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Environmental history of Mexican North Pacific fishing communities☆

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ABSTRACT

Environmental history studies have focused on the negative environmental and equal rights access to natural resources, more recently scholars becoming interested in the study of successful cases of natural resources management. We present a successful co-management fisheries case that is product of a century of environmental history in the Mexican North Pacific region. In this historical process, the passage from rancher settlers to well-organized fishermen in fishing cooperatives took place together with the transition from an intensive exploitation to a sustainable co-management system. External factors played a crucial role in regional fisheries development, first by triggering their being with the arrival of a Japanese company and, afterwards by changing its course during the Great Depression. Two current threats have emerged from unpredictable and detrimental marine environmental factors related to global warming, and from cultural roots loss due, once more, to external factors. We conclude that, at present, the nature of the next historical stage of this enlightened environmental history self-learning case remains unknown.

1. Introduction

An extensive human impact on the coastal zones and inshore biota characterized the exploitation of marine resources during the twentieth century that especially affected fisheries (Schwerdtner-Máñez and Pauwelussen, 2016). In that context, the world's coastal fringe encompasses 8% of the ocean surface, is the habitat of nearly 90% of the total number of marine species (Gorman, 1993: 106–107), and 99% of the about fifty million fishermen worldwide make use of coastal fisheries (Berkes et al., 2001). In addition, pollution of coastal waters and overexploitation of fisheries because of ill management are common (see McNeill, 2000; Roberts, 2009).

From the perspective of the study of environmental history, there is a trend to aim at proposals of theoretical approaches, comprehensive methods, and renewed perspectives (Carey, 2009; Pawson and Dovers, 2003). In the case of studies of the history of coastal Marine Protected Areas, these have not only showed evidence of one of the most viable and politically acceptable approaches to marine conservation for 50 years (Wells et al., 2016), but together with studies of the history of fisheries –like those made in developing countries (Espinoza-Tenorio et al., 2010a)– they have provided plenty of experiences that help to build knowledge for future management of marine and coastal ecosystems. One of the conclusions of studies of the history of Marine Protected Areas and fisheries is the key factor role played by community based perceptions and knowledge in the (frequently missing) success of adopted policies. In fact, most environmental history studies have focused on the negative impacts on ecosystems, the unequal rights to access natural resources (Bourassa and Strong, 2000: 156; Jorgenson and Rice, 2007: 273–274; Weisz, 2007: 290; Endfield, 2009), and the lack of suitable policies or political willingness to solve the problems –like in Mexico (Espinoza-Tenorio et al., 2010b; Nava Fuentes et al., 2017). These characteristics of recent environmental history studies further evidence the contributor's focus in describing today's ecological crisis, propose solutions for it (Carey, 2009), and also, on the understanding of the relationships between peripheral regions and countries in order to adapt and improve development strategies (Barton, 2006: 367). Recently, scholars have been interested in the study of fisheries from the fishermen's perception and knowledge (Ramírez-Sánchez and Pinkerton, 2009; Alcalá and Camargo, 2011; Belton, 2012). The histories of successful marine natural resource management have become more common in recent years. Examples are the studies by Velez et al. (2014), who in a non-take zone for lobsters within a marine protected

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area of southern Mexico recorded the positive perception of fishers, and by Pérez-Ramírez et al. (2012), who reviewed the fishermen's success in empowerment through a certification processes of lobster species in northwestern Mexico. Environmental history aids to understand the interactions between societies and their environment in different ways through the identification of strategies for the use of resources, of the forms of perception and appropriation of nature, and of the productive organization inserted in different types of life, among others. Sustainable practices that can be adapted and implemented in present case studies can be identified through the analysis of these interactions and, in that sense, applied environmental history (Fernández Prieto y Picado Umaña, 2014) can contribute to the solution of environmental issues and to revalue of cultures that lead to the construction of sustainable communities. Indeed, environmental history research analyses –both of negative and positive aspects of human-nature interactions– becomes a means to find a pathway to collective community-based solutions to overfishing, to the resolution of conflicts within fishing communities, and to provide ideas for sustainable fisheries to counteract the global ecological crisis in coastal zones.

To understand complex systems like the marine ecosystems where fisheries occur, the best conceptual frame available today is the complementary framework of environmental, historical, and political ecology. We agree with the conclusion of Davis (2009:286) in her editorial of Geoforum: …"if more scholars interested in environmental change over time, whatever their discipline or sub-discipline, explore the complex links between stories of environmental change, the "science" used to bolster those stories, the biophysical data, and the political and economic forces motivating the use of a particular story over another, I believe we would produce more historical research that has the potential to make significant contributions to environmentally sound and socially just development today" … Historical political ecology provides an excellent example of at least one way to conduct this kind of research. Political ecology can be used to understand the decisions that communities make about the natural environment in the context of their political environment, economic pressure, and societal regulations. It can also help to understand a diversity of issues that occur in marine socio-ecosystems, going from socio-productive organizational arrangements to conflicts and their possible negotiation (Bebbington et al., 2010).

Political ecology is characterized by the conjunction of various research lines (critical ecological economic s, Marxist ecology, critical geography, environmental history, social anthropology, political sociology and socio-cultural studies) and comes from distinct traditions (Anglo-Saxon, Ibero-American, Indian, etc.). It embraces the studies of access, plundering, use, and of the beneficial ownership of territories and the resources they contain (in many cases including the recognition and verification of existing counterforces, along with proposed alternatives) (Delgado and Fonseca, 2013).

The importance of this complex research approach is the fact that it allows to unveil causes and not only symptoms of theoretical-empiric issues, which entails to profound understanding of contemporary social and productive relationships at all time and spatial scales.

The present research attempts to carry out a historical analysis similar to that made for other regional cases: Endfield 2009: 228; McNeill, 2000; Barton, 2006: 366; Jorgenson and Rice, 2007: 273–288. Additionally, our research attempts to show how the combination of local knowledge with scientific knowledge (Withers and Finnegan, 2003; Moller et al., 2004) in fisheries management leads to more efficient and sustainable alternative measures, because socio-environmental dynamics can hardly be explained according to a single cognitive system.

Methodologically, the increased diversity involved in the knowledge dialogue established between local and scientific knowledge nourishes a richer knowledge horizon. Moreover, due to the different origins of these forms of knowledge these provide the capability of approaching issues from a wider perspective, therefore reaching higher levels of understanding.

Our reference to local knowledge is similar to the Traditional Ecological Knowledge defined by Huntington (2000) as: "… the knowledge and insights acquired through extensive observation of an area or a species. This may include knowledge passed down in an oral tradition, or shared among users of a resource." This defines the community's knowledge, on which our work was based, and that was addressed through fieldwork and historical research.

In this study case we see the opportunity to investigate the dialogue between past and present worries and experiences in an attempt to write the future (O'Connor, 1997), and to make a contribution to the search for solutions to overfishing, conflicts within fishing communities, and the global ecological crisis in coastal zones.

The main objective was to reconstruct and analyze the environmental history of Mexican North Pacific (MNP) fishing communities from 1912 to 2011, in order to explain the configuration of their specific territory and its implications in the particularities of the seascape and landscape, and to identify the main socio-environmental factors that have influenced these communities to the search for the sustainable management of their fisheries. We analyze the appropriation of a geographical space to determine a particular territory through fishing and to establish fishing communities. This historical process reveals how fishermen organized in cooperatives and how they improved their fishing management aiming at sustainable development. Finally, our research explains how these fishing communities came to be by their own initiative, thus becoming enlightening examples of social organization and co-management. Importantly, in this case decision-making processes, problem solving, and adoption of strategies to avoid overexploitation followed a bottom-up approach, as opposed to the top-down approaches that usually have not yielded good results.

2. Methods

The research involved an interdisciplinary method (Table 2). Formal (scientific data and official information) and local knowledge were integrated to contrast, compare, complement data, and overcome the apparent contradictions between them. Triangulation was used to validate the data, allowing highlighting the complexity and richness of this research in a rigorous framework (Denzin and Lincoln, 2000; Castillo et al., 2005; Hay, 2010: 69–79; Memon and Kirk, 2011: 107). Data collection and fieldwork were carried out between 2011 and 2013. Data collection consisted in qualitative and quantitative information searched for in documents, databases, images, and cartography, and gathered from key informants. The fieldwork consisted in application of ethnographic techniques as in-depth, semi-structured, open group interviews, participatory workshops, and non-participant observation. A code was developed for use in the results section to identify the key informants (identifiable in Table 2). The documented environmental history was classified according to previously identified historical stages (Alvarez et al., 2015), important events, internal and external factors, development and management changes, and their social, political and economic implications.

2.1. Study area

The MNP fishing communities in the El Vizcaíno Natural Protected Area Biosphere Reserve (the largest biosphere reserve in the world) located in the centre of the Baja California Peninsula have historically been relatively isolated (Cariño et al., 2004; Cariño and Monteforte, 2008). The study area is limited to the east by the El Vizcaíno Desert, to the north and west by the Pacific Ocean, and to the south by the San Ignacio coastal lagoon. The Development Plan of the Baja California Sur state government considers this region as a stand-alone Planning Unit because of its economic and geographical homogeneity (GBCS, 2011). Internationally, it is recognized for its long-standing tradition of abalone and lobster management (García, 2009), and known because of

Table 1
Main fisheries in the region (modified from WinklerPrins et al., 2016).

Organism	Species	Fishing zone (season)	Marketing form	Destination
Abalone	*Haliotis corrugata* W. Wood, 1828, *Haliotis fulgens* Philippi, 1845 and *Haliotis assimillis* Dall, 1878	Pacific coast of Vizcaino (March until quota)	Canned	Export (China and Japan)
Lobster	*Palinurus inflatus* (Bouvier, 1895)	Pacific coast of Vizcaino (Nov.-Feb.)	Live	Export (China)
Sea snail	*Megastraea undosa* (W. Wood, 1828)	Isla Natividad-Punta Abreojos	Canned (brined)	National market
Pismo clam	*Tivela stultorum* (Mawe, 1823)	El Delgadito y Punta Malcomb, Punta Abreojos	Live (whole), fresh, frozen, and canned	Regional and national niche markets
Various scale fish	Several species	Pacific coast of Vizcaino (when lobster and abalone are closed)	Fresh	Regional

opportunities to watch the Grey Whale (*Eschrichtius robustus*) in its breeding territory (Reilly and Thayer, 1990).

Overall, today's population size ranges from temporary fishing camps with less than five inhabitants to permanent settlements of up to 2500 inhabitants. According with the 2010 census of the National Institute of Statistics and Geography (INEGI 2010), in the area there were four major camps with a total of 5910 dwellers. Data from the State Government of Baja California Sur (GBCS) report that, in 2008, the fishing production reached 175,120 tons live weight, worth nearly US$72.69 million (GBCS, 2010). The main species captured in the MNP fisheries are listed in Table 1.

3. Results and discussion

The environmental history of the study area is described in three main historical stages in the development of fisheries management, as previously identified by Alvarez et al. (2015): 1) Pre-fishing co-operatives, 1912–1939; 2) Consolidation of fishing cooperatives, 1940–1979; and 3) Fisheries co-management, 1980–2011.

3.1. Pre-Fishing Cooperatives stage (1912–1939)

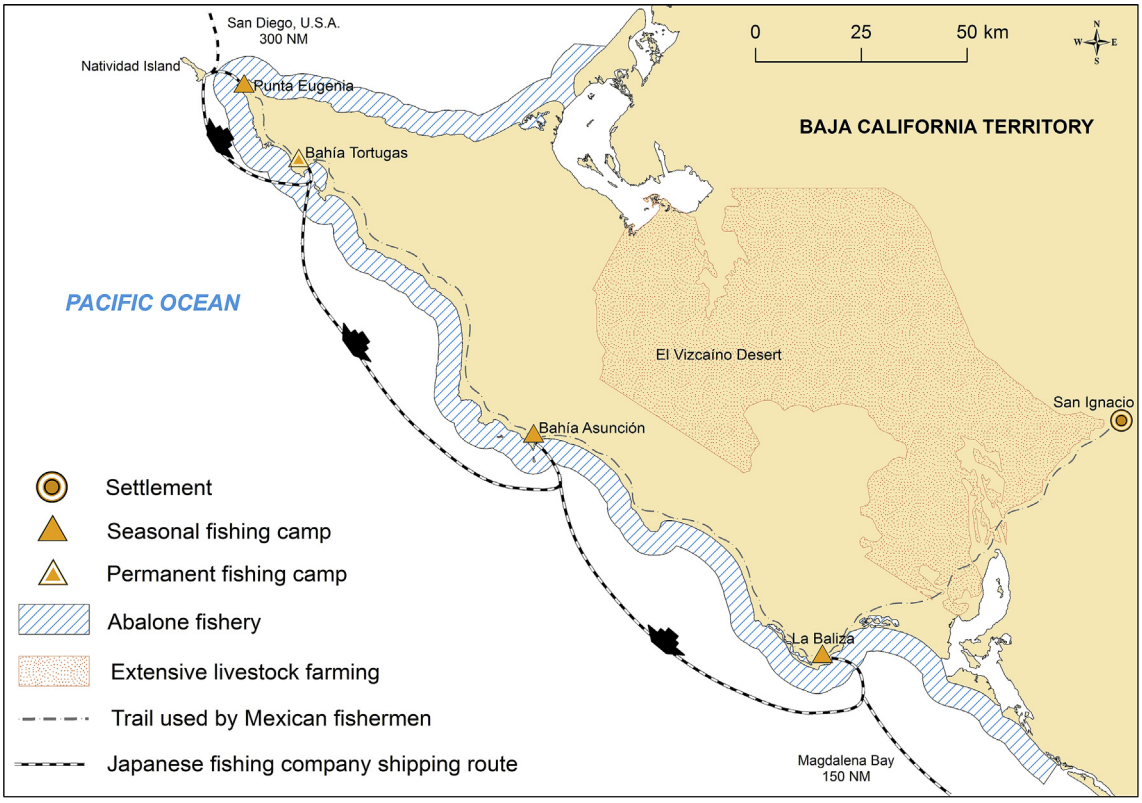
In 1910, a Japanese fishing company decided to exploit the Pacific coasts of both California and Baja California. This company was granted fishing concessions by the post-revolutionary Mexican government to establish fisheries from the US-Mexico border to Magdalena Bay, south of El Vizcaíno Desert (Fig. 1a and b). The Baja California Territory was geographically and politically remote and did not represent any priority for the newly established government in Mexico City (Estes, 1977), one thousand miles away.

The company firstly focused on the abalone fishery with an intensive management scheme lacking a catch quota and a restricted season. In practice, the activity ran from March to November, when Japanese fishermen returned to Ensenada in Mexico or San Diego in California to re-supply for the next season. The Japanese fishermen started to recruit ranchers who lived in the oases and small ranches in El Vizcaíno Desert, to increase the catch. Japanese company found among the ranchers hard workers whom they could train in fishing methods and the use of gear. These ranchers had lived there since the eighteenth century, working in small agricultural fields and grazing cattle in the arid mountains. They had adapted to live in severe

Table 2
Method used to build the environmental history of fishing communities along the Mexican North Pacific coast.

Technique	Number	Materials	Collection	Information source	Fishing community/ camp	Informant code (quoted in text)
Grey literature review	NA	NA	NA	Historic documents, local literature, journal articles, databases, images, photographs, cartography	NA	NA
In-depth interview	7	Handbook, voice recorder, field notebook	Recorded[a] and transcribed, note taking	Fishing cooperatives founders (age > 70) (FCF)	Bahía Tortugas (BT) Malarrimo (MA) Punta Abreojos (PA) Punta Eugenia (PE)	FCF BT 1 FCF BT 2 FCF MA FCF PA 1 FCF PA 2 FCF PE 1 FCF PE 2
Semi-structured interview	4	Questionnaire, voice recorder, field notebook	Recorded and transcribed, note taking	Fishing cooperative executive (FCE), an independent fisherman (IF) and Natural Protected Area officers (age 35–45) (NPAO)	Punta Abreojos (PA) Bahía Tortugas (BT) NA	FCE PA IF BT NPAO 1 NPAO 2
Open/group interview (OGI)	6	Handbook, field notebook, photographic camera	Note taking at work place (boat, beach, unloading catch, etc.)	Groups of fishermen, cooperative members (age 25–55)	Bahía Asunción Bahía Tortugas Malarrimo Punta Abreojos Punta Eugenia Rancho San Andrés	OGI
Participatory workshop (PW)	2	Outline, flipchart, large format maps, voice and video recorders, laptop, projector, field notebook, photographic camera	Recorded and transcribed, elaboration of participatory maps and charts, note taking	Retired fishermen and elder settlers (age > 55)	Bahía Tortugas (BT) Punta Abreojos (PA)	PWBT PWPA
Non-participant observation	NA	Field notebook, photographic camera	Note taking	Fishermen and fishing communities settlers	NA	NA

[a] One interview was not recorded because the key informant did not allow it.



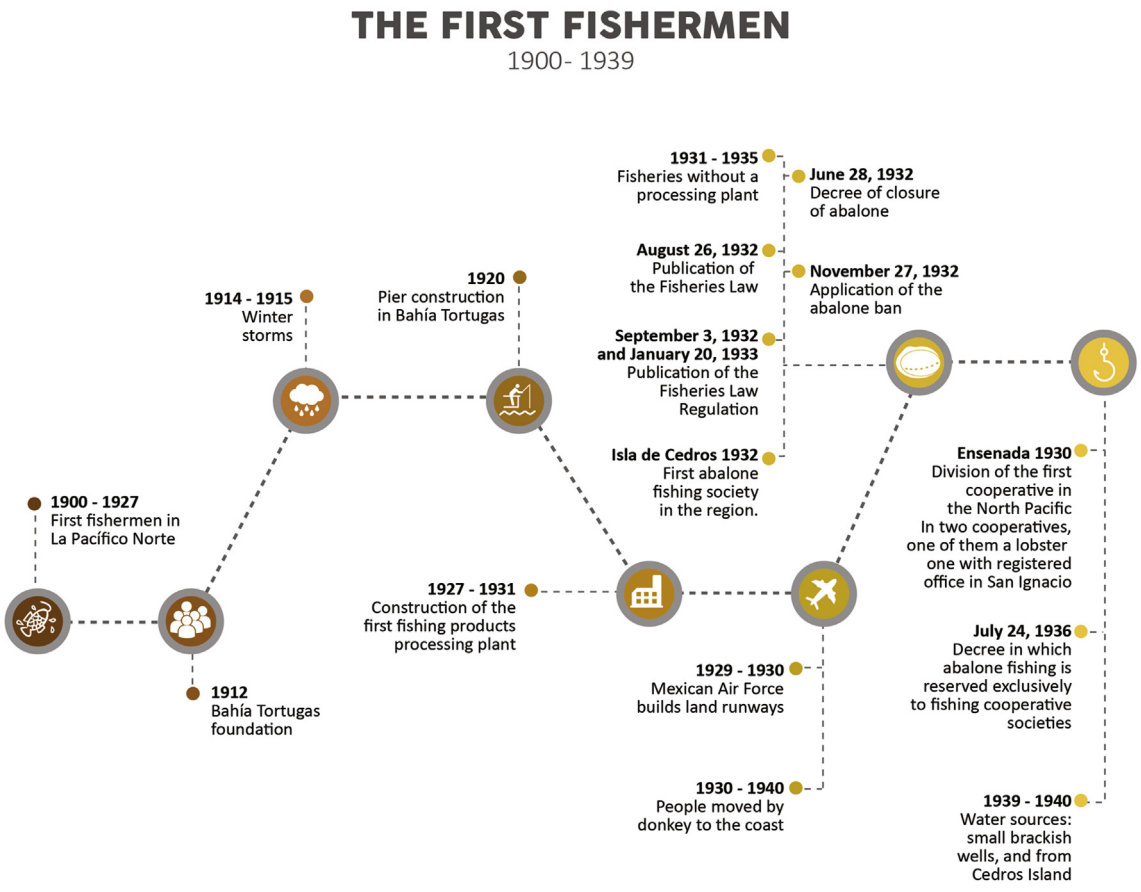


Fig. 1. (a). Fishing activity between 1912 and 1939. The concession was granted to a Japanese company. (b). 1912–1939: timeline (modified from WinklerPrins et al., 2016).

isolation and scarcity.

The first fishing community was founded in 1912, and although the original name of that community was San Bartolomé, the fishermen knew it as Bahía Tortugas. Several fishing camps were established along the coast, as a function of the places and distances accessible to the rowing boats. The fishermen used 14–16 feet wooden rowing boats that were vulnerable to rough winds and sea, even in some spots very close to the coast. These boats could reach only two or three nautical miles (nm) from the coast at most. It represented only one informal established fishing zone along the length of El Vizcaíno Desert coastline; its width was imposed by the environmental and technological conditions (FCF MA; FCF PA 1; FCF PE 1; FCF PE 2; PW BT; PW PA; FCF PA 2) (Fig. 1a and b). A larger boat collected the catch from every fishing camp and took it to Bahía Tortugas for shipment to Ensenada or San Diego. The boat returned to Bahía Tortugas with a cargo of food, goods, and fishing supplies. Until the late 1920s, all the transportation was by sea; later, small airfields were built and the catch was transported by airplane to Ensenada or San Diego (Estes, 1977; FCE PA; FCF PA 1; OGI; FCF PA 2).

The Mexican fishermen used burden beasts to travel between their ranches and the coast, along narrow paths in the desert. The journey to San Ignacio and ranches –to visit families after the end of a fishing season– lasted more than one week, a considerable amount of time bearing in mind the desert climatic conditions. Their lifestyle underwent a drastic change, from being solely ranchers to being fishermen who travelled back home at the end of each fishing season (FCE PA; FCF PA 1; FCF PA). This contributed substantially to the social appropriation of a geographic regional space and to the construction of a broader territory (Giménez and Héau, 2007:11–16) that encompassed the original ranchers' landscape and the fishermen's seascape (Alvarez et al., 2015).

The harshness of the environment obliged Mexican fishermen to collect water, wood, and construction materials, activities very difficult to achieve on an individual basis. These duties were organized and shared out among the community, and settled the basis of community management and sense of belonging to the landscape, seascape, and fisheries. The fishermen knew how to ration their drinking water, since the incoming vessels were the only source of supply. They used seawater for all other purposes including the cleaning of the fishing gear. In the 1930s some springs were found close to Bahía Tortugas and to some fishing camps; thus, slightly brackish water from wells replaced the use of seawater. A homemade desalination plant went only part way towards countering the water scarcity (García, 2009; FCE PA; FCF MA; OGI; FCF PA 2).

The Japanese company decided to engage in tuna fishing when the abalone stocks became overexploited and did not recover as fast as previously thought. In the USA there was a high demand for alternative sources of protein at the onset of World War I. The Japanese imported sophisticated tuna fishing techniques, which later achieved paramount importance in the Eastern Pacific Ocean tuna fishery (Estes, 1977). The company was successful during the next twenty years; its most important investment was the construction of a seafood processing plant in Bahía Tortugas, which would drive the region's economic growth for several decades. However, in the early 1930s –following the Depression– the company went bankrupt (Estes, 1977; García, 2009).

The third main fishery in the El Vizcaíno Desert coastal region was lobster; it was small, informal, and carried out by some Europeans and Mexicans through the first three decades of the twentieth century. In the 1930's, the first fishing cooperative along the MNP coasts was founded in Ensenada –as part of a federal government initiative to encourage permanent settlements and to protect national marine coasts and its resources with the general fishing law (Castillo-Valdez, 2006)– with concessions granted on the basis of a similar management scheme previously arranged with the Japanese company. This cooperative replaced the Japanese fisheries for abalone and lobster, but the Mexican fishers from El Vizcaíno Desert, who had mastered the techniques, decided to continue with those fisheries (FCF PE 1; FCF PE 2). The working relationship of the Japanese company and the new cooperative managers with respect to Mexican fishermen was of the employer-employee type. In 1939, the cooperative split in two and one of them moved to San Ignacio, by then the main village close to the El Vizcaíno Desert coast. The new cooperative specialized in lobster fishing along this region and hired local fishermen during the fishing season (García, 2009; FCF BT 2; PW BT).

The first federal fishing law and related regulations were decreed during the 1930s. The Government imposed an official abalone season and granted the exclusive abalone fishery rights to cooperatives that had already engaged in this activity. This action gave legitimacy and certainty to the management of fisheries by these cooperatives. In 1935, the seafood processing plant in Bahía Tortugas was reopened (Table 2) (García, 2009; FCF PE 1; FCF PE 2).

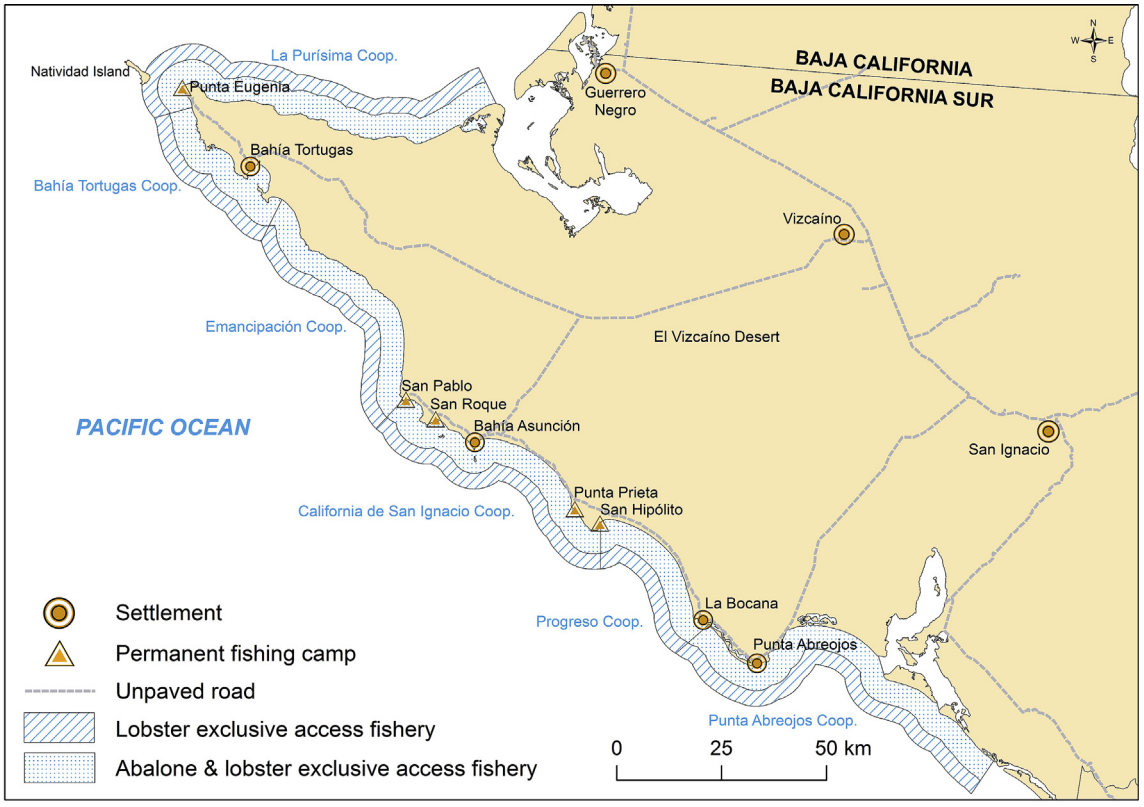
3.2. Consolidation of fishing cooperatives stage (1940–1979)

Between the 1940s and the 1960s, new fishing cooperatives were organized to link the existing fishing camps; the first two cooperatives were in Bahía Asunción and Bahía Tortugas (García, 2009; FCF BT 1; FCF PA 1; FCF PA 2). Around 1950, six fishing cooperatives came into existence along the El Vizcaíno coast. As a result, the fishing zone was divided into six individual fishing areas from north to south, one for each new cooperative (Fig. 2a and b) and according to the area where the members of those cooperative had been fishing (FCE PA; FCF MA; FCF PE; OGI; PW BT; OGI). The cooperatives themselves, revealing local knowledge of the territory, made this division aiding the allocation process and demonstrating the growing self-strong social organization. These fishing zones –a social structure shaping a marine environment– were defined on the basis of newly acquired local knowledge about management of natural resources (mainly abalone and lobster), empirical appraisal of fishing stocks, and coastal and marine conditions.

The labor relationship between managers and fishermen was not truly cooperative but rather entrepreneurial (García, 2009; FCF BT 1; FCF PE 1; FCF PE 2), at their onset, the cooperatives operated through manager-based decision making. The opinion of members was hardly taken into account, and profits of the season were not transparently and equitably administered. The managers were known by the fishermen as *armadores* (masters), because they established the fishing camps and provided the fishing gear at the beginning of every season and, at its end, they removed the infrastructure, collected the gear, and *disappeared* until the next season.

During the 1940s, fishing cooperatives underwent important changes. The first and main seafood processing plant owned by cooperatives located in Bahía Tortugas was closed for a second time in 1940, reopened in 1944 and remained operational until 1998. The dock in Bahía Tortugas was improved and its settlement grew substantially; the other cooperatives established their own settlements. Thus, by the early 1950s all the present communities had been created. Also in Bahía Tortugas, a branch of the Cooperative Development Bank was established to provide financial support and supply fishing gear. To survey the potential for oil and gas production in the El Vizcaíno region, the Mexican state oil company (PEMEX) opened dirt roads between San Ignacio and Punta Abreojos, and from there, to Bahía Tortugas. The travel time by truck from Tortugas to San Ignacio was reduced to two days (FCF BT 1; FCF PE 1; FCF PE 2; FCF PA 2). Fishing cooperatives built power plants to supply electricity to the settlement, desalinization plants to supply fresh water, and other public services (FCF BT 1; FCF PA 1; IF BT; FCF PA 2). During 1956 and 1957, following the growth of the fisheries and the subsequent population increase, the ministry of social affairs of the federal government supplied houses in Bahía Tortugas (García, 2009).

Between the late 1940s and the 1960s, new technological developments allowed the improvement of the fisheries. Larger boats (PW



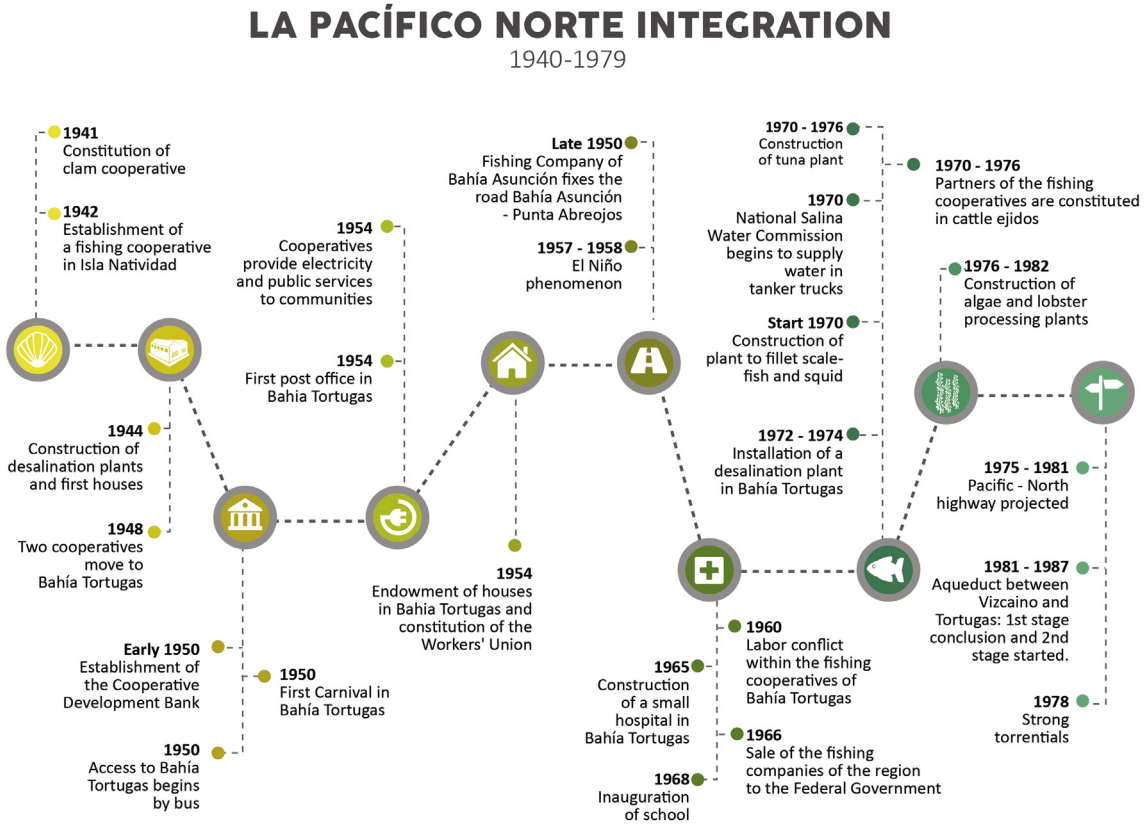
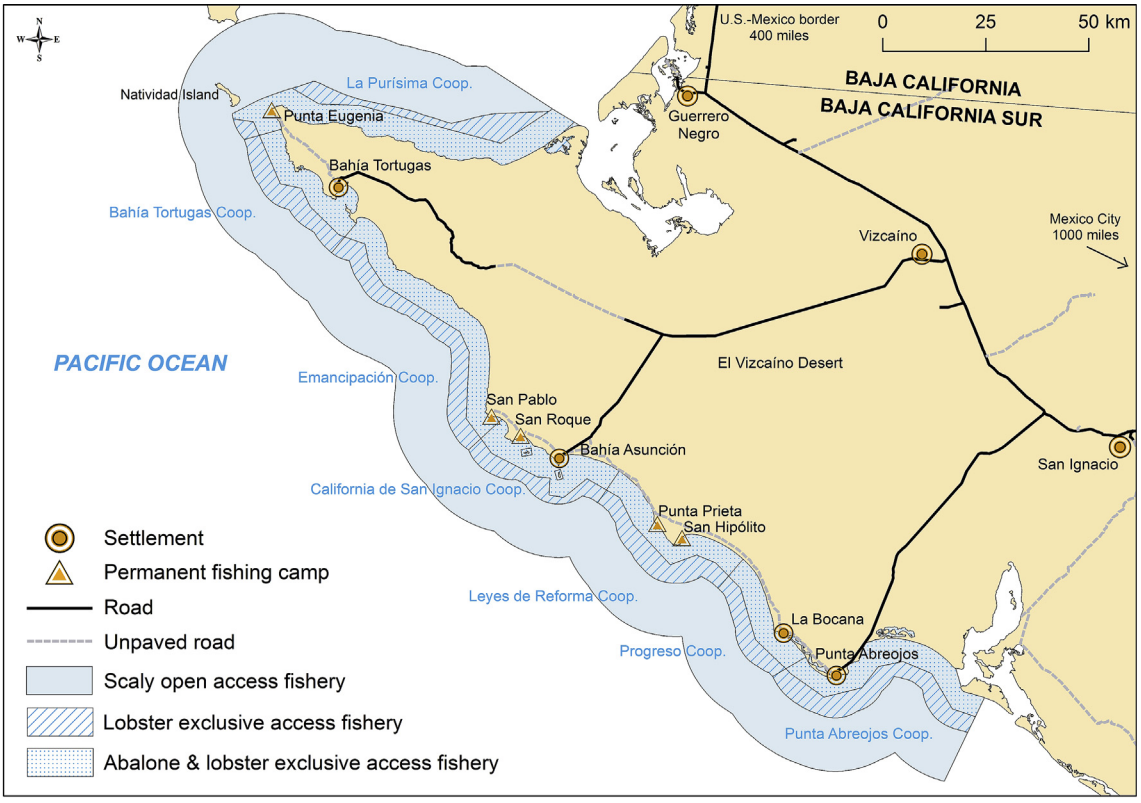


Fig. 2. (a). Organization of the Mexican fishermen in cooperatives and division of the fishing region into six zones between 1940 and 1979. (b). 1940–1979 timeline (modified from WinklerPrins et al., 2016).



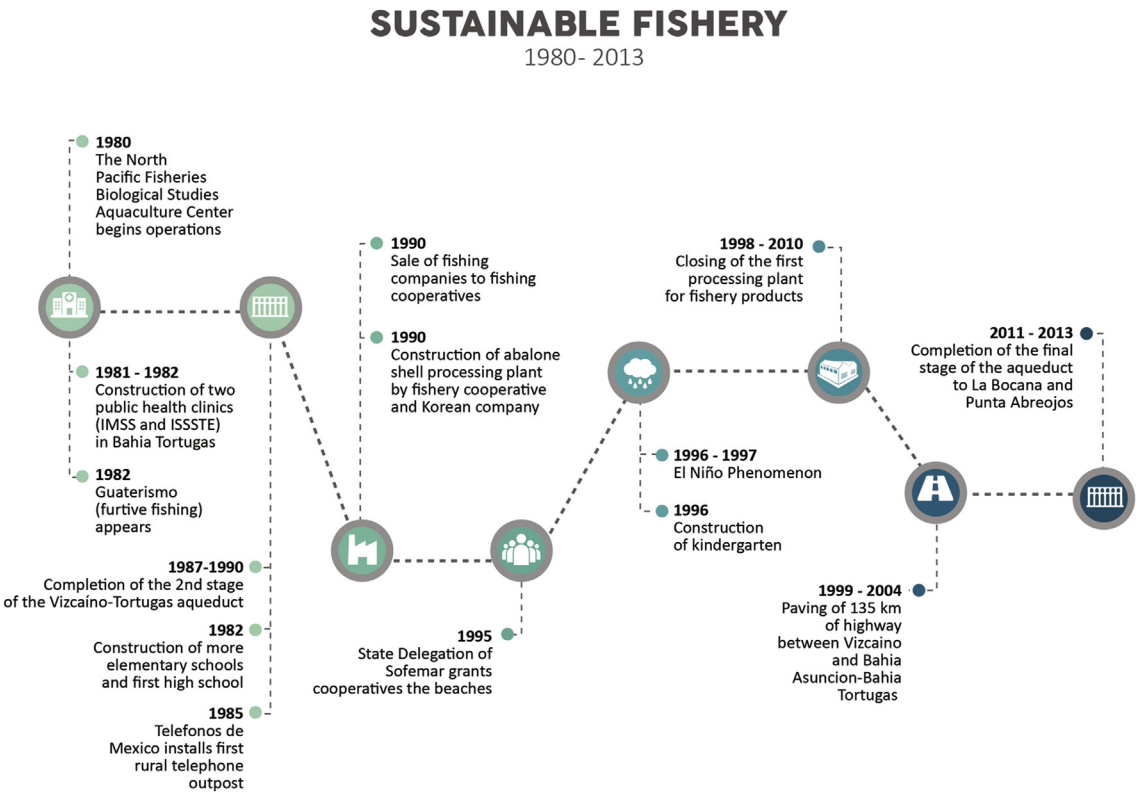


Fig. 3. (a). Reconfiguration of the fishing zones caused by the split of the Bahía Asunción cooperative into two. Establishment of open-access fishing zone for scale fish to 20 nm in response to technological improvements. (b). 1980–2013 timeline (modified from WinklerPrins et al., 2016).

PA) with outboard engines replaced the old rowing boats. Although the early engines were not very powerful (15 hp), fishermen could operate across larger areas, increasing the volume of the catch with relatively lower input of manpower (FCF MA; FCF PE 1; FCF PE 2; FCF PA 2). Once again, the character of the marine area changed. Territorially, every fishing cooperative zone managed two strips, one of 4 nm from the coastline for abalone, and another one of up to 12 nm for lobster fisheries (FCF PA 1; PW BT). Weather and marine hazards only became a limiting factor during extreme events; this also contributed to the increase in skills and day-to-day harvest. By the end of the 1950s, fishermen indirectly perceived changes in global weather and cyclic oceanographic processes through a decrease in their abalone stocks. The major feature identified by cooperative members was an increase in seawater temperatures –the phenomenon now known as the El Niño event. Warmer currents and an increase in the occurrence of high-intensity storms affected El Vizcaíno coasts. Sediment discharge from streams to coastal waters followed, in turn causing high mortality in abalone stocks and the displacement of other ecologically dependent species.

Fishermen could now stay longer at the coast with their families. As the engine-driven boats became the norm, the number of fishing camps reduced; the fishermen could navigate and return safely to their settlements (FCE PA; FCF PE 1; FCF PE 2; OGI). Since availability of fresh water remained as the most important factor limiting development, new desalination plants were installed. Governmental supply of fresh water in tanker trucks started in 1970 along dirt roads; every family received a very limited daily amount, which could reach up to 80 L, depending on the family size (OGI).

During the 1950s and 1960s several national trade union leaders advised cooperative members about the scope of the existing legal framework and showed them how the mismanagement in the fisher cooperatives violated their rights. The fishermen went on strike and the federal government had to intervene to cope with the situation. The managers were dismissed and from then onwards the fishermen assumed responsibility for management of the cooperatives (Table 3) (García, 2009; FCF PA 1; FCF PE 2; FCF PA 2). Internal organization grew stronger, and more power was given to decision-making by consensus without government involvement, such as the informal division of fishing territories into six different areas (FCF BT 1). In addition, during the 1960s, primary-sector cooperatives in Mexico at large also grew strong; in this context, the government granted the fishing cooperatives the right to exclusive access to inshore fisheries in the North Pacific region. The so-called Cooperative Fisheries Concession increased the strength of the cooperative organizational structure.

The Mexican federal government purchased the seafood-processing plants in Bahía Tortugas, which had been managed by the fishing companies and to which the cooperatives delivered their catch (García, 2009; OGI). During the 1970s, the federal government boosted the establishment of a common agricultural land structure (the *ejido*) to encourage rural activities inland and to colonize uninhabited regions, both inland and at the coast. The *ejidos* consisted of relatively large areas of land (in the order of hundreds of hectares) for agriculture and cattle grazing and relatively small tracts of land (*fundo urbano*) for human settlement. In this scheme, the farmers with a right to access to land (*ejidatarios*) are ruled by a general assembly while a board of several members elected every three years is in charge of the executive actions. The board and the assembly meet on a monthly basis to decide upon all activities developed at the *ejido*. In the case of fishing cooperatives, adoption of the *ejido* initiative was compulsory if they were to retain access to fishing zones and to protect their fishing rights. In addition, they were granted land for agriculture and cattle grazing. Although cattle ranching proved to be successful in the rangelands, crop production is very limited because of water shortage (FCF BT 1; NPAO 1; NPAO 2).

At this stage, the fisheries management scheme continued without major change in species and with an intensive harvest and no catch quota. Although regulations such as fishing seasons were enforced for both the abalone and the lobster fisheries (FCF PA 1; FCF PA 2), by the end of the 1970s, both fisheries had become overexploited. It seems that the technological improvements and a better knowledge of the marine environment worked against the maintenance of a balanced fishing effort. Management strategies that were ill defined contributed to considerable pressure on the fishing stocks (FCE PA). Tuna fishery re-emerged in the area during the late 1960s and 1970s, and a new seafood processing plant was built in Bahía Tortugas with governmental subsidy (García, 2009; IF BT).

3.3. Fisheries Co-Management stage (1980–2011)

The period 1980–2011 encompassed the creation of new fishing zones following more technological and infrastructure developments, the creation of the Biosphere Reserve, and the splitting into two of one of the fishing cooperatives following an internal conflict in Bahía Asunción (FCF PA 2; OGI) (Fig. 3a and b). Fishing boundaries were changed to create a fishing area for the new cooperative thus created. In this way, each of the seven fishing cooperatives was granted a 4 nm strip for the abalone fishery and a 12 nm strip for the lobster fishery. There was also, for the entire MNP, a single 20 nm strip giving open access to the scale-fish fishery (FCE PA; FCF BT 1; FCF PA 1; PW BT).

The fishermen changed their wooden boats for better fiberglass boats with more powerful engines and equipped with global positioning systems (GPS), echo sounders, and radios. This helped to solve boundary conflicts, and it also allowed cooperatives to fish up to 20 nm offshore and to catch scale fish in general; thus, the fisheries also included middle-to-deep-sea fishing (FCE PA; FCF MA; PW BT; PW PA). Concerning the marine territory of the Biosphere Reserve natural protected area, 5 km buffer zones were created around islands and other priority areas where fishing was not allowed, except to previously established fisheries (NPAO 1; NPAO 2).

In the early 1980s, the fishing cooperatives continued with an intensive management scheme for the lobster and abalone fisheries; the consequences were a dramatic depletion of stocks during that decade (FCE PA; INE, 1995). In addition, poaching started to be a serious problem because of an increase in market prices of abalone and lobster (PW PA). Fishing cooperatives reduced fishing effort and at the same time improved their fishing methods and gear (Ponce et al., 2009; FCE PA). To prevent poaching, the cooperatives set aside a considerable amount of their profits for surveillance (McCay et al., 2014). The lobster fishery became more profitable than that of abalone because the stocks recovered more rapidly, it was easier to fish, and there was a continuous growth of its prices (FCF MA). The fishing cooperatives decided to seek help from regional scientific centers to confront the overexploitation and to learn from specific studies on fisheries ecology (FCF BT 1). The fishing cooperatives gradually changed their intensive management to fisheries co-management. This involved cooperation with the federal government, research institutions, and non-governmental organizations. The government provided loans and operational surveillance, and research institutions and non-governmental organization undertook a systematic study of fisheries ecology to pose sustainable management strategies. Cooperatives reorganized their structure to encompass an internal surveillance board, and coordinated efforts with neighboring cooperatives and the Mexican navy. After five years of coordinated surveillance efforts, not a single poaching event was reported (FCE PA; NPAO 1; OGI; PW PA).

By the end of the 1980s, the MNP fishing cooperatives –as they had by then become known– had contributed to the formulation of official policy instruments for abalone and lobster fisheries put into effect by the government, such as a minimum legal size for lobster, and the replacement of old pots by biodegradable ones with an escape window to allow the release of sub-legal-sized lobsters (FCE PA). The ecological studies further discovered a differentiated spawning season along the waters fished by the MNP fishing cooperatives. This led to enforcement

of an official harvest season settled by the government that varied from year to year; in general, the fishing season ran from November to February and recognized a lag time of two weeks at the most from the beginning of the first cooperative season to the next one, and subsequently so. This allowed cooperatives to sell live lobsters in Asian markets and to obtain a larger profit. No official catch quota was imposed, and its definition was left in the hands of cooperatives as a component of the co-management scheme. MNP fishing cooperatives have used their historical catch records to determine an optimal quota and to precisely define the fishing seasons (FCE PA).

Concerning the abalone fishery, a minimum legal size was established, the fishing season was reduced to February and March, and the federal government's Regional Fishing Research Centre (CRIP) informs cooperatives of the catch quota for each season. Quotas vary substantially on a seasonal basis but a minimum catch per effort unit (CPUE) of 10 tons is considered profitable. In addition, the CRIP has contributed to co-management efforts by sponsoring the establishment of abalone nurseries in the cooperatives so that fishing zones can periodically be seeded.

In 1988 the entire El Vizcaíno Desert region, including the area fished by the MNP fishing cooperatives, was decreed as a Biosphere Reserve. The natural protected area was created to help the conservation of the Baja California pronghorn, the grey whale, and heritage cave paintings, but also aimed to protect the MNP fishing cooperatives. The cooperatives helped to define the management plan for the natural protected area while establishing a 5 km marine buffer zone to protect their fishing areas, another result of co-management. This buffer zone was recognized by the Mexican fishing law as the inshore abalone fishery zone; in consequence, trawling was prohibited, as well as any other activity potentially harmful to the inshore fishery sector (NPAO 1; NPAO 2).

In 1992, the federal government formalized the fishing rights over zones that cooperatives had already decided upon, but under a new access scheme, which opened the possibility of obtaining fishing concessions to other participants such as private companies. In the case of the MNP fishing communities, it was because of their strong social organization that they kept their exclusive access rights and obtained others, such as for the turban snails, sea cucumber, and octopus for a 20-year period (FCE PA; FCFBT 1; OGI).

Co-management of the lobster fishery has been so successful that the MNP fishing cooperatives together with a cooperative on Natividad Island (Fig. 1a and b) were the second after Australia in being granted international certification (in 2004), and received re-certification in 2010. The certification followed close research collaboration with the CRIP, with a regional scientific institution (CIBNOR), and with a non-governmental organization for community and biodiversity (COBI), as documented by Foley and McCay (2014).

The algal blooms known as red tides, triggered by El Niño have become more frequent and represent the major environmental concern for cooperatives because of the potential impact in all catch seasons (FCE PA; OGI). The fishermen have become knowledgeable enough to adapt to changing environmental conditions through the use of local knowledge acquired over decades. One simple example is the interpretation of the relationship between the presence of mist, or clouds on the horizon or at the top of hills on neighboring islands, and the ease or difficulty of navigation; knowledge similar to that documented from many fishing communities around the world. More deeply, the fishermen have observed the modification of the lobster habits and behavior given that the location of bait has changed lobster-mating habitat (FCF BT 1; FCF MA; OGI). As a result of this local knowledge, the cooperatives have established different strategies to face the challenge that represents the environmental and climate change, as self-imposed fisheries quotas and special saving funds for contingency cases.

Until 2003, the development of the MNP fishing cooperatives infrastructure was uncertain. Although the fishing cooperatives provided almost all the public services to their communities, it became increasingly difficult to bear the economic costs (FCE PA; IF BT). Once again, the achievements related to organization and fisheries management –accomplished until now– played an important role, since the cooperatives had the capabilities to administrate public resources investment in the region to develop basic infrastructure. In that sense, the government began to build infrastructure, supplying power plants and fresh water, and also building two health centers in Bahía Tortugas, as a very first start. The North Pacific road, which communicates the northern MNP with the town of Vizcaíno had been a dirt road for almost 20 years. Since 1982, however, new and more direct roads have been built, and the catch can be transported more safely and quickly by truck (OGI). At the beginning of the twenty-first century, most of this road was paved, as were the original tracks to Bahía Asunción and Punta Abreojos (Fig. 3a and b) (NPAO 1; NPAO 2).

In the early 1990s, the existing fishing companies were purchased by the cooperatives, but after a decade they were closed, together with the first and main seafood processing plant. The main reasons were the USA embargo on the Mexican tuna fishery and the lack of an alternative market for the products.

At the same time, one of the longest aqueducts ever built in Mexico was constructed to supply fresh water from the town of Vizcaíno to the northern MNP (Fig. 3a and b). This was a major achievement for the MNP fishing cooperatives, whose population had suffered water scarcity for eight decades (FCE PA; FCF BT 1; FCF MA; PW BT; IGI). Since about 2000, other economic activities have started, such as ecotourism, commerce and services, and housing developments for expatriates from the USA (ALCOSTA, 2009). From about 2005, the settlements of the MNP have been provided with the majority of public services (FCE PA; FCF PA 1; FCF PA 2; OGI).

Seasonal extreme rainstorms and subsequent flash floods have challenged fishing and other daily activities. Suddenly filled dry riverbeds represent hazards to people, settlements, and gear (FCF PA 1; OGI; FCF PA 2).

The strategies adopted more recently by fishing cooperatives and related with co-management have included a gradual reduction in the number of cooperative members, a reduction of catch quotas, and the observance of fishing seasons. The consequence has been the recovery of fisheries (mainly lobster), but on the other hand, the incorporation of new members to cooperatives is nowadays too slow (up to 10 years) and there are few available positions, contributing to young people seeking other opportunities and lifestyles.

3.4. Break points and continuities

We were able to document a successful natural resource management, as reported for lobster fisheries and fishermen in southern Mexico by Velez et al. (2014) and by Pérez-Ramírez et al. (2012) in northwestern Mexico. The environmental history made possible to analyze the MNP fishing communities in three stages, and to find break points and continuities that allowed the development of the MPN fishing communities over decades and their current successes. As mentioned by Fernández Prieto and Picado Umaña (2014), using as an example the environmental history of these communities might contribute to solve emergent environmental issues and may help to value their culture –which lead to the construction of well-organized fishing cooperatives.

This research proves that the conceptual frames of environmental historical and political ecology (Delgado and Fonseca, 2013) have helped to understand the development of the solitary fishing cooperatives in isolated aridscapes and seascapes where abalone and lobster fisheries thrived. We added a case to Davis' (2009:286) claim, documented environmental change over time, and explored the complex links between the fishermen stories of environmental change, some biophysical data, and the political and economic forces motivating the use of a particular story over another.

Undoubtedly, the first break point and origin of the community as we now know it was the Japanese fishing company arrival to

Northwestern Mexico. This company triggered the appropriation of an isolated unpopulated coastal region by local non-coastal people. Another break point in this first stage we called Pre-Fishing Cooperatives (1912–1939) was the teaching of fishing techniques by the Japanese fishermen to local ranchers. The teaching-learning process allowed that local novel fishermen continued fishing even after the Japanese company abandoned the region and ended the resources' exploitation because of the 1920′s world economic crisis.

Mention should be made of the severe environmental conditions and the geographical isolation. Freshwater has always been the main limiting factor for the settlement and development of these fishing communities. Both critical features could have hindered the continuity of fishing when the Japanese company retired and cause the return of fishers to their original lives and in-land traditional activities. However, the fishermen used their adaptation skills to the environmental conditions imposed by aridity and to the isolation involved in living in the middle of a large peninsula. Helped by these skills, fishermen continued fishing, seasonally migrating from inland ranches or small towns to the coast during the fishing seasons.

The fishing region was slowly built based on informal community-based organization and on a sense of commons that slowly became apparent (FCE PA) among the fishermen. Both simple organization and communality allowed their subsistence as a group by shifting individual's roles and responsibilities towards the community itself. In particular, responsibility was a key factor that gave place to the second stage.

The first break point of the second stage (1940–1979) was the formation of the fishing cooperatives. Therefore, we called this stage “The consolidation of Fishing Cooperatives”. This process was motivated by another national scale break point at the time in which the federal government implemented an initiative to encourage fisheries development throughout the country, as was identified by Castillo-Valdez (2006). Therefore, the integration of fishing cooperatives in the region was relatively easy, because the organizational level achieved by fishermen since the beginning allowed them to share the fishing zones among various cooperatives with consensus and respect. Another break point of this second stage deals with technology. Motorboats represented more certainty for the fishermen in the sea, and increased the capacity for marine resources exploitation. In the first half of this second stage, more fishing communities settled, and the multiplication of settlements represented a transcendental break point, because it was the starting point in which fishermen and their families converted into permanent residents of the coastal region. Sense of belonging and territory appropriation were key factors that yielded continuity. In the second half of the second stage another important break point occurred: an internal labor conflict rose among cooperatives. Actually, the cooperatives were not managed as cooperatives and the fishermen's high organizational level made them to stand for their rights, which resulted in the building of a real cooperative organization. This process was in concordance with the sprouting of labor rights taking place during that time at the national and international level. McCay et al. (2014) reported that, during these years, cooperatives became more consolidated and powerful. A “sense of belonging” to cooperatives by fishermen was developed.

Since then, there has been a continuous mode of operation characterized by a cooperative system, which can still be seen nowadays. Thus, a third stage was reached, the operating system in which the cooperatives continued to provide the basic services to the communities allowed continuity and strengthened the region. In this third stage we called Fisheries Co-Management (1980–2011), the first break point was the overexploitation of the fisheries resources as a consequence of the intensive exploitation of abalone. The cooperatives searched for academic and NGOs assistance to implement management strategies to recover the fishing stocks. The relationship among researchers and environmentalist was fruitful –which was also highlighted by Foley and McCay (2014), stocks recovered, and cooperatives obtained the rights of exclusive access to the fishing zones of abalone and lobster. As well, an international eco-certification was obtained. These important break points allowed the MNP fishing cooperatives to remain operating under a co-management scheme.

In relation with communities' development, the government finally brought public basic services, a break point that, on one side, gave certainty to the communities' families, and on the other side, represented an important diminution of expenses by the cooperative.

The communitarian organizational scheme allowed for resolution of issues, which maintained the continuity of the fishing communities in the region and strengthened it in different aspects: 1) the fishing cooperatives obtained the renovation of exclusive rights to their fishing zones; 2) the latter event, increased the number of species authorized to be fished; 3) the lobster fisheries continue to have a sustainable fishery certification and a MSC standard ecolabel; 4) there is strong government support; and 5) there is a close relationship among cooperatives, academia, NGOs, and government.

The future stage will be limited by the fishing cooperatives' responses to the emergent challenges of environmental and climate change issues, which is in agreement with the findings of McCay et al. (2011) and Micheli et al. (2012). These external factors will again turn into new break points that will put the organization of the communities to test.

The MNP fishing communities are the consequence of the appropriation of an isolated region that was initiated by an overseas agent: a Japanese company, which triggered the construction of a distinctive territory by Mexican inland ranchers that became fishermen settled on the coast. Severe environmental conditions, fisheries stocks as the only feasibly exploitable resource, and the remarkable adaptability of the *ranchero* culture led to a strong social organization institutionally established as cooperatives, as mentioned by McCay (2017). This cooperative organization was the key factor for the recovery from decaying fisheries, while co-management strategies emerged by themselves relying on strong relationships between the cooperatives, the government (federal, state, and municipal), the natural protected area, and the scholars and NGOs; as was the case in the collaborative example of Isla Natividad (Comunidad y Biodiversidad, A. C. (n.d.)) identified by McCay et al. (2014) and McCay (2017).

4. Conclusions

Our research revealed a self-learning, enlightened resource management case as the product of a century of environmental history. In this historical process we observed, on one side, the passage of rancher settlers to well-organized fishermen in fishing cooperatives, and on the other side, the transition from an intensive system of exploitation to one of sustainable co-management of resources. It was interesting to observe that the trigger for the development of this region was an external factor (a Japanese company) with an intensive exploitation approach that led to the overexploitation of fisheries. Another external factor (the Great Depression) was, once again, what caused that the exploitation of the fisheries was left in the hands of an internal agent (Mexican fishermen), who finally fitted in this region by establishing a strong community organizational system and evolving to a sustainable fisheries management approach.

But what the future of the Mexican North Pacific fishing communities will be remains to be an unanswered question. In what way will the cooperative members develop? How will younger generations be accommodated? Will the new members be able to assimilate the knowledge and social organization from the elder fishermen? Can a successful natural resources management scheme be maintained in the long term? Giving answers to these interrogations is not easy, even more in the face of two recent threats: harmful and unpredictable marine environmental events related to global warming, and the loss of cultural roots due to external factors like global communication services, divergent economic activities and local youth migration. The

nature of the next historical stage remains unknown.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.ocecoaman.2018.08.029.

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Universidad Autónoma de Baja California

Doctorado en Medio Ambiente y Desarrollo

Ensenada, B.C. a 17 de Enero de 2011

DRA. MARTHA MICHELINE CARIÑO OLVERA
UNIVERSIDAD AUTÓNOMA DE BAJA CALIFORNIA SUR
Presente.-

Por este medio quiero hacer de su conocimiento que con base en la recomendación del Comité de Estudios de Posgrado del Doctorado en medio Ambiente y Desarrollo, esta Coordinación a mi cargo se ha permitido nombrarla **SINODAL** del estudiante PABLO ABDIEL ÁLVAREZ MORALES.

Asimismo, le agradeceré que tenga a bien programar de manera semestral una reunión con el comité, que permita a la estudiante presentarles los avances en el desarrollo de la investigación y pueda usted enriquecer y apoyar el mismo para que sea concluido en los tiempos acordados.

Esperando reciba el presente de conformidad, quedo de usted.

ATENTAMENTE

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