

COMPOSITION, DENSITY AND BIOGEOGRAPHIC AFFINITIES OF THE ROCKY INTERTIDAL FISHES ON THE WESTERN COAST OF THE BAJA CALIFORNIA PENINSULA, MEXICO

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ABSTRACT

The composition, density and biogeographic affinities of the rocky intertidal fishes of the western coast of the Baja California peninsula, Mexico, were studied from June 2006 to January 2009. A total of 5,489 specimens belonging to 48 species, 39 genera and 20 families were registered. *Clinocottus analis* was the dominant species on the northern and central coast (north to Punta Abreojos), and *Entomacrodus chiostictus* was dominant farther south. Based on distribution and density of permanent species, the area between Punta San Juanico and Bahía Magdalena represents the distributional boundary for northern (warm-temperate) and tropical fish elements. Most of species (85%) showed zoogeographical affinities with the San Diegan province, followed by species related to the Mexican (58%) and Cortez (56%) provinces. The known northernmost geographical ranges are extended for *Sargocentron suborbitalis*, *Labrisomus multiporosus* and *Bathygobius ramosus*; while the southernmost ranges extended for *Clinocottus analis*, *Oligocottus rubellio* and *Amphistichus koelzi*.

INTRODUCTION

The rocky intertidal zone is one of the most studied marine biotopes worldwide due to its easy access and the special adaptations of its biota to the dynamic environmental conditions (Gibson 1969, 1982; Stephenson and Stephenson 1972; Horn et al. 1999; Horn and Martin 2006). The fish fauna of these biotopes is characterized by having special physiological and morphological adaptations to inhabit the pools and crevices through the intertidal zone (Gibson 1969; Horn et al. 1999; Horn and Martin 2006).

The taxonomic and ecological studies of the rocky intertidal fish fauna in the Northeastern Pacific are well documented for the United States of America and Canada (cf. Chotkowski et al. 1999; Prochazka et al. 1999;

Horn et al. 2006; Horn and Martin 2006; Blanchette et al. 2008) but insufficiently represented for the western rocky coast of Mexico. Recent studies on rocky tide pool fishes in northwestern region of the Baja California Peninsula (BCP) have been focused on taxonomical and ecological issues. Ruiz-Campos (1986) and Ruiz-Campos and Hammann (2002) analyzed the dynamics, composition and feeding relationships of the rocky intertidal fish community in Granada Cove (Punta Morro) at Bahía Todos Santos. For this same bay, Ruiz-Campos and Hammann (1987) reported 13 species, with the woolly sculpin *Clinocottus analis*, the most abundant fish. On the other hand, Stepien et al. (1991) found 19 species in a cold, upwelling area off Punta Clara (55 km SW of Ensenada) and remarked on the importance of this site in the Californian-Oregonian coastal marine zoogeographic transition. Recently, Ruiz-Campos et al. (2010) provided weight-length and length-length relationships for nine common rocky intertidal fish species of the western coast of the BCP. Except for the localities cited above, a long portion of the rocky shores of the BCP has not been quantitatively assessed for tide pool fishes. Briggs (1960) and Horn et al. (2006) identified Bahía Magdalena as a geographical distributional limit for boreal and tropical species; however this statement has not been properly documented for rocky tide pool fishes, with strong fidelity and connection to these biotopes (Pfister 1999). Pondella et al. (2005) analyzed the biogeography of the nearshore rocky-reef fishes at southern California and Baja California islands, and found that Punta Eugenia (Baja California Sur) showed a greater faunal break than Point Conception (California), as well as the presence of a clinal transition pattern in species composition from north to south throughout the San Diegan Province. Hastings (2000) established a significant correspondence between the ranges of chaenopsid fishes and the tropical eastern Pacific marine prov-

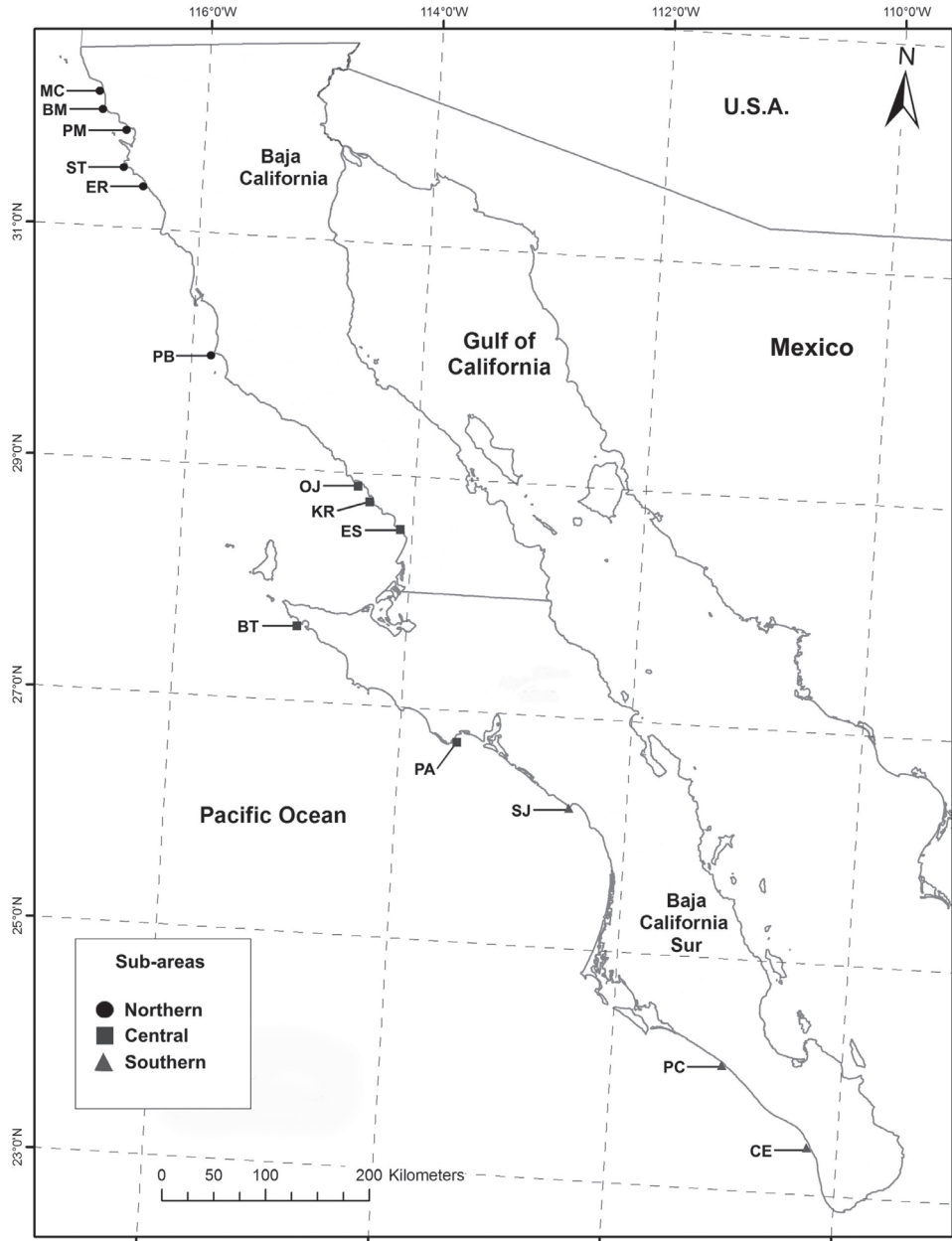


Figure 1. Sampling sites for rocky intertidal fishes in the western coast of the Baja California Peninsula, during June 2006 to January 2009. MC= Medio Camino, BM= Bajamar, PM= Punta Morro, ST= Santo Tomas, ER= Erendira, PB= Punta Baja, OJ= Los Ojitos, KR= Krutsio, ES= La Esmeralda, BT= Bahía Tortugas, PA= Punta Abrejos, SJ= San Juanico, PC= Punta [Playa] El Conejo, and CE= Los Cerritos.

inces, including the southern part of the BCP from Bahía Magdalena into the Cortez province.

We analyze here the taxonomic composition, density, zonation and zoogeographic relationships of the rocky intertidal fish communities through a latitudinal interval of nine degrees in the western coast of the BCP, in order to determine species' abundances and distribution patterns.

METHODS

Fish sampling was carried out in 14 rocky intertidal sites of the Baja California Peninsula (fig. 1) during low

tide conditions from June 2006 to January 2009. The northernmost site was Medio Camino, Baja California (32°10'N) and the southernmost, Los Cerritos, Baja California Sur (23°20'N). The study area was divided into three sub-areas following Allen and Pondella (2006): northern (NS: Medio Camino to Punta Baja), central (CS: Los Ojitos to Punta Abrejos) and southern (SS: San Juanico to Los Cerritos). Fishes were sampled across mesolittoral zones (high, middle and low intertidal) established for this area by Ruiz-Campos (1986) and Ramírez-Valdéz (2009). In order to compare the species composition and abundances among sites, the length

and width of each tide pool were measured. Fish were sampled using manual aspersion pumps, one containing a solution of 20% quinaldine (Gibson 1999) and the other 10% clove oil (Munday and Wilson 1997; Griffiths 2000). After 10 minutes of the application, narcotized fishes were removed from each tide pool using dip nets. The number of fishes collected in each pool was counted and expressed as average density (number of individuals captured per square meter of sampled pool) in each sub-area.

Specimens were fixed in 10%-formalin or 96%-ethanol, identified and deposited in the Fish Collection of the Universidad Autónoma de Baja California (UABC). Species identifications were based on Jordan and Evermann (1896), Bolin (1944), Hubbs (1952), Briggs (1955), Springer (1962), Miller and Lea (1972), Fischer et al. (1995), Allen and Robertson (1998), Thomson et al. (2000), and Robertson and Allen (2002). The taxonomic arrangement and nomenclature follows Nelson et al. (2004).

The species composition similarity among sites of the study area was calculated using the square root transformed average abundances of the permanent species, by means of the Bray–Curtis coefficient (Brower et al. 1997) and the UPGMA (Unweighted Pair Group Method with Arithmetic Mean) clustering method. The determination of permanent species for the study sub-areas was based on Ramírez-Valdéz (2009).

RESULTS AND DISCUSSION

Species Accounts

A total of 5,489 fish belonging to 48 species, 39 genera and 20 families were collected throughout the study area. For each fish species, we present the following: *Distribution*, the known distribution range for the species as described by Love et al. (2005); *Records*, include the collection records for each species during the study period (June 2006 to January 2009), indicating for each locality the catalog record (UABC Fish Collection) with the highest number of specimens, denoted by square brackets; *Density*, average density of individuals/m² of sampled pool in the study sub-areas; *Zonation*, the distribution of the species crossing the intertidal zones described by Stephenson and Stephenson (1972): high intertidal (HI), middle intertidal (MI) and low intertidal (LI); *Affinity*, the zoogeographic region(s) and province(s) where the taxon is known to occur, following the marine coastal regionalization of Briggs (1974): California Region (CR) and its San Diegan (SDP) and Cortez (CP) provinces; Tropical Eastern Pacific Region (TEPR) and its Mexican (MP), Panamic (PP) and Galapagos Islands (IGP) provinces; Eastern Pacific Boreal Region (EPBR) and its Oregonian (OP) and Aleutian (AP) provinces; and Amphiamerican (AA).

Family Muraenidae

Gymnothorax mordax (Ayres, 1859). California moray
Distribution: Point Conception, California to Bahía Magdalena, Baja California. *Records*: Bahía Tortugas (1982 [1]). *Density*: 0.1 ind/m² [CS]. *Zonation*: LI. *Affinity*: CR (SDP).

Muraena lentiginosa (Jenyns, 1842). Jewel moray
Distribution: Bahía Magdalena, Baja California to Islas Lobos de Afuera, Peru, including Gulf of California, and Islas Galapagos. *Records*: Los Cerritos (2159 [1]). *Density*: 0.2 ind/m² (SS). *Zonation*: LI. *Affinity*: CR (SDP and CP) and TEPR (MP, PP and IGP).

Family Mugilidae

Chaenomugil proboscideus (Günther, 1861). Snouted mullet
Distribution: Bahía Magdalena, Baja California Sur to Panama, including the Gulf of California. *Records*: Los Cerritos (0814 [6]). *Density*: 0.1 ind/m² (SS). *Zonation*: HI. *Affinity*: CR (CP) and TEPR (MP and PP).

Mugil curema (Valenciennes, 1836). White mullet
Distribution: Atlantic and Pacific oceans; Newport Bay, southern California to Chile, including the Gulf of California and Islas Galapagos. *Records*: Los Cerritos (2001 [1]). *Density*: 0.2 ind/m² (SS). *Zonation*: HI. *Affinity*: AA.

Family Atherinopsidae

Atherinops affinis (Ayres, 1860). Topsmelt
Distribution: Near Sooke Harbour, Vancouver Island, British Columbia to Cabo San Lucas, Baja California Sur, with an isolated population in upper Gulf of California. *Records*: Punta Morro (1951 [19]) and Bahía Tortugas (2000 [17]). *Density*: 0.2 ind/m² (NS) and 0.4 ind./m²(CS). *Zonation*: HI. *Affinity*: EPBR (OP) and CR (SDP and CP).

Leuresthes tenuis (Ayres, 1860). California grunion
Distribution: San Francisco, northern California to Bahía Magdalena, Baja California Sur. *Records*: Punta Morro (1953 [17]), La Esmeralda (1954 [1]) and Bahía Tortugas (1762 [6]). *Density*: 0.1 ind/m² (NS) and 0.9 ind/m² (CS). *Zonation*: HI. *Affinity*: CR (SDP and OP).

Family Holocentridae

Sargocentron suborbitalis (Gill, 1863). Tinsel squirrelfish
Distribution: Gulf of California to Ecuador, including the southern end of the BCP and Islas Galapagos. *Records*: Los Cerritos (1833 [8]) and San Juanico (2148 [1]). *Density*: 0.4 ind/m² (SS). *Zonation*: HI and MI. *Affinity*: CR (CP) and TEPR (MP, PP and IGP).

Family Scorpaenidae

Scorpaena guttata (Girard, 1854). California scorpionfish
Distribution: Santa Cruz, central California to Gulf of

California. *Records*: San Juanico (2153 [1]). *Density*: 0.3 ind/m² (SS). *Zonation*: LI. *Affinity*: EPBR (OP) and CR (SDP and CP).

Family Cottidae

Clinocottus analis (Girard, 1858). Woolly sculpin

Distribution: Cape Mendocino, California to Punta Asuncion, Baja California Sur, including Isla Cedros and Isla Guadalupe (UABC-0398). *Records*: Bajamar (1734 [67]), Punta Morro (1862 [108]), Punta Santo Tomas (1828 [52]), Punta Baja (1693 [43]), Krutsio (1749 [64]), Los Ojitos (1815 [156]), La Esmeralda (1904 [68]), Bahia Tortugas (1984 [53]), and Punta Abreojos (1931 [25]). *Density*: 4.6 ind/m² (NS) and 4.7 ind/m² (CS). *Zonation*: HI, MI and LI. *Affinity*: EPBR (OP) and CR (SDP).

Clinocottus recalvus (Greeley, 1899). Bald sculpin

Distribution: Mill Beach near Brookings, southern Oregon to Punta Rompiente, Baja California. *Records*: Bajamar (1735 [11]), Punta Santo Tomas (1829 [4]) and Punta Baja (1694 [18]). *Density*: 1.0 ind/m² (NS). *Zonation*: HI, MI and LI. *Affinity*: EPBR (OP) and CR (SDP).

Oligocottus rubellio (Greeley, 1899). Rosy sculpin

Distribution: Fort Bragg, northern California to Isla San Martin, Baja California. *Records*: Punta Baja (1696 [1]). *Density*: 0.1 ind/m² (NS). *Zonation*: MI. *Affinity*: EPBR (OP) and CR (SDP).

Oligocottus snyderi (Greeley, 1898). Fluffy sculpin

Distribution: Chernabura Island, western Gulf of Alaska; Samsing Cove near Sitka, southeastern Alaska to Punta Cono, Baja California. *Records*: Punta Santo Tomas (1830 [9]), and Punta Baja (1805 [38]). *Density*: 0.3 ind/m² (NS). *Zonation*: MI and LI. *Affinity*: EPBR (AP and OP) and CR (SDP).

Family Serranidae

Epinephelus labriformis (Jenyns, 1840). Flag cabrilla

Distribution: San Diego and upper Gulf of California to Paita, Peru, including Islas Galapagos. *Records*: San Juanico (2154 [1]). *Density*: 0.3 ind/m² (SS). *Zonation*: LI. *Affinity*: CR (SDP and CP) and TEPR (MP, PP and IGP).

Family Pomacanthidae

Pomacanthus zonipectus (Gill, 1862). Cortez angelfish

Distribution: Redondo Beach, southern California and upper Gulf of California to Mancora, Peru and Islas Galapagos. *Records*: San Juanico (2152 [1]). *Density*: 0.3 ind/m² (SS). *Zonation*: MI. *Affinity*: CR (SDP and CP) and TEPR (MP, PP and IGP).

Family Kyphosidae

Girella nigricans (Ayres, 1860). Opaleye

Distribution: Otter Rock, Oregon to Cabo San Lucas, Baja California Sur, with an isolated population in the Gulf of California. *Records*: Punta Morro (1863 [85]), Punta Santo Tomas (1832 [6]), Punta Baja (1692 [85]), Krutsio (1842 [34]), Los Ojitos (1846 [37]), La Esmeralda (1633 [37]), Bahia Tortugas (1763 [33]), Punta Abreojos (1898 [14]) and Punta Conejo (1949 [8]). *Density*: 2.1 ind/m² (NS), 1.2 ind/m² (CS) and 2.3 ind/m² (SS). *Zonation*: HI, MI and LI (juveniles and sub-adults). *Affinity*: CR (SDP and CP) and TEPR (MP).

Hermosilla azurea (Jenkins and Evermann, 1889). Zebra-perch

Distribution: Klamath River estuary, California to Gulf of California. *Records*: Punta Morro (1707 [8]), Punta Baja (1691 [9]), La Esmeralda (1994 [19]), Los Ojitos (1745 [40]), Bahia Tortugas (2193 [7]), and Punta Abreojos (1899 [42]). *Density*: 0.6 ind/m² (NS and CS). *Zonation*: MI and LI (juveniles and subadults). *Affinity*: EPBR (OP), CR (SDP and CP) and TEPR (MP).

Family Cirrhitidae

Cirrhitus rivulatus (Valenciennes, 1855). Giant hawkfish

Distribution: Bahia Magdalena, Baja California Sur to Ecuador, including Gulf of California and Islas Galapagos. *Records*: Los Cerritos (1836 [4]). *Density*: 0.2 ind/m² (SS). *Zonation*: MI and LI. *Affinity*: CR (SDP and CP) and TEPR (MP, PP and IGP).

Family Embiotocidae

Amphistichus koelzi (Hubbs, 1933). Calico surfperch

Distribution: Cape Flattery, Washington to Arroyo San Isidro, Baja California. *Records*: Punta Morro (1928 [1]) and Los Ojitos (1927 [1]). *Density*: 0.1 ind/m² (NS and CS). *Zonation*: MI (juveniles). *Affinity*: EPBR (OP) and CR (SDP).

Hyperprosopon anale (Agassiz, 1861). Spotfin surfperch

Distribution: Seal Rock, Oregon to Bahia Blanca, Baja California. *Records*: Punta Baja (1924 [8]) and Los Ojitos (1926 [2]). *Density*: 0.1 ind/m² (NS and CS). *Zonation*: MI (juveniles). *Affinity*: EPBR (OP) and CR (SDP).

Hyperprosopon argenteum (Gibbons, 1854). Walleye surfperch

Distribution: Vancouver Island, British Columbia to Punta San Rosarito, Baja California, including Isla Guadalupe. *Records*: Punta Morro (1955 [1, juvenile]). *Density*: 0.6 ind/m² (NS). *Zonation*: MI. *Affinity*: EPBR (OP) and CR (SDP).

Micrometrus aurora (Jordan and Gilbert, 1880). Reef perch

Distribution: Tomales Bay, northern California to Isla Cedros, Baja California. *Records*: Punta Baja (1810 [13]). *Density*: 0.1 ind/m² (NS). *Zonation*: MI. *Affinity*: EPBR (OP) and CR (SDP).

Family Pomacentridae

Abudefduf declivifrons (Gill, 1862). Mexican night sergeant
Distribution: Bahia Magdalena, Baja California Sur and Gulf of California to Costa Rica. *Records:* Los Cerritos (1795 [173]). *Density:* 4.6 ind/m² (SS). *Zonation:* MI and LI (juveniles and adults). *Affinity:* CR (SDP and CP) and TEPR (MP and PP).

Abudefduf troschelii (Gill, 1862). Panamic sergeant major
Distribution: King Harbor, Redondo Beach, southern California to Pucusana, Peru, including Gulf of California and Islas Galapagos. *Records:* Punta Conejo (1825 [1], juvenile). *Density:* 0.3 ind/m² (SS). *Zonation:* MI. *Affinity:* CR (SDP and CP) and TEPR (MP, PP and IGP).

Hypsypops rubicundus (Girard, 1854). Garibaldi
Distribution: Monterey Bay, California to southwest corner of Gulf of California, Baja California Sur. *Records:* Punta Baja (2113 [1]). *Density:* 0.1 ind/m² (NS). *Zonation:* MI (juveniles). *Affinity:* EPBR (OP), CR (SDP) and TEPR (MP).

Microspathodon bairdii (Gill, 1862). Bumphead damselfish
Distribution: Gulf of California, including the southern tip of the BCP to Ecuador and Islas Galapagos. *Records:* Los Cerritos (1771 [1]). *Density:* 0.2 ind/m² (SS). *Zonation:* MI (juveniles). *Affinity:* CR (CP) and TEPR (MP, PP and IGP).

Stegastes flavilatus (Gill, 1862). Beaubrummel
Distribution: Isla Cedros and Rocas Chester, Baja California to Pucusana, Peru, including Gulf of California and Islas Galapagos. *Records:* Los Cerritos (2168 [3]) and San Juanico (2155 [1]). *Density:* 0.3 ind/m² (SS). *Zonation:* MI (juveniles). *Affinity:* CR (SDP and CP) and TEPR (MP, PP and IGP).

Family Labridae

Halichoeres notospilus (Günther, 1864). Banded wrasse
Distribution: Bahia San Juanico, Baja California Sur and Gulf of California to Islas Lobos de Afuera, Peru and Islas Galapagos. *Records:* San Juanico (2149 [1]). *Density:* 0.3 ind/m² (SS). *Zonation:* MI. *Affinity:* CR (CP) and TEPR (MP, PP and IGP).

Oxyjulis californica (Günther, 1861). Señorita
Distribution: Salt Point, California to Bahia Magdalena, Baja California Sur. *Records:* La Esmeralda (1998 [1]). *Density:* 0.1 ind/m² (CS). *Zonation:* LI. *Affinity:* EPBR (OP) and CR (SDP).

Thalassoma lucasanum (Gill, 1862). Cortez rainbow wrasse
Distribution: Islas San Benito and Isla Cedros, and Rocas Chester (27°53'N, 115°04'W), Baja California Sur to Ecuador, including Gulf of California and Islas Galapagos. *Records:* Los Cerritos (1968 [1]). *Density:* 0.2 ind/m² (SS). *Zonation:* LI. *Affinity:* CR (SDP and CP) and TEPR (MP, PP and IGP).

Family Pholidae

Apodichthys fucorum (Jordan and Gilbert, 1880). Rockweed gunnel

Distribution: Banks Island, British Columbia to Punta Escarpada, Baja California. *Records:* Punta Santo Tomas (1831 [1]) and Punta Baja (2146 [1]). *Density:* 0.2 ind/m² (NS). *Zonation:* MI. *Affinity:* EPBR (AP and OP) and CR (SDP).

Family Labrisomidae

Labrisomus multiporosus (Hubbs, 1953). Porehead blenny
Distribution: Laguna Guerrero Negro, Baja California Sur and Gulf of California to Islas Chincha, Peru, including Islas Galapagos. *Records:* Punta Morro (1868 [8]), Los Ojitos (1850 [3]), La Esmeralda (1690 [14]), Bahia Tortugas (2191 [8]), Punta Abreojos (1942 [14]), San Juanico (2156 [39]), and Los Cerritos (2161 [3]). *Density:* 0.2 ind/m² (NS), 1.0 ind/m² (CS) and 3.4 ind/m² (SS). *Zonation:* MI and LI. *Affinity:* CR (SDP and CP) and TEPR (MP, PP and IGP).

Malacoctenus hubbsi (Springer, 1959). Redside blenny
Distribution: Bahia Sebastian Vizcaino, Baja California and upper Gulf of California to Acapulco, Mexico. *Records:* Los Cerritos (1958 [16]). *Density:* 0.5 ind/m² (SS). *Zonation:* MI and LI. *Affinity:* CR (SDP and CP) and TEPR (MP).

Paralichthys integripinnis (Smith, 1880). Reef finspot
Distribution: Santa Cruz Island and Naples (Santa Barbara County), southern California to Bahia Almejas, Baja California Sur. *Records:* Punta Morro (1858 [45]) and Punta Abreojos (1941 [6]). *Density:* 1.1 ind/m² (NS) and 0.6 ind/m² (CS). *Zonation:* MI and LI. *Affinity:* CR (SDP).

Family Clinidae

Gibbonsia elegans (Cooper, 1864). Spotted kelpfish
Distribution: Piedras Blancas Point, California to Bahia Magdalena, Baja California Sur, including Isla Guadalupe. *Records:* Punta Morro (1865 [13]), Punta Santo Tomas (1827 [18]), Punta Baja (1811 [6]), Krutsio (1752 [2]), Los Ojitos (1910 [4]), La Esmeralda (1997 [7]) and Bahia Tortugas (1980 [4]). *Density:* 0.5 ind/m² (NS) and 0.1 ind/m² (CS). *Zonation:* MI and LI. *Affinity:* EPBR (OP) and CR (SDP).

Gibbonsia montereyensis (Hubbs, 1927). Crevice kelpfish
Distribution: Vancouver Island, British Columbia to Punta Rompiente, Baja California Sur, including Isla Guadalupe. *Records:* Punta Morro (1916 [1]) and Los Ojitos (1912 [1]). *Density:* 0.5 ind/m² (NS) and 0.2 ind/m² (CS). *Zonation:* MI and LI. *Affinity:* EPBR (OP) and CR (SDP).

Heterostichus rostratus (Girard, 1854). Giant kelpfish
Distribution: British Columbia to Cabo San Lucas,

Baja California Sur, including Isla Guadalupe. *Records*: Punta Morro (2176 [1]) and Bahia Tortugas (1981 [3]). *Density*: 0.3 ind/m² (NS) and 0.1 ind/m² (CS). *Zonation*: MI and II. *Affinity*: EPBR (OP), CR (SDP) and TEPR (MP).

Family Chaenopsidae

Coralliozetus micropes (Beebe and Tee-Van, 1938). Zebra-face blenny

Distribution: Bahia Magdalena, Baja California Sur and upper Gulf of California. *Records*: Los Cerritos (1959 [1]). *Density*: 0.2 ind/m² (SS). *Zonation*: MI. *Affinity*: CR (SDP and CP).

Family Blenniidae

Entomacrodus chiostrictus (Jordan and Gilbert, 1882). Notchfin blenny

Distribution: Bahia San Ignacio, Baja California Sur and Gulf of California to Colombia, including the offshore islands, except Islas Galapagos. *Records*: Los Cerritos (1961 [69]). *Density*: 4.7 ind/m² (SS). *Zonation*: MI and LI. *Affinity*: CR (CP) and TEPR (MP, PP and IGP).

Hypsoblennius gentilis (Girard, 1854). Bay blenny

Distribution: Monterey Bay, California to Gulf of California. *Records*: Los Ojitos (1635 [1]). *Density*: 0.1 ind/m² (CS). *Zonation*: MI. *Affinity*: CR (SDP and TPER (MP)).

Hypsoblennius gilberti (Jordan, 1882). Rockpool blenny

Distribution: Morro Bay, California to Bahia Magdalena, Baja California Sur. *Records*: Punta Morro (1871 [22]), Punta Baja (1976 [1]), Los Ojitos (1683 [10]), Krut-sio (1843 [3]), La Esmeralda (1630 [5]), Bahia Tortugas (1765 [2]) and San Juanico (2192 [9]). *Density*: 0.9 ind/m² (NS), 0.2 ind/m² (CS) and 2.0 ind/m² (SS). *Zonation*: MI and LI. *Affinity*: EPBR (OP), CR (SDP) and TEPR (MP).

Hypsoblennius jenkinsi (Jordan and Evermann, 1896). Mussel blenny

Distribution: Morro Bay, California to Puerto Marques, Mexico, including Gulf of California. *Records*: Punta Morro (1741 [1]), La Esmeralda (1800 [5]), Punta Abreojos (1939 [7]), and Bahia Tortugas (1936 [2]). *Density*: 0.6 ind/m² (NS and CS). *Zonation*: MI. *Affinity*: EPBR (OP), CR (SDP and CP) and TEPR (MP).

Ophioblennius steindachneri (Jordan and Evermann, 1898). Panamic fanged blenny

Distribution: Isla Guadalupe [Reyes-Bonilla et al. 2010] and Arrecife Sacramento in Baja California, and upper Gulf of California to Islas Lobos de Afuera, Peru, including Islas Galapagos. *Records*: Punta Abreojos (1940 [1]), San Juanico (2151 [1]) and Los Cerritos (1837 [28]). *Density*: 0.1 ind/m² (CS) and 0.9 ind/m²

(SS). *Zonation*: MI and LI. *Affinity*: CR (SDP and CP) and TEPR (MP, PP and IGP).

Family Gobiesocidae

Gobiesox papillifer (Gilbert, 1890). Bearded clingfish

Distribution: San Pedro, southern California to Bahia de Panama, including Gulf of California. *Records*: Punta Conejo (1824 [2]). *Density*: 2 ind/m² (SS). *Zonation*: MI. *Affinity*: EPBR (OP), CR (SDP and CP) and TEPR (MP and PP).

Gobiesox rhesodon (Smith, 1881). California clingfish

Distribution: Pismo Beach, California to Bahia Magdalena, Baja California Sur. *Records*: Punta Morro (11867 [31]). *Density*: 1.1 ind/m² (NS). *Zonation*: MI. *Affinity*: EPBR (OP) and CR (SDP).

Rimicola eigenmanni (Gilbert, 1890). Slender clingfish

Distribution: Palos Verdes, southern California to Bahia San Juanico, Baja California Sur. *Records*: Punta Morro (1908 [1]). *Density*: 0.8 ind/m² (NS). *Zonation*: MI. *Affinity*: EPBR (OP) and CR (SDP).

Tomicodon boehlkei (Briggs, 1955). Cortez clingfish

Distribution: Cabo San Lucas, Baja California Sur to upper Gulf of California. *Records*: Los Cerritos (1978 [37]). *Density*: 2.1 ind/m² (SS). *Zonation*: MI. *Affinity*: CR (CP) and TEPR (MP).

Tomicodon zebra (Jordan and Gilbert, 1882). Zebra clingfish

Distribution: Bahia Magdalena, Baja California Sur to Oaxaca, Mexico, including Gulf of California. *Records*: Los Cerritos (1969 [28]). *Density*: 0.8 ind/m² (SS). *Zonation*: MI. *Affinity*: CR (SDP and CP) and TEPR (MP).

Family Gobiidae

Bathygobius ramosus (Ginsburg, 1947). Panamic frillfin

Distribution: Bahia Magdalena, Baja California Sur and upper Gulf of California to Paita, Peru. *Records*: San Juanico (2150 [10]), Punta Conejo (1758 [18]) and Los Cerritos (1768 [32]). *Density*: 1.7 ind/m² (SS). *Zonation*: MI and LI. *Affinity*: CR (SDP and CP) and TERP (MP and PP).

Richness, Density and Similarity of Species

Of the 48 fish species registered in the study, the largest numbers were captured at Punta Morro (Baja California) and Los Cerritos (Baja California Sur) with 16 and 17 species, respectively. The lowest number of species (3) occurred at Bajamar (open coast). At the sub-area level (combined sites), the number of species was 23 in the north, 17 in the center, and 25 in the south (tab. 1). The most speciose families were Blenniidae (5), Pomacentridae (5), Gobiesocidae (5), Cottidae (4) and Embiotocidae (4). These families have also been reported as the most dominant both in species rich-

TABLE 1
 Fish density (individuals/m² of sampled tidepool) in rocky intertidal sites of the western coast of the Baja California peninsula, Mexico.
 M = mean, SD = standard deviation. Abbreviations of sites as in figure 1.

Sub-area	NS					CS					SS			
	MC	BM	PM	ST	ER	PB	OJ	KR	ES	BT	PA	SJ	PC	CE
Number of sampling events	1	4	14	2	3	4	5	2	6	2	2	1	1	3
Taxa	M	M±SD	M±SD	M	M±SD	M±SD	M±SD	M	M±SD	M	M	M	M	M±SD
<i>G. mordax</i>														
<i>M. lentiginosa</i>														0.2 ±0.5
<i>C. proboscideus</i>														0.1 ±0.2
<i>M. curema</i>														0.2 ±0.4
<i>A. affinis</i>			0.2±0.5											
<i>L. tenuis</i>			0.1±0.5											
<i>S. suborbitalis</i>									0.1 ±0.3	0.4		0.3		0.4 ±0.2
<i>S. guttata</i>										1		0.3		
<i>C. analis</i>	17.9	4.8±3.2	5.5±2.5	11	1.4 ±1.3	1.9 ±0.5	5.1 ±2.6	5.7	2.2 ±1.8	14.6	0.1			
<i>C. reabrus</i>		0.7±0.6		0.3		0.2 ±0.4								
<i>O. rubello</i>						0.1 ±0.2								
<i>O. Snyderi</i>	4.1			0.7	0.1 ±0.1	0.8 ±0.1								
<i>E. labriformis</i>														
<i>P. zonipectus</i>														
<i>G. nigricans</i>	12.3		2.3±2.2	0.4	0.1 ±0.2	2.3 ±2.1	0.9 ±0.6	1.5	1.4 ±1.2	0.8	0.9		2.3	
<i>H. azurea</i>			0.2±0.3			0.1 ±0.2	0.5 ±0.6		0.3 ±0.5	0.6	0.8			0.2 ±0.1
<i>C. rivulatus</i>														
<i>A. kodzi</i>			0.6±0.2				0.1 ±0.2							
<i>H. anale</i>			0.6±0.2				0.1 ±0.1							
<i>H. argenteum</i>														
<i>M. aurora</i>						0.1±2.5								4.6 ±7.3
<i>A. declivifrons</i>														
<i>A. troschelii</i>												0.3	1.0	
<i>H. rubicandius</i>														
<i>M. bairdii</i>														
<i>S. flavilatus</i>						0.1								0.2 ±0.4
<i>H. notospilus</i>												0.3		0.5 ±0.4
<i>O. californica</i>									0.1			0.3		
<i>T. lucasanum</i>														0.2 ±0.4
<i>A. fucorum</i>														
<i>L. multiporosus</i>			0.8±0.2	0.3		0.1	0.3 ±0.5		0.5 ±0.5	2.9	0.2	13.2		0.1 ±0.1
<i>M. hubbsi</i>														0.5 ±0.6
<i>P. integrissimus</i>			1.1±1.2											
<i>G. elegans</i>			0.4±0.4	1.3		1.0-6.0	0.8 ±0.7	0.8	0.2 ±0.4	2.0	0.6			
<i>G. montereyensis</i>			0.5±0.2				0.2 ±0.2							
<i>H. rostratus</i>			0.3							0.1				
<i>C. micropes</i>														0.2 ±0.4
<i>E. diostictus</i>														4.7 ±3.2
<i>H. gilberti</i>			1.2±0.6		0.8 ±0.7	0.8 ±0.1	0.1 ±0.1	0.1	0.2 ±0.1	2		2.4		
<i>H. gentilis</i>							0.1 ±0.2							
<i>H. jenkinsi</i>			0.6±0.2							0.8	0.7	0.3	2.0	1.9 ±0.8
<i>O. steindachneri</i>														
<i>G. papillifer</i>														
<i>G. thessodon</i>			1.1±1.1											2.1 ±1.1
<i>R. eigenmanni</i>			0.8±0.3											0.8 ±1.1
<i>T. boehlkei</i>														1.3 ±0.7
<i>T. zebra</i>												3.4	4.0	
<i>B. ramosus</i>														

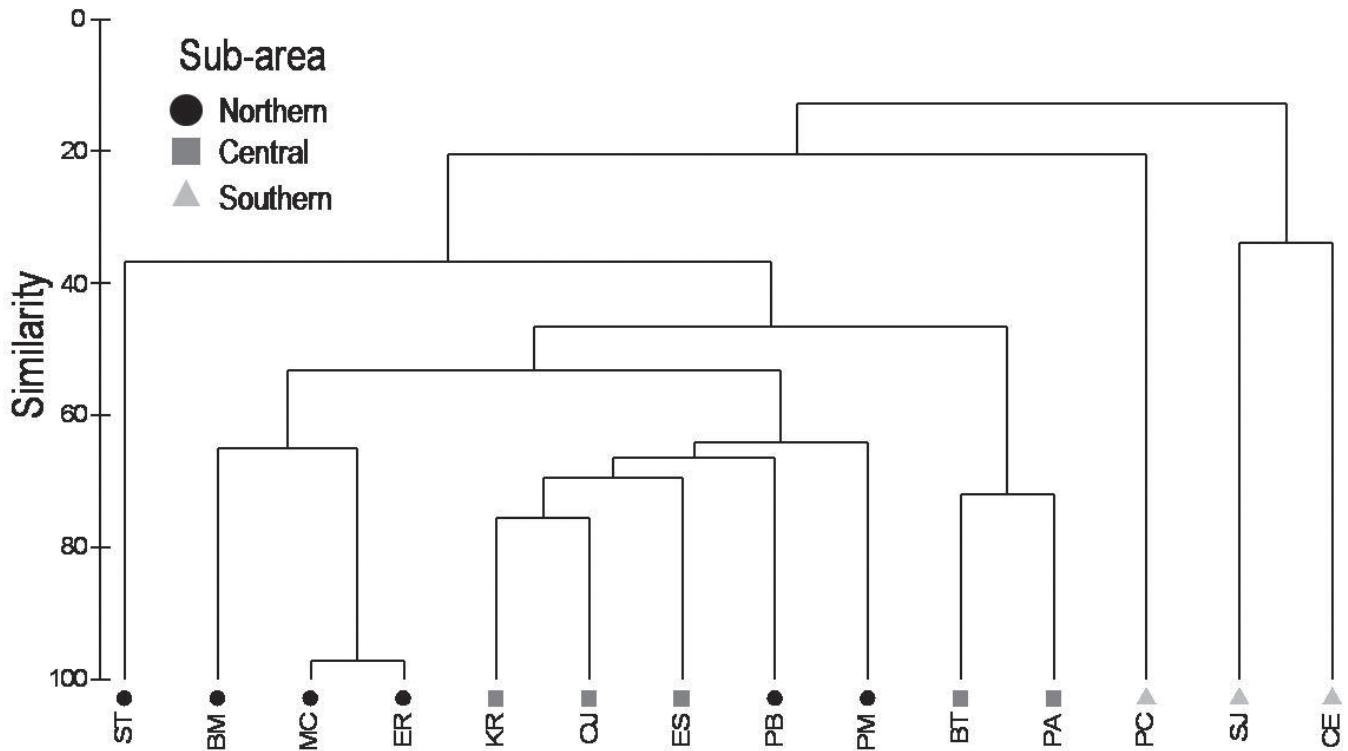


Figure 2. Cluster analysis of 14 rocky intertidal sites of the western coast of the Baja California peninsula, based on the composition of permanent fish species using Bray-Curtis index. Abbreviations of sites as in figure 1.

ness and abundance in tide pools from the northeastern Pacific (Yoshiyama 1981; Grossman 1986; Matson et al. 1986; Yoshiyama et al. 1986; Stepien et al. 1991; Polivka and Chotkoswski 1998; Chotkoswski et al. 1999; Allen and Pondella 2006).

Species with the highest densities in the northern sub-area (combined sites; tab. 1) were *Clinocottus analis*, *Girella nigricans*, *Paraclinus integripinnis* and *Gobiesox rhesodon*. In the central sub-area, *C. analis* and *G. nigricans* were again the most abundant species, followed by *Labrisomus multiporosus* and juveniles of *Leuresthes tenuis*. Finally, in the southern sub-area, *Entomacrodus chiostictus*, *Abudefduf decliviformis* and *L. multiporosus* dominated in abundance. Two species exhibited a peculiar distribution pattern within the study area, where the boreal species *Clinocottus analis* was the most abundant fish for the northern and central sub-areas, while the tropical species *Labrisomus multiporosus*, was one of the three most abundant species for the southern sub-area. Both species coexist in tide pools in the central part of the study area (Punta Abreojos to Los Ojitos), where they possibly inhabit different microhabitats. The dominance of *Clinocottus analis* and *Girella nigricans* was also reported by Ruiz-Campos (1986) for intertidal sites in the northern sub-area (Bahia Todos Santos).

The cluster analysis of sampling sites (fig. 2) showed two major groups, the first formed by the two south-

ern sites (Los Cerritos and San Juanico) and the second subdivided into five subgroups at a level of similarity >50%: (1) Santo Tomas, (2) Bajamar-Medio Camino-Erendira, (3) Krutsio-Los Ojitos-Esmeralda-Punta Baja-Punta Morro, (4) Bahia Tortugas-Punta Abreojos, and (5) Punta Conejo. The highest similarity values were registered among sites exposed to open coast (tab. 2): Medio Camino and Eréndira (100%), Punta Abreojos and Bahia Tortugas (80%), Krutsio and Medio Camino (75%), and Krutsio and Erendira (75%). Punta Conejo had low species similarities with other southern sites (San Juanico and Los Cerritos), which might be explained by differences in habitats; the intertidal at Punta Conejo is characterized by the formation of large shallow pools with cobble-pebble bottom and low exposure to sea swell, as well as containing a low number of species (4).

Zoogeographic Relationships and Considerations

Based on the zoogeographic regionalization scheme of Briggs (1974), we determined that the intertidal fish fauna of the western rocky coast of the Baja California Peninsula possesses a higher affinity to the San Diegan province (85%), followed by the Mexican (58%) and Cortez (56%) provinces. Likewise, 46% of the recorded species exhibited an affinity with the Oregonian province. Stepien et al. (1991) remarked on the importance of

TABLE 2

Percent of similarity (Bray-Curtis' index) for rocky intertidal fish species (permanent) among collecting sites in the western coast of the Baja California peninsula, Mexico. Values in bold indicate significant similarity ($\geq 60\%$).

Collecting sites	MC	BM	PM	ST	ER	PB	OJ	KR	ES	BT	PA	SJ	PC
BM	57.1												
PM	31.6	22.2											
ST	40.0	50.0	12.5										
ER	100.0	57.1	31.6	40.0									
PB	66.7	54.5	34.8	22.2	66.7								
OJ	42.9	30.8	64.0	18.2	42.9	55.6							
KR	75.0	57.1	42.1	40.0	75.0	50.0	57.1						
ES	50.0	36.4	69.6	22.2	50.0	50.0	66.7	66.7					
BT	50.0	28.6	42.1	40.0	50.0	33.3	42.9	50.0	66.7				
PA	40.0	22.2	47.6	28.6	40.0	28.6	37.5	40.0	57.1	80.0			
SJ	13.3	14.3	15.4	0.0	13.3	10.5	19.0	13.3	21.1	13.3	23.5		
PC	25.0	0.0	10.5	0.0	25.0	16.7	14.3	25.0	16.7	25.0	20.0	26.7	
CE	0.0	0.0	6.3	0.0	0.0	0.0	7.4	0.0	8.0	9.5	17.4	35.7	9.5

Abbreviations: (MC) Medio Camino, (BM) Bajamar, (PM) Punta Morro, (ST) Santo Tomas, (ER) Erendira, (PB) Punta Baja, (OJ) Los Ojitos, (KR) Krutsio, (ES) La Esmeralda, (BT) Bahía Tortugas [El Playon], (PA) Punta Abreojos, (SJ) San Juanico, (PC) Punta Conejo, and (CE) Los Cerritos.

Punta Clara, an area of cold water upwelling ca. 55 km SW of Ensenada, in the Oregonian-Californian coastal marine zoogeographic transition; however this transition should be extended southward to Punta Baja (30°N), where upwelling also frequently occurs.

The zoogeographical affinities of the rocky intertidal fish fauna in the region were predominantly boreal both in the northern (87%) and central (71%) sub-areas, while in the southern sub-area affinities were predominantly tropical and subtropical (92%). Furthermore, it is notable that a high percentage (54%) of species occurs in both coasts of the BCP (amphipeninsular distribution; cf. Castro-Aguirre et al. 2005). These distributions reflect the ample zoogeographic transition zone that exists along the western coast of the BCP (Hubbs 1960; Briggs 1974; Brusca and Wallerstein 1979; Hastings 2000; Pondella et al. 2005; Castro-Aguirre and Espinosa Pérez 2006), with a remarkable change in the intertidal fish composition between Bahía San Juanico (Scorpion Bay) and Bahía Magdalena, where a number of species of northern (warm-temperate) and tropical affinities reach their respective distributional limits.

In relation to species' affinities based on their distribution ranges, a high percentage of the species are endemic to the Tropical Eastern Pacific Region (98%). Of particular interest is the fact that the austral distribution ranges of the following species with boreal affinity do not extend beyond Bahía San Juanico: *Clinocottus analis*, *C. recalvus*, *Oligocottus snyderi*, *O. rubellio*, *Amphistichus koelzi*, *Micrometrus aurora*, *Hyperprosopon anale*, *H. argenteum*, *Gibbonsia montereyensis*, *Apodichthys fucorum* and *Rimicola eigenmanni*. Also, the northern ranges of the following eleven species of sub-tropical or tropical affinity do not extend beyond Punta San Juanico: *Muraena lentiginosa*, *Chaenomugil proboscideus*, *Sargocentron suborbitalis*, *Cirrhitis rivulatus*, *Abudefduf declivifrons*, *Microspathodon*

bairdii, *Halichoeres notospilus*, *Coralliozetus micropes*, *Tomiodon boehlkei*, *T. zebra* and *Bathygobius ramosus*.

The distribution ranges of six species recorded in this study are extended as follows: toward the north for *Labrisomus multiporosus* (500 km, until Bahía Todos Santos, 31°51'N), *Sargocentron suborbitalis* and *Bathygobius ramosus* (450 km and 420 km, respectively, until Punta San Juanico, 26°14'N); and toward the south for *Clinocottus analis* (85 km, until Punta Abreojos, 26°42'N), *Oligocottus rubellio* (65 km, until Punta Baja, 29° 57' N), and *Amphistichus koelzi* (370 km, until Los Ojitos, 28°52'N). The range extensions documented here could represent recent dispersals promoted by El Niño or La Niña oceanographic events (McClatchie et al. 2008; Durazo 2009) or simply reflect the limited sampling on the Pacific coast of the peninsula prior to this study (cf. Chotkowski et al. 1999). Our present records and observations based on voucher specimens might support future taxonomic, ecologic and biogeographic studies in this peninsular coastal region as well as for establishing the significance of the climatic changes on fish distributions.

ACKNOWLEDGEMENTS

We thank B. Ruttenberg, O. Molina, D. M. González, R. Vidal, D. Palacios and J.C. Chávez for assisting in the fish sampling. Martha E. Valles assisted in processing part of the fish specimens. This study was funded by the Universidad Autónoma de Baja California (Project 194 "Composición Taxonómica y Ecológica de los Peces del Intermareal Rocosó en la Zona de Transición Biogeográfica Californiana-Mexicana, Península de Baja California, México;" lead by G. Ruiz) and Programa Interdisciplinario de Aprovechamiento y Conservación de los Ecosistemas Costeros (lead by E. Carpizo). GRC, AFGA, JLCA and JDC appreciate the support of the Sistema Nacional de Investigadores (México) for research grants; ARV

thanks the support of CONACyT for study grant. The collection permit (DGOPA.06470.120907.3728) was provided by the Dirección General de Ordenamiento Pesquero y Acuícola de SAGARPA. Dr. Milton S. Love and three anonymous reviewers made useful comments and recommendations that significantly improved the content of the manuscript. Finally, we thank the Sociedad Cooperativa Bahía Tortugas and Sociedad Cooperativa Punta Abreojos, for allowing us the access to the study sites.

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