An Evaluation of Fishing Practices in the Small Scale Fisheries of the Golfo de Fonseca, Honduras. Recommendations for Management

Stephen J Box
&
Ricardo Salgado Bonilla

2009

Abstract

The artisanal and small scale fisheries within the Honduran Golfo de Fonseca underpin the local economy and are an essential livelihood within small coastal communities. As a mixed fishery, confined within the shallow waters and mangrove estuary of the Golfo de Fonseca, the fishermen exploit a range of demersal and bentho-pelagic fish species using gill nets, hook and lines and bottom set long lines. In addition to fish, shrimp are an important resource and are targeted with trammel and cast nets.

In the absence of official statistics, anecdotal evidence suggests that all sectors of the fishery are in decline. This study aimed to assess whether unselective practices could be an important contributory factor to the purported decline and to identify management options that aim to increase the sustainability of the fishery. The study re-evaluated existing catch and length frequency data sets and collected new information during field work and through interviews with fishermen and other stakeholders.

We found that fishing within the Golfo de Fonseca predominantly uses gears with broad selectivity. Over a third of the landed catch by weight is low grade, low value fish. There is currently no market incentive for selectivity with little price premium for fish size compared to total fish volume. Of extreme concern is that large proportions of fish of commercially valuable species were being landed at sizes below the size of maturity. Within the group of the commercially most important fin fish, the "Babosas" (*Cynoscion spp*) the percentage of individuals within the landed catch that were below the estimated size at maturity ranged from 22 % (Babosa; *C. squamipinnis*) to 81 % (Corvina; *C. reticulates*). The majority of the landings of low value species and small sized individuals are mainly from the ubiquitous use of trammel nets that target shrimp. For every one pound of shrimp being landed, over five pounds of fin fish are also being landed.

The sustainability of fin fishing is likely directly inhibited by the shrimp fishing. Since it is the same fishermen who are reliant on both resources integrating shrimp management and fish management is recommended. Rather than specifying changes in gear types which are unlikely to occur due to limitations in enforcement, a more feasible option based on current management capacity is to identify and instigate a closed season for shrimp fishing that corresponds to peak abundance of small individuals of commercial fish species that use the area as a nursery ground. This would help to minimise the incidental catch of undersize fish by trammel nets which currently reduces the economic efficiency and ecological sustainability of the fishery.

In addition the study found that the extensive use of bottom set long-lining was likely to threaten the most ecologically vulnerable species found in the Golfo de Fonseca including the commercially important catfish *Bagre pinnimaculatus* and large pelagic species including sharks.

Based on the precautionary principle of sustainable fisheries management, long lining within the gulf should be prohibited until their effect on these vulnerable species can be investigated.

The lack of fishing selectivity was identified to be a clear problem in the Golfo de Fonseca fishery, however it is considered to be symptomatic of wider problems in the ecosystem and with the socioeconomic structure of the fishery as a whole. Other serious threats exist that are evidently going to affect sustainability, including the loss of critical habitat, water pollution and disruption in trophic webs that support the fish. From the perspective of gear selectivity, the current market structure rewards volume over quality and provides no incentive for using more selective methods of fishing. Addressing this problem first is necessary before any regulation in fishing methods will likely be successful.

Table of Contents

List of Tables

List of Figures

General Introduction

Fishing, the action of catching fish, has been an essential livelihood since the hunter-gather activities of prehistoric man. Fish provide an essential source of high quality protein, but fishing in itself has also become a defining part of the cultural identify of coastal communities, intertwined with their social structure.

With the exception of fish farming (aquaculture) fishing remains to this day a hunter-gather activity. Fishermen harvest their catch from wild fish populations and the replenishment of this resource is reliant on natural biological processes. Populations of wild fish (stocks) are controlled by the same three biological principles that control the dynamics of any other natural population: birth rate, growth rate and mortality. Fishing can be viewed as part of the mortality of fish stocks and man, simply as another predator.

It is within this framework that fisheries management must fit. Management aims to balance the social, cultural, economic and political context of fishing, against the inflexibility of biological principles. Typically, political and social objectives are to secure employment, ensure food security and increase revenue, with the ultimate goal of increasing living standards. The biological objective, by default, is to maintain the population of the fish so that they retain their function in the ecosystem. This often means identifying the maximum sustainable yield that a fishery can extract [1].

Frequently the social and political objectives overshadow biological reasoning. This can become exacerbated when a population of fish becomes severely depleted threatening the long-term sustainability of the fishery and the communities who rely on it. As stocks diminish social, spatial and technological competition increases at multiple scales. At a local level fishermen extend their range beyond traditional boundaries competing with neighbouring communities. At a regional level fishermen can cross national boundaries poaching fish from the territorial waters of other countries, often fuelling international tensions.

The failure of effective fisheries management therefore has far reaching implications. Declining catches usually result in increasing poverty in coastal communities, with the situation aggravated by few local alternatives to fishing. At this point it becomes clear that the economic and social objectives of management have clearly not been met. Ecologically, overfishing is also harmful, removing functionally important species from food chains, unbalancing trophic levels and upsetting ecosystems. It is then equally clear then that the biological objectives cannot be met unless management can effectively address the social, economic and political forces driving overfishing. As a consequence, the fishery management process must not only evaluate ecology and analyze the capacity and incentives of the fishing community, but must also consider the management authority as a key stakeholder [2].

With this theoretical setting we approach this study to assess the small scale fisheries of the Honduran Gulf of Fonseca. The aim is to evaluate the current fishing practices and their selectivity with the goal of identifying methods that can reduce accidental catch and increase sustainability.

Considering the existence of a recent and comprehensive 182 page report on the *artes de pesca* that details the capture techniques, presents catch data and describes the fishing communities [3], we aim here not to superfluously repeat that study. Instead we use information from within that report and combined with field observations, interviews with stakeholders, legal documents and scientific literature we freshly evaluate the current fishing practices and look to identify the most effective management options available given local social and political context. We aim to assess the fishery from both a socioeconomic and a biological perspective and identify the most likely root causes of fisheries decline; highlight current weaknesses that will prevent sustainability; and evaluate all available management options to identify practices that could effectively address fishery decline.

Background

Geopolitical considerations

The geopolitical situation and ecological characteristics of the Golfo de Fonseca make it a complicated location for fisheries management. The gulf extends into Central America from the Pacific Ocean, where the national borders of the Republics of Honduras, Nicaragua, and El Salvador, meet. The Gulf is a shallow sedimentary, estuarine ecosystem that is 60 km wide and 50 km long, with a coastline of 409 km. It includes 18 islands and six main watersheds with an aquatic area of 2015 square km and over 1,100 square km of mangroves [4].

Honduras shares political jurisdiction of the Gulf of Fonseca with Nicaragua and El Salvador. Fish stocks straddle these national boundaries, anthropogenic impacts on the marine environment have their origins in all three countries and all nations have significant numbers of small scale fishers that contend for the same fish. In essence each country shares a common resource, yet to date have rarely shared a common management objective. Whilst political steps are being taken that attempt to address some anthropogenic impacts, specifically pollution discharged in to gulf in the form of untreated sewage, industrial toxins, and agricultural run-off, Antigua Convention 2003 [5], tackling trans-boundary fisheries management is currently lacking the science and the political will to be effective.

The fisheries management of the Honduran portion of the Golfo de Fonseca must therefore accept the biological limitations ascribed by the geopolitical conditions and the aim of this study is to identify mechanisms that can enhance Honduran fishing livelihoods until the day that a more effective tri-nation management plan can be implemented.

Fisheries Management

Fisheries management actions are ideally based on an understanding of the fishing community, reliable and comprehensive biological data on the fish species and consideration of interactions between the ecosystem and the fish. To be effective management must also possess a legislative arm that can integrate communication and enforcement to implement strategies. This ideal scenario is however rarely found and the Golfo de Fonseca is no exception [6].

Fisheries management therefore must often start by identifying the most appropriate management strategies in a given situation based on currently available data, the actual state of regulatory authorities and the local social, cultural and political considerations. At the same time the short comings in data (both biological and social) and in regulatory capacity need to be highlighted with the aim to eventually strengthen management. Ultimately management should become a dynamic process which evolves as new information becomes available and adapts to new circumstances as they arise.

The fisheries management toolbox

The traditional approach of legislative fisheries management uses one of four basic concepts. These are defined as direct or indirect methods that can control either entry into the fishery (the number or effort of the fishermen) or the products leaving the fishery (the catch of fish). This forms a simple matrix of management options (Table 1).

Table 1 – Fisheries management matrix

	Input controls	Output controls
Indirect	a	b
Direct	c	d

Indirect mechanisms essentially aim to change the cost: benefit ratio for the economics of fishing. Direct mechanisms by contrast set predefined limits usually targeted at biological aspects of the fishery. There are a variety of management tools that are used in fisheries which are outlined briefly in Table 2. Whilst the focus of this study is to assess fishing gear and make recommendations, since management of fishing gear should be a consideration within a larger management plan, alternative approaches should be considered in relation to sustainability within the Honduran Golfo de Fonseca fishery.

Table 2 – General Options for Fisheries Management

Name	Definition	Aim
General Licenses	Licensing of individuals, or vessels	Define and quantify the fishing community to inform government policy on fisheries, and to enable fishery management legislation.
Limited entry licensing	Limiting the number of fishing or boat licences (either transferable or non transferable)	basic form of effort control and can be form of taxation
Catch quotas	Limits the amount of fish that can be landed in a fishery	basic form of output control
Market quotas	Applying quotas at the point of trade	limit market business instead of directly limiting fishing
Fishing rights ownership & Individual Transferable quotas (ITQ)	The ownership of the right to fish. ITQ's allocates fishing rights to individuals that can be traded as commodities	balance fishing capacity and fishing possibilities and promote stewardship through ownership.
Closed seasons	Preventing fishing at certain times of year, or during certain periods	provide protection during spawning, or during a particularly vulnerable and time-critical stage of the life-cycle.
Size limits	Restricting the size of the fish anyone is allowed to catch, or market (either minimum or maximum)	protect either sexually-immature fish, or larger more-fecund fish (or both)
Gear restrictions	Limitations on fishing methods or gear design that can be used in a certain area	protecting young fish and conserving stocks, preventing damage to substrates, reducing by-catch, or reducing the proportion of low-value catch

Results

The Fishery

The Honduran Golfo de Fonseca supports a small scale fishery (also called an artisanal fishery) [6]. The fishery is composed of communities who use small boats and low technology fishing gear to fish close to their home (generally within 20 miles) either to supply a limited commercial chain or for subsistence. Vasquez et al (2005) describes the fishery, the fishing communities, the boats and gears extensively. Here we summarize and re-evaluate some of the results they present.

Active Fishing Population

Anecdotal estimates of the number of fishermen in the Golfo varied widely during our field work. Verbal suggestions put the number around 3000 active fishermen and one Nicaraguan report suggesting there were 14,000 Honduran fishermen in the gulf [7]. In the absence of accurate official records the most probable estimate comes from Vasquez et al (2005) of between 700 and 1000 fishermen. To evaluate the reliability of this estimate we looked at the total catch in the year 2004 -2005 and calculated a catch per fishermen per day of between 19 – 27 lbs (Table 3).

Based on reports from interviews with fishermen an average catch of between 19 – 27 lbs per fishermen per day correlates with their verbal estimates. Economically this estimate also makes sense. From interviews with fishermen, after overhead costs, a fisherman is likely to be making no more than 5 or 6 lempira a pound on the total catch. With this volume of catch a fisherman would be earning around 120 lempira per day. This income level matches field interview reports, the value calculated in Vasquez et al (2005) of 157 lempiras, and is realistic given the general socio-economic conditions for the area.

Table 3 – Estimate of average catch per person per day

Number of fishermen per day	**700 – 1000**
Total catch (2004 – 2005)	6910094 lbs
Estimate of catch per person per day	19 – 27 lbs

Fishing Gear

Current fishing techniques

There are two main types of boats used for fishing. Small canoes that are rowed from the shore and larger (15 – 30 ft) motor boats with engines usually from 15 – 40 Hp that fish further from the shore. These boats generally hold 2 fishermen and an assistant and do not venture out beyond the opening of the gulf. For the purposes of this study we will ignore the first type of fisherman as they are difficult to quantify, catch a small volume of fish usually only for subsistence, have a very limited range and do not enter either the market chain or the reporting system. Instead we will focus on the motorised artisanal fleet, that whilst low technology has a significant fishing pressure due to its sheer number of people.

In 2005 there were 1619 boats reported in a survey by Vasquez et al. Of which an average of 320 were fishing each day. We were not given access to boat licensing or fishing permit information to corroborate this estimate but the number matches the estimates of catch per day from the above calculations. Formalizing a boat registry and fishing license scheme where the data is readily available and current is the first important step in managing a fishery. Without this information it is very difficult to calculate fishing pressure and catch per unit effort statistics, both of which are important to evaluate fishery sustainability.

Applicable laws

The legal regulations pertaining to fishing are clearly defined in the *Ley de Pesca 1959* and the Reglamento general de pesca 2002. The laws of relevance to this study detailing the fishing gears are described in Table 4

Table 4 – Summary of legislation relevant to fishing gear

Reglamento	Summary
Fin fish	The opening in the mesh of fishing nets must not be less than 3 inches
Artesanal shrimp	The use of nets of mesh number 8 combined with a net of mesh 7 ½ commonly known as "witches" is prohibited.
	Nets known as "sleeves" are prohibited when they have a mesh smaller than 2 ½ inches
Fishing of post-larval shrimp	Only allowed with the hand net known as a "chayo" that is 1.5 yards in size with a mesh of 0.5 mm.
	It is prohibited indefinitely to use bags to catch shrimp larvae

There are two main forms of fishing gears used in the Golfo, nets or hook and lines. Shore based collection of *curiles* (clams) and *Los punches* (crabs) are not included in this discussion as the selectivity of hand collecting is not gear related.

Nets

Gill nets

A gill net is a single woven mesh of fine filaments usually made of nylon. They are suspended in the water column by floats on one side and lead weights on the other. The name "Gill net" suggests that fish are captured by trapping them behind their gill cover. However, gill nets also catch fish (and other marine animals) in additional ways (Table 5)

Table 5 – Methods of fish capture within gill nets

Type of capture	Definition
Gilled	Fish caught directly behind the gill cover
Wedged	Trapped in the mesh opening beyond the gills and further down the body
Snagged	attached to the netting at the head region but not at the gills
Entangled	wrapped into the netting, held by pockets of netting or attached to the net by teeth, fins, spines or other projections. Fish may become entangled once already caught by another method

The catch selectivity of a net mainly comes from the match between fish girth and mesh size. For an individual fish to be meshed the girth must match the mesh perimeter. For any given mesh size, different fish sizes will be caught by different catch processes (Table 5). Smaller fish are mainly gilled or wedged whilst the largest fish are mainly snagged. Entangling is less size dependent and may affect both large and smaller individuals and is particularly important mechanism in trammel nets.

In addition to mesh size, additional factors that can affect the selectivity include the thickness of the mesh material and even the colour of the mesh. In general, nets constructed of thinner twine catch considerably more fish than nets made of coarser materials. Colour wise, the 'best' colours for the net differ from species to species. This can also be dependent on the water colour and the bottom colour and show seasonal differences. These considerations are however important since in some fisheries the difference in catch between the "best" and the "worst" colour, has been shown to be a factor of two.

In the Gulf fishermen do use gill nets normally with a mesh of 65mm (2.5"). This is below the legal minimum of 3" and has probably decreased to increase yields as larger fish have become scarcer. Management restrictions placed on mesh size have traditionally aimed to set a minimum gap so that the majority of fish caught are above the size needed to reach maturity. The mesh minimum allows juvenile fish the opportunity to escape. However, mesh size not only causes a lower size range of selectivity (where fish escape through the openings), but also an upper size where fish cannot fit into the opening to get caught (with the exception of entanglement). There is an increasing body of evidence that in certain situations reducing the mesh size to increase adult female escapement (and thus increasing egg production) may be a better management strategy than increasing mesh sizes to improve recruitment [8] Recent (2005) research on a demersal fish showed that the larvae produced by older maternal fish grow faster, survive starvation better, and are much more likely to survive than the offspring of younger fish [9]. Consequently the shift to smaller nets may not necessarily be a management concern. However in the case of the Golfo de Fonseca where large fish are still going to be removed through other fishing mechanisms, it is unlikely that smaller nets are going to do anything more than extend the range of fish sizes to include smaller size classes.

Trammel Nets (*Trasmallos*)

Trammel nets are gillnets of a special design constructed by joining two or three parallel sheets of netting. The outer sheets are made of netting with larger mesh-sizes. The middle sheet is very loosely hung allowing bags of this netting to be drawn through the larger mesh-sizes of the outer net sheets. The trammel net design enables it to catch shrimp in bags of the inner netting as well as gilling and entangling fish.

In the Golfo de Fonseca trammel nets called “brujas” currently use two sheets of netting one 50mm and the other 60mm to target shrimp. Shrimps however make up only 15 % of the catch with the remainder being fish, mainly pescado blanco (38%) and babosa (24 %) (Valesquez et al 2005).

Trammel nets are to some extent reliant on the same selectivity criteria as gill nets. However, trammel nets can catch fish in folds of the inner portion of the netting. This in theory decreases the selectivity of this form of fishing. The main selectivity problem with trammel nets in the Golfo is that these nets are designed to target shrimp and thus use a smaller mesh size than standard gill nets. Because of the net’s ability to also trap small fish and large fish these nets remove a wide spectrum of size classes when deployed successfully. Trammel nets therefore are not only the most widely used, but also the least selective form of fishing in the Golfo.

Cast net - *Atarraya*

This is a circular net with a mesh size of 20mm. The edge of the circle is weighted and the middle has a rope attached so that when thrown it forms a bag through the water column to capture shrimp. Small fish especially juvenile species found cohabiting with shrimp will also be caught by this method. It is likely that these small fish are subsequently used as bait for line fishing.

The Sleeve *La manga*

This is a course woven net that forms a screen and is placed in mangroves using stakes during high tide. As the tide recedes the net is dragged through the shallow water trapping the fish and crustaceans that are retained in the course mesh.

Hook and Line

There are two types of hook and line fishing. One is long lining and the other is with a pole and single line and hook.

Long lining (*palangre*)

Longline fishing is normally considered a commercial fishing technique [10]. The method uses a long line, called the main line, to which baited hooks are attached at the end of short lengths of line which are attached to the main line using a clip or swivel. Long-lines in the Golfo de Fonseca are demersal (bottom) lines. They typically consist of about 3000 m length of 3 mm nylon as the main line with about 1000 hooks (usually number 6 in size) separated by 3m to 6m and suspended from the main line by about 1m.

Long lines are set and retrieved after several hours (either set at dawn and collected at dusk or vice versa). They target bottom dwelling fish including cat fish, but bottom set long lines are also specifically targeting sharks and rays.

Hand Lines

Hook and lines are normally used by fishermen as they wait to collect the nets or long lines that they have set. They target high value species such as snapper and grouper that are harder to catch with nets as they are often solitary and dispersed and generally do not move a great deal. However they are attracted to the bait of hooks.

The selectivity of hooks

Hooks may be differentiated by their general shape and size (measured by gape width) as well as other parameters such as shank length, wire dimension, material, point shape and the finish (e.g. colour, coating etc). The means that the numbers of different hook types is very large.

The traditional 'J' shape "eagle claw style" hooks that are widely used in the Golfo de Fonseca are considered less efficient than the more modern circular hooks which have higher hooking efficiency and lower levels of escape when a fish is caught [10]. The size of the hook influences the selective properties, with larger hooks generally targeting larger fish. However if the hook becomes too large fishing power decreases. In the Golfo, fishermen generally use a hook size "6" (shank length of about 2 ½" and hook width around1"). This is a very general gauge hook suitable for a wide variety of catch sizes.

What is considered equally important to the hook and the selectivity is the bait that is used. The choice of bait is often particularly suited to a target fish and is normally a matter of local knowledge, preference and social and cultural rite. In general fresh bait with a high fat content works best. In the Golfo they mainly use anchovies and small fry. The use of juvenile fish as bait is illegal under current fisheries legislation, but it is not known whether people know about or comply with this regulation. It is likely that bi-catch of small fish from the *atarraya* nets would subsequently be used as bait.

Gear summary

Trammel nets (*bruja's*) are the most ubiquitous method in the Golfo, despite being specifically banned by the reglamento of 2002. Trammel nets are likely to be the most popular because they are the least selective mechanism that can catch both shrimp and a wide range of fish sizes. A standard fishing boat however will often go fishing with trammel nets in addition to standard gill nets and *atarrayas* to maximise the chances of catching a range of fish and shrimp. Gill nets and trammel nets will be set and then collected several hours later. During the interval they will fish with lines. Fishermen tend to use long lines on different fishing excursions to those using fishing nets.

The Fish

Life Style

There are two main types of fish found in the gulf. Demersal (bottom dwelling) fish that are found in the mud and brackish water conditions of estuaries and mangrove lagoons, which feed on worms, crustaceans and small fish. The second are pelagic (in the water) or bentho-pelagic (in the water close to the bottom) that feed on other fish [11, 12]. The only exceptions are the snapper and grouper species that are found in low quantities. These species are normally associated with hard bottom or reef habitats but have a life cycle linked to mangroves which they use for nursery habitat and thus are likely in the area as part of their life cycle migrations.

The composition of the fish species (primarily bottom dwelling) within the area clearly demonstrates that the sedimentary ecosystem developed by the mangrove estuary is fundamental to the ecology of the fishery. The sedimentary ecosystem supports the crustaceans, tube worms and other invertebrates that form the food source for the majority of the fish species in the area. The pelagic species in turn are then likely attracted by the high concentration of fish supported within the area.

The abundance of crustaceans has developed a second avenue of the mixed fishery within the gulf; shrimp. Shrimp live in muddy bottom environments often associated with brackish waters and mangrove estuaries. The shrimp fishery is important for the artisanal fleet, yet the shrimp also play an important role in the food chain. The complexity of the inter-relationship between the shrimp fishery and the fish fishery as well as the role of mangroves and habitat availability will be discussed in later sections.

Resilience and Vulnerability to Fishing

Overall the resilience of most of the exploited species is moderate to high. This means that their life history traits such as rapid growth, low age of sexual maturity and high fecundity mean that their populations can grow quickly (double in a short intervals) and thus they can rapidly replace losses due to mortality (including fishing) [13]. However there are some causes for concern. Several species are either High or very highly vulnerable (shaded grey in Table 6). In general the specie of concern are the larger species including all three of the shark species fished in the gulf. Similar to sharks the baracuda and Mackrel are also highly vulnerable as large pelagic species. Of highest concern is the status of two commercially very important species “Curvinilla” *Cynoscion albus* (the largest of the Babosa group) and the large cat fish *Bagre pinnimaculatus* which is one of the main targets of long line fishing. *Bagre* is particularly vulnerable because of its very long regeneration time (>14 years to double its population) and based on this information alone, *Bagre* and all of the highlighted species (also see Table 6) should be the focus of specific management attention.

Table 6 – Main species of the Golfo de Fonseca fishery detailing ecological traits and their resilience and vulnerability to fishing

	Common name	Latin name	Food	Life Style	Habitat	Max Size (cm)	Minimum population doubling time (yrs)	Resilience	Vulnerability
PESCADO BLANCO	Palometa	*Eucinostomus currani*	vegetable matter, micro-invertebrates and detritus	demersal	Found over soft bottoms of coastal waters. Juveniles are commonly found in estuarine regions, mangroves, tidal streams and rivers far from the coast.	21	15 months	High	Moderate
PESCADO BLANCO	Ruco guilile	*Haemulopsis leuciscus*	polychaetes, copepods and amphipods	demersal; brackish; marine	Inhabits coastal seas on sandy or muddy bottoms. Found in estuaries	41	1.4 – 4.4	Medium	Moderate
PESCADO BLANCO	Pancha Negra	*Paralonchurus goodei*	worms and other marine invertebrates	benthopelagic; brackish; marine	sandy coasts, bays and estuaries	35	< 15 months	High	Low to Moderate
PESCADO BLANCO	Pancha bocona	*Ophioscion scierus*	shrimps and other benthic invertebrates	demersal; marine	Found in shallow water	35	< 15 months	High	Low to moderate
PESCADO BLANCO	Pancha coneja	*Menticirrhus nasus*	polychaetes, crustaceans and mollusks	demersal; marine	Inhabits coastal waters, bays and lower parts of estuaries	50	1.4 – 4.4	Medium	Low
PESCADO BLANCO	Pancha rayada	*Paralonchurus dumerilii*	Benthic invertebrates such as marine worms	demersal	Found along sandy shores and bays, also in estuaries	45	1.4 - 4.4	Medium	Moderate
PESCADO BLANCO	Barracuda	*Sphyraena ensis*	Smaller fish	pelagic-neritic; marine	All areas	127	4.5 - 14	Low	High to Very high
PESCADO BLANCO	Macarela	*Scomberomorus sierra*	Adults feed on small fishes, particularly anchovies (*Anchoa* and *Cetengraulis*) and clupeids (*Odontognathus* and *Opisthonema*).	pelagic-neritic; oceanodromous to 12m	Occurs near the surface of coastal waters	99	1.4 – 4.4	Medium	High
PESCADO BLANCO	Barbudo	*Polydactylus spp* (*possible approximans)*	Omnivorous, feeds on worms, sand crabs, shrimp, clams; sometimes feeds on fish like small anchovy	demersal; marine; <30m	shallow water near the coast, on sand and mud bottoms	36	< 15 months	High	Low
	Liza†	*Mugil spp. e.g. Mugil hospes*		Demersal brackish marine	Coastal marine and estuarine areas	25	1.4 – 4.4	Medium	Low to moderate
BABOSAS	Babosa	*Cynoscion squamipinnis*	Fish shrimps and crustaceans	Bentho-pelagic	brackish marine water Coastal water, shores and estuaries	64	1.4 - 4.4	Medium	Moderate
BABOSAS	Pinchada	*Cynoscion phoxocephalus*	Fish, shrimps and other crustaceans	Demersal	Inhabits coastal waters and estuaries with high salinities	60	1.4 – 4.4	Medium	Moderate
BABOSAS	Corvina	*Cynoscion reticulatus*	Fish, shrimps and other crustaceans	demersal	Inhabits coastal waters and estuaries with	90	1.4 – 4.4	Medium	Moderate

					high salinities				
	Curvinilla	*Cynoscion albus*	Fish, shrimps and cephalopods	benthopelagic	Inhabits coastal waters; brackish marine. Juveniles enter estuaries, river mouths, and shallow bays	130	4.5 - 14	Low	High
	Guavina	*Nebris occidentales*	N/A	N/A	Found in the surf zone of coastal waters, in estuaries and coastal lagoons	60	1.4 – 4.4	Medium	Moderate
ROJO	Pargo*	*Lutjanus. colorado*	Invertebrates and fish	Reef associated marine / brackish	juveniles in estuaries	91	4.5 – 14	Low	Moderate
		Lutjanus novemfaciatus	feeds on big invertebrates (such as crabs, prawns and shrimps) and fish	Reef associated brackish marine	Juveniles may be encountered in estuaries with mangroves and mouths of rivers	170	> 14 years	Very low	Very high
ROBALOS	Robalo*	*Centropomus armatus*	N/A	Demersal brackish marine	Estuaries	37	< 15 months	High	Low
		Centropomus medius	Fish and crustaceans	Demersal brackish	Estuaries	65	< 15 months	High	Low
		Centropomus nigrescens	N/A	Demersal brackish	Mangroves, lagoons and estuaries	123	1.4 – 4.4	Medium	moderate
		Centropomus robalito	Fish crustaceans and molluscs	Pelagic –neritic brackish marine	Estuaries	35	<15 months	High	Low
		Centropomus unionensis	N/A	N/A	N/A	46	<15 months	High	Low
		Centropomus viridis	N/A	Demersal marine	N/A	112	1.4 - 4.4	Medium	Moderate
OTROS	Jurel	*Caranx caninus*	Fish and shrimps	Pelagic-oceanic	oceanodromous	101	1.4-4.4	Medium	moderate
	Galiciano	*Bagre pinnimaculatus*	N/A	Demersal brackish	Coastal waters	95	> 14 years	Very Low	High
	Ruco	*Conodon serrifer*	N/A	Demersal marine	Benthic over soft sediments of coastal waters	34	1.4 – 4.4 years	Medium	Low to moderate
		Pomadasys panamensis	N/A	Demersal marine	Sandy bottoms of coastal areas	39	1.4 – 4.4	Medium	Moderate
	Tiburón	*Sphyrna lewini*	Fish and cephalopods	Pelagic - oceanic	Juveniles in coastal areas	430	4.5 - 14	Low	Very high
		Sphyrna media	N/A	Demersal marine	In-shore areas over continental shelf	150	4.5 - 14	Low	High
		Rhizoprionodon longurio	N/A	Benthopelagic marine	Inshore waters	110	4.5 – 14	Low	Moderate to high
	Salmonete (Chivo rosado)	*Pseudopeneus grandisquamis*	Benthic invertebrates and small fish	Benthic (pelagic spawners)	Marine brackish waters	60	N/A	N/A	N/A

†Exact species not confirmed for Golfo de Fonseca example assumed by known distributions

The catch

The mixed species fishery of the Golfo Fonseca contains at least 60 species that are of varying degrees of commercial importance. The most important groups by weight are listed in Table 7. The food, life style and habitat of the main fish species found are detailed in Table 6 along with estimates of their resilience and vulnerability to exploitation that are calculated based on a selection of life history traits. In these tables and estimates of selectivity we use the catch data collected during 2004 – 2005. This is a unique dataset as the only size, frequency catch data currently available. The duration of the current study prevented the option of building a more current dataset as to be effective it must span at least 12 months.

Limitations: Unfortunately the gear with which the fish were caught is not reported so for the purposes of this study we assess the general selectivity of the fishery and evaluate this in terms of possible influences on population dynamics. Other limitations with the estimates and projections made here are highlighted as they occur.

Table 7 - Proportion of Total Catch per Group of Fish Species (From Evalua de Pesca)

Total catch = 6910094 lbs		
Fish Types	Description	% by weight
Blanco	Generic mixture of small white fleshed fish	33
Babosas	5 species within the family *Sciaenidae*	29
Peces Gato	Several species of cat fish including *Bagre pinnimaculatus*	10
Lisa	Collective of species within the family Mugillidae	7
Rojo	Species including red snappers and small groupers	5
Raya	Rays	3
Tiburon	At least 3 species of shark	1
Other	All other fish species and the blue crab (Jaiba)	12

Pescado Blanco – a serious management concern

Numerically "pescado blanco" accounts for the highest proportion of landed catch with over 33 % of the reported total weight (Table 7). However this is unsurprising since *Pescado Blanco* is a collective name for at least 40 different fish species. Within Pescado blanco, 11 species account for around 88% of the total weight (Table 9).

There is extreme difficulty from a management perspective of assessing the selectivity of fishing gear when data are classified in to very broad collective groups of species. However the fact that these fish are all put together into a collective, combined with the exceptionally low market price (average of just 4 lempiras a pound) indicates that Pescado Blanco is probably the collective term for "all fish that are small and white fleshed and accidentally caught" i.e. non target catch, or bi-catch. The majority of this catch comes from shrimp fishing with Trammel nets (38.7 % by volume of trammel landings were classified as Pescado Blanco (Table 8). There is further evidence that *Pescado Blanco* is indeed accidental catch of low grade fish, because several species found in "Pescado Blanco" also have their own category. This is likely caused because small fish are classified in to the collective and larger individuals of the same species get placed into their own category. Examples of this phenomenon found in the catch data include *Lisa, Peces gato* and *Pancha rayada*.

Table 8 – Proportion of different catch categories catch in different fishing mechanisms

Trasmallo	% catch	Atarraya	% catch	Palangre	% catch	La manga	% catch	Líneas de mano	% Catch
Pescado blanco	38.27	C.tití	44.07	Wiche	38.42	pescado blanco	No data	Pargo	No data
Babosas	23.92	Camarón cola verde	24.82	raya	22.27	pargo,		Mero	
Camarón yumbo	9.32	C. fiebre	15.16	Galeciano	15.5	ruco,		Robalo	
Camarón rallado	6.41	Usugo	8.21	Corbina	12.43	róbalo			
Pargo	3.38	Tilapia	7.74	bagre	11.32				

This presents a second difficulty in assessing the fishery. Any size frequency data presented from the single group e.g. pancha rayada will already be missing data for the small size classes. These smaller fish will have been put into Pescado Blanco. Thus the results will give an unrealistically positive analysis of the size structure of the catch. For this reason no species that are found within "Pescado Blanco" category will have their size structure selectivity assessed here.

Table 9 –Composition of fish within the white fish "pescado blanco" group

Pescado Blanco = 2280 mil lbs		
Nombre	*Nombre científica*	%
Pancha rayada	*Paralonchurus dumerilii*	20
Peces gatos	*F. aeridae*	13
Pancha Negra	*Paralonchurus goodii*	10
Pancha bocona	*Ophioscion scierus*	9
Barbudo	*Polidactilus sp.*	9
Palometa	*Eucinostomo currani*	8
Barracuda	*Sphyraena ensis*	6
Ruco guilileo	*Haemulopsis leuciscos*	5
Pancha coneja	*Menticirrhus nasus*	5
Macarela	*Scombermorus sierra*	3
Otras especies		12

This highlights the urgent need for a high quality data set assessing the bi-catch of shrimp nets and a full size and species quantification of "pescado blanco". The incredibly low price of Pescado Blanco means that the economics of fishing this group cannot be viable and thus it must be supported by other higher profit catch made during the same trips. Identifying and mitigating *Pescado Blanco* is a key aim for management and this will be discussed further in the recommendations.

Babosa – the commercial core of the fin-fish fishery

The Babosa group (a class of 5 closely related species of Sciaenidae) can be considered as the most important commercial fish species within the fin fish sector of the Golfo de Fonseca fishery. Babosas as a group accounted for 29 % by weight of all fish landed in 2004 -2005 and retain a stable market value (around 12 lempiras in 2004 and 15 lempiras per pound in January 2009). Importantly the "babosa" group includes the top two individual species in terms of weight landed per year. *C. squamipinnis* (known locally simply as *babosa*) is the most important commercial fish in the gulf by weight, itself alone accounting for nearly 13 % of all landings. Pinchada (*C. Phoxocephalus*) is second making up another 9 % of the total landings by weight (Table 10).

Babosas are caught in nets or on lines, but it is likely that much of the volume of the catch is being caught as bi-catch in trammel nets that are targeting shrimp. Almost a quarter of the catch by volume (23.9 %) of trammel nets are classified as "Babosa". The landing of babosa as bi-catch from shrimp nets may explain the high numbers of smaller individuals in the size frequency data (figures 1 – 4) which reflects in the high proportion of immature sized fish that are being landed (Table 10).

Our calculations based on published literature for the size at maturity of these species [13], indicate that immature size fish account for 60 % of the individuals within the catch in pinchada (*C. Phoxocephalus*), 50 % in Guavina (*Nebris occidentales*) and 22 % in Babosa (*C. squamipinnis*). A literature value for the sexual maturity size for Corvina (*Cynoscion reticulatus*) could not be found, however since this is a larger fish than the others within the group we use a conservative estimate of 25cm as the size at maturity. Even with this conservative size minimum, 81 % of the individuals being landed were below it.

Most strikingly the data for Corvina shows two very distinct size brackets, one of small individuals and one of large. It is a likely conclusion that the small fish being landed (12 cm – 21 cm) are Corvinas that were the bi catch of shrimp trammel nets. The larger size bracket (52 cm – 83 cm) reflects the size of fish caught within the targeted fishery using gill nets or hooks.

The landing of immature fish should be a serious management concern. Losing immature fish from the stock reduces the eventual reproductive ability of the population. If this continues it may present a serious risk to the sustainability of the fishery. Babosa as a group and individually are commercially the most important fish (excluding shrimp) it is recommended they should receive priority in management strategies.

When defining the management of these species and mechanisms to help sustainability there needs to be clear identification of the different species within this category. Specifically it is important to reliably identify Curvinilla (*C. albus*) and report its catch data separately. This species is the most likely of all the species within the group to be in danger of over exploitation because it is the largest of the family and thus reaches maturity later. This can be seen in the long time required to double its population (4.5 – 14 years; Table 10) compared to other species within the group (1.4 – 4.4 years) making it highly vulnerable. High quality data is urgently needed on this and all Babosa species to be able to instigate effective management strategies.

Table 10 - Babosas Catch Volume (total catch = 2021256 lbs; 2004 - 2005)

Common	Name	Total catch 2004 - 2005	% Babosa catch	% Total catch	Peak catches[†]	Mean size (cm) (± 1 S.D)	Min	Max	Size at mature (A_{50})	% of individuals < mature state
Barbosa	C squamipinnis	883 mil	42.7%	12.8 %	50% Total Jan – Mar (peak Jan / Feb 16 %)	27.0 cm ± 5.9	10	52	22[+]	**22 %**
Pinchada	C. phoxocephalus	626 mil	31%	9.0 %	51% total December – March (Peak Jan 16 %)	24.6 cm ± 4.6	15	38	25[+]	**60 %**
Curvinilla	C. albus	257 mil	13 %	3.7 %	51% December to march (peak Jan 16 %)	23.3 cm*	N/A	N/A	N/A	N/A
Guavina	Nebris occidentales	213 mil	10.5 %	3.1 %	48 % Dec to March, 10% August, (Peak Enero 15%)	24.6cm ± 4.8**	15	40	25[?]	**50%**
Corvina	*Cynoscion reticulatus*	184 mil	9.1 %	2.7 %	50% December to March (peak december 14 %)	26.3cm ± 18.7**	12	83	>25[?]	**81%**

†over 10% total year catch in one month

**Estimated Length (L) from average weight (W) given in Evalua de pesca (117g) and L:W conversion $W = aL^b$ with (a = 0.024 and b = 2.824; constants taken for this species from fishbase.org)*

*** calculated from graph data in Evalua de pesca as averages given in document seem unlikely given the data that is also presented in document*

+ size from Evalua de pesca

? estimate based on size of fish and known maturity of other fish in the genus

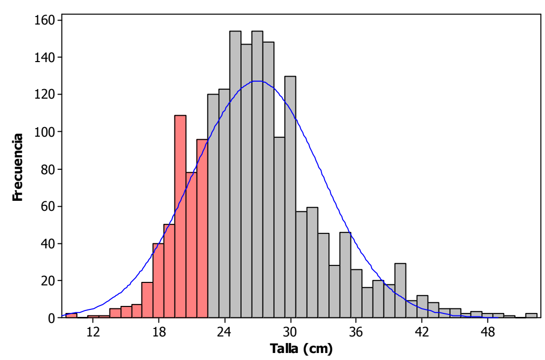

Figure 1 – Size frequency for catches of *C. squamipinnis* (line shows normal distribution and red shading indicates catch below size of maturity)

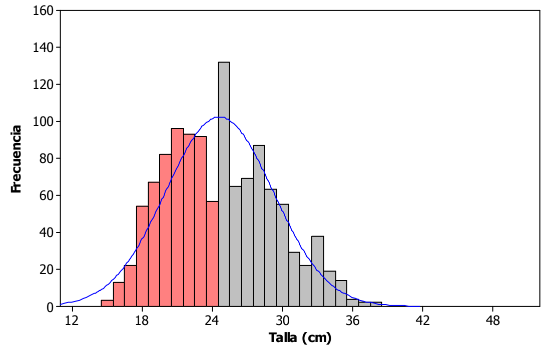

Figure 2 - Size Frequency for catches of *C. phoxocephalus* (line shows normal distribution and red shading indicates catch below size of maturity)

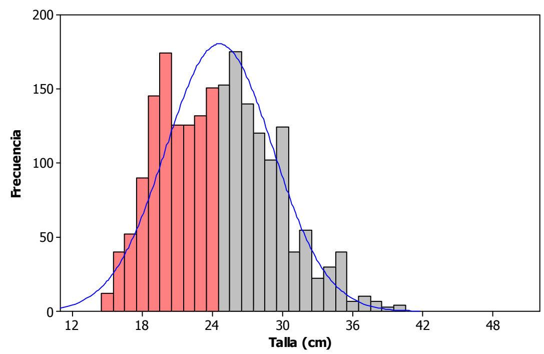

Figure 3 – Size Frequency for catches of *Nebris occidentals* (line shows normal distribution and red shading indicates catch below size of maturity)

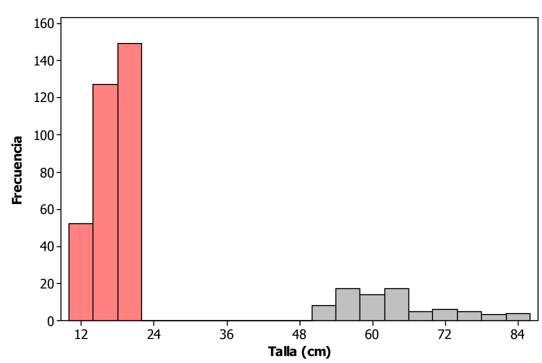

Figure 4 – Size frequency data for catches of *Cynoscion reticulates* (red shading indicates catch below size of maturity)

Pescado Rojo – Data deficiencies and a clear management alternative

The group "Pescado Rojo" includes the high value species of Robalo, Grouper (mero) and Snapper (pargo). This group has the highest price of all fish species within the fishery (average > 17 lps per pound in 2005). However the supply is low, with these species making up only 5.35 % of the total weight of catch in the gulf. Unfortunately there is very little information on which to base a catch assessment.

There is limited information on the actual species of grouper and snapper being caught but we preliminary identify the likely species in Table 11.

Table 11 – Species of snapper, grouper and snook likely to be found in the Golfo de Fonseca (information from fishbase.org and Smithsonian institute online database for fishes of the NE Pacific)

Snapper	Grouper	Snook
Lutjanus aratus	Alphestes multiguttatus	Centropomus armatus
Lutjanus argentiventris	Cephalopholis panamensis (most common)	Centropomus medius
Lutjanus colorado	Dermatolepis dermatolepis	Centropomus nigrescens
Lutjanus guttatus	Epinephelus analogus	Centropomus robalito
Lutjanus inermis	Epinephelus labriformis	Centropomus unionensis
Lutjanus jordani	Epinephelus niphobles	Centropomus viridis
Lutjanus novemfasciatus		
Lutjanus peru		

No length frequency data for these catch is available. In regards to selectivity, these species would normally be caught by hook and lines and since they are being caught from shallow waters they are likely bought on board still alive, without injuries common to rapid pressure change (burst swim bladder or stomach). As a consequence their catch selectivity is due to the fishermen deciding whether to throw them back or keep them. This is not gear selection but human choice and thus comes down to education and markets. If the fisherman cannot sell a very small fish and knows that by putting it back they will likely make more money from the same fish (by allowing it to get larger and also to reproduce) then selectivity will be positive. If fishermen believe there is no point throwing it back and whatever it is worth now is better than any future reward, then selectivity will be poor.

The rojo group therefore exemplify the need for environmental education as a management tool to increase selectivity for larger fish, rather than legislation for different gear types. Included in this educational message must be the importance of spawning aggregations and breeding cycles. The limited reported catch data (which we calculated from the financial information within Evalua de pesca and adjusted due to an obvious error in the data[1]) show that pescado rojo have an average catch across the

[1] Value of catch for June seems erroneously high by a factor of 10. At this peak it would have meant landing 340 mil pounds of pescado rojo, which is exceedingly unlikely since it is when the price is highest and normally if there was a peak in supply there would be suppression in price. This value has been reduced it be a factor of ten. It is also assumed that data collection did not include whole month of August

year of 36.7 thousand pounds (± 6.9 thousand). Variation comes from a peak in catches during winter (November through to January) and a decline in summer (Figure 5 – Weight of total catch per month for pescado rojo). This is of concern as these months normally correspond to the reproductive timing for grouper species and some snapper species. Further studies are needed however to confirm when these species actually spawn and to identify aggregation locations that may be sites for protected areas.

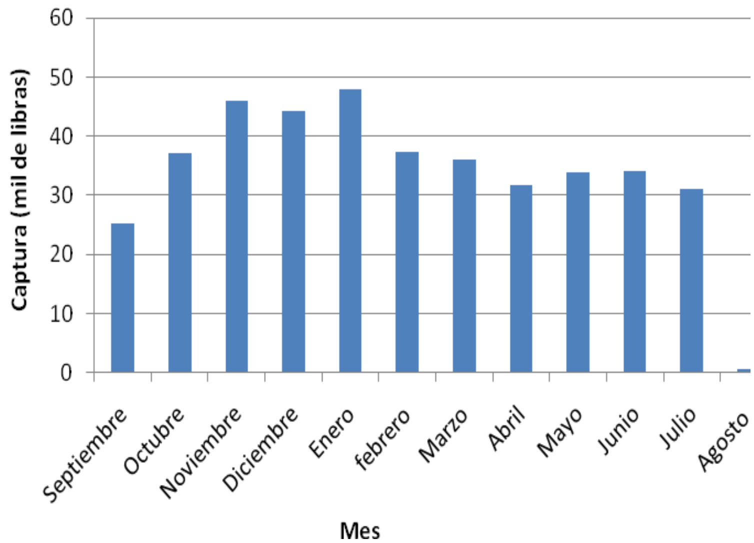

Figure 5 – Weight of total catch per month for pescado rojo

Grouper and snapper are reef fish or hard bottom associated, which means they would not normally be found in large numbers in the sedimentary system of the gulf. They are therefore likely in the area to feed, spawn or grow in the mangroves and thus the Golfo may be a critical life phase for regional populations that migrate to the gulf. Understanding the ecosystem within the Golfo Fonseca and how this interlinks with the life cycle and migratory patterns of key species is imperative to be able to effectively manage Pescado rojo. It is clear however that gear restrictions will not be an effective tool for these species.

Table 12 - Summary of management Importance and focus

	Percentage weight of total catch	Total Value (millions Lempiras)	Average price per pound (Lps) (2005)	Percentage of total fish revenue	Management Highlights
Babosa	29 %	24	12	**50.6 %**	Most important group but concern over high levels of immature fish capture
Pescado Blanco	**33 %**	9.4	4	19.8 %	High differential between quantity & value. Concern that high proportion likely derived from bi-catch with bad economics of fishery
Bagres	10 %	4.9	8	10.3 %	Concern over vulnerable species within this group and method of capture (Long line)
Rayas	3 %	3.2	7	6.8 %	Multi species group and more information needed on species actually caught. Concern over method of capture (Long line)
Lisa	7 %	2.9	7	6.1 %	Multi species group that in general has a high resilience to fishing. More information needed on species composition of catch
Tiburon	1 %	1.7	10	3.6 %	Concern over method of capture (Long line) and that group and all species are highly vulnerable to exploitation
Pescado Rojo	5 %	1.3	17	2.7 %	Highest value group but likely highly vulnerable to exploitation especially if aggregations are targeted. More information urgently needed
Otros	*10 %*	*4*	*7*	*8.4 %*	*N/A*
Total	6.9 million lbs	47.4	9.3	High yield but low average price of captured fish. Economics are sustained by volume not quality. Management should aim to substitute volume for increased price; lowering exploitation but maintaining total value.	

Table 13 - Fishing Mechanisms of Concern

	Management Concern
Trammel	Targeting shrimp, but have a high bi-catch rate of fish especially of small size classes and low value fish (Pescado Blanco). Concern that this is adversely impacting all other fish stocks especially since this is the main fishing mechanism in the gulf. The key management priority is to address this problem. From a legislative standpoint trammel nets (brujas) in this form are currently illegal. There is also a regulated season for shrimp fishing that also seems to be ignored. Further legislation without enforcement seems superfluous at this stage so alternative management options needs to be found.
Long line	Long lines in general increase fishing power and decrease selectivity. Bottom set long lines are especially good at catching sharks and other large predatory species which are of increasing international conservation concern. Long lines are considered a commercial fishing technique and are legislated as such in Honduran regulations on fishing. Commercial fishing is banned in the Golfo but it is unclear legally whether this applies to making long lining illegal. Methods to curb the use of long lines and replace with single lines should be sought as a management priority.
Atarraya	These small nets used in mangroves and ponds are likely to be catching juvenile fish that are using the same habitat as shrimp for their nursery. Further information needs to be collected on the extent of this problem and to evaluate the non shrimp mortality rate. Efforts to encourage the return to the water of live juvenile fish are a priority.

Conclusions and recommendations

Conclusions

This study has drawn the following conclusions:

1. There is low selectivity within the current Golfo de Fonseca fishery driven by the market structure that is likely to severely affect the sustainability and future incomes of the small scale fisheries of the area

The Golfo de Fonseca small scale fishery is a multispecies fishery where commercial products have diversified to include more than 60 species of fish, shrimp, crabs and bivalves that are bought by local traders. The ability to sell different grades of fish to different market sectors makes the fishery in general very efficient, resulting in little waste. This is a positive attribute; however it may also promote unselective fishing mechanisms. Anecdotal reports from fishermen suggest that this fishery is in decline. Whilst there is no official data to support this, it is clear from the fishermen that catches are perceived to be falling, despite fishing methods becoming more intensive and increasingly less selective. The use of passive and highly efficient fishing techniques such as nylon nets several hundred meters in size and long lines up to 3 km long was found to be the norm across the area.

At its core, unselective fishing techniques when combined with a market place for each of the products may be the critical combination for perpetuating unsustainable practices in the area. The diverse product structure may obscure the fact that many of the fish are not worth catching and that the economics of catching them do not make sense. In its worst form the capture of one species of an economically marginal product prevents another potentially more valuable resource from becoming viable. This harms the total potential of the fishery and reduces its overall economic yield.

The fishery in the Golfo is currently based on a market that rewards volume instead of quality. With a low price per pound of most fish (averaging 9 lempiras) paid to the fishermen by middle men, there is the incentive to catch in quantity to compensate for low value. Since there is only a small or sometimes no price premium for larger fish, there is little incentive to target these individuals. Unselective fishing is therefore as likely to be a direct response to the market structure as it is to the state of the fish populations. If fishermen had a financial incentive to be selective then they would be, without it there is no alternative. Until the market chain is restructured to reward stewardship, unselective fishing will continue to be the only economically viable solution.

However, there is a second important driver to unselective fishing as detailed in conclusion 2.

2. Shrimp fishing is causing unselective fishing of fin fish creating an unwitting paradox for fishermen

Shrimp fishing using trammel nets (brujas) is the most common form of fishing in the Golfo. Trammel nets are used to target shrimp, but because of their design and small mesh size they also catch large amounts of fin fish. With the trammel nets used in the Golfo, for every 1 lb of shrimp that is caught, over 5 lbs of fin fish are also captured. Whilst this fish is not discarded and is a marketable commodity, in general these trammel nets catch low value fish (4 – 10 lempiras per pound). This low market value is not because they are catching worthless species, but most likely because they catch valuable fish (e.g. babosa) at a size so small that they are yet to reach their market value. This means that trammel nets by removing small, immature fish from the population, not only reduce the reproductive potential of the stock (affecting sustainability), but also reduce the potential economic value of the resource.

There is a real conflict therefore, between shrimp fishing with trammel nets and sustainable fin fishing. Since it is the same individual fishermen that are fishing both for shrimp and for fish, the problem ironically is created by an individual with the affects detrimental to the same individual. It is this fundamental paradox that needs to be resolved.

In its current form the un-selectiveness of shrimp fishing in the Golfo will have a detrimental impact on the sustainability of fin fishing for three reasons:

a. the bi-catch of small fish from trammel nets reduces the recruitment of adult fish in other target fisheries.

b. The bi-catch from *atarrayas* of juvenile fish in nursery areas (mangroves) will affect recruitment into the fishery as a whole

c. The loss of a food source. Since shrimp are an important food source for most of the commercial fish species in the Golfo, their will affect the food supply to the higher trophic levels ultimately affecting fish populations.

Identifying these links and understanding the connections between species within the ecosystem, is essential to understanding how to maximise the economic value of the fishery as a whole and concurrently ensure sustainability of all sectors within it. Currently the unselective shrimp fishing is likely one of the greatest threats to productivity and sustainability of the fin fishery.

3. The prevalence of Long-lining is likely to over-exploit the most vulnerable species

The use of long-lining in essence increases fishing effort greatly whilst only increasing fishing costs slightly. It therefore significantly changes the economics of the fishery, but at the same time it normally affects the sustainability of the fishery and can generate other ecological concerns.

Bottom set long lines, which are the predominant form in the Golfo, are specifically targeting bottom dwelling and bentho pelagic predators including sharks, large cat fish, barracuda and mackerel. All these species were highlighted in this study as being highly vulnerable to exploitation because of their life history traits. Long lines therefore are the mechanism that will exploit these vulnerable species and does so with an effort that is likely far above the levels of sustainable yields.

Long lines are also associated with high accidental catch rates of non-fish species including turtles and sea birds. There is no data for the Golfo on this and it is highly recommended that a study into accidental catch of long-lines is implemented.

Because of their high fishing power, low selectivity and high accidental catch rates, long lines are under close scrutiny world wide and many countries, particularly those with sensitive inshore fisheries have banned their use. It is unclear in the current fisheries legislation whether the use of long lines in the Golfo de Fonseca is against the law. Irrespective of its current legal standing, as a simple matter of scale long lines should be discouraged in any area where a small scale fishery is looking for sustainability.

To provide some context; if the estimated 1000 fishermen that daily fish in the Golfo, each decide to set one long line with 3000 hooks (which is the average number on the lines commonly used) there would be 3 million hooks fishing in the Golfo. That is the equivalent to 15 hooks in every 100 square meters across the entire aquatic area of the Golfo. This estimate is just an example of the enormous fishing power long lines can generate, and it must be considered that this estimate does not include the long lines used by Nicaraguan and Salvadorian fishermen in the same body of water.

4. Ecosystem degradation is likely to be linked to unselective and unsustainable fishing practices.

The reported use of unselective fishing techniques is a worrying tendency that will exacerbate fisheries decline. However, in addition to the market forces that help perpetuate this scenario, it must also be considered that the use of unselective gear may be a symptom of problems within the Golfo de Fonseca ecosystem as a whole (of which the fishery is a part) rather than simply the original cause of fisheries decline.

As the quality and quantity of critical fish habitat (such as mangroves) declines due to land development, alternative uses, pollution and other human impacts, the volume of fish that the ecosystem can support will be reduced. Likewise, if the abundance of food is decreased, (either through removal by human collection or by also being affected by loss of habitat or other human impacts) then again the total amount of fish that can be fed and supported will decrease.

These processes would cause a decrease in fish populations to occur, even in the absence of any fishing pressure. Fishing however will exacerbate population decline and obviously unsustainable fishing methods are important to combat and work to remedy. But it is easy to single out fishing as an "obvious" cause of decline whilst ignoring other important drivers of population dynamics. The use of unselective fishing gear may be ultimately caused because the coastal ecosystem can no longer support higher volumes of fish and thus fishermen through simple economics are forced to adopt less selective methods. In reality it is often the combination of multiple factors that results in declining fisheries however if other impacts affecting the productivity of a fishery are not addressed then it is highly unlikely that sustainable fisheries will be established by just managing the *fishing* component.

Mangroves and the ecosystem they create are the critical habitat for the Golfo de Fonseca fishery. The Golfo de Fonseca contains some 22 % of the entire mangrove area of the Pacific coasts of all the states of Central America [14]. Over 60 % of the Golfo de Fonseca's mangroves are found within the Honduran territorial boundaries (estimate from 2001) [4]. These extensive systems are recognized as being one of the most important shrimp and fish nurseries within the Pacific Central American Coastal Large Marine Ecosystem (LME) that extends along the Pacific Coast of Central America, from Mexico to the equator[2]. As a consequence, mangrove destruction and the general degradation of habitat within the Honduran portion of the Golfo de Fonseca will not only be affecting the sustainability of the small scale fisheries of Honduras but is likely to be having much larger scale repercussions on the marine resources of the entire region. Actively addressing mangrove destruction and degradation is a key part of designing a sustainable fishing plan for the area.

5. Any new fisheries legislation based on top down management principles will not promote sustainability in the Golfo de Fonseca fishery when enforcement is unfeasible

Existing fisheries legislation as defined by the *ley de pesca* 1959 and the *reglamento general de pesca* 2003, contains many articles that at their core aim to promote a sustainable fishery. They provide protection for critical habitats (article 52), safeguard reproduction, juvenile survival and early life stages (article 41 and 46) and ban unselective fishing techniques (reglamento 2003 see Table 4 – Summary of legislation relevant to fishing gear). The issue is not in the legislation but the awareness by stakeholders of these laws and the current ability or motivation within the area to enforce them. Designing further legislation will not solve these two problems and on the contrary will likely just distract attention away from the actual underlying problem; ongoing and persistent fisheries decline.

A bureaucratic approach to fisheries management often tends to seek legislative solutions to the problems facing a fishery. This includes placing legal restrictions on fishing gear, fishing season, and fishing areas, setting total allowable catches and size minimums within markets. If these methods can be correctly specified and enforced they should be able to maintain a sustainable fishery. However, if the goals of the management methods (sustainability) are either not explained or not understood by the

[2] FAO Large Marine Ecosystem designations

affected party (the fishermen) or if the legislation cannot adequately be enforced by authorities, widespread fishing in contradiction to the legislation will occur.

In reality fishermen will only be deterred from breaking fishing regulations if their expected loss from being caught exceeds their expected gain[3]. The loss however does not necessarily have to simply mean instigating a system of financial penalties – fines, which by their nature would incur a further level of oversight and bureaucracy to implement. “Loss” can also be defined by an understanding of the real loss of future earnings that occurs by breaking regulations that aim to safe guard sustainability (and in so doing, the future livelihoods of the community).

This second definition of “loss” is the message that is key to being able to develop a sustainable small scale fishery in an area such as the Golfo de Fonseca. It is unrealistic to believe that the enforcement power or the executive capacity, as it is currently structured, will exist in the near future to be able to effectively exert top down control on the Golfo small scale fishery. The area is too large, the fishery and market chain is fragmented and decentralised and, as a small scale fishery, with relatively low per capita revenue generation, there is limited financial interest to motivate much investment in scaling up management efforts.

However, the same problem that makes centralised top down management impractical; small segregated communities, can also be turned into an advantage by a different management approach. For millennia small communities successfully managed sustainable fisheries. Local fishing cooperatives with regulations based on traditional knowledge and a historical connection to the sea, have maintained resources for the members of the community. The real problem in these communities today is the loss of traditional knowledge and innate understanding of resource management and the sense of ownership of the resource (real and perceived) that went with it.

A truly effective management strategy would not be to make new legislation, but to rebuild this knowledge by educating fishermen in simple concepts behind sustainable resource use and re-empower them by granting fishing rights and stewardship for different areas. If the fishing community as a collective understands that certain practices directly threaten their future livelihoods, then perpetrators within their community will lose social standing, or have locally implemented fines or punishments administered. It is increasingly apparent that for successful management to occur authorities must provide incentives for conservation based on fishers' rights and identify mechanisms that work at a local level.

Where a management authority trying to work at a large spatial scale cannot detect activity that is damaging the sustainability of the fishery, nor is able to implement penalties to act as a disincentive, there are two choices. (1) Scale up the management and enforcement effort and incur the related costs. Or (2) decentralise the authority to a local scale at which both these processes can function using identified incentives for self governance. With this approach the management authority then becomes less of an authoritarian regulator and more of an advisory body, making recommendations to the communities that aim to maintain their stock in the best condition. Costs of enforcement should decrease and instead be diverted in to identifying sustainable management practices, monitoring the overall state of the fishery and looking for other mechanisms to decrease overcapacity in the fishery

[3] this assumes that the fishermen are aware of the legislation they are breaking in the first place

(i.e. identifying realistic alternative livelihoods). The cooperative management approach helps to integrate managers into the fishery rather than being seen as a regulatory body which is politically, socially and spatially removed from the fishermen.

Recommendations

Legislative Recommendations

If enforcement is achievable, either by agreements within and between local fishing cooperatives or through governmental control, the restrictions should be placed on the following fishing practices within the Golfo de Fonseca. These regulations if part of a larger management strategy would be advantageous to the sustainability of the fishery.

1. Prohibit the use of long lines based on FAO precautionary principle

   Current fisheries legislation would generally enhance the sustainability of fishing within the Golfo de Fonseca. However, due to concerns over the vulnerability of several bentho-pelagic species, including sharks, it is strongly recommended that the prohibition of long-lining be considered within the area. Long-lining is known to have high fishing efficiency for these species and since there is no fisheries data sufficient to evaluate the current status of these vulnerable species, the precautionary principle established under the FAO guidelines for sustainable fisheries should prohibit long-lining until evidence can demonstrate that it is not a threat. Of additional consideration is that long-lining is normally considered a commercial fishing activity and commercial fishing is banned within the Golfo waters. Therefore if this law is clarified there may already be enough legal authority without the need for drafting new regulations.

2. Management of shrimp should be correlated with fish life-cycle management.

   The seasonal restrictions for shrimp fishing should be set and publicised as per the *ley de pesca* (1959) and *reglamento* (2003). This seasonal restriction would not only assist in the sustainable management of shrimp (by protecting their critical periods in their life cycle) but would also help protect fish from being removed as bi-catch in trammel nets. The exact timing of this restriction should be considered not just from the life-cycle biology of shrimp, but must also take into consideration the life cycle of key bi-catch species such as Babosa. The seasonal restriction should be set to coincide with the peak abundance of immature fish that are recruiting to the area and are captured by trammel nets. This should reduce the overall mortality of juvenile fish and increase the likelihood that fish will recruit to the fishery and make it to reproductive size.

   It is believed that of all the legislative management choices this may be the most feasible option to implement at the current time, since prohibiting the catching and marketing of shrimp could be more easily enforced than other legislation.

It must be noted that further gear restrictions have not been recommended here since there is not enough evidence that they would significantly improve the sustainability of the fishery nor that further gear restrictions can be enforced due to the limited capacity of regulating agencies. Since restricting fishing methods ultimately limits the effectiveness of fishing, it normally leads to increases in time, fuel, man-power or other economic variables leading to higher total costs. By significantly affecting the economics of fishing, without having a larger strategy within which gear changes are part of a process, it is thought that the move would just provoke socio-political resistance and inhibit engagement by the community in future (and potentially more effective) management initiatives. Until incentives are in place to benefit fishermen when they use sustainable methods (i.e. price premiums for larger fish caught on a hook and line), further restrictions will be unlikely to succeed.

Management recommendations

The current problems with the fishery in the Golfo de Fonseca are a complicated web of historical, social, political, institutional, technological and ecological factors. Using a predetermined set of management tools and applying them as individual compartmentalized concepts to this fishery is unlikely to correctly address these interconnected issues. Therefore to achieve the goal of a sustainable fishery, management needs to approach the problem with new holistic perspectives and look for coordinated, integrated solutions.

Successful managers must avoid becoming stuck on a prefixed course of action that there is no reason to believe is attainable, at a reasonable cost, or within a reasonable timeframe. In essence sustainable management will only occur when managers understand that they do not already know the answer, especially before they have really identified the problem. Managers must be connected to the community they manage, respond to feedback and truly understand that often the simplest and most feasible solutions are grown from empowering the community themselves. Local knowledge is often the best management resource and in seeking solutions managers must ask "*what can fisheries management do for fishermen?*".

To succeed, strategies must therefore be based on a sound understanding of the ecology as well as the social framework that makes up the fishery. The greatest obstacle in achieving successful management of the marine resources of the area, identified by this report, is the lack of accurate and reliable data on with which to work.

Ecologically the priorities for further study should be:

A. To identify critical food-web connections that include how predators (including fishermen) and foraging species link together and rely upon lower trophic groups.

B. Identify and monitor critical habitat areas that provide food and shelter to the fish population.

C. Evaluate life cycles and migration routes and identify key locations such as spawning aggregation sites and nursery grounds.

From these results management has a starting point. It can identify things that are essential to the sustainability of the fishery. It can prioritize threats and evaluate issues. Without information, management has nothing on which to build and then has no way to assess whether its efforts are working. By taking ecological data as the beginning, managers can then work to integrate the social context, to identify the human aspects to the problems. Following this process, managers are able to then more effectively use their resources, target the priorities and spend financial and social capital to its maximum effect. Whilst fisheries are important economic resources, it is by first understanding the fish that managers can then understand the fishery.

Time Frames and Approaches

Immediate action (within the next 12 months) should be taken to implement a community consultation and education programme concerning long lines and their affect on fisheries sustainability. This should coincide with a specific scientific study on long lining within the golfo. The community process should aim to clearly explain the problems concerning long line usage, and ask each community to try to present workable solutions (perhaps limiting length, number of hooks or hook size). Work should target individual groups of fishermen centered on their local buyers (who own and lease the majority of fishing gears) and focus on convincing each group that it is in their own best interests to collectively give up or reduce the use of long-lines. This is likely to be more effective than simply publicizing a "ban" on long lining and trying to enforce a centralized policy. Involving fishermen in the process of gear selection is a more effective mechanism for change than trying to implement it forcibly [6].

Developing the scientific data on which to base a closed season for shrimp will take more time, but the process of biological study should be started as soon as possible. Attention should be focused on investigating the life cycle of key fish species to determine the recruitment dynamics of the fishery and can describe the time of year when the maximum number of fish will be in the size range that can be caught by atarrayas and when they can be captured in trammel nets. The study should focus attention on these specific gear types and collect size frequency data for different species across the year. This would aim to identify peaks in the volume of small fish being caught and identify critical months for different species [15]. One approach to collecting this information is to encourage greater participation of the fishermen and fish buyers in the recording of this data. This approach has the additional benefit that they then become part of the management process and it develops a channel of communication between the fishers and the scientists and managers. To success however the aims and significance of the project must be clearly explained in terms of the benefits to the fishermen that helping to collect the data will ultimately bring. In the end this should be an ongoing educational process as well as a data collection exercise.

The current important work that aims to identify size at maturity for Babosa within the golfo should be accelerated and expanded to other fish species as understanding this biology is a fundamental part of fisheries management. Once again this could involve fishermen in sample collection. Ideally this work should be expanded to include gut contents analysis.

In general all areas of fisheries data collection are currently so limited and it inhibits the ability to effectively manage this fishery at any scale (community, local, national or international). The lack of a long term data set combined with insufficient data collection activity a the present time means that there is no actual data on which to base the claim that "the fisheries in the Golfo de Fonseca are in decline and are unsustainable". Whilst the present report does not suggest this statement is in fact erroneous it does demonstrate the immediate need for a centralised and sustained data collection programme combined with regular and accurate analysis. It is strongly recommended that a fisheries research strategy be designed and implemented immediately. This plan could follow an approach as set out in "*Guidelines for designing data collection and sharing systems for co-managed fisheries Part 1 & 2"* [15] or similar publications. The insufficient data collection and analysis efforts means that Honduras is currently not able to comply with its international obligations as a signatory to the 1995 FAO Code of conduct for Responsible Fisheries [16].

Bibliography

1. Bonfil, R., *The purpose of stock assessment and the objectives of fisheries management*, in *Management techniques for Elasmobranch fisheries*. 2005, FAO. p. 6-14.
2. Beddington, J.R., D.J. Agnew, and C.W. Clark, *Current Problems in the Management of Marine Fisheries.* Science, 2007. **316**: p. 1713-1716.
3. Vasquez, D.P., M. Mendez, and R. Martinez, *Informe de evaluacion y ordenacion de recursos pesqueros en el Golfo de Fonseca, Honduras (septiembre 2004 – agosto 2005)*. 2005, Secretaría de Agricultura y Ganadería de Honduras.
4. COHDEFOR, *Estado de la gestión compartida de áreas protegidas en Honduras*, C.H.d.D. Forestal, Editor. 2005, UICN (Unión Mundial para la Naturaleza): Tegucigalpa. p. 48.
5. UNEP, *Convention for Cooperation in the Protection and Sustainable Development of the Marine and Coastal Environment of the North East Pacific (Antigua Convention)*. 2002: Antigua, Guatemala.
6. Garcia, S.M., et al., *Towards integrated assessment and advice in small-scale fisheries*, in *FAO Fisheries Technical paper* 2008, FAO.
7. CCAD. *Taller Inicial Proyecto integral Golfo de Fonseca, Chianandega*. 2007.
8. Milton, D., *Selectivity for barramundi (Lates calcarifer) in the Fly River, Papua New Guinea: implications for managing gill-net fisheries on protandrous fishes.* Marine and Freshwater Research 1998. **49**(6): p. 499-506.
9. Tamada, K. and K. Iwata, *Intra-specific variations of egg size, clutch size and larval survival relatedto maternal size in amphidromous Rhinogobius goby.* Environmental Biology of Fishes, 2005. **73**(4): p. 379-389.
10. Hovgård, H. and H. Lassen, *Manual on estimation of selectivity for gillnet and longline gears in abundance surveys.* , in *FAO Fisheries Technical Paper*. 2000, FAO.
11. Nansen, F., *Preliminary Report Cruise No. II - Surveys of the Fish Resources on the Pacific Shelf between Southern Mexico and Colombia - Part 2: Nicaragua - Honduras - El Salvador (20 May - 2 June 1987)* in *Project Reports*. 1987, FAO.
12. Robertson, D.R. and G.R. Allen. *Shorefishes of the Tropical Eastern Pacific online information system. Version 1.0*. 2008 [cited.
13. Froese, R. and D. Pauly. *www.fishbase.org*. World Wide Web electronic publication 2008 [cited.
14. Spalding, M.D., F. Blasco, and C.D. Field, *World Mangrove Atlas*. 1997: The International Society for Mangrove Ecosystems.
15. Halls, A.S., et al., *Guidelines for designing data collection and sharing systems for co-managed fisheries Part 1 & 2*, FAO, Editor. 2005: Roma.
16. FAO, *Code of Conduct for Responsible Fisheries*. 1995: Rome.