THE FISH ASSEMBLAGES FROM THE NEARSHORE AREA OF PUNTA BAJA, B.C., MÉXICO, THE SOUTHERN LIMIT OF THE SOUTHERN CALIFORNIA BIGHT

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ABSTRACT

The area off Punta Baja, Baja California, Mexico, is an important coastal fishing ground. The nearshore fishes were sampled on a seasonal basis over a period of three years, from spring 2000 to winter 2003. Beam-trawl and otter trawl were towed along 5 m and 10 m depth contours; a gill net was placed between the 5–10 m depth. Low temperatures were registered from 10.8 to 15.4˚C (mean = 13.5˚C ± 0.2 SE). A total of 3,509 fish individuals were collected belonging to 62 fish species. The most abundant and important fish species (ICI: index of community importance composite) by the contribution of the three sampling gears was the white croaker (*Genyonemus lineatus*). Separately, the most important species varied with sampling gears, depths, years, and were the bay pipefish (*Syngnathus leptorhynchus*), the walleye surfperch (*Hyperprosopon argenteum*), the Pacific sanddab (*Citharichthys sordidus*), and *G. lineatus.* Fish abundances showed differences between seasons in all sampling gears and depths. Positive correlations between fish abundances collected with otter trawl (5 and 10 m depth) and temperature were found. The fish community of the Punta Baja area was characterized by species associated with *Macrocystis* sp. beds, sandy bottom, and deeper species like scorpaenids, all typical species from the Southern California Bight. This data represents a baseline against which any future development affecting local ecosystems can be measured.

INTRODUCTION

Temperate waters vary more seasonally than tropical waters. Upwellings along the coast of California and the Pacific Northwest are areas often with extremely cool surface waters (DeMartini and Sikkel 2006). These cold water regions are produced by the effects of ocean circulation and local wind patterns (Álvarez- Borrego 2004).

The coastal waters of Baja California are also characterized by upwellings, often associated with rocky points. These appear to be seasonally strongest in the southern region (Punta Baja to Punta Eugenia) from March to June (Bakun and Nelson 1977). Within these areas of local upwelling, there exist disjunct distributions for certain marine forms, including fishes, which are characteristic of more northern, cool temperate waters (Hubbs 1948; Emerson 1956).

Many fish species are shared between the coastal waters of California and Baja California. California's inshore fishes are separated into two faunal provinces: the northern cool temperate (Oregonian) which extends well into British Columbia to the north and terminates near Point Conception to the south; and the San Diegan warm temperate province to the south which extends south to Bahía Magdalena, Baja California Sur, México (Horn et al. 2006). Some of the latter species have their principle spawning areas off Baja California and these centers may serve as a source of eggs, larvae or YOY for California waters (Moser et al. 1993). The larvae of nearshore fish species may experience southward flow during upwelling and northward flow during relaxation events (Shanks and Eckert 2005). Presently, however, there is little available information on the coastal fish assemblages between Bahía de San Quintín, Baja California and Bahía Magdalena, Baja California Sur, México (Rosales-Casián 2004).

Punta Baja, located 390 km south of the U.S.-Mexico border, and 61 km south of San Quintín, is an important area within this little documented region. Punta Baja is a rocky headland that protects Bahía El Rosario from the wind-generated high waves. Strong upwelling is present the entire year, and the cold upwelled water generated by these winds is transported southwards into the interior of the bay (Amador-Buenrostro et al. 1995). Punta Baja is a departure site for coastal commercial fishing on the northwestern coast of Baja California, which ranks second after San Quintín, and the fishery includes ocean whitefish (*Caulolatilus princeps*), the California sheephead (*Semicossyphus pulcher*), kelp bass (*Paralabrax clathratus*), California halibut (*Paralichthys californicus*), and the rockfish species of the genus *Sebastes* (Rosales-Casián and Gonzalez-Camacho 2003).

Upwelling regions with their burgeoning planktonic resource base are sites of major fisheries worldwide. Bays and lagoons are important fish habitats which often support spawning and nursery sites as well as abundant adult populations (Allen et al. 2006). Commonly, there are major fisheries associated with upwelling regions that

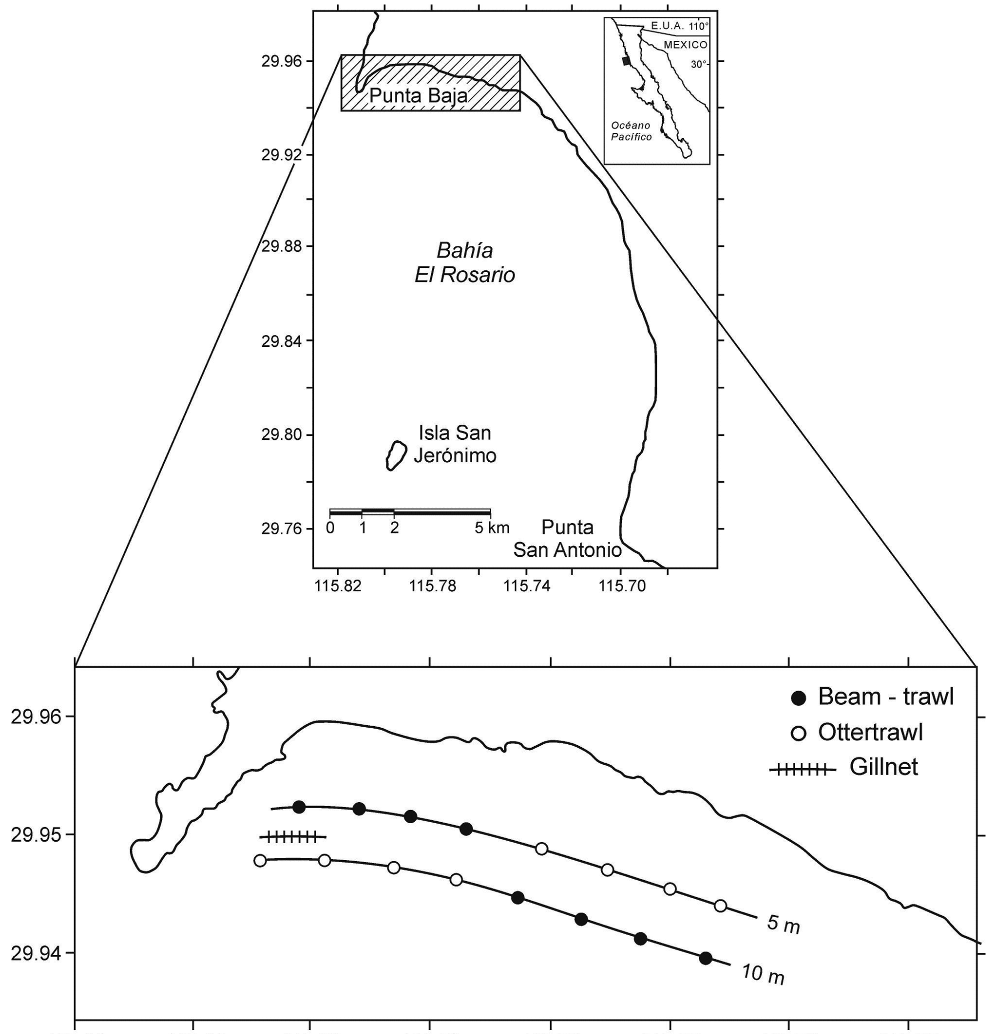

Figure 1. Localization of the study site and sampling stations in the area of Punta Baja, Baja California, México.

thrive on abundant resources. The community structure in these ecosystems is sensitive to climate variability and change, whose fluctuations in fish numbers impact both higher and lower trophic levels (Anderson and Lucas 2008). The area around Punta Baja today is an almost pristine and underdeveloped coastal region, though the threat of development in such a coastal site persists. The purpose of this study was to prepare a baseline of the area's fish assemblage and its relationship to those of adjacent and better understood sites to the north. Such a baseline is important prior to possible development or other environmental changes such as those related to global warming.

METHODS

Study Area

Punta Baja, Baja California (29°57.28'N, 115°48.09'W) is situated at 390 km south of the Baja California (México)-California (USA) border, accessed by 16 km of dirt road southwest from the town of El Rosario (fig. 1). Punta Baja is the north limit of Bahía El Rosario and Punta San Antonio the south limit (24.5 km); toward the middle of the bay is Agua Blanca fish camp (8 km south), and other important sites are Isla San Jerónimo and the Sacramento Reef at the south part of the bay (fig. 1).

Sampling Methods

The semiprotected area was sampled on a seasonal basis from spring 2000 (April 1, 2000) to winter 2003 (March 7, 2003). For the samplings, a 5 or 6 m boat with outboard motor was used. The beam trawl and otter trawl were used to capture small or slow moving fishes, and a gill net was used to capture relatively bigger and faster swimming fishes (Kramer 1990; Rosales-Casián 2004).

A variable mesh monofilament gill net (30 × 2.5 m) was placed close to a *Macrocystis* sp. bed (5–10 m depth) at the beginning of sampling and recovered at the end,

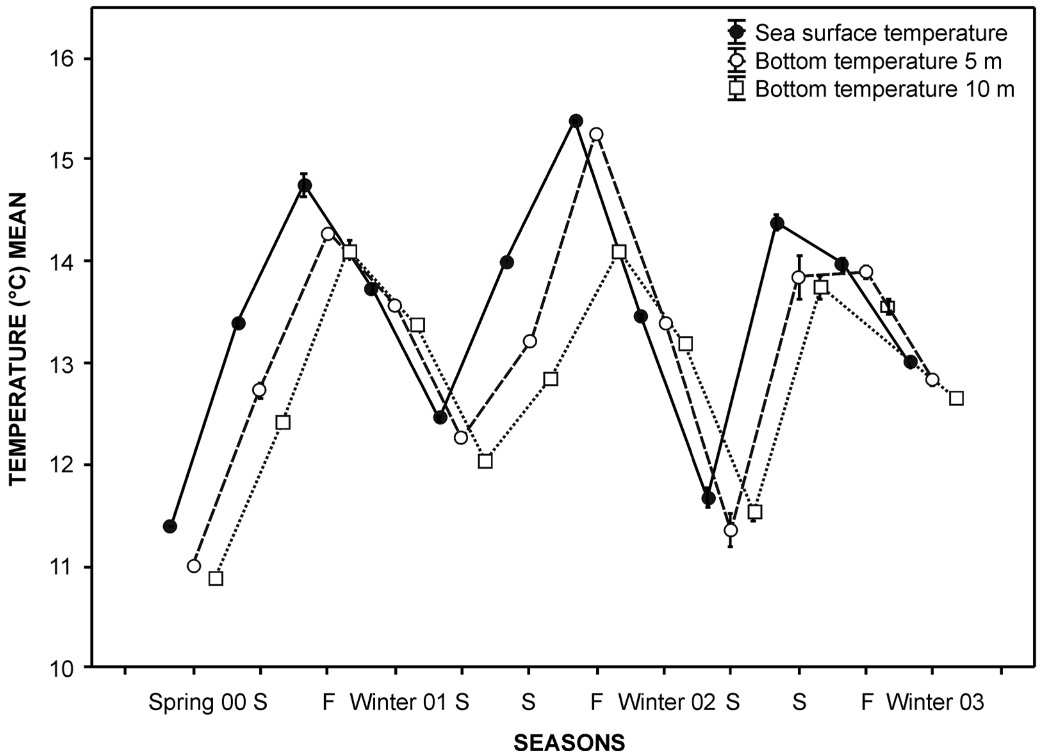

Figure 2. Temperature (°C) means distribution in the area of Punta Baja, Baja California, México (2000–2003).

for a time of six hours (07:30–13:30 hr). Four replicated 5 min tows with a 1.6 m beam trawl (horizontal 1.6 m, vertical 0.343 m opening, and 3 mm mesh size), and a 7.5 m otter trawl (10 m length with 19 mm mesh in body and 5 mm in bag end) were made at a speed of approximately 1.5 and 2.0 knots, respectively; the sampling was carried out along the 5 and 10 m depth contours, and parallel to shore. At each trawl, seawater temperature (°C) was measured at the surface and near-bottom.

Fish Identification and Measurements

All collected fishes were identified, counted, measured (standard and total length) to nearest millimeter, and weighed. Biomass was recorded to ±0.1 g for fishes weighing up to 150 g, and to ±1.0 g for those with greater weights. Identification of most species was based on Miller and Lea (1972). Rays were identified, measured, weighed, and released alive in situ.

Data Analysis

The annual total abundance (all species combined), total numbers per species, relative abundances, and frequencies of occurrence were computed by depth, sampling gear, and seasons. The gill net catch was grouped on a three-month basis to configure with the four seasons.

The data of fish abundance collected with beam trawl at 5 m depth, and with otter trawl at 5 and 10 m depths were not found to be distributed normally (Kolmogorov-Smirnoff test; KS = 0.1849, 0.1427 and 0.1695, p = 0.100, 0.200, and 0.150, respectively). Therefore, seasonal means of abundance were adjusted using a log(x+1) transformation to ensure that values were or approximated a normal distribution. To determine changes in abundances with time, a one-way ANOVA was performed on the log(x+1) transformed abundance data. To measure the degree of association between temperature (bottom and surface) and fish abundance, the Spearman correlation was used (Zar 1984).

To estimate the community contribution of each species, the Index of Community Importance (ICI) was used (Stephens and Zerba 1981; Love et al. 1986; Rosales-Casián 1997; Rosales-Casián 2004). The species were ranked by percentage of abundance as well as in percentage of frequency of occurrence, and the sum of the two ranks were the respective value of ICI for each species.

RESULTS

The overall mean of sea surface temperature at Bahía El Rosario during 2000–2003 was 13.5°C (± 0.2 SE: standard error). At 5 m and 10 m depths the mean temperatures were 13.1°C (± 0.2 SE), and 12.9°C (± 0.1 SE), respectively. Low temperatures were present in all spring seasons (fig. 2), the lowest (10.8°C) in spring 2000 and at all depths: surface (mean = 11.4°C ± 0.0 SE), 5 m

TABLE 1
Composition of trawl catches ranked by numerical, relative and cumulative abundances in the area of Punta Baja, Baja California, México, from April 2000 to March 2004.

Fish species	No	% Rel	% Cum
Genyonemus lineatus	658	18.75	18.75
Hyperprosopon argenteum	433	12.34	31.09
Engraulis mordax	301	8.58	39.67
Micrometrus minimus	250	7.12	46.79
Seriphus politus	247	7.04	53.83
Citharichthys sordidus	228	6.50	60.33
Syngnathus leptorhynchus	225	6.41	66.74
Embiotoca jacksoni	143	4.08	70.82
Citharichthys stigmaeus	128	3.65	74.47
Phanerodon furcatus	125	3.56	78.03
Amphistichus argenteus	113	3.22	81.25
Gibbonsia elegans	90	2.56	83.81
Cymatogaster aggregata	78	2.22	86.04
Sardinops sagax	67	1.91	87.95
Aulorhynchus flavidus	56	1.60	89.54
Synodus lucioceps	54	1.54	91.08
Heterostichus rostratus	45	1.28	92.36
Syngnathus californiensis	39	1.11	93.47
Scomber japonicus	32	0.91	94.39
Atherinops californiensis	25	0.71	95.10
Umbrina roncador	23	0.66	95.75
Gibbonsia metzi	18	0.51	96.27
Paralichthys californicus	13	0.37	96.64
Rhacochilus toxotes	10	0.28	96.92
Oxyjulis californica	8	0.23	97.15
Rhacochilus vacca	8	0.23	97.38
Sebastes rastrelliger	7	0.20	97.58
Sebastes sp.	6	0.17	97.75
Sebastes auriculatus	6	0.17	97.92
Pleuronichthys guttulatus	6	0.17	98.09
Sebastes paucispinis	5	0.14	98.23
Scorpaenichthys marmoratus	5	0.14	98.38
Cheilotrema saturnum	5	0.14	98.52
Hexagrammos superciliosus	4	0.11	98.63
Platyrhinoidis triseriata	4	0.11	98.75
Pleuronichthys verticalis	3	0.09	98.83
Paralabrax nebulifer	3	0.09	98.92
Artedius lateralis	2	0.06	98.97
Amphistichus rhodoterus	2	0.06	99.03
Strongylura exilis	2	0.06	99.09
Amphistichus koelzi	2	0.06	99.15
Apodichthys flavidus	2	0.06	99.20
Brachyistius frenatus	2	0.06	99.26
Ulvicola sanctaerosae	2	0.06	99.32
Ophidion scrippsae	2	0.06	99.37
Xystreurys liolepis	2	0.06	99.43
Scorpaena guttata	2	0.06	99.49
Girella nigricans	2	0.06	99.54
Leuresthes tenuis	2	0.06	99.60
Gibbonsia montereyensis	2	0.06	99.66
Paralabrax maculatofasciatus	1	0.03	99.66
Odontopyxis trispinosa	1	0.03	99.72
Chirolophis nugator	1	0.03	99.74
Peprilus semillimus	1	0.03	99.77
Raja binoculata	1	0.03	99.80
Heterodontus francisci	1	0.03	99.83
Trachurus symmetricus	1	0.03	99.86
Menticirrhus undulatus	1	0.03	99.89
Sebastes carnatus	1	0.03	99.91
Paralabrax clathratus	1	0.03	99.94
Leptocottus armatus	1	0.03	99.97
Atherinops affinis	1	0.03	100.00
Total	3509	100.0	

depth (11.0˚C ± 0.0 SE), and 10 m depth (10.9˚C ± 0.05 SE). High temperatures were present in fall 2000, 2001, and summer 2002 (fig. 2). The highest mean temperatures were recorded during fall 2001 at all depths: surface: 15.4˚C (± 0.03 SE), 5 m-depth: 15.3˚C (± 0.03 SE), and 10 m depth: 14.1˚C (± 0.0 SE) (fig. 2).

A total of 3,509 individuals were collected belonging to 62 fish species (table 1). The most abundant species were the white croaker, *Genyonemus lineatus* (18.8%), the walleye surfperch, *Hyperprosopon argenteum* (12.3%), the northern anchovy, *Engraulis mordax* (8.6%), the dwarf surfperch, *Micrometrus minimus* (7.1%), and the bay pipefish, *Syngnathus leptorhynchus* (7%). Sixteen fish species accounted for 91% of the total abundance, and the other species contributed 1.3% per species or less (table 1).

At 5 m depth, a total of 458 fishes were collected with beam-trawl tows, with an overall mean of 9.2 fish/tow (± 1.2 SE: standard error). The highest mean catch was 21.8 fish/tow (± 3.1 SE) during winter 2001, and the lowest was 2.3 fish/tow (± 0.8 SE) during spring 2002 (fig. 3). At 10 m depth, the total number of fish collected was 531 individuals, and with an overall mean abundance of 11.1 fish/tow (± 1.9 SE); the highest mean abundance (46.5 fish/tow ± 3.9 SE) was seen in spring 2000, with the lowest of 2.8 fish/tow (± 0.8 SE) in spring 2002 (fig. 3). Significant differences in the mean abundances between seasons at 5 m depth (ANOVA, $F = 3.775$, $p = 0.001$), and 10 m depth (ANOVA, $F = 13.684$, $p = 0.000$) were found.

No correlations were found between the fish abundance collected by beam-trawl tows at 5 m, with temperature from surface, 5 m and 10 m bottom ($R = 0.0645, 0.1677, 0.1579$; $p = 0.662, 0.254$, and 0.283, respectively). Fish abundance at 10 m depth was also not correlated with temperature (Spearman $R = -0.154, -0.077, -0.161$; $p = 0.299, 0.605$ and 0.273, respectively).

With otter-trawl tows (5 m depth), the total catch was 1,013 fishes with an overall mean catch of 21.1 fish/tow (± 2.5 SE). The highest mean was present in summer 2002 with 42.3 fish/tow (± 17.1 SE), and the lowest in spring 2002 (4.3 fish/tow, ± 0.5 SE) in June (fig. 4). The total catch of the otter trawl at 10 m depth was 820 fishes, with an overall mean catch of 16.3 fish/tow (± 2.2 SE); the highest mean catch was in winter 2002 (35.3 fish/tow, ± 14.2 SE), and the lowest (2.8 fish/tow, ± 0.5 SE) in summer 2000 (fig. 4). Significant differences in the mean abundances at 5 m depth between seasons (ANOVA, $F = 4.200$, $p = 0.001$), and at 10 m depth (ANOVA, $F = 4.726$, $p = 0.000$) were found.

Significant correlations of the otter trawl fish abundances (5 m depth) with the surface temperature, 5 m bottom and 10 m bottom temperatures (Spearman $R = 0.492$, $p = 0.004$; $R = 0.530$, $p = 0.000$; $R = 0.536$, $p =$

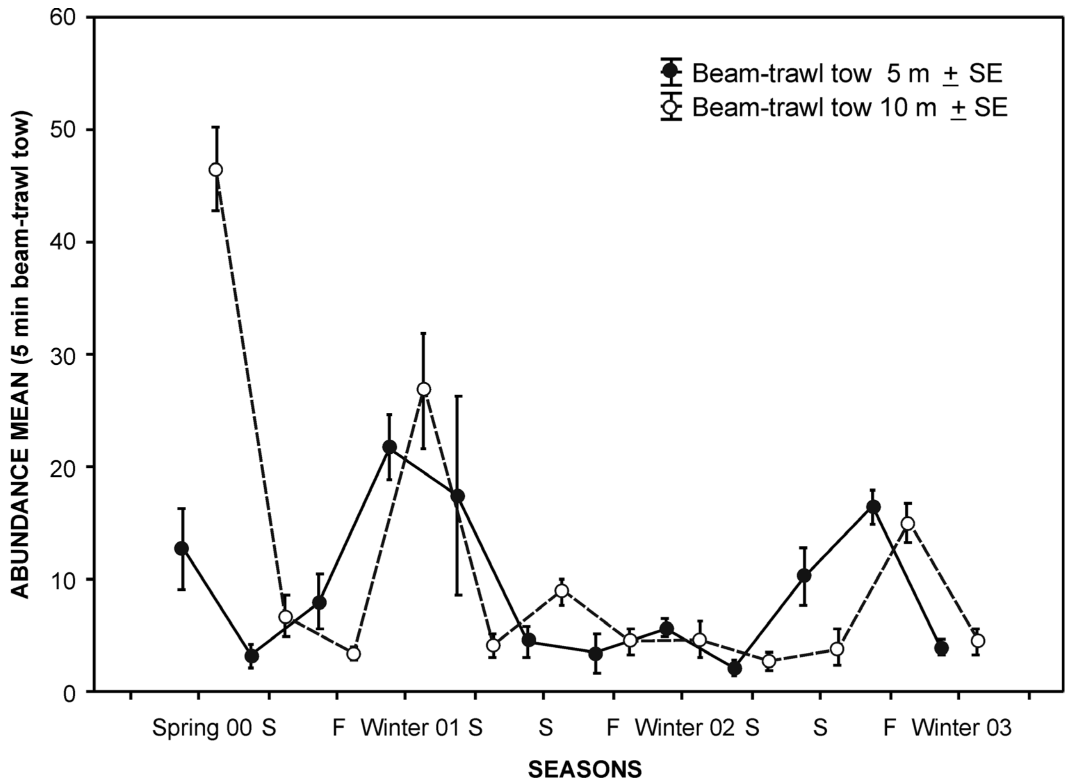

Figure 3. Abundance means of beam-trawl tows (5 and 10 m depth) in the area of Punta Baja, Baja California, México.

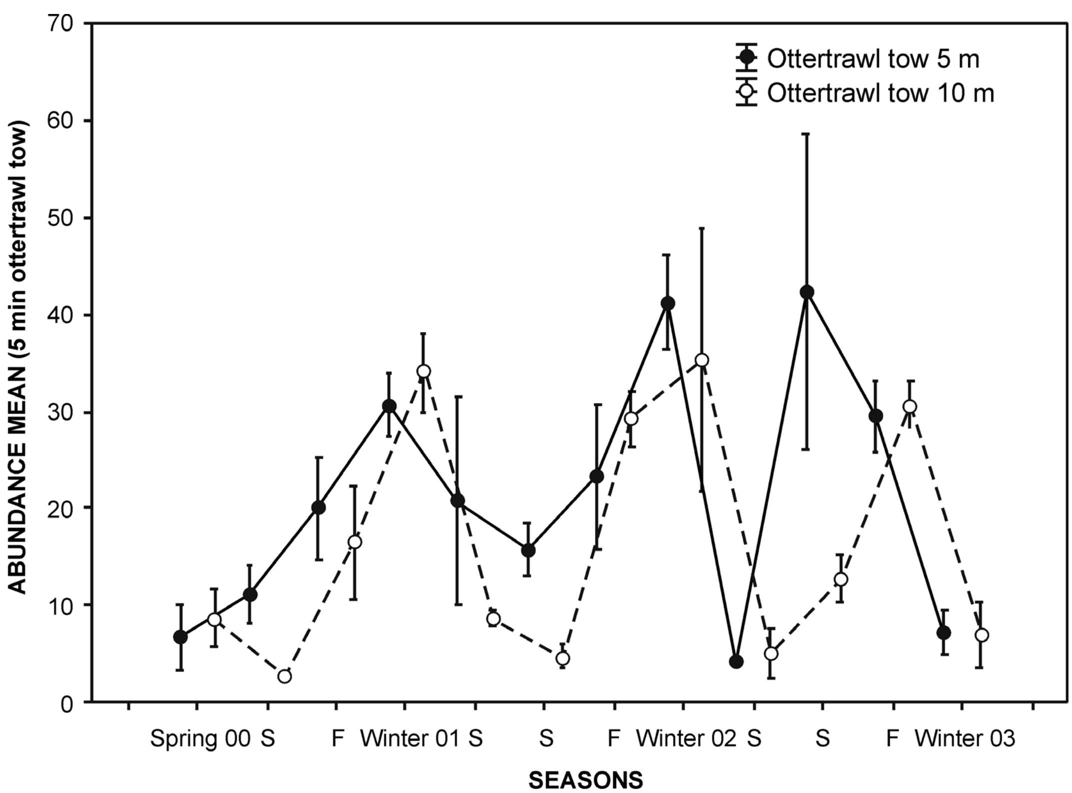

Figure 4. Abundance means of otter-trawl tows (5 and 10 m depth) in the area of Punta Baja, Baja California, México.

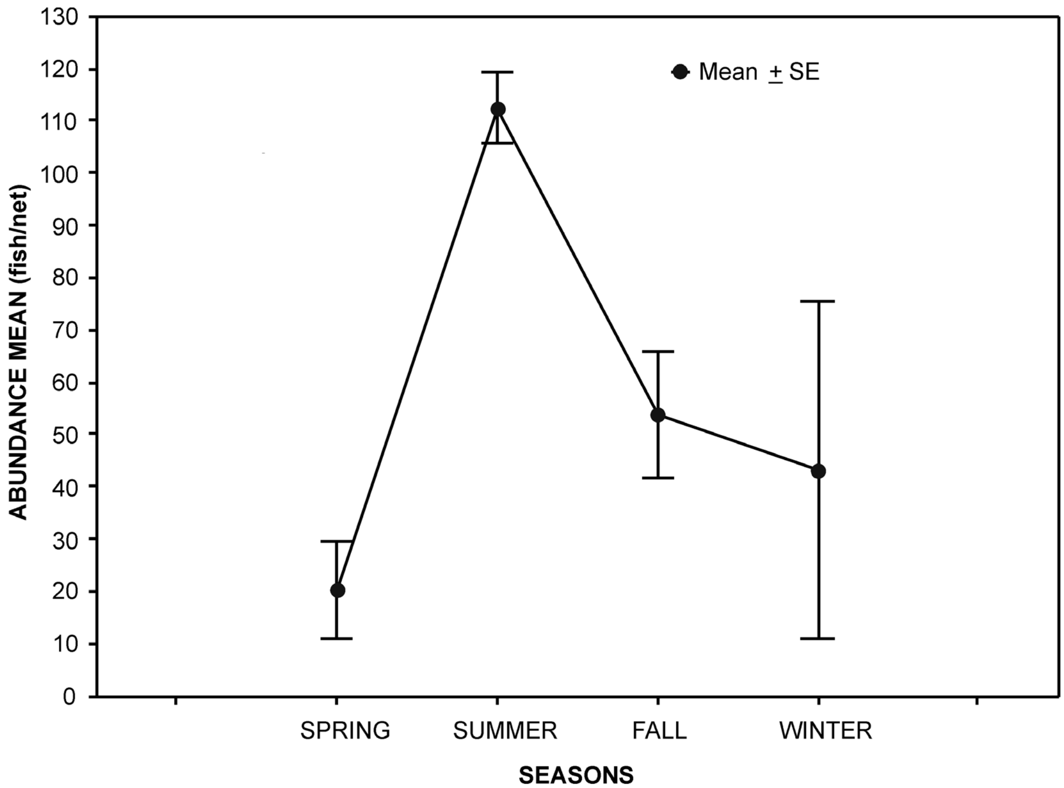

Figure 5. Abundance means of gill net catch in the area of Punta Baja, Baja California, México.

0.000, respectively) were found. At 10 m depth, the fish abundances in otter trawls were also significantly correlated with the surface temperature, and with 5 m depth and 10 m depth temperatures (Spearman R = 0.414, p = 0.003; R = 0.558, p = 0.000; R = 0.537, p = 0.000, respectively).

An interannual (2000–2001, 2001–2002, and 2002–2003) comparison of the abundances collected with beam trawl at 5 m depth, and otter trawl at 5 m and 10 m depths were not significant (ANOVA, F = 1.146, p = 0.326: F = 1.161, p = 322; F = 0.278, p = 0.758, respectively); the three-year abundances for the beam trawl at 5 m depth and the otter trawl (5 m and 10 m depths) were grouped together. The interannual comparison of abundances detected differences in the beam trawl abundances only at 10 m depth (ANOVA, F = 6.080, p = 0.004), and the Index of Community Importance (ICI) was determined separately by year.

The overall mean of the gill net catch was 57.3 fish/net (± 13.1 SE). The seasonal abundance of the gill net catch showed that the lowest mean abundance was present during spring (20 fish/net ± 20.8 SE), followed by the greatest increase in summer (112.3 fish/net ± 7.2 SE), and the number declined in fall and winter (fig. 5). The analysis of variance detected significant differences between the seasonal mean abundances (ANOVA, F = 172.086, p = 0.000). The fish abundance collected by gill net was not correlated with temperatures from surface, 5 m bottom, or 10 m bottom (Spearman R = –0.1049, –0.1049, –0.1156, p > 0.05, respectively).

A total of 458 individuals belonging to 24 fish species were collected with beam-trawl tows at 5 m depth (table 2). The most abundant species were the white croaker (*G. lineatus*, 26.4 %), the bay pipefish (*S. leptorhynchus*, 14.2 %), and the walleye surfperch (*H. argenteum*, 12.9 %). In frequency, the bay pipefish occurred in 66.7 % of the tows, followed by the dwarf surfperch (*M. minimus*, 41.7 %), and the spotted kelpfish (*Gibbonsia elegans*, 37.5 %). The order of most important fish species by the ICI were the bay pipefish, the white croaker, the dwarf surfperch, the walleye surfperch, and the spotted kelpfish (table 2).

With respect to the otter-trawl tows at 5 m depth during the complete study, the total number captured was 1,013 fishes belonging to 37 species (table 3). The walleye surfperch, *H. argenteum*, contributed the highest abundance (17.5%), the northern anchovy, *E. mordax* in second place with 10.4%, and the queenfish, *S. politus* in third (9.4%). The fish species with the highest frequency of occurrence was *E. jacksoni* that was present in 54.2% of the samples, followed by *S. leptorhynchus* (52.1%), and *H. argenteum* with 47.9% (table 3). The order in species importance (ICI rank) was the walleye surfperch (*H. argenteum*), the bay pipefish (*S. leptorhynchus*), the dwarf

TABLE 2
Fish species composition and Index of Community Importance (ICI) by the beam-trawl tows (5 m depth) in the area of Punta Baja, B.C., México (2000–2003).

Fish Species	Number	% Relative	Rank 1	% FO	Rank 2	ICI
Syngnathus leptorhynchus	65	14.2	2	66.7	1	3
Genyonemus lineatus	121	26.4	1	29.2	4.5	5.5
Micrometrus minimus	45	9.8	4	41.7	2	6
Hyperprosopon argenteum	59	12.9	3	29.2	4.5	7.5
Gibbonsia elegans	28	6.1	6	37.5	3	9
Citharichthys sordidus	25	5.5	7	27.1	6	13
Engraulis mordax	29	6.3	5	12.5	8.5	13.5
Heterostichus rostratus	9	2.0	10	14.6	7	17
Cymatogaster aggregata	15	3.3	9	12.5	8.5	17.5
Phanerodon furcatus	19	4.1	8	10.4	11	19
Embiotoca jacksoni	8	1.7	11.5	10.4	11	22.5
Citharichthys stigmaeus	8	1.7	11.5	8.3	13	24.5
Gibbonsia metzi	5	1.1	14	10.4	11	25
Seriphus politus	5	1.1	14	4.2	15	29
Syngnathus californiensis	5	1.1	14	4.2	15	29
Oxyjulis californica	3	0.7	16	4.2	15	31
Aulorhynchus flavidus	2	0.4	17	2.1	20	37
Pleuronichthys verticalis	1	0.2	20	2.1	20	40
Synodus lucioceps	1	0.2	20	2.1	20	40
Gibbonsia montereyensis	1	0.2	20	2.1	20	40
Artedius lateralis	1	0.2	20	2.1	20	40
Paralichthys californicus	1	0.2	20	2.1	20	40
Hexagrammos superciliosus	1	0.2	20	2.1	20	40
Sebastes rastrelliger	1	0.2	20	2.1	20	40
Total	458	100.0				

surfperch (*M. minimus*), the black surfperch (*E. jacksoni*), and the Pacific sanddab, *C. sordidus* (table 3).

The beam-trawl tows at 10 m depth during 2000–2001 captured a total of 334 fishes belonging to 20 fish species (table 4a). The most abundant species were the white croaker (*G. lineatus*, 31.7%), the queenfish (*Seriphus politus*, 11.7%), and the Pacific sanddab (*C. sordidus*, 10.5%). The species with greatest occurrence were the spotted kelpfish (*G. elegans*) and the black perch, *Embiotoca jacksoni* (43.8%, both), and the white croaker and the speckled sanddab, *Citharichthys stigmaeus* (37.5%, both). The most important species (ICI rank) were *G. lineatus*, *C. stigmaeus*, *C. sordidus*, *G. elegans*, and *H. argenteum* (table 4a).

In 2001–2002, the beam-trawl tows at 10 m depth collected 92 individuals from 17 fish species (table 4b). The most abundant fish species were *S. leptorhynchus* (16.3%), *Phanerodon furcatus* (13.0%), and *G. elegans* (12.0%), while the species with the highest frequency of occurrence were *S. leptorhynchus*, *M. minimus*, and *C. sordidus* (43.8%, each). The order for the five most important fish species according to Index of Community Importance (ICI) were the bay pipefish, the dwarf surfperch, the Pacific sanddab, the spotted kelpfish, and the white seaperch (table 4b).

In 2002–2003, the beam-trawl tows at 10 m depth collected 105 individuals belonging to 17 fish species (table 4c). The northern anchovy (*E. mordax*) was the most abundant (20.0%), followed by the white croaker, *G. lineatus* (16.2%), and the bay pipefish, *S. leptorhynchus* (11.4%). The species that occurred most frequently in the samples were the Pacific sanddab, *C. sordidus* (43.8%), the bay pipefish *S. leptorhynchus* (37.5%), and the dwarf surfperch, *M. minimus* (31.3%). The order of the most important fish species (ICI rank) was *C. sordidus*, *S. leptorhynchus*, *E. mordax*, *G. lineatus*, and *M. minimus* (table 4c).

At 10 m depth, the otter trawl collected a total number of 820 fishes belonging to 32 fish species, during the three years (table 5). The most abundant fish species were *G. lineatus* (14.9%), *E. mordax*, and *S. politus* that contributed with 13.2 and 10.7%, respectively. The species that occurred with highest frequency in the samples were *G. lineatus* (52.1%), *C. sordidus* (50%), and *M. minimus* (41.7%). The most important fish species (ICI rank) for the otter-trawl catch (10 m depth) were the white croaker (*G. lineatus*), the Pacific sanddab (*C. sordidus*), the dwarf surfperch (*M. minimus*), the speckled sanddab (*C. stigmaeus*), and the northern anchovy (*E. mordax*) (table 5).

The total gill net catch was 687 fishes belonging to 32 species, and eleven of those species accounted for 90% of total abundance (table 6). The most abundant species were *G. lineatus* (32.4%), *H. argenteum* (17%), the barred surfperch, *Amphistichus argenteus* (13.7%), the Pacific sardine, *Sardinops sagax* (4.8%), and the Pacific mackerel, *Scomber japonicus* (4.7%). The fish species with greatest %

TABLE 3
Fish species composition and Index of Community Importance (ICI) by otter-trawl tows (5 m depth) in the area of Punta Baja, B.C., México (2000–2003).

Fish Species	Number	% Relative	Rank 1	% FO	Rank 2	ICI
Hyperprosopon argenteum	177	17.5	1	47.9	3	4
Syngnathus leptorhynchus	78	7.7	5.5	52.1	2	7.5
Micrometrus minimus	86	8.5	4	43.8	4.5	8.5
Embiotoca jacksoni	63	6.2	8	54.2	1	9
Citharichthys sordidus	64	6.3	7	43.8	4.5	11.5
Seriphus politus	95	9.4	3	33.3	8.5	11.5
Genyonemus lineatus	78	7.7	5.5	35.4	7	12.5
Engraulis mordax	105	10.4	2	20.8	12	14
Phanerodon furcatus	50	4.9	9	41.7	6	15
Gibbonsia elegans	24	2.4	11	27.1	10	21
Heterostichus rostratus	21	2.1	13.5	33.3	8.5	22
Cymatogaster aggregata	22	2.2	12	22.9	11	23
Aulorhynchus flavidus	43	4.2	10	12.5	15	25
Citharichthys stigmaeus	21	2.1	13.5	18.8	13	26.5
Amphistichus argenteus	9	0.9	15	12.5	15	30
Gibbonsia metzi	7	0.7	16	12.5	15	31
Syngnathus californiensis	14	1.4	15	10.4	17	32
Sebastes sp.	6	0.6	17	8.3	18.5	35.5
Sebastes rastreliger	5	0.5	18	8.3	18.5	36.5
Synodus lucioceps	4	0.4	21	6.3	21.5	42.5
Paralichthys californicus	4	0.4	21	6.3	21.5	42.5
Pleuronichthys guttulatus	4	0.4	21	6.3	21.5	42.5
Sebastes paucispinis	5	0.5	18	4.2	25.5	43.5
Scorpaenichthys marmoratus	3	0.3	23	6.3	21.5	44.5
Sardinops sagax	5	0.5	18	2.1	31.5	49.5
Oxyjulis californica	2	0.2	27.5	4.2	25.5	53
Amphistichus rhodoterus	2	0.2	27.5	4.2	25.5	53
Strongylura exilis	2	0.2	27.5	4.2	25.5	53
Amphistichus koelzi	2	0.2	27.5	2.1	31.5	59
Platyrhinoidis triseriata	2	0.2	27.5	2.1	31.5	59
Umbrina roncador	2	0.2	27.5	2.1	31.5	59
Apodichthys flavidus	2	0.2	27.5	2.1	31.5	59
Brachyistius frenatus	2	0.2	27.5	2.1	31.5	59
Ulvicola sanctaerosae	1	0.1	33.5	2.1	31.5	65
Sebastes auriculatus	1	0.1	33.5	2.1	31.5	65
Paralabrax maculatofasciatus	1	0.1	33.5	2.1	31.5	65
Artedius lateralis	1	0.1	33.5	2.1	31.5	65
Total	1,013	100.0				

occurrence in samplings coincided with the most important species (ICI): *G. lineatus*, *A. argenteus, A. californiensis*, *H. argenteum*, and *S. japonicus* (table 6).

The ICI composite by the contribution of the three sampling gears showed that the most important fish species was the white croaker, *G. lineatus* (table 7), followed by two species (*S. japonicus* and *Atherinopsis californiensis*) that were present in the gill net only. In fourth and fifth place were *M. minimus* and *S. leptorhynchus* that were recollected with beam trawl and otter trawl, and sixth place was occupied by the walleye surfperch *H. argenteum* captured with three gears (table 7).

DISCUSSION

Low temperatures were registered at the study site (10.8–15.4°C) of Punta Baja. Temperatures at Punta Baja were lower than those measured at Punta Entrada off Bahía de San Quintín which is characterized by upwelling, and which showed an annual range of 11.2–18.6°C (Rosales-Casián 1997). The presence of intense upwelling was the result of the Punta Baja effect at the study site, and this wind-induced upwelling is generated almost the entire year, which likely causes cold water to be transported southwards to the interior of Bahía El Rosario (Amador-Buenrostro et al. 1995).

In the present study of Punta Baja, a total of 62 fish species was identified. The site closest to Punta Baja with published fish research is the Bay and Coast of San Quintín (Rosales-Casián 2004). In the Coast of San Quintín, a total of 71 fish species belonging to 33 families was identified and showed 24.7 % higher fish abundance (Rosales-Casián 1996; 2004) than Punta Baja. In the present study, however, the beach seine gear was discarded in Punta Baja because of high waves and rocks on bottom at nearshore.

A total of 40 species were shared between the sites of Punta Baja and the coast of San Quintín. Sixteen fish species were recorded at Punta Baja but not at the

TABLE 4
Fish species composition and Index of Community Importance (ICI) by the beam-trawl tows (10 m depth) in the area of Punta Baja, B.C., México, during (a) 2000–01, (b) 2001–02, and (b) 2002–03.

a

Species 00-01	No.	% Rel	R 1	% FO	R 2	ICI
G. lineatus	106	31.7	1	37.5	3.5	4.5
C. stigmaeus	20	6.0	5	37.5	3.5	8.5
C. sordidus	35	10.5	3	31.3	6	9
G. elegans	10	3.0	10	43.8	1.5	11.5
H. argenteum	21	6.3	4	25.0	8	12
M. minimus	19	5.7	6	31.3	6	12
E. jacksoni	9	2.7	11	43.8	1.5	12.5
S. leptorhynchus	17	5.1	7	31.3	6	13
S. politus	39	11.7	2	12.5	15.5	17.5
E. mordax	15	4.5	8	18.8	10.5	18.5
S. sagax	7	2.1	12	18.8	10.5	22.5
S. lucioceps	13	3.9	9	12.5	15.5	24.5
S. californiensis	4	1.2	14.5	18.8	10.5	25
A. flavidus	3	0.9	16.5	18.8	10.5	27
C. aggregata	5	1.5	13	12.5	15.5	28.5
P. furcatus	4	1.2	14.5	12.5	15.5	30
H. superciliosus	3	0.9	16.5	12.5	15.5	32
H. rostratus	2	0.6	18	12.5	15.5	33.5
A. argenteus	1	0.3	19.5	6.3	19.5	39
P. guttulatus	1	0.3	19.5	6.3	19.5	39
Total	334	100.0				

b

Species 01-02	No.	%Rel	R 1	% FO	R 2	ICI
S. leptorhynchus	15	16.3	1	43.8	2	3
M. minimus	10	10.9	4.5	43.8	2	6.5
C. sordidus	10	10.9	4.5	43.8	2	6.5
G. elegans	11	12.0	3	37.5	4	7
P. furcatus	12	13.0	2	18.8	7	9
H. rostratus	6	6.5	7	25.0	5	12
E. mordax	9	9.8	6	18.8	7	13
C. aggregata	3	3.3	9	18.8	7	16
G. lineatus	5	5.4	8	12.5	10	18
S. lucioceps	2	2.2	11	12.5	10	21
S. californiensis	2	2.2	11	12.5	10	21
G. metzi	2	2.2	11	6.3	14.5	25.5
H. argenteum	1	1.1	15	6.3	14.5	29.5
P. triseriata	1	1.1	15	6.3	14.5	29.5
G. montereyensis	1	1.1	15	6.3	14.5	29.5
U. sanctaerosae	1	1.1	15	6.3	14.5	29.5
S. sagax	1	1.1	15	6.3	14.5	29.5
Total	92	100.0				

c

Species 02-03	No.	% Rel	R 1	% FO	R2	ICI
C. sordidus	11	10.5	4	43.8	1	5
S. leptorhynchus	12	11.4	3	37.5	2	5
E. mordax	21	20.0	1	25.0	5.5	6.5
G. lineatus	17	16.2	2	25.0	5.5	7.5
M. minimus	6	5.7	6	31.3	3	9
G. elegans	7	6.7	5	25.0	5.5	10.5
C. stigmaeus	5	4.8	7.5	25.0	5.5	13
C. aggregata	5	4.8	7.5	12.5	10	17.5
E. jacksoni	4	3.8	10	18.8	8	18
A. argenteus	4	3.8	10	12.5	10	20
P. furcatus	3	2.9	12	12.5	10	22
H. argenteum	4	3.8	10	6.3	15	24.5
S. sagax	2	1.9	13	6.3	15	27.5
S. lucioceps	1	1.0	15.5	6.3	15	30
O. trispinosa	1	1.0	15.5	6.3	15	30
C. nugator	1	1.0	15.5	6.3	15	30
A. flavidus	1	1.0	15.5	6.3	15	30
Total	105	100.0				

TABLE 5
Fish species composition and Index of Community Importance (ICI) by otter trawl tows (10 m depth) in the area of Punta Baja, B.C., México (2000–2003).

	Number	% Rel	Rank 1	% FO	Rank 2	ICI
Genyonemus lineatus	122	14.9	1	52.1	1	2
Citharichthys sordidus	82	10.0	5	50.0	2	7
Micrometrus minimus	84	10.2	4	41.7	3	7
Citharichthys stigmaeus	67	8.2	6	35.4	4	10
Engraulis mordax	108	13.2	2	29.2	8	10
Seriphus politus	88	10.7	3	20.8	9.5	12.5
Hyperprosopon argenteum	54	6.6	7	31.3	6	13
Syngnathus leptorhynchus	38	4.6	8	31.3	6	14
Embiotoca jacksoni	34	4.1	9	31.3	6	15
Cymatogaster aggregata	28	3.4	10	20.8	9.5	19.5
Synodus lucioceps	15	1.8	11	14.6	12	23
Phanerodon furcatus	11	1.3	13	14.6	12	25
Gibbonsia elegans	9	1.1	14	14.6	12	26
Sardinops sagax	19	2.3	10	8.3	17.5	27.5
Heterostichus rostratus	7	0.9	15.5	12.5	14.5	30
Aulorhynchus flavidus	7	0.9	15.5	12.5	14.5	30
Amphistichus argenteus	5	0.6	17	8.3	17.5	34.5
Sebastes auriculatus	4	0.5	18.5	8.3	17.5	36
Gibbonsia metzi	4	0.5	18.5	8.3	17.5	36
Syngnathus californiensis	14	1.7	12	4.2	24.5	36.5
Paralichthys californicus	3	0.4	20.5	6.3	21	41.5
Oxyjulis californica	3	0.4	20.5	6.3	21	41.5
Ophidion scrippsae	2	0.2	23.5	6.3	21	44.5
Scorpaenichthys marmoratus	2	0.2	23.5	4.2	24.5	48
Xystreurys liolepis	2	0.2	23.5	4.2	24.5	48
Pleuronichthys verticalis	2	0.2	23.5	4.2	24.5	48
Sebastes rastrelliger	1	0.2	28.5	2.1	29.5	58
Peprilus simillimus	1	0.2	28.5	2.1	29.5	58
Raja binoculata	1	0.1	28.5	2.1	29.5	58
Pleuronichthys guttulatus	1	0.1	28.5	2.1	29.5	58
Paralabrax nebulifer	1	0.1	28.5	2.1	29.5	58
Scorpaena guttata	1	0.1	28.5	2.1	29.5	58
Total	820	100.0				

San Quintín coast: *M. minimus, G. elegans, G. metzi, G. montereyensis, Aulorhynchus flavidus, Sebastes paucispinis, Strongylura exilis, Ulvicola sanctaerosae, Artedius lateralis, Apodichthys flavidus, Brachyistius frenatus, Ophidium scrippsae, Leuresthes tenuis, Paralabrax maculatofasciatus, Raja binoculata*, and *Chirolophis nugator.* However 27 species found at the Coast of San Quintín (Rosales-Casián 1997) were not common with Punta Baja.

The fish community of Punta Baja was characterized by species associated with small patches of *Macrocystis* sp. beds, mainly, from the sandy bottom areas (*G. lineatus*, *S. politus*, *C. sordidus*), and also deeper species like scorpaenids. The most abundant species belong to Embiotocidae, Scorpaenidae, Sciaenidae, and Clinidae families (eleven, five, four, and four species, respectively), accounting for 65% of total abundance.

In San Diego Bay, California (388 km north of Punta Baja), a total of 78 fish species was identified (Allen et al. 2002), however 38% of the species registered at Punta Baja were not present at San Diego Bay, and vice versa: 58% of the species registered at San Diego were not common with Punta Baja. This variation can be due to the environmental differences between the semiprotected area of Punta Baja and the coastal lagoon of San Diego, and the long sampling period (1994–1999) in San Diego Bay which preceded the current study period of 2000–2003. In a study at the marine reserve of Cabrillo National Monument localized at the protected southwestern side of Point Loma at the mouth of San Diego Bay (Craig and Pondella 2006), a total of 47 fish species was identified, and shared 23 species with Punta Baja, but the gill net was the only common sampling gear. In another gill net study at Santa Catalina Island, 67 species were registered, however there was a stronger representation of rocky-reef fishes with *Heterodontus franciscanus* as the most abundant (Pondella and Allen 2000), while at Punta Baja the first species was a sandy-bottom habitant (*G. lineatus*), which at Santa Catalina Island was positioned at number 64.

The collection of two species at Punta Baja, the penpoint gunnel (*Apodichthys flavidus*), and the mosshead warbonnet (*Chirolophis nugator*), is interesting because their southern distributions are established at Santa Barbara Island and San Miguel Island, respectively, in

TABLE 6
Fish species composition and Index of Community Importance (ICI) by the gill net (5–10 m depth) in the area of Punta Baja, B.C., México (2000–2003).

Species	Number	% Rel	Rank 1	% FO	Rank 2	ICI
Genyonemus lineatus	209	30.42	1	66.67	1.5	2.5
Amphistichus argenteus	94	13.68	3	66.67	1.5	4.5
Hyperprosopon argenteum	117	17.03	2	41.67	5	7
Scomber japonicus	32	4.66	5	41.67	5	10
Atherinops californiensis	25	3.64	7.5	50.00	3	10.5
Phanerodon furcatus	26	3.78	6	33.33	7.5	13.5
Sardinops sagax	33	4.80	4	25.00	9.5	13.5
Seriphus politus	20	2.91	10	41.67	5	15
Embiotoca jacksoni	25	3.64	7.5	33.33	7.5	15
Synodus lucioceps	18	2.62	11	25.00	9.5	20.5
Umbrina roncador	21	3.06	9	16.67	13	22
Rhacochilus toxotes	10	1.46	13	16.67	13	26
Rhacochilus vacca	8	1.16	14	16.67	13	27
Citharichthys stigmaeus	7	1.02	15	16.67	13	28
Paralichthys californicus	5	0.73	16.5	16.67	13	29.5
Engraulis mordax	14	2.04	12	8.33	24	36
Cheilotrema saturnum	5	0.73	16.5	8.33	24	40.5
Girella nigricans	2	0.29	19	8.33	24	43
Paralabrax nebulifer	2	0.29	19	8.33	24	43
Leuresthes tenuis	2	0.29	19	8.33	24	43
Scorpaena guttata	1	0.15	26.5	8.33	24	50.5
Heterodontus francisci	1	0.15	26.5	8.33	24	50.5
Gibbonsia elegans	1	0.15	26.5	8.33	24	50.5
Platyrhinoidis triseriata	1	0.15	26.5	8.33	24	50.5
Trachurus symmetricus	1	0.15	26.5	8.33	24	50.5
M. undulatus	1	0.15	26.5	8.33	24	50.5
S. carnatus	1	0.15	26.5	8.33	24	50.5
Citharichthys sordidus	1	0.15	26.5	8.33	24	50.5
Sebastes auriculatus	1	0.15	26.5	8.33	24	50.5
Paralabrax clathratus	1	0.15	26.5	8.33	24	50.5
Leptocottus armatus	1	0.15	26.5	8.33	24	50.5
Atherinops affinis	1	0.15	26.5	8.33	24	50.5
Total	687	100.0				

Southern California (Love et al. 2005). The presence of a continuous upwelling at Punta Baja may provide a "cold oasis" for opportunistic northern species, whose eggs are dispersed by different ways, and which use these local disturbances for survival of later developmental stages (DeMartini and Sikkel 2006). In an analysis of the oceanographic conditions, nutrient and phytoplankton dynamics in the San Quintín area, it was found that low salinity water parcels arrive to the area, and it is suggested that they originate at the subarctic or at the Columbia River, implicating a genetic flux by spores, eggs, etc. (Alvarez-Borrego 2004). As evidence, at El Socorro coast, a site between Punta Baja and Coast of San Quintín, in December 2008 a green sturgeon (*Acipenser medirostris*) was captured 200 km south of the southern limit of known distribution (Bahía de Todos Santos), and may it be using these water parcels during La Niña conditions (Rosales-Casián and Almeda-Jauregui 2009).

The California halibut (*Paralichthys californicus*), an important component in fish species assemblages in the Southern California Bight (Kramer 1990), was ranked 23rd (0.37% relative abundance) at Punta Baja. In the Coast of San Quintín, influenced as well by upwelling, the California halibut occupied the 9th place with also a low relative abundance (2.7%) and that compared with Bahía de Todos Santos (232 km north) where this flatfish contributed a greater relative abundance (13.0%) and was ranked 2nd place (Rosales-Casián 1997). Juvenile California halibut appear to succeed better in bays and estuaries and prefer a range of temperatures between 15–23°C (Innis 1990), the benefit being a faster growth because of high food production and warm waters (Kramer 1990), and therefore, the low temperatures registered at Punta Baja do not suggest it is a prime habitat for this species.

The gill net overall mean abundance on a seasonal basis at Punta Baja (CPUE 57.3 fish/net) was higher than the 16.9 fish/net found at the Coast of San Quintín (Rosales-Casián 1997) and the 27.5 fish/net found at Cabrillo National Monument, San Diego, California (Craig and Pondella 2006), but was lower than the mean CPUE of 193.3 fish/net found at the Scripps Coastal Reserve (Craig et al 2004). Sampling with a gill net is

TABLE 7
Composite ICI for the fish species assemblage at Punta Baja, B.C., México (2000–2003).

Fish species	ICI composite	Beam-trawl	Otter trawl contributions	Gill net	Sum
Genyonemus lineatus	1	2	1	1	4
Scomber japonicus	1			4	4
Atherinopsis californiensis	3			5	5
Micrometrus minimus	4	3	4		7
Syngnathus leptorhynchus	5	1	6.5		7.5
Hyperprosopon argenteum	6	5	2.5	3	10.5
Hexagrammos superciliosus	7	20			20
Cymatogaster aggregata	8	11	11		22
Embiotoca jacksoni	9	9	5	8.5	22.5
Rhacochilus toxotes	10			23	23
Sebastes sp.	11		23.5		23.5
Scorpaenichthys marmoratus	11		23.5		23.5
Rhacochilus vacca	13			24	24
Phanerodon furcatus	14	10	9	6.5	25.5
Heterostichus rostratus	15	12	14		26
Gibbonsia montereyensis	16	27			27
Odontopyxis trispinosa	16	27			27
Chirolophis nugator	16	27			27
Sebastes paucispinis	16		27		27
Cheilotrema saturnum	20			28	28
Ophidion scrippsae	20		28		28
Seriphus politus	22	13	8	8.5	29.5
Syngnathus californiensis	22	14.5	15		29.5
Girella nigricans	24			30	30
Leuresthes tenuis	24			30	30
Aulorhynchus flavidus	24	18	12		30
Amphistichus rhodoterus	27		30.5		30.5
Strongylura exilis	27		30.5		30.5
Xystreurys liolepis	27		30.5		30.5
Gibbonsia metzi	30	16	18		34
Amphistichus koelzi	31		35		35
Apodichthys flavidus	31		35		35
Brachyistius frenatus	31		35		35
Heterodontus francisci	34			36.5	36.5
Trachurus symmetricus	34			36.5	36.5
Menticirrhus undulatus	34			36.5	36.5
Sebastes carnatus	34			36.5	36.5
Paralabrax clathratus	34			36.5	36.5
Leptocottus armatus	34			36.5	36.5
Atherinops affinis	34			36.5	36.5
Amphistichus argenteus	41	19	17	2	38
Engraulis mordax	42	7	6.5	27	40.5
Synodus lucioceps	42	14.5	16	10	40.5
Paralabrax maculatofasciatus	44		41		41
Peprilus simillimus	44		41		41
Raja binoculata	44		41		41
Sardinops sagax	47	17	19	6.5	42.5
Citharichthys stigmaeus	48	8	10	25	43
Citharichthys sordidus	48	4	2.5	36.5	43
Oxyjulis californica	50	21	23.5		44.5
Umbrina roncador	51		35	11	46
Sebastes rastrelliger	52	27	21		48
Pleuronichthys guttulatus	53	27	26		53
Gibbonsia elegans	54	6	13	36.5	55.5
Pleuronichthys verticalis	55	27	30.5		57.5
Sebastes auriculatus	56		23.5	36.5	60
Artedius lateralis	57	27	41		68
Ulvicola sanctaerosae	57	27	41		68
Paralabrax nebulifer	59		41	30	71
Paralichthys californicus	60	27	20	26	73
Scorpaena guttata	61		41	36.5	77.5
Platyrhinoidis triseriata	62	27	35	36.5	98.5

an effective method of taking fish species in sites with rocky and sandy bottoms, the otter trawl is most effective on sandy bottoms (Craig et al. 2004; Craig and Pondella 2006).

Comparison of the coastal fishes from Punta Baja with northern sites in California is difficult because of the differences in sampling methods. The fish species richness registered at Punta Baja was similar to the Scripps Coastal Reserve at La Jolla (San Diego, California), where a total of 59 fish species was found using otter-trawl tows and gill nets, but scuba surveys and ichthyocide in tidepools were also used (Craig et al. 2004).

Like many sites of coastal Baja California, Punta Baja has been under pressure for development, which has now mostly been suspended. Only at Bahía de Santa Rosalillita, 210 km south of Punta Baja (the Nautical Stairway, Okolodkov et al. 2007) were facilities to launch boats and two rocky stone jetties recently constructed to receive boats from California and to move the vessels overland to Bahía de Los Ángeles, another proposed site for a large marina. Future development may still occur, however.

The 62 fish species identified at the Punta Baja area belong to a typical temperate community (Allen et al. 2006) of the Southern California Bight. The present study constitutes a baseline reference for possible future developments, and major anthropogenic impacts.

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