightful 2005), SPSS 12.0 and JMP 6.0 (SAS Institute 2005).

The Consensus Analysis Model and knowledge assessment

In order to determine the variation in ecological knowledge among the participants, I used ANTHROPAC X (Borgatti 2001) to perform cultural consensus analysis (Romney, Weller and Batchhelder 1986; Weller 1987). Cultural consensus analysis utilizes the patterns of agreement, or consensus, among informants to measure informants' agreement about a domain. The basic premise of the Cultural Consensus model is that

> If individuals share a common culture, give their answers independently, and have competences that are constant over all questions, the expected agreement between any pair of individuals is simply the product of their competences, when competence refers to an individuals agreement with the culturally defined standard or truth (Boster 1991:5).

Consensus analysis, a derivative of factor analysis, achieves three principal goals. First, it tests whether the agreement between the informants is enough to assume that a shared cultural model is driving the informant's responses to the question(s). Second, it estimates the culturally-correct answers for the questions asked. Third, it estimates cultural competence for each informant based on the informants' agreement with the culturally-correct answers (Romney, Weller and Batchelder 1986; Weller *et al*. 1993; Borgatti 1996).

There is debate related to whether the 'cultural competence' estimated by using Consensus Analysis can be used to estimate individual knowledge scores about a domain (see Brewer 1995; Brewer, Romney and Batchelder 1991; Boster, Johnson and Weller 1987; Boster 1985a; 1985b; Furlow 2003). In a test in which the correct answers are known and in which the questions asked are all about the same domain of knowledge (for example, scientific names of fish), it's easier to assume that cultural competency represents cultural knowledge (Borgatti 1996:43-45).

There has been more debate, however, about the applications of the cultural consensus model to questions for which there is no known answer (see Furlow 2003 for a review). Furlow (2003), Boster, Johnson, and Weller (1987), and Brewer (1995) used correlations of informants' scores in multiple questions about a domain of knowledge to test whether consensus analysis was an appropriate measure of true competence, but their conclusions varied. Brewer (1995), for example, concluded that correlations between informants' consensus analysis competency scores on multiple questions were strong enough to conclude that consensus represented true competency. Furlow (2003) compared informants' cultural consensus competency scores in questions about two subjects that he considered to be very closely related cultural domains (knowledge of racing bicycle brands and knowledge about the greatest cyclists of all time) and found that the correlations were not sufficiently strong for the informants' aggregate competency scores to represent true knowledge. Similarly, Ross (2002:149) argues that competence scores should not be used as an evaluative term, because in a sample involving one expert and several non-experts the expert would receive a low competence score because she does not participate in the non-experts' cultural model.

My approach to this debate is empirical, following Romney (1994). Some, but not all, all consensus is based on shared experience and/or shared knowledge (Romney 1994). The validity of the Consensus Analysis model to measure true competency depends on the domain being investigated as well as with social and historical factors of information distribution, and should be assessed on a case-by-case basis (Romney 1994). Under a combination of certain conditions agreement does represent knowledge. These conditions are: 1) The questions' topics deal with the same or very similar domains of knowledge, 2) There is a logical independent process or constrain that will tend to result in more agreement between more knowledgeable individuals compared with less-knowledgeable individuals (e.g. there are correct answers, even if the researcher does not know them), 3) The informants being compared can be reasonably assumed to share a cultural model regarding the questions asked, and 4) Preliminary analysis of each question's response patterns show that a single shared cultural model might be driving responses to the question (Batchelder and Romney 1988; Boster and Johnson 1989; Romney 1994; Romney, Weller, and Batchelder 1986; Weller 1987).

These conditions apply to my system of study. In this study, the ecological knowledge assessment tasks were about different aspects of a very particular domain (knowledge about fish and coastal ecosystems) and the questions were asked to professional fishers, who can be assumed to be experts (although with various degrees of expertise) in fishing. Differences between ‘experts’ and ‘novices’ are not a source of confusion for estimating agreements in this research; therefore competency measures participation in a cultural model regarding expert knowledge. Furthermore, there actually are correct answers to ecological knowledge questions, although I, as a novice in matters of fishing, do not know them. Fishers’ cultural models of ecological knowledge result from many years of experience with local ecosystems and are based in real observations of the physical world. Finally, the application of the cultural consensus model to the ecological knowledge assessment questions showed that for each of the questions a single cultural model appeared to be driving the answers. In Chapter 5 I will explain these results in more detail.

Correlating ecological knowledge and success in fishing.

The principal hypothesis of this research, that there is a significant correlation between ecological knowledge and success in fishing, was tested by correlating ecological knowledge assessment scores with measures of success. The principal indicator of success, resulting from the exploratory phase, was the success rating of a respondent by other fishers. I also employed other indicators such as a material wealth index, income derived from fishing, and home ownership. Pearson product-moment correlation was used as a correlation statistic when both variables were at the interval or ratio level of measurement. Spearman’s rho rank-order correlation statistic was used when one or both correlated variables were a dichotomous variable or at an ordinal level of measurement.

To further assess the pattern relationships between the variables, co-variation of measures of ecological knowledge with culturally-valid measures of success was also explored through linear regression analysis. Distribution-free statistical measures were also used for specific comparisons between variables, and for purposes of triangulation.

Summary statement on methodology

This research followed a qualitative-quantitative, exploratory-explanatory design (Johnson 1998). In that sense, this research was adaptive, since the variables to be measured to test the project hypotheses were developed empirically, and refined as the research progressed. Although time consuming, this approach combines the contextual richness of descriptive ethnography with the explanatory power of quantitative inquiry and is thus an effective way to test hypothesis about culture and cultural knowledge (Johnson 2000; 2002; Ross 2002). Specifically, in dealing with cultural knowledge it is important to frame explanatory, quantitative research questions in terms that make sense to the people answering the questions.

For example, in this study it would have been impractical to catalog all the possible cultural knowledge that fishers can have about more than 100 species of fish and shellfish that live in a hard-to-observe environment. Instead, I investigated the most essential domains of ecological knowledge about a few important fishery species. Carefully constructing questions about these types of knowledge, I was able study the patterns of shared knowledge about these domains and relate it to characteristics of the informants. Only then standard statistical and quantitative approached could be used to make the results of this research replicable and falsifiable, as well as culturally-valid.

CHAPTER 4

CULTURAL MODELS OF SUCCESS IN THE SOUTHEASTERN PUERTO RICAN FISHERIES

At the start of my dissertation fieldwork I talked with some fisheries officials who worked for the state's Department of Natural Resources (DRNA) agency. I explained my project and told them that I wanted to document fishers' ecological knowledge for possible use in management, as well as to investigate what constitutes success for fishers. The reactions to my project were mixed. Reactions were indifferent or mildly condescending, as if there was very little to be gained studying the knowledge of fishers. One of the first responses I got was: "*oh, but we hear about fishers'* ***anecdotes*** *all the time*!".

Fishery officials are knowledgeable and competent people in their own right. They truly care about conserving the marine environment in Puerto Rico. Their own cultural model as fisheries scientists, however, reifies the statistical population model, with its many assumptions, as the highest form of knowledge regarding fisheries. When I explained to fishery officials that I wanted to be systematic about studying fishers' 'ecological culture', and that I had actually trained quite extensively in ecological sciences, their attitudes changed a little, and disregard was replaced by puzzlement. My reading of that puzzlement was: How could anybody who has been exposed to fish population modeling be interested in exploring fishers' 'anecdotal' information?

I expected the reactions described previously from fishery officials. When I asked them what they believed fishers wanted to achieve by fishing and how they went about it, however, the lack of insight evident from the answers took me by surprise. One fishery biology official told me: "*Fishers behave erratically and non-rationally*". Another one told me: "*Only the smarter fishers want to invest and make money*". A third one took the prize for a biased answer: "*Frankly, all they (the fishers) want to do is catch a few pounds of fish so they can drink it away*". Aside from being completely dismissive towards a group of people (fishers), who are among the most hardworking people I have ever met, fishery officials' answers to my questions demonstrated an utter lack of knowledge of what fishers want and what constitutes success for fishers. How can a fishery be managed if the motivations driving of economic behavior are not understood?

The late Douglass C. North, economist and Nobel Prize laureate, developed an economic theory of human institutions (North 1990; 1993; North and Thomas 1973). In his Nobel Prize essay he affirmed that most Western-led development initiatives in the world had failed because neo-classical economic theory, and especially its assumptions about the drivers of human behavior, are "simply an inappropriate tool to analyze and prescribe policies that will induce development" (North 1993). In his essay, North asked: "*How can one prescribe policies when one does not understand how economies develop?*"(ibid.). North's (I am sure he was influenced by the work of many anthropologists) response to the neoclassical economic model was to develop a theory of human institutions. North's definition of human institutions was:

> Institutions form the incentive structure of a society and the political and economic institutions, in consequence, are the underlying determinant of economic performance. Institutions are the formally-devised constraints that structure human interaction. They are made-up of formal constraints (rules, laws, Constitutions), informal constraints

> (norms of behavior, conventions, and self-imposed codes of conduct) and their enforcement characteristics. Together they define the incentive structure of society and specifically economies (North, 1993: 2).

In line with North's (1993) arguments, I contend that Puerto Rican fishers' goals and models of success in fishing cannot be assumed based on bioeconomic models developed elsewhere, especially the ones developed in temperate fisheries which have very different social and ecosystem dynamics from tropical fisheries (Polunin and Roberts 1996; Sale 1991; Ruddle 1996). Furthermore, goals and models of success can vary significantly between regions of the same country, if economic, historical, and ecological constrains are different. Local and regional social and ecological systems can have markedly different economic, political, and cultural histories that can greatly affect properties of the systems such as patterns of resource use and cultural models of success (Berkes, Colding and Folke 2003).

'Success' is an eminently social and contextualized construct, a "pattern of effective performance in the environment, evaluated from the perspective of development in ecological and cultural context" (Masten and Coatsworth 1995:21). During the remainder of this chapter I detail my exploration of cultural models of success in fishing held by small-scale fishers in southeastern Puerto Rico.

Cultural Models of Success in small-scale fishing: goals and motivation

Don Teófilo, a fisher from the coastal village of Aguirre in Salinas, Puerto Rico told me the following words when I asked him what it means to be a successful fisher:

> You have to live from fishing two or three years to understand what I am going to tell you. To know '**como es que se bate el cobre**' (adage meaning knowing how things work

> out in the real world), how things work, how does one live from fishing. And how hard it really is (to live from fishing):
>
> Why do we fish? Because being a fisher -do you understand me?-, you being a fisher and being able to bring nourishment to your community, and liking the work you do... ah! One feels fulfilled and satisfied. Because one lives for the benefit of a community. And the community helps you in your daily life, because of the quality of the fish that you bring back from the sea. That is how it is, do you understand me? Fishing is what we call honorable work"

Don Teófilo, is, according to the majority of people related to fishing whom I talked to during my research, a very successful fisher. It seems that throughout the southeastern coast of Puerto Rico everyone knows him. Teófilo was born in a few feet from the water's edge about 65 years ago, and as far in his genealogical past as he can remember, his family have been fishers. He grew up facing the Bay of Jobos and watching the seasons and the changes in the air, water, flora, and fauna. Apart from 8 years in the 1960's when he emigrated briefly to work in a steel mill in New Jersey, Don Teófilo's economic life has taken place between the sea and the sugarcane field. Don Teófilo is a master *yola* builder and has taught many people how to fish. Fishers of all ages in Aguirre routinely come to his house to ask about fishing techniques and advice on where to fish. It would be difficult to find someone related to fishing in Aguirre who would say that Don Teófilo is not a very successful fisher.

Don Teófilo, however, is not rich or wealthy by any middle-class standards. He did put his children through school. His daughter went to college and became an engineer. His son became a fisher and Don Teófilo built him his first *yola* and gave him fishing gear to get started. Don Teófilo owns a neat waterfront house in a working class coastal community and has good fishing equipment and two solid boats, but he and his wife Doña María still go out to fish and work part-time to supplement their small social security allowances, and will probably need to work at some level of intensity for the rest of their lives.

Don Eddie, another widely-regarded very successful fisher from nearby Santa Isabel, lives in an almost identical economic situation and still fishes and works as a boat mechanic at 69 years old (in 2004). Similar economic situations face Don César and Don Eusebio, two master fishers from Arroyo who have taught several *arroyano* generations how to fish. Don Pablo and Don Aquiles from Guayama, other two very successful fishers, are slightly better off economically than the other fishers due to their links with larger markets of fish buyers, but still they work very hard, and they are very much working class Puerto Ricans.

All of the successful fishers I described have five common characteristics and are reflections of local models of success in fishing. First, they are widely regarded by fellow fishers and other coastal residents as successful and knowledgeable fishers. Second, people from these fishers' neighboring communities seek them when they want to buy fish and/or shellfish. Third, through their participation in fishing and by sharing their knowledge about fishing, these fishers have built strong social relationships with fellow fishers and their families. Fourth, while remaining working class, they have achieved some economic stability. Their economic stability is buttressed by the fact that expert fishers are valuable for a poor coastal community. Like Don Teófilo told me: "*one lives for the benefit of a community. And the community helps you in your daily life, because of the quality of the fish that you bring back from the sea*". Lastly, all of the fishers above have fulfilled what I found to be the two highest-level, most widely-shared goals of a small-scale fisher in my study region: to be able to make a living from fishing, and to be able to raise or substantially help one's family through fishing (household social reproduction (Folbre 1994; Polanyi 1946, Stanfield 1982).

Don Teófilo's statement contains within it the two highest-level cultural models related to success in fishing that I found during this research. These highest-level cultural models represent the goals of a fisher, what a fisher wants to achieve from engaging in fishing. As D'Andrade and Strauss (1992) showed, high-level cultural models will be most influential on people's behavior. First and foremost, a fisher wants to 'make a living' from fishing. This does not mean that they make a living *only* from fishing. Few fishers in Puerto Rico are only fishers throughout their lives. For most, fishing is an important part of their personal and household economy, which helps them avoid total dependency on proletarian labor and which bails them out in times of need (Griffith and Valdés-Pizini 2002). Thus, if fishing enables a fisher to live and 'pay the bills' one of their major goals is met (see Cooley 2002). The second major goal for fishers in southeastern Puerto Rico was to achieve household social reproduction. Every single fisher that I talked to during this research told me that they valued fishing because they had been able to raise their families and care for the members of their family through fishing.

It is not only individual fishers and heads of households who participate in fishing along the rural coasts of Puerto Rico. Entire extended households and families are sustained by fishing and participate in activities related to fishing (Griffith, Valdés-Pizzini and García-Quijano 2006). Don Pablo, a fisher from Guayama, described how he was raised from fishing, and in turn his children were raised from fishing:

> I am now 64, and out of 16 siblings 12 are still alive. My old man raised us from fishing. I survived from fishing. At 10-12 years old, I started to go fishing with him…but fishing, this is what I love. I love fishing because fishing really is something great. Me and my wife, and my five children, they are all raised, my kids, from fishing. I raised those kids

> from fishing. They went to school! Almost all of them went to school. I tell my daughters: 'now you have a television in your room, you went to the university and everything'. And it all has mostly come from fishing.

Don Eddie, a fisher from Santa Isabel, describing another fisher he considered to be very successful, told me:

> There is a fisher from around here, a friend of mine, his name is Enrique, that I think is a very successful fisher. He is a long-liner, and he has dedicated his life to fishing. I admire him, because he goes out to sea at dusk and comes back early the next morning, and this is how he has raised and sustained his family.

Throughout this study, descriptions of successful fishers included being able to support a family by fishing. Subsistence and household social reproduction seem to be the lighthouses that guide fishers' economic behavior. As evident from the preceding statements, and as agreed by my key informants, prestige as a fisher is a good indicator of success in fishing (Poggie (1978) and Poggie and Pollnac (1979) reported the same phenomena in their work with Puerto Rican fishers). Fishers from a coastal area tend to know who their successful peers are. The benefits of a fishers' prestige are not only symbolic. A prestigious fisher enjoys deference and reciprocity that has economic benefits. A consistent catcher of fish is a valuable member of a working-class coastal community (especially historically, but still nowadays) and the fisher will probably be able to count on the community's help in times of economic need.

Just being able to spend time in the sea, in contact with local ecosystems, is a rewarding experience that merits spending considerable effort and sacrifice to keep. As I will detail later in this chapter, 'having love for fishing' is a necessary characteristic of a potentially successful fisher in the fishers' folk model of success. The use of the word 'love' itself implies a deep attachment to fishing, one that might include undergoing journeys of sacrifice and periods of despair to maintain that attachment. Many of my informants were forced, at one time or another, to leave fishing and coastal living in order to do proletarian labor in the capital city of San Juan or in the United States. Don Edgar's account of being separated from fishing and local ecosystems, exemplifies similar stories shared by other fishers and is remarkably similar to a prototypical account of homesickness or lovesickness.

> I went to the United States, to New York, once. I worked as a stevedore and I made good money. Oh, I still remember those (times)! I walked around lost, in the streets, tears in my face. I told myself: I cannot stay here, this cannot go on. All I thought about was the mangrove channels, the keys, the fish. During the day, I surveyed them in my mind; at night, I dreamed about them.
>
> And, one day, my friend who had found me the job (in New York) told me: 'Look, Edgar, I feel bad because you work very well, you are a nice young man and you are very good to us. But, if you go on like this you are going to die! When you got here you were a robust man and now, look at yourself!'. I had lost 40 pounds. I was gaunt, dry! I had to buy (smaller) clothes and all that. They took me to the doctor and the doctor said: 'But this man is healthy! He just does not eat!'. And it was true. I do not know what the devil was happening to me. But as soon as I returned (to Puerto Rico) and went fishing, I got my appetite again. I got here and right away (makes a sound like that of a balloon getting filled with air). I got fat again. If I had stayed there for six more months, I would have returned inside of a pine box!

Anyone who has ever been homesick or lovesick can relate to Don Edgar's words. Don Edgar was talking about love for a trade, for a familiar ecosystem. The previous stories of belonging to a community, helping and raising a family, and of a deep love for a trade and for local ecosystems, eases understanding of why fishers fight to stay in business and sometimes carry on with fishing even when they could be following more economically-rewarding activities. A person would probably go to great lengths to avoid the kind of sadness Don Edgar reported feeling when he was separated from fishing.

There are, however, less ‘emotional’, more ‘economic’ aspects of fishers’ behavior and fishers’ cultural models of success than just ‘love of fishing’. The highest level cultural models of success, the ‘goals of a successful fisher’ described above resonate with the ‘subsistence ethic’ of peasant economies (Chayanov 1966; Scott 1976; Wharton 1963). The widely-shared goals, to ‘subsist’/‘live’ from fishing, to ‘raise a family’ from fishing, and to be able to continue fishing due to love for fishing, all lack a motivational assumption common to economic models: the intention to maximize profits (also see Durrenberger 1995). If the highest goals of a fisher are to subsist, to help raise a family, and to keep fishing, then it would make sense to assume that failure means not subsisting economically, not being able to help raise a family, and not being able to keep fishing. Sustained failure in these three areas would be catastrophic to the fishers who I worked with.

These three goals can be met without catching vast amounts of fish, especially in the context of rural coastal subsistence in Puerto Rico, which routinely combines fishing with other forms of labor and production. In fact, too much exploitation might be deleterious for an economy geared towards subsistence and continuity rather than to maximizing profits. By and large, all of the fishers that I interviewed as key informants demonstrated an awareness of the potentially deleterious effects of overexploitation on their capacity to make a continued living from fishing. As Don Teófilo put it, using a popular adage, overexploitation means: “*Hartura pa’ hoy, hambre pa’ mañana*” (A very full belly for today, hunger for tomorrow). As widely recognized expert fishers, my key informants tended to be older than the average fisher (average age 62 years old) and is also quite possible that they have more conservation-oriented values regarding the marine environment than other fishers. Many of the key informants reported having been taught conservation-oriented practices and/or values by fishers one or two generations older than them. This predates the modern Occidental environmental movement, which started in the 1960's after Rachel Carson's Silent Spring (Carson 1962).

If the cultural model of success in fishing described here is accurate, it means that fishers in this study's region would probably see an advantage in keeping fish and shellfish exploitation below widespread degradation levels. A collapse in fish populations would mean that fishing will cease to be a viable way to make a living. This would be catastrophic in terms of the cultural model of success because fishers' ability to help their families would be compromised and they would also lose their standing in the community as providers of food. In his work about peasant economies, James Scott (1976) proposes that working-class people who depend on natural resources and thus face risks inherent to ecosystem dynamics (fishers also face risks of capsizing, loss of equipment and drowning on a daily basis) tend to take a safety-first, risk minimizing approach to economic behavior. In Scott's own words: *"what safety-first does imply…is that there is a defensive perimeter around subsistence routines within which risks are avoided as potentially catastrophic and outside of which a more bourgeois calculus of profit prevails"* (Scott, 1976: 24). In my opinion, assuming a '*bourgeois calculus of profit*' *(ibid)* is a sure way to miss in attempting to predict small-scale fishers' economic behavior.

Ecological knowledge plays a large role in fishers' risk-minimizing strategies. Contrary to what a DRNA fishery official (and some fishers) told me, I found that most fishers have a clear idea that marine resources are limited, and especially in Puerto Rico, with its narrow continental shelf area as compared to places like Florida and Cuba. During our interviews several key informants also stressed the need to protect estuarine areas due to estuaries' importance as nurseries of valuable fish species and as the preferred habitats for bait species which constitute food for commercial species. Also, a recurrent theme emerging from the interviews was that a common practice is to use different fishing strategies together, either on single trips or during closely spaced trips, to maximize the probability of getting at least one kind of catch and to spread out the fishing pressure among multiple species. Mixed fishing strategies appear to be an adaptive response of the biomass distribution of tropical, reef-estuarine ecosystems, in which fish biomass is high in total numbers, but spread among multiple species with relatively low biomass for each species (Munro 1984; Polunin and Roberts 1996; Sale 1991; 2002). As a local adage told repeatedly by several fishers during my interviews goes: *"El mar es la mejor nevera" (*The sea is the best freezer*)*, meaning that fish that are left alive in the sea will not rot away and will be available to be caught another day. Catching more than what the fisher can eat and/or sell will result in rotting and/or unfresh fish, which is not a good thing; as Griffith, Valdés-Pizzini and García-Quijano (2006) report, Puerto Rican fishers' comparative advantage over fish importers is that local fishers can provide the costumer with fresh fish.

In the preceding discussion I have detailed high-level cultural models of success reported by fishers in Southeastern Puerto Rico and how economic/subsistence behavior might relate to those models. The cultural model of success in fishing also includes personal, social, and material determinants of success in fishing, as well as indicators of success-what are the observable signs that a fisher is successful. In Chapter 3 I briefly described my approach to explore, elicit and operationalize determinants and indicators of success that resulted from my interviews with expert fishers. In the remaining sections of this chapter I present the components of fishers' cultural models of success. I also explain the process of developing measures of success from key informant interviews and the overall distribution of success –related measures for the 41 respondents of the explanatory phase of this research.

The components of fishers' cultural model of success

During my semi-structured interviews I asked four general questions about success in fishing (see Appendix II for interview protocol):

1) What, for you, represents success as a fisher?
2) What does it mean to be successful for you and other fishers?
3) What are the determinants of success? What traits, personal and otherwise, help make a fisher successful?
4) What are the indicators of success? If you saw a fisher you did not know and you wanted to assess how successful they are: What would you ask them? What would you observe about them?

Rich and lengthy conversations resulted from each one of these questions. The cultural model of success presented here is only a simplified version of the highly detailed stories and discussions elicited during my key informants' interviews. In the following paragraphs I present the most important determinants and indicators of success in my key informants' accounts. I will also explore variation and distribution in several variables relating to the cultural model of success in fishing. For numeric, ordinal or interval level numeric variables, a Shapiro-Wilk test (Malkovich and Afifi 1973) was used to test the variable distribution for normality. A p-value > .05 rejects the hypothesis that the sample is not normal and supports an assumption of normality.

Determinants of success

Love for fishing

A successful fisher should have love for fishing: As I have already discussed, ‘love for fishing’ is an important motivator for economic activities. The ‘love’ that a fisher has for fishing will play a important role in his determination and dedication to fishing, attitude toward learning about fishing, and ability to bounce back from temporary setbacks and continue to fish. That love for fishing is necessary in order to fish for a living is nowhere in my interviews more apparent that in the case of Don Filiberto. He is an elderly fisher from Salinas who once lost his brother when they capsized and were lost at sea for two days. He told me that he would rather return to fishing and face overwhelming feelings of fear and sadness in the water over renouncing to fish for a living. ‘Love for fishing’ cannot be measured with survey techniques, so it was left out of subsequent analysis as a determinant.

Dedication to fishing

A successful fisher should have dedication to fishing. My key informants universally agreed on this. Fishing requires a lot of work to learn, to master, and to perform on a daily basis. Dedication is very important in offsetting the natural variability of available fish and fishers’ vulnerability to market fluctuations. I measured dedication as fishers’ self-reports of total hours a week dedicated to fishing-related activities.

1) Hours spent fishing- The respondents of the structured questionnaire reported spending an average of 28.0 hours/week fishing (Std. Dev. =12.90), with the majority of them fishing between 20 to 45 hours/week (see figure 4.1). The result for the Shapiro-Wilk test for normality was (p=0.08, 41degrees of freedom).

2) Total hours spent fishing and in other activities related to fishing- The respondents of the structured questionnaire reported spending an average of 45.3 hours/week in fishing and related activities (Std. Dev. = 20.14), with the majority of them fishing between 40 to 75 hours/week (see figure 4.2). The result for the Shapiro-Wilk test for normality was (p=0.642, 41degrees of freedom).

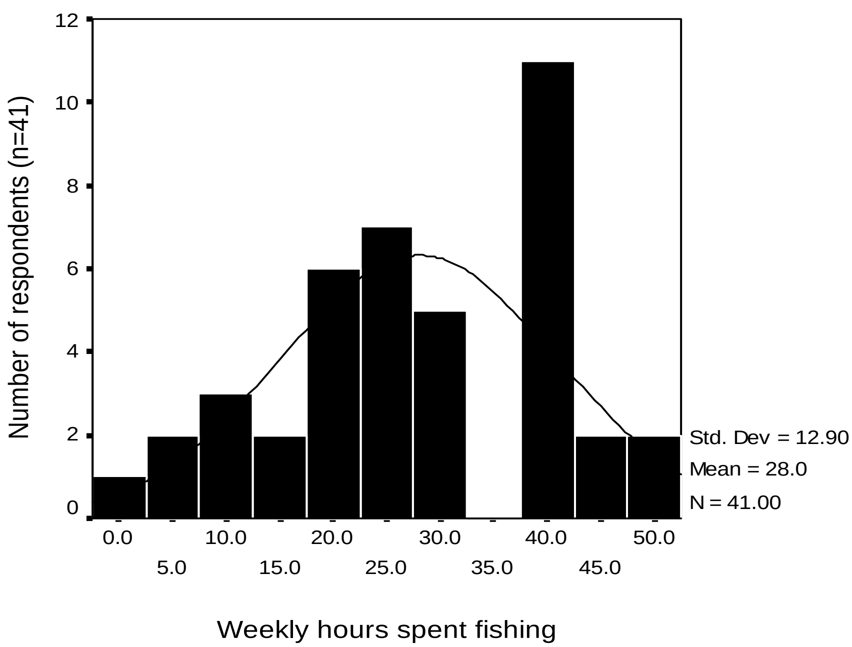


Figure 4.1. Histogram of weekly hours spent fishing reported by questionnaire respondents

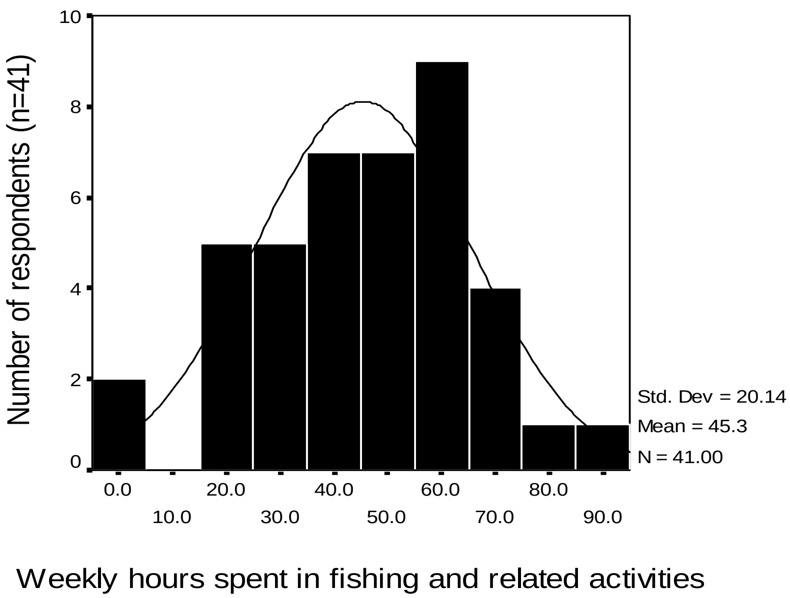


Figure 4.2. Histogram of weekly hours spent fishing plus weekly hours spent in activities related to fishing.

Ecological knowledge

A successful fisher should have a detailed knowledge of local marine ecosystems, specifically the '*zonas de pesca*'(fishing areas). 'Fishing areas' are the patchily-distributed areas where the proper conditions (e.g. substrate type, depth, temperature, salinity, visibility, fish/shellfish movements) come together to allow sufficiently large and accessible concentrations of fishery species for harvesting. Fishing areas change over time. Finding a fishing area based on reasoning about ecosystem parameters is more important than knowing the specific areas themselves. The measurement and variability in ecological knowledge is addressed in Chapter 5.

Sharing of information with other fishers

A successful fisher should spend time talking to other fishers and comparing notes with other fishers about fishing. Several of my key informants insisted that this was a very important component of local success in fishing. Most key informants reiterated that the only way to keep track of changes and conditions in the dynamic and complex marine environment was to spend a lot of time talking to each other and comparing notes.

As Don Teófilo told me one day, after his friend Don Rafael stopped by to report that he had just seen a school of mackerel enter the Bay of Jobos: "*One-hundred eyes see much better than two, no matter how good the two eyes are. The fish sometimes just come into a bay and leave. If I tell my friends when I see the fish coming in, they might tell me in the future when it is them who see the fish*". The time a fisher spends sharing information with other fishers strengthens social relationships and increases the likelihood that fellow fishers will lend a helping hand if the fisher ever needs it. I measured variations in the time spent sharing with other fishers by asking structured questionnaire respondents about the approximate number of hours each week they spent talking to other fishers.

The respondents reported spending an average of 17.8 hours/week talking to other fishers about the fishing activity. (Std. Dev. = 14.82), with the majority of them talking to other fishers between 10-20 hours/week (see figure 4.3). The result for the Shapiro-Wilk test for normality was ($p=0.01$, 41degrees of freedom).

Respect and reverence

A successful fisher should have '*respeto y seriedad*' (respect and reverence) for the marine and coastal environment and for fellow fishers. This cultural model, similar to the 'respect' cultural model described by McGoodwin (1994) in his work with Mexican fishers, entails a general attitude of thinking carefully about the consequences of one's actions for oneself, for the environment/resources and for other fishers who depend on those resources.

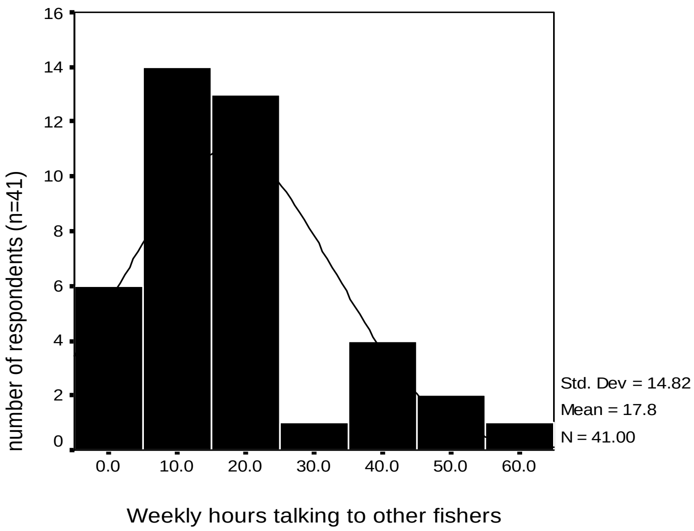


Figure 4.3. Histogram of weekly hours spent talking to other fishers about the fishing activity.

A fishers' failure to maintain 'respect and reverence' can over time lead to malicious gossip and/or sabotage. Several fishers told me the story of a well-known and otherwise well-liked fisher who was landing very large catches of fish day after day until gossip and repeated sabotage of his boat made him temporarily leave fishing. Eventually, he returned at a diminished capacity. Variation in 'respect and reverence' was partially measured (one could never measure this completely) by asking questionnaire respondents' a series of questions regarding cooperation and solidarity with other fishers and attitudes and values about the marine environment.

Attitudes towards the marine environment- To assess attitudes towards the marine environment, I asked the respondents to rate their agreements towards 4 statements, using a five-point Likert scale where "1"=strong agreement, "3"=neutral, and "5"=total disagreement. For simplification, the answers were re-coded to indicate favorable, neutral or unfavorable position towards the marine environment. For comparisons among respondents, favorable responses were assigned a score of 2, neutral responses a score of 1, unfavorable responses a score of 0. The statements were:

-Fishers (including myself) are true environmentalists: **Favorable: 30, Neutral: 7, Unfavorable: 4**

-If fishers take care of the sea, the sea will take care of the fishers: **Favorable: 37, Neutral: 4, Unfavorable: 0**

-I fish to survive, not to have great profits: **Favorable: 34, Neutral:5, Unfavorable:2**

Attitudes towards other fishers- I asked the respondents to rate their agreements towards 6 statements, using a five-point Likert scale where “1”=strong agreement, “3”=neutral, and “5”=total disagreement. For simplification, the answers were re-coded to indicate favorable, neutral or unfavorable orientations towards other fishers. For comparisons among respondents, favorable responses were assigned a score of 2, neutral responses a score of 1, unfavorable responses a score of 0. The statements were:

-Maintaining good relationships with other fishers is important for my success in fishing: **Favorable: 36, Neutral: 5, Unfavorable: 0**.

-Fishers in my community tend to cooperate and help each other out: **Favorable:35, Neutral: 4, Unfavorable: 2**

-If I have an accident or emergency at sea, I can count on other fishers to help me: **Favorable: 37, Neutral: 4, Unfavorable:0**

-If another fisher has an emergency at sea, He/she can count on me for help: **Favorable: 41, Neutral:0, Unfavorable:0**

-If I lost my boat and/or gear or got sick, I can count on other fishers to help me out until I get back on my feet: **Favorable: 27, Neutral: 5, Unfavorable: 9**

- If another fisher in my community lost his/her boat and/or gear or got sick, he/she can count on me for help until they get back on their feet: **Favorable: 36, Neutral: 5. Unfavorable: 0**

Scoring 'respect and reverence'- Although these two dimensions of reverence and respect (to the environment and to other fishers) seem separate, they were always mentioned together by my key informants. Ethnecological research has shown that small-scale resource users often regard the non-human environment and social relationships and institutions as equally-important parts of their subsistence ecology (see Gragson and Blount 1999; Berkes, 1993; Berkes *et al.*1998; Gadgil and Berkes 1991). I computed aggregate scores for each respondent on the questions about reverence and respect. The highest possible score, reflecting uniformly favorable attitudes towards the environment other fishers, was "18". A uniformly neutral fisher would score a "9", while a fisher reporting uniformly negative attitudes would score a "0". The average aggregate score for respondents was 16.2 (Std. Dev. 2.53), with a vast majority of the informants scoring between 16 and 18 (see figure 4.4). The distribution was highly skewed to the higher scores (Shapiro-Wilk normality test p=.01, 41 degrees of freedom).

The very small variation and the pattern of very favorable scores in attitude towards other fishers and the environment could be due to a variety of factors, such as: 1) A widespread cultural model of 'respect and reverence' towards the environment and other fishers. If the peer pressure on fishers that appear to be lacking 'respect and reverence' is as intense as described by the key informants, it may happen that, at least in verbal discourse, this has become the standard response; 2) That, because the questions were asked during a time of struggle between fishers and the state, fishers were experiencing high labor-group solidarity, and 3) Because the struggle against the state was related to environmental regulations, I (a university-based outsider) only got politically-guarded responses. Another reason might be that my wording of the questions resulted in bias towards positive answers.

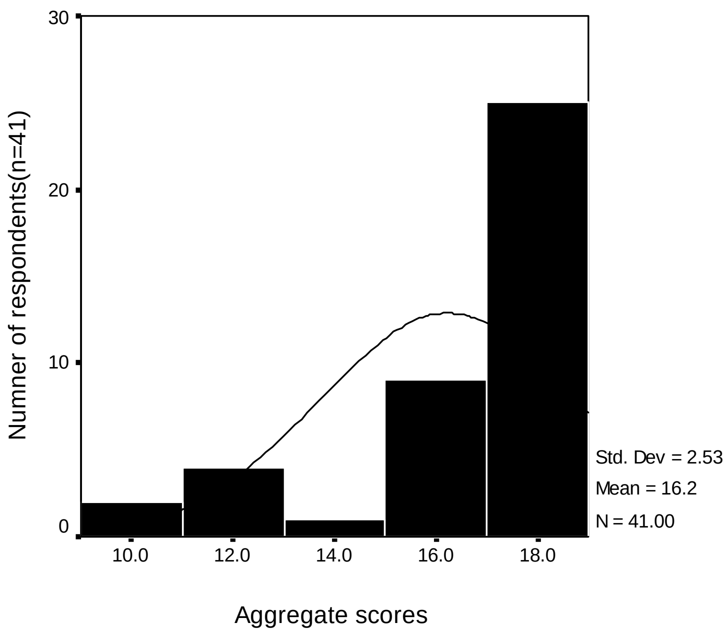


Figure 4.4. Histogram showing aggregate scores in nine questions about attitudes towards the environment and other fishers. Higher scores represent more favorable attitudes.

Curiosity and interest in fishing

A successful fisher has curiosity and interest in fishing. Several of the most experienced key informants report that local marine ecosystems are so complex and dynamic, that a fisher must always remain alert and never stop learning about the marine environment. The older fishers also point out that they are able to tell if a fisher will be successful in the future based on the curiosity about the workings of fishing shown. I was not able to measure variations in curiosity and interest using survey research techniques.

Building and repairing fishing gear

A successful fisher should know how to build or at least maintain/repair his/her fishing gear. According to many informants, the cost of having gear repaired by other fishers or the cost of frequently buying new gear would make a serious dent in a fishers' household economy. Furthermore, as I observed, the fishers who were very good at repairing nets or traps, such as Don Elizam in Aguirre and Don César in Arroyo, made sizable extra money by fixing gear that was beyond other fishers' ability to repair. I measured variation in this determinant of success by asking fishers if they built and/or repaired the different types of gear they reported utilizing. I classified fishers as to whether they 1) both built and repaired their gear, 2) repaired but not built their own gear, or 3) neither built nor repaired their gear.

All of the structured questionnaire respondents who were not exclusively divers reported owning at least one type of fishing gear. To assess variability in this determinant of success, fishers were rated on the following scale, based on self-reports. Both building and repairing their fishing gear= "2"; Repairing, but not building, their own fishing gear, "1"; Neither built nor repaired their fishing gear= "0". Five respondents were exclusively divers and this question wasn't applicable to them. Of the 36 remaining respondents, the vast majority, 32, reported both building and repairing their fishing gear. Two respondents repaired but did not build their fishing gear, and two respondents neither repaired nor built their own fishing gear. These results underscore the small-scale, low-capital nature of fishing in southeastern Puerto Rico. These results also mirror my ethnographic experience. Practically all of the fishers that I met and interviewed engaged in both building and maintenance of fishing gear. The fishers who made extra money repairing gear usually repaired badly damaged nets or traps that needed an specially skillful person to repair. It seems from these results that being able to repair and/or build fishing gear is a necessary skill of commercial fishers in the study region and all fishers need to learn to perform.

Economic gratification orientation

A successful fisher should invest money wisely. Several fishers told me that as a result of the small profit margins of fishing, a fisher that goes into any significant debt to replace fishing gear or a boat might never recover enough to be successful in fishing again. They also argued that, since the disbandment of the state fisheries development CODREMAR, access to loans and emergency funds has become more difficult (also see Pérez 2005). They placed a high premium on having funds available for an emergency.

To measure variability in this determinant of success, I utilized the ‘economic gratification orientation’ measurement technique used by Poggie (1978); Pollnac and Poggie (1979), and Pollnac, Gersuny, and Poggie (1975) with fishers in Puerto Rico, New England, and Panama. We asked the respondents what they would do with a specific amount of money if they received the money as inheritance or as a gift. Because of the amount of money in question may very well determine what is done with it, we asked the question three times to each respondent, each time with a successively larger amount of money: $500, $1000, and $5000. I followed the approached outlined by Poggie (1978) to code the answers to these questions. Responses to the question were coded depending on whether they represented a ‘deferred’, ‘mixed’ or ‘immediate’ approach to money investment. A ‘deferred’ approach was defined as an inclination towards investing in future beneficial activities, such as buying/repairing gear, buying or improving a house, or putting it the bank. An ‘immediate’ approach was defined as a non-investment (for example, throwing a party, buying clothes, going on vacation, purchasing a non-work vehicle, etc.). A ‘mixed’ response was a response that included elements of the two. Each ‘deferred’ response was assigned a score of “2”, each “mixed” response a score of “1” and each ‘immediate’ response a score of “0”. The scores were then added and a total score was calculated for each informant. The maximum possible score was “6” (an uniformly ‘deferred’ orientation) and the minimum possible score was “0” (an uniformly ‘immediate’ orientation).

The respondents of the structured questionnaire scored and average of 5.5 (out of 6) for economic gratification orientation (Std. Dev. 1.25). The majority of the respondents (33) reported a uniformly-deferred orientation, with the most common answers being, in order: Investing in fishing gear/boat, Investing in a house, and paying off debts. The few non-deferred (immediate) answers involved giving money to family members in need, and traveling to visit family who had emigrated. One respondent reported he would use some of the money to fix his son’s tombstone. When the amount of money changed, the size of the investment changed, rather than the respondent’s gratification orientation. These results support Poggie’s and Pollnac results from 25 years earlier, in which they found that small-scale fishers in Puerto Rico, have a highly-deferred orientation towards money management, due in part to a subsistence ethic and to offset the high-risks and low-profit margins inherent in fishing (Pollnac and Poggie 1979; Poggie 1978; Scott 1976). The low variability in these results support my key informants’ reports that any fisher who wants to be successful has to be willing to invest the proceeds of fishing wisely and conservatively.

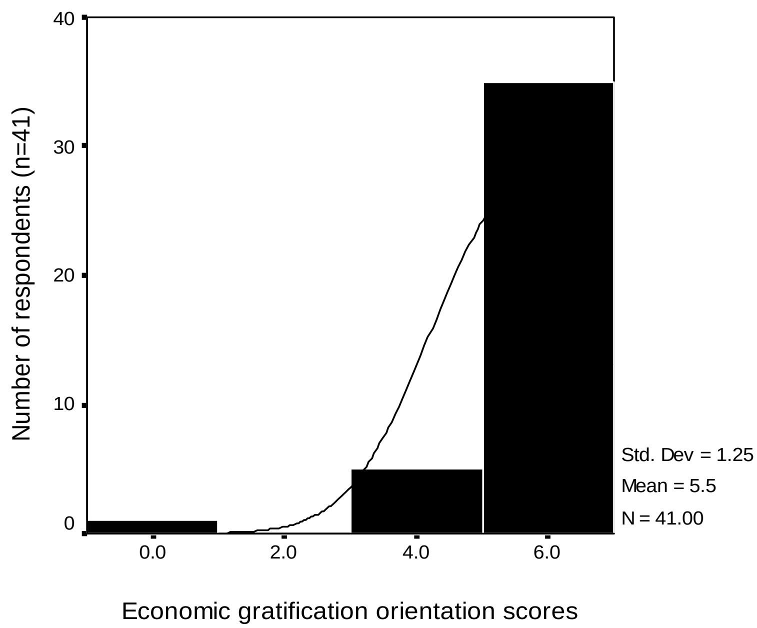


Figure 4.5. Histogram showing aggregate Economic Gratification Orientation scores for respondents of the structured questionnaire.

Dexterity

A successful fisher should have navigational and gear-handling dexterity (also see Palsson and Helgason 1999) . This was widely mentioned as a determinant of success. Like 'love for fishing', however, dexterity in navigation and handling gear cannot be measured with survey research techniques.

Luck

A successful fisher should also have some luck. Although luck and the avoidance of bad luck was mentioned several times, most fishers agreed that luck was a minor determinant of success. More importantly, several fishers agreed that periods of good and bad luck cancel each other out over time. Don Filiberto described himself as a 'generally lucky fisher' even though he lost a brother in a fishing accident. I suspect he meant that he was lucky because he had been able to fish for a living throughout his life.

Indicators of success in fishing

As I detailed in Chapter 3 landings and/or catch rates do not seem to be very good indicators of fishing success. Instead, the ability to consistently catch enough fish to make a living over the years is a more significant measure of success. As I detailed previously in this work, state-gathered landings data are not reliable enough to use for fisher-to-fisher comparisons. Furthermore, because fishing in southeastern Puerto Rico forms part of an economic subsistence pattern that routinely combines fishing with other activities, fishers can be involved in fishing with various degrees of intensity at different times and still be successful fishers (Griffith and Valdés-Pizzini 2002). Many successful fishers in the area are career part-timers who have managed to make fishing a continuously integral part of their economic activities.

Other researchers have come across the challenge of measuring differential success in Puerto Rican fisheries. John Poggie and Richard Pollnac (Poggie 1978; 1979; Pollnac and Poggie 1978), explored the relationships between culturally relevant traits of individuals and their success as small-scale fishers in Puerto Rico. Poggie (1979) found that success in fishing is a complex phenomenon and that success rankings by peers were among the few ways one could differentiate between more and less successful fishers. My analysis of key informant interviews, support Poggie's findings. Reputation was the indicator of success most often mentioned. As Don Berto, a fisher from Santa Isabel, put it: "*We know who the successful fishers are around here. There are not too many of us*".

To get additional information about the indicators of success, I presented key informants with a hypothetical situation. I asked them to tell me, how they could tell if a fisher was successful, and if they could do so even when they did not personally know the fisher. A common answer was that they could only ascertain a fishers' success by observing the fisher in action and compare them to fishers they know. They also said that they would ask the fisher whether he/she had been able to live and raise a family from fishing These answers underscore the context-dependent nature of success (Masten and Coatsworth 1995; Bjarnason and Thorlindsson 1993). In the following paragraphs I will summarize the most important indicators of success according to key informant fishers.

Raising a family through fishing and fishing income

One can tell a fisher is successful if the fisher has been able to help raise a family through fishing. To assess variability in fishers' self-reports of having raised a family by fishing, I asked structured questionnaire respondents: 1) Whether they felt they had been able to raise or substantially help their family through fishing, and 2) What percentage of their household income came from fishing. On the first question, 28 fishers answered that they had been able to raise a family by fishing, and 13 fishers felt that had not succeeded in doing so. On the second question, the respondents reported an average of 51.2% of their household income coming from fishing (Std. Dev. 33.56). The distribution of responses in this case is bimodal (figures 4.6 and 4.7). Of the 38 fishers who answered this question (three fishers declined to answer), 19 reported that less than 50% of their income came from fishing, with most of them reporting around 20% of their income coming from fishing. Of the 19 fishers who reported 50% or more of their income coming from fishing, ten reported between 50 to 80% and the remaining nine reported that all of their income came from fishing.

These results could indicate the existence of two separate strategies for engaging in fishing together with other economic activities. One strategy would involve maintaining fishing as the major economic activity of the household, and the other would be to engage in other activities, keeping fishing as a minor source of income. The interpretation of these results is muddled by contextual situations, however. For example, if the household includes other breadwinners, a full-time fisher might still report that fishing is not the major economic contributor to the household economy.

To verify whether there was a strong relationship between reports of succeeding or not succeeding in raising a family through fishing and the income derived from fishing, I computed an *Eta*, nominal-by-interval variable correlation between the two variables. The *Eta* correlation coefficient was (0.435), a strong correlation. Fishers who reported higher percentages of income coming from fishing tended to report that they had been successful in raising a family by fishing, and viceversa. This response pattern seems to indicate that the respondents of the structured questionnaire answered the question about raising a family from fishing based on the contribution of fishing to their household economies. All but two of the fishers with more than 50 % of their income attributed to fishing also reported having raised their families by fishing. This might indicate that 50% is the cutoff point above which a fisher views his/her household as dependent on fishing.

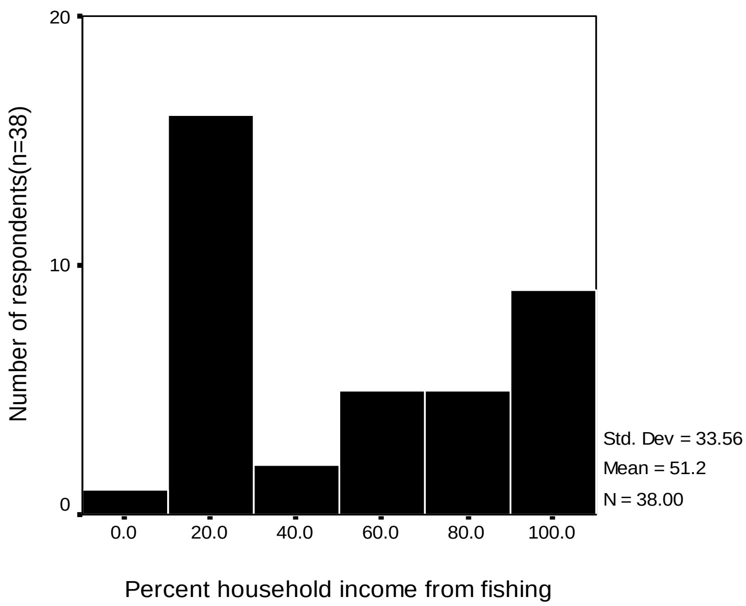


Figure 4.6. Histogram showing variability and distribution of reported percentage household income from fishing.

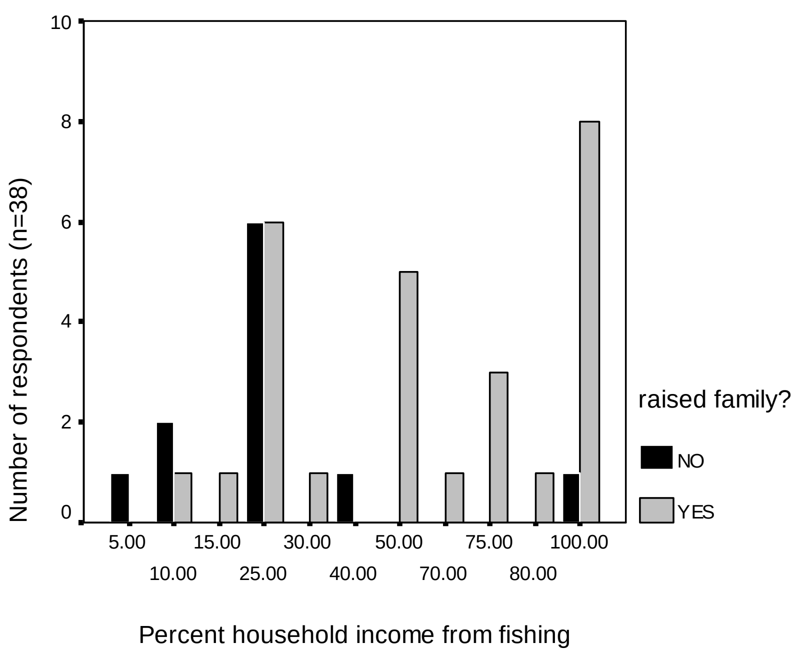


Figure 4.7. Clustered bar graph illustrating the relationship between respondents' reports of raising a family by fishing and percentage income derived from fishing.

Material standard of living.

One can tell if a fisher is successful by their material standard of living. There was widespread agreement among the key informants about using the income provided by fishing to invest in improving their family's quality of life. I partially-measured material standard of living by asking the structured questionnaire respondents about which of 20 items in a material culture checklist could be found in their household (please see table 4.1 for the list of items included). The list of items and services used was modified from the list Pollnac and Poggie (1978) used to assess 'material culture' for fishers in Cabo Rojo, Puerto Rico. The additions on my list reflected the added items that a Puerto Rican working-class family might be expected to own at the time of this research (25 years after Pollnac and Poggie's study).

I used Guttman scaling routine from ANTHROPAC X (Borgatti 2001; Guttman 1944; 1950) to test for unidimensional scalability of the 20 items in the material culture list. Guest (2002) provides a useful example and discussion of using Gutmann scaling to rank individuals according to wealth in an Ecuadorian fishing village, which I used as a template for my scaling analysis. My initial Guttman scaling analysis resulted in a Coefficient of Reproducibility (CR)=0.80 and a Coefficient of Scalability (CS)=0.12. CR and CS are two statistics that measure the unidimensional scalability of items in a case-by-item matrix; a CR >0.90 and a CS >.30 are conventionally accepted as strong evidence of unidimensional scalability. My scores CR=0.80 and CS=0.12 were not good enough to assume unidimensional scalability of the 20 items. Upon further inspection of my item list, I noticed that I had included several high-tech entertainment items that could obscure the relationships between items, since their presence might signal an affinity for high-tech entertainment over material achievement. These items were: a) DVD

Player, b) A video game player, c) A personal computer, d) a VCR Player, d) Cable TV and d) Internet access. I had also included two items, gas stove and electric stove, of which the presence of one would probably preclude the presence of the other, since most households only have one stove of either kind. I substituted those two items with just one entry just indicating whether the household had a stove or not. After the changes I ran the Guttman scaling procedure on a new 13 item list (table 4.2) and got a more acceptable scores of CR=0.87 and CS=0.21, which are considerably closer to values representing a one-dimensional scale.

Using the modified list of 13 items, I added the items reported by each respondent to give them a material culture index score. The 41 structured questionnaire had an average score of 9.9 (Maximum possible score=13; Std. Dev. 1.33), with the majority of respondents reporting between nine and eleven items in their household (see figure 4.8). This variable did not have a normal distribution (Shapiro-Wilk test p=0.01)

Home ownership

Home ownership was measured separately because a home and associated land represents a large investment and a great deal of economic security for a working-class Puerto Rican Family. Of the 41 fishers who answered the structured questionnaire, 31 reported owning the home they live in. Ten fishers did not own their homes.

Peer assessments of success in fishing

The respondents of the structured questionnaire rated each other in a Likert Scale of 0-4, with (4)=Very successful, (1)=Having little success, and (0)= do not know . The average ratings score for the respondents of the structured questionnaire was 2.91 (Std. Dev. = .75; see fugure 4.9). The result for the Shapiro-Wilk test for normality was (p=0.062, 41 degrees of freedom).

Table 4.1. Table showing the original 20 items used in the material culture index.

Item in household	# respondents	%
Running water	41	100.0
Electric power	41	100.0
Washing machine	41	100.0
Color television	41	100.0
Refrigerator	40	97.6
Car	36	87.8
Microwave oven	32	78.0
Gas stove	29	70.7
Stereo music system	26	63.4
Videocassete Player	26	63.4
Ceiling fans	24	58.5
Water heater	20	48.8
Electric stove	16	39.0
Cable TV	15	36.6
Air conditioning	14	34.1
Video game player	14	34.1
DVD Player	10	24.4
Personal Computer	10	24.4
Clothes Dryer	7	17.1
Internet access	7	17.1

Table 4.2. Table showing the 13 items included in the final material culture index.

Item in household	# respondents	%
Running water	41	100.0
Electric power	41	100.0
Washing machine	41	100.0
Color television	41	100.0
Refrigerator	40	97.6
Car	36	87.8
Microwave oven	32	78.0
stove/range	41	100.0
Stereo music system	26	63.4
Ceiling fans	24	58.5
Water heater	20	48.8
Air conditioning	14	34.1
Clothes Dryer	7	17.1

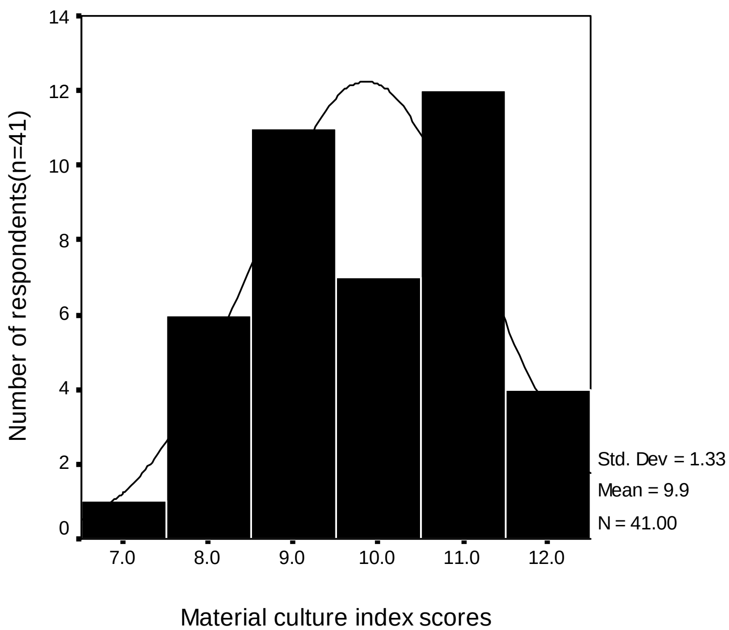


Figure 4.8. Histogram showing variability and distribution of material culture index scores for respondents of the structured questionnaire

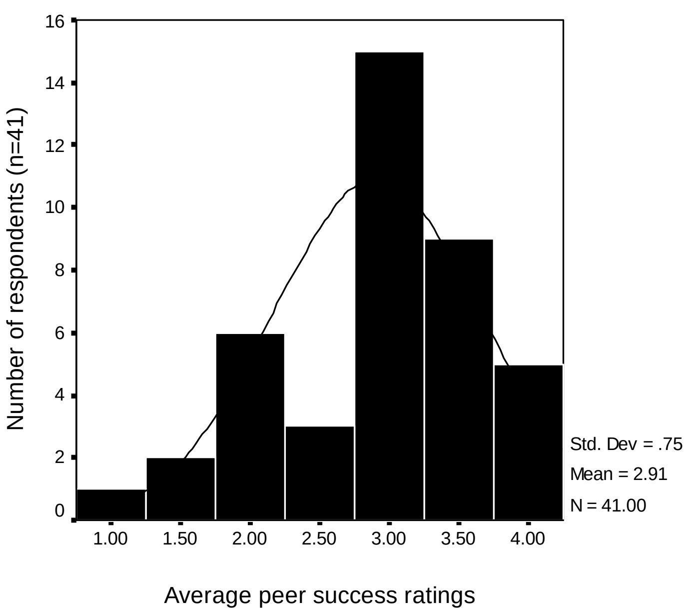


Figure 4.9. Histogram of average peer success ratings for questionnaire respondents.

Other variables

At the outset of this research, I expected several easily-measured variables to be important indicators of fishing success. These variables included ownership of a boat, size of boat and engine, ownership of fishing gear and other means of production, and money invested in fishing equipment (see Durrenberger 1997; Pallson 1988; Palsson and Durrenberger 1982). As I began this research it became clear, however, that the aforementioned variables were potentially confusing in these small-scale, multi-species and multi-gear fisheries. For example, buying a boat and fishing gear is a significant investment, and many young fishers spend a couple of years going out to fish a '*proeles*' (strikers) before they can buy a boat, so the mere fact of owning a boat is an indicator of some success, as well as a determinant of further success in fishing.

Different fishing strategies require boats of different sizes. For example, Don Teófilo and Don Elizam from Aguirre, owned very small *yolas* because their main activity was net fishing inside bays. Fishers who engaged mostly in trap fishing, such as Don Aquiles in Guayama, needed a larger *yola* to haul fish traps to offshore fishing areas. They are all equally-regarded as successful fishers by their peers. Personal preferences will also affect the size of a fishers' boat. The size of an engine will vary according to the size of the boat the engine needs to push through the water. Due to varying prices of the gear building materials required by different fishing techniques the amount of money invested in fishing equipment cannot be used for meaningful comparisons between fishers. Because boat size, engine size, and the amount money invested in fishing did not form part of the cultural models of success described by the key informants they are not discussed in this chapter.

A comparative exploration of the cultural model of success

In the preceding sections of this chapter I drew on ethnographic work with key informant expert fishers to elicit a cultural model of success. I operationalized some of the key variables described by fishers as forming part of the model of success, and described the patterns of variation related to those variables in the responses of 41 fishers who participated in an ethnographically-informed structured questionnaire. I also discussed the reasons why some variables exhibit more variation than others and why some variables, such as peer assessment of success and the percent of a fishers' household income derived from fishing, appear especially robust in describing variations in success according to the local cultural model. In the next section I will explore co-variation of some of the key success-related variables, with the exception of the variables directly related to Local Ecological Knowledge. Intracultural variation patterns in ecological knowledge will be discussed in Chapter 5.

Covariation in measures of success

Success (in fishing and in other life activities) is a multidimensional construct (Palsson and Durrenberger 1982; 1982; Poggie 1979; Freeman *et al.* 1981). All of the key informants described a variety of social, cognitive, and economic factors of success in fishing. Several of these factors had to be present in an individual fisher at the same time in order for the fisher to be considered successful by his peers. Even after offering detailed explanations of the factors that contribute to- and indicate success in fishing, many of my key informants would say that ultimately, success in fishing is an overall quality of a fisher that has to be observed in context. As Doña Lydia, a fisher from Guayama told me: *"You have to see these young (fishers) in action* *to be able to say if they will be successful in fishing. Some of them are good in some aspects of fishing, some of them are better in others. Fishing requires 'habilidad'(dexterity) and patience, both out in the water and on land''*. When I asked Don César (from Arroyo) what was, in his opinion, the most important determinant of success in fishing, his answer was: "*That is a hard question, kid! A variety of factors have to occur for a fisher to be successful. All of the things that I just mentioned to you, knowledge, patience, attitude, are important.*" As evident from accounts such as Doña Lydia's and Don César's above, co-ocurrence and co-variation of variables affecting success is an important aspect of the cultural model of success in fishing. In the next sections of this chapter I will detail some of the patterns of correlation between the '*variety of factors*' determining and indicating success.

Determinants of success

Table 4.3 shows Spearman Rank-order correlations (Spearman 1906) between measures of six variables identified as important determinants of success by key informant fishers. These variables were:

-Weekly hours spent fishing (HOURFISH)

-Weekly hours spent fishing plus hours spent in activities related to fishing (HOURTOT)

-Weekly hours spent talking to other fishes about fishing(HOURSHARE)

-Scores in "reverence and respect" toward the environment and other fishers (REVRESP)

-Scores based on whether a fisher built and repaired their own fishing gear (GEARWORK)

-Economic Gratification Orientation Scores (EGOCOM).

Table 4.3. Spearman rank-order correlations between determinants of success in fishing.

Variable	HOURFISH	HOURTOT	HOURSHARE	REVRESP	GEARWORK	EGOCOM
HOURFISH	1.000	0.687(**)	0.213	0.067	0.096	-0.199
HOURTOT	_	1.000	0.349(*)	0.053	0.207	-0.062
HOURSHARE	_	_	1.000	0.364(*)	-0.112	0.042
REVRESP	_	_	_	1.000	0.012	0.092
GEARWORK	_	_	_	_	1.000	0.241
EGOCOM	_	_	_	_	_	1.000

(**) significant at 0.01 level (2-tailed)
(*) significant at 0.05 level (2-tailed)

Because the variables in table 4.3 were identified as important determinants of success in fishing during extensive ethnographic work, the ideal expectation would be that all the variables correlated significantly with each other. As evident from the data, this is not the case, but several interesting patterns emerge from examining the correlation scores. Out of 15 possible correlations between different variables, only three (HOURFISH-HOURTOT, HOURTOT-HOURSHARE, HOURSHARE-REVRESP) were statistically significant (2-tailed test of significance). The first two statistically significant correlations are explainable by simple construct overlap. Hours spent fishing are a significant part of the total hours spent in activities related to fishing, and thus co-variation should be expected. Likewise, hours spent talking to other fishers likely form part of the total hours a fisher spends dedicated to fishing activities, specially since in Puerto Rico most fishers go out to sea in pairs (see Pérez 2005; Valdés-Pizzini 1985; 1987). The significant positive correlation between “reverence and respect” and hours spent talking to other fishers is conceptually logical. The more positive values towards other fishers and things related to fishing, the more likely a fisher will remain socially-active with other fishers, and vice versa. These two variables correlated significantly, even though one of them (HOURSHARE) exhibited high within-sample variability (Mean 17.8, Std. Dev. 14.82), while REVRESP had much lower variability (Mean 16.2, Std. Dev. 2.53). The significant correlation between these two variables provides evidence towards the social nature of fishing and the link between good social relations between fishers and dedication to fishing. It also provides evidence to the internal validity of the ‘reverence and respect’ measure, that is, that REVRESP was measuring at least some real dimension of attitudes and values (Johnson 1998).

There was little within-sample variation in economic gratification orientation (Mean 5.5, Std. Dev. 1.25) and in repairing and building gear. The universally-high scores in ECOCOM and GEARWORK underscores the basic importance of these variables for success in fishing, but diminishes their usefulness to explain differential success. It is also interesting that the three variables that exhibited a statistically significant relationship with at least one other determinant of success can sensibly be assumed to be related to ecological knowledge, since two of them control experience with local environments (HOURFISH and HOURTOT), and the other two are measure participation in social activities which probably include social sharing of ecological knowledge.

Co-variation in indicators f success

Table 4.4 shows Spearman rank-order correlations between measures of 4 variables identified by key informants as indicators of success in fishing. These variables are:

-Average ratings by peers as a successful fisher (SUCRATE)

-Respondents scores in 13-item material culture index (MATCULT)

-Self-reports of percentage income coming from fishing (FISHINC)

-Self-reports of owning the property the respondent lives in (OWN)

Table 4.4. Spearman rank-order correlations between indicators of success in fishing

Variable	SUCRATE	MATCULT	FISHINC	OWN
SRATE	1.000	0.208	0.401(*)	0.218
MATCULT	_	1.000	0.233	-0.015
FISHINC	_	_	1.000	-0.156
OWN	_	_	_	1.000

(*) significant at 0.05 level (2-tailed)

As with the determinants of success in fishing, my initial expectation was that all of the indicators of success would correlate significantly with each other. The only pair of indicators of success that had a statistically significant correlation, however, were peer success ratings (SUCRATE) and percentage income from fishing (FISHINC). It makes sense that these variables would have more co-variation between them than with more material measures of success. These two variables are probably the more direct indicators of success in fishing, since the widespread occupational multiplicity of fishers in the study region makes it difficult to ascertain whether the material possessions of a fisher's household were acquired with money from fishing. Furthermore, personal preferences towards' the possession of material items might vary between respondents without having anything to do with their success as fishers. Two equally-successful fishers might have different opinions about whether a clothes dryer or air conditioning represent necessary items for his/her household.

The lack of significant correlation between home ownership (OWN) and any of the other indicators of success (especially material culture) was surprising. Most of my key informants reported that owning a home was a definite milestone in their economic success, and there was enough variation in the dichotomous variable (31 "yes" and 10 "no") for this variable to exhibit a co-variation pattern with other indicators of success. A larger sample or more research on the dynamics of home and land ownership in the study region's rural coastal areas might be needed to illuminate this matter.

Co-variation of determinants and indicators of success

Spearman rank-order correlations between determinants and indicators of success for fishers surveyed with the structured questionnaire are shown in table 4.5. All of the determinants and indicators of success used above are included in the correlation matrix, with the exception of measures of ecological knowledge. The only statistically significant correlations are between household percent income derived from fishing (FISHINC) and two measures of fishing dedication and effort: weekly hours spent fishing and total hours spent in fishing-related activities (HOURFISH and HOURTOT). Other than corroborating that time spent in fishing-related activities is related to the percentage income a fishers derives from fishing, the two statistically significant correlations in table 4.5 do little to clarify the relationships between indicators of success and determinants of success for the 41 structured questionnaire respondents.

Significant correlations between interacting variables described in a cultural model represent evidence about the model's validity, as long as the model makes sense in social and ecological context (Hendwerker 2002; Pallson and Durrenberger 1982). In the results presented above I found more significant correlations, and thus evidence of model validity when correlate between determinants of success or indicators of success alone, than when I attempted to correlate between determinants and indicators of success. As with many researchers who have attempted to differentially measure what causes fishing success, including those who have used detailed ethnographically-informed methods and *emic* measures of success, significant variation in success is unaccounted for (Palsson and Durrenberger 1982; 1990; Palsson and Helgason 1999; Acheson 1977; Palsson 1988; Poggie 1979; Thorlindsson 1988; Russell and Alexander 1998).

Table 4.5. Matrix of Spearman rank-order correlation scores between determinants and indicators of success, without including measures of Local Ecological Knowledge (LEK). Columns in the matrix represent determinants of success and rows represent indicators of success.

	HOURFISH	HOURTOT	HOURSHARE	REVRESP	EGOCOM	GEARWORK	LEK?
SRATE	0.252	0.173	0.054	0.100	0.119	0.094	?
FISHINC	0.466**	0.355*	0.261	0.048	0.262	0.200	?
MATCULT	0.003	0.243	0.082	0.156	0.119	0.203	?
OWN	0.194	0.292	0.070	0.033	-0.156	0.035	?

(**) significant at 0.01 level (2-tailed)
(*) significant at 0.05 level (2-tailed)

There is a missing component, however, in this analysis. In analyzing variation in success-related variables I have, up to this moment, left out measures of local ecological knowledge. Does ecological knowledge explain some of the unexplained variance in culturally-relevant indicators of success? This is one of the questions I will explore in Chapters 5 and 6 of this dissertation.

Summary and Conclusion

The effective management of tropical fisheries and other small-scale, resource-dependent activities requires that close attention is placed to the social and cultural drivers of economic behavior and the human institutions that direct and constrain behavior. Douglass C. North (1993) asked: "*How can one prescribe policies when one does not understand how economies* *develop?"* Paraphrasing North's question for adapting it to tropical small-scale fisheries management, one could ask: How can one prescribe fisheries policy when one does not understand what fishers want to achieve from fishing? In other words, what does it mean for a group of fishers to be successful in fishing? I found that social recognition as a member of the community of 'true fishers', as well as making enough profits to ensure reproduction of the domestic unit, are the most widely shared goals of a potentially successful fisher. I also found that due to the historical subsistence strategy of combining agricultural work-part-time fishing in the area, being a full-time fisher was not a necessary condition of being a very successful fisher. The local cultural model of success in fishing appears to be more concerned with survival and continuity of fishers and their families than with maximizing profits and catches. Predictability and reliability of fish catches appear to be more important drivers of fishing behavior than just achieving large catches on the short term.

The emphasis on minimizing risk rather than attempting to maximize profits from fishing resonates with the subsistence ethic that researchers such as Scott (1976) and Chayanov (1966) have described for rural, natural resource-dependent peasant communities. Interviews and ethnographic participant observation indicate that the low profits associated with a safety-first approach to fishing were compensated with more than just the predictability of catches. Fishers enjoy prestige and deference in their communities because they have the special skill of being able to bring food from the sea.

According to key informants, some of the important characteristics a fisher should have to be successful in fishing are love for fishing, dedication to fishing, knowledge about local marine ecosystems, sharing knowledge and information with other fishers, having reverence and respect towards fellow fishers and the marine environment, having curiosity and interest about fishing, investing money wisely, navigational and gear-handling dexterity, and also some luck.

Some of the indicators of fishing success mentioned by my key informants were: the fishers' reputation as a good fisher around his community, being able to have a dependable income from fishing, having been able to raise a family from fishing, and the fishers' material standard of living. Variables used by other researchers as indicators of success, such as investment in fishing, boat and gear ownership and boat size, were not regarded by key informant fishers as clear determinant or indicators of success (see Durrenberger and Palsson 1982; Pallson 1988; Russell and Alexander 1996). Fishers' reputations as successful fishers and percentage income derived from fishing appear to be robust and context-sensitive measures of success in local fisheries. In southeastern Puerto Rico's small-scale fisheries, there appears to be no unique, numerical, reliable measure of success such as Catches per unit effort (CPUE's) or profitability, as one could expect with more industrialized fisheries.

I measured variability in measures of determinants and indicators of success with a structured questionnaire that I administered to 41 fishers. I correlated variables representing determinants and indicators if success to explore the validity of the cultural model of success. Without including measures of ecological knowledge, relatively few statistically significant correlations between determinants and indicators of success were found. Please see Figure 4.10 for a schematic representation of the fishers' cultural model of success. In chapters 5 and 6 of this dissertation I will explore, among other things, whether a significant amount of unexplained variance in indicator of success can be explained by ecological knowledge.

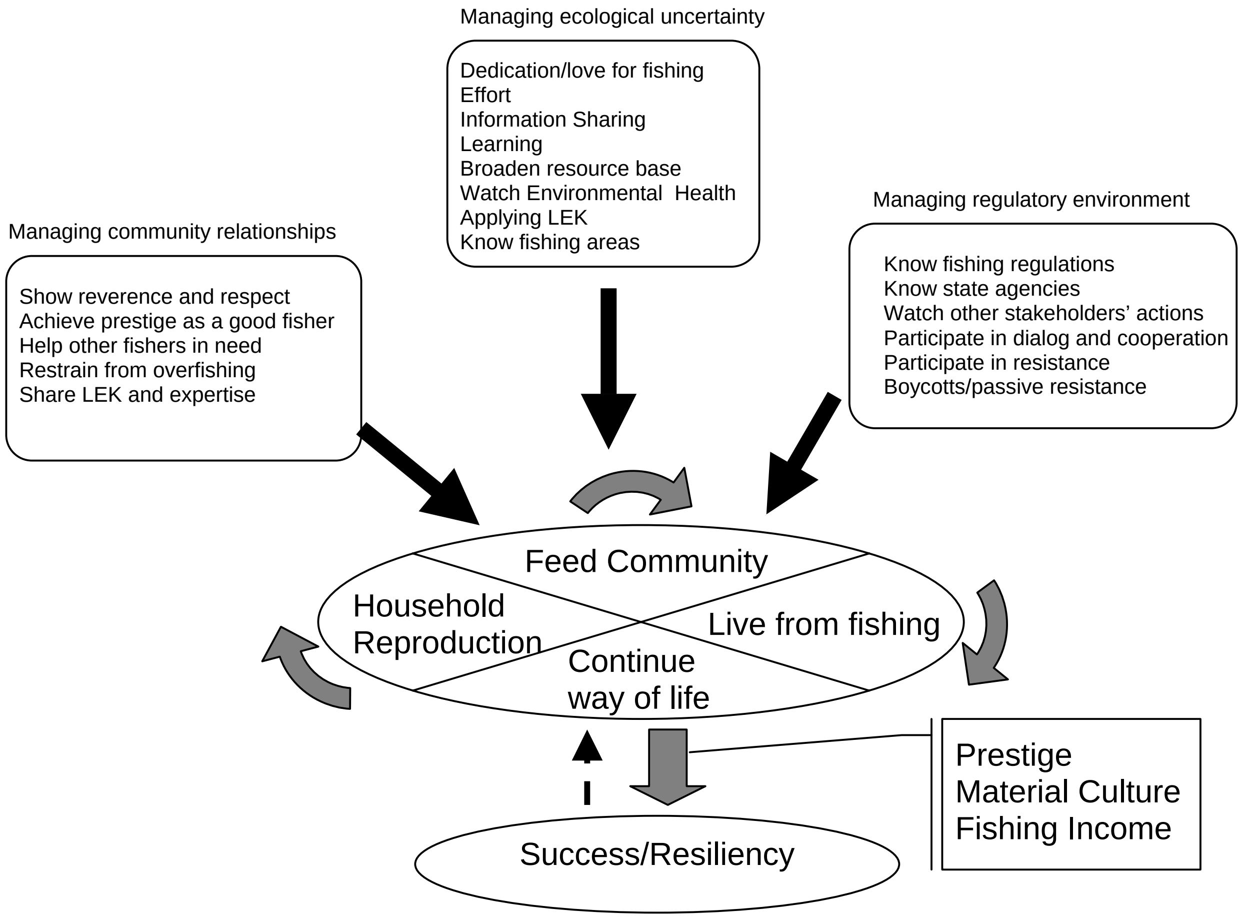


Figure 4.10. Schematic representation of the cultural model of success in fishing described by this research. By simultaneously managing ecological uncertainty, community relationships, and relationships with the regulatory environment, fishers increase their chances of accomplishing their goals, which are to make a living from fishing, to raise a family from fishing, to continue their way of life as commercial fishers, and to help feed their communities. Success is the product of the degree to which fishers achieve these goals. Resiliency is the degree to which fishers can continue to meet their goals over time in a changing environment. There are no clear-cut formulas for success, because the components of the cultural model are mutually-reinforcing. Success in managing one of the domains below will increase the capacity for success in the others.

CHAPTER 5

THE CONTENT AND DISTRIBUTION LOCAL ECOLOGICAL KNOWLEDGE

> "La pesca significa vida, porque en la medida en que haya una variedad de especies en nuestras costas, los pescadores podremos sobrevivir." (Fishing means life, because as long as there is a variety of (fish and shellfish) species near our coasts, we fishers will be able to survive)—Don Lázaro, a fisher from Patillas, Puerto Rico.

Don Lázaro uttered the words quoted above during our first interview in Patillas, Puerto Rico. Two very important characteristics of the ecology and ethnoecology of fishers in this study's region are contained in Don Lázaro's words. First, that fishers such as Don Lázaro equate their survival with the health of the ecosystems they depend on. Second, that due to the ecological structure of tropical estuarine and reef fisheries (high total biomass which is distributed among many species that have relatively low biomass), Puerto Rican fishers recognize that they rely on continued biodiversity of the ecosystems as well as on total productivity of ecosystems. In my key informant interviews I asked fishers to describe what changes in the health of local ecosystems, if any, they had noticed during the years they had spent fishing in local waters. The key informants (specially the eldest among them) talked extensively about the times when coastal ecosystems appeared to be healthier than today. Of the 21 informants, 18 used the phrase '*variedad the pejes*'(variety of fish), instead of '*muchos pejes*'(a lot of fish) when describing a healthy coastal ecosystem. This suggests that fishers are highly aware that they need a diverse fish and shellfish ecosystem to survive.

The reliance on a wide variety of fish is a widely-documented characteristic of tropical, small-scale fisheries, and fishers in these systems have adapted to this by using a wide variety of gear types and by engaging in multiple and complementary forms of fishing, targeting multiple species, over space and time (Johannes 1981; Ruddle, 1994; 1996a; 1996b; Berkes *et al.* 2001; McGoodwin 1990). Few tropical species, save for deep water snappers and possibly the spiny lobster occur on sufficient numbers to be able to withstand a specialized fishery for a long period of time. Even the deep water snappers are fished as a species assemblage (in Puerto Rico the assemblage consists of the silk snapper, queen snapper, blackfin snapper, cardinal snapper, and vermillion snapper) rather than as a single-species fishery (Suarez Caabro 1979; Valdés-Pizzini 1985). Intensification of fishing on certain species due to the species becoming a highly sought-after item by costumers has frequently resulted in the species becoming rapidly overfished and the object of species-specific regulations such as strict size-limits and seasonal closures. Some recent examples of such high-value species are the spiny lobster (*Panulirus argus*) and the queen conch (*Strombus giga*) (DRNA 2004).

The rise and fall of attempts at fishery modernization and industrialization in Puerto Rico has been well-recorded by maritime anthropologist Ricardo Pérez (2000; 2005). Among the factors that made industrialization of Puerto Rican fisheries difficult has been that harvestable biomass on Caribbean estuarine-reef ecosystems is distributed among many species of fish and shellfish (Munro 1984; Polunin and Roberts 1996; Sale 1991; 2002). Under those conditions the specialization in a few fish species using one or two types of gear and expensive and specialized fishing vessels comes at the expense of flexibility in harvesting strategies that allows fishers to take advantage of the specific conditions they encounter when they go out to sea. Specialization of fishing fleets is a widely-observed factor in fishing communities' vulnerability to environmental and market fluctuations (Jacob *et al.* 2001).When the resource consists of a few abundant fishery species, such as the case of the north Atlantic cod fisheries, it might make economic sense for a fishing fleet to become highly-specialized. Even in those cases, the streamlining of the resource-extractive economy resulting from industrialization and specialization has often resulted in fishery collapses and loss of fishers' livelihoods (Jacob *et al.* 2001; Finlayson and McCay 1998). The emphasis on flexibility and the ability to harvest a variety of species was an important theme in my interviews and conversations with expert fishers.

Ecosystem complexity effects on ecological knowledge

In Chapter 4 I discussed how the cultural models of fishing success in Southeastern Puerto Rico developed in a socioeconomic context characterized by heterogeneity and unpredictability of opportunities for employment and for covering the basic needs of subsistence. The coastal marine ecosystems that tropical reef-estuarine fishers depend on for making a living are likewise complex and characterized by patchiness and habitat heterogeneity (Almany 2004; Jones and Syms 1998; Polunin and Roberts 1996).

Figures 5.1 and 5.2 illustrate just how heterogeneous and patchy local coastal marine habitats can be. Over a few square kilometers of coastal area, fishers can find a variety of coral reef formations (patch reefs, fringing reefs, spur-and-groove reefs, and submerged deep-water reefs), seagrass prairies and sand bottom areas, algal-dominated bottoms, mangrove forests and mangrove channels, a large estuary, and mud flats. These habitats are characterized by different combinations of ecological parameters such as water turbidity, salinity, depth, bathymetric relief, availability of nutrients, and faunal assemblages (Jackson 1991; Sale 1991; 2002).

The bathymetry and composition of these coastal habitats is ever-changing. For example, reef corals tend to build upwards by creating massive calcium carbonate structures that might modify currents, sediment transport, and availability of nutrients through the area (Fagerstrom 1987). Red mangrove (*Rhizopora mangle*) stands and to a lesser extent seagrass pairies can act as sediment traps and rapidly change coastal morphology (Kathiresan 2003; Woodroffe 1992; Wolanski 1995). Likewise, the rate of estuarine sediment deposition can affect nutrient availability, water turbidity, and even affect the rates of survival of reef-building corals offshore (Cortés and Hatziolos 1999). To these natural processes that result in natural ecological complexity we can add the effect of human activities along the coast, including deforestation, recreational activities, industrial activities, and fishing, which can also cause fast ecosystem change.

The factors outlined above have been often used to illustrate the enormous challenge of managing tropical reef-estuarine fisheries such as the ones found in southeastern Puerto Rico (Polunin and Roberts 1996; Munro 1984). There is simply not enough knowledge of the species and ecosystem processes at work in tropical reef-estuarine fisheries to be able to predict ecosystem responses to management and therefore what is considered state-of-the art knowledge of the ecosystems changes very rapidly. (Berkes *et al.* 2003; Folke 2004; Pomeroy 1992; Ruddle 1996). Even in reefs and associated systems that are located close to large populations in the Caribbean, new species of fish are still being discovered. In January 2006; as I wrote the last chapters of this dissertation, an international team of marine scientists reported close to 200 new species of fish discovered in the Caribbean island atoll of Saba, located less than 300 miles from Puerto Rico (Conservation International 2006). Many of these species had been know to local fishers for years.

Figure 5.1. Map showing the distribution of underwater habitats along the coastline between municipalities of Arroyo and Guayama in the study region. Modified from maps generated by Kendall et al. (2001) by benthic mapping using aerial photographs.

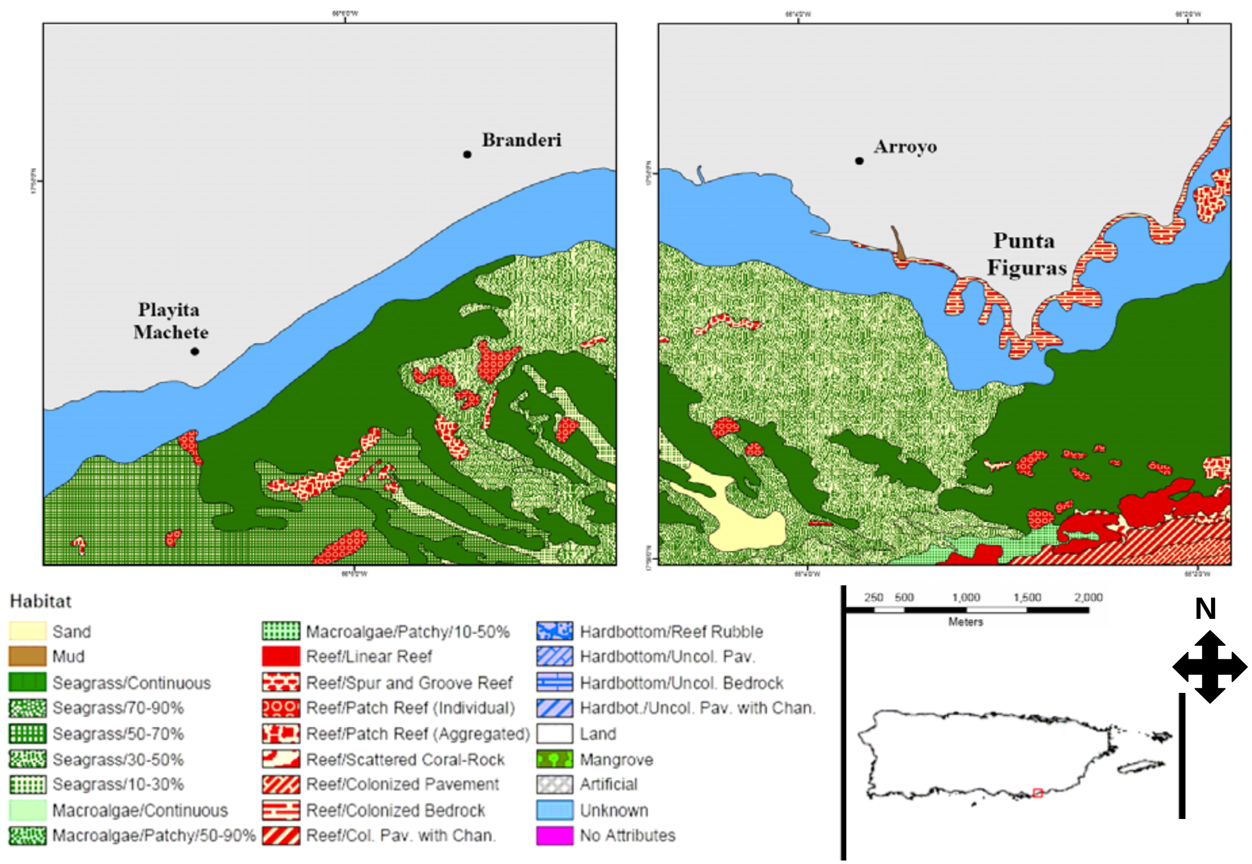
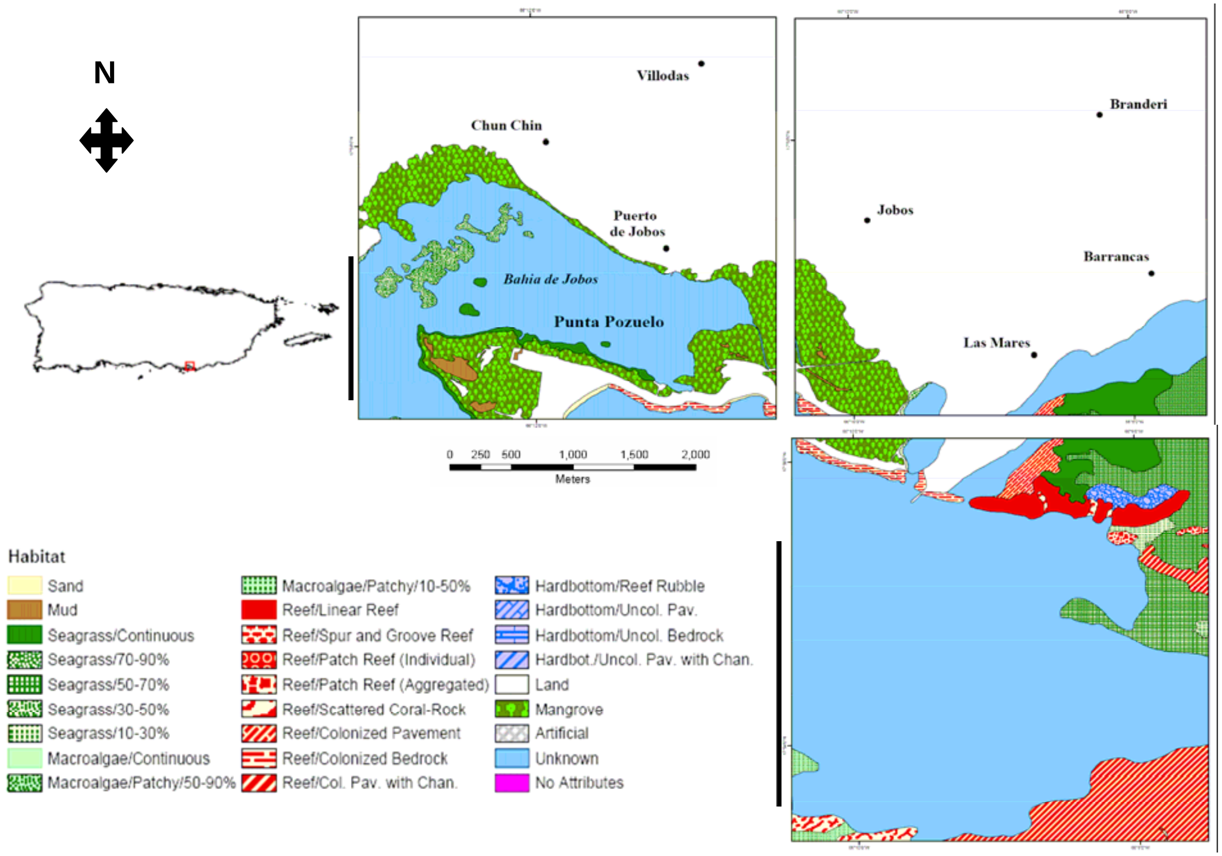


Figure 5.2. Map showing the distribution of underwater habitats along the coastline between municipalities of Guayama and Salinas in the study region. Modified from maps generated by Kendall et al. (2001) by benthic mapping using aerial photographs.



Fishers, ecosystem scientists and fishery managers face similar cognitive challenges when dealing with ecosystems.. They need to be able to decipher discernable patterns and achieve predictability of state and location of fishery resources among considerable complexity and rapid change. They are neither omniscient nor can they observe and understand all of the processes at work in local coastal ecosystems (Holling 2001; Berkes *et al.* 2001; Berkes, Colding and Folke 2003). Therefore, they have to rely on proxies, correlations, and inferences made based upon discontinuous and limited data that is not always representative of the larger scale ecosystem. More often than not, the available information can be used only to describe large-scale processes affecting entire ecosystems or parts of ecosystems, rather than to assess and predict the state of specific populations or population assemblages (Acheson and Wilson 1996; Berkes, Colding, and Folke 2003).

The more ecological knowledge a fisher, a resource manager, or an ecosystem scientist has the more chances she will have to make predictions about the status and location of fishery resources. In that sense, Scientific Ecological Knowledge (SEK) and Local Ecological Knowledge (LEK) of tropical coastal ecosystems share similar constrains and goals and, although the tools that they use to collect information are often very different. SEK and LEK are often in practice influenced by each other due to communication between local resource users and scientists.

The consequences of failing to adequately predict the numbers and location of resource species through space and time are decidedly direr for small-scale fishers than for ecosystem scientists. While scientists and their research groups can always come another day to perform data collection or they can sit back and ponder the statistical significance of the error in their predictions, the fishers depend on being able to land predictable catches to make a living. Managing ecosystem complexity and uncertainty is more urgent for fishers than for scientist in terms of their personal household economies. As I embarked on this research and attempted to understand how fishers used ecological knowledge to make a living in local coastal ecosystems, it became clear to me that I needed to explore how fishers managed the enormous cognitive task of achieving adequate knowledge of the 100+ species fished in a highly complex ecosystem.

Ecological narratives

During the semi-structured interviews I asked a series of open-ended questions about the ecological knowledge needed for fishing in the study region. The key informants' answers to these questions constituted the bulk of the text data for my interviews and, try as I might, I will not be able to do justice to the level of detail and insight about local ecosystems contained in their ecological narratives. The principal open-ended question I asked during the elicitation of ecological narratives was:

-In your opinion, what does a fisher need to know to be able to make a living from fishing? What is the most important knowledge?

In the context of this overarching question, I then asked a series of probing questions about knowledge of biological, meteorological, hydrological, and ecological factors that might have been related to the fishing activity. I also asked separate questions about navigational knowledge and techniques and about perceived patterns of change in local ecosystems and fishers' assessments of the causes and severity of those changes.

By asking a broad, open-ended question to start talking about ecological knowledge I wanted to make sure that I did not let my biases and previously-formed ideas about marine ecosystems to influence the interviews. It was, however, an almost-unnecessary precaution in the end, since practically all of my key informants had very clear ideas about what the important ecological knowledge was. Furthermore, they were so much more knowledgeable about local ecosystems than I was that any pre-conceived ideas that I might have had likely would not have influenced their answers at all. The ecological narratives told by my key informants constituted the basis of the ecological knowledge assessment questions administered in the explanatory phase of this research.

In the following pages I will present and detail the dominant themes and shared cultural models in the key informants' ecological narratives. How do fishers make sense of the large amount of ecological and biological information needed to have success in fishing? The answer to this question is not simple, but by following the exploratory-explanatory approach to studying cultural models outlined earlier in this dissertation I was able to get an idea of at least part of the answer. One of the phrases most frequently repeated by the key informant fishers throughout the interviews about important ecological knowledge was "*conocer las áreas de pesca*" (knowing the fishing areas). Over the remainder of this chapter I will argue that this deceptively simple phrase represents a high-level cultural model of fishers' knowledge that influences topics such as individual fishery species' biology, trophic relationships, navigational and gear handling knowledge and dexterity, and ecosystem change. What exactly are "the fishing areas" and why is this concept important for the study of fishers' ecological knowledge?

“The fishing areas”

All of the fishers I interviewed mentioned that an important part of ecological knowledge a fisher must have is knowledge of ‘*las áreas de pesca*’ (the fishing areas). The first few times I heard this answer I assumed that when they said ‘fishing areas’ they were specifically referring to productive places along the coast that were known to be productive areas for fishing. For example, the *Los Guajiles* bank, a submerged reef located several miles offshore to the south of Guayama, is well known as a fishing area for groupers such as the red hind (*Epinephelus guttatus)* and the yellowfin grouper (*Mycteroperca venenosa)*. Likewise, the fringing reefs that surround Berbería Island, a small key located close to the coast to the southwest of Santa Isabel, are a well-known fishing area for octopus. The channels between the *Cayos Caribe*, located near the mouth of the Bay of Jobos are a preferred area for fishers looking to ambush and capture schools of fast-moving fish such as schooling jacks and mackerel that enter the bay in search of food. The seagrass prairies located off the coast of Arroyo are productive for collecting Queen conch (*Strombus gigas*), while the muddy bottoms in the bays between Salinas and Santa Isabel are prime lane snapper (*Lutjanus synagris*) fishing grounds.

As I talked to more fishers, however, it became clear that the geographic location of ‘the fishing areas’ was not as definite as I believed initially. Several of the most experienced of the key informants included in their ecological narratives detailed descriptions of how fishing areas change over time due to sedimentation, storm events, and, in the last few decades, pollution and degradation caused by local coastal industries. Other key informants, when talking about their navigational knowledge, referred to the process of discovery and ‘marking’ of new fishing areas that they had found to be productive. When I asked probing questions about what exactly fishers referred to when they talked about fishing areas, it became clear that ‘fishing areas’ had a complex definition. As I suspected in the early phases of interviewing, a fishing area can be a specific geographic location which is known for producing predictable catches of a species or a species’ assemblage of fish and/or shellfish. These locations usually have well-established names that most fishers in the region know or have at least heard about. Some of the examples of ‘fishing areas’ that fit this definition are Investigador Reef, Media Luna Reef, Los Guajiles Bank, and the Arroyo Shallows.

The key informants, however, most often used the term ‘fishing areas’ to refer to areas that, because of their habitat and ecological characteristics, might be a good place to land a predictable catch of fish. In our third formal interview, Don Teófilo gave me a useful explanation of this usage of the term ‘fishing area’.

> “…you know, not all of the areas along these coasts are adequate for fishing, let’s say to put a fish pot in the water. You have to think that for you to use a fish pot, you have to be near the ‘veriles’(ecotones between different bottom types) , near the rocky bottom where fish abound. Because if you put your fish pot, let’s say in a sand flat, where the fish you want are not abundant, far from the reefs or the ‘veriles’, or seagrasses, the movement of the fish will not work in your favor.
>
> The sea is immense, but it has areas, fishing areas, where you can fish. And you have to know these fishing areas. If you fish where the fish are not abundant, you are not going to have a good catch. The fishes have their areas, where they live, except for the pelagic fish who run, and come, pursuing food, and if there is no food, then they leave. But most fish have their areas where they live. It’s like people, people have their areas where they live too. We have our habitats and fish have their habitats, too. Because in that large Ocean you won’t find fish everywhere. You need to have some knowledge.

Don Teófilo’s explanation underscores some of the characteristics of a ‘fishing area’ as defined by the fishers I interviewed. First of all, a fishing area is a place where a fisher might expect to find a reasonably predictable concentration of fish. Like Don

Teófilo pointed out in his statement above, the sea is immense, and only certain areas, certain habitats, will have desired fish. Because certain species of fish are best caught using some specific types of gear, it is also the important for the fisher to know what kinds of fishes he/she might find in a given area, compared to the fishing gears he/she will use. As I will detail in a later section of this chapter, species–habitat matching is a very common way in which fishers think about places they might go looking for fish. Because the specific locations of good fishing areas change over time, a focus on knowing what makes a good fishing area rather than just the locations of fishing areas is very important for sustained success in catching fish. Continuing his explanation about fishing areas, Don Teófilo said:

> Near the reefs, for example. If there are reefs, there will be fish. If there are 'veriles', seagrasses, there will be fish. If you come upon a dead area, an area without life, only sand, or mud, you will not find fish, except for maybe a pelagic fish (de carrera) passing by. But living in those areas, no. There are many new dead zones, in this times in this bay and these coasts. That is why many people go out and try to fish and because they don't have this knowledge of the fishing areas, is difficult for them. Because they do not have the knowledge of where to look for fish.
>
> You have to ask yourself: Where are the fish? Where food is abundant. Where there are reefs, or seagrasses, or mangroves, places where there is protection for fish and food that the fish can eat. This is the most important knowledge. To know there are places that are good fishing areas, like coral reefs, rocks, seagrasses, and places like that."

As evident in these words, one of the ways a fishing area is defined is by ecological/environmental parameters. According to Don Teófilo in the statement above, of the ecological/environmental parameters that define a fishing area are: 1) the type of habitat, defined by the type of substrate (bottom composition), and 2) availability of food for the pursued species. Don Teófilo also makes clear in his statements that, in his opinion, people who do not know how to find a fishing area will have a difficult time catching fish. Thus a clear determinant in Don Teófilo's model of fishing success is knowledge of fishing areas.

A fishing area may only be considered as such during certain times of the year. Thus seasonality also has an effect on what is considered a fishing area (also see Cordell (1974)). Although seasonality in tropical ecosystems is often less dramatic than in temperate systems, most of my key informants reported that many species are predictably seasonal in their movements between habitats and/or geographic locations. Don Pablo, a fish pot fisher from Guayama, discussed seasonality of fish movements and of fishers' activities during one of our interviews in December 2003:

> Carlos: so you say this (December) is the time of lobster fishing? So there are other times of the year that you practice different kinds of fishing?
>
> Don Pablo: Yes. The lobster likes the cold waters, so it comes nearshore on the colder months. The '*cabrilla*' (red hind, *Epinephelus guttatus*) season is coming next, in January and lasts until March. After that, in the summer, one can catch a variety of fish. Lobster becomes scarce, but there is more fish, you can catch a few hundred pounds of fish and 20 pounds of whatever lobster is left, each week. You can catch '*chapín*' (trunkfish, *Lactophrys trigonus*), '*juey dormí'o*' (Batwing Coral Crab, *Carpilius Corallinus*), fish that one can always sell well.
>
> Carlos: Is that in the summer?
>
> Don Pablo: Yes, in the hotter months. Most fishes go away with the cold waters in this time of the year. But the lobster comes near the coast, and that makes up for it. The lobster can take more cold.
>
> Carlos: And what else do you do throughout the year?
>
> Don Pablo: In the summer, we go to the offshore banks. In the lobster season, we fish mostly in 'rastreales' (local habitat classification meaning rocks interspersed with sand). The lobster likes that area better than the large rocks in the reefs. Then, when the lobster goes away to deeper waters, we go back to the banks again. We catch the red hind and the '*peje puerco'* (queen triggerfish) in the reefs

> near the banks. In one week, in the Guajiles bank, we catch a lot of red hind, right after they get together to spawn. But I never catch them before, when they are full of eggs! I wait so that they have a chance to release their eggs.

The preceding interview fragment illustrates a point also made by most key informants, that a fishing area can be recognized as suitable or not depending on season, bottom composition (sand, reef, mud etc.) and the seasonal movements of fishery species, which can also be related to changes in water temperature. This interview fragment also hints at how, in attempting to manage the uncertainty associated with habitat heterogeneity and ecological complexity, fishers visit different fishing areas at different times in order to capture certain species that live in the areas. For example, Don Pablo states that when it is lobster season he will go to the kinds of fishing areas that in his opinion and in the opinion of other fishers are preferred by lobsters, such as areas of coral reef colonies and/or rocky aggregations that are interspersed with sandflats. This kind of underwater habitat is locally called a *rastreal* (plural *rastreales*). Don Pablo's explanation's of seasonal shifting between fishing areas resonates with recent research in tropical Pacific fisheries, in which fishers have been found to move their fishing effort between habitat types as productivity of habitat patches varied through the seasons (Aswani and Lauer 2006).

In the warmer months, Don Pablo fishes in seamounts and reefs off the coast, which he calls *Los Bancos* (The Banks). In banks such as *Los Guajiles* he fishes for a variety of reef fish such as the red hind and the queen triggerfish (*Balistes vetula*). He also mentioned that he sometimes takes advantage of spawning aggregations of fish such as the red hind which happen predictably in space and time (also see Johannes 1978;

1981). Don Pablo fishes almost exclusively with fish pots, so he almost never fishes in the estuaries and the nearshore reefs where net fishing is a preferred strategy.

Don Pablo's statement above is highly representative of what I found to be a common way the key informants went about explaining the ecological knowledge they needed to fish. Encyclopedic knowledge of fish species (for example, the high value spiny lobster), which is obviously needed to pursue a particular species, is invoked by the fisher in the context of a fishing area. At the beginning stages of my interviews, I attempted several times to have an extended conversation about a particular important species of fish. Every time I attempted this, however, the fishers invariably would talk as well about other fish and about the biotic and abiotic factors in the fish's habitats. It became clear after some time, that fishers thought it was futile to talk about a specific fish alone: a fish was part of a larger ecosystem. Rather than interacting only with the fishes they capture and sell, fishers' interact with an underwater/aquatic landscape, much in the way people on land interact with terrestrial landscapes (Crumley, 1998; Crumley and Marquart, 1987). Several times in my interviews a fisher would remind me of this, when I attempted to talk about only one species of fish. During our third interview, Don Gero from Aguirre told me:

> "When we are thinking about finding some *sierra* (mackerels), we cannot think only about the *sierras*. Because, these fishes are '*de carrera'* (pelagic, migratory fishes) and they move, looking for food. If they come to these bays or these reefs, they come after the food, the baitfish, the sardine, the scad, the ballyhoo, and if the food goes, they go. We always find them where the food is. Then, we use our nets, or our troll lines. But first, we have to know that where the food is, the mackerels will be."

Don Gero's statement illustrates how, even when thinking about mackerel (*Scomberomorus maculatus*), a fish that usually forms large aggregations of only one species (Froese and Pauly 2005), fishers have to think about other components of the ecosystem that are associated with the fishery species (in this case, the fishery species' prey).

The fact that I was able to elicit only very few extended conversations about only one kind of fish is also probably related to my original question. I had asked the key informant fishers: What does a fisher need to know to be able to make a living from fishing? What is the most important knowledge? And they were answering exactly that. In a fishery with the ecological complexity and biomass distribution of the tropical reef-estuarine fisheries of southeastern Puerto Rico, the most important ecological knowledge is to be able to put desired resource species in the context of a larger ecosystem, and to pursue these species within the context of the ecological landscape. This does not mean that fishers do not have extensive encyclopedic and biological knowledge of many species. They certainly do, and as I will detail in Chapter 6 using the example of the spotted goatfish (*Pseudupeneus maculatus)*, fishers' encyclopedic knowledge of the movements and biology of certain species of fish has the potential to make an important contribution to the sustainable and balanced utilization of marine resources in Puerto Rico. In the context of everyday fishing, however, the most important ecological knowledge for my key informants was about fishes in the context of their ecosystems.

The fishing areas and parameter-based ecological thinking

The fishing areas are places where, because of a combination of factors, ecological, bathymetric, and seasonal, fish can be caught. The fishing areas for different fish and shellfish will vary in factors such as bottom/substrate composition, depth, salinity, water turbidity, sediment input, currents, nutrients, prey species populations, and the species assemblages found. These ecological parameters (Johnson, Mason, and Raven 1968) will determine what species can be found by fishers and in what quantity. Because these parameters can change over time in a particular underwater locality, fishing areas can and do change over time. Some localities, such as specific seamounts, reefs, and seagrass prairies have been productive fishing grounds over time and thus they are named and recognized as a fishing area. A 'named' fishing area such as 'Berberia', 'Investigador', 'Los Guajiles' and 'Media Luna' (all important fishing locations for fishers in southeastern Puerto Rico), however, almost invariably refers to a relatively large or loosely-defined geographic location. Inside of these larger geographic locations fishers have to find smaller fishing areas, such as 'veriles', transition zones between reefs and seagrasses, with which they actually interact.

All of the key informants at one point or another stated that they search and choose locations for fishing based on ecological parameters, a concept introduced by Johnson, Mason, and Raven (1968) to explain ecosystem characteristics affecting plant abundance and diversity. The fishers' themselves did not use the word 'parameters'; this is my interpretation of their meaning. The word most commonly used by the informants was '*factores'* (factors). Don Teófilo liked to emphasize this. As he repeatedly told me as we talked about fishing and local ecosystems: "!*Son muchos los factores, Carlitos, son muchos los factores*!" (There are many factors, Carlitos, there are many factors!). His words still resonate in my mind like a mantra.

When ecological parameters change, the species found by fishers in a fishing area might change. Don Aquiles related to me how he has observed, over the years, how offshore underwater habitats that were once reefs have become sandy or muddy. Don Aquiles is exclusively a fish pot fisher and has not dived for more than two decades. His observations have happened via proxies, by observing the assemblages of species he has caught at specific sites over the years. Don Aquiles also makes clear his awareness that local ecosystems are always changing, and that fishers need to accept that fact as something that comes with the territory of being a fisher:

> Aquiles: I am going to tell you something. Many of the reefs around here have become clogged!. Now I am catching fish in what should be reefs that are not reef fish! I lift a trap, in areas that are supposed to be reefs, and it comes back full or plumas (pluma porgy). And that kind of fish is not a reef fish!
>
> Carlos: Are the porgies sand fish, then?
>
> Aquiles: Yes, sand! Also the trunkfish. You put your fishpot in the banks and it comes back with trunkfish. And you think 'look at this, this fishpot is here near the reefs and catching trunkfish and lane snappers. Those are sand fish, not reef fish! Because, I can tell you from the kinds of fish that you bring if you were in the reefs, in the sand, or in deep waters. I would tell you: "you went to the reefs today, didn't you? But now, it's harder because many reefs are clogged with sand. I cannot tell you: in this area, I am going to catch this and this fish. You should write this down, this is important data for your study! This is how the sea is, always changing.

Besides species assemblages, many fishers also reported watching for the abundance of particular species of fish and shellfish to assess changes in fishing areas and local environmental health. The fishers' repeatedly referred to their observations of key species to back their arguments for ecosystem change. Two of the most widely mentioned fish species in this context were the liza (*Mugil liza*) and the rainbow parrotfish (*Scarus guacamaia*). The liza was widely mentioned as an indicator of estuarine ecosystem health, while the rainbow parrotfish was considered an indicator of the health of coral reef ecosystems. Both previously abundant species have become very rare in their respective habitats, even though fishers report that neither of the two species has ever been heavily fished or targeted by local fishers as a highly-desirable species. Therefore the fishers attribute the disappearance of large numbers to general environmental degradation. Biologically, both the liza and the rainbow parrotfish appear to be well-suited to be regarded as indicator species. The liza is strongly associated with estuarine waters and coastal lagoons, and the rainbow parrotfish is exclusively a coral reef-associated species (Froese and Pauly 2005). The rainbow parrotfish is also classified as a vulnerable species in the IUCN Red list (Froese and Pauly 2005). Other species of fish and shellfish mentioned as indicators of ecosystem health were the queen conch (seagrasses), Atlantic barracuda (all ecosystems), white mullet (estuarine bays), Land crabs (terrestrial sections of mangroves) and the long-spine sea urchin (*Diadema Antillarum*) (coral reefs). What these species have in common is that they occupy important positions in the ecosystems they inhabit, thus fitting the ecological definition of a keystone species (Odum, 1971; Paine, 1969; Schulze and Mooney, 1993). Please see table 5.1 for a list of some of the species mentioned as indicators of ecosystem health by the key informants. Although the fishers I interviewed explained some changes in ecosystem parameters as part of natural sedimentary and ecological dynamics, many accounts of changes in local ecosystems that the fishers talked about were related to anthropogenic activities, mostly the result of industries and tourism developments along the coast.

Table 5.1 . Species mentioned by fishers as indicators of ecosystem health

Species		Habitat	Role
lisa	*Mugil liza*	Estuaries/mangrove channels	Detritivore/prey species
rainbow parrotfish	*Scarus guacamaia*	Coral reefs	Grazer/algal control
queen conch	*Strombus giga*	Seagrasses	Grazer
Atlantic barracuda	*Sphyrraena barracuda*	All Ecosystems	Apex predator
white mullet	*Mugil curema*	Estuaries/bays	Detritivore/prey species
land crab	*Cardisoma guanhumi*	Mangroves/terrestrial	herbivore, plant disperser
snook	*Centropomus undecimalis*	Estuaries	Predator
long-spine sea urchin	*Diadema antillarum*	coral reefs	Grazer/algal control

Species-habitat matching

Finding out from my interviews with expert fishers that ecological parameter-based thinking about underwater landscapes (fishing areas) provided me with important insights for measuring variability in knowledge about local ecosystems. Matching fish and shellfish species to underwater habitats appears to be one of the ways fishers think about what fish and shellfish assemblages they might find under different sets of conditions. This resonates with previous research with fishers in western Puerto Rico and the Dominican Republic, in which habitats were found to be an important driver of folk classification of fish and shellfish (Valdés-Pizzini *et al.* 1996; 2001; García-Quijano 2001).

In order to gain a better understanding of which fishery species the fishers associate with different habitat types, I conducted a multiple freelist exercises with 55 of the fishers that I talked to during this study. In these exercises I asked the fishers to list all of the species of fish that they associated with 8 habitat types: mangroves, bays, reefs, seagrasses, sandflats, mud bottoms, deepwaters, and pelagic open waters. Although there is a more specific local taxomony of habitat types that includes mixed habitats and borders between habitats, I decided to use only 8 habitats categories used here because there was variable consensus between fishers of different communities in the meaning of other habitat names. I analyzed the freelists for each type of habitat using ANTHROPAC X (Borgatti 2001). An average of 67.7 species were mentioned for each habitat type (Std. Dev. 9.3), with reefs having the most mentioned species (84) and pelagic open waters the fewest (56).

Table 5.2a and 5.2b show the ten most salient species (Smith's S salience) for each habitat type. The ten species represent the species that, in the opinion of the fishers I interviewed, are the most representative for each habitat. Several of the key informants' narratives about local ecosystems make mention of fish species movements between habitats, 'habitat connectivity' (Aguilar 2004; Mumby 2006; Roberts 1997;), noting that some species are found in almost every kind of underwater habitat, while others are associated with one or two specific habitats. Most species in tables 5.2a and 5.2b were among the top ten in salience for only one or two habitats, but several appeared among the most salient for several habitats, most notably the mutton snapper (Seven habitat types), the lane snapper (Five habitat types) and the schoolmaster snapper (Five habitat types). These three fishes, specially the mutton snapper and the lane snapper, are very important commercial and food fishes throughout the study region.

To assess the degree of overlap between the species assemblages mentioned by fishers as representative for each habitat type, I calculated Bray-Curtis dissimilarity coefficients between habitat types. The Bray-Curtis dissimilarity coefficient measures dissimilarity of species' composition between two assemblages or population samples and is calculated by:

$$\text{BC dissimilarity}_{ij} = \frac{(b + c)}{(2a + b + c)} \text{, (Gauch, 1982)}$$

where *a* is the number of species common to both groups, *b* is the number of species restricted to group *i*, and *c* is the number of species restricted to group *j* (Gauch, 1982; Krebs, 1999). Larger values for this statistic reflect greater distances, and thus less similarity, between the species assemblages mentioned by fishers for each habitat type.

Table 5.3 shows the Bray-Curtis dissimilarity coefficients between the species assemblages mentioned for the 8 habitat types. The habitats with the two most similar species assemblages were mangroves-bays (BC=0.4; 6 shared species). Mangroves did not have any of their 10 most salient species in common with either openwater or seagrasses (BC=1). The three habitat types that, on average, had more species in common with other habitats were bays (average BC=0.67), followed closely by reefs and mudflats (average BC=0.73), while openwaters (average BC=0.87) and deepwaters (average BC=0.84)) tended to have the fewest species in common with other habitats. A comparative assessment of the distances between habitat assemblages using hierarchical cluster analysis suggests that a perceived ecological salinity/depth gradient might be driving similarities in memberships. See figure 5.3 for a graphical representation of the distances between assemblages using Hierarchical Cluster Analysis (Gower 1988).

Habitat connectivity (the degree of species 'shared' by different habitats) in tropical reef-estuarine ecosystems is an important and developing topic of research that has important implications for the management of multi-species fisheries over areas of high ecosystem heterogeneity (Aguilar 2004; Mumby 2006; Roberts 1997). This important topic has remained understudied, in part, due to the large numbers of observations and extensive sampling over time needed to assess connectivity between habitats. This topic of study in marine ecosystems could benefit from the extensive and chronologically-deep experience of small-scale fishers with local ecosystems; and the tapping of fishers' knowledge about habitat connectivity with the methods outlined in this section constitutes an interesting possible avenue for collaborative management and research.

Measuring intra-group variability in local ecological knowledge

In the preceding sections of this chapter I discussed the ways in which the fishers who collaborated with me in this study deal with the cognitive challenges involved in fishing for multiple species of fish and shellfish in a complex and dynamic coastal ecosystem. My interviews with fishers revealed that, while fishers amass encyclopedic knowledge about many species, thinking about the ecosystem as a whole and about the ecological parameters (species diversity, trophic relationships, salinity, depth, type of habitat, substrate, seasonality, species assemblages, etc.) is of paramount importance for fishers managing the complexity of a multi-species tropical fishery. This gave me the insight needed to explore how ecological knowledge varies between fishers. It became clear to me that if I had to choose a few questions about Local Ecological Knowledge to ask a large number of fishers and be able to make comparisons between fishers, those questions probably should be about the ecological parameters that help fishers in predicting where to find fish.

Table 5.2a. Ten most salient species for four habitat types mentioned by fishers in habitat-centered freelists (n=55). Salience was determined using ANTHROPAC X (Borgatti 2002), Smith's S salience measure.

Mangroves (75 species)			**Bays (71 species)**		
Spanish	**English**	**Scientific**	**Spanish**	**English**	**Scientific**
jarea	white mullet	*Mugil curema*	jarea	white mullet	*Mugil curema*
robalo	snook	*Centropomus undecimalis*	robalo	snook	*Centropomus undecimalis*
pargo	schoolmaster snapper	*Lutjanus apodus*	sama	mutton snapper	*Lutjanus analis*
lisa	liza	*Mugil liza*	sabalo	tarpon	*Megalops atlanticus*
picuilla	southern sennet	*Sphyraena picudilla*	pargo	schoolmaster snapper	*Lutjanus apodus*
sabalo	tarpon	*Megalops atlanticus*	picuilla	southern sennet	*Sphyraena picudilla*
mojarra	yellowfin mojarra	*gerres cinereus*	arrayao	lane snapper	*Lutjanus synagris*
crianza	juvenile fish	*N/A*	manati	manatee	*Trichechus manatus*
congre	green moray	*Gymnothorax funebris*	sierra	spanish mackerel	*Scomberomorus maculatus*
picua	atlantic barracuda	*Sphyraena barracuda*	picua	atlantic barracuda	*Sphyraena barracuda*

Mud (70 species)			**Deepwaters (67 species)**		
Spanish	**English**	**Scientific**	**Spanish**	**English**	**Scientific**
arrayao	lane snapper	*Lutjanus synagris*	chillo	silk snapper	*Lutjanus vivanus*
jarea	white mullet	*Mugil curema*	cartucho	queen snapper	*Etelis oculatus*
robalo	snook	*Centropomus undecimalis*	mero	red grouper	*Epinephelus morio*
burro	whitemouth croaker	*Micropogonias furnieri*	negra	blackfin snapper	*Lutjanus bucanella*
cachupin	Irish mojarra	*Diapterus auratus*	cabrilla	red hind	*Epinephelus guttatus*
sama	mutton snapper	*Lutjanus analis*	colirrubia	yellowtail snapper	*Ocyurus chrysurus*
pargo	schoolmaster snapper	*Lutjanus apodus*	moniama	cardinal snapper	*Pristipomoides macropthtalmus*
chopa	Bermuda sea chub	*Kyphosus sectator*	sama	mutton snapper	*Lutjanus analis*
mojarra	yelowfin mojarra	*Gerres cinereus*	mero guasa	misty grouper	*Epinephelus mystacinus*
lisa	liza	*Mugil liza*	sierra canalera	king mackerel	*Scomberomorus cavalla*

Table 5.2b. Ten most salient species for four habitat types mentioned by fishers in habitat-centered freelists (n=55). Salience was determined using ANTHROPAC X (Borgatti 2002), Smith's S salience measure.

Reefs (84 species)			Sand (71 species)		
Spanish	**English**	**Scientific**	**Spanish**	**English**	**Scientific**
pargo	schoolmaster snapper	*Lutjanus apodus*	pluma	pluma porgy	*Calamus pennatula*
loro	parrotfish	*Sparidae*	arraya'o	lane snapper	*Lutjanus synagris*
colirrubia	yellowtail snapper	*Ocyurus chrysurus*	carrucho	Queen conch	*Strombus giga*
mero	red grouper	*Epinephelus morio*	sama	mutton snapper	*Lutjanus analis*
boquicolora'o	striped grunt	*Haemulon plumierii*	chapin	trunkfish	*Lactophrys trigonus*
sama	mutton snapper	*Lutjanus analis*	mantarraya	spotted eagle ray	*Aetobatus narinari*
langosta	spiny lobster	*Panulirus argus*	cojinua	bar jack	*Carangoides ruber*
gallo	squirrelfish	*Holocentrus adscensionis*	colirrubia	yelowtail snapper	*Ocyurus chrysurus*
pulpo	octopus	*Octopus vulgaris*	jurel	Crevalle jack	*Caranx hippos*
arraya'o	lane snapper	*Lutjanus synagris*	picuilla	southern sennet	*Sphyraena picudilla*
Open waters (56 species)			**Seagrasses (68 species)**		
Spanish	**English**	**Scientific**	**Spanish**	**English**	**Scientific**
dorado	dolphinfish	*Coryphaena hippurus*	arrayao	lane snapper	*Lutjanus synagris*
marlin	blue marlin	*Makaira nigricans*	sama	mutton snapper	*Lutjanus analis*
sierra canalera	cero	*Scomberomorus regalis*	salmonete	spotted goatfish	*Pseudupeneus maculatus*
peto	wahoo	*Acanthocybium solandri*	colirrubia	yellowtail snapper	*Ocyurus chrysurus*
atunes	tunas	*Thunnus sp.*	carrucho	queen conch	*Strombus giga*
tiburon	sharks	*Carcharinidae*	boquicolora'o	striped grunt	*Haemulon plumierii*
picua	Atlantic barracuda	*Sphyraena barracuda*	manati	manatee	*Trichechus manatus*
sama	mutton snapper	*Lutjanus analis*	langosta	spiny lobster	*Panulirus argus*
bonito	little tunny	*Euthynnus alletteratus*	balaju	ballyhoo	*Hemyramphus brasiliensis*
aguja blanca	white marlin	*Tetrapturus albidus*	cojinua	bar jack	*Carangoides ruber*

Table 5.3. Bray-Curtis assemblage dissimilarity coefficients between habitat types. The ten most salient species in the freelists for each habitat were used for calculating the coefficients.

	Mangroves	Bays	Reefs	Mud	Deepwater	Openwater	Seagrasses	Sandflats	Average Distance To Other Habitats
Mangroves	0	0.4	0.9	0.5	1	0.9	1	0.9	0.80
Bays		0	0.7	0.5	0.9	0.8	0.7	0.7	0.67
Reefs			0	0.7	0.7	0.9	0.5	0.7	0.73
Mud				0	0.9	0.9	0.8	0.8	0.73
Deepwater					0	0.8	0.8	0.8	0.84
Openwater						0	0.9	0.9	0.87
Seagrasses							0	0.6	0.76
Sandflats								0	0.77

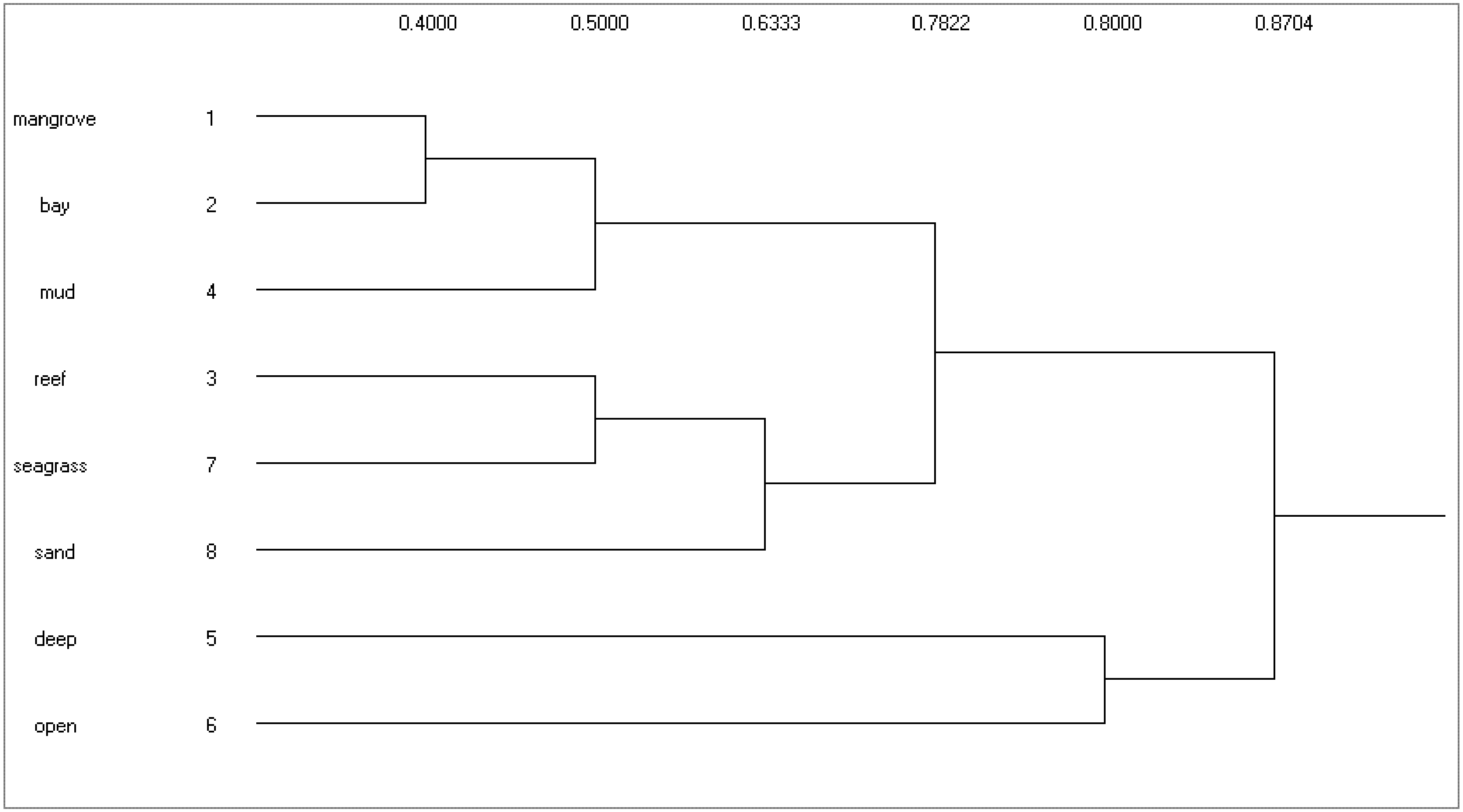


Figure 5.3. Hierarchical cluster analysis dendrogram showing relative distances between habitat types based on dissimilarities in the ten most salient species in the freelists for each habitat (55 freelist exercises). There is an apparent salinity/depth gradient related to relative distances. The three principal clusters represent roughly shoreline/estuarines habitats (1,2,4), nearshore/shallow marine habitats (3,7,8), and offshore habitats (5,6). Cluster analysis was performed with UCINET 6 (Borgatti, Everett, and Freeman 2002). The numbers on the top along the x-axis refer to the average distances between groups.

During a visit to Don Teófilo after the formal interviews were over, I told him that I was in the process of designing a few questions about local ecosystems to ask a variety of fishers that would make sense to them. Don Teófilo provided me with another important insight when he told me that, since all fishers must catch a variety of species consistently, what he would do is get a list of a variety of species and ask other fishers about where they would expect to find those species and how they would try to catch them. In a similar context, Don Eddie told me that an additional thing he would ask would be what kinds of fishing gear can be sued to fish for the different species, a topic which had been mentioned by several fishers during interviews. I had already planned to build a list of important fishery species and ask questions about them, but Don Teófilo's and Don Eddie's advice helped me to focus on asking the same few questions about a list of important species, thus focusing the data gathered on the link between species and ecological parameters.

Fishery species included in the ecological knowledge assessment questions

In chapter 3 I explained how I built a list of 16 species that in the opinion of the key informants were important for local fisheries for use in structured questionnaire questions. To verify that these 16 species were considered as important by the structured questionnaire respondents, I asked the respondents to rate these species on a 4-point scale according to their importance. The average answer for all of the 16 species was 'very important'. Using a list of these 16 species, I asked the fishers: 1) In what kinds of habitats are the species most commonly caught, 2) In what times of the year are the species most commonly caught, 3) With what types of fishing gears are the species captured, and 4) Whether the species are usually found alone (solitary), in mono-specific groups, or together with other species.

Other domains of ecological knowledge considered as important were relevant for specific groups of fish and shellfish, not necessarily included in the important species list, but of economic/ecological importance. For asking questions about these other domains, I developed lists of species relevant to the question. For example, key informant fishers throughout this study told me that knowledge about ciguatera seafood poisoning (a fairly common and sometimes lethal syndrome, caused by bioaccumulation of toxins secreted by reef-associated dinoflagelates *Gambierdiscus toxicus* and *Ostreopsis lenticularis* (Tosteson *et al.* 1988; Morris 1980) has become more important as diagnoses' of ciguatera poisoning have increased over the last few decades, according to fishers. Due to fear of lawsuits, loss of clientele, or simply due to a fear of causing harm to their clients, many fishers have placed a premium on knowing which species are causing ciguatera poisoning to avoid eating them and selling them to clients. Using a list of ciguatera-suspect species based on key informant fishers' accounts and from the literature on ciguatera, I asked the structured questionnaire respondents to tell me whether, in their opinion, the species in the lists were always, frequently, sometimes, rarely, or never associated with ciguatera poisoning.

Similarly, I used a list of fishery species that are routinely caught using bottom lines, including deep water snappers, to ask about at which depths the fish are commonly found, another important domain of knowledge according to some fishers. Finally, I used a list of fishery species associated with estuarine environments to ask structured questionnaire respondents whether the species were found in several types of estuarine environments according to salinity.

The answers to the ecological knowledge assessment questions were coded according to the following scheme:

1)Where are fishery species' found (WHERE): a) freshwater, b) bays, c)reefs, d)sand, e)deepwater, d)mud, e)grass, f) everywhere, g) do not know.

2)At what times of the year are fishery species' found (SEASON): a)winter, b)spring, c)summer, d)fall, e)first half of the year, f)second half of the year, g) end of one-year/beginning of the next, h)caught throughout the year, i)do not know.

3)Species' aggregation habits (AGGREG): a)found alone, b)found in mono-specific groups, c)found in multi-species groups, d) do not know.

4) Types of fishing gear used to catch species (CAPGEAR): Each unique combination of gear types was coded as separate answer. For example, if a respondent reports that fishery species X is caught with gear types a and c, the coded answer would be 'ac').

5) Species' association with ciguatera fish poisoning (CIGUATOX): a)always poisonous, b)frequently poisonous, c)sometimes poisonous, d)rarely poisonous, e)never poisonous.

6) Depth at which bottom-caught fishery species are found (DEPTHFIND): Answers were coded by the minimum depth where the species was reported to be found in *brazas* (+/- a fathom): a)less than 20, b)20, c)50, d)80, e)100, f)150, g)200, h)do not know

7) Type of estuarine areas where fishery species are found (ESTUARINE): Answers were coded by the salinity regime the species were reported to be found: a)freshwater only, b)brackish water only, c)saltwater only, d)fresh and brackish water, e)fresh and saltwater, f)brackish and saltwater, g) found in all.

Table 5.4. Ecological knowledge assessment questions administered to structured questionnaire respondents. The entry named "16 important/salient species" refers to the 16 species identified as important for local fisheries through freelisting exercises described in chapter 3.

Question (translated and paraphrased from Spanish questionnaire format)	**Answer format**	**List of species used for question**
Q. LEK1. I would like to ask you to tell me in which kinds of environments the following fish/shellfish are found. Please use your own words.	(species local name) is found in: ______________________	**16 important/salient species**
Q. LEK2. I would like to ask you to tell me at what times of the year are the following fish/shellfish found	(species local name) is found: ______________________	**16 important/salient species**
Q. LEK3. I would like for you t tell me whether the following fish/shellfish species are usually found alone, in groups of the same species, or in groups with other species.	(species' local name) is found: 1)alone, 2)in same-species groups, 3) with other species, or 0) do not know	**16 important/salient species**
Q. LEK4. I would like to ask you what kind(s) of fishing gear are used to capture the following fish/shellfish. Are the following fish caught with (recite different kinds of gear). Please indicate as many kinds of gear as are used for the species.	(species' local name) is captured with: 1)fishpots, 2)surface nets, 3)bottom nets, 4) bottom hook-and-line, 5) troll surface line, 5) diving, or 0) do not know	**16 important/salient species**
Q. LEK5. Now I would like to ask you about ciguatera poisoning. Are adult fish of these species always, frequently, sometimes, rarely, or never poisonous?	(species' local name) is: 1)always poisonous, 2)frequently poisonous, 3) sometimes poisonous, 4) rarely poisonous, 5) never poisonous, or 0) do not know	**19 ciguatera-poisoning associated species**
Q. LEK6. I would like to ask you about fish that are caught in deeper waters. At what depths are the following fish/shellfish species found?	(species' local name) is caught at: ________________________ depth in 'brazas' (depth unit similar to a fathom)	**12 deep-water or bottom line-caught species**
Q. LEK7. I would like to ask you in which of these types of underwater environments are the following fish/shellfish found. Please indicate if the fish are found in more than one of these.	(species' local name) is found at: (names after local taxonomy of estuarine environments) 1)rivers (freshwater), 2)mangrove roots, 3)channels, 4)shorelines, 5)bays, 6)saltwater, or 0) do not know	**18 estuarine-associated species**

Table 5.5. List of species used in the ecological knowledge assessment questions. Only English common names are used, please see Appendix XY for Spanish common names and scientific names of these species.

16 important/salient species	19 ciguatera-poisoning associated species	12 deep-water or bottom line-caught species	18 estuarine-associated species
mutton snapper	Crevalle jack	yellowtail snapper	white mullet
Spanish mackerel	amberjack *	mutton snapper	liza
king mackerel	Atlantic barracuda	lane snapper	snook
yellowtail snapper	bar jack	cardinal snapper	Atlantic tarpon
lane snapper	blue runner	blackfin snapper	sardine**
red hind	black jack	silk snapper	sardine**
red grouper	yellow jack	queen snapper	herring**
queen conch	horse-eye jack	misty grouper	half-beak
white mullet	schoolmaster snapper	yellowfin grouper	ballyhoo
striped grunt	silk snapper	red hind	thread herring
spiny lobster	spanish hogfish	jewfish	sardine**
queen triggerfish	octopus	Nassau grouper	yellowfin mojarra
silk snapper	red grouper		land crab
spotted goatfish	yellowfin grouper		peneid shrimp
octopus	misty grouper		oysters**
rainbow parrotfish	jewfish		largehead hairtail
	mutton snapper		croaker
	spanish mackerel		southern sennet
	cero		

* 3 species, *Seriola sp.* genus
** Local name at generic level. Exact species unknown

Intracultural variation in ecological knowledge

I used Consensus Analysis (Romney, Weller, and Batchelder 1986) to measure patterns of agreement and disagreement in the 41 structured questionnaire respondents' answers to the ecological knowledge assessment questions. As I detailed in Chapter 3 of this work, consensus analysis is a direct measure of the patterns of agreement and disagreement between respondents to a questions or series of questions. The three assumptions of the cultural consensus model (upon which consensus analysis is based) are that respondents share a common culture, that they answer questions independently from each other, and that the competence of the respondents on the topic of questioning is constant over all questions (Kempton, Boster, and Hartley 1995; Romney, Weller, and Batchelder 1987).

There is debate in the literature as to whether patterns of agreement and disagreement reflect true knowledge of a domain of knowledge in which correct answers are not known (Furlow 2003, Johnson and Weller 1987; Brewer 1995; Ross 2002). In Chapter 3 I detailed the assumptions under which a respondent's degree of agreement with other informants' over a series of questions might be considered to be a measure of 'true knowledge or competency' in a subject and which are relevant to this study. These assumptions are: 1) The questions ask about topics that deal with the same or very similar domains of knowledge, 2) There is a logical independent process or constrain that will tend to result in more agreement between more knowledgeable individuals compared with less-knowledgeable individuals (e.g. there are correct answers, even if the researcher does not know them, 3) The informants being compared can be reasonably assumed to share a cultural model regarding the questions asked, and 4) Preliminary analysis of each question's response patterns show that a single shared cultural model might be driving responses to the question (Boster and Johnson 1989; Romney, Weller, and Batchelder 1986; Romney, Batchelder and Weller 1987; Weller 1987).

The data about ecological knowledge gathered in this study seems to meet these assumptions. Assumption1: The seven ecological knowledge assessment questions administered are all about fishing and fishery resource species. Assumption 2: There probably are correct answers to the questions asked, and a fishers' success in finding fish over time will reinforce answers that more closely reflect what goes on underwater in marine environments. In the question about fishing gears, more knowledgeable and experienced fishers will probably know more accurately which gear types can be used to capture a fishery species. Likewise, in the question about ciguatera poisoning, there is a strong incentive to know which fishery species are potentially toxic for fishers wanting to avoid trouble and wanting to keep their clientele. Assumption 3: All of the structured questionnaire respondents fish for a living, thus they can be reasonably be expected to share a cultural model of expertise in fishing, even if they vary in their knowledge. Assumption 4: When multiple-choice Consensus Analysis procedures (ANTHROPAC X, Borgatti 2001) were run for each of the ecological knowledge assessment questions, large (Average 5.404, Std. Dev. 2.655) first-to-second eigenvalue ratios were found for the answers to each of the seven ecological knowledge assessment questions, while there were very few negative factor loadings for individual respondents, which suggests a good fit of the observed responses' matrix and the cultural consensus model. This means that there is high probability that, for each question, a single cultural model is driving the observed responses. (Romney, Weller, and Batchehelder 1986; Kempton, Boster, and

Hartley 1999). Please see table 5.6 for the first-to-second eigenvalue ratios for each of the questions.

Table 5.6. Consensus analysis first and second eigenvalues for structured questionnaire respondents' answers to ecological knowledge assessment questions. In all of the cases the ratio of the first to the second eigenvalues is larger than 3:1, suggesting an adequate fit to the cultural consensus model (Romney, Weller, and Batchelder 1986)

Ecological knowledge assessment question	Variable	1st Eigenvalue	2nd Eigenvalue	1st:2nd Eigenvalue ratio
Where species are found	WHERE**	15.880	1.986	7.994
Season when species are found	SEASON**	13.022	2.426	5.367
Species' aggregation habits	AGGREG**	13.320	4.253	3.132
Gear used to capture species	CAPGEAR**	11.348	2.896	3.919
Species' association with ciguatera toxicity	CIGUATOX*	17.453	1.728	10.101
Depth at which species are found	DEPTHFIND*	10.433	2.995	3.483
Estuarine environment where species are found	ESTUARINE*	8.485	2.214	3.832
Mean				**5.404**
Standard Deviation				**2.655**

* - Used modified species list
**- Used 16 salient species

Several lines of inquiry can be explored through the use of consensus analysis when the questions, the respondents, and the data gathered meet the assumptions outlined previously in this section. The first is whether one or more cultural models appear to be driving the response patterns. Based on the ratios between first and second eigenvalues for all the questions, it appears there is a single cultural model driving responses for each of the questions. Another one is to estimate the 'culturally correct' answers to each question. The third is to estimate each respondent's agreement with the collective cultural model and thus their cultural knowledge.

Culturally correct answers to the ecological knowledge assessment questions

In this section I will present the 'culturally correct' answers to the ecological knowledge assessment questions administered via the structured questionnaire. Quantitative techniques such as consensus analysis allow the opportunity to summarize variable responses to specific questions into culturally-correct answers with associated rates of agreement. Agreed-upon answers can then be used to make valid comparisons between groups, or between individuals and their group (Miller *et al.* 2004). For example, Miller *et al.* (2004) used Consensus Analysis on yellowfin tuna fishery questions to compare culturally correct answers and average competencies between fishers and scientists related to the fishery. Kempton, Boster, and Hartley (1996) used consensus analysis to summarize and compare responses about general environmental knowledge and values for American public groups expected to differ in these domains. Among the products of both studies that can be very useful for policy making are culturally-valid summaries of agreed-upon statements about topics of interest for the studied groups of people. Tables 5.7 and 5.8 show the culturally-correct sets of answers for the seven ecological knowledge assessment questions.

It is evident just by looking at the information summarized in tables 5.7 and 5.8 that studying local ecological knowledge with the data gathering and analysis methods detailed in this work can produce very useful information about a variety of fishery species. Let us take the mutton snapper (*Lutjanus analis*) as an example. We know from fishery records that the mutton snapper is the 6th most captured fishery species in Puerto Rico (Griffith, Valdés-Pizzini, and García-Quijano 2006). We know from the ethnographic work conducted during this study, as well as from sources such as Suarez

Caabro (1979) and Griffith, Valdés-Pizzini and Garcia-Quijano (2006) that the mutton snapper is a very important food fish species, that it sometimes forms large spawning aggregations, and that it is an specially important and salient fish in south-southeastern Puerto Rico, because the species thrives in the kinds of shallow-mid water ecosystems found in the area. Fishers mentioned the mutton snapper as characteristic of 5 habitats during the habitat-species freelists. Looking at the culturally correct answers calculated through consensus analysis (LEK consensus statements) for the mutton snapper regarding the 7 ecological knowledge assessment questions, we can also see that, according to the measured consensus among the 41 structured questionnaire respondents, the mutton snappers is: 1) found/captured most often at or near reefs, 2) caught more often during the summer months, 3) usually found in aggregations of the same species, 4) most often caught with bottom lines, 5) considered as a fish which is never toxic, and 6) usually found at less than 20 fathoms depth. This is all very specific information gathered trough collaboration with many fishers which can be compared to the available western/scientific information and further used to complement, supplement, or validate information available to resource managers. Information of similar detail, cultural validity, and scope was gathered about local ecological knowledge of many fishery species during this work.

The data gathered this way can also serve as pilot data for more detailed ethnoecological studies, such as, for example, collaborating with fishers to find out more about certain species' seasonal migrations, habitat preferences, and spawning aggregation habits. Because it also provides a snapshot of the information that fishers, as a group, will use to pursue and capture prey species, data such as this can also be useful for management in the estimation and prediction of fishers' harvesting behavior related to a variety of species of fish and during different seasons of the year.

Table 5.7. Consensus answers to ecological knowledge assessment questions asked using the list of 16 important/salient fishery species.

Fishery species	WHERE	SEASON	AGGREG	CAPGEAR
mutton snapper	reefs	summer	groups same species	bottom lines
Spanish mackerel	deepwater	winter	groups same species	troll line
cero	deepwater	winter	groups same species	troll line
yellowtail snapper	reefs	all year	groups same species	bottom lines
lane snapper	mud bottoms	all year	groups same species	bottom nets, bottom lines
red hind	reefs	winter	groups same species	bottom lines
red grouper	reefs	all year	groups same species	bottom lines
queen conch	grass	all year	groups same species	diving
white mullet	bays	all year	groups same species	surface nets
Striped grunt	reefs	all year	groups same species	bottom nets
spiny lobster	reefs	all year	groups same species	fishpots
queen triggerfish	reefs	all year	groups other species	fishpots, bottom lines
silk snapper	deepwater	all year	groups same species	bottom lines
spotted goatfish	grass	fall	groups same species	fishpots
octopus	reefs	all year	solitary	diving
rainbow parrotfish	reefs	all year	groups other species	fishpots

Inter-informant variability in ecological knowledge

In this section I will present the patterns of variation in ecological knowledge among the structured questionnaire respondents, based on their answers to the seven ecological knowledge assessment questions. Then I compare patterns of variability in knowledge across the different questions to explore how closely the domains of knowledge identified through key informant interviewing are related to each other.

Table 5.8. Consensus answers to the ecological knowledge assessment questions asked using modified fishery species lists. Depths in DEPTHFIND are in *brazas*, a locally-used unit of depth, similar to a fathom.

Species	CIGUATOX	Species	DEPTHFIND	Species	ESTUARINE
Crevalle jack	always toxic	**yellowtail snapper**	less than 20 *brazas*	**white mullet**	fresh and brackish water
amberjack *	always toxic	**mutton snapper**	less than 20 *brazas*	**liza**	fresh and brackish water
Atlantic barracuda	always toxic	**lane snapper**	less than 20 *brazas*	**snook**	fresh and brackish water
bar jack	never toxic	**cardinal snapper**	less than 20 *brazas*	**Atlantic tarpon**	brackish water only
blue runner	always toxic	**blackfin snapper**	more than 50 *brazas*	**sardine****	brackish water only
black jack	always toxic	**silk snapper**	more than 50 *brazas*	**sardine****	brackish water only
yellow jack	never toxic	**queen snapper**	more than 100 *brazas*	**herring****	brackish water only
horse-eye jack	always toxic	**misty grouper**	more than 20 *brazas*	**half-beak**	brackish water only
schoolmaster snapper	frequently toxic	**yellowfin grouper**	more than 20 *brazas*	**ballyhoo**	saltwater only
silk snapper	never toxic	**red hind**	less than 20 *brazas*	**thread herring**	brackish water only
spanish hogfish	sometimes toxic	**jewfish**	less than 20 *brazas*	**sardine****	brackish water only
octopus	never toxic	**Nassau grouper**	less than 20 *brazas*	**yellowfin mojarra**	brackish water only
red grouper	never toxic			**land crab**	brackish water only
yellowfin grouper	never toxic			**peneid shrimp**	brackish water only
misty grouper	never toxic			**oysters****	brackish water only
jewfish	never toxic			**largehead hairtail**	brackish water only
mutton snapper	never toxic			**whitemouth croaker**	brackish water only
spanish mackerel	never toxic			**southern sennet**	brackish water only
cero	never toxic				

* 3 species, *Seriola sp.* genus

** Local name at generic level. exact species unknown

Previously in this work I have discussed the reasons why agreement with group consensus (knowledge of the culturally correct answers) in the ecological knowledge assessment questions asked as part of the structured questionnaire, can be considered a good indicator of true competency in local ecological knowledge related to small-scale fishing in this study's region. I used 'estimated knowledge' scores from ANTHROPAC X (Borgatti 2001) multiple choice consensus analysis as a proxy for each respondent's cultural competency in the ecological knowledge assessment questions. Estimated knowledge, or cultural competency, is the degree to which each respondent's answers coincide with the estimated 'culturally correct' answers for each question (Borgatti 1996). For the remainder of this work, I will refer to the structured questionnaire respondents' cultural competency/estimated knowledge scores as *ecological knowledge scores.*

Table 5.9 shows the range of variation of scores for each of the ecological knowledge assessment questions. Possible score values were between zero (no agreement with the group's consensus) and 1 (total agreement with the group's consensus). The very few and small negative knowledge scores were changed to zero, since a negative score, like a zero, signifies very small participation in the group's consensus.

Although there was considerable variation in knowledge scores in all of the ecological knowledge assessment questions, I found that the ecological knowledge scores did not vary together significantly for all of the questions. Table 5.10 shows Pearson product-moment correlations comparing the scores obtained by the structured questionnaire respondents in each of the ecological knowledge assessment questions. The correlations were calculated in order to explore each variable's contributions to total variability, to look at co-variation patterns, and to assess whether respondent's cultural competency carried over from question to question.

Table 5.9. Descriptive statistics of 41 respondents' scores on the seven ecological knowledge assessment questions.

Variable name	mean score (n=41)	Std.Dev.	min.	max.
WHERE**	0.6022	0.1611	0	0.85
SEASON**	0.5366	0.1733	0	0.8
AGGREG**	0.5422	0.1793	0	0.84
CAPGEAR**	0.5056	0.1458	0.04	0.69
CIGUATOX*	0.6293	0.1733	0	0.86
DEPTHFIND*	0.4583	0.2107	0	0.74
ESTUARINE*	0.3983	0.2213	0	0.79

* - Used modified species list
**- Used 16 salient species list

Several patterns of co-variation in knowledge scores can be observed from table 5.10. First, that there are statistically significant positive correlations between the respondents' knowledge scores about the habitats where one can find important fishery species (WHERE) and knowledge scores on every other question except for the question about salinity regimes. Second, that while ecological knowledge scores on most questions significantly correlated with scores on WHERE, there was only one statistically-significant correlation that did not include this question (between knowledge about the depths where deepwater species are found (DEPTHFIND) and about fishery species' association with ciguatera poisoning (CIGUATOX). The significant positive correlation in knowledge scores between DEPTHFIND and CIGUATOX makes conceptual sense in that many of the species that are commonly associated with ciguatera poisoning are deepwater benthic fish, so fishers who know more about these species might also know more about ciguatera poisoning

Table 5.10. Pearson product-moment correlation matrix comparing cultural competency scores in seven ecological knowledge assessment questions. Each variable represents a question.

	WHERE	SEASON	AGGREG	CAPGEAR	DEPTHFIND	CIGUATOX	ESTUARINE
WHERE	1	.450(**)	.354(*)	.404(**)	.428(**)	.327(*)	0.286
SEASON	_	1	0.265	0.073	0.11	0.256	0.299
AGGREG	_	_	1	0.178	0.251	0.302	0.019
CAPGEAR	_	_	_	1	0.056	0.034	0.198
DEPTHFIND	_	_	_	_	1	.355(*)	0 .151
CIGUATOX	_	_	_	_	_	1	0.113
ESTUARINE	_	_	_	_	_	_	1

(**) significant at 0.01 level (2-tailed)
(*) significant at 0.05 level (2-tailed)

The lack of significant correlations between knowledge about estuarine species' salinity preferences (ESTUARINE) and any other of the ecological knowledge assessment questions might have occurred because the list of species used in the salinity preferences questions was very dissimilar from the lists of species used for the other questions.

The significant correlations between WHERE and the other ecological knowledge assessment questions makes sense conceptually, since from the extensive ethnographic interviews with expert fishers it was clear that knowledge about fishing areas and species-habitat matching was a very important type of knowledge for fishing in the study region. I expected, however, that there would be more significant correlations between scores in the other domains of knowledge that were identified by fishers as very important for fishing. After all, these domains were identified by extensive and careful ethnographic work and the instruments asking about the domains were tested in collaboration with expert fishers. That this expectation was not fulfilled, while surprising, might point to a hierarchical arrangement in the types of ecological knowledge needed to fish. Is knowledge about the kinds of habitats where fishery species are found the principal driver of variation in local ecological knowledge for the structured questionnaire respondents?

Principal Components Analysis of ecological knowledge scores

To further verify the effects of scores on particular questions on the overall observed variability in ecological knowledge scores, I performed a Principal Components Analysis (PCA; Varimax rotation with Kaiser normalization) using SPSS 11.0. Kaiser-

Meyer-Orkin Normalization test scores for sample adequacy were adequate (p= .643), as were scores for the Bartlett's Test of Sphericity (X^2=45.774, p=.001, 21 degrees of freedom). Thus, the data seems to meet the assumptions for PCA. The Varimax rotation converged after only 3 iterations. Please see table 5.11 for summary results of the PCA procedure.

Table 5.11. Summary of results for the Principal Components Analysis (Varimax Rotation, Kaiser Normalization) procedure performed using knowledge scores for the 7 ecological knowledge assessment questions. The Varimax rotation converged after only 3 iterations. Composite variable EKOS and EKCF were created form the two underlying factors identified through this procedure. EKOS and ECKF represent two overlapping, but different, dimensions of ecological knowledge.

Question/Variable	**Component (factor)**	
	1	**2**
WHERE	0.561	0.626
SEASON	0.39	0.495
AGGREG	0.646	__
CAPGEAR	__	0.713
CIGUATOX	0.762	__
DEPTHFIN	0.705	__
ESTUARINE	__	0.706
% variance	**28.03**	**23.76**
Composite variable name	**EKOS**	**EKCF**

The PCA procedure isolated 2 underlying factors that accounted for 51.8 percent of the observed variance in ecological knowledge scores. Only question variables with factor loadings greater than 0.1 were counted for each factor. As previously suggested by the analysis of the correlations between ecological knowledge scores for each variables, the scores in question variable WHERE had the most influence in the total variance observed across the two factors, as evidenced by its factor loadings (0.561 in Factor 1; 0.626 in Factor 2), followed by SEASON (0.390 in Factor 1; 0.495 in Factor 2), and

AGGREG (0.646 in Factor 1; 0.126 in Factor 2). Although none of these variables had the highest factor loadings in any of the two factors, they had the largest total factor loadings and where the only variables with factor loading scores above 0.1 for both factors. What WHERE, SEASON, and AGGREGG have in common is that the represent questions measuring general ecological knowledge (where, when, and in what kinds of groups are fish/shellfish found) about 16 very important/salient fishery species in this study's region). This supports the findings of ethnographic research with key informants. General ecological knowledge about a variety of species, specially knowledge about fishing areas, or where fishery species can be found, was repeatedly pointed out as the most important knowledge needed for fishing.

The first underlying factor identified by PCA, accounting for 28.030 percent of the observed variance, was composed of question variables CIGUATOX, DEPTHFIND, AGGREG, WHERE, and SEASON, in order of importance. I named this factor Ecological Knowledge plus Offshore Species (EKOS). Habitats, seasonality, and depth are all very important ecological parameters for predictably finding desired offshore fish assemblages, while knowledge of which species of fish can be toxic is essential for a fisher wanting to maintain a base of buyers/clients and avoid problems and/or lawsuits. Many fish species traditionally associated with ciguatera poisoning are marine, open/deepwater, reef-dwelling fish such as large, adult jacks, barracudas, groupers, and snappers (Tosteson, Ballantine and Durst 1988; Craig 1980; Lawrence *et al.* 1980).

The second underlying factor identified by PCA, accounting for 23.762 percent of the observed variance, was composed of question variables CAPGEAR, ESTUARINE, WHERE, SEASON, and AGGREG, in order of importance. I named this factor

Ecological Knowledge plus Coastal Fishing (EKCF). Again, for any kind of fishing general ecological knowledge is needed, but the knowledge needed for coastal and estuarine fisheries includes knowledge of a wide variety of gear types, such as gillnets, trammel nets, beach seines, fishpots, handlines, surfcasting, castnets, spearfishing while skindiving or scuba diving, conch collecting, octopus hooks, and lobster lassoes, for use in bays, estuaries, shallow reefs, seagrasses, and mudflats. This might explain the convergence of CAPGEAR and ESTUARINE in the same factor Deepwater or open water fishing is usually only done by hook-and-line (troll or bottom line), longlines, and fishpots.

I used the SCORE/REGRESSION function in SPSS 11.0 to create two composite variables, EKOS and ECKF, based on each factor. Scores for each factor were assigned to the 41 respondents, based on the respondents' scores on each factor. I chose these two variables, along with WHERE (the question variable that influenced observed variance the most), as representative of ecological knowledge for use in testing the effect of knowledge on fishing success in Chapter 6. The groupings of question variables in each underlying factor seem to make ethnographic and fishery-related sense, thus using the two composite variables EKOS and ECKF seems reasonable. We must keep in mind, however, that my interpretation of the relationships between these variables is only an interpretation, thus the factors groupings might be driven by other, unknown, factors. More research using similar questions with larger samples of fishers might be necessary to support of falsify this interpretation.

Summary and Conclusion

In this chapter I discussed the process of ethnographically eliciting and exploring, and then measuring variability, in local ecological knowledge held by fishers in my study area. The coastal and marine environment that southeastern Puerto Rican fishers interact with is characterized by a large degree of habitat and ecosystem patchiness and heterogeneity, which in turn is reflected in the diversity, abundance, and distribution over space and time of fishery resource species. More than 100 species of fish and shellfish are fished or are otherwise considered to be of some importance for the fishers with whom I collaborated. Species diversity, habitat complexity, and ecosystem change were dominant themes in my interviews and conversations with key informant fishers throughout the ethnographic/exploratory phase of this study. The fishers whom I talked to were very aware that, because of the biomass distribution of fish and shellfish in the waters around the study region, the amount of biodiversity in fish and shellfish populations is intimately tied with their ability to make a living through fishing. I found that this is an integral part of many fishers' worldview, a finding that could have implications for future dialog between fishers and the fishery management sector.

Flexibility in finding, capturing, and eventually marketing a variety of fish species is of paramount importance for fishers' economies. Fishers need to manage the complexity in their social-ecological system in order to live from fishing. Fishers need some predictability in catches, while at the same time being able to take advantage of opportunities that might present themselves. Fishers, ecological scientists, and resource managers face a similar challenge. They need to make predictions about marine resources' distribution and make decisions based on those predictions while working among considerable uncertainty and rapid change. One of the ways in which fishers achieve this is by the application of local ecological knowledge about local ecosystems.

In this study I wanted to be able to describe and test variability in ecological knowledge, but to do this, I first had to understand how fishers managed the cognitive task of fishing for dozens of species in a complex and changing environment. Because of this, the focus of my ethnographic research was on finding out the most important knowledge/types of knowledge needed by fishers to be able to fish successfully. I found that thinking about local ecosystems holistically, in terms of underwater landscapes, or 'fishing areas' is an important way of overcoming the cognitive challenges related to ecosystem complexity. Fishing areas are places where, because of a combination of ecological, bathymetric, seasonal, and historical factors, or parameters, fish can be caught. The term 'fishing area' has a dual meaning. On the one hand, the term might be used to refer to a specific marine/geographic location were a specific fishes are known to be found. On the other hand, the term is often used to refer to the kinds of places where, due to combinations of environmental parameters, fish can be expected to be found. Thinking about the ecosystem in terms of ecological-parameters is of paramount importance for fishers dealing with the complexity of a multi-species tropical fishery.

That parameter-based thinking and the recognition of the immense complexity of ecosystems figures repeatedly and saliently in fishers' ecological narratives is very significant because the fishers insights, based on Local Ecological Knowledge, resonate strongly with some of the most cutting-edge resource management research (both of the interdisciplinary and purely ecological varieties). This body of cutting-edge research characterized by a recognition of the inherent complexity of ecological systems, the incorporation of Complex Systems Theory (Ludwig, Hillborn, and Walters 1993; Levin 1998) into ecological studies, and the identification and monitoring of ecological parameters (instead of just population counts of resource species) as a way to describe ecosystem dynamics (see Acheson and Wilson 1996; Berkes, Colding and Folke 2003; Holling 1992; 2001; Holling and Meffe 1996; Holling, Gunderson and Peterson 2002; Ludwig, Hilborn, and Walters 1993; Noorgard 1994; Levin 1998; Walters 1986; 1997, among others)

I conducted multiple habitat-centered freelists of fish and shellfish species to explore which species the fishers believed to be associated with several habitat types. The representations of habitats and associated species and the perceived patterns of species assemblage similarities and connectivity between habitats that I was able to describe with this information represent informative and useful representations of fishers' knowledge of local ecosystems (see tables 5.2-5.3 and figure 5.3). Habitat connectivity in tropical coastal ecosystems is a growing field of study which can greatly benefit from fishers' knowledge and extensive observation of the habitat distribution of fish and shellfish species.

In the explanatory phase of this research I measured variability in knowledge about seven domains of local ecological knowledge that were identified as important for fishing during ethnographic work. In order of importance, these domains were: 1) what kinds of underwater habitats can import fishery species be found, 2) during which seasons of the year they can be found, 3) the species' aggregation habits, 4) types of fishing gear are used to capture the species, 5) species' propensity to be associated with ciguatera poisoning, 6) the depth's at which deepwater species are found, and 7) the salinity ranges where the species can be found. I asked these questions about several important and/or relevant species for each question and measured variation in ecological knowledge from the patterns of agreement of the 41 structured questionnaire respondents, using Consensus Analysis (Romney, Weller, and Batchelder 1986).

For each one of the questions, the patterns of agreement show that a single shared cultural model seems to be driving respondents' answers. Using bivariate correlations to compare respondents' scores in each question, however, I found that agreement patterns and knowledge scores did not co-vary significantly across all of the variables and that knowledge about matching important fishery species (Question 1, variable name: WHERE) to habitat types seemed to explain some of the observed variation across variables. Principal Component Analysis of the respondents' knowledge scores for each variable seemed to confirm this, and to further suggest that two strong multi-variable underlying factor might explain the observed patterns variation in knowledge scores across questions. One of these factors consists of general ecological knowledge plus knowledge specific to offshore fishing, while the other factor consists of general ecological knowledge plus knowledge specific to near-shore fishing. In chapter 6 I will test this study's central hypotheses by exploring correlation and co-variation of measures of ecological knowledge and of success among the 41 structured questionnaire respondents. I will use respondents' scores in three domains (the question variable WHERE and in composite measures of the two underlying factors identified through Principal Component Analysis) as measures of ecological knowledge.

CHAPTER 6

THE VALUE OF ECOLOGICAL KNOWLEDGE FOR FISHERS AND FOR COASTAL FISHERY MANAGEMENT

This chapter discusses the central theme of this dissertation: the value of local ecological knowledge. This chapter is divided into two sections, each section exploring the value of ecological knowledge at a different scale. The first section explores the value of local ecological knowledge for individual fishers (and by extension their households) by testing this project's central hypothesis, that ecological knowledge accounts for a significant amount of measurable variability in success in fishing, with success being defined as *"a pattern of effective performance in the environment, evaluated from the perspective of development in ecological and cultural context"* (Masten and Coatsworth 1995:21). The second section deals with the potential value of fishers' local ecological knowledge for locally-adaptive fishery management. In this section I will use a case study of fishers' recommendations for the rescue of an important food fish fishery to illustrate how fishers' local ecological knowledge could potentially complement western fishery management. This chapter builds on- and is informed by the previous chapters' discussions on eliciting, describing, and measuring variation in cultural models of success and the workings of local ecosystems, while maintaining an grounding in ecological, cultural, historical and economic context.

Section I. The value of local ecological knowledge for individual fishers: Are more knowledgeable fishers more successful than others?

I operationalized the principal hypothesis of this project, that that ecological knowledge accounts for a significant amount of measurable variability in success in fishing, as:

H_1: Fishers who exhibit higher cultural competency in questions about ecological knowledge (knowledge being measured as agreement with the collective cultural model of all the fishers in the sample) will also score higher in locally-informed measures of success.

In Chapter 4, I described some important components of the cultural model of success in fishing for southeastern Puerto Rican fishers. In Chapter 5 I described the process of using in-depth ethnographic work to develop a set of questions about important knowledge for successful fishing. I measured variability in several indicators of success in fishing and in responses to questions about important ecological knowledge, through structured interviews with 41 fishers chosen at random (but see discussion in Chapter 3 on response rates) from the universe of identified active fishers in the study area.

How does ecological knowledge figure in the total variability of success-related measures measured in this study? I concluded chapter 4 with a table (Table 4.5) showing correlations between (material and cultural), locally-elicited and validated determinants and indicators of success in fishing. In table 4.5 I left the far right column purposefully empty, to signify that ecological knowledge was yet to be included in the equation, and implying that it was this research's expectation that ecological knowledge would contribute to explaining some of the variability in success, through significant positive correlations with indicators of success. Table 6.1 shows the updated success determinants-by-indicators correlation matrix, with three measures of ecological knowledge included.

Table 6.1. Matrix of Spearman rank-order correlation scores between determinants and indicators of success in fishing. Columns in the matrix represent determinants of success and rows represent indicators of success. The three columns on the right represent measures of local ecological knowledge.

	Weekly hours spent fishing	Weekly hours talking to other fishers about fishing	Scores in "Reverence and Respect" index	Economic Gratification Orientation	Repair and maintenance of own gear	Ecological knowledge: matching species with habitats	General ecological knowledge plus offshore fisheries (Factor 1)	General ecological knowledge plus coastal fisheries (Factor 2)
Average success rating by peers	0.252	0.054	0.100	0.119	0.094	0.327*	.423**	-0.072
Percent income derived from fishing	0.466**	0.261	0.048	0.262	0.200	0.132	0.017	-0.006
Score in 13-item material culture index	0.003	0.082	0.156	0.119	0.203	-0.067	-0.181	0.062
Home ownership (binary)	0.194	0.070	0.033	-0.156	0.035	0.118	-0.053	0.211

(**) significant at 0.01 level (2-tailed)
(*) significant at 0.05 level (2-tailed)

It is useful to evaluate the data summarized in Table 6.1 in contrast to what would have been data showing uniform support to the project's initial hypothesis (H_1). In other words, that the measures of ecological knowledge would have significantly correlated with all of the indicators of success significantly and with correlation coefficients of large magnitude compared with other determinants of success. After having learned, however, through participant observation and ethnographic work, about the local socioeconomic reality of coastal subsistence patterns that include fishing, results showing uniform positive significant correlations between knowledge and the different indicators of success would actually have been confusing or difficult to explain. Success is a complex and multidimensional construct, and even more so in light of the historical and economic realities of small-scale fishing in the former sugarcane landscape of southeastern Puerto Rico. Thus it would be hard to expect a few factors to explain variability in all the different dimensions of fishing success.

For example, through ethnographic work I found out that, contrary to my initial expectations, many fishers that were widely considered successful and expert fishers, to the extent of being mentors and teachers to generations of younger fishers, had been career part-time fishers (albeit consistently over many years) instead of full-time fishers. Don Eddie from Santa Isabel (also a carpenter/mechanic), Don Filiberto from Salinas (also a industrial welder/operator), and Don Tomás from Aguirre (also a centrifuge operator for sugarcane factories) were good, but far from isolated, examples of this). This is a result of the socioeconomic reality of rural/coastal subsistence in southeastern Puerto Rico, where land-based jobs have been alternated and/or interspersed with fishing for at least two-hundred years (Griffith and Valdés-Pizzini 2002). Knowing that many expert fishers are part-time fishers, it would have made little conceptual sense if the percentage of income derived from fishing would correlate very strongly with ecological knowledge. This property (occupational multiplicity across levels of expertise) of the local social-ecological system of coastal subsistence makes percent income derived from fishing a complex and not easily interpretable measure of success, although it forms part of the local cultural model.

Similarly, because of that same property of occupational multiplicity, as well as because some fishers live in households where other members contribute income from to other sources, it is hard to ascertain how much of a fishers' material wealth and their home ownership status is attributable to fishing. Individual catch rates are not available in a useful form from state records, as explained in Chapter 3, while estimating reliable CPUE's with appropriate time depth (several years) for a large enough sample of fishers was beyond the scope and funding level of this study. Thus the only measure directly related to fishing that was conceptually and practically useful to measure success in fishing was peer success ratings of respondents by other fishers.

Poggie (1978) and Pollnac and Poggie (1779) faced similar challenges when attempting to measure variability in fishing success in southwestern Puerto Rican small-scale fisheries. Measuring inter-informant reliability of success rankings, they concluded that evaluations of success by fellow fishers constituted, not only a valid measure of success in fishing, but also the most reliable one (Poggie 1978; also see Guest 2000). This measure of success would probably be adequate only for small-scale fisheries where most fishers know each other, as is the case in the fishing communities in which Poggie and Pollnac worked, as well as throughout this study's region. Each respondent's success rating was evaluated by between 4 and 10 fellow fishers, with the average being 6.4 raters per respondent.

Two out of the three measures of ecological knowledge included in the correlation matrix (table 6.1), exhibit statistically significant positive correlations with respondent's average peer success ratings, but none of the measures of ecological knowledge correlated significantly with any of the other indicators of success. These two measures of success were knowledge about matching species with habitats (variable WHERE), and the first composite measure of ecological knowledge identified through Principal Components Analysis (variable EKOS). In other words, the respondents' average success ratings, resulting from other fishers' evaluations of his/her success, correlated significantly with the respondents' scores in two out of three measures of ecological knowledge (p-values= SUCRATE-EKOS (.006, 2-tailed), SUCRATE-WHERE (.037, 2-tailed), 41 df.).

Two out of the three measures of ecological knowledge correlated positively and significantly with the more reliable indicator of fishing success used in this study, while other determinants of success that form part on the cultural model do not exhibit such correlations. These results partially support this study's principal hypotheses (H_1). The correlations are not overly strong (0.327 and 0.423), however, and bivariate correlations are only one way of testing the relationships between variables (Zar 1999; Hollander and Wolfe 1999). I will thus explore in more detail the relationships between respondents' average peer success ratings and the measures of ecological knowledge.

I used S-Plus 4.0 (Insightful 2005) to run linear regression procedures (model: one-way ANOVA) between respondents' average success ratings (SUCRATE) and the three measures of general ecological knowledge. To offset the relatively small sample size of 41 respondents I used bootstrap re-sampling (S-Plus 5.0, 5000 resamples) to create exact (distribution free) confidence intervals (C.I.) for the regression coefficients. The 95% C.I.'s calculated by the bootstrap procedure were similar to the parameter-estimated 95% C.I.'s in all the cases, and the regression intercepts fell well inside the C.I. ranges, thus supporting the use of linear regression to illuminate the relationship between these variables (see Edginton 1969; 1980; Noreen 1989).

Supporting the results of the rank-order bivariate correlations, a significant linear effect was found between the respondents' average success rating and two of the measures of ecological knowledge detailed in Table 6.1. The strongest relationship found was between the success ratings and variable EKOS (composite variable of general ecological knowledge plus knowledge about offshore fishing). Variation in EKOS can explain about 28.9 % of the variation in success ratings (p-value=.0002) and there appears to be a linear relationship between the variables.

A significant relationship was also found between average success ratings and respondents' scores in the question about species-habitat matching (WHERE). The variable WHERE accounted for 14.6% of the variation in the respondent's peer success ratings (p-value=.014) and there also appeared to be a linear relationship between the variables. As could be predicted from the Spearman correlation scores presented in table 6.1, there was no significant linear relationship (p-value=.306) between the composite variable EKCF (Ecological knowledge plus coastal fishing) and respondents' peer success ratings.

The lack of significant relationships between peer success ratings and the composite ecological knowledge measure EKCF (general ecological knowledge plus coastal fisheries) is surprising, since this variable shares several factors (related to the three questions about general ecological knowledge) with the composite variable EKOS. The answer to the question of why the composite variable EKOS is a much better predictor of respondents' peer success ratings than EKCF lies in what are the specific components of the variable EKOS, namely the question variable that measured knowledge about the depths at which fishery species are found (variable DEPTHFIND). Besides knowledge about matching species and habitats (WHERE), the only other question in which respondents' scores correlated significantly with success ratings was the question about the depth's in fathoms, where some offshore and deepwater species were usually found was DEPTHFIND (Spearman's rho=.422, p=.006). This question did not correlate significantly with other questions, other than the question about ciguatera poisoning-associated species (CIGUATOX), thus it was not included by itself as a measure of general ecological knowledge, but rather was initially analyzed as part of the composite variable EKOS.

A linear regression analysis run between this question (DEPTHFIND) and average success rates showed a significant linear relationship (r^2= .167, p= .008, df.=39). No additional questions exhibited a significant relationship with any measure of success in the fishers' cultural model, but, assuming a causal relationship, respondent's scores in two of the questions (WHERE and DEPTHFIND) accounted for most of the variability observed in average success ratings. What these two questions have in common is that they deal with different aspects of the location of fish and shellfish in time, WHERE horizontally and by bottom type and DEPTHFIND vertically. This lends support to the assertion of several of my key informants, that thinking about fishery species in terms of where one might find different assemblages of the species, is the most important ecological knowledge. This result is also consistent with findings by Valdés-Pizzini *et al*. (1996; 2001), that habitat is a very important classification criteria in Puerto Rican fishers' folk taxonomies. Table 6.2 shows the results of linear regression between average peer success ratings and respondents' scores in the four variables discussed above.

The explanatory model used for this research is directional, that is, I expected ecological knowledge to have an effect on measures of success, and not viceversa. I also explored the relationship in the opposite direction, with a heuristic two-sample research design, for triangulation purposes. I used a Wilcoxon sum-rank two-sample test (a non-parametric test of differences between sample means (Hollander and Wolfe 1999)), with average peer success ratings as a grouping (independent) variable, to test the hypothesis that respondents who received average peer success ratings in the lower half of the range for that variable (1-2.50) would have different mean ecological knowledge scores than respondents who scored in the upper half of the range (2.51-40). The results from the Wilcoxon rank-sum test show a pattern of relationships between the variables similar to the relationship suggested by linear regression exercises. Respondents with peer success ratings on the lower half of the range had significantly lower means in scores than respondents on the upper half of the range for variables WHERE (p=.044), DEPTHFIND (p=.016), and EKOS (p=.019); and lower, but not statistically significant, scores for variable EKCF (.632). Table 6.3 shows summary for the two-sample Wilcoxon rank-sum tests.

Table 6.2. Summary of results from linear regression procedures between peer success ratings and three measures of ecological knowledge. The linear regressions and a bootstrap with 5000 permutations for calculating exact confidence intervals were calculated using S-Plus 4.0 (Insightful 2005).

Dependent Variable: Average peer success ratings on a 5-point scale (SUCRATE), n=41								
Independent	**R^2**	**df.**	**F**	**p-value**	**Constant (B_0)**	**Intercept (B_1)**	**95% Confidence Interval (C.I.) for B1**	**95% C.I. for B1 from Bootstrap (5k resamples)**
EKOS	0.289	39	15.85	0.0002	2.909	0.402	0.198 to 0.606	0.217 to 0.614
WHERE	0.146	39	6.65	0.014	1.842	1.771	0.382 to 3.170	0.231 to 2.937
DEPTHFIND	0.167	39	7.814	0.008	2.244	1.450	0.401 to 2.498	0.539 to 2.593
ECKF (N.S.)	0.027	39	1.07	0.306	2.909	0.122	0.116 to 0.361	0.114 to 0.383

Table 6.3 . Summary of results from two-sample Wilcoxon rank-sum tests.

Grouping variable- SUCRATE			Mean knowledge scores			
Group	Average success ratings	n	EKOS	WHERE	EKCF	DEPTHFIND
1	1-2.50	11	-0.67	0.518	-0.417	0.34
2	2.51-4	30	0.246	0.633	0.633	0.502
	p-value		**0.019**	**0.044**	**0.632**	**0.016**

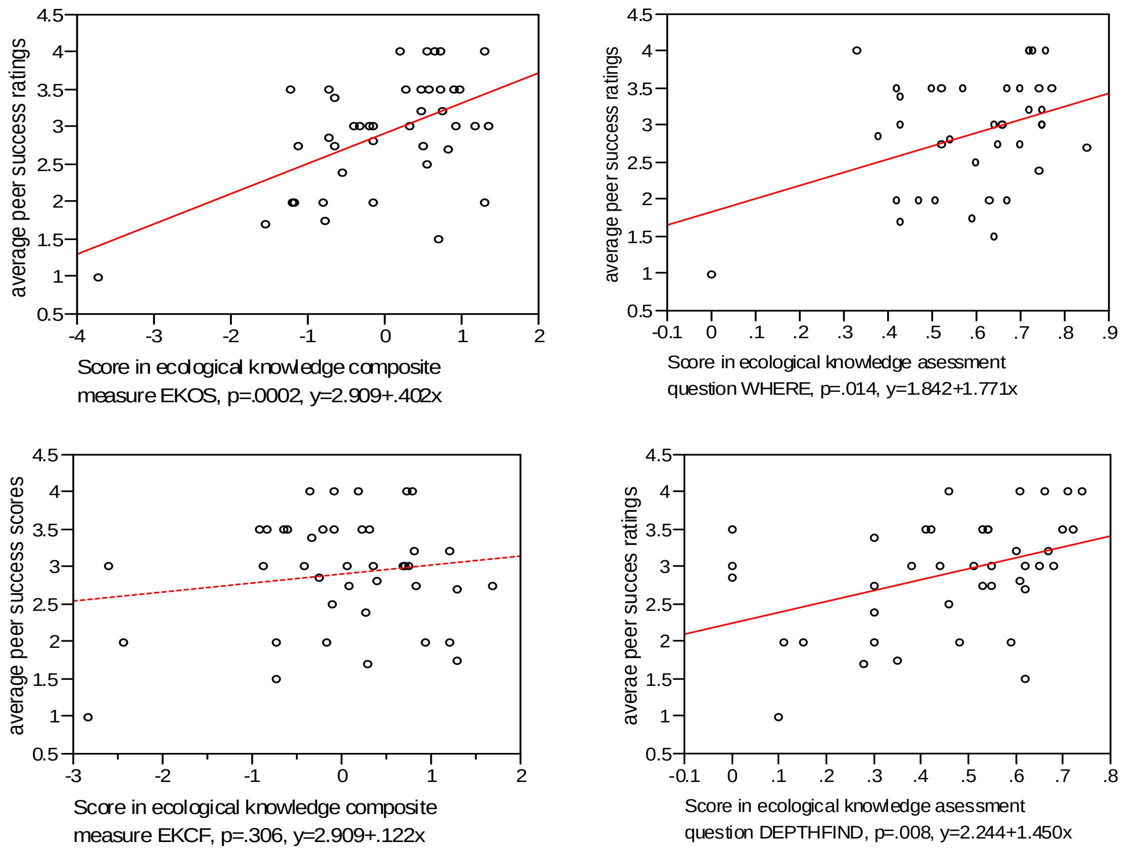


Figure 6.1. Linear regression of the relationship between average success ratings and respondents' scores in four measures of ecological knowledge.

Discussion and evaluation of an alternative hypothesis: Are both success ratings and ecological knowledge artifacts of sociability?

The central finding of the quantitative, explanatory phase of this dissertation is that ecological knowledge (measured as agreement with collective consensus) of matching important fishery species with ecological parameters such as habitat type and depth co-varies significantly with a social measure of success in fishing (fishers' reputation as successful fishers). This suggests that competency in cultural knowledge about fish and fishing has a real effect on success, the pattern of effective performance in the social-ecological system, and that, due to the small size of social networks between fishers, this pattern can be observed and assessed by a fisher's peers.

A possible alternative explanation to the observed relationships between agreement in ecological knowledge and success could be that both agreement about ecological knowledge and fishers' success reputation are a function of communication between fishers. In this case both would be purely social measures, not related to performance in the marine environment where fish are caught. I will call this the 'comprehensive information economy' explanation, after Boster's (1995) insightful investigation of the effect of social networks and knowledge transmission on distributed cognition. In a scenario such as this the more sociable fishers share more of the information with other fishers, are more socially visible and thus would be more likely to be considered as successful by their peers. Thus the observed patterns in agreement and in peer assessments of success would both be artifacts of a fishers' sociability.

The 'comprehensive information economy' explanation, however, did not seem likely after finding out from structured questionnaire data that no significant correlation existed between peer success ratings and the hours a fisher reported spending talking to other fishers (Spearman's rho (average success ratings-hours talking to other fishers)= 0.054, p=0.738). Respondents' reports of hours spent talking to other fishers did not exhibit significant correlations with scores in any of the measures of ecological knowledge. Thus a widely-perceived effective pattern of performance in the social-ecological system, independent of sociability, seems to be at least partly responsible for variations in success ratings. Similarly, there appears to be a mechanism, other than social transmission exclusively, that results in the observed patterns of agreement in ecological knowledge.

Section II. An example of a possible application of local ecological knowledge for coastal ecosystem and fishery management.

In this section I will use a case description to illustrate how (besides the obvious main role of providing high-quality protein to those whom might otherwise not have access to it) local ecological knowledge held by fishers can be of value for local communities in the management of local marine and coastal resources.

It is interesting, almost paradoxical, that while ecological and environmental social sciences need to move more towards the integration of qualitative and quantitative research in order to gain the explanatory and predictive power than will enable these fields to affect environmental policy, the characteristic that will always set environmental anthropologists and related practitioners apart will always be their dominion of local discourses and narratives. Even quantitatively-intensive accounts of environmental ethnographic research are, at their best and at their most basic, a good narrative told by a combination of words and numbers, with the words being chosen very carefully to reflect local understandings, concerns, and realities, and the numbers chosen even more carefully to emphasize and understand the importance of the human components of ecosystems . Narratives and case studies are very valuable for the understanding of social-ecological systems, because they represent the combinations of situations, parameters, and factors that actually took place, and thus they constitute a proven possible point along the continuum of conditions that are actually possible in social-ecological systems (see Allen and Hoekstra 1992:1-13; Berkes, Colding and Folke 2003; Greenberg and Park1994).

Introduction and the fishery problem

This section is about a local ecological knowledge-based solution, proposed by fishers, for a problem that plagues attempts at management of tropical multi-species fisheries. This problem is the difficulty of using mesh sizes to manage fisheries in which target species have a wide variety of sizes, body shapes, growth rates, and sizes-at-reproductive maturity. Mahon and Hunter (2001:356) state that “Given the variety of growth rates and maturity schedules of reef fish commonly taken in fish traps (fish pots) in the Caribbean, no single mesh size will optimize the yield or protect against recruitment overfishing for the entire range of the exploited species”.

Because of the factors mentioned above, as well as other related to fishes anatomical features (for example, some fishes are better than others at squeezing through holes and tight spaces), large trap mesh sizes for tropical fisheries have the potential to affect the species catch composition to the extent that some species are underexploited, while others, because they have to ‘pick up the slack’ for the species that are escaping, become overexploited (Bonshack *et al*. 1989; Stevenson 1978; Rosario and Sadovy 1971; Ward 1988; Robichaud, Hunte, and Oxenford 1999). The scenario created by sweeping and careless implementation of trap mesh sizes in multi-species fisheries can deny fishers the resilience gained by catching more variety of fishes, while at the same time failing to adequately protect fishery stocks.

This is only one among the many problems that the ecological complexity of tropical reef-estuarine fisheries pose to western fisheries management (Polunin and Roberts 1996; Ruddle 1994; 1996a; Johannes 1998). This is also the kind of problem that I suspect local ecological knowledge of small-scale fishers is best equipped to deal with, due to the length and breadth of their experience in managing complexity and uncertainty with very limited technology.

In writing this section I am fulfilling a request, by several of the key informant fishers I collaborated with during the time I spent in Puerto Rico. At different times they requested that I dedicate a small piece of 'my report', as they called this dissertation, to the story of the spotted goatfish. The story they told me is a story of how, because of sweeping regulations mandating the increase of mesh sizes to allow for young fish of some species to escape fish traps, another important commercial and food species of fish that has formed part of their economy and diet for many years has been swept out of their fishery species repertoire.

The spotted goatfish, (*Pseudupeneus maculatus*, Mullidae (goatfishes) is a small (maximum size, 30 cm), specialized bottom foraging fish that uses two sensitive barbs located on the sides of its mouth to hunt for benthic crustaceans, mollusks, and polychaetes (Munro 1976;1983; Cervigón *et al.* 1992). It inhabits shallow waters up to depths of 90 meters, especially over sand and rock bottoms, and beds of seagrass in reef areas. The spotted goatfish is distributed throughout the Western tropical Atlantic and the Caribbean and is known as an important food fish for a large part of its range (Froese and Pauly 2003; Cervigón *et al*. 1992). Fishers report that this fish is caught almost exclusively by fish traps.

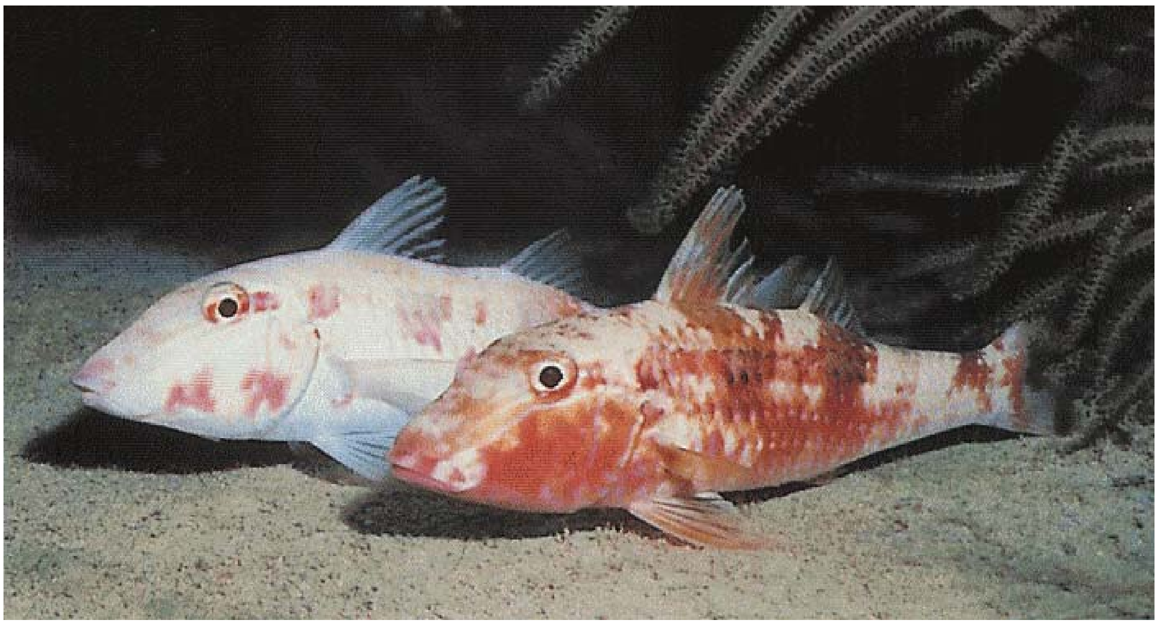


Figure 6.2. The Spotted goatfish (*Salmonete, 'salmonete colora'o'*). *Pseudupeneus maculatus*, Mullidae (Photo from Humann 1994).

In Puerto Rico, the spotted goatfish forms only a small part of reported landings (0.91% (NOAA fisheries landings, 1998-2003), but according to fishers in this study's region, this species is underreported in landings because it is a food fish species much more than it is a commercial species. Very often, when a spotted goatfish is caught, it is consumed within the fishers' household or given to family or friends rather than sold to the public. In my freelists about important fishery species, the spotted goatfish was widely mentioned and formed part of the group of important species used for questions about ecological knowledge. This is in part because the flesh of this fish species is so prized locally due to its flavor and consistency, that when a goatfish is caught it is better used for food rather than being sold by the pound (these fish are very small and light). There is, however, a market for the fish around fishing communities where people are familiar with its delicate flavor. Don Elizam described the culinary value of the spotted goatfish:

> Look, people around here are crazy about the *salmonete* (local name for *Pseudupeneus maculatus*). That is because of the natural gravy that comes out of it and mixes so well with rice, do you understand me? My mom would make white rice and would put the fried *salmonete* right on top of it, and that little fish would ooze a red gravy that looked like *achiote*, a natural gravy, that would mix with the rice. It was delicious! You didn't need any red beans or anything, no more than just the fish and the rice!

Other key informants and people that lived in the coastal communities throughout the study region confirmed this. When asking about this fish, people around the area repeatedly wondered out loud about what had happened with this food fish, so common in their diets before but now seldom seen or consumed. In doing so, they echoed what was the fishers' complain about this fishery species and fish trap mesh size regulations: that increased minimum mesh sizes for traps implemented for fisheries in Puerto Rico had removed the sported goatfish from the list of fishery species that are available for fishers in the area.

The fishers' argument was simple, and, perhaps unbeknownst to them, supported by independent research in trap mesh size selectivity in Puerto Rico. The fishers argue that the minimum mesh sizes (5.1 centimeters, hexagonal mesh) are simply too large to be able to catch adult specimens of this fish species, due to this fish's small size, cylindrical, elongated form with small body-depth compared to size (20-25% of body length), and it's uncanny ability to squeeze through tight holes. One of the fishers compared the spotted goatfish to a common household mouse (*Mus musculus*), an animal famous for managing to squeeze through the tightest of crevices. Thus, the sweeping application of mesh size regulations had greatly reduced the fishers' ability to catch this important food fish and had in turn increased the pressure on other, larger species, such as the red hind (*Epinephelus guttatus*) or the coney (*Epinephelus fulvus*), which are caught by traps in similar locations as the spotted goatfish. One of the key informants, Don Eddie, summarized the situation like this:

> "Look, let me tell you about one of those situations. You know that little fish, the *salmonete*, right? Well, that fish is small, adult fishes are small. The government has prohibited the use of our regular one-inch mesh sizes for out pots, and for some species, that is good. But not in this case. Why? Because the *salmonete* escapes on any larger mesh size! Any mesh size larger than an inch! If you use as much as one inch and a half, you stop catching *salmonetes*. That little fish is almost like an eel. So, when they forbid us to use one-inc mesh sizes, they, *como quien dice* (local adage meaning saying something without really saying it), forbid us from fishing for *salmonete*. In the last few years I only see this little fish as bycatch from gillnets, by chance."

As I will explain below, don Eddie (as well as other fishers I talked to) recognizes the value of mesh size regulations, thus neither he not the other fishers who mentioned this situation mentioned that they wanted to see mesh size regulations removed. Their suggestion was of a different nature. Before going into their recommendations, however, let us briefly compare the key informants' allegations with western scientific assessments of the effects of mesh size regulations on the species caught by fish traps. As I said previously in this section, there is a recognition that fish trap mesh size regulations do affect the composition of fishery captures, sometimes in unforeseen ways (Mahon and Hunte 2001). Rosario and Sadovy (1991) performed a field experiment measuring the species composition of the catch for fish traps of different mesh sizes, placed in a variety of bottom substrate types in southern Puerto Rico. Among their findings is that spotted goatfish catches decreased dramatically for any mesh sizes larger than 1.2*1.2 cm (square) or 3.8 cm (hexagonal) and virtually ceased to exist at mesh sizes of 5.1 cm or larger (Rosario and Sadovy 1991). This is a remarkable example of scientific assessments of fishery management measures coinciding with fishers' insights and reservations.

As I have stated before, none of the fishers that talked to me about the situation with the spotted goatfish fishery even suggested that it would be a good thing to do away with trap mesh size regulations. They recognized that some very important economic species can benefit from mesh size regulations. The six fishers with whom I talked about this at length suggested virtually the same solution to the underutilization of the spotted goatfish fishery, one that fits very well with the fishers' strategies of managing complexity by changing fishing strategies through space and time. The solution they suggested, albeit simple, was informed by shared local ecological knowledge: This solution was that, for the times of the year that spotted goatfish move close to the coast, a limited number of smaller-mesh fish traps to be allowed for fishers who depend on spotted goatfish and fish the areas where this fish is known to frequent. Don Eddie said about this:

> The *salmonete* is a particular fish, with the times of the year. For much of the year you don't see it, because it is in the deeper waters, where nobody will lower a heavy fish pot. Then, in July, you start to see three or four of them. Near September, then it is that you can catch a lot of *salmonetes*. It goes on like that, maybe until December, when it starts to emigrate to deeper waters again. And you won't see a *salmonete* again until July of the next year.
>
> So what can we do about this? They should tell us: 'look, for the time of the *salmonete* runs I'm going to give you the opportunity to use a few fish pots with a

> mesh that can actually be used to catch *salmonetes*. And that is it, problem solved. It would be easy and we would be happy.

Don Berto, another expert fisher from Santa Isabel, and a friend of Don Eddie, told me when I asked about the spotted goatfish:

> You have talked to Eddie, right? He and I talk about this all the time, about how we don't have the opportunity to catch *salmonete* anymore. That little red fish has disappeared! And it would be so easy, if they let us use the smaller wire meshes when the *salmonete* is running near these coasts. This is important for your report, for your university, write it down!.

The *salmonete* was one of the 16 species included in the ecological knowledge assessment questions asked to the 41 structured respondents and the 'culturally correct answers' identified through consensus analysis lend some support to these key informants' arguments. According to the consensus of the 41 structured questionnaire respondents' the spotted goatfish is 1) mostly caught near seagrasses, 2) mostly caught during the fall season, 3) mostly found in groups with other spotted goatfishes, and 4) mostly caught with fish traps. These results, when compared with the statements by key informants, lend credence to the informants' theory that the spotted goatfish is known to undergo group seasonal migrations that only place a significant number of individuals of this species within capture range for a certain part of the year. The fishers' consensus might be the best source of information about the movements of this fish species, since very little about the seasonal movement patterns of tropical fish is known to western science and the field of knowledge is still evolving (Polunin and Roberts 1996; Johannes 1978; 1981; 1998; Roberts 1997; Aguilar-Perera 2004).

Apart from fulfilling a request made by several of the fishers who collaborated with me the most, I included the case of the spotted goatfish fishery and fishers' recommendations for management because this case constitutes a great example of how fishers' adaptive strategies for dealing with ecosystem complexity and heterogeneity (for example, fishing multiple species, switching between fishing areas and types of fishing gear to accommodate for different species biology, size, habitat preferences and seasonal movement patterns) can be combined with western fisheries management strategies such as mesh size regulations. Cooperation and knowledge sharing with small-scale fishers in cases such as the spotted goatfish fishery could have the potential of greatly increasing the effectiveness of such management measures, often-criticized from within western science circles due to their effects on the adaptability and resilience of social-ecological systems, when applied sweepingly and without attention to context (see Acheson and Wilson 1996; Berkes, Colding, and Folke 2003; Holling 1993; Ludwig, Hillborn, and Walters 1993;).

Summary and conclusion

This chapter discusses the central theme of this dissertation: the value of local ecological knowledge. Local ecological knowledge is the product of both social and a result of the functioning of a particular human ecosystem. I have called local ecological knowledge *Ethnoecological capital* because it is both *natural capital* (Costanza *et al.* 1997) and also *social/cultural capital* (Berkes and Folke 1998). This chapter explores the value of local ecological knowledge for fishers and for coastal ecosystem/fisheries management separately, over two sections that illustrate different ways of looking at the value of local ecological knowledge.

In the first section of this chapter I explored this topic by testing this research project's central hypothesis, that for small-scale fishers in southeastern Puerto Rico there would be a positive and significant relationship between fishers' scores in question about local ecological knowledge and culturally-relevant measures of success in fishing. I again re-stated the projects' assumptions about the suitability of using consensus between fishers as a proxy of local ecological knowledge in the case of this project and emphasized that the domain of knowledge of ecological knowledge about local fisheries and fisheries' ecosystems is suitable for this analysis.

Using bivariate correlations, parametric linear regressions, and distribution-free tests such as bootstrap resamples and rank-sum tests, I tested the relationships between fishers' scores in four measures of ecological knowledge and measures of success. The only measure of success that exhibited statistically significant covariation with ecological knowledge measures was the respondent's average ratings as a successful fishers, evaluated by fishers in the respondent's community, a measure that has been fund to be one of the most reliable and accurate indicators of success for fishers in small, rural communities (Guest 2000; Poggie 1978; Pollnac and Poggie 1979). Other culturally-relevant, material measures of success did not exhibit statistically significant covariation with ecological knowledge. This might be because these measures, while culturally-relevant, might be influenced by factors other than an effective pattern of performance in the social and ecological context of small-scale fishing.

The largest and most significant relationships occurred between respondents' average peer success ratings and measures of ecological knowledge that dealt specifically with knowledge about the habitat preferences (both horizontal (substrate type) and vertical (depth) of important fishery species). This supports the findings reached through ethnographic work with key informants that in the region's fisheries, the most important ecological knowledge a fisher needs is to know in which kinds of habitats to find a variety of important fish species. The findings of the ethnographic-qualitative (exploratory) and quantitative (explanatory) phases of this research thus support each other in the matter of what is the most important knowledge.

In the last section of this chapter I used the case of the spotted goatfish (*Pseudupeneus maculatus*) trap fisheries to illustrate how fishers' knowledge could be used to inform and increase the effectiveness of western resource management. Fishers' perceive that their extensive knowledge of topics such as fish seasonal movement patterns and the habitats preferred by fishery species can be useful to inject some flexibility in fisheries regulations such as fish trap mesh sizes, which can be effective but have been criticized from within western management circles because of the measures' lack of flexibility and adaptability to social and ecological context (Mahon and Hunte 2001). An interesting avenue of research is to could be to explore how such complementary uses of fishers and managers, perspectives might work out in real management situations (like, for example, Hunn *et al.* 2003).

CHAPTER 7

CONCLUSION: ECOLOGICAL KNOWLEDGE AND SUCCESS IN SMALL-SCALE FISHING

In the introductory section of this chapter I will present, the principal findings of this dissertation, followed by some of the implications of my results for several fields of anthropological and interdisciplinary inquiry. I end the chapter by discussing the limitations of this research and opportunities for future study.

Principal findings of this dissertation

For the fishers with whom I collaborated, the pursuit of success in fishing is a social and sometimes moral pursuit, driven by a peasant subsistence ethic rather than by calculations of monetary profit. The cultural models of success in fishing are more concerned with survival and continuity of fishing and coastal subsistence than with maximizing profits and catches on the short term. Success is a multi-dimensional construct, consisting of social, material, and ecological determinants and measures of performance.

Social recognition as a member of the community of “true fishers”, as well as making enough profits to ensure reproduction of the domestic unit, are the most widely shared goals of a potentially successful fisher. Due to the historically determined subsistence strategy of combining agricultural work and part-time fishing, being a full-time fisher was not a necessary condition of being a very successful fisher.

Thinking about the ecosystem in terms of ecological parameters (e.g. species assemblages, trophic structures, bottom composition, salinity, seasonality, depth, changes of parameters over time), is of paramount importance for fishers dealing with the complexity of a multi-species tropical fishery. *Las áreas de pesca* (the fishing areas) an ecosystem-like concept (Berkes *et al*. 1998), composed of abiotic (bottom type, salinity), biotic (fish and shellfish), bathymetric (depth) and seasonal components, is prominent in fishers' thinking about local marine environments.

Fishers' recognize the value of biodiversity in fish and shellfish species for their continued success in fishing. Flexibility in pursuing and utilizing the variety of fish and shellfish species is very important for fishers' economic pursuits.

Puerto Rican fishers' understanding of local ecosystems is more akin to advanced *ecosystem ecology* than to traditional population biology, which dominates the science used by agency-based fishery management. To put it in simple terms, Population biology (for example, a yield-per-recruit model) focuses on predictions of numbers that describe populations of fishery species; while ecosystem ecology (and most of the key informants' reasoning about ecosystems) focuses on attempting to understand the complexity inherent in the ecosystem and then to think about what kinds of combinations of parameters might result in ecosystem continuity and/or change.

Ecological knowledge about important fishery species' distribution according to environmental parameters (measured as cultural competency in the collective body of ecological knowledge) co-varied significantly with fishers' reputations as successful fishers, as evaluated by other fishers in their community. Fishers' practical experience in dealing with complexity can be of helpful for the balanced and socially-just utilization of coastal resources.

Ethnoecology

Ethnoecology is an interdisciplinary field that studies people's beliefs, knowledge and worldviews about the natural/physical environment and further investigates how the information contained in those units of culture relates to subsistence behavior, performance and social organization, drawing on theories and insights from the social end ecological sciences (Gragson and Blount 1999; Nazarea 1999; Frechione, Posey and Silva 1989). By undertaking an exploration of how Puerto Rican fishers' LEK has been shaped by the complexity of social-ecological surroundings and conditions, this dissertation adds to the literature describing the interplay between human-ecosystem interactions and bodies of knowledge resulting from those interactions.

Some of the most important recent advances in the study of distributed cognition of ecological or ethnobiological knowledge have included 1) a systematic assessment of intracultural variation in a domain of knowledge pertaining to the natural environment, and 2) an external validation of cognitive performance. Usually a social assessment (e.g. kinship, expertise, others) is combined with an 'objective assessment' such as identification of plant or animal specimens according to local folk taxonomies, scientific taxonomies, or both. By combining these techniques, one can relate an abstract concept (distributed cognition) to a measurable reality (competence in answering questions in a domain) (see Boster 1986; 1986b; Boster, Berlin and O'Neill 1986; Medin *et al*. 2005; Stepp 2003; Zarger 2004;). One can also underscore the effects of distributed cognition on variation in human activities, well-being, and social roles. For example, Boster's (1985; 1986; 1991) findings that knowledge of Aguaruna manioc cultivar varieties is distributed along female kinship lines might have the implication that the transmission of agroecological knowledge between mother and daughters provides the crucial social service of maintaining a broad knowledge base about different cultivar varieties, which might increase the resilience of food production systems to environmental fluctuations and crop diseases.

In this research project I combined different techniques to measure intracultural variation in competence about a complex domain of knowledge for which, contrary to domains such as plant and animal specimen identification, there is no definite answer key to compare answers to. Answers to questions such as fish habitat preferences are better answered in terms of probabilities or frequencies (e.g. fish A is found in habitat type A 90% of the time and between habitat types B and C the remaining 10% of the time) instead of by absolute statements. By using cultural consensus between fishers as a measure of competency, I set the collective experience of fishers' in my sample as the baseline to make comparison between fishers.

Students of Information Ecology, a developing subfield of Human Ecology and Ethnoecology, have made interesting advances in conceptualizing human ecosystem interactions by looking at the role of distributed and shared ecological information in human activities (Stepp *et al*. 2003; Casagrande 2002; Abel and Stepp 2003; Wyndham 2004; Kuchka 2001). This research presents a case of distributed information whose main function is to help the holders of the information to recognize and predict patterns amidst great complexity, effectively reducing massive amount of information to manageable levels. Ecological knowledge and social behavior, such as sharing communication, and teaching, tend to go hand in hand, because, as Don Teófilo once told me, "a hundred eyes will always see better than two".

Consensus and competency

Consensus is not always a measure of true knowledge (Furlow 2003; Ross 2002), but I propose that under certain assumptions, consensus can safely be assumed to be a measure of true knowledge. These assumptions, which are central for the validity of this research, are 1) that by careful ethnographic research, the researcher is able to ask a series of culturally-valid questions about aspects of a domain on knowledge, 2) that the informants who are being compared can be reasonably assumed to share a cultural model about the domain of knowledge in question (e.g. local fishing expertise), and 3) that there is an independent process or constrain that will result in more accurate, correct information about the natural world to become the subject of consensus among the studied population (e.g. correct, ecologically-accurate information about the movement patterns of fish and shellfish will result in more efficient fishing and more predictable catches and thus will tend over time to become the default consensus by information sharing, and validated and/or rejected by further experiences).

Bodies of local ecological knowledge evolve over time, thus new insights and better information reached by creative individuals can, at times, be more accurate than the consensus for specific pieces of information. It is highly unlikely, however, that this idiosyncratic knowledge will be better than the consensus for every species and every piece of important ecological knowledge, because an individual’s experience with the vast and complex underwater landscapes will always be much smaller than the collective experience. To the best of my knowledge, my system of study for this research meets these assumptions.

Implications for fisheries social science

A long-standing debate in maritime anthropology has been whether fishing success is predominantly affected by technology and modes of production, rather than the personal characteristics of fishers such as knowledge and dexterity (this debate is generally called "the skipper effect debate"). Most studies deconstructing the determinants of fishing success have left 'knowledge' as a ghost variable, of unknown magnitude and variability, to be assessed in the future or perhaps never (see Poggie 1979; Poggie and Pollnac 1979; Durrenberger 1993; Durrenberger and Palsson 1983; 1986; Palsson and Durrenberger 1982; 1983; 1990; Palsson and Helgason 1999; Russel and Alexander 1995). Using sequences of methods such as those used in this research, one can attempt to shed some light in ecological knowledge effects in success, depending, of course, on the specific fishery characteristics.

Researchers such as (Durrenberger 1993; Durrenberger and Palsson 1983; 1986; Palsson and Durrenberger 1982; 1983; 1990; Palsson and Helgason 1999; White 1989; 1992; Bjarnason and Thorlindsson1993) have explored the variety of factors that might lead to social and physical patterns of effective performance in fishing. Most of these studies have assumed that the size of the catch and/or the return rates on fishing effort (catch per unit-effort, CPUE) are the best indicators of fishing success. I have not made such an assumption, rather choosing to explore what constitutes success for the fishers in this study's region empirically, paying close attention to cultural and socioeconomic context. I found that success in fishing, for the fishers in this study's region, cannot be meaningfully measured as catch rates.

Combining the insights from the study of peasant economies, which focuses on rural peoples' strategies for subsistence (Cashdan 1990; Chayanov 1966; Scott 1976; 1998; Wolf 1969) with Ethnoecology's focus on worldviews and explanatory models about the workings of ecosystems (Gragson and Blount 1999; Frechione, Posey and Silva 1989), I have found that the bodies of knowledge about the natural environment described by fishers reflect an understanding that the patterns of productivity of local marine ecosystems are not suitable for a fishery focused on profits or intense short-term exploitation. The knowledge needed to be successful in fishing is geared more to adapting to ecological complexity and the patchiness of fishery resources availability than to focus on a few economically important species for profitability. This ethnoecological worldview is compatible with a subsistence economy geared towards reducing uncertainty and minimizing the risk of total loss of income rather than towards maximizing the opportunities for profit.

Survival and continuation of the household appear to be the principal economic goals for fishers in this study’s region, and their success in their enterprises should be evaluated in their own terms. Recent developments in the research focus of fishery management agencies have resulted in great advances in the understanding of fishing communities and their economies (Durrenberger and King 2000; Griffith and Valdés-Pizzini 2002, McGoodwin 1990, among many others), but the practicalities and paradigms of management, plus the diversity of fishing communities and , still present the danger of misrepresentation of the drivers of fishers’ economic behavior. Assumptions about human behavior that do not take into account worldviews, subsistence strategies and human institutions often result in predictive failure and subsequent ecological and social disasters and tragedies (Scott 1976; 1996; North 1993).

Ecosystem concepts in traditional societies

The last two decades have witnessed a realization that advanced ecosystems ecology, which is influenced by complexity and chaos theories, has more in common with traditional bodies of ecological knowledge than with quantitative population ecology (Berkes 1996; Berkes *et al*. 1998; Berkes, Colding, and Folke 2003; Folke, Berkes and Colfing 1998; Hunn *et al*. 2003; Gagdil and Berkes 1995; Griffith 1999; Johannes 1978; 1981). Among the most important commonalities between some traditional systems of ecological knowledge and ecosystems ecology are 1) the emphasis thinking about a unit of analysis that includes abiotic factors of the environment as well as a group or assemblage of interacting biological populations (e.g. a watershed or a landscape) and 2) the embracing of complexity (chaos, non-equilibrium, nonlinearity, unpredictability) as an interesting and even desirable characteristic of ecosystems rather than something to be avoided and or assumed away in explanatory models (Berkes 1999; Berkes *et al*. 1998; Inglis 1993; Levin 1998; Stepp *et al*. 2003).

The worldviews espoused by the Puerto Rican fishers I collaborated with during this research were characterized by: 1) their emphasis on “fishing areas” as units of thinking about ecosystems and 2) their emphasis on adaptation to an heterogeneous and changing environment through thinking about ecological parameters rather than about populations, are very similar to the concepts of complex, chaotic ecosystems described above. This research provides a case study of such concepts existing and informing a system of ecological knowledge that is not ‘traditional’ in the way that South Pacific, Artic, or Native American bodies of ecological knowledge are (although several of my key informants reported that their families had been involved in fishing for at least 5 -6 generations).

Ecosystems ecology critiques of most western science-based, top-down resource management are often very similar to the arguments many Puerto Rican fishers used to express their dissatisfaction with resource management by state agencies. Fishers interviewed throughout this study and also throughout a larger-scale study involving coastal communities around Puerto

Rico (Griffth, Valdés-Pizzini and García-Quijano 2006) repeatedly complained that state-based resource management fails to take into account local and even regional specifics related to the state of resources and the social and ecological histories of specific locales and populations, both human and non-human. Fishers everywhere complained that the fisheries are managed "*from air conditioned offices*", applying 'models developed for continental fisheries without taking the time and effort to assess situations directly in the field (also see Griffith, Valdes-Pizzini and García-Quijano 2006).

Don Lázaro, an expert fisher from Patillas, told me that, in his opinion, the main problem with the state's style of fisheries management was that "there was a serious discrepancy between "*la ley de la pesca versus la realidad de la pesca*" (the laws that govern fishing versus the reality of fishing). According to him, the laws regarding fishing attempt to be so exact, that they completely miss that coastal ecosystems in Puerto Rico are very complex, especially because of the patchiness in resource availability. In his own words, "a fisher that doesn't have flexibility/room to operate cannot subsist from fishing in these coasts".

The insights from ecosystems' ecology and complexity theory also resonate with peasant studies' theories about how increasing legibility and standardization of human activities driven by a state machine end up compromising the ability of people to survive in the world (Wolf 1969; Scott 1976; 1998). As Don Lázaro put it when talking about the fishery code: "*Esta Ley esta fuera de control"* (This law is out of control). Don Lázaro's words make me think of a runaway train, one of simplification and avoiding ambiguity for bureaucratic and administrative comfort. In its haste and zeal, the train (the state) fails to realize that the world is complex and ambiguous no matter what the train does and will react in unknown ways to the state's attempts towards control.

For example, Don Lázaro reports that his favorite kind of fishing is for deep-water snappers, and that, like many others, because of the way that the size-limit regulations are enacted, he is forced to be wasteful, which causes him a lot of grief and constrains the time and effort he spends fishing. He added that regulations on deep-water fishing are making it so difficult, that most young fishers are turning into full-time divers, a type of fishing that he views as potentially more destructive, if done carelessly, than deep-water snapper fishing.

Limitations and possibilities

The main limitation of the explanatory phase of this research is related to sample sizes and to the low response rates (about 40%) for my structured questionnaire. While these low response rates and the low sample size (n=41 out of more than 100 fishers in the sample universe) resulted from situations largely out of my control, such as the political situation between fishers and the resource management sectors, they affected the inferential significance of my sample in unknown ways. By spending great effort to ensure the internal validity (e.g. that my questions addressed important, relevant issues and that they measured what they were intended to measure), by combining parametric and distribution-free statistical tests, and by paying close attention to variable characteristics, I attempted to minimize the effects of sample size on my results. The increase in inferential power that can be achieved by such strategies, however, is important but limited. Future research with larger sample sizes will greatly increase the inferential significance of my results.

Another limitation of this study comes from its cross-sectional nature and associated lack of time-depth. Do the fishers communities' perceptions of who is a successful fisher change over time? How is ecological knowledge associated with individual fishers' resilience, the ability to bounce back from setbacks (Holling 2003), or 'roll with the punches' (Cook *et al*. 2004)?

Coastal subsistence in this study's region includes activities other than fishing, and local people's knowledge about social-ecological cycles and processes larger than those directly-related to fishing might be responsible for general success patterns that result in overall material well-being. Future research about the intracultural distribution of knowledge about these larger-scale processes and its relationship with general measures of success might complement this study by explaining some of the unaccounted-for variability in success.

Future studies can address the limitations of this study questions by employing diachronic approaches, such as focusing in life histories or studying patterns of performance in the fisheries human ecosystem in a longitudinal fashion. For example, a future study based on the results presented in this chapter might be to use a longitudinal research design to assess the relationships between variability in different kinds of ecological knowledge and the *actual* patterns of fishing performance, measured by CPUE's or other similar measures, for a group of fishers over time. The limitations and handicaps of this project point to possibilities for growth and further study.

REFERENCES

Abel, T. and J. R. Stepp 2003. A New Ecosystems Ecology for Anthropology. Conservation Ecology **7**:art12.

Acheson, J. 1977. Technical Skills and Fishing Success in the Maine Lobster Industry. Pages 1-38 *in* Lechtman, H. and R. Merril, editor. Material Culture: Styles, Organization and Dynamics of Technology. West Publishing, St. Paul, MN.

Acheson, J. 1981. Anthropology of Fishing. Annual Review of Anthropology **10**:275-316.

Acheson, J., and J. Wilson. 1996. Order Out of Chaos: the Case for Parametric Fisheries Management. American Anthropologist **98**:579-594.

Agrawal, A.1995. Dismantling the Divide between Scientific and Indigenous Knowledge. Development and change **26**:413-439.

Aguilar-Perera, A. 2004. Coastal Habitat Connectivity of Reef Fishes from Southwestern Puerto Rico. Ph. D. University of Puerto Rico-Mayaguez, Mayaguez.

Allen, T. and T. Hoekstra 1992. Toward a Unified Ecology. Columbia University Press, New York.

Almany, G. 2004. Priority Effects of Coral Reef Fish Communities of the Great Barrier Reef. Ecology **85**:2872-2880.

Andersen, R., and C. Wadel. 1972. Introduction. *in* Andersen, R. and C. Wadel, editor. North Atlantic Fishermen: Anthropological essays on modern fishing. University of Toronto Press, Toronto.

Aswani, S., and M. Lauer. 2006. Incorporating Fishermen's Local Knowledge and Behavior into Geographical Information Systems (GIS) for Designing Marine Protected Areas in OceaniandHuman Organization **65**:81-102.

Aswani, S. and R. Hamilton. 2004. Integrating Indigenous Ecological Knowledge and Customary Sea Tenure with Marine and Social Science for Conservation of Bumphead Parrotfish (Bolbometopon muricatum) in the Roviana Lagoon, Solomon Islands. Environmental Conservation **31**:69-83.

Babbie, E. 1990. Survey Research Methods. Wadsworth, Belmont, Ca.

Batchelder, W. and A.K. Romney. 1988. Test Theory Without an Answer Key. Psychometrika **53**:71-92.

Battiste, M. and J. Henderson 2000. Protecting Indigenous Knowledge and Heritage: A Global Challenge. Purich Publishing, Saakatoon, Saskatchewan, Canada.

Berkes, F. 1993. Traditional Ecological Knowledge in perspective. Pages 1-10 *in* J. Inglis, editor. Traditional Ecological Knowledge: Concepts and Cases. International Development Research Centre, Ottawa, Canada.

Berkes, F. 1999. Sacred Ecology: Traditional ecological knowledge and resource management. Taylor and Francis, Philadelphia, PA.

Berkes, F., J. Colding, and C. Folke. 2003. Introduction. Pages 1-29 *in* F. Berkes, Johan Colding, and Carl Folke, editor. Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press.

Berkes, F., M. Kislaliogu, C. Folke, and M. Gadgil. 1998. Exploring the Basic Ecological Unit: Ecosystem-like Concepts in Traditional societies. Ecosystems **1**:409-415.

Berkes, F. andC. Folke 1992. A systems perspective on the interrelations between natural, human-made and cultural capital. Ecological Economics **5**:1-8.

Berkes, F. and C. Folke 1998. Linking Social and Ecological Systems for Resilience and Sustainability. Pages 1-26 *in* C. Folke and F. Berkes, editor. Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge, UK.

Berlin, B. 1992. Ethnobiological classification: Principles of categorization of plants and animals in traditional societies. Princeton University Press, Princeton.

Bernard, H. R. 1995. Research Methods in Anthropology: Qualitative and quantitative approaches, 2nd edition. Altamira Press, Walnut Creek, CA.

Bernard, H. R. and G. Ryan 1998. Text Analysis: Qualitative and Quantitative Methods. Pages 595-645 *in* H. R. Bernard, editor. Handbook of Methods in Cultural Anthropopology. Altamira Press, Walnut Creek, CA.

Bjarnason, T., and T. Thorlindsson. 1993. In Defense of a Folk Model: The "Skipper Effect" in the Icelandic Cod Fishery. American Anthropologist **95**:371-394.

Blaikie, P., K. Brown, M. Stocking, L. Tang, P. Dixon, P. Sillitoe. 1997. Knowledge in Action: Local Knowledge as a Development Resource and Barriers to its Incorporation in Natural Resource Research and Development. Agricultural Systems **55**:217-237.

Blount, B. G. 2000. Coastal Refugees: Marginalization of African-Americans in the marine fisheries of Georgia. Urban Anthropology **29**:285-313.

Blount, B. G. 2001. Indigenous Peoples and the Uses and Abuses of Ecotourism. Pages 503-516 *in* L. Maffi, editor. On Biocultural Diversity: Linking Language, Knowledge, and the Environment. Smithsonian Institution Press.

Blount, B. G. 2002. Keywords and cultural models in representation of environmental knowledge: Theory, methods, and a case study. University of Georgia, Athens, GA.

Bohnsack, J., D. Sutherland, D. Harper, D. McClellan, M. Hulsbeck and C. Holt. 1989. The effects of fish trap mesh size on reef fish catch off southeastern Florida. Marine Fisheries Review **51**:36-46.

Borgatti, S. 1996. ANTHROPAC 4.0 Methods Guide. Analytic Technologies, Natick, MA:.

Borgatti, S. 2001. ANTHROPAC. *in*. Analytic Technologies, Cambridge, MA.

Boster, J. 1986. Exchange of Varieties and Information between Aguaruna Manioc Cultivators. American Anthropologist **88**:429-436.

Boster, J. 1991. The Information Economy Model applied to biological similarity judgment. Pages 203-225 *in* J. L. Lauren Resnick, and Stephanie Teasley, editor. Socially Shared Cognition. American Psychological Association, Washington, DC.

Boster, J. 1996. Human Cognition as a Product and Agent of Evolution. *in* R. E. andK. Fukui, editor. Redefining Nature: Ecology, Culture, and Domestication. Berg, Oxford.

Boster, J., Brent Berlin, and John O'Neill. 1986. The correspondence between Jivaroan and scientific Ornithology. American Anthropologist **88**:569-583.

Boster, J., J. Johnson, and S. Weller. 1987. Social position and shared knowledge: Actors' perceptions of status, role, and social structure. . Social Networks **9**:375–387.

Boster, J. andJ. Johnson 1989. Form or Function: A Comparison of Expert and Novice Judgments of Similarity among Fish. American Anthropologist **91**:866-889.

Boster, J. and R. D'Andrade 1989. Natural and Human Sources of Cross-Cultural Agreement in Ornithological Classification. American Anthropologist **91**:132-142.

Boster, J. 1985. 'Requiem for the Omniscient Informant': There's Life in the Old Girl Yet. Pages 177-197 *in* J. Dougherty, editor. Directions in Cognitive Anthropology. University of Illlinois Press, Urbana.

Boster, J., and S. Weller. 1990. Cognitive and Contextual Variation in Hot-Cold Classification. American Anthropologist **92**:171-178.

Breton, Y., and E. Lopez-Estrada. 1989. Ciencias Sociales y desarrollo de las pesquerias: modelos y metodos aplicados al caso de México. INAH, Mexico, D.F.

Breton, Y., E. Lopez, E. Coté, and D. Buckles. 1985. Pescadores y Desarrollo Nacional: Hacia una Valoración de la Dimensión Social de la Pesca en Mexico. Université Laval, Quebec.

Brewer, D. 1995. Cognitive indicators of knowledge in semantic domains. Journal of Quantitative Anthropology **5**:107-128.

Brewer, D., A. K. Romney and W. Batchelder. 1991. Consistency and consensus: a replication. Journal of Quantitative Anthropology **3**:195-205.

Brosius, J. P. 1997. Endangered people, endangered forest: environmentalist representations of indigenous knowledge. Human Ecology **25**:47-69.

Brush, S. 1993. Indigenous Knowledge of Biological Resources: The Role of Anthropology. American Anthropologist. **95**:653-686.

Cadilla, J. 1988. Elementos de la Geografía de Puerto Rico. Editorial Librotex, San Juan.

Cambers, G. 1998. Coping with Beach Erosion: Case Studies from the Caribbean. UNESCO Publishing, Paris.

Carson, R. 1962. Silent Spring. Houghton Mifflin, Boston.

Casagrande, D. 2002. Ecology, Cognition, and Cultural Transmission on Tzeltal Maya Medicinal Plant Knowledge. Ph. D. Dissertation. The University of Georgia, Athens.

Cashdan, E., editor. 1990. Risk and Uncertainty in Tribal and Peasant Economies. Westview Press.

Casson, R. 1983. Schemata in Cultural Anthropology. Annual Review of Anthropology **12**:429-462.

Cervigón, F., R. Cipriani, W. Fischer, L. Garibaldi, M. Hendrickx, A.J. Lemus, R. Márquez, J.M. Poutiers, G. Robaina and B. Rodriguez. 1992. Fichas FAO de identificación de especies para los fines de la pesca. Pages 503 *in* Guía de campo de las especies comerciales marinas y de aquas salobres de la costa septentrional de Sur América.United Nations Food and Agriculture Organization, Rome.

Chayanov, A. 1966. Theory of Peasant Economy. Academic Books, New York.

Cohen, J. 1960. A Coefficient of Agreement for Nominal Scales. Educational and Psychological Measurement **20**:37-48.

Colby, B., S. Kennedy, and L. Milanesi. 1991. Content Analysis, Cultural Grammars, and Computers. Qualitative Sociology **14**:373-384.

Colby, B. N. 1966. The Analysis of Culture Content and the Patterning of Narrative Concern in Texts. American Anthropologist **68**:374–388.

Collier, J. 1967. Visual anthropology: photography as a research method. Holt, Rinehart and Winston, New York, NY.

Comitas, L. 1962. Fishermen and Cooperation in Rural Jamaica. Ph.D. Dissertation. Columbia University, New York.

Cook, W., D. Casagrande, D. Hope, P. Groffman, and S. Collins. 2004. Learning to roll with the punches: Adaptive experimentation in human-dominated systems. Frontiers in Ecology and the Environment **2(9)**:467-474.

Cooley, D. 2002. Cultural Models and Fishing Knowledge: A Case Study of Commercial Blue Crab Fishermen in Georgia, USA. Ph.D. Dissertation. The University of Georgia, Athens.

Cordell, J. 1974. The lunar tide fishing cycle in Northeastern Brazil. Ethnology **13**:379-392.

Cortés, J. and M. E. Hatziolos. 1999. Status of coral reefs of Central America: Pacific and Caribbean Coasts. Status of Coral Reefs of the World: 1998. Australian Institute of Marine Science.

Costanza, R., B. Low, E.Ostrom, J.Wilson. 2001. Institutions, Ecosystems, and Sustainability. Lewis Publishers, Boca Raton, Florida.

Costanza, R., Ralph D'Arge, Rudolf de Groot, Stephen Farber, Monica Grasso, Bruce Hannon, Karin Limburg, Shahid Naeem, Robert V. O'Neill, Jose Paruelo, Robert G. Raskin, Paul Sutton, Marjan van den Belt. 1997. The Value of the World's Ecosystem Services and Natural Capital. Nature **387**:253-260.

Craig, C. P. 1980. It's Always the Big Ones that Should Get Away. Journal of the American Medical Association **244**:272-272.

Crumley, C. 1998. Foreword . Pages ix-xiv *in* W. Baleé, editor. Advances in Historical Ecology. Columbia University Press, New York.

Crumley, C. L., and W. H. Marquardt. 1990. Landscape: A unifying concept in regional analysis. Pages 73-79 *in* K. Allen, S. Green, and E. Zubrow, editor. Interpreting Space: GIS and archaeology. Taylor and Francis, Bristol, PA.

Cruz-Torres, M. 2004. Lives of Dust and Water: An Anthropology of Change and Resistance in Northwestern Mexico. University of Arizona Press, Tucson.

D’Andrade, R. 1984. Cultural Meaning Systems. Pages 88-119 *in* R. Schweder and R. LeVine, editor. Culture Theory: Essays on Mind, Self, and Emotion. Cambridge University Press, Cambridge.

D'Andrade, R., and C. Strauss, editor. 1992. Human motives and cultural models. Cambridge University Press, New York.

D'Andrade, R. G. 1987. Modal responses and cultural expertise. American Behavioral Scientist **31**:266-279.

D'Andrade, R. G. 1989. Culturally Based Reasoning. *in* A. Gellatly, D. Rogers, and J. Sloboda, editor. Cognition and social worlds. Clarendon Press, Oxford.

D'Andrade, R. G. 1995. The Development of Cognitive Anthropology. Cambridge University Press, Cambridge.

de Blij, H. and P. Mueller. 2005. Geography: Realms, Regions, and Concepts. John Wiley and Sons.

Delgado, P., and S. Steadman. 2004. The U.S. Caribbean Wetlands and Fish: A Vital Connection. NOAA Fisheries, Silver Springs, MD.

DeWalt, B. 1994. Using Indigenous Knowledge to Improve Agriculture and Natural Resource Magagement. Human Organization **53**:123-131.

Dietz, J. 1986. Economic History of Puerto Rico. Princeton University Press, Princeton, N.J.

Dietz, J. 2003. Puerto Rico: Negotiating Development and Change. L. Rienner, Boulder, Colorado.

DRNA. 2004. Puerto Rico Fishing Regulations. *in*. Departamento de Recursos Naturales y Ambientales.

Durrenberger, E. P. 1993. The Skipper Effect and Folk Models of the Skipper Effect among Mississippi Shrimpers. Human Organization **52**:194-202.

Durrenberger, E. P., and Gílsi Pálsson. 1983. Riddles of Herring and Rhetorics of Success. Journal of Anthropological Research **39**:323-335.

Durrenberger, E. P., and Gílsi Pálsson. 1986. Finding Fishing: The Tactics of Icelandic Skippers. American Ethnologist **13**:213-229.

Durrenberger, E. P. and T. King, editor. 2000. State and Community in Fisheries Management: Power, Policy, and Practice. Bergin and Garvey, Westport, Conn.

Durrenberger, E.P. 1997. Fisheries Management models: assumptions and realities, or why shrimpers in Mississippi are not firms. Human Organization **56**:158-166.

Dwass, M. 1957. Modified randomization tests for non-parametric hypotheses. Annals of Mathematical Stastistics **28**:181-187.

Edgington, E. S. 1969. Approximate randomization tests. Journal of Psychology **72**:143-149.

Edgington, E. S. 1980. Randomization tests. Marcel Dekker, New York.

Ellen, R. 1979. Introductory Essay. *in* R. Ellen and D. Reason, editor. Classifications in their social context. Academic Press, London.

Fagerstrom, J. A. 1987. The Evolution of Reef Communities. Wiley, New York.

Figueroa, L. 1991. Facing Freedom: The Transition form Slavery to Free Labor in Guayama, Puerto Rico, 1860-1898. University of Wisconsin, Madison.

Finlayson, A., and Bonnie McCay. 1998. Crossing the Threshold of Ecosystem Resilience: The Commercial Extinction of Northern Cod. Pages 311-337 *in* C. Folke and F. Berkes, editor. Linking Social and Ecological Systems: Institutional Learning for Resilience. Cambridge University Press, Cambridge.

Fish, S. and S. Kowalewski, editor. 1990. The Archaeology of Regions: The case for full-coverage survey. Smithsonian Institution Press, Washington, D.C.

Folbre, N. 1994. Who Pays for the Kids? Gender and the Structures of Constraint. Routledge, New York.

Folke, C. 1991. Socioeconomic Dependence on the Life-supporting Environment. Pages 77-94 *in* C. Folke, T. Kabenger, editor. Linking the Natural Environment and the Economy: Essays from the Eco-Eco Group. Kluwer Academic Publishers, Dordretcht, The Netherlands.

Forman, S. 1967. Cognition and the catch: the location of fishing spots in a Brazilian coastal village. Ethnology **6**:417-426.

Freeman, L., Romney, A., Ferreira-Pinto, J., Klein, R. and Smith, T. 1981. Guatemalan and U.S. Concepts of Success and Failure. Human Organization **40**:140-145.

Froese, R. and D. Pauly 2005. FISHBASE. http://www.fishbase.org. Electronic Database.

Furlow, C. 2003. Comparing Indicators of Knowledge within and between Cultural Domains. Field Methods **15**:51-62.

Gadgil, M., P. Olsson, F. Berkes, and C. Folke. 2003. Exploring the Role of Local Ecological Knowledge for Ecosystem Management: Three Case Studies. Pages 33-52 *in* F. Berkes, J. Colding and C. Folke, editor. Navigating social-ecological systems: building resilience for complexity and change. Cambridge University Press, Cambridge, U.K.

Gadgil, M. andF. B. 1991. Traditional Resource Management Systems. Resource Management and Optimization **18**:127-141.

García-Quijano, C. G. 2001. Ethnoecology of a Caribbean reef fishery system. *in* 2001 Annual Meetings of the American Anthropological Association, Washington, DC, USA.

Gardner, P. 1976. Birds, words, and a requiem for the omniscient informant. American Ethnologist **3**:446-468.

Garro, L. 1986. Intracultural variation in folk medical knowledge: a comparison of curers and non-curers. American Anthropologist **88**:351-370.

Garro, L. 1988. Explaining high blood pressure: Variation in knowledge about illness. American Ethnologist **15**:98-119.

Garro, L. 2000. Remembering what one knows and the construction of the past: A comparison of Cultural Consensus Theory and Cultural Schema Theory. Ethnos **28**:275-319.

Gatewood, J. 1984. Is the Skipper Effect really a false ideology? American Ethnologist **11**:378-379.

Gauch, H. G. 1982. Multivariate Analysis in Community Ecology. Cambridge University Press, Cambridge, U.K.

Geertz, C. 1973. The Interpretation of Cultures: Basic Essays. Basic Books, New York.

Giutsi-Cordero, J. 1994. Labor, Ecology, and History in a Caribbean Sugar Plantation: Piñones (Loíza), Puerto Rico. Ph.D. Dissertation. SUNY Binghamton, Binghamton, NY.

Gosz, J. R. 1999. The North American Regional LTER. Long Term Ecological Research Network. *in* International LTER Report. http:\\www.lternet.com.

Gower, J. C. 1988. Classification, geometry and data analysis. Pages 3-14 *in* H. Bock, editor. Classification and Related Methods of Data Analysis. North Holland.

Gragson, T. andB. Blount. 1999. Introduction. *in* T. Gragson, and Ben Blount, editor. Ethnoecology: Knowledge, resources, and rights. University of Georgia Press, Athens.

Greenberg, J. and T. Park. 1994. Political Ecology. Journal of Political Ecology **1**:1-12.

Griffith, D. 1999. The Estuary's Gift: An Atlantic Coast Cultural Biography. Pennsylvania State University Press.

Griffith, D., and M. Valdés-Pizzini. 2002. Fishers at work, workers at sea: A Puerto Rican Journey through labor and refuge. Temple University Press, Philadelphia.

Griffith, D., M. Valdés-Pizzini and C. García-Quijano. 2006. Socioeconomic Profiles of Fishers, their Communities, and their Reponses to Marine Protective Measures in Puerto Rico. Technical Report National Oceanic and Atmospheric Administration.

Griffith, D., M. Valdés-Pizzini,and J. Johnson. 1992. Injury and therapy: Semiproletarianization in Puerto Rico's artisanal fisheries. American Ethnologist **19**:53-74.

Guest, G. 2000. Using Guttman scaling to Rank Wealth: Integrating Quantitative and Qualitative Data. Field Methods **12**:346-357.

Guttman, L. 1944. A basis for scaling qualitative data. American Sociological Review **9**:139-150.

Guttman, L. 1950. The basis for scalogram analysis. Pages 60-90 *in* S. Stouffer, editor. Measurements of prediction. Princeton University Press, Princeton, NJ.

Hamilton, R. and R. Walter 1999. Indigenous ecological knowledge and its role in fisheries research design: A case study from Roviana Lagoon, Western Province, Solomon Islands. SPC Traditional Management and Knowledge Information Bulletin **13-25**.

Handwerker, W. 2002. The Construct Validity of Cultures: Cultural Diversity, Culture Theory, and a Method for Ethnography. American Anthropologist **104**:106-122.

Handwerker, W. and P., Borgatti, S. 1998. Reasoning with Numbers. *in* H. R. Bernard, editor. Handbook of Methods in Cultural Anthropology. Altamira Press, Walnut Creek, CA.

Holland, D. and N. Quinn 1987. Culture and cognition. Pages 3-40 *in* D. Holland, and N. Quinn, editor. Cultural models in language and thought. Cambridge University Press.

Hollander, M., and D. Wolfe. 1999. Nonparametric Statistical Methods, 2 edition. John Wiley and sons, New York.

Holling, C. 2001. Understanding the complexity of economic, ecological, and social systems. Ecosystems **4**:390-405.

Holling, C., Gunderson, L., and Peterson, G. 2002. Panarchies and sustainability. Pages 63-102 *in* L. Gunderson and C. Holling, editor. Panarchy, Understanding Transformations in Systems of Humans and Nature. Island Press, Washington, D.C.

Holling, C. S. and G. Meffe. 1996. Command and control and the pathology of natural resource management. Conservation Biology **10**:328-337.

Holling, C. S. 1992. Cross-scale morphology, geometry, and dynamics of ecosystems. Ecological Monogrpahs **62**:447-502.

Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2nd edition. New World Publications.

Hunn, E. 1977. Tzeltal folk zoology: The classification of discontinuities in nature. Academic Press, New York.

Hunn, E. 1995. Ethnoecology: The relevance of Cognitive Anthropology for Human Ecology. Pages 439-455 *in* B. Blount, editor. Language, culture, and society. Waveland Press, Prospect Heights, Illinois.

Hunn, E., Darryl Johnson, Priscilla Russell, and Thomas Thronton. 2003. Huna Tinglit Traditional Environmental Knowledge, conservation, and the management of a "Wilderness" Park. Current Anthropology **44**:S79-S103.

Inglis, J. 1993. Preface. Pages vi-vii *in* J. Inglis, editor. Traditional Ecological Knowledge: Concepts and Cases. International Development Research Centre, Ottawa, Canada.

Insightful. 2005. S-Plus for Windows.

Consevation International 2006. Expedition Discovers Marine Treasures In Netherlands Antilles: New Species of Fish, Seaweeds Found On Caribbean's Saba Bank.

Jackson, J. 1991. Adaptation and diversity of coral reefs. BioScience **41**:475-482.

Jackson, J., M. Kirb, W. Berher, K. Bjorndal, L. Botsford, B. Bourque, R. Bradbury, R. Cooke, J. Erlandsson, J. Estes, T. Hughes, S. Kidwell, C. Lange, H. Lenihan, J. Pandolfi, C. Peterson, R. Steneck, M. Tegner, R. Warner. 2001. Historical overfishing and the recent collapse of coastal ecosystems. Science **293**:629-638.

Jacob, S., F. L. Farmer, M. Jepson, and C. Adams. 2001. Landings and Definition of Fishing Dependent Communities: Potential Social Science Contributions to Meeting National Standard 8. Fisheries **26**:16-22.

JAPR. 1988. Junta Azucarera de Puerto Rico: Informe Anual 1987-1988. Estado Libre Asociado de Puerto Rico.

JOBANERR. 1997. Central Aguirre: Su Historia y Desarrollo. Boletín Informativo de la Reserva Nacional de Investigación Estuarina Bahía de Jobos **3**:1-3.

JOBANERR. 2000. Management Plan for the Jobos Bay National Estuarine Research Reserve. National Oceanic and Atmospheric Administration, Aguirre, PR.

Johannes, R. E. 1978. Traditional Marine Conservation Methods in Oceania and their Demise. Annual Review of Ecology and Systematics **9**:349-364.

Johannes, R. E. 1981. Words of the Lagoon: fishing and marine lore in the Palau District of MicronesiandUniversity of California Press, Berkeley.

Johannes, R. E. 1998. The Case for Data-less Marine Resource Management: Examples from Tropical Fisheries. Trends in Ecology and Evolution **13**:243-246.

Johannes, R. E. 2001. The need for the study of indigenous fishers' knowledge. SPC Traditional Management and Knowledge Information Bulletin **13**:28-29.

Johnson, J. C. 1990. Selecting Ethnographic Informants. Sage Publications, Newbury Park, CA.

Johnson, J. C. 1998. Research Design and Research Strategies in Cultural Anthropology. Pages 131-171 *in* H. R. Bernard, editor. The Handbook of Methods in Cultural Anthropology. Altamira Press.

Johnson, J. C. 2000. The Systematic Collection of TEK. *in*. Issues Positions Papers. Ecological Knowledge Working Seminar II 'Exploring and reconciling competing systems of ecologically-framed Knowledge: Lessons from Maritime Canada and North Atlantic Fisheries" June 17th - 21st, 2000 St. Francis Xavier University Antigonish, Nova Scotia.

Johnson, J. C., and David C. Griffith. 1998. Visual Data: Collection, Analysis, and Representation. Pages 211-230 *in* V. andE. S. DeMunck, editor. Using Methods in the Field. Altamira Press, Walnut Creek, CA.

Johnson M., L. Mason, and P. Raven. 1968. Ecological parameters and plant species diversity. American Naturalist **102**:297-306.

Jones, G., and C. Syms. 1998. Disturbance, Habitat Structure and the Ecology of Fishes on Coral Reefs. Australian Journal of Ecology **23**:287-297.

Kathiresan, K. 2003. How do mangrove forests induce sedimentation? Revista de Biología Tropical **51**:355-360.

Kaufmann, L. and P. Dayton 1997. Impacts of marine resources extraction on ecosystem services and sustainability. Pages 275-290 *in* G. Daily, editor. Nature's services: Societal dependence on natural ecosystems. Island Press, Washington, DC.

Kay, P. 1964. A Guttman scale model of Tahitian consumer behavior. Southwestern Journal of Anthropology **20**:160-167.

Kempton, W. 1981. The folk classification of ceramics: A study of cognitive prototypes. Academic Press, New York.

Kempton, W., J. Boster, and J. Hartley. 1995. Environmental values in American culture. MIT Press, Cambridge, MA.

Kendall, M. S., M.E. Monaco, K.R. Buja, J.D. Christensen, C.R. Kruer, M. Finkbeiner, and R.A.Warner. 2001. Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands. NOAA Fisheries.

Killworth, P., E. C. Johnsen, C. McCarty, G. Shelley, H. R. Bernard. 1998. A Social Network Approach to Estimating Seroprevalence in the United States. Social Networks **20**:23-50.

Killworth, P., C. McCarty, H. R. Bernard, E. Johnsen, J. Domini, G. Shelley. 2003. Two interpretations of reports of knowledge of subpopulation sizes. Social Networks **25**:141-160.

Kinzig, A. P. 2001. Bridging Disciplinary Divides to Address Environmental and Intellectual Challenges. Ecosystems **4**:709-715.

Krebs, C. J. 1999. Ecological Methodology. Addison-Welsey Educational Publishers, Menlo Park, CA.

Krushensky, R. D. and J. Schellekens. 2001. Geology of Puerto Rico. Pages 10-59 *in* W. J. Bawiec, editor. Geology, geochemistry, geophysics, mineral occurrences, and mineral resources assessment for the Commonwealth of Puerto Rico. United States Geological Survey, Washington, D.C.

Kuchka, H. 2001. Method for theory: a prelude to human ecosystems. Journal of Ecological **5**:1-78.

Lawrence, D. N., M.B. Enriquez, R.M. Lumish and A. Maceo. 1980. Ciguatera fish poisoning in Miami. Journal of the American Medical Association. **244**:254-258.

Levin, S. A. 1998. Ecosystems and the Biosphere as Complex Adaptive Systems. Ecosystems **1**:431-436.

Llorens, H. 2005. Fugitive Blackness: Representations of Race, Art, and Memory in Arroyo, Puerto Rico. Ph. D. Dissertation. University of Connecticut, Storrs.

Ludwig, D., R. Hilborn, and C. Walters. 1993. Uncertainty, resource exploitation, and conservation: lessons from history. Science **260**:17-36.

Maffi, L. 2001. Introduction. Pages 1-25 *in* L. Maffi, editor. On Biocultural Diversity: Linking Language, Knowledge, and the Environment. Smithsonian Institution Press.

Mahon, R. and W. Hunte. 2001. Trap mesh selectivity and the management of reef fishes. Fish and Fisheries **2**:356-375.

Masten, A. and J. Coatsworth 1995. Competence, resilience, and psychopathology. Pages 715-752. *in* D. Cicchetti and D. Cohen, editor. Manual of Developmental Psychopathology. John Wiley and Sons, New York.

Matos-Caraballo, D. 2002. Overview of Puerto Rico's Small-Scale Fisheries Statistics 1998-2001. *in* 55th Gulf and Caribbean Fisheries Institute Meeting, Cancun, Mexico.

McCay, B. 1978. Systems Ecology, People Ecology, and the Anthropology of fishing. Human Ecology **6**:397-422.

McGoodwin, J. 1990. Crisis in the world's fisheries: People, problems, and policies. Stanford University Press, Stanford.

McGoodwin, J. 1994. "Nowadays, nobody has any respect": The demise of folk management in a rural Mexican fishery. Pages 43-54 *in* C. Dyer, and C. McGoodwin, editor. Folk Management in the world's fisheries: Lessons for modern fisheries management. University Press of Colorado, Niwot.

Medin, D., Elizabeth Lych, John Coley, and Scott Atran. 1997. Categorization and reasoning among tree experts: do all Roads lead to Rome? Cognitive Psychology **32**:49-96.

Medin, D., N. Ross, S. Atran, D. Cox, J. Coley, J. Proffitt and S. Blok. 2005. Folkbiology of freshwater fish. Cognition **99**:237-273.

Miller, M., J. Kaneko., P. Bartram, J. Marks, D. Brewer. 2004. Cultural Consensus Analysis and Environmental Anthropology: Yellowfin Tuna Fishery Management in Hawaii. Cross-Cultural Research **38**:289-314.

Mills, L. S., Michael Soule, and Daniel Doak. 1993. The Keystone-Species Concept in Ecology and Conservation. BioScience **43**:219-220.

Mintz, S. 1956. Cañamelar: the subculture of a rural sugar plantation proletariat. Pages 314-417 *in* J. Steward, editor. The People of Puerto Rico: A study in Cultural Anthropology. University of Illinois Press, Urbana.

Mintz, S. 1960. Worker in the Cane: A Puerto Rican Life History. Yale University Press, New Haven.

Mintz, S. 1974. Caribbean Transformations. Aldine Publishing Co., Chicago.

Morelock, J. 1978. The Shoreline of Puerto Rico. Department of Natural Resources, San Juan, Puerto Rico.

Morelock, J., W. Ramirez, and M. Barreto. 2002. The World's Coasts: Puerto Rico. Kluwer Press.

Morris, J. G. 1980. Ciguatera fish poisoning. Journal of the American Medical Association **244**:272-274.

Muhr, T. 2004. Atlas.ti. *in*. Scientific Software Development GmbH, Berlin.

Mumby, P. 2006. Connectivity of reef fish between mangroves and coral reefs: Algorithms for the design of marine reserves at seascape scales. Biological Conservation **128**:215-222.

Munro, J. 1976. Aspects of the biology and ecology of Caribbean reef fishes: Mullidae (goatfishes). Journal of Fisheries Biology **9**:79-97.

Munro, J. 1983. The biology, ecology and bionomics of the goatfishes, Mullidae. Pages 142-154 *in* J. Munro, editor. Caribbean Coral Reef Fishery Resources. ICLARM.

Munro, J. L. 1984. Yields from Coral Reef Fisheries. FISHBYTE **2**:13-15.

Munro, J. L. 1996. The Scope of Reef Fisheries and their Management. Pages 1-14 *in* N. V. andC. R. Polunin, editor. Reef Fisheries. Chapman and Hall, London.

Nazarea, V. 1999. A View from a Point: Ethnoecology as Situated Knowledge. Pages 3-20 *in* V. Nazarea, editor. Ethnoecology: Situated Knowledge/Located Lives. University of Arizona Press., Tucson.

Nazarea-Sandoval, V. 1995. Local Knowledge and agricultural decision making in the Philippines: Class, gender, and resistance. Cornell University Press, Ithaca and London.

Nietschmann, B. 1973. Between Land And Water:The Subsistence Ecology of the Miskito Indians, Eastern NicaraguandSeminar Press, New York.

Nietschmann, B. 1989. Traditional sea territories, resources, and rights in Torres Strait. Pages 60-93 *in* J. Cordell, editor. A Sea of Small Boats. Cultural Survival, Cambridge, Mass.

Noreen, E. 1989. Computer-intensive methods for testing hypotheses: An introduction. John Wiley & Sons.

Norgaard, R. B. 1994. Development Betrayed: the End of Progress and a Coevolutionary Revisioning of the Future. Routledge, New York.

North, D. 1990. Institutions, Institutional Change, and Economic Performance. Cambridge University Press, New York.

North, D. 1993. Economic Performance Through Time. 1993 Nobel Prize in Economics acceptance lecture. The Bank of Sweden.

North, D. and R. Thomas 1973. The Rise of the Western World: A New Economic History. Cambridge University Press, Cambridge.

Odum, E. 1971. Fundamentals of Ecology. Saunders, Philadelphia.

Olsson, P., Carl Folke, Fikret Berkes. 2004. Adaptive Co-Management for Building Resilience in Social-Ecological Systems. Environmental Management **34**:75-90.

Orlove, B. 1991. Mapping reeds and reading maps: the politics of representation in Lake TiticacandAmerican Ethnologist **18**:3-38.

Ott, R. L., and M. Longnecker. 2001. An introduction to statistical methods and data analysis. Duxbury.

Paine, R. 1969. A Note on Trophic Complexity and Species Diversity. American Naturalist **100**.

Pálsson, G. 1988. Models for Fishing and Models of Success. Maritime Anthropological Studies **1**:15-28.

Pálsson, G., and Agnar Helgason. 1999. Schooling and Skipperhood: The Development of Dexterity. American Anthropologist **101**:908-923.

Pálsson, G., and E. P. Durrenberger. 1982. To Dream of Fish: The Causes of Icelandic Skippers' Fishing Success. Journal of Anthropological Research **38**:227-242.

Pálsson, G., and E. P. Durrenberger. 1983. Icelandic Foremen and Skippers: The Structure and Evolution of a Folk Model. American Ethnologist **10**:511-527.

Palsson, G., and E.P. Durrenberger. 1990. Systems of Production and Social Discourse: the Skipper Effect Revisited. American Anthropologist **92**:130-141.

Pandolfi, J., J. Jackson, N. Baron, R. Bradbury, H. Guzman, T. Hughes, C. Kappel, F. Micheli, J. Ogden, H. Possingham, E. Saland2005. Are U.S. Coral Reefs on the Slippery Slope to Slime? Science **307**:1725-1726.

Pandolfi, J., R. Bradbury, E. Sala, T. Hughes, K. Bjorndal, R. Cooke, D. McArdle, L. McClenachan, M. Newman, G. Paredes, R. Warner, J. Jackson. 2003. Global Trajectories of the Long-Term Decline of Coral Reef Ecosystems. Science **301**:955-958.

Paolisso, M., and E. Chambers. 2001. Culture, Politics, and Toxic Dinoflaggellate Blooms: the Anthropology of Pfiesteria. Human Organization **60**:1-12.

Paulay, G. 1997. Diversity and distribution of reef organisms. Pages 303-304 *in* C. Birkeland, editor. Life and Death of Coral Reefs. Chapman and Hall, New York.

Pelto, P. J. andG. H. P. 1978. Anthropological research: The structure of inquiry. Cambridge University Press, Cambridge.

Peluso, N. 1995. Whose woods are these?: Counter-mapping forest territories in Kalimantan, IndonesiandAntipode **27**:383-406.

Pérez, R. 2000. Fragments of Memory: The State and small-scale fisheries modernization in southern Puerto Rico. Ph.D. University of Connecticut, Storrs.

Pérez, R. 2005. The State and Small-Scale Fisheries in Puerto Rico. University of Florida Press, Gainesville, FL.

Pinkerton, E., editor. 1989. Co-Operative management of local fisheries. University of British Columbia Press, Vancouver.

Pinkerton, E. 1989. Introduction: Attaining better fisheries management through Co-Management-Prospects, problems, and propositions. Pages 3-33 *in* E. Pinkerton, editor. Co-Operative management of local fisheries. University of British Columbia Press, Vancouver.

Poggie, J. J. 1978. Deferred gratification as an adaptive characteristic for small-scale fishermen. Ethos **6**:115-123.

Poggie, J. J. 1979. Small-scale fishermen's beliefs about success and development: A Puerto Rican case. Human Organization **38**:6-11.

Polanyi, K. 1946. Origins of Our Time: The Great Transformation. Gollancz, London.

Pollnac, R. 1998. Aspects of the human ecology of the coral reefs of Atulayan Bay. Pages 77-140 *in* R. Pollnac, editor. Rapid Assessment of Management Parameters for Coral Reefs. - Coastal Resources Center-University of Rhode Island, Narraganset, RI.

Pollnac, R. 1998. Aspects of the human ecology of the coral reefs of Discovery Bay. Pages 140-199 *in* R. Pollnac, editor. Rapid Assessment of Management Parameters for Coral Reefs. Coastal Resources Center-University of Rhode Island, Narraganset, RI.

Pollnac, R., and John Poggie. 1978. Economic gratification orientations among small-scale fishermen in Panama and Puerto Rico. Human Organization **37**:355-367.

Pollnac, R., and R. Ruiz-Stout. 1977. 1977. Small-scale fishermen's attitudes toward the occupation of fishing in the Republic of PanamandPages 16-20 *in* R. B. Pollnac, editor. Panamanian small-scale fishermen: society, culture, and change. International Center for Marine Resources Development, University of Rhode Island, Kingston.

Pollnac, R., C. Gersuny, and John Poggie. 1975. Economic Gratification patterns of fishermen and millworkers in New England. Human Organization **34**:1-7.

Polunin, N., C.M. Roberts, D. Pauly. 1996. Reef fisheries: problems and prospects. Pages 361-377 *in* N. P. andC. Roberts, editor. Reef Fisheries. Chapman Hall, London.

Pomeroy, R. 1992. Management options for small-scale fisheries. *in* J. L. Munro and P. E. Munro, editor. The management of coral reef resource systems. International Center for Living Aquatic Resources Management, Manila, Philippines.

Posey, D., J. Frechione, J. Eddins, L. Francelino da Silva, D. Myers, D. Case, and P. MacBeath. 1984. Ethnoecology as Applied Anthropology in Amazonian Development. Human Organization **43**:95-107.

Pottier, J., A. Bicker, and P. Sillitoe, editor. 2003. Negotiating Local Knowledge: Power and Identity in Development. Pluto Press.

Prugh, T., R. Costanza, J. Cumberland, H. Daly, R. Goodland, R. B. Norgaard. 1999. Natural Capital and Human Economic Survival, 2nd edition. CRC Press - Lewis Publishers, Boca Raton.

Rhoades, R. 1998. Participatory Watershed Research and Management: Where the Shadow Falls. International Institute for Environment and Development. Sustainable Agriculture and Rural Livelihoods Programme, London.

Riesco, M. and E. Cepeda. 1996. Peces y Mariscos Comestibles de Puerto Rico. University of Puerto Rico Sea Grant College Program, Mayaguez, Puerto Rico.

Roberts, C. 1997. Connectivity and Management of Caribbean Coral Reefs. Science **278**:1454-1457.

Roberts, C. andN. Polunin. 1996. Preface. *in* N. Polunin and C. M. Roberts, editor. Reef Fisheries. Chapman and Hall, London.

Robichaud, D., W. Hunte, and H. Oxenford. 1999. Effects of increased mesh size on catch and fishing power of coral reef fish traps. Fisheries Research **39**:275-294.

Romney, A. K. 1993. Cultural knowledge and cognitive structure. Pages 254-283 *in* M. Suarez-Orozco, G. Spindler, and L. Spindler, editor. The making of Psychological Anthropology. Harcourt Brace, New York.

Romney, A. K. 1997. When Does Consensus Indicate Cultural Knowledge? Cognitive Science News **7**:3-8.

Romney, A. K., . S. C. Weller and W. H. Batchelder. 1986. Culture as Consensus: A Theory of Culture and Informant Accuracy. American Anthropologist **88**:313-338.

Romney, A. K., W. Batchhelder, and S. Weller. 1987. Recent applications of cultural consensus theory. American Behavioral Scientist **31**:163-177.

Rosaldo, R. 1989. Culture and Thruth: The Remaking of Social Analysis. Beacon Press, Boston.

Rosario, A. and Y. Sadovy 1991. Trap Mesh Selectivity off the West Coast of Puerto Rico (January, 1990–December, 1990). Fisheries Research Laboratory, Department of Natural Resources, San Juan, Puerto Rico.

Ross, N. 2002. Cognitive aspects of intergenerational change: Mental models, cultural change, and environmental behavior among the Lacandon Maya of Southern Mexico. Human Organization **61**:125-138.

Ross, N. 2004. Culture and Cognition: Implications for Theory and Method. Sage Publications, Thousand Oaks, Ca.

Ross, N., and D. Medin. 2003. On the Tip of the Tongue: Cultural models, Expertise, and the Organization of Knowledge. Field Methods.

Ross, N., D. Medin, J. Coley and S. Atran. 2003. Cultural and Experiential Differences in the Development of Folkbiological Induction. Cognitive Development **18**:25-47.

Ruddle, K. 1993. The Transmision of Traditional Ecological Knowledge. Pages 17-32 *in* J. Inglis, editor. Traditional Ecological Knowledge: Concepts and Cases. International Development Research Centre, Ottawa, Canada.

Ruddle, K. 1994. Local Knowledge in the folk management of fisheries and coastal marine environments. Pages 161-206 *in* C. Dyer and J. McGoodwin, editor. Folk Management in the world's fisheries; Lessons for modern fisheries management. University Press of Colorado, Niwot.

Ruddle, K. 1996. Geography and Human Ecology of Reef Fisheries. Pages 137-160 *in* N. Polunin, and C. M. Roberts, editor. Reef Fisheries. Chapman and Hall, London.

Ruddle, K. 1996. Traditional Management of Reef Fishing. Pages 315-335 *in* N. Polunin, and C. M. Roberts, editor. Reef Fisheries. Chapman and Hall, London.

Russell, S. D. 1997. Class Identity, Leadership Style, and Political Culture in a Tagalog Coastal Community. Journal of Philippine Studies **28**.

Russell, S. D., and R. T. Alexander. 1996. The Skipper Effect Debate: Views from a Philippine Fishery. Journal of Anthropological Research **52**:433-460.

Russell, S. D., and R. T. Alexander. 1998. Measuring Seining Strategies and Fishing Success in the Philippines. Human Organization **57**:145-158.

Saavedra, M. V. 2004. Pescadores Planean Marcha al Capitolio. Page 21 *in* Primera Hora, San Juan, Puerto Rico. 24 April 2004.

Sale, P. 1991. The Assembly of Reef Fish Communities: Open Non-equilibrial Systems. Pages 564-598 *in* P. Sale, editor. The ecology of fishes on coral reefs. Academic Press, New York.

Sale, P. 2002. The Science We Need to Develop for More Effective Management. Pages 361-376 *in* P. Sale, editor. Coral Reef Fishes. Dynamics and diversity in a complex ecosystem. Academic Press, San Diego.

SAS Institute. 2005. JMP for Windows. *in*.

Scharer, M., M. Prada, R. Appeldoorn, R. Hill, P. Sheridan, and M. Valdés-Pizzini. 2004. The Use of Fish Traps in Puerto Rico: Current Practice, Longterm Changes, and Fishers' Perceptions. *in* 55th Gulf and Caribbean Fisheries Institute, Xel-Hah, Mexico.

Schulze, E., and H. Mooney. 1993. Ecosystem function of biodiversity: a summary. Pages 497-510 *in* E. Shulze and H. Mooney editor. Biodiversity and ecosystem function. Springer-Verlag, Berlin.

Scott, J. 1976. The Moral Economy of the Peasant: Rebellion and Subsistence in Southeast AsiandYale University Press, New Haven.

Scott, J. 1985. Weapons of the Weak: Everyday Forms of Peasant Resistance. Yale University Press, New Haven.

Scott, J. 1998. Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed. Yale University Press, New Haven.

Seguinot, J. 2000. Gestión ambiental de la población residente en la Reserva Nacional Estuarina de la Bahía de Jobos (JOBANERR), Guayama. Report submitted to JOBANERR, Aguirre, PR.

Sillitoe, P. 1998. The development of indigenous knowledge. Current Anthropology **39**:223-252.

Simon, J. 1991. ResamplingStats for Windows.

Smith, A., and Fikret Berkes. 1993. Community-Based Use of Mangrove Resources in St. Lucia. International Journal of Environmental Studies **43**:123-131.

Smith, M. E. 1977. Introduction. Pages 1-23 *in* M. E. Smith, editor. Those who live from the sea: a study in maritime anthropology. West Publishing Co.

SPSS. 2004. SPSS for Windows.

St. Martin, K. 2000. Operationalizing Ecological Knowledge. *in*. Issues Positions Papers. Ecological Knowledge Working Seminar II 'Exploring and reconciling competing systems of ecologically-framed knowledge: lessons from Maritime Canada and North Atlantic Fisheries" June 17th - 21st, 2000 St. Francis Xavier University. Antigonish, Nova Scotia.

Stanfield, R. 1982. Towards a value standard in economics. Economic Forum 13:67-85.

Stepp, J. R. 2002. Highland Maya Medical Ethnobotany in Ecological Perspective. Ph. D. Dissertation. University of Georgia, Athens.

Stepp, J. R., E. C. Jones, M. Pavao-Zuckerman, D. Casagrande, R. K. Zarger. 2003. Remarkable Properties of Human Ecosystems. Ecology and Society **7**:11.

Stevenson, D. K. 1978. Management of a Tropical Fish Pot Fishery for Maximum Sustainable Yield. *in* Proceedings of the 30th Gulf and Caribbean Fisheries Institute.

Steward, J., editor. 1956. The People of Puerto Rico: A Study in Social Anthropology. University of Illinois Press, Urbana.

Stockton, S. 2002. The Cognitive Ecology of the Upper Chatahoochee Watershed. Ph.D. Dissertation. The University of Georgia, Athens.

Strauss, C. and N. Quinn 1997. Introduction. *in* C. .Strauss and N. Quinn, editor. A cognitive theory of cultural meaning. Cambridge University Press, Cambridge.

Suarez-Caabro, J. 1979. El Mar de Puerto Rico: Una Introducción a las Pesquerías de la Isla. Editorial de La Universidad de Puerto Rico, Rio Piedras, PR.

Thorlindsson, T. 1988. The Skipper Effect in the Icelandic Herring Fishery. Human Organization **47**:199-212.

Toro-Sugrañes, J. 1995. Historia de los Pueblos de Puerto Rico. Editorial Edil, Río Piedras, Puerto Rico.

Tosteson, T., D. Ballantine, C. Tosteson, V. Hensley, A. Bardales. 1989. Associated bacterial flora, growth, and toxicity of cultured benthic dinoflagellates *Ostreopsis lenticularis* and *Gambierdiscus toxicus*. Applied and Environmental Microbiology **55**:137-141.

Tosteson, T. R., D.L. Ballantine and H.D. Durst. 1988. Seasonal frequency of ciguatoxic barracuda in Southwest Puerto Rico. Toxicon **26**:795-801.

Umpierre, M. 2003. Estudio sobre las condiciones socioambientales de las comunidades aledañas a la reserva nacional de investigación estuarina de Bahía de Jobos (JOBANERR). Project Report Jobos Bay National Estuarine Research Reserve, Aguirre, Puerto Rico.

Valdés-Pizzini, M. 1985. Social Relations of Production in Puerto de la Corona: Capitalism and Development in the Puerto Rican Fisheries. Ph.D. SUNY-Stony Brook, Stony Brook.

Valdés-Pizzini, M. 1987. Apuntes Sobre el Desarrollo Histórico de la Pesca en Puerto Rico. UPR Sea Grant College Program Publications, Mayaguez, Puerto Rico.

Valdés-Pizzini, M. 1990. Fishermen Associations in Puerto Rico: Praxis and Discourse in the Politics of Fishing. Human Organization **49**:164-173.

Valdés-Pizzini, M. 2001. Historical Contentions and Future Trends in the Coastal Zone: The Environmental Movement in Puerto Rico. UPR-Sea Grant Publications, Mayaguez.

Valdés-Pizzini, M., J. Posada, I. López and D. Cabán. 1996. Cognitive Constructions of Fishery Resources Among the Fishers of Southwestern Puerto Rico. *in* Proceedings of the 49th Annual Meeting of the Gulf and Caribbean Fisheries Institute (GCFI), Barbados.

Valdés-Pizzini, M., J. Posada, M. Rosado, and K. Grove. 2004. Territorializando Paisajes: El Uso del Espacio y los Recursos entre los Pescadores del Suroeste de Puerto Rico. Pages 17-48 *in* M. Valdés-Pizzini, editor. Territorios litorales: Recorridos antropológicos por el espacio costero. UPR Sea Grant College Program Publications, Mayaguez, Puerto Rico.

Van Young, E. 1992. Mexico's Regions. University of California-Center for U.S. Mexican Studies, San Diego.

Vázquez-Orlandi, J. 1998. Aguirre y su Gente. Publicaciones Puertorriqueñas, San Juan, Puerto Rico.

Wallerstein, I. 1979. The Capitalist World-Economy. Cambridge University Press, Cambridge.

Walters, C. 1986. Adaptive Management of Renewable Resources. McMillan, New York.

Walters, C. 1997. Challenges in Adaptive Management of Riparian and Coastal Ecosystems. Conservation Ecology **1**:1-3.

Ward, J. 1988. Mesh size selection in Antillean arrowhead fish traps. Pages 455-467 *in* S. Venema, J. Moller-Christensen and D. Pauly, editor. Contributions to Tropical Fisheries Biology. Food and Agriculture Organization.

Warren, D. 1991. Using indigenous knowledge in agricultural development. The World Bank, Washington, D.C.

Weller, S. 1987. Shared knowledge, intracultural variation, and knowledge aggregation. American Behavioral Scientist **31**.

Weller, S., L. Pachter, R. Trotter II, and R. D. Baer. 1993. Empacho in Four Latino Groups: A Study of Intra- and Inter-Cultural Variation in Beliefs. Medical Anthropology **15**:109-136.

Weller, S. C. 1998. Structured interviewing and questionnaire construction. Pages 363-407 *in* H. R. Bernard, editor. Handbook of Methods in Cultural Anthropopology. Altamira Press, Walnut Creek, CA.

Weller, S. C. and A.K. Romney. 1988. Systematic data collection. Sage Publications, Newbury Park, CA.

Wharton, C. R. 1963. The Economic Meaning of Subsistence. The Malayan Economic Review **8**:46-58.

White, D. 1989. Knockin 'em Dead: Alabama Shrimp Boats and the "Fleet Effect." Pages 25-37 *in* J. S. Thomas, R.L. Maril, and E.P. Durrenberger, editor. Marine Resource Utilization: A Conference on Social Science Issues. University of South Alabama Publication Services, Mobile.

White, D. 1992. Belief in differential skill among U.S. Gulf of Mexico shrimp fishermen. American Anthropologist **94**:450-452.

Wolanski, E. 1995. Transport of sediment in mangrove swamps. Hydrobiologia **295**:31-42.

Wolf, E. 1959. Sons of the Shaking Earth. University of Chicago Press, Chicago.

Wolf, E. 1966. Peasants. Basic Books, Englewood Cliffs, NJ.

Wolf, E. 1969. Peasant Wars of the Twentieth Century. Basic Books, Englewood Cliffs, NJ.

Woodroffe, C. 1992. Mangrove sediments and geomorphology. Pages 7-41 *in* A. Robertson, and D. Algongi, editor. Tropical mangrove ecosystems. American Geophysical Union, Washington, D.C.

Wyndham, F. 2004. Learning Ecology: Ethnobotany in the Sierra Tarahumara, Mexico. Ph. D. Dissertation. The University of Georgia, Athens.

Zar, J. 1999. Biostatistical Analysis. Prentice Hall, Upper Saddle River, NJ.

Zarger, R. 2002. Children's Ethnoecological Knowledge: Situated Learning and the Cultural Transmission of Subsistence Knowledge and Skills among Q'eqchi' MayandPh. D. Dissertation. The University of Georgia, Athens.

APPENDIX

SOME IMPORTANT FISHERY SPECIES

This list of important fishery species was developed in collaboration with local fishers. Importance might be economic, culinary, cultural, or ecological. Common names gathered from interviews with fishers, using photographic specimens.

FISHES

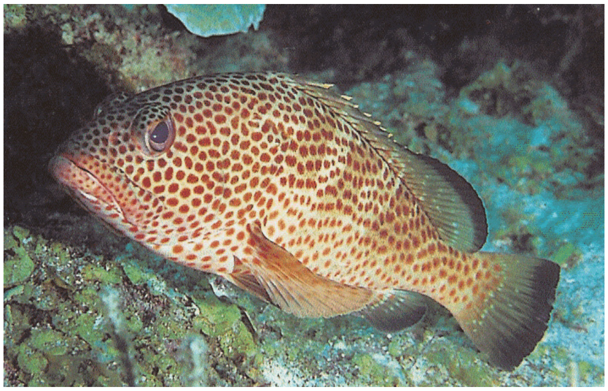
Sama *(Lutjanus analis)*, mutton snapper. Lutjanidae (Snappers), Perciformes. **Photo Source:** FISHBASE; http://filaman.ifm-geomar.de/Collaborators/CollaboratorSummary.cfm?ID=529

Arraya'o *(Lutjanus synagris)*, lane snapper. Lutjanidae (Snappers), Perciformes. Photo Source: FISHBASE; http://filaman.ifm-geomar.de/Collaborators/CollaboratorSummary.cfm?ID=268

Colirrubia, (Ocyurus Chrysurus), yellowtail snapper, Lutjanidae (Snappers), Perciformes. Photo Source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Sierra, sierra carite, *(Scomberomorus maculatus)*, Spanish mackerel, Scombridae (mackerels, tunas, bonitos), Perciformes. Photo Source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=126

Cabrilla, mero cabrilla, *(Epinephelus guttatus)*, red hind, Serranidae (sea basses, groupers, and fairy basslets), Perciformes. Photo Source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

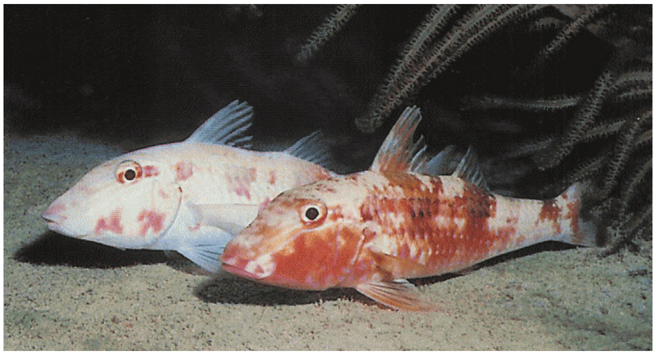


Boquicolora'o, cachicata, chicata, (Haemulon plumierii), white grunt, Haemulidae (grunts), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

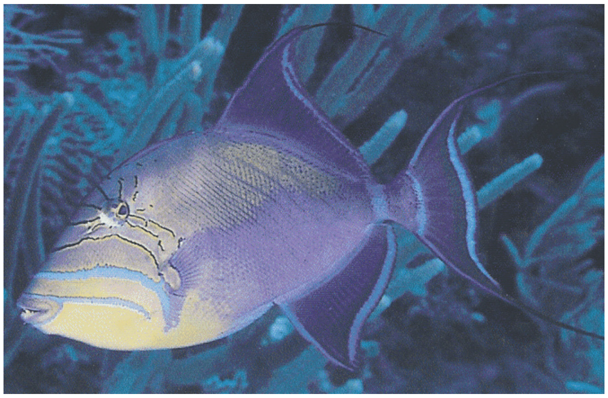
mero, mero común, *(Epinephelus morio)*, red grouper, Serranidae (sea bassess, groupers, and fairy basslets), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Chillo, *(Lutjanus vivanus)*, silk snapper, Lutjanidae (snappers), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=185

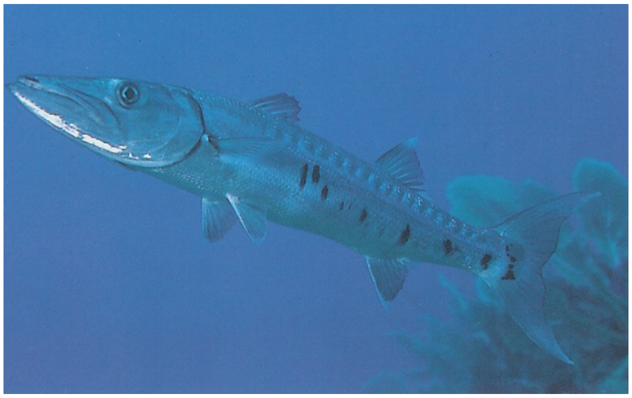
Salmonete, salmonete colora'o, *(Pseudupeneus maculatus), spotted goatfish*, Mullidae (goatfishes), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



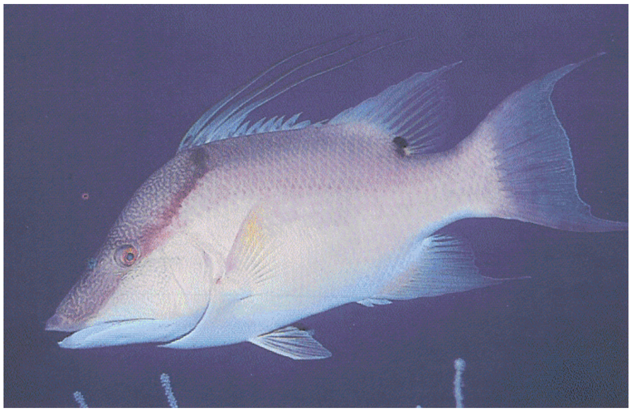
Pejepuerco, pejepuerco azul, *(Balistes vetula),* queen triggerfish, Balistidae (triggerfishes), Tetraodontiformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Picúa, picúa brava, diente de perro, *(Sphyraena barracuda),* Atlantic barracuda, Sphyraenidae (barracudas), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



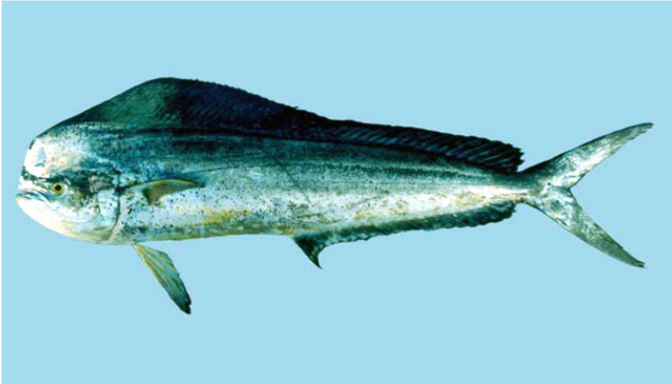
Capitán, *(Lachnolaimus maximus)*, hogfish, Labridae (wrasses), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Pargo, pargo común, *(Lutjanus apodus)*, Lutjanidae (snappers), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1404

Cartucho, *(Etelis oculatus)*, queen snapper, Lutjanidae (snappers), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1391

Dorado, *(Coryphaena hippurus)*, common dolphinfish, Coryphaenidae (dolphinfishes), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=6



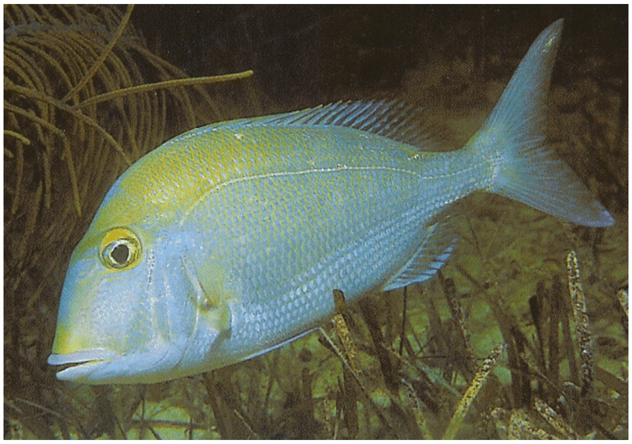
Balajú, *(Hemiramphus brasiliensis)*, ballyhoo, Hemirapmhidae (halfbeaks), Beloniformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1059

Peto, *(Acanthocybium solandri)*, wahoo, Scombridae (mackerels, tunas, bonitos), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=89

Jarea, *(Mugil curema),* white mullet, Mugilidae (mullets), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1086

Cojinúa, *(Carangoides rubber),* bar jack, Carangidae (jacks and pompanos), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1918

Pluma, boca de caballo, *(Calamus pennatula),* pluma porgy, Sparidae (porgies), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

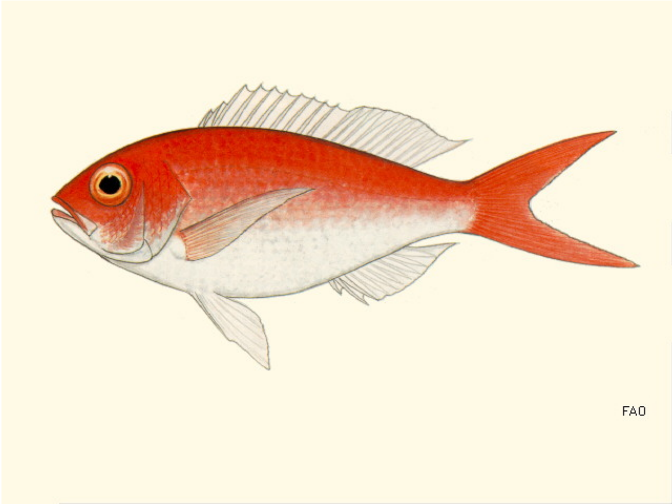


Picuílla, (*Sphyraena picudilla*), Sphyraenidae (barracudas), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1237

Chapín, *(Lactophrys trigonus)*, Buffalo trunkfish, Ostraciidae (boxfishes), Tetraodontiformes. Photo source: http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=1107

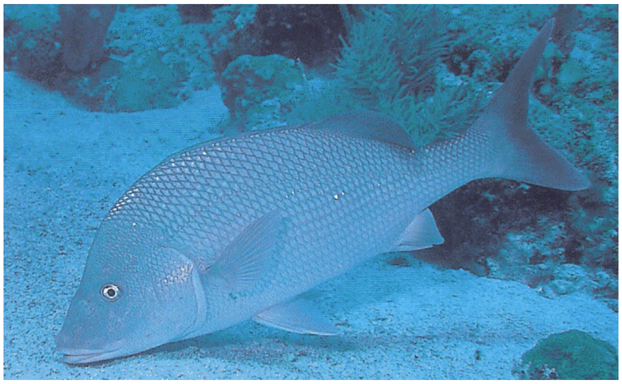
Colombiana, (Haemulon macrostomum), Spanish grunt, Haemulidae (grunts), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Moniama, *(Pristipomoides macrophtalmus)*, cardinal snapper, Lutjanidae (snappers), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=206

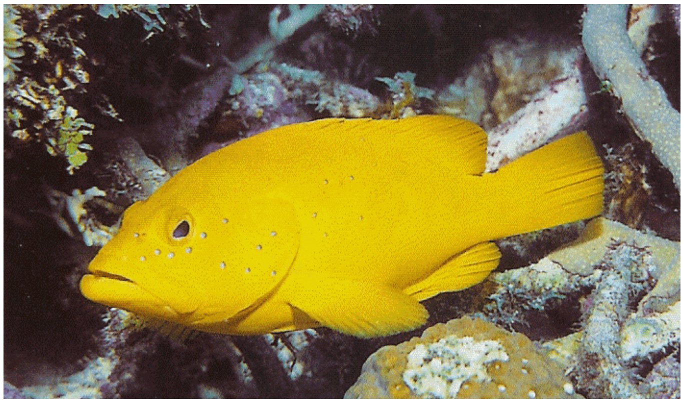


Mero cherna, cherna, *(Epinephelus striatus)*, Nassau grouper, Serranidae (sea bassess, groupers, and fairy basslets), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Vieja, chicata blanca, *(Haemulon album)*, white margate, Haemulidae (grunts), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



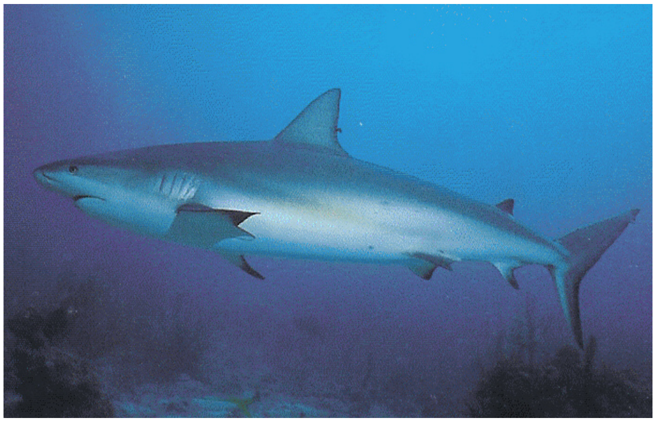
Mero fino, mero mantequilla, *(Cephalopolis fulva)*, coney, Serranidae (sea basses, groupers, and fairy basslets), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Burro, corvino, boca de ratón, *(Micropogonias furnieri)*, whitemouth croaker, Sciaenidae (drums and croakers), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=7620

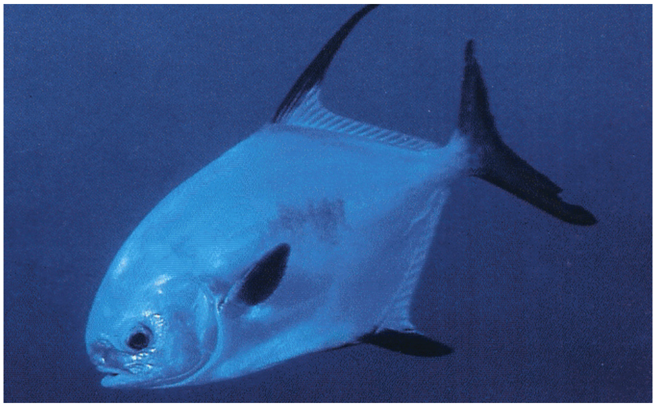
Robalo, *(Centropomus undecimalis)*, snook, Centropomidae (snooks), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=345

Tiburón, Tiburón gris,*(Carcharinus perezii),* Caribbean reef shark, Carcharhinidae (requiem sharks), Carcharhiniformes, Elasmobranchii. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

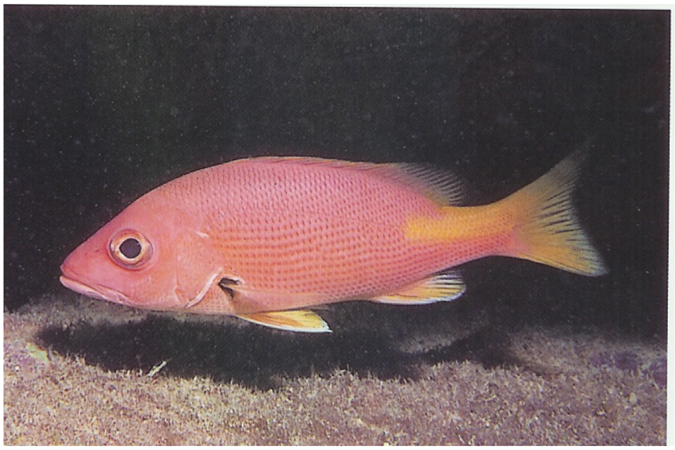


Buchúa, Besugo, *(Rhomboplites aurorubens),* vermilion snapper, Lutjanidae (snappers), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Pámpano, *(Trachinotus falcatus),* permit, Carangidae (jacks and pompanos), Perciformes. Phot source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Negra, Chillo Alanegra, *(Lutjanus bucanella)*, blackfin snapper, Lutjanidae (snappers), Perciformes, Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

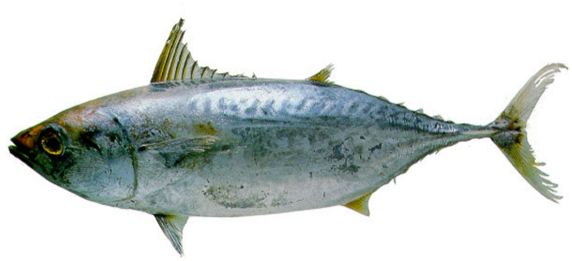


Lisa, macho de lisa, *(Mugil liza)*, Mugilidae (mullets), Perciformes. (No photo available)

Corcovado, *(Selene setapinnis)*, Atlantic Moonfish, Carangidae (jacks and pompanos), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=378

Boqueta, Bocúa, *(Cetengraulis edentulus)*, whalebone anchovy, Engraulidae (anchovies), Clupeiformes. (No photo available)

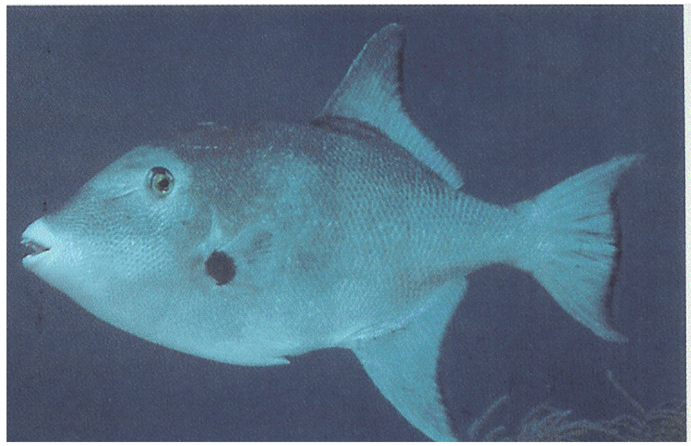
Bonito, Vaca, *(Euthynnus alleteratus)*, Little tunny, Scombridae (mackerels, tunas, bonitos), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=97



Albacora, bonito del Artico, *(Katsuwonus pelamis)*, Skipjack tuna, Scombridae (mackerels, tunas, bonitos), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=107

Marlin, aguja azul, *(Makaira nigricans)*, Atlantic blue marlin, Istiophoridae (billfishes), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=216

Pejepuerco gris, pejepuerco oceánico, *(Canthidermis sufflamen),* Ocean Triggerfish, Balistidae (triggerfishes), Tetraodontiformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Sardina de pluma, *(Opisthonema oglinum),* Atlantic thread herring, Clupeidae (herrings, shads, sardines, menhadens), Clupeiformes. Photo source: Suárez Caabro, J. 1979. El Mar de Puerto Rico. Editorial de La Universidad de Puerto Rico.

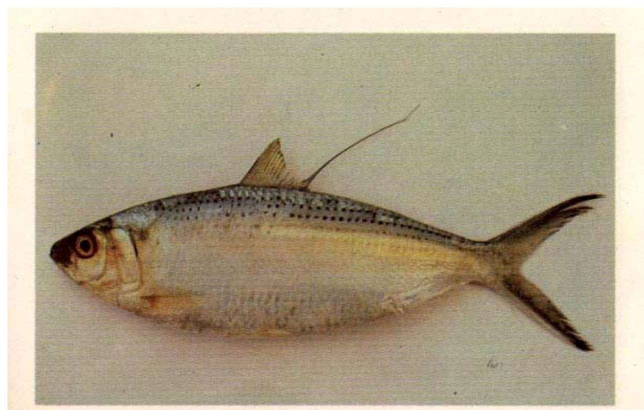
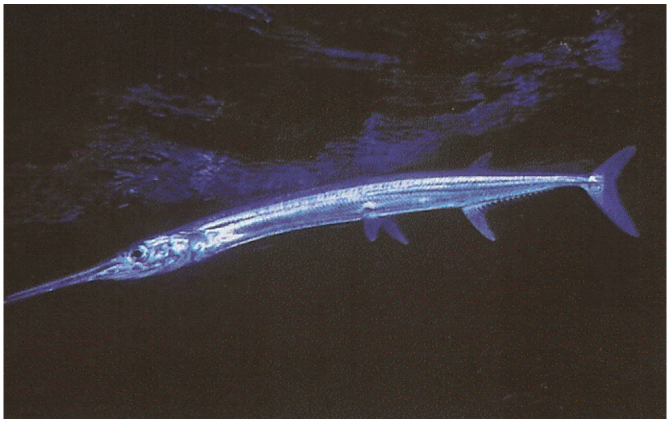


Lámina II. Arenque (Atlantic Thread herring), *Opisthonema oglinum* (Lesueur), L. t. 20 cm.

* L.t. - largo total

Bocona, sardina, setí *(Anchoa hepsetus),* anchovy, Engraulidae (anchovies), Clupeiformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1133

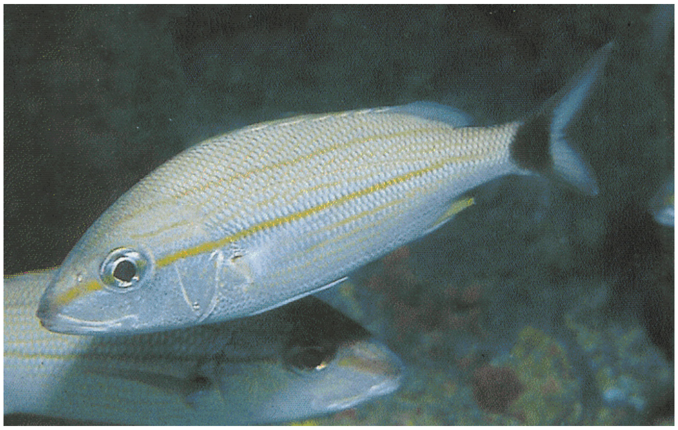
Agujón, *(Tylosurus crocodilus),* needlefish, Belonidae (needlefishes), Beloniformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Chopa, chopa de orilla, *(Kyphosus sectator),* Bermuda sea chub, Kyphosidae (sea chubs), Perciformes. Photo source: http://www.fishbase.com/Summary/speciesSummary.php?ID=2498

Sábalo, *(Megalops atlanticus),Atlantic tarpon* Megelopidae (Tarpons), Elopiformes. Photo source: Carlos García-Quijano field pictures, Ponce, PR, 2004.

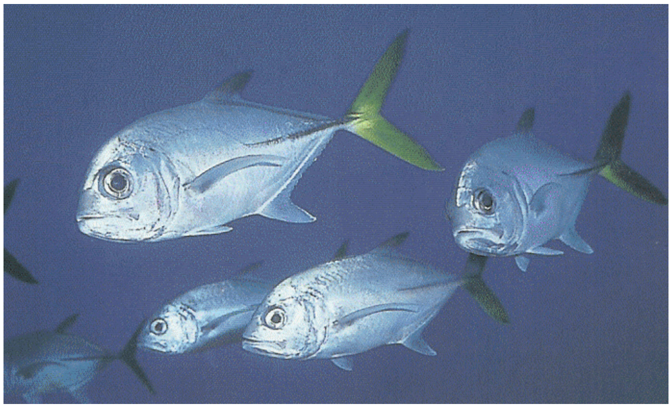
Mula, mulita, *(Haemulon aurolineatum),* tomtate grunt, Haemulidae (grunts), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



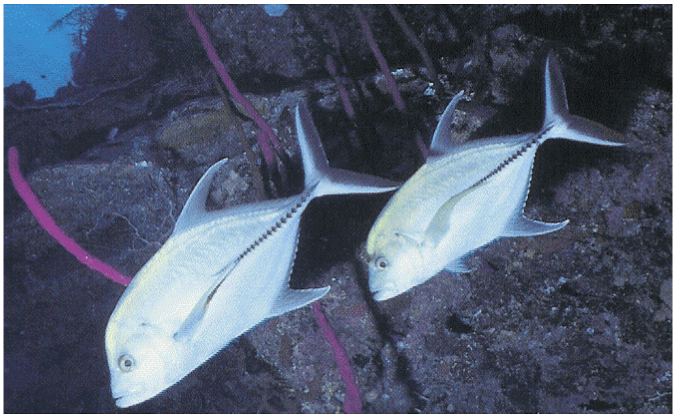
Ronco, corvino, *(Odontoscion dentex),* reef croaker, Sciaenidae (drums and croakers), Perciformes. Photo Source: FISHBASE; http://www.fishbase.com/Summary/speciesSummary.php?ID=1185

Chicharro, *(Selar crumenophthalmus),* Bigeye scad, Carangidae (Jacks and Pompanos), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

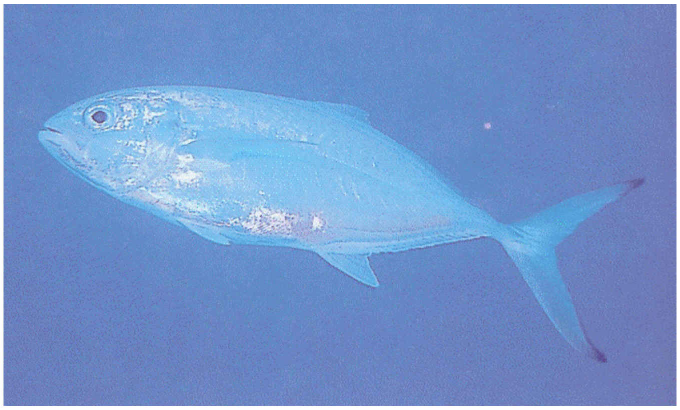
Jurel Ojón, *(Caranx latus),* horse-eye jack, Carangidae (jacks and pompanos), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



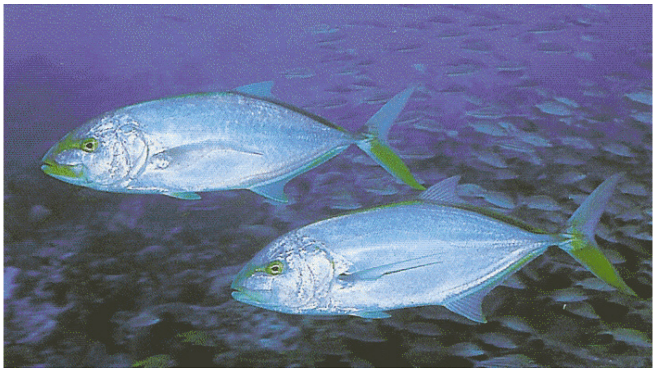
Jurel negrón, *(Caranx lugubris),* Carangidae (jacks and pompanos), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Cojinúa medregala, *(Caranx crysos),* blue runner, Carangidae (jacks and pompanos), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

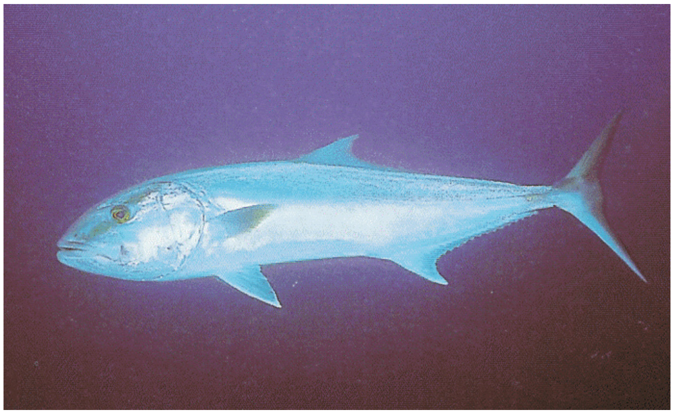


Jurel, Jurel rabiamarillo, *(Carangoides bartholomaei),* yellow jack, Carangidae (jacks and pompanos), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

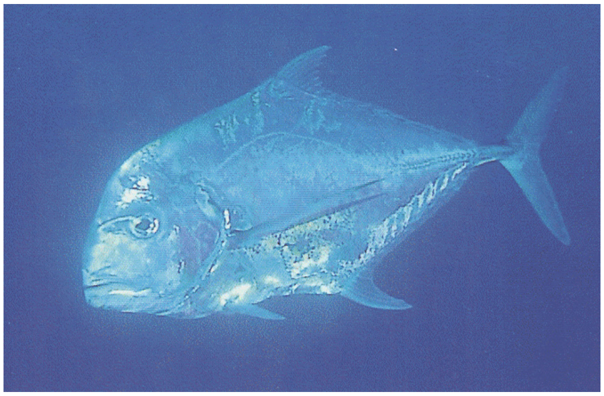


Salmón, silvín, *(Elagatis bipinnulata),* rainbow runner, Carangidae (jacks and pompanos), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=412

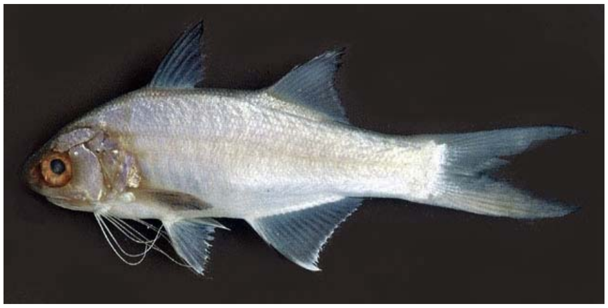
Medregal, *(Seriola dumerili),* Greater Amberjack, Carangidae (jacks and pompanos), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



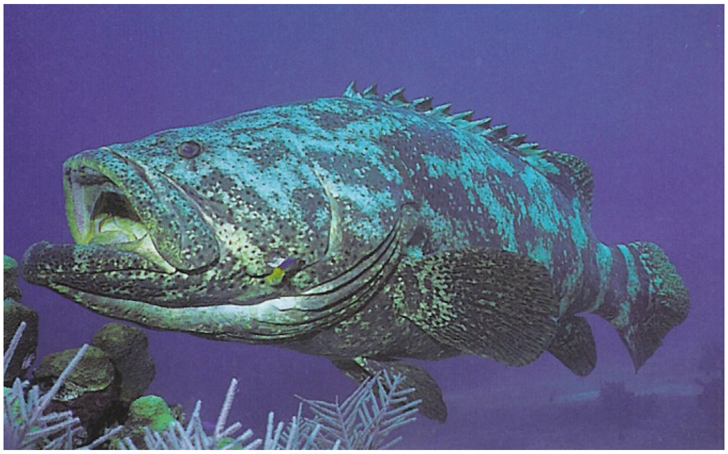
Pompano, corcobado de pluma *(Alectis ciliaris),* African pompano, Carangidae (jacks and pompanos), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Barbú, *(Polydactylus virginicus),* barbu threadfin, Polynemidae (threadfins), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=1112



Mero sapo, batata, *(Epinephelus itajara),* jewfish, itajara, Serranidae (sea basses, groupers,and fairy basslets, Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

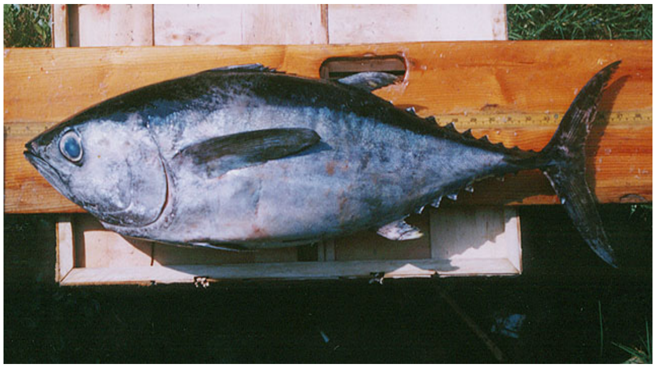


Congre, *(Gymnothorax funebris)*, green moray, Muraenidae (moray eels), Anguilliformes. Photo source: FISHBASE; http://www.fishbase.org/Summary/SpeciesSummary.php?id=7546

Gallo, candil, candelero, *(Holocentrus adscensionis)*, squirrelfish, Holocentridae (squirrelfishes and soldierfishes), Beryciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

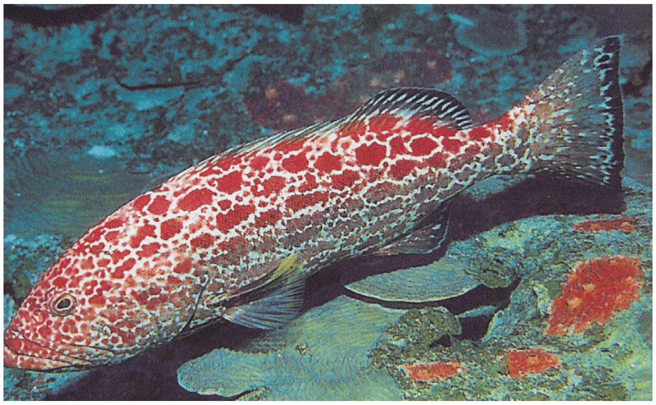
Atún albacora, tuna albacora, *(Thunnus alalunga)*, Albacore, Scombridae (mackerels, tunas, and bonitos), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=142

Albacora, atún común, *(Thunnus atlanticus)*, blackfin tuna, Scombridae (mackerels, tunas, and bonitos), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=144



Atún cola amarilla, albacora, *(Thunnus albacares)*, yellowfin tuna, Scombridae (mackerels, tunas, and bonitos), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=143

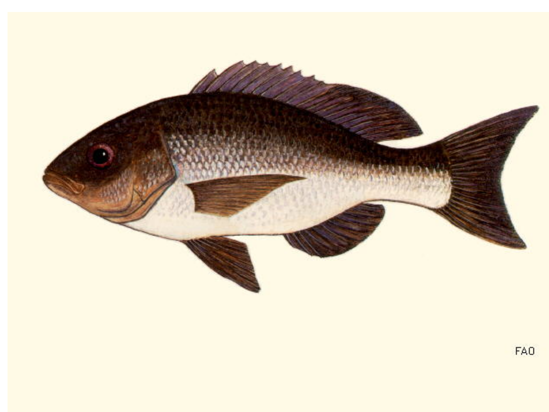
Guajil, mero guajil, *(Mycteroperca venenosa)*, yellowfin grouper, Serranidae (sea basses, groupers, and fairy basslets), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



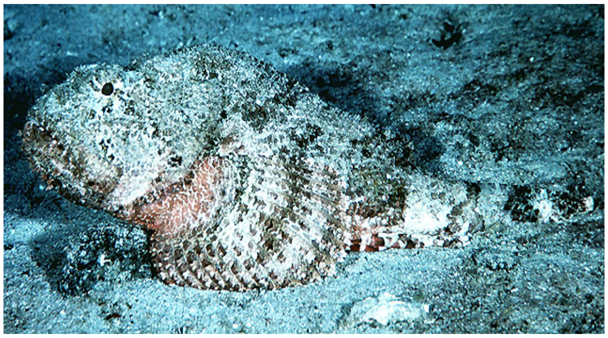
Salmonete de altura, salmonete amarillo, *(Mulloidichthys martinicus)*, yellow goatfish, Mullidae (goatfishes), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Pargo prieto, *(Lutjanus griseus)*, grey snapper, Lutjanidae (snappers), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

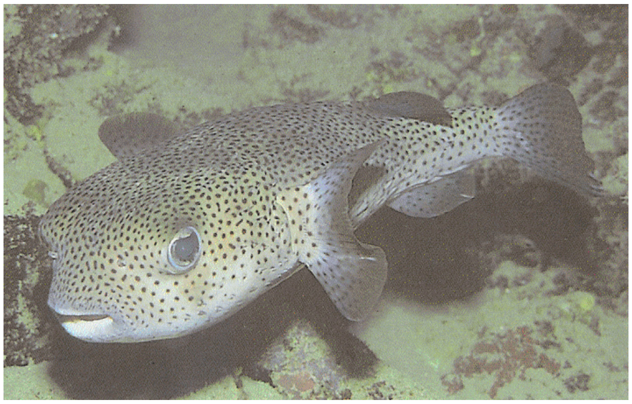
Chopa negra, chopa del hondo, *(Apsilus dentatus)*, Lutjanidae (snappers), Perciformes. Picture source: FISHBASE; http://www.fishbase.org/Summary/speciesSummary.php?ID=85



Veneno, rascana, rascazo, *(Scorpaena plumieri)*, spotted scorpionfish, Scorpaenidae (Scorpionfishes and rockfishes), Scorpaeniformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

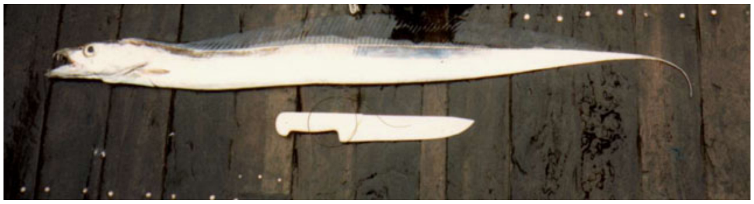


Guanábana, guanábano, *(Diodon hystrix),* porcupinefish, Diodontidae (Porcupinefishes), Tetraodontiformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



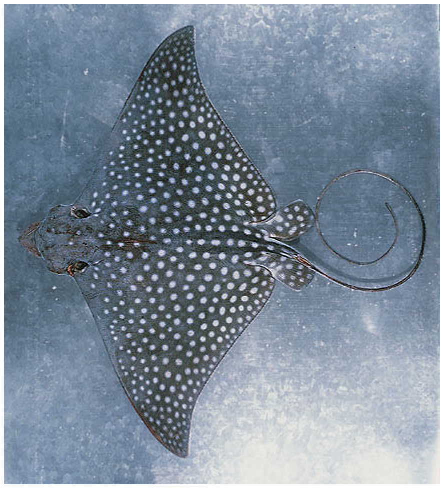
Tamboril, tambor, *(Sphoeroides splengeri)*, bandtail buffer, Tetraodontidae (puffers), Tetraodontiformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Sable, machete, *(Trichurus lepturus)*, cutlassfish, largehead hairtail, Trichuridae (cutlassfishes), Perciformes. Photo source: FISHBASE; http://www.fishbase.org/Summary/speciesSummary.php?ID=1288



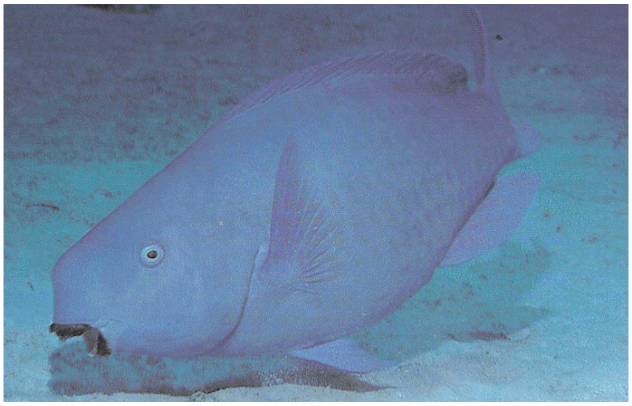
Casabe, *(Chloroscombrus chrysurus),* Atlantic bumper, Carangidae (jacks and pompanos), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=385

Chucho, mantarraya, *(Aetobatus narinari),* spotted eagle ray, Myliobatidae (eagle and manta rays), Rajiformes, Elasmobranchii. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=1250



Guacamayo, loro guacamayo, monchile, *(Scarus guacamaia)*, rainbow parrotfish, Scaridae (parrotfishes), Perciformes. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Loro azul, loro brinda'o, (*Scarus coeruleus)*, blue parrotfish, Scaridae (parrotfishes), Perciformes. Photo source: Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



Loro trompa de botín, cotorro, *(Scarus vetula)*, queen parrotfish, Scaridae (parrotfishes), Perciformes. Photo source: Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

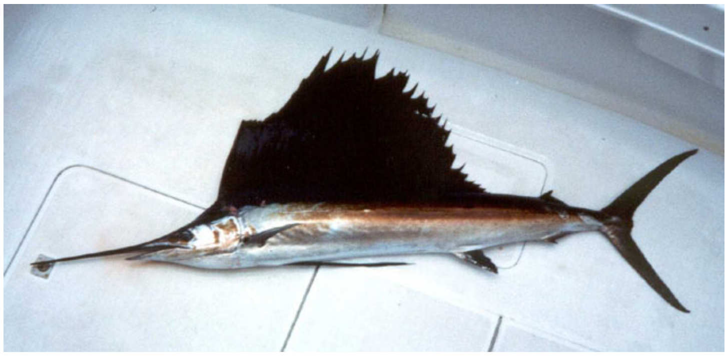
Loro verde, *(Sparisoma viride),* stoplight parrotfish, Scaridae (parrotfishes), Perciformes. Photo source: Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Sierra canalera, sierra de canal, *(Scomberomorus cavalla),* king mackerel, Scombroidae (mackerels, tunas, and bonitos), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=120

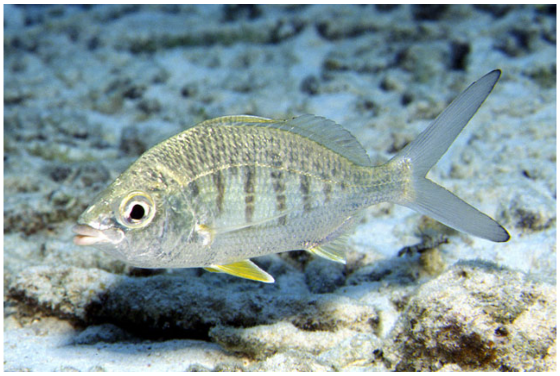
Aguja blanca, *(Tetrapterus albidus),* Atlantic white marlin, Istiophoridae (billfishes), Perciformes. Photo source: http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=219

Emperador, pez espada, *(Xiphias gladius)*, swordfish, Xiphiidae (Swordfishes), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=226

Vela, pez vela, *(Istiophorus albicans)*, Atlantic sailfish, Istiophoridae (billfishes), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/SpeciesSummary.php?id=78

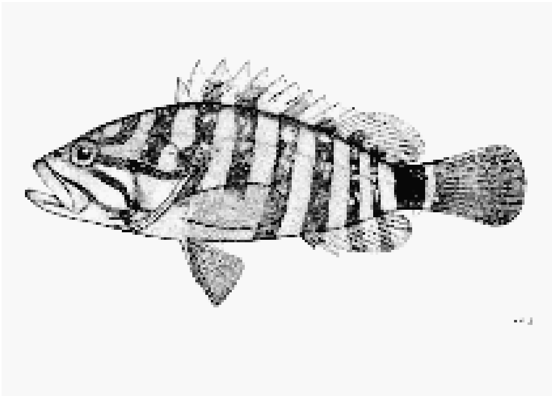


Moniama, mojarra, cachupín de cayo, *(Gerres cinereus)*, Yellowfin mojarra, Gerreidae (mojarras), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1054

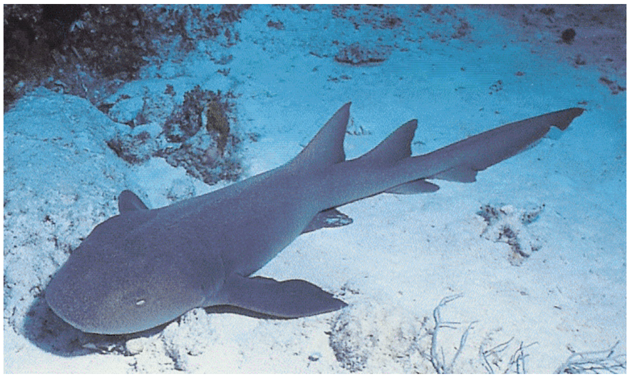


Cachupín, mojarra de orilla, pluma mojarra, *(Diapterus auratus)*, Irish mojarra, Gerreidae (mojarras), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=3563

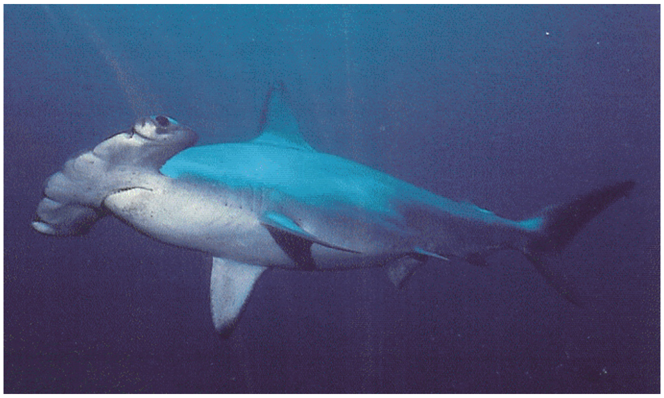
Mero guasa, *(Epinephelus mystacinus)*, misty grouper, Serranidae (sea basses, groupers, and fairy basslets), Perciformes. Photo source: FISHBASE; http://filaman.ifm-geomar.de/Summary/speciesSummary.php?ID=1206



Gata, tiburón gata, *(Ginglymostoma cirratum)*, nurse shark, Ginglymostomatidae (nurse sharks), Orectolobiformes, Elasmobranchii. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

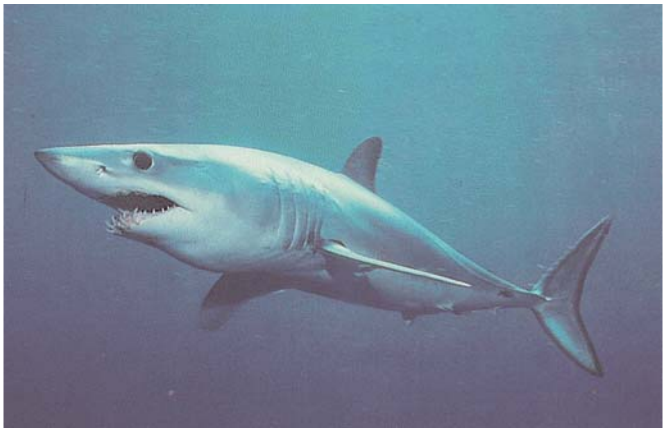


Cornúa, cornuda, martillo, *(Sphyrna lewini)*, scalloped hammerhead, Sphyrnidae (hammerheads, bonnetheads, and scoophead sharks), Carcharhiniformes, Elasmobranchii. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.



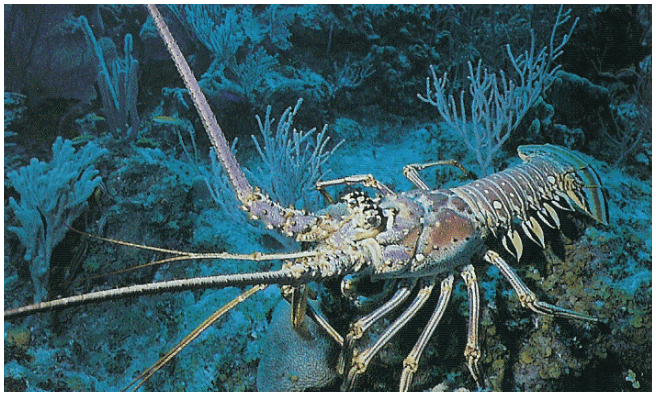
Tintorera, tiburón limón, *(Negaprion brevirostris),* lemon shark, Carcharhinidae (Requiem sharks), Carcharhiniformes, Elasmobranchii. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

Mako, tiburón carite, *(Isurus oxyrinchus),* shortfin mako, Lamnidae (mackerel sharks), Lamniformes, Elasmobranchii. Photo source: Humann, P. 1994. Reef Fish Identification: Florida, Caribbean, Bahamas, 2 edition. New World Publications.

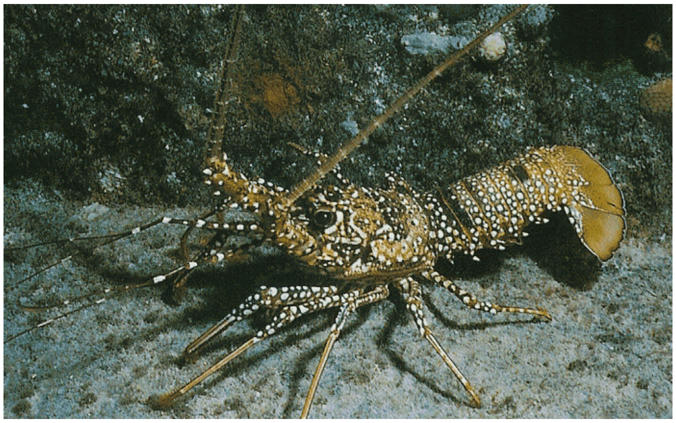


CRUSTACEANS

Langosta, *(Panulirus argus),* Caribbean spiny lobster, Paniluridae (spiny lobsters), Decapoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.

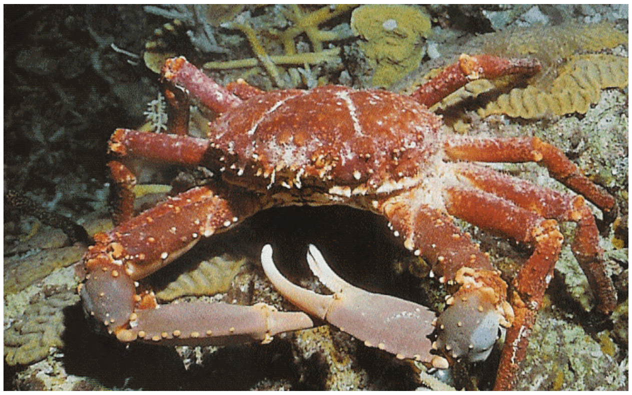


Guinea, langosta pinta, *(Panulirus guttatus),* spotted spiny lobster, Paniluridae (spiny lobsters), Decapoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.



Guábara, chágara, *(Scyllarides aequinoctialis),* Spanish lobster, Scyllaridae (slipper lobsters), Decapoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.

Centollo, King Crab, *(Mithrax spinosissimus)*, channel clinging crab, Majidae (clinging crabs), Decapoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.



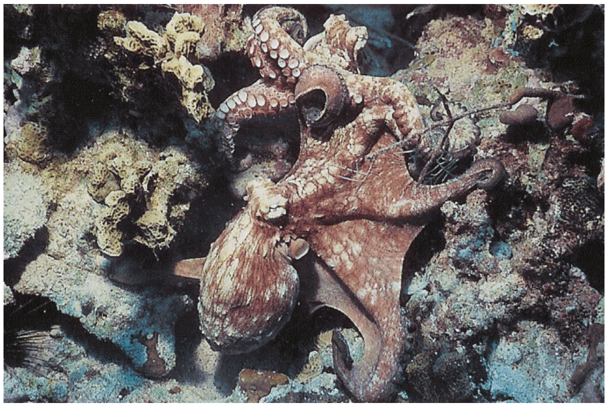
Juey dormío, *(Carpilius corallinus)*, batwing coral crab, Xanthidae (stone crabs), Decapoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.

Cocolía, *(Callinectes sapidus* and/or *Callinectes ornatus)*, blue crab, Portunidae, Decapoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.

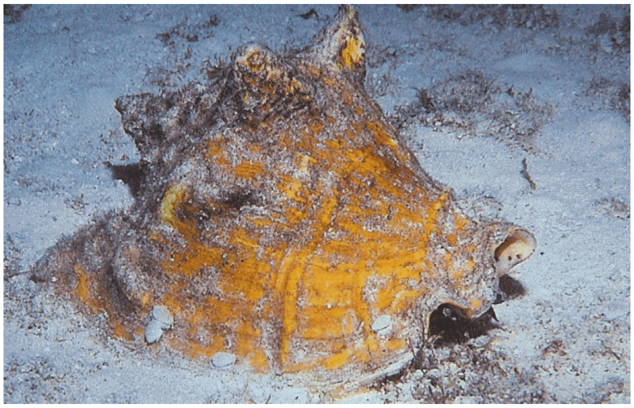
Juey, juey de tierra, juey palancú, (Cardisoma guanhumi), Atlantic blue land crab, Gecarcinidae, Decapoda. Photo source: Florida fish and Wildlife Conservation Commission; http://marinefisheries.org/recreational/bluelandcrab.htm

MOLLUSKS

Pulpo, *(Octopus vulgaris),* common octopus, Octopoda, Cephalopoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.



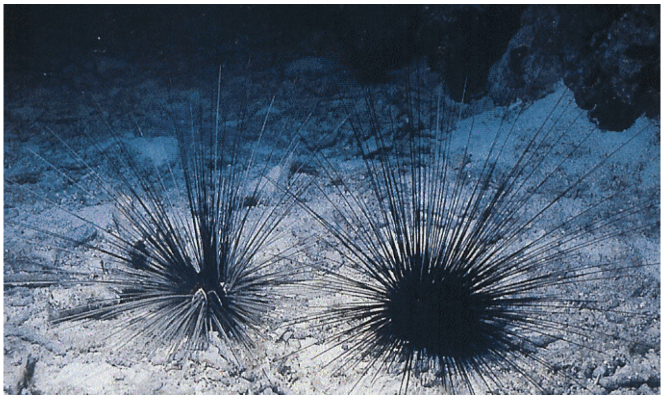
Carrucho, *(Strombus gigas),* queen conch, Strombidae, Gastropoda. Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.



Burgao, caracol de tapa, *(Cittarium pica),* West Indian topsnail, Trochidae, Gastropoda. Photo source: http://www.gastropods.com/4/Shell_24.html

ECHINODERMS

Erizo negro, *(Diadema Antillarum),* long-spined urchin, Echinoidea (sea urchins). Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.



Erizo blanco, *(Tripneustes ventricosus),* West Indian sea egg, Echinoidea (sea urchins). Photo source: Humann, P. 1992. Reef Creature Identification: Florida, Caribbean, Bahamas. New World Publications.