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Social Institutions for Fisheries Management in the Mexican Tropical Pacific

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Abstract: Small scale fishing provides important social and economic benefits to families in developing countries where fishing cooperatives reflect official government policy in order to fuel their own development. These social institutions for local fishing management are capable of strengthening formal management plans and dealing with several problems those small scale fisheries face. In this study, techniques of participant observation were applied to examine some historical, technological, socioeconomic and fishing organization aspects, related to the development of the cooperative system, the formation and the performance of social institutions for local fishing management on the tropical pacific coast of Mexico in one of the largest and estuarine systems on the Chiapas coast. Development of the cooperatives is associated with a process of technological change, specifically changes related to fishing techniques and gear. Access to fishing is self-regulated by a complex structure of roles, norms, values and knowledge that exists inside the cooperative. This can contribute to improved policies, development programmes and fishing management.

Key words: Chiapas, estuaries, biosphere reserve, politics of fishing development, small-scale fishing

INTRODUCTION

In Mexico, as in many developing countries with marginalized coastal zones, small scale fishing (researchers have preferred to use the concept small-scale fishery instead artisanal fishery because of the descriptive validity and the operative utility of the concept in the context of the fishery management. For these reason, the small-scale fishery include the artisanal, peasant, tribal and traditional fisheries (McGoodwin 1990)) provides important social and economic benefits to communities and fishing families (BNP, 2008; FAO, 2010). However, many face problems of poverty, lack of alternative employment, inappropriate incentives, conflicts over resource access, depletion of fish populations and weak fishing management (OECD, 2006; Salas *et al*., 2007; Cinti *et al*., 2010).

The problems related to fisheries are difficult to deal with especially, when very little attention has been paid by fishing science to gain knowledge on these problems and possible solutions. In addition, conventional methods of evaluation and management are inadequate for dealing with specific necessities (Mahon, 1997; Berkes, 1986). The sector is characterized by a constant lack of information, even in areas where the government has established development policies and formal fishing management plans, such plans are applied sometimes without any knowledge of the socioeconomic context, resulting in disastrous consequences for fishing communities (McGoodwin, 1987).

Ben-Yami and Anderson (1985) pointed out that in developing countries, fishing cooperatives embody the official policy of encouraging small scale fishing. Historically, The Mexico state has supported technological advances in fishing and the establishment of cooperatives in the fishing sector. Fishing cooperatives of Mexico, such as those along the Pacific coast, incorporate the majority of existing small scale fishermen (OECD, 2006).

Formal small scale fishing management has been carried out through concession contracts, close seasons and prohibitions, as well as controls on fishing techniques (Espinoza-Tenorio *et al*., 2011). Although, this has been the dominant scheme for resource management, some cooperatives have formed social institutions for local fishing management enabling them deal with

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problems such as resource depletion and conflicts over resource access (Basurto *et al*., 2012). A social institution is a complexity of positions, roles, norms and values that allow their members organize their social relations and adjust their behaviour in order to survive and attain a viable sustenance in a given environment (Turner, 1997).

Wherever social institutions for local fishing management exist, they can provide the basis to strengthen formal management plans, thus conserving resources and maintaining the different benefits that fishing provides (McGoodwin, 1990). This is possible because the social institutions of the fishing framework that are developed *in situ*, integrate local ecological knowledge, practices, commitment to place and the organizational capacity of fishermen to sustain their livelihoods (McGoodwin, 1990; Basurto *et al*., 2012). Furthermore, local resource management practices use these social institutions to represent typical fishing management measures, such as technical controls, effort and catch. In this study, researchers largely used participant observation techniques to examine some historical, technological, socioeconomic and fishing organization aspects, related to the development, of the cooperative system and the formation and performance of social institutions for local fishing management in the tropical Pacific of southern Mexico. The study area is part of one of the largest and diverse estuarine systems on the coast of Chiapas, an area where very little research on small-scale fishing cooperatives has been carried out.

MATERIALS AND METHODS

Study area and overview of the fishing cooperatives: The Chantuto-Panzacola estuary system is located on the Pacific coast, in the South-Eastern Soconusco region of Chiapas state, Mexico (Fig. 1). With an extension of 18,000 ha, it includes a permanent opening to the sea (Boca San Juan), a long stretch of estuary parallel to the coast (El Hueyate) and 5 tributaries (San Nicolas, Cacaluta, Dona Maria, Cintalapa and Vado Ancho). It is part of the La Encrucijada Biosphere Reserve (REBIEN) which includes the highest altitude mangroves of the Mesoamerican Tropical Pacific (up to 35 m high), highly productive coastal lagoons and one of the most important wetland system in the country due to its biological richness, diversity and productivity. This is a natural protected area, recognized as a RAMSAR site which forms part of the World Network of Biosphere Reserves of the UNESCO's MAB program.

As in the past, fishery resources currently provide an important source of animal protein for residents of this area. Archaeological explorations in the zone (Drucker, 1948; Voorhies, 1976) have revealed the importance of fish, crustaceans and molluscs in the diet of the Chantuto people, early inhabitants of the Chiapas coast, believed to have preceded the Mokayas, considered the first sedentary agriculturalists in Mesoamerica.

The estuary system includes a considerable ichthyological diversity, made up of 143 species of

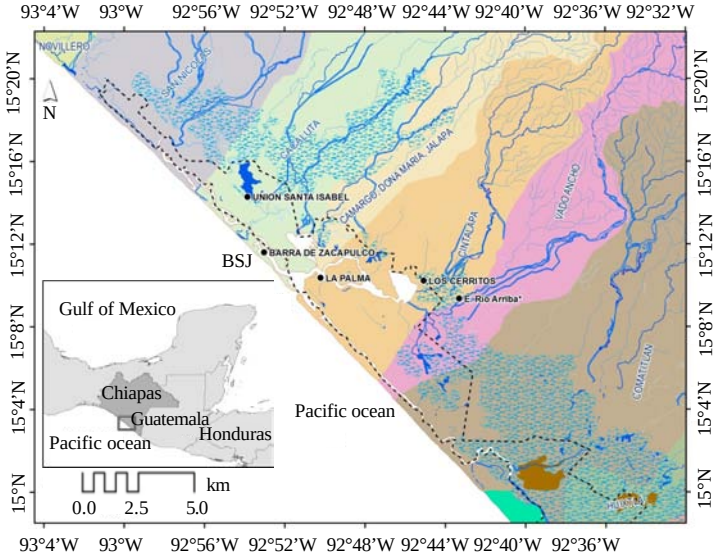

Fig. 1: Location of fishing cooperatives (including the Fishing Division*), Boca San Juan (BSJ), drainage basins and the core area of the REBIEN (dotted line)

Table 1: Basic information of the cooperatives in the estuary system

	Cooperative				
			Los Cerritos		
Items	Barra de Zacapulco	La Palma	Las Lauras	E. Rio Arriba	Union Santa Isabel
Foundation (year)	1978	1941	1942	1999	1989
Fishermen according to data of NFR* (num.)	126	126	90	64	107
Fishermen according to field data (num.)	154	150	125	89	131
% of variation in fishermen (1996-2012)	+22.2	+19.0	+38.8	+39.0	+22.4
Interviews carried out (num.)	33	32	22	16	29
Fishermen (male) interviewed (num.)	33	26	19	16	29
Fisherwomen interviewed (num.)	0	6	3	0	0

NFR = National Fishing Registry; *The total of fishermen recorded is 26.5% greater than in the NFR census

estuarine fish. For over 70 years, fish and crustacean fisheries which are the principal source of economic activity in the zone, exercise their traditional system of resource tenure together a formal system of co-operative fishing that temporarily confers property rights and management responsibilities to legally established groups. The adoption of this system has followed a national trend by which governmental assistance, destined to foment fishing, encouraged fishermen to regulate their activities.

The study area includes 4 fishing cooperatives and a fishing division (Fig. 1 and Table 1). The La Palma and Barra de Zacapulco cooperatives are located in the central part of the estuarine system (close to Boca San Juan) while the Union Santa Isabel and Los Cerritos cooperatives, as well as the Embarcadero Rio Arriba Fishing Division are located towards the end of the system. While fishing in the region is based on the capture of many species of fish and crustaceans, fishing organizations located at the end of the estuarine system including Barra de Zacapulco, are more oriented to catching shrimp, mainly from January to June, contrasting with the La Palma cooperative which catches fish all year round. Fishermen organizations in the estuarine system have multiple fisheries agreements to exploit the distribution of species and their habitat preferences.

Ethnographic and semi-structured interviews: The first encounter with the fisheries was in April, 2008 when the opportunity arose to accompany a group of biologists during a field trip to collect fish in the REBIEN. Initial observations of fishing activities and interactions with some fishing cooperative directors, fishermen and families generated an interest in the conditions under which these ancestral fisheries were established and are currently managed. This preliminary contact allowed the development of early communication relationships which subsequently helped identify possible key informants. In July, 2009 with the help of a graduate student who had maintained contact with the area since 2008, research proposals were formally presented to the Board of Directors of each cooperative, resulting in the authorization of access to, the study area. Most of the data was collected on multiple visits to the field between this date and February, 2012. Researchers used mainly participant observation techniques (Pujadas *et al*., 2010), including informal and semi-structured interviews, document revision, photographs and a field journal. Researchers also compiled data using video records taken during workshops with fishermen. These workshops whose aim is the comprehensive strengthening of fisheries, are promoted by fishermen, policy makers, academics and other stakeholders in the fishery. Most local names of fish species, related to, each type of fishing gear, were collected during one of these workshops. Others were obtained when fish were landed at the cooperative collection points.

To document the current performance of the fisheries as regards technological factors and organization; informal interviews were applied to fishermen in the cooperative facilities and some of the fishing households where basic services, food and drinks were provided. Participant observation was implemented in both locations but principally in cooperative facilities during meetings visits by officials and the landing and sale of fishing products. This method, was also carried out to obtain information regarding fisheries performance. Accordingly, researchers obtained preliminary information on existing cooperative and inter-cooperative agreements regarding the local management of fisheries, cooperative structure and functions, the roles and functions of women in fisheries and at home, fishing gear and their relation to the catch and the activities and events that affect fishing trips. Subsequently, to supplement and confirm the information obtained, researchers obtained access to historical documents and other cooperatives through informants belonging to the fishing community. This was possible thanks to the relationship of trust and rapport established with fishery directors and involvement with unions and the wider community. Considerable, time was spent collecting documentary evidence (initially transcribed on the site and subsequently by photographing and audio recording for later transcription), attending meetings and during cooperative research in the fishing areas and vicinity.

For socioeconomic factors, information was obtained by applying a semi-structured interview with a structure

and content based on preliminary information generated during informal interviews with fishermen, participant observation in homes and cooperative facilities and video records during workshops with fishermen which were used to identify local expressions and issues related to fishing organization. The protocol for semi-structured ethnographic interviews, outlined in Garcia-Quijano (2009) was used as a guide for the presentation and question and topic order of the semi-structured interview. In total, 132 individuals, encompassing fishermen and cooperative directors were interviewed using stratified random sampling (Kronen *et al*., 2007), with a distribution proportional to the size of the cooperatives. Only fishermen who were active were considered and whenever possible researchers also interviewed fisherwomen who met this condition. Some interviews were audio-recorded, using the Audacity software (version 1.2.6) for later transcription. The interviews lasted between 30-40 min with questions related to, socioeconomic aspects and how the fisheries are organized. Information was obtained on age, years of fishing experience, education level, type and size of fishing families, the level of dependency on fishing, property rights regarding distinct modes of production, capture yields, organization and the costs and revenues associated with this activity. Additional data was obtained on existing arrangements for local fisheries management which was subsequently categorized following the typology proposed by Cochrane (2002) used for the description on local management regimes.

Finally, after familiarization with all the information on fishing operations in the study area, the historical reconstruction of the cooperatives development and processes of technological change were researched by means of unstructured interviews applied to the oldest fishermen in the area (some of them cooperative founders). Documentary evidence obtained in cooperative facilities and fishery directors' homes was also consulted. The information was validated by triangulation with additional, informers and a bibliographical review of the literature on fishing techniques, the fishing legal framework and wildlife resources related to the history of fishing.

RESULTS

The cooperative system in small scale fishing

The politics of fishing development and formal fishing management in Mexico and estuarine systems: Ben-Yami and Anderson (1985) pointed out that in developing countries fishing cooperatives embody the official government policy of encouraging small scale fishing. Historically, the Mexican state has supported technological advances in fishing and the establishment of cooperatives in the fishing sector. Since, their early development (1934-1940), Mexican fishing policies have experienced close ties with rural development processes such as the 20th century agrarian reform that led to the establishment of cooperatives as a form of strengthening the social sector (OECD, 2006). During a period characterized by inexperience in the design of fishing policies (Espinoza-Tenorio *et al*., 2011), cooperatives in Mexico emerged to stimulate fishing, assign and recognize resource rights and distribute benefits amongst the poorest fishermen. Between 1938 and 1992, small scale fishing cooperatives were widely favoured by the Mexican state which provided exclusive access to the most valued fishing resources, such as shrimp which were subsequently regulated through concessions, close seasons and controls on fishing gear (Espinoza-Tenorio *et al*., 2011); periodic inspections and monitoring complemented this regulation. Over the years, Mexican cooperatives have experienced several political reforms and administrative structural changes as a response to financial problems, demands of the private sector, influence of international policies and the growing emphasis on power decentralisation. Initiating with the creation of the La Palma cooperative on the coast of Chiapas in 1941, as part of the government cooperative drive, fishing cooperatives in estuarine systems have existed in Mexico for over 70 years.

The La Palma cooperative later gave rise to the Barra de Zacapulco and Los Cerritos cooperatives, the latter originating in the Las Lauras community. Some members of the Los Cerritos cooperative moved to, the Embarcadero Rio Arriba cooperative, leading to the establishment of the E. Rio Arriba Fishing Division. Often, as is the case in the study area, when a new cooperative arises readjustments take place in fishing grounds and on occasions social conflicts occur which are finally, resolved through negotiations before government bodies. For example, the emergence of the cooperative Union Santa Isabel led to strong disputes related to the partitioning of fishing areas, as this area was previously designated to the Barra de Zacapulco cooperative.

Processes of technological change: The regions cooperatives have experienced processes of technological change not only characterized by the diversification and perfection of techniques and fishing gear but also by the traditional processes of preserving and preparation of dry-salty shrimp, the fishing product which provides the greatest economic and social benefits in the zone. In the

early 1940s, fishermen of the region used hooks and fishing line made from a natural fiber extracted from the local maguey (*Agave* sp.) plant. The line was darkened by submerging in water with red mangrove bark (*Rizophora mangle*). This reduced its visibility in the water therefore increasing fishing effectiveness. Trammel nets were also made using the same technique.

Cast nets woven with cotton string (1 and ½ mesh) were used to catch a variety of crustacean species. Also cubos or harpoons with a metal point and a long cedar (*Cedrela odorata*) handle, tied with mecate (maguey cord) on the opposite end were used to catch a variety of snook (Centropomidae), snappers (Lutjanidae) armado fish (*Atractosteus tropicus*) and crocodiles (*Crocodylus acutus*) a species officially protected in Mexico, since 1970. Harpoons were thrown from cedar or guanacastle (*Enterolobium cyclocarpum*) canoes that were 6-7 m long and 0.7 m wide, made by fishermen using adzes and axes. Oars are still made from this material.

Harpoons are still made with 3 points and are known as trinches (3 prong fishing spear) or llanas. These are used to assure the catch when fishing with a hook. However, they are of little use for catching fish and have been displaced by mechanical harpoons ((speargun and fisga) the fisga is a steel rod (approximately 70 cm long and 0.5 cm diameter) with a pointed end and a rubber band attached to the other end. To launch the fisga it requires holding the rubber band and stretching it in the same way as a projectile is launched with a slingshot) which are usually used with diving masks to observe the fish underwater. The speargun is more widely used for catching snappers and snooks while the fisga is used to catch saltwater and freshwater mojarra (Gerreidae and Cichlidae) in addition to snooks. This relationship of fishing gear and target species is the opposite to that presented by Morales in La Palma.

After the 1950s, fishing in the zone underwent pronounced changes which contributed to a notable increase in catch. Cast nets were initially made from cotton string but this was replaced by silk and then nylon. These new materials provided greater resistance, elasticity and durability than cotton. Soon nets were incorporated applying 3-ply cords with rudimentary winches (malacates). These materials also favoured the creation of 50 m longlines (cimbras) used to catch catfish (Ariidae), snappers and snooks, as well as one of the largest species of saltwater catfish, the tacazonte (*Sciades hymenorrhinus*) which can grow up to 2 m in length. Despite these changes in materials and gear, the nets are still made by hand, using plastic, metal or wooden needles made by fishermen from red mangrove. Some fishermen occasionally make nets, harpoons and oars during free time which are then sold when someone places an order.

Perhaps the greatest technological change has been the introduction of the outboard motor which favoured the development of commerce and the opening of national and international shrimp markets. Motors were introduced in the mid-1950s and their widespread use was made possible due to government support. Trade was benefitted with the construction of roads as part of the government's Plan Hidraulico de la Costa de Chiapas (hydraulic plan of the coast of Chiapas) (1979-1991) as the products were delivered to market, fishing no longer fulfilled subsistence needs. However, the project which sought to improve infrastructure in terms of roads, drains, containment walls and thus, expand the agricultural frontier, altered the natural channels and therefore the hydrological regimes of the rivers that flow into the estuarine system, provoking constant floods and siltation of fishing areas. These problems were accentuated by impacts from Tropical Storm Mitch in 1998 and Hurricane Stan in 2005. This problem is a prime example of the major environmental threats facing estuarine systems in Mexico: Changes in river hydrology, river pollution, vegetation removal, coastal erosion and overfishing.

While shrimp corrals or barriers (tapos) have been used in the region since, the 1950s, their origin in Mexico dates back to the prehispanic era. The first tapos built in the study area were known as experimental tapa and consisted of cotton nets which took 3 months to make. Fishing with stow nets (copos fijos) began in the 1960s. Tapos and stow nets allowed an increase in fishing effort and yield of the shrimp catch. Reyna was the first to review the use of tapos in La Palma for catching shrimp. La Palma no longer uses tapos because with the development of other cooperatives and consequent readjustments in fishing areas, they lost access to deep and quiet waters which are a requisite for using this gear. Nevertheless, their disappearance has been compensated by a greater use of stow nets.

Traditionally, cooperatives have marketed fresh shrimp but they are also consumed and sold dried and salted by individual fishermen, their families and other intermediaries during times of abundant catch, as cold storage capacity is insufficient. Until the end of the 90s, it was common to dry shrimps using improvised drying patios on the streets that consisted of old nets placed over layers of salt. Floors or drying patios of shells is an even older practice (Voorhies *et al*., 1991). Originally, red

mangrove bark was used to colour shrimp. In the cooperatives today, more local women and occasionally men are seen buying and cooking shrimp with salt and colouring over a wood fire for later sale. These women are known as, palenqueras as they are often seen walking with baskets filled with shrimp balanced on their heads.

Social institutions for local fishing management

Fishermen, production and organization of fishing: Roles, status, routines, procedures, conventions, organizational forms and values are elements that characterize relationships between members of a social institution (March and Olsen, 1989; Turner, 1997). At the Barra de Zacapulco, 154 fishermen operate, 150 in La Palma, 214 in Los Cerritos (125 in Las Lauras and 89 in E. Rio Arriba) and 131 in Union Santa Isabel (Table 1). In these cooperatives, fishermen are organized into groups with different hierarchies and functions (Table 2). At the top are the directors and members, recognized by local society and the state because they are the owners of the fishing permits. Historically, almost all economic and technical assistance has been channelled toward this group: subsidies for boats, motors, petrol and marketing, nets and shrimp postlarvae for extensive farming, hydraulic and fishing projects, temporary employment, experimental aquiculture projects, training courses, advice and technical studies. Some of these resources are provided by international, federal, state and municipal non-fishing agencies.

Below the directors and members are occasional fishermen who regularly participate without pay as part of the tequios (a form of communal research enforced by the cooperative so non-cooperative members can earn access to fishing grounds). This research may be to rehabilitate fishing areas or to build or maintain the cooperatives retention walls and rustic infrastructure. These fishermen, most of whom are sons of members, represent the generational reproduction necessary in the cooperatives. This group includes acasillados, recognized for their long-term work in the tequios and the first in line to be new members. These fishermen do not have a servile and dependant relationship with the cooperative, as did the acasillado labourers in the haciendas during the class struggle in rural Mexico in the 19th century.

At the bottom of the hierarchy are free fishermen and women. Free fishermen operate occasionally because they are linked to the community or are sons of members. In some cooperatives, women play multiple roles in fishing. Besides attending to home and family, they accompany the husband fishing. This is a livelihood strategy to assure greater income which they would have to share if they were to fish with a non-family member. Family responsibility is typically their principal reason for beginning to fish. It is uncommon to see a young single woman fishing.

Table 2: Position and functions of a fisher in an estuary system cooperative

Position of a fisher in a cooperative	Activities* and functions
Director	1) Calls, directs, supervise and pay[a]. Becomes involved if there is no payment
	2) Calls, presents reports and seeks consensus
	3) Sometimes participates in shrimp fishing
	4) Sometimes fishes but for self-subsistence
Member	1) When there is payment[a], may be replaced by an occasional fisherman
	2) May be elected as director or leader of the assembly meeting
	3) May be part of the fishing group
	4) Access to fishing
Occasional fisherman acasillados	1) Sometimes may receive part of the payment[a]
	2) Sometimes may attend meetings, having voice but no vote. May be elected member
	3) -----
	4) Access to fishing only in the company of members
Occasional fisherman non-acasillados	1) Works without payment
	2) Sometimes may attend meetings, having voice but no vote
	3) ----------
	4) Access to fishing only in the company of members
Woman	1) Sometimes substitutes the spouse in work which does not demand great physical strength
	2) ----------
	3) ----------
	4) Access to fishing with spouse or son
Free fisher	4) Access to fishing only in the company of members

*Type of activities: 1) Cooperative work (tequio); 2) Holding assembly meetings; 3) Fishing exclusively for the cooperative; 4) Fishing for subsistence and sale; [a]When dealing with temporary employment provided by the government in order to confront low employment or natural disasters

Some women sell fish and crustaceans which they obtain from fishermen or the cooperative, as intermediaries or at regional markets. In order to add value to their product, they cook the shrimp with salt and colouring and also make pulp from the *chacalin* or long arm river prawn (*Macrobrachium tenellum*) by removing the head and exoskeleton. The pulp rather than the whole prawn is more accepted and valued by consumers. To date, 59 women have received economic support for marketing fish products.

Furthermore, some fisherman's wives who have migrated with the cooperatives permission, help maintain their husband's membership by taking on their responsibilities, contributing money or work towards the running of the collective. The most active women work at home, in fishing and in armado fish aquaculture, an activity currently being fomented by the government. Despite all these social functions, the role of women in fishing continues to be undervalued.

Field data indicates that fishermen are aged between 17-95 years with a mean age of 45.3 years (Table 3).

Table 3: Socioeconomic structure of the cooperatives in the estuary system

Data based on fishermen's responses (N = 132)	Cooperative				
			Los Cerritos		
	Barra de Zacapulco	La Palma	Las Lauras	E. Rio Arriba	Union Santa Isabel
Fishermen* (num.)	154	150	125	89	131
Fishermen's age (Years; Min[a]-Max[b], average)	17-82, 44.4	24-83, 47.9	18-94, 43.7	22-95, 43.7	28-64, 47.0
Graduated primary school (%)	41.3	30.0	15.0	25.0	50.0
Experience in fishing (average years)	30.9	33.5	23.0	26.4	24.7
Mean income for a day's work fishing ($/day)	12.69	9.40	9.60	7.93	14.84
Average cost of a day's work fishing ($/day)	3.13	3.29	3.20	4.12	2.37
Other income sources (%)	39.4	40.6	40.9	37.5	27.6
People dependent on the fisherman (Min[a]-Max[b] num., average)	1-5, 2.6	1-8, 3.0	1-5, 2.8	1-7, 3.4	1-5, 2.7
Family members in fishing (average)	7.4	14.4	11.6	1.8	11.9

*Fishermen who according to field data, belong to the cooperative; [a]Min. = Minimum; [b]Max. = Maximum

However, the majority (66.7%) are between age 30 and 59. The illiteracy rate for fishermen age 43 and over is 12.9%. On the cooperative level, illiteracy is greatest in Union Santa Isabel with a rate of 29.4% and lowest in La Palma and Las Lauras each with 11.8%. In the cooperatives, the absence of basic elementary education (reading and writing) leads to low participation in administrative positions and vulnerability when dealing with buyers. As regards educational level, 66.1% of fishermen have finished at least the first grade of primary school, 26.1% have finished at least 1 year of secondary school and 7.8% have finished at least one year of high school. Among these, only one out of nine women have attended high school. At least 33.9% of fishermen have finished primary school and 7.8% have finished high school. As a whole, fishermen have an average of 4.4 years of schooling. These educational, levels are low and are similar to those presented by De la Cruz-Gonzalez in a recent study, on socio-demographic and economic aspects of fishermen of the La Joya-Buenavista-Cordon Estuarico estuary system on the Pacific coast of Chiapas.

In the study area, 78.4% of fishing families possess a nuclear structure (mother, father and children). The most common family size is three members (31.1% of families). In 7 out of 10 families, the fisher is the only economic provider. On average, 2.7 additional family members depend on the fisherman for food and income. The mean number of dependents per fisherman by cooperative is 2.6 in Barra de Zacapulco, 3.0 in La Palma, 3.0 in Los Cerritos (2.8 in Las Lauras and 3.4 in E. Rio Arriba) and 2.7 in Union Santa Isabel. The age of dependants ranges from 1-104 years with an average age of 24.7.

Taking into account all cooperatives, 31.2% of fishermen have one family member (father, husband, wife or child) associated with the fishing sector. Of these, 9 out of 10 fish and 45.9% of these are sons of fishermen. This ensures the reproduction of local ecological knowledge and the generational continuity of fishing.

Over half (54.5%) of the fishermen have learned to fish from their fathers but a large number (24.2%) have learned on their own by emulating others. Fishermen have between 2-71 years of experience with a mean of 28.3 years. The age at which people begin to fish ranges from 6-56 year with a mean age of 16.2. While 3 out of 10 fishermen do not have an outboard motor over 90% own their main means of production: fishing gear and cayucos (canoes), modern boats made of fiberglass with the same dimensions as older canoes. The most common type of motor is 15 hp (62.7%).

In general, friendship determines fishing groups. (30.0%), although family ties are also important: 13.8% of fishermen fish with a son and 9.7% with a brother. Almost, always, 2 people fish in a cayuco but some fishermen fish alone when catching crabs or shrimp in paradero-namely, only fishing near the tapo. Groups of up to 5 or 7 fishermen may fish together when they use spoon nets in the tapo or stow nets fixed with stakes, respectively.

The majority of fishermen (69.4%) fish 6 days a week. The workday ranges from 2-13 h with a mean of 5.6 h. Workdays may occasionally be unfruitful but 73.4% of fishermen claim to have a regular catch (fish and shrimp) of 1-8 kg day^{-1}. During the 2011 rainy season, researchers recorded catches of up to 270 kg day^{-1} (90 kg for shrimp and 180 kg of chacalín) with stow nets in Las Lauras. 1-2 kg of daily catch is destined for family consumption (80.6%).

Excluding days without catch, the majority of fishermen (91.8%) stated that they obtain daily income of between $10.00 and 309.00 MXN ($0.71 and 22.03 USD), mean income is $174.70 MXN ($12.45 USD). Researchers occasionally recorded fishermen earning over $1,000.00 MXN ($71.31 USD) in one day when catching shrimp and chacalin in the tapo or with a stow net. Fishing is the principal source of annual income (90.9%) but 4 out of 10 fishermen receive income from other sources: Transportation of passengers across the lagoons, sales from small shops and welfare assistance for elders are the most frequent (1.5% each).

Table 4: Local management regimes of the cooperatives in the estuary system

	Cooperatives			
Measures of fishing control	Barra de Zacapulco	La Palma	Los Cerritos	Union Santa Isabel
Technical controls				
Temporary prohibition of area	Yes*	No	Yes	Yes*
Permanent prohibition of area	No	No	Yes	No
Zoning	Yes	Yes	Yes	Yes
Mesh size	Cast net	Cast net and trammel net	Cast net and trammel net	Cast net
Control of effort				
No. of fishermen	Yes	Yes	Yes	Yes
Times and days of fishing	Both	Days of fishing	Both	Both
Gear among cooperatives	Hook, harpoons and cast net	Hook, harpoons and cast net	Cast net and trammel net	No
Regulation of highly effective fishing gear	Stow nets and tapos	Stow nets	Stow nets and tapos	Stow nets and tapos
Restriction of fishing methods	No	No	Trammel net as fence and use of nets[a]	No
Controls of catch				
Inspection and supervision	Yes	Yes	Yes	Yes
Protected species	Yes	Yes	Yes	Yes
Limiting trips per day	No	No	Yes	No

*Belen, Sabana, Sabanita, San Abraham, El Campito, Vidalito, La Pululera and Chantuto from Poza Aguada to Santa Isabel; [a]Nests = Artificial refuges of branches, where fish congregate and are sheltered

Although, 8.3% of fishermen said their fishing excursions did not incur any costs because they did not use outboard motors or buy ice to conserve the products, the cost of a day's fishing ranged from between $8.00 and 130.00 MXN ($0.57-9.27 USD) with an average of $43.70 MXN ($3.11 USD). For 89.26% of fishermen, a day fishing costs between $8.00 and 72.00 MXN ($0.57 and 5.13 USD). Fuel is the main cost (79.3%), despite the fact that 16.3% of fishermen have government petrol subsidies. Costs, income and catches are shared equally between unrelated fishermen who fish in groups. In repartitions among family members, after subtracting operational costs, income and catches are prioritized to cover household needs.

Government and local fishing management: The fishing cooperatives represent an alternative to conventional methods of fishing management (Deacon and Ovando, 2013). Frequently the literature portrays these cooperatives as having the following characteristics:

- Better organization of labour
- Greater equity in income distribution
- More rational resource exploitation (MacGoodwin, 1980; Acheson, 1981)
- Congruency between fishing management and objectives related to conservation of key habitats

In the region, researchers found that cooperatives played a key role by participating in fisheries management, channelling state support to strengthen fishing, providing information on markets for fishing products, facilitating marketing, obtaining loans for traders, covering expenses due to illness and death and representing the interests of their members before the government, other cooperatives, fishermen without fishing rights (farmer-fishermen) and other individuals and groups not involved with fishing. Occasionally, the cooperatives use their political power to obtain financing and support for projects. They also demonstrate their capability to independently resolve matters of interest for the entire community, such as supply contracts and land possession. The cooperatives occasionally provide money for sports, education and acquisition of land for collective use, as an example of social responsibility.

Technical controls and those governing effort and catch are typical measures of fishing management. Management regimens are a combination of these controls (FAO, 1999a). In order to confront the randomness of fishing, reduce conflict caused by different fishing gear and assure the reproductive potential of resources and catch for their associates, the cooperatives of the zone have designed and put into practice a broad range of control measures that regulate fishing activities and as a whole may be considered to be a local management regime (Table 4). Collective actions, unlike individual efforts, provide a buffer that allows fisher to confront many elements that they have no control over, such as climate, fluctuations in resource distribution and abundance, costs of fishing and income from products sale (Acheson, 1981).

Established technical controls on fishing include temporary and permanent close-seasons in certain areas, zoning and regulations regarding mesh size (for cast nets and trammel nets). Officially, 527 cayucos (boats) and 1,553 nets (1,482 cast nets and 71 trammel nets) are officially registered as fishing material.

Table 5: Fishing gear of the cooperatives in the estuary system

Fishing gear	Cooperative: Barra de Zacapulco (n = 33)	La Palma (n = 32)	Los Cerritos (n = 38): Las Lauras (n = 22)	Los Cerritos (n = 38): E. Rio Arriba (n = 16)	Union Santa Isabel (n = 29)	Principal species*
Falling gear						
Cast nets:						Whiteleg shrimp, camaron blanco (Litopenaeus vannamei); blue shrimp, camaron azul (*L. stylirostris*); longarm river prawn, chacalin, camaron chango (Macrobrachium tenellum); white mullet, liseta, romita (Mugil curema) and yellow fin snook, juela, juelita, hojuelita (Centropomus robalito)
Frequency of use (%)	90.9	68.8	95.0	100	100	
Volume of the catch* (kg/shrimp/day)	-	30.7	86.7	-	-	
Gillnets and entangling nets						
Trammel net:						White mullet, liseta, romita (*M. curema*) and blue sea catfish, bagre de pampa, zunte (Ariopsis guatemalensis)
Frequency of use (%)	27.3	18.8	45.5	18.8	3.4	
Volume of the catch* (kg/fish/day)	-	41.5	86.8	-	-	
Grappling and wounding (harpoons)						
Speargun and fisga:						Colorado snapper, *pargo rojo* or *colorado* (*Lutjanus colorado*); pacific dog snapper, *denton, pargo dienton* (*L. novemfasciatus*); black snook, *robalo romo* or *chato* (*C. nigrescens*) and three spot cichlid, *Mojarra tahuina* (*Cichlasoma trimaculatum*)
Frequency of use (%)	18.2	3.1	5.0	6.3	3.4	
Volume of the catch* (kg/fish/day)	-	41.4	-	-	-	
Trinche, llana, three prong fishing spear						
Frequency of use (%)	0.0	3.1	0.0	0.0	0.0	Colorado snapper, *pargo rojo* or colorado (*L. colorado*); longspine grunt, mapache, roncador (*Pomadasys macracanthus*) and white mullet, *liseta, romita* (*M. curema*)
Volume of the catch* (kg/fish/day)	-	2.5	-	-	-	
Hooks and *Lines cimbra*, tiburonera, longlines						
Frequency of use (%)	3.0	3.1	0.0	0.0	0.0	Catfish, *bagre* (Ariidae)
Cuerda, handlining, hook						
Frequency of use (%)	33.3	40.6	15.0	43.8	13.8	Yellow snapper, *miche* (*L. argentiventris*); colorado snapper, *pargo rojo* or *colorado* (*L. colorado*) and white snook, *robalo hocicudo* (*C. viridis*), bait: Shrimp (*Litopenaeus* sp.); jacks (*Caranx* sp.) and other
Volume of the catch* (kg/fish/day)	-	64.7	15.0	-	-	
Mota, feather[a]						
Frequency of use (%)	12.1	0.0	0.0	0.0	0.0	
Trolling line						
Frequency of use (%)	6.1	3.1	0.0	0.0	0.0	Colorado snapper, *pargo rojo* or *colorado* (*L. colorado*) and black snook, *robalo romo* or *chato* (*C. nigrescens*), bait: Artificial bait; Pacific fat sleeper, sambuco, popoyote, pupo (*Dormitator latifrons*) and other
Volume of the catch* (kg/fish/day)	-	4.4	-	-	-	
Traps *Copo fijo*, stow net						
Frequency of use (%)	8.4	20.0	2.4	2.2	5.3	Whiteleg shrimp, *camaro blanco* (*L. vannamei*); blue shrimp, camaron azul (*L. stylirostris*); longarm river prawn, *chacalin, camaron chango* (*M. tenellum*) and pacific fat sleeper, *sambuco, popoyote, pupo* (*D. latifrons*)
Volume of the catch* (kg/shrimp/day)	-	106.6	270.0	-	-	
Nasa, charanga, fish pots						
Frequency of use (%)	0.0	3.1	5.0	0.0	0.0	Giant swimcrab, *jaiba negra* (*Callinectes toxotes*) and warrior swimming crab, *jaiba verde* (*C. bellicosus*)
Volume of the catch* (kg/crab/day)	-	24.5	-	-	-	

*Data during the rainy season of 2011 and dry season of 2012; [a]*Mota*, feather = Fishing with double hook which involves use of feathers as bait

Nevertheless, other fishing gears are also used in the zone. To facilitate their recognition, researchers have catalogued them following the FAO's classification of fishing gear (Nedelec and Prado, 1990), researchers have retained local names and for each researchers review frequency of use, volume of catch, principal species with scientific names, the most widely used names in English and vernacular names in Spanish (Table 5). Cast nets, handlines (hooks) and trammel nets are the most common fishing gear with a frequency of use of 89.2, 29.2 and

Fig. 2: Construction of the tapo (shrimp corral or barrier) in Lagoon Panzacola: a) A group of fishermen around the tapo still under construction wait for the start of the second and final cooperative workday; b) Figure representing the finished tapo; c) Setting up the tarred mesh on the frame made of wooden parts of varying dimensions; d) Divers place sacks of sand to press the tarred net against the frame; e) Mallet made from red mangrove (*Rhizophora mangle*), one of the handmade manual tools used in making gear; Photos c and d denote a type of cooperative division of labour

22.3%, respectively. Fishing gear frequency of use is in accordance with that mentioned by Mach and Jones in a study of perceptions of fishing in the same zone.

Controls on fishing effort limit the number of fishermen that possess fishing rights and establish authorized fishing schedules, workdays, gear and techniques for neighbouring cooperatives (hook, harpoons and cast nets). They also limit the number of highly effective fishing gear: Tapos and stow nets, the use of the latter governed by the changing elements (seasonal rains, tides and the lunar cycle). These measures reflect local environmental knowledge and an adaptive capacity for a more adequate and appropriate exploitation of the diversity of species and their habitat preferences.

Despite their effectiveness, stow nets are not selective and impede the migration of fish and crustaceans within and outside the estuarine system. Fishermen are aware of this but they justify the use of these nets to assure the economic survival of their households and cooperatives. The cooperatives regularly charge a commission of $4.00 MXN ($0.28 USD) per kilogram of product sold. Half of this goes to cover administrative salaries and the rest to the cooperative's operative costs (e.g., business travel and office expenses, petrol and ice). Sometimes the cooperatives pay a commission (in kind) to their associates for operating the cooperatives stow net.

Seasonal access to a tapo is assigned using a rota system that includes different groups of fishermen from 2 cooperatives. Cooperative construction and maintenance work is also organized this way (Fig. 2). A tapo in the Chantuto lagoon is shared between the Barra de Zacapulco and Union Santa Isabel cooperatives while the Las Lauras and E. Rio Arriba cooperatives share a tapo situated in the Panzacola lagoon.

Tapo construction and maintenance which requires hard physical labour is divided among the youngest fishermen. Elderly fishermen, participate in less strenuous work, such as mending and joining nets. They also participate in the despulgue of the shrimp that is selection of the catch after fishing with the cooperative stow net.

To prevent depletion of the shrimp population and thus, ensure the continuing participation of the cooperatives in the catch, a tapo should not be used >6 months per year (January to June) in this period whereby the greatest profits are obtained, only men fish. In order to fish, distribute and watch over the catch, camps are set up. Frequently, when other fishing gear is used, landings are carried out on the cooperative's grounds. A few years ago, the government began

regulating the tapos, as well as offering advice for calculating the amount of wood needed for tapo construction, supplying tapo nets and occasionally shrimp post larvae. Government intervention has also included assistance for feasibility and environmental impact studies, fishermen are also provided with official government identification cards.

As a complement, output controls that govern the catch aim to prevent the fishing of protected species (*Mugil cephalus* and *M. curema*) and limit the number of fishing trips per day. Collection sites and fishing areas are inspected and monitored to assure greater compliance of controls. Violation of controls is punished with temporary fishing restrictions, community work to help with the tequio whereby only eventuales participate, economic sanctions or confiscation of fishing gear and other equipment. Sometimes, fishermen with repeated violations are expelled from the cooperative. Controls are defined in cooperative or federation of cooperatives assemblies and legitimized as regulations or working agreements, sometimes with the intercession of a notary. Bad weather, religious and school holidays influence fishing trips. The community behavioral rules involve a diversity of Christian manifestations that have an impact on the local mechanisms of fishing organization. Recently, Sunday has been declared a day off (this day is dedicated to the Lord), in addition to the existing festivities and celebrations for the patron saint that take place each year. Fishing is interrupted on the patron saints day and sometimes the succeeding day due to a lack of trade. Major traders know that few fishermen return to work the day after the patron saints day. Government regulations, legislation and the Management Program of the REBIEN are also considered.

DISCUSSION

Implications for fishing management and politics of fishing development: The successful integration of the norms, rules and knowledge of social institutions into formal management plans, implies an improved understanding of the conditions under which such institutions are formed, remain relatively stable, persist and function in order to shape social relations and adjust behaviour related to the access and exploitation of natural resources. A fisheries management plan that integrates socioeconomic and institutional information, together with biological and ecological knowledge, enables anticipate the potential impacts that public intervention has on resources and users (FAO, 1995, 1999a; Cochrane, 2002). This is fundamental in this zone, classified as having a high level of marginalization (CONAPO, 2010). The information presented can help decision making related to diverse aspects of fishing activities. For example, socioeconomic information can be used in the construction of core indicators of the sector to analyse and monitor the situation over time. In addition, information on fisher and fishing gear that had not been formally recorded until now can be used in the creation of improved policies and programs for the development and sustainable management of fisheries. The state must assume a relevant role in the legitimization of all individuals that work within the fishing sector, hence favouring adequate incentives that reduce their existing marginalization in decision making processes and the wider sphere of social benefits that are only provided to legally established groups. As several researchers have pointed out locally-centered fishing management can be based on fishermen's ecological knowledge, an improved compilation of fishing statistics, resource and ecosystem conservation and the necessary operation and monitoring to achieve successful management plans (Cycon, 1986; Prince, 2003; Garcia-Quijano, 2009; Cinti *et al*., 2010). In working towards these aims, the cooperatives are an important ally to the fisheries authorities. During their development, the cooperatives not only experienced technological changes that resulted in a notable increase in captures but also developed skills to defend the interests of the collective and to act as social institutions for the management and conservation of local resources. Case studies worldwide have shown a similar situation and suggest that fishing cooperatives deserve more attention from researchers and policy makers in order to widen their participation in formal fishing management (Deacon and Ovando, 2013).

Historic development of fishing in the zone may reflect a specific case but its structure and emplacement is a microcosm of the principal attributes of small-scale fisheries in coastal habitats: High sensibility to environmental disturbances, multiple species and a large number of fishermen and fishing gear exerting pressure on fishing resources (McGoodwin, 1990). The lessons learned from the Chantuto-Panzacola fisheries can be useful for understanding similar situations around the world.

Diversifying economic activities may reduce pressure on resources in zones highly dependent on fishing (FAO, 1999a). Educational level is intrinsically connected to access to a well-paid job and improved living conditions. Improving the educational level of the fishermen would help to broaden their participation in administrative positions and reduce their vulnerability in the face of buyers, as well as helping broaden the possibilities of access to other employment aside from fishing. Currently, fishermen are generally apathetic about assuming administrative responsibilities, partly due to low income and having to make decisions within the

conflictive panorama of the fishing sector. In the past, when fishing areas were more productive, these positions were highly disputed.

Maintaining the reproductive potential of resources as well as stability, employment and income (cash and kind) in the fishing community should be a priority. The local management regime developed by cooperatives could be used as the basis for prioritizing the benefits that fishing in the zone provides. These measures, once evaluated could be formally accepted or reinforced before trying to develop and apply new norms. In contrast to top-down measures, local controls may reduce costs of management and increase the level of acceptance and compliance with regulations (Acheson 1975; Berkes 1986; FAO1999b; Cochrane 2002).

CONCLUSION

Following a national trend, cooperatives have been established to formalize fishing activities and to strengthen the social sector. Their development has implied a process of technological change (a result of market access, public intervention and the use of local materials and skills), particularly in the design, creation and adoption of fishing techniques and gear which has allowed an increase in fishing effort and capture yields.

Social institutions for local fishing management at the local level, structure the social relations and behaviour of their members. This allows cooperatives to respond to the interests of fishermen (not only those recognized by the state), the general community and fishing management. Social values, such as cooperation and responsibility are as important for collective reproduction as legal rights to natural resource exploitation. This has provided a good basis for the application of regulations and research agreements which allow peaceful coexistence and day to day undertaking of fishing activities.

Local fishing control measures can be assessed in order to strengthen formal fishing management plans. As well as, considering potential impacts on natural resources, future state interventions in the fishing sector should also take into account resource users, for which the socioeconomic aspects examined in this study are of crucial importance.

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