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ECOSYSTEM STATUS AND TRENDS IN THE GULF OF CALIFORNIA

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EDITORS

THE ARTISANAL FISHERY OF BAHÍA DE LOS ÁNGELES AND ÁNGEL DE LA GUARDA ISLAND, GULF OF CALIFORNIA, IN 1995

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Bahía de los Ángeles is a small village in the Gulf of California, northwestern Mexico, devoted to fishing inside the bay and around nearby islands. Fishing started in the 1930s, and has changed in response to resource abundance, market demands, accessibility, and legal restrictions. We studied fishing there from 1993 to 1995, but had generated data also during the previous 11 years. Most fishing was done by "free fishermen," working out of fishing camps at 59 insular and 8 coastal sites. Fishing included 58 species of fish of 34 families. Between 1984 and 1996, fishing volumes fluctuated between 306 and 798 ton / year, without any trend. Although, scalefish produced most of the landings, sea cucumber was important. Multispecies fishery was highly efficient in the use of the catch. Fishing depths were usually 10.2 to 89.5 fathoms, but could be as deep as 200 fathoms. Gillnets and three-layer trammel nets were the most common fishing gear. In any single year, 8–15 fishing zones, out of 26, were used. No rules existed as to exclusive access to resources by the local community, although they could have helped to reduce fishermen competition, reduce the risk of resource depletion, and reduce by-catch spoilage.

1. INTRODUCTION

The town of Bahía de los Ángeles (28°56'N and 113°31'W) is a small fishing village within a large bay bearing the same name, on the western side of the Gulf of California, northwestern Mexico. Fishing is carried out inside the bay, as well as around the island of Ángel de la Guarda, in Canal de Ballenas, and in Canal de Salsipuedes. During the late 1930s and the 1940s fishing and mining attracted people to the then little populated area of Bahía de los Ángeles (Caroline Shepard,

long time resident of Bahía de los Ángeles and director of the local museum, pers. comm., 1997). At this time, fishing was centered on totoaba (*Totoaba macdonaldi*), for its swimming bladder; sharks, for their liver oil, and sea turtles, for their meat (especially the Olive Ridley (*Lepidochelys olivacea*), and the caguama prieta (*Chelonia mydas*; Arvizu-Martínez, 1987).

Until the construction of the transpeninsular highway, and the paved road that links this to Bahía de los Ángeles, transport of the products to Ensenada, Tjuana, and the United States was slow, hindering commercial fishing. Construction of these roads promoted increases in fishing volume and number of species targeted for commercial fishing. Although fishing in this area is important, and the region has attracted the attention of the academia, commercial fishing had not been analyzed. The objective of this study was to characterize the artisanal fishery of Bahía de los Ángeles and nearby Ángel de la Guarda island. Almost 20 years have elapsed since our study, and conditions and pressures on fishing, as well as other economic activities, have changed in Mexico. Although our study is focal, it reflects one of the fishing realities in the central Gulf of California, at the time. Our study, along with that of Chenaut (1985), will serve as a reference with which to measure such changes, current or future.

2. METHODS

2.1. Study area

This study includes the waters in Bahía de los Ángeles and those surrounding Ángel de la Guarda island, including Canal de Ballenas and Canal de Salsipuedes (see Figure 1). We include the villages of Bahía de los Ángeles, Las Ánimas, San Rafael and San Francisquito. The area is in the arid Gulf coast of Central Baja California. The climate of this region is arid, with mean annual temperature of 22.8ºC (range 15–33.6ºC), and mean annual precipitation of 83 mm (range 9–235 mm; INEGI, http://mapserver.inegi.gob.mx). The waters in the area exhibit year-round upwelling in Canal de Ballenas and Canal de Salsipuedes (Álvarez-Borrego 1983), which leads to an important concentration of plankton and high diversity and abundance of fish. Aridity of the region and lack of sources of fresh water prevent agriculture, and the only economic activities are fishing and tourism, and, in the past, mining.

In 1990 Bahía de los Ángeles had 443 inhabitants (INEGI 1991), 250 of which were full-time residents. Four years later the number of full-time residents had increased to 378, but the floating population stayed around 200 people. In 1997, the total population was between 600 and 750 people (C. Shepard, com. pers., 1997; R. Espinoza, com. pers., 1997), making it the second most populated community in

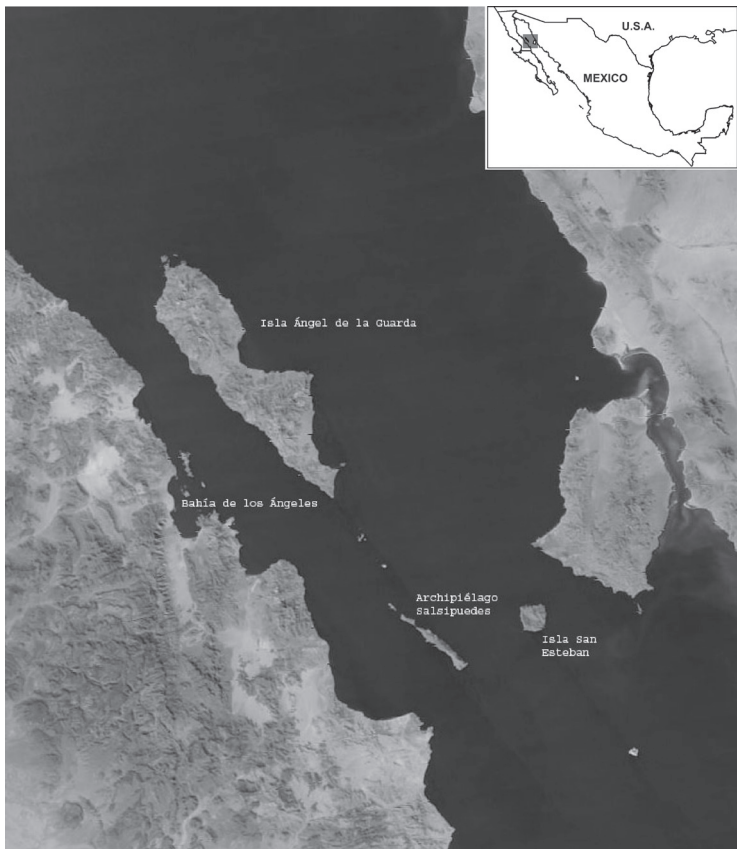

FIGURE. 1. Study area.

the Midriff island region of the Gulf of California, with about 11% of the population of this region. This increase resulted from the immigration of people from the states surrounding the Gulf of California, other than the state of Baja California (Bourillón-Moreno 1996).

Both in 1990 (INEGI 1991) and in 1994 (AZ-G, unpubl. field notes) there were slightly more males than females in Bahía de los Ángeles (52 and 54%, respectively). In 1994, 36% of the males (70 people) were fishermen. They were between 16 and 80 years of age, but 85.7% were 45 years or younger. This age composition differs from that during the 1980s along the western coast of Baja California, where ages of fishermen were between 12 and 29 years (Avilés-Muñoz and Figueroa-Ramírez 1989). During our study, males younger than 16 years of age, in Bahía de los Ángeles, attended school.

Whereas 52.8% (n = 53) of the fishermen between 16 and 30 years of age of Bahía de los Ángeles were employed in fishing only part-time, 66.7% of those older than 30 years (n = 63) were semi-permanent fishermen. Most of older males in the community were full-time fishermen at one time, and those that remained active advised younger fishermen in the reparation of fishing gear.

Males that were not fishermen worked as masons and painters, merchants, laborers, mechanics, and cowboys. When fishing was bad, many fishermen tried to get jobs as construction workers (in masonry and painting). Similar to other regions in Mexico, "free fishermen" (those not belonging to any fishers cooperative) did not own boats, and often combined fishing with other jobs elsewhere, especially when fishing was unproductive (see Gatti 1986).

The fishing population of the Bahía de los Ángeles region included 23 permitholders, and 47 free fishermen (which don't have permits). There were also 233 registered foreign (to the region) fishermen (Subdelegación Federal de Pesca, December 1994). Free fishermen sold their catch on the beach or directly to the permit-holders, and their products could be recorded under the name of the later, or not be recorded at all.

2.2. Field work

Between June 1993 and June 1995, AZ-G made 14 visits to the region. On the first visit he selected adequate informants (*sensu* Hernández and Ramos 1976), based on previous acquaintance with some fishermen. He made some informal interviews and participated directly in fishing trips. To characterize the fishing population we used partial results of a census made in the spring of 1994 by the Instituto para el Desarrollo Integral de la Familia (Mexicali, BC, unpublished). We also used the information gathered by AZ-G during 11 years of field work previous to this study.

Fishing activity was characterized based on the volume of landed catch (and recorded), fishing gear used, and the fishing zones, methods and seasons. Species fished were identified in situ with the aid of field guides (Miller and Lea 1972, Castro 1983, Eschmeyer and Herald 1983). Specimens were photographed for later identity checks, and the fishermen were interrogated about the species that were captured. We interviewed 23 active fishermen, 2 fishery inspectors, and the director of the local museum, the delegate (representing the municipal president), two local physicians, several elder fishermen, and other persons with a good knowledge of the area.

Although a complete record of the actual captures was not available, the official statistics, based on the reports by the fishermen themselves, were good indicators of capture dynamics. We reviewed this information for the period between 1984 and 1996 at the Subdelegación Federal de Pesca, Secretaría del Medio Ambiente,

Recursos Naturales y Pesca (SEMARNAP), in Baja California. Tallying the capture data from highest to lowest yearly volume, we considered those species that accounted for 90% of all capture volume as the main fishery resources. Information on fishing zones derives from seven years of data (1990–1996). For each of the zones we determined the main fishing target species in the same manner as above.

3. RESULTS AND DISCUSSION

3.1. Labor organization

Most fishing was carried out by free fishermen employed by others, as it occurs elsewhere in Baja California (Avilés-Muñoz and Figueroa-Ramírez 1985, 1989). These fishermen did not belong to any formal organization and sold their fishing products to one of the permit-holders. Therefore they were dissociated from the market, contrary to fishermen affiliated to cooperatives in Sonora and Sinaloa (McGoodwin 1987) and the west coast of Baja California (Avilés-Muñoz and Figueroa-Ramírez 1989).

There were two basic labor arrangements. One was that of "employed fishermen," fishermen that made individual arrangements with the permit-holders and fished for a daily salary, a commission, and/or a payment for amount worked. Under these arrangements, the permit-holders provided fishing equipment (skiff, motors, fuel and water containers, fishing gear, ice chests, etc.), and bought the produce. Their fishing was directed at specific target species.

The second arrangement, "work teams," involved fishermen that owned some equipment (Gatti 1986, Avilés-Muñoz and Figueroa-Ramírez 1987, 1989). There were few fishermen in Bahía de los Ángeles organized this way. They had a much more multi-specific catch and fished closer to the village than the previous fishermen.

The social/fishing environment within the community was notoriously little conflictive and exhibited strong inter-personal relations. In both cases the teams were commonly integrated by relatives and friends.

3.2. Fishing camps

The continuous increases in the price of gasoline and motors promoted an increase in the use of islands and islets of the region, to increase fishing ranges. Originating from Bahía de los Ángeles (at least 70 individuals), San Rafael (approximately 7), Las Ánimas (5), San Francisquito (13) and El Barril (10), most fishermen used different areas of the Ángel de la Guarda archipelago to establish temporary fishing camps at 59 sites on the islands (including the islands of San Esteban and San Pedro Mártir), and 8 sites on the coasts of Baja California. These camps consisted of one

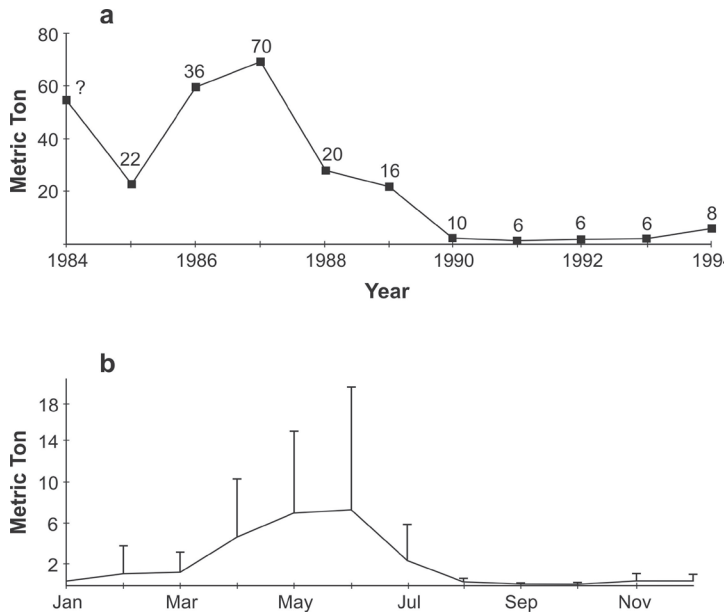

FIGURE. 2. Landings of Rooster hind from Puerto Refugio.

or more shacks (made from wooden poles and planks, cardboard, and plastic sheets), that harbored between 4 and 7 fishermen each, and/or were used to store up to 6–7 fishing equipments.

Fishing camps on the peninsular shore were used continuously for several months by fishermen from other places, but seldom by local fishermen. Island camps were seasonal, visited less frequently than peninsular ones, and non-periodically throughout the year. The smallest of these camps was less than 25 m^2, while the largest was over 6,700 m^2, and they all were close to fishing zones. Most camps had only a shack or cleared areas surrounded by rocks where fishermen stayed from some hours to a few days.

A fishing camp was set up or not depending on the abundance of a resource or the demand for it. For example, during the mid 1980s, baqueta (*Epinephelus acanthistius*) fishery was based at Puerto Refugio (see Figure 2a), in the Spring and Summer of every year (see Figure 2b). The fishing camp, peopled by an average of 24 fishermen, consisted of six cabins and gasoline-based electric generators (A Z-G unpublished data). In the spring and summer of 1987, at its highest occupancy, it had 70 fishermen, 30 skiffs, and 4 small boats (12 ton of storage capacity and manned by 4–6 people each).

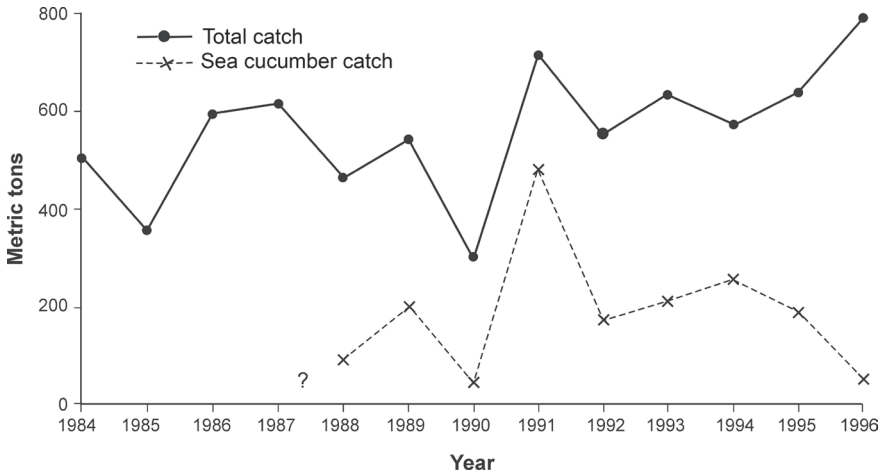

FIGURE. 3. Landings of fish at Bahía de los Ángeles.

Many fishermen alternated in their use of the camps, in agreement with the movements of fish stocks, and any fishermen could use a number of camps throughout the year, and a single camp could be used by different fishermen in succession. This style of using the islands of the region by fishermen has existed at least since the 1940s (José María González, pers. comm., June 1985). Not all fishermen were respectful for the camps, and local fishermen complained that fishermen coming from Sonora, across the Gulf of California, left behind abundant trash in them.

3.3. Fishing catch volumes

Reported fishing catch volumes for Bahía de los Ángeles between 1984 and 1996 fluctuated between 306 and 798 ton / year, averaging 535. There was no significant trend during the 1984-1994 period ($p = 0.0748$, $r2 = 0.26$, based on the logarithms of capture volumes; see Figure 3). Scalefish fishery ("pesca de escama") produced an average 400 ton / year between 1984 and 1996 (range = 233-740). This fishery dropped significantly during 1984–1991 ($p = 0.034$, $r2 = 0.554$; see Figure 3), but increased significantly from 1991 to 1996 ($p = 0.042$, $r2 = 0.684$).

Total catch volumes include "scale fish" fishing, as well as sea cucumber (*Isostichopus fuscus* and *I. inornata*). Captures of the later, however, began to be recorded in 1988, although its fishery in the entire Gulf of California began in 1985. From 1988 to at least 1994 the development of this fishery greatly influenced the fishing in the region. Its capture increased from 92.754 ton in 1988 to 378.904 ton in 1989. Sea cucumber represented 15.7% of total fishing volume in 1990 and 67.6% in 1991.

These changes reflected the increased demand of the product by the foreign markets, especially those of Korea and Japan (Secretaría de Desarrollo Económico 1994), and were completely marginal to the population dynamics of the species. In 1994 the "hard sea cucumber" (*I. inornata*) was officially banned from fishing in the Gulf (Diario Oficial de la Federación 1994), and catch of sea cucumber altogether was dropped from the records.

Sea cucumber was captured by the same local fishermen that, at other times, fished scale fish, but also by fishermen from Sonora and Baja California Sur. When the sea cucumber populations begun to be depleted, fishermen competed intensively with each other, and improved their equipment as to reach cucumber beds farther from their locations of residence, and to remain there for longer times.

Capturing sea cucumbers on shores of other communities generated many conflicts between fishermen, as local fishermen claimed exclusive rights over the resources adjacent to their communities. In addition to causing competition between fishermen, this single-resource production (based on the high market price and directed at export), caused intensive use, and impacts, on the shores of some islands (Bourillón-Moreno 1996). Official protection of the hard sea cucumber apparently caused fishermen to return to their traditional fishing resources. As a secondary consequence, the conflicts that had developed among fishermen smoothed, and the amount of trash at fishing camps diminished.

3.4. Fishery resources and seasonality

The local, artisanal fishery included many neritic species, fished in small amounts, mostly near the coast. We recorded 58 species of fish of 34 families that were included in the catch (see Table 1). Of these, 48 (81.4%) were commercial species: 40 (67.8%) for direct human consumption, 2 (3.4%) for consumption and as bait, and 3 (5.1%), exclusively for bait. The other 11 species (18.6%) were captured incidentally. Of the 48 targeted species, 13 were the most important resources, based on catch volumes.

Fishermen exhibited high efficiency in the use of their catch and little wastage, when fishing multispecifically. This style of fishing was carried out year-round, and included resident fish species as well as species present seasonally. When year-round fishes were targeted, fishermen usually specialized in specific fishing zones, moving between them to improve their success.

3.5. Fishing gear

Fishing was carried out at depths ranging from 10.2 to 89.5 fathoms (see Table 2), although at certain sites southwest and northwest of Ángel de la Guarda they could fish as deep as 200 fathoms. There was no relationship between fishing depth and

TABLE 1. Fish species captured by Bahía de los Ángeles fishermen. 1994. ? = denotes that identification was not certain, * = indicates species informed by fishermen, but not recorded by us, Tar. = targeted, Inc. = incidental capture, E.I. = economically important, L.C. = local consumption.

Family	Scientific name	Common name	Notes
Alopiidae	*Alopias superciliosus*	Perro, judio, chango, zorro, bigeye thresher	Tar., E.I.
Carcharhinidae	*Carcharhinus leucas*	Tiburón toro, gambuzo, bull shark	Tar., E.I.
	C. limbatus	Volador, cazón, blacktip shark	Tar., E.I.
	Galeocerdo cuvier *	Tiburón tigre, tintorera, tiger shark	Tar., E.I.
	Negaprion brevirostris *	(Tiburón limón, tiburón amarillo, lemon shark)	Tar., E.I.
	Prionace glauca	Tintorera, tiburón azul, blue shark	Tar., E.I.
Ginglymostomatidae	*Ginglymostoma cirratum* ?	(Tiburón gata, nurse shark)	Inc.
Heterodontidae	*Heterodontus francisci*	Gato, cornudo, horn shark	Inc.
Lamnidae	*Isurus oxyrinchus*	Tiburón mako, alecrín, bonito shark, shortfin mako	Tar., E.I.
	Carcharodon carcharias	Tiburón blanco, great white shark	Tar., E.I.
Scyliorhinidae	*Cephaloscyllium ventriosum*	Swell shark	Inc.
	Parmaturus xaniurus	Filetail catshark	Inc.
Sphyrnidae	*Sphyrna lewini*	Tiburón martillo, cornuda, scalloped hammerhead	Tar., E.I.
Squatinidae	*Squatina californica*	Angelito, Pacific angel shark	Tar., E.I.
Triakidae	*Mustelus lunulatus*	Tiburón mamón, Sicklefin smooth-hound	Inc., E.I.
Gymnuridae	*Gymnura marmorata*	Raya mariposa, California butterfly ray	Inc.?, E.I.
Mobulidae	*M. birostris*	Giant manta	Inc., L.C., bait
Myliobatidae	*Myliobatis californica* *	Tecolote, raya gavilán, manta, bat ray	Inc.
Rajidae	*Raja* sp.	Raya, skate	Inc., E.I.

Family	Scientific name	Common name	Notes
Rhinobatidae	*Rhinobatos productus*	Pez guitarra, shovelnose guitarfish	Inc.?, E.I.
	Zapteryx exasperata	Pez guitarra, banded guitarfish	Inc.
Chimeridae	*Hydrolagus colliei*	Spotted ratfish	Inc.
Diodontidae	*Diodon holocanthus*	Pez erizo, long-spine porcupinefish	Inc.
Balistidae	*Balistes polylepis*	Cochi, cochito, finescale triggerfish	Tar., E.I.
Carangidae	*Seriola lalandi*	Jurel de Castilla, jurel, yellowtail amberjack	Tar., E.I.
Clupeidae	*Ophistonema libertate*	Sardina machete, Pacific thread herring	Tar., bait
	O. medirastre	Sardina, Middling thread herring	Tar., bait
Coryphaenidae	*Coryphaena hippurus*	Dorado, common dolphinfish	Inc., L.C., bait
Engraulidae	*Engraulis mordax*	Northern anchovy	Tar., E.I.
	Anchoa helleri	Gulf anchovy	Tar., E.I.
Gerreidae	*Eucinostomus* sp.	Mojarrita plateada, flagfin	Tar., bait
Haemulidae	*Anisotremus davidsonii*	Sargo	Tar., E.I.
Istiophoridae	*Istiophorus platypterus*	Pez vela, Indo-Pacific sailfish	Inc., E.I.
Labridae	*Thalassoma lucasanum*	Vieja, Cortez rainbow wrasse	Tar., E.I.
Malachantidae	*Caulolatilus princeps*	Blanco, ocean white fish	Tar., E.I.
Merlucciidae	*Merluccius productus*	Merluza, north Pacific hake	Tar., E.I.
Moronidae	*Stereolepis gigas*	Pescada, giant sea bass	Tar., E.I.
Mugilidae	*Mugil cephalus*	Lisa, liseta, flathead mullet	Tar., E.I.
Paralichtyidae	*Paralichthys aestuarius*	Lenguado, halobato, Cortez halibut	Tar., E.I.
Scianidae	*Cynoscion parvipinnis* ? *	(Curvina, shortfin corvina)	Tar., E.I.
	C. xanthulus	Curvina, Orangemouth corvina	Tar., E.I.
Scombridae	*Katsuwonus pelamis*	Bonito, skipjack tuna	Tar.?, E.I.
	Sarda orientalis ? *	(Bonito, Mexican bonito)	Tar.?, E.I.
	Scomber japonicus	Macarela, chub mackarel	Tar., E.I.

Family	Scientific name	Common name	Notes
Scombridae (cont'd)	*Scomberomorus sierra*	Sierra, Pacific sierra	Tar., E.I.
Scorpaenidae	*Scorpaenodes xyris*	Rainbow scorpionfish	Inc.?, E.I.
	Sebastes sp.?	(Rockfish)	Inc.
Serranidae	*Diplectrum euryplectrum* ? *	(Cabicucho, bighead sand perch)	Tar.?, E.I.
	D. Pacificum *	Cabaicucho, inshore sand perch	Tar.?, E.I.
	Epinephelus acanthistius	Baqueta, Rooster hind	Tar., E.I.
	E. analogus	Pinta, cabrilla pinta, spotted grouper	Tar., E.I.
	E. itajara	Mero, goliath grouper	Tar., E.I.
	Mycteroperca jordani	Baya, Gulf grouper	Tar., E.I.
	M. rosacea	Cabrilla sardinera, leopard grouper, golden grouper	Tar., E.I.
	M. xenarca	Garropa, broomtail grouper	Tar., E.I.
	Paralabrax auroguttatus	Extranjero, lucero?, goldspotted sand bass	Tar., E.I.
	P. maculatofasciatus	Arenera, cerotera, cabrilla, spotted sand bass	Tar., E.I.
Synodontidae	*Synodus* sp.	Chile, lizardfish	Inc.

the number of species captured.

Several types of fishing gear were used. Gillnets were placed either straight or used to circle fish were placed on the surface, in mid-water or on the bottom. Generally, they had only one layer, but sometimes three-layer trammel nets ("redes atrasmalladas" or "trasmallos") were used. In Bahía de los Ángeles, fishermen often constructed an artisanal, rustic trasmallo, using two nets and pieces of cord along the breadth of the net at fixed distances. The later were intended to catch the fish without killing them. Single lines were either hand-held or on a pole and rod, either with hooks or with curricanes. Longlines were also used. The gear was completed with devices to hurt and retain the fish, like harpoons, hooks and clubs.

The most common gillnets were of monofilament with 3", 3.2", 4.5", 5" and 8" mesh, and of cotton twine with 1.5" and 5.1" mesh. These nets were commonly between 120 and 180 fathoms in length. Fishing lines were of nylon, of different caliber.

TABLE 2. Main fishing zones for the artisanal fishery based at Bahía de los Ángeles, Gulf of California, Mexico, in 1995.

Fishing zone	Depth	# species		# species / year			Principal species	
	phathoms	Total	90%	Mean	S.D.	n	resources	%
Bahía de los Ángeles	10.2 (9.9)	>65	13	37.3	6.3	7	sea cucumber, shark	56.8
Isla Ángel de la Guarda	33 (52.9) to 231.2 (181.6)	>30	7	12	8.5	7	sea cucumber	65
Bahía San Francisquito	64 (57.9)	>20	2	7.2	3.5	6	sea cucumber, shark	63
Bahía de las Animas	53 (84.5)	37	16	20.6	6.5	5	sea cucumber, algae octopus, flathead mullet	53.9
Isla Las Ánimas	89.5 (49.6)	26	10	12.8	7.3	4	sea cucumber, shark, yellowtail amberjack	59.2
El Barril		33	11	15	5.3	6	flatfish, shark, ocean white fish	53.8
Punta La Gringa		17	35.3	5.2	6.3	5	sea cucumber, scallops	65.1
Ensenada de Guadalupe	45.7 (27.8)	21	28.6	7.2	5.1	6	sea cucumber	51.8
Isla Coronado	15.8 (15.8)	23	26.1	14.5	6.4	2	sea cucumber, shark	69.4
Puerto Refugio	33.8 (31.5)	26	50	8.5	9.1	4	sea cucumber, shark, gold spotted sand bass, yellowtail amberjack	56.8
Puerto Los Choros		1	100	1		1	sea cucumber	100
La Víbora	41.9 (31.6)	24	33.3	8.3	5.1	4	shark	52.4
Bahía San Rafael	48.1 (67.1)	>33	48.5	11.8	8.8	6	octopus, flatfish, gold spotted sand bass, ocean white fish, Sicklefin smooth-hound	54.5

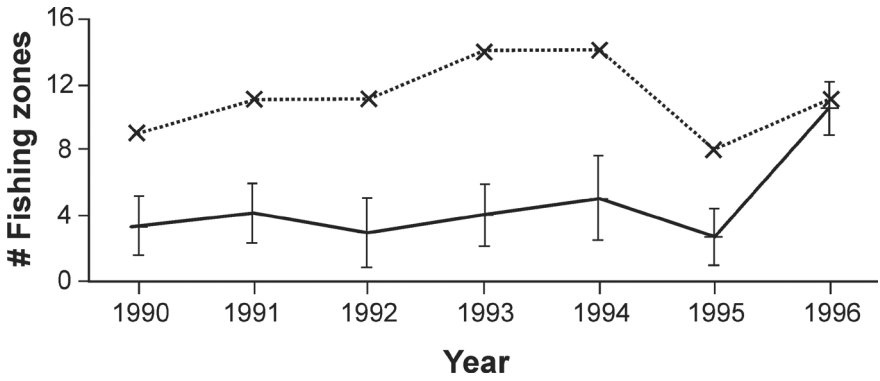

FIGURE 4. Total (dotted line) and average (solid line, ± S.D.) number of fishing zones that provided ≥ 90% of total resources each year.

3.6. Fishing zones

The names used by fishermen to fill in their landing reports did not necessarily reflect the exact fishing zone. Often, the geographical definition of such names was very ambiguous. By accompanying fishermen in their activities, we delimited the fishing zones with higher use.

The fishing office at Bahía de los Ángeles has 26 declared fishing zones, 15 of them in our study area; 3 are clearly outside it, and the remainder were not locatable. Thirteen of these fishing areas were the most important (see Table 2). During the years before our study the number of fishing zones had increased, apparently due to: 1) newer equipment (motors over 100HP), 2) an apparent depletion of some resources in traditional fishing zones and, 3) an increase in the number of fishermen and fishing skiffs in the region, leading to more competition and the exploration of new zones.

Sea cucumber and sharks were fished in 76.9% and 53.8% of the fishing zones, respectively. The other resources were captured in less than 16% of the fishing zones. The largest diversity in fishing products came from the bays and coasts (see Table 2), rather than from open waters. From 1990 to 1996 the fishing zone that provided most product was Bahía de los Ángeles itself (73.6%, see Table 2). The other fishing zones provided only small catches: waters adjacent to Ángel de la Guarda island (6.7%), Bahía de San Francisquito (5.2%), Bahía de Las Ánimas (3.6%), waters near Isla Las Ánimas (3.5%), and El Barril (2.9%)

In any single year, between 8 and 15 fishing zones were used, and not all fishing zones were used all years (see Figure 4). The fact that in 1993 and 1994 15 and 14

zones, respectively, were used (previously no more than 11 had been used in any single year) was due probably to the El Niño Southern Oscillation event that caused low captures, forcing fishermen to roam through all zones. The number of fishing zones used in any single month increased from 3.3 (± 1.7, n = 12) to 10.5 (± 1.6, n = 12) from 1990 to 1996, and between 1990 and 1995 only 26 to 37% of all zones were used in any given year, whereas 95% of them were used in 1996 (see Figure 4).

4. FINAL COMMENTS

The fishing community of Bahía de los Ángeles did not escape from the demographic events and problems faced by other rural fishing communities that are isolated and have serious limitations in their basic services. In some areas of the Upper Gulf of California, were fishing communities are close to each other, there is an informal control over fishing territories. Foreign fishermen were allowed to participate only as crew of fishing teams, and must pay a fee to do so (Cudney-Bueno and Turk 1998). No such territorial control was evident in Bahía de los Ángeles during our study. Here, fishing represented the permanent source of income for local fishermen, but only in occasions, a partial source of income for foreign fishermen. Also, whereas local fishermen fish for self-consumption and for within-community sale, the foreign fishermen were market-oriented and delivered their produce to intermediaries or to permit-holders. This lack of fishing zone control has affected local fishermen when highly-priced resources are fished.

Therefore, the disadvantages of open fishing zones should be evaluated, especially when it is used for monospecific exploitation based on species with high commercial value, rather than for their local use. Such fishing promotes spoilage of the by-catch, which, because of its lower value, is discarded. Regulation of the fishery should consider territorial exclusivity rights, or at least fishing priority, for the local fishermen. This might help to reduce competition for resources and in reduce the risk of their depletion.

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REFERENCES

Álvarez-Borrego, S. 1983. Gulf of California. In: C.B.H. Ketchum (ed.), *Estuaries and Enclosed Seas. Elsevier*. Amsterdam, pp. 427–449.

Arvizu-Martínez, M.J. 1987. Fisheries activities in the Gulf of California. Mexico. *CalCOFI Rep.* 27: 32–36

Avilés-Muñoz, A.M., and L. Figueroa-Ramírez. 1985. La pesca en los ecosistemas costeros y sus delaciones con la plataforma continental de Baja California. Inst. Inv. Soc., Univ. Aut. Baja Cal., Mexicali, BC.

Avilés-Muñoz, A.M., and L. Figueroa-Ramírez. 1987. Pesquerías ribereñas en Baja California. *Rev. Inst. Inv. Soc.* 5 (12–13): 11–40.

Avilés-Muñoz, A.M., and L. Figueroa-Ramírez. 1989. Aspectos sociales y demográficos de la pesca ribereña. In: M. Sirichiesa and P. Moctezuma (eds.), *La pesca en Baja California*. UABCS, La Paz, BCS, pp. 185–203.

Bourillón-Moreno, L. 1996. Actividad humana en la región de las Grandes Islas del Golfo de Caliofrnia, México. M.Sc. thesis. ITESM, Campus Guaymas, 230 pp.

Castro, J.I. 1983. The Sharks of North American Waters. Texas A&M, University, Texas, 180 pp.

Cudney-Bueno, R., and P.J. Turk-B. 1998. Pescando entre mareas del Alto Golfo de California. Serie Técnica No.1. CEDO Puerto Peñasco, Sonora, Mexico, 166 pp.

Chenaut, V. 1985. Los pescadores de Baja California (Costa del Pacífico y Mar de Cortés). Cen. Inv. Est. Sup. Antrop. Soc., Mexico City, 180 pp.

Diario Oficial de la Federación (DOF). 16/05/1994. Norma Oficial Mexicana NOM-059-ECOL-1994, que determina las especies y subespecies de flora y fauna silvestres terrestres y acuáticas en peligro de extinción, amenazadas, raras y las sujetas a protección especial, y que establece especificaciones para su protección.

Eschmeyer, W.N. and E.S. Herald. 1983. A Field Guide to Pacific Coast Fishes of North America. Houghton Mifflin, Boston, 336 pp.

Gatti, L.M. 1986. Los pescadores de México: la vida en un lance. Centro de Investigaciones y Estudios Superiores en Antropología Social, Mexico City, 129 pp.

Hernandez-X., E., and A. Ramos-R. 1976. Metodología para el estudio de agroecosistemas con persistencia de tecnología agrícola tradicional. In: E. Hernández X. (ed.), *Agroecosistemas de México*. Colegio de Postgraduados, Chapingo, Mexico, pp. 321–333.

Instituto Nacional de Estadística, Geografía e Informática (INEGI). 1991. XI Censo General de Población y Vivienda. Resultados definitivos, datos por localidad. Baja California. INEGI, Aguascalientes.

Miller, D.J., and N.R. Lea. 1972. Guide to the coastal marine fishes of California. Bulletin of the California Department of Fish and Game 157, 249 pp.

McGoodwin, J.R. 1987. Mexico's Conflictual Inshore Pacific Fisheries: Problem Analysis and Policy Recommendations. *Human Organization* 46: 221–232.

Secretaría de Desarrollo Económico. 1994. Catálogo de especies de interés comercial de Baja California. Gobierno del Estado de Baja California, Mexicali, BC.

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Exploring Mexico's northwest, the Baja California Peninsula, its surrounding oceans, its islands, its rugged mountains, and rich seamounds, one feels diminished by the vastness and the greatness of the landscape while consumed by a sense of curiosity and awe. In a great natural paradox, we see the region's harsh arid nature molded by water through deep time, and we feel that its unique lifeforms have been linked to this desert and sea for thousands of years, as they are now.

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