Chapter 11
Shifting Baselines in the Galapagos White Fin Fishery, Using Fisher's Anecdotes to Reassess Fisheries Management: The Case of the Galapagos Grouper

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Abstract This study links social and ecological aspects of the white fin fishery in San Cristobal Island. This is a traditional fishery focused at first on the Galapagos grouper (*Mycteroperca olfax*), a top predator and an iconic species of the archipelago as part of a traditional dish to celebrate Easter on the continent. We used anecdotal information and perceptions provided by three generations of fisherman to understand the impacts of fishing on the dried and salted fishery. Significant differences were found among fishers' groups surveyed and interviewed for this study. The oldest group indicated a greater past abundance of the Galapagos grouper than the other two younger age groups. The close relationship between fishers and their activity have generated certain knowledge about marine environments, its species, and the dynamics developed in their fishing areas, creating a perception of changes in this fishery.

Introduction

Overfishing, pollution, habitat destruction, diseases, and human-induced climate change are affecting marine ecosystems in profound ways (Jackson et al. 2001; Pauly 2000; Pauly et al. 2002; Jacquet and Pauly 2007). Among them, overfishing can alter dramatically the structure and function of marine ecosystems. This is because fishing at first usually focuses on top predators that play key ecological roles in marine systems (Pauly et al. 1998; Pitcher 2001; Myers and Worm 2003; Pauly et al. 2005; Worm et al. 2006). Scientists and natural resource managers usually lack accurate and necessary data related to fisheries and fishing pressure, as well as information related to the biology of species necessary for sustainable fishing activities. Moreover, our perceptions about the ocean are constantly

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changing (Roberts 2003). Given this gap of knowledge, Pauly (1995) in his *shifting baseline syndrome* of fisheries highlights the importance of understanding how each generation of fishers perceives marine changes, fish depletion, and the intensity of human impact over the marine ecosystems through time.

Unconventional sources of information such as historical accounts, archaeological data, genetic analysis, and anecdotal information had been used to recreate the status of marine resources prior to exploitation (Pinnegar and Engelhard 2008; Sáenz-Arroyo et al. 2006; Rochet et al. 2008; Lotze and Worm 2009). Critical information gathered from fishermen on environmental, ecological, and biological variables (*fishers' ecological knowledge*, *FEK*) could be used to understand how these changes affect marine resources and influence fishers' activities. In turn, this information can support more assertive management actions to preserve marine ecosystems (Neis et al. 1999; Johannes et al. 2000; Crowder 2005; Murray et al. 2006; Wilson et al. 2006; Grant and Berkes 2007; Schafer and Reis 2008).

In the Galapagos Islands, fishing is an important economic activity and, although the number of fishermen has declined steadily since the 2000s, still represents an important source of income in the local economy. During the nearly 70 years of continuous fishing in the Galapagos, fishermen have developed an important link with marine resources creating social-ecological relationships where the access, use, and control of these resources have been marked by climatic, socioeconomic, political, and management regimes (González et al. 2008; Tapia et al. 2008, 2009). In this sense, San Cristobal is the island with major fishing tradition in Galapagos, and the largest number of boats and fishers engaged in this activity (Reck 1983; Castrejón 2008).

With few exceptions (Reck 1983; Granda 1995; Ruttenberg 2001; Okey et al. 2004; Hearn et al. 2005; Peñaherrera 2007; Peñaherrera and Hearn 2008; Bustamante et al. 2008; Castrejón 2008; Sonnenholzner et al. 2009; Edgar et al. 2010), the impacts of fishing in the Galapagos are still poorly understood for most species, and key historical information regarding the status of these species prior to fishing pressure is largely unavailable. The Galapagos grouper locally known as *bacalao* (*Mycteroperca olfax*, Serranidae) is a species that plays an important role in the composition of the marine ecosystem and is vulnerable to fishing pressure because of its restricted distribution and its special life history characteristics (e.g., slow growth, long life span, complex life cycle, reproductive conditions, and its role as a top predator in the trophic cascade, occupying the 4.5 trophic level) (Reck 1983; Coello and Grimm 1993; Nicolaides et al. 2002).

For decades *bacalao* was the most valuable commercial species in the composition of the white fin fishery in Galapagos. It was the main supply for dried and salted fish used in the preparation of *Fanesca*, an Ecuadorian traditional dish consumed during the religious holiday of Easter. However, with the emergence of fishing of other species (e.g., lobster and sea cucumber) and tourism, the presence of the Galapagos grouper in the catch composition of this fishery is significantly lower

than decades ago and highly variable (Granda 1995; Peñaherrera 2007; Gagern 2009).

In the Galapagos, fishers' ecological knowledge could provide important information to determine changes in the status of marine resources across time, especially when biological data is lacking. With this context, the objectives of this research were as follows: first, to briefly describe the dynamics of the white fin fishery in San Cristobal Island and, second, to identify signs of shifting baselines from a representative element of this fishery, such as the Galapagos grouper.

Using anecdotal and quantitative information from three generations of fishermen, this research tries to find out the differences in perceptions across generations of fishermen about the Galapagos grouper. A good understanding of the different views within the fisheries communities would contribute to the generation of comprehensive plans for better conservation and fisheries management.

Research Site

Our research focused on the artisanal fishing fleet of San Cristobal, Galapagos Islands. The Galapagos Marine Reserve (GMR) is one of the largest marine protected areas in the world. It comprises the coastal and marine area within a range of 40 nautical miles (nm) surrounding the archipelago and inland waters (50,100 km^2). The Galapagos Archipelago includes both a marine protected area of approximately 138,000 km^2 and a land National Park of 8,000 km^2. The National Park encompasses 97 % of the land territory of the Galapagos, while the remaining 3 % is spared for human habitation (Heylings et al. 2002).

The archipelago has a wealth of marine and coastal habitats characterized by the interaction of a set of oceanographic, climatic, and geological conditions where the confluence of the Peru, Panama, and Cromwell currents allows the existence of ecosystems that harbor distinctive marine communities (Bustamante et al. 2002). There are about 444 fish species, out of which 41 are endemic, representing 9.2 % of the total species recorded (Peñaherrera 2007).

San Cristobal has the second largest population within Galapagos (7,475 persons, INEC 2010). Fishermen represent 3.6 % of the total population, with fishing being one of the main economic forces after tourism, conservation, and the public administration. In recent years, the profitability of fishing has declined as a result of overfishing of the sea cucumber and the spiny lobster fishery. In the whole archipelago, there are a total of 1,023 fishermen registered in the Galapagos National Park, and in Puerto Baquerizo Moreno, San Cristobal, there are 520 fishermen, which comprises 50.8 % of all the fishermen of the islands (Castrejón 2008).

Methods

To assess the status of the white fin fishery, we gathered fisher's anecdotal information and we quantified fishers' perceptions about changes in the Galapagos grouper past abundance.

We sampled active fishermen registered under any of the two cooperatives and also retired fishermen that belong to the first families who participated in this activity in the 1940s and 1950s and whose historical knowledge extends as far back as the beginning of the activity.

Snowball sampling method was used (Goodman 1961) where key informants led us to other individuals and these in turn to others, creating a chain of information. The first group of respondents, indicated by key informants, was located randomly for a start sample in the pier where they spend most of the day, in the fishing cooperative, and in the Central Park. For in-depth interviews, we located the oldest fishermen. Interviews were conducted one-on-one at home and fully recorded.

In order to quantify how the experiences of fishermen have changed over time, we consider primarily the methodological approach used by Sáenz-Arroyo et al. (2005a, b), Bunce et al. (2008), and Parson et al. (2009) who first tested quantitatively and qualitatively shifting baselines in coastal and island environments. Surveys and interviews were conducted between January and March 2010. First, we implemented a closed-question questionnaire to 124 fishermen who accounted for 24 % of the fishing population. The questionnaire was structured in two sections (1) social features of the fisherman, including demographic, social, and economic characteristics, and (2) information on fishing activities, including the perceived changes in this fishing type on the marine ecosystem and possible implications.

Upon completion of the survey, we conducted semi-structured interviews with key players involved in fisheries, identified by their knowledge and experience in their activity. We quantified the perception of fishermen regarding fishing decline and changes in the state of the marine ecosystem from a representative element, in this case the Galapagos grouper.

Active and retired fishermen came from three age groups: young (15–35 years, $N = 41$), middle age (36–50, $N = 49$), and older ($\geq$51 years, $N = 34$). Initially, in order to determine the degree to which the fishermen of San Cristobal perceive the decline of white fin fishery and identify shifting baseline signals, fishermen were asked to (1) list white fin fish species they believed have declined during their fishing time, to later compare the perception of declining species cited by older fishermen to younger ones. To facilitate identification of species, we developed a guide with 68 color images of fish of commercial interest, placed by family and identified with the common and scientific names. This guide was developed from the one generated by the Charles Darwin Foundation (CDF) (2005) of fish species in the Galapagos Marine Reserve. (2) To assess the status of the Galapagos grouper, specifically, fishermen were asked to detail the best catch in relation to the biggest individual that they have ever captured and the total amount of pounds of grouper

fished in their best fishing day. Fishermen also estimated the length of the largest grouper they have captured, showing the distance from his fingertips to the shoulders, or using both arms if the individual was longer. The length of the fish was rounded to the nearest centimeter and converted to biomass using conversion values length–weight ($W = aL^b$) (Hart and Reynolds 2002) with constant factors for this species published in FishBase (2009) (http://www.fishbase.org/search.php).

Furthermore, 23 interviews were conducted with fishermen whose fishing participation is recognized for their experience and knowledge. The interviews were held in San Cristobal and Santa Cruz. The information generated in the interviews was digitally recorded and transcribed in full. Data was organized by age and name. Fishermen' comments collected in the interviews were organized by themes, and identified the most representative observations in relation to changes on the status of this fishery over time. Data was analyzed using SPSS Statistical Analysis Program (IBM Statistics v17).

Results

Fishermen Characterization

Currently, Puerto Baquerizo Moreno has the largest number of boats (212 among small and big ships) and fishermen engaged in fishing (520 fishers). Fishermen can be classified in three groups: full-time, part-time, and casual fishermen with over 50 % of the fishermen doing fishing full time. Also, most fishers are generalists; this means that they change target species based primarily on the availability of the marine resource, market demand, and management measures established by the Galapagos National Park. Under their control, a fisherman with fishing license (PARMA) can capture any fishery resource whose extraction is legally authorized. The fishing method most often used is the handline known as *empate*, followed by the lure or drag (*señuelo* or *arrastre*) and the hookah diving or air line diving. The use of different fishing gear and its adaptations with certain modern materials is determined in part by the regulations of the Galapagos Marine Reserve and by the fishers' needs to improve their fishing efficiency. During their fishing trips, most fishermen use fiber boats towed by a bigger boat when they go on long trips.

Here we describe fishermen by their age class to explore the influence of age in fishing behavior and perceptions:

Old fishermen ($\geq$51 years, $N = 34$): 61.8 % of them migrated to Galapagos in the early 1930s. At the time of their arrival, their age ranged between 1 and 10 years old. For those that are alive, they have lived in the islands for more than 70 years. They started fishing between 1940 and 1960; consequently, 61.8 % of the old fishers' group has between 30 and 50 years of fishing experience. 50 % of fishers in this group currently go fishing on trips from 15 to 20 days as the other age groups; but the other percentage used to go fishing on trips mostly from 8 to 12 days. 47.1 % of the old fishermen are dedicated exclusively to the white fin fishery.

Middle-aged fishermen (36–50 years, $N = 49$): 51 % of this group were born in the Galapagos, and the other percentage mostly arrived at an early age. They began fishing mainly between 1970 and 1990; only the 20.4 % started in the 1990s. Almost 70 % of fishermen have more than 10 years of fishing experience, and only 20.4 % are dedicated exclusively to the white fin fishery. Important to note, 85.71 % of fishermen in this group fish on long trips from 15 to 20 days.

Young fishermen (15–35 years, $N = 41$): like middle-aged fishermen, half of them were born in the Galapagos; a second subgroup of migrants arrived to the islands with the sea cucumber fishing boom in the 1990s, and a third more recent group of fishermen have seasonal participation in fishing combined with work on other activities, such as tourism and construction. 68.3 % started their activity between the 1990 and 2000, and 87.8 % have between 10 and 20 years of fishing experience. They prefer to go fishing on a daily basis (usually four times a week). The few young fishers that go on long trips reported mainly fish from 15 to 20 days as the other groups.

In terms of economic status and expectations, most fishermen focused their fishing effort on the white fin, sea cucumber, and spiny lobster fishery (young = 85.4 %, middle-aged = 69.4 %, old = 41.2 %), but more recently, fishermen have been diversifying their activity because they believed that the cost-effectiveness of fishing has declined, as more than 70 % of fishermen reported decrease in profitability. Over 30 % of fishermen reported a decline in fishing landings compared with previous years. In addition, between 20 and 25 % recognize that prices in the local markets fluctuate widely and are controlled by intermediaries that take advantage of the situation. As a result, fishermen prefer other more lucrative activities, such as tourism, and recently middle-aged fishers are working in construction.

Almost 40 % of young and middle-aged fishers reported being interested in fishing other types of species like shark and sea urchin. Although they recognized that the National Park would never accept these fisheries, they believe that these species would give them profitability because they are in high demand by the market. On the other hand, the 64 % of the older fishers are not interested in fishing other type of species.

Fishers' Perceptions of the White Fin Fishery Depletion

Out of the 124 fishermen surveyed, 113 perceived a decline of up to 21 species as part of the white fin fishery. On average, 14 species were perceived as having declined. From them, a total of 10 species were mentioned in all the age groups (Table 11.1). *Mycteroperca olfax* and *Epinephelus mystacinus* (Misty grouper) were perceived as the most depleted species by fishermen. Additionally, other species were mentioned by an important percentage of fishermen in each age group: young fishermen identified *Acanthocybium solandri*, the middle-aged indicated *Seriola rivoliana*, and the old group described *Epinephelus cifuentesi* as the species depleted in their catches. Also, young fishermen reported as depleted three

Table 11.1 List of species most mentioned as depleted by the three fishermen groups, which shows the differences in perceptions between each age group

			Age groups (young, middle-aged, old)					
Family	Species	Common name	Total freq.	*J* ($n = 41$)	*M* ($n = 49$)	*O* ($n = 34$)	Trophic level	Habitat
Serranidae	*Mycteroperca olfax*	Galapagos grouper	108	32	45	32	4.5	Demersal, marine
	Epinephelus mystacinus	Misty grouper	55	17	22	15	4.5	Bathy demersal, marine
	Dermatolepis dermatolepis	Leather bass	16	4	4	8	4.5	Reef-associated, marine
	Paralabrax albomaculatus	White-spotted sand bass	17	5	5	7	4.5	Reef-associated, marine
	Epinephelus cifuentesi	Olive grouper	21	4	6	11	3.96	Demersal, marine
	Hemilutjanus macrophthalmos	Grape-eye sea bass	1	1	–	–	4.16	Demersal on rocky bottoms
Scombridae	*Thunnus albacares*	Yellowfin tuna	3	2	1	–	4.34	Pelagic-oceanic, oceanodromous, brackish, marine
	Thunnus obesus	Bigeye tuna	1	1	–	–	4.49	Pelagic-oceanic, oceanodromous, marine
	Acanthocybium solandri	Wahoo	17	7	6	4	4.4	Pelagic-oceanic, oceanodromous, marine
Scorpaenidae	*Pontinus clemensi*	Mottled scorpion fish	15	6	4	5	3.64	Demersal, marine
Mugilidae	*Mugil galapagensis*	Galapagos mullet	17	3	6	8	2.46	Demersal
	Xenomugil thoburni	Thoburn's mullet	17	3	6	8	2.29	Pelagic-neritic, marine
Malacanthidae	*Caulolatilus princeps*	Ocean whitefish	1	1	–	–	3.9	Reef-associated, marine
	Caulolatilus affinis	Bighead tilefish	1	–	–	1	3.74	Demersal

(continued)

Table 11.1 (continued)

Family	Species	Common name	Age groups (young, middle-aged, old)				Trophic level	Habitat
			Total freq.	*J* ($n = 41$)	*M* ($n = 49$)	*O* ($n = 34$)		
Lutjanidae	*Lutjanus argentiventris*	Yellow snapper	3	1	–	2	4.03	Reef-associated, marine
	Lutjanus novemfasciatus	Dog snapper	5	1	2	2	4.1	Reef-associated, marine
Labridae	*Semicossyphus darwini*	Galapagos sheephead wrasse	3	1	1	1	3.81	Reef-associated, marine
Haemulidae	*Xenichthys agassizii*	White salema	4	2	1	1	3.36	Reef-associated, marine
	Xenocys jessiae	Black-striped salema	3	2	–	1	3.4	Reef-associated, marine
	Haemulon scuderii	Grey grunt	1	–	–	1	4.2	Reef-associated, marine
Carangidae	*Seriola rivoliana*	Almaco jack	14	3	8	3	4.5	Reef-associated, marine

species that were not mentioned by the middle-aged and the older fishermen (*Thunnus obesus*, *Caulolatilus princeps*, and *Hemilutjanus macrophthalmos*); and old fishermen reported two species (*Caulolatilus affinis* and *Haemulon scudderii*), which were not described by any fishermen of the other age groups.

As expected, fishermen with more fishing experience recalled a greater past abundance of species. According to their perception, species started to decline in different periods of time. Old fishermen reported that the declining of white fin species started around the 1960s (70.5 %), and others from the same group said it started around the 1980s. Similarly, middle-aged fishermen reported the 1980s (77.5 %), and young fishermen mentioned the 1990s (70.7 %). The older group attributes the decline to the *Sociedad Pesquera de Galápagos*, *Predial*, which increased the number of boats and fishers because the demand for Galapagos fish raised the pressure in this fishery. The amount of fish that fishers caught at that time exceeded the type of fishing that was mainly for local consumption.

They perceived that fishing was more productive and profitable back then. Old fishermen sensed that the time they spend and the distance they had to travel to fish were smaller before. At that time, fishing operations lasted 8–12 days, enough to bring a good catch; also they could chose the size of the fish they sold and gave away smaller fish to relatives and friends. Likewise, they used to cut the head and tail before salting and drying the fish. Nowadays, they have to travel longer distances and spend more time to find fish, and the fish merchant is the one who dried the fish.

Old fishermen perceived a higher reduction in the number of species, across time, compared to the other age groups of fishermen surveyed. Figure 11.1 shows an ANOVA test that compares the perceptions of the three age groups.

Interestingly, the three groups agree that the main reason for the decline of the white fin fishery is the overfishing. They believe that the continuous fishing pressure on these resources over the years is affecting their abundance. Old fishermen reported that they previously fished only 6 months a year for the salt and dried season; but today, fishing occurs all year round, so species do not have enough time to grow and reproduce. Moreover, fishermen recognize that economic and political pressures within fishing cooperatives increased the number of fishermen and boats, creating more competition and therefore more pressure on fish stocks. Older fishermen indicated that there are some fishers, especially from the young group, who fished species at their reproductive stage or when they have not yet reached sexual maturity. Some noted that there are fishermen who use underwater guns and the Hawaiian spear for white fin fishery, which is not allowed by the GMR regulations.

*Fisher's Perceptions of Decline in Indicator Species (***Mycteroperca olfax***)*

Despite the lack of statistically significant differences in a reduction in the size of the Galapagos grouper across age groups (one-way ANOVA, $F = 0.868$,

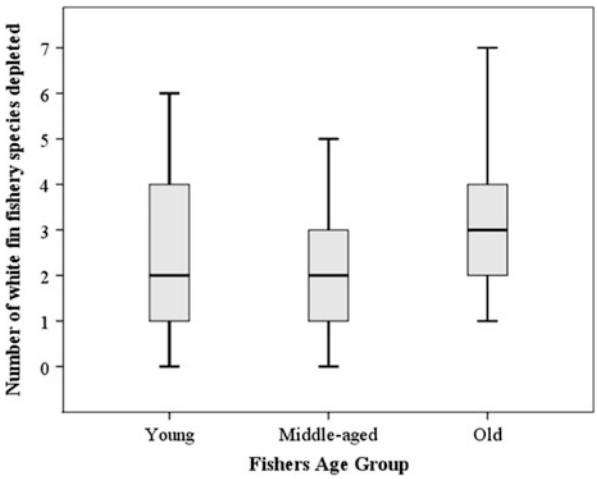

Fig. 11.1 Number of species that belong to the white fin fishery listed as depleted by three generations of fishermen (one-way ANOVA, $F = 3.210$, $p = 0.044$, HSD significant differences between the young and old age groups, $p \leq 0.05$)

$p = 0.422$), we found statistically significant differences in their best day's catch (Fig. 11.2). Older fishermen reported to have fished a higher amount of fish on their best fishing day. The study also found significant differences in the estimated weight of this species (biomass) across time (Fig. 11.3).

Fishermen observations indicate that 67.49 % species perceived as declined belong to the Serranidae family. From the 124 fishermen surveyed, 108 reported the Galapagos grouper as the species with the highest decline (33.44 %). Different age groups argue different reasons for changes in the *bacalao's* abundance, including overfishing, environmental change, and increased presence of sea lions in the fishing banks, among others. 70 % of old fishermen attributed this species decline to overfishing; on the contrary, only 29 % of young and 23.7 % of middle-aged fishers mentioned this reason as the main cause of this species' decline. Even though these were the most frequent responses within each age group, these percentages of fishermen did not represent a majority in each age group. The old fishermen perceived and explained the system dynamics in a distinct way compared to the other fishers' age groups.

Discussion and Conclusions

This chapter provides insights about the shifts of fishermen perceptions regarding marine resource status and trends through time of the white fin fishery across age groups in San Cristobal Island. The dynamic socio-ecological relationships between fishermen and marine resources have been developed across time in Galapagos (González et al. 2008), and fisher knowledge can complement scientific information and provide practical data that can be used in fisheries management

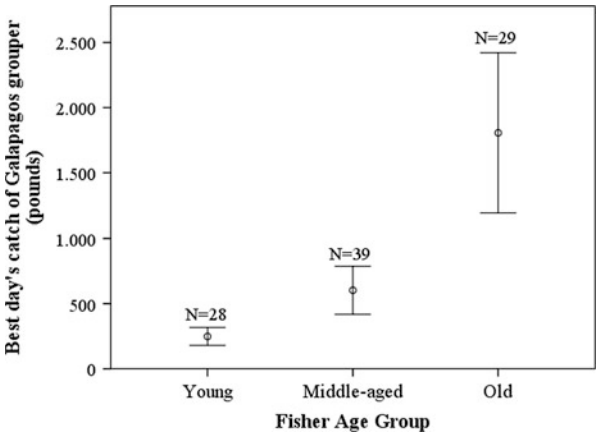

Fig. 11.2 Best catch of Galapagos grouper indicated by three generations of fishermen, recalling their best fishing day in terms of fished pounds (one-way ANOVA, $F = 20.897$, $p = 0.000$, Games-Howell significant differences among the three groups of fishermen, $p \leq 0.05$)

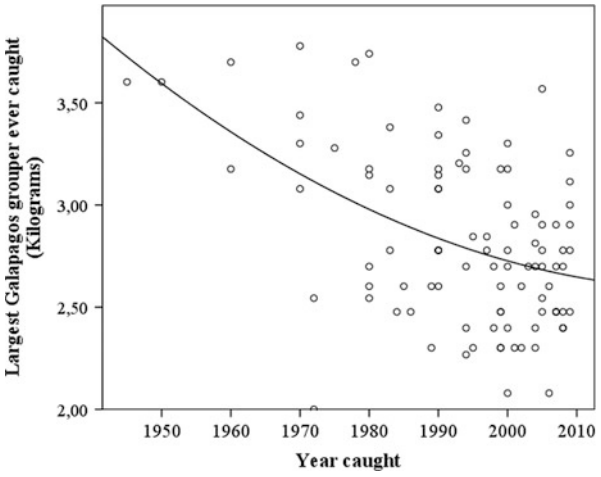

Fig. 11.3 Estimated weight of the Galapagos grouper (biomass) ever caught plotted against the year in which fishermen recalled the year of most abundance (second-order regression *line* shown $r^2 = 0.229$, $p = 0.000$)

(Johannes 1998; Silvano and Begossi 2005; Grant and Berkes 2007; Zukowski et al. 2011).

Due to the lack of continued fisheries data, often the only information available is fishers' anecdotes about past abundance, and its use is helpful to fully comprehend the extent to which fisheries have transformed marine ecosystems over the years (Johannes et al. 2000; Murray et al. 2006). Understanding the reciprocal interactions between fishers and marine resources, the knowledge and experiences produced around these interactions are necessary to understand the impact of fisheries on natural system and the changes that certain impacts of natural system can produce on fisheries dynamics (Perry and Ommer 2003). In this sense, fisher's anecdotes can make a valuable contribution to scientific knowledge about the state of the abundance of marine populations (Rochet et al. 2008; Ainsworth et al. 2008).

In our study, fishermen report that the composition of catches in the white fin fishery has changed across time. This is consistent with what has been seen along the years. Reck (1983) and Granda (1995) reported almost the same number of species in their studies (41–38, from 17 families); but Molina et al. (2004) reported an increase in 56 species from 18 families. Currently, the exploitation has been focused on 68 species belonging to 27 families, mostly Serranids, Scombrids, and Mugilids (Castrejón 2008). Recently, Gagern (2009) shows that there are enormous changes in the composition of landings, and the most significant change applies to the Galapagos grouper, which used to be the unique objective in the white fin fishery.

In San Cristobal, according to fishermen's perceptions, the relationship between white fin fishing resources and users has been very dynamic. At the begining of this fishery, the target species were different. They started fishing mainly the Galapagos grouper, and later diversified their fishing to other associated species, mainly Serranids. Over the years, young fishermen have expanded much more their target species, focusing not only on the coastal-demersal fish catch as the older fishers used to do but much more on pelagic species.

Regarding the dynamics and trends of the Galapagos grouper as a fishing resource of the white fin fishery, our results provide important insights which could complement scientific information for this fisheries management in the Galapagos Islands. In San Cristobal, 76 % of the fishers from the older group started their activity in the decades of 1940 and 1960, way before Reck initiated his research on the status of the white fin fishery (handline fishery) in 1976,[1] which is considered the baseline study of this fishery providing important information of catch composition and biological data of the *bacalao*. Until this period of time, this fishery lacked scientific data, except for fishers' historical and anecdotal information. In this sense, most of older fishermen reported that changes in the Galapagos grouper abundance started around the decade of the 1950s, almost three decades before Reck's study (1983), thus shifting the baseline of this fishery decades earlier from the first scientific information gathered on this resource.

Shifting baselines could be possible in the San Cristobal white fin fishery because, as Pauly (1995) observed, most marine ecosystems were assessed by scientists only after many species had declined and the historical amnesia has contributed to this phenomenon, where our perception of what is natural shifted toward more degraded ecosystems. As result, it is hard to assess the present state of marine ecosystems and suggest some management actions without knowing about the extent and drivers of past changes (Roberts 2003; Lotze and Worm 2009).

This chapter shows signs of shifting baselines among generations of fishermen regarding the white fin fishery impacts on target species (Figs. 11.2 and 11.3), which is a consistent result with similar studies carried out in other marine ecosystems (Sáenz-Arroyo et al. 2005b; Bunce et al. 2008). Fishers' perception on the

[1] Quiroga and Orbes (1964) and Barragan (1975) presented technical reports about the white fin fishery fleet composition and the fishing method, but they did not present information about the catch composition and the status of the species in the handline fishery at that time.

species decline and changes in the abundance of the Galapagos grouper are indicative of the historic pressure of this fishery, highlighting evidence of its change. The difference among fishers groups regarding the decline of *bacalao* in the composition of this fishery could be related to several factors, such as overfishing, reduction in breeding success due to biological changes associated with fishing pressure, environmental variations that affect species biology, and changes in fishing effort in areas with lower abundance of this species. Gagern (2009) has shown that there are enormous changes in the composition of landings since its beginning (he has considered as a baseline Reck's study—1983) and noticed that since 1983 until 2008, the Galapagos grouper shows a decline in total catches.

In relation to the size of the Galapagos grouper gathered through fishers' anecdote information, there are some inconsistencies. Although older fishermen recalled having caught larger individuals, no statistical differences were found and some of their estimation on the Galapagos grouper size in their best fishing day is 37 % greater than the maximum adult size indicated for this species (93.5 cm; Reck 1983; Gagern 2009[2]). It is important to note that perceptions are not exact, and inaccurate estimates could be due to several factors, such as the general tendency of people to exaggerate past events and romanticize "better past times," the inability to recall exact details, the difficulty in numerical calculations, and illiteracy (Sáenz-Arroyo et al. 2005a).

We found differences among the three age groups recalling their best fishing day (Fig. 11.2). The older fishermen recalled have landed a greater amount of *bacalaos* than the young groups. Additionally, the older group reported have caught the largest Galapagos grouper in the period of 1950–1980 when it started to decline gradually (Fig. 11.3). According to Reck (1983) the average of yearly landings of Galapagos grouper were 124.811 kg fresh weight; on the other hand, Gagern in 2009 only reported 61.086 kg, showing a notable decrease in the landings of this species.

Anecdotal reports from semi-structured interviews carried out to old fishermen showed that key events influenced greatly the way fishing was made in San Cristobal, in the early stages of the fishing activity. Some events, such as the creation of the freezing plant *La Predial* (1945–1955), the establishment of the American naval base in Baltra during the World War II (1945), and the continued technical development of fishing in the following decades, which reached its greatest progress in 1960 when the North American ships began to buy fish directly from the local fishers. The high seasonal demand and high prices for salted Galapagos grouper during October to March across decades also drove fishing efforts. All these events triggered not only the number of fishermen and boats that made up the Galapagos' artisanal fishing fleet but also their perception toward the *bacalao* fishing.

[2] Gagern's study presents a comparative analysis with Reck about the status of *Mycteroperca olfax*. His results show length distributions similar to Reck.

Later in the 1990s, more profitable fisheries developed such as the sea cucumber (*Isostichopus fuscus*) and the spiny lobster (*P. penicillatus* and *P. gracilis*) and moved the white fin fishery to third place in importance. However in the last decade, the marine reserve restrictions, coupled with the low profitability of the new fisheries, the growing demand for fresh frozen fish to be exported outside of the Galapagos which is uncontrolled and unrestricted so far, and the increased demand of local fish to satisfy the ever-growing tourist industry are factors that have intensified the pressure on the Galapagos grouper fishery.

Despite the special management regime of the Galapagos Islands, the coastal marine ecosystem has been changed by fishing activities and climatic events such as *El Niño* (Ruttenberg 2001; Bustamante et al. 2008). Top predators represent more than 66 % of the total biomass flow and more than 60 % of the total number of trophic connections (Bustamante et al. 2008). According to Vinueza et al. (2006), the Galapagos marine ecosystem seems to be characterized by the role of the top species and their strong interactions in the trophic chain, which would be higher if fishing pressure decreased, and also by environmental incidence on these ecological processes. In this sense today, Ruttenberg (2001) considered likely that the sequential decline, mainly of species that occupy the top levels in the food chain, had led to significant changes in the structure and functioning of coastal marine environments of the archipelago.

The Galapagos grouper is one of the main predators in Galapagos, Malpelo, and Cocos Islands in Costa Rica (Nicolaides et al. 2002). Currently, the species is considered vulnerable by the Red List of Threatened Species of the IUCN. The Galapagos grouper occupies the top level in the trophic chain along with other species such as sharks, whales, seabirds, and sea lions, among others (Mills et al. 1993; Bustamante et al. 2008). Therefore, its depletion could affect the structure, function, and diversity of marine subtidal ecosystems.

Nicolaides et al. (2002) reported that 21 % of *bacalao* was below the size of sexual maturity (female); their results showed fewer males in relation to females, suggesting a depletion of larger animals (males). Probably fishermen catch them before they undergo the sex change from female to male which characterizes most Serranids, affecting their reproductive success and population size. This species has an annual reproductive cycle with its spawning peak between the months of October and December. Like other groupers, they form spawning aggregations that coincide with increases in the sea surface temperature which mark the cold-warm season change (Reck 1983; Coello and Grimm 1993). These months were reported by fishermen as the most productive; therefore, fishermen focused their fishing effort on these aggregations likely decreasing the reproductive success of this species.

Taking in consideration the vulnerable ecological characteristics within the white fin fishery resources, the signals of shifting baselines, the differences in perceptions across age groups of fishermen, and the diversification of target species in later years, the following points should be further investigated: first, the

importance of including fishermen age and age groups as significant variables within the management strategies of natural resource management and conservation in the Galapagos fisheries. This chapter has shown that different age groups have different perceptions and attitudes toward the species and fishing in general. Age groups might have to be treated differently because they have different expectations and behaviors but also different fishing techniques, experiences, and knowledge levels. Second, it is especially important to monitor more the representative species catches in this fishery, as they may be affected too by historical fishing pressure as the Galapagos grouper. *Epinephelus mystacinus* (Misty grouper), *Paralabrax albomaculatus* (White-spotted sand bass), *Dermatolepis dermatolepis* (Leather bass), *Epinephelus cifuentesi* (Olive grouper), and *Hemilutjanus macrophthalmos* (Grape-eye sea bass) are also species that have a long history of suffering high fishing pressure. In order to prevent the decline in more top predators, it is important to study the biology of each species, integrating to studies of fishermen's perceptions in order to prevent further undesired changes in the ecosystem function that will not only affect the availability of marine resources but also would have social and economic consequences, since a significant part of the population is engaged in this fishery.

Finally, the white fin fishery has never been restricted as the sea cucumber and the spiny lobster fisheries. Throughout time, the composition of this fishery has dramatically changed, and top predators have been affected by the continuous fishing pressure. These species play an important role in the function of the marine ecosystem, and their decline draws attention of urgent management actions on this fishery. There is recognition from the users of the marine resources, about changes in the status of this fishery. The number of threatened species has increased, especially Serranid species. In order to keep the well functioning of the marine ecosystem and satisfy the social and economic needs of the fishermen household, it is important to ensure the representativeness of every species because the only way to keep the fish populations in good conditions is to have a sustainable fishing activity.

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Appendix

Table 11.2 Fishermen' comments from the older group, recalling past abundance of species in the white fin fishery

Fisher group	Comment
Old (>51 years), $N = 34$	Fishers fished white fin species all year round and this creates pressure in this fishery. Its species have decreased because of its over exploited.
	There is no depletion, there is the same amount of species, but divided amongst more fishers because now there are more fishers than before.
	The fishing activity has diminished a lot. The majority of the people who were fishers have changed to other activities as tourism.
	This fishery has been depleted. When I first came, the white fin fishery was good, in 8 days we already brought the catch. There is a decrease of species.
	This fishery has diminished a lot. Today fishers do not bring as much fish as before. Years ago, we did not fished in the farthest islands, but now fishers traveled around the all Archipelago looking for good places to fish.
	Before, fishers used to fish only for 6 months, and then they rested the other months, now they fish all year round and do not let the species grow.
	Today fishers spend more money than what really earn from this fishery. It is more difficult to fish because you need more days to catch a better amount of fish.
	Species have decreased because there are more fishers and fishing boat.
	The fishing volume is not the same as before. In 12 days you could make a good catch, now we have to go further, and even do it that, we do not bring enough fish.

Table 11.3 Comments extracted from the interviews to the middle-aged and older fishermen about changes in the abundance and size of the Galapagos grouper, an indicator species of the whitefish fishery

Fishermen age	Comments
38	Bacalao has been fished a lot, there is over exploitation. It has changed in abundance and size, before they were bigger than now. The same as the bacalao is happening to the Misty grouper.
38	There is almost no bacalao left, it is not like before; many sea lions compete with the fishers for this species and they also scare them away.
41	There are changes in its abundance there is not as much as before. There are some changes in its size. Sometimes when you catch them they are big but not huge.
47	Nowadays the bacalao has declined in quantity and size; all the boats go to the same place and fish the same species. Also there are people who use underwater guns on the white fin species and this fishing method scares the fish to deep water.
54	Before there was a lot of bacalao and you did not need to go as far as today, possibly climate change and over exploitation have finished this fish. There is no respect for the size of the fish, some fishers do not let them grow and now they fish all sizes.
61	The bacalao has decreased because the growing presence of Sea lions and the continuous fishing activity. Before you only caught quality bacalao, small fish were returned to the sea. Now you get more species and even the small ones.
62	There are ships from the continent which are fishing inside the Marine Reserve pressuring more the marine environment. Before you caught bacalaos in all areas and picked the better ones, the little ones were returned to the sea, but now you have to get whatever falls in the hand line.
65	Today there is more pressure in the dried and salted fishery because it takes from 7 to 8 months long.
65	Before the 6 months fishing for the whitefish fishery was respected, there were bigger fish and more abundant. Now there are many fishers from here and other places that fishes all year round.
66	The quantity of bacalao has dropped. If you go to the bottom, you can find big ones but not so many like before. Many fishers and boats do not let them grow.
71	Before they were bigger, now they are smaller, you cannot see as much as before. It has been fished a lot and without a banning period it is over. Before you let the smaller ones go, now you pick them all.
73	I fished during the time where there was a lot of bacalao. The dried and salted fishery has been done a lot and it has diminished. Now you do not see bacalao as before. Formerly you only fished bacalao and you sold it dried and salted without the head and tail. Today fishers dried and salted the complete body.
76	There is less bacalao than before and it is because some fishers catch them with a Hawaiian spear and underwater gun and this scare the aggregations. Older fishers used to catch them with the hand line, but nowadays some young fishers use other methods because it takes less time fishing with them.
76	Too many exploitation of the bacalao, it does not get bigger in size or in quantity, before we were few fishers and we picked less, now there are a lot of fishers who pick more.
79	Before we used to fish bigger fish. Now there are small and the quantity has changed.
83	Before we used to fish only bacalao, people did not want other fish. The size also has diminished. In my times you only picked the big ones and returned the small ones to the sea, today there are more fishers and boats and they do not let the bacalao grow.

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