CHECKLIST AND BIOGEOGRAPHY OF FISHES FROM GUADALUPE ISLAND, WESTERN MEXICO

HÉCTOR REYES-BONILLA, ARTURO AYALA-BOCOS, SAÚL GONZÁLEZ-ROMERO, ISRAEL SÁNCHEZ-ALCÁNTARA AND MARIANA WALTHER MENDOZA
Universidad Autónoma de Baja California Sur
Departamento de Biología Marina
Apartado postal 19-B, CP 23080
La Paz, B.C.S., México.
Tel: (612) 123-8800, ext. 4160; Fax: (612) 123-8819
hreyes@uabcs.mx

YULIANA R. BEDOLLA-GUZMÁN AND ARTURO RAMÍREZ-VALDEZ
Universidad Autónoma de Baja California
Facultad de Ciencias Marinas, Instituto de Investigaciones Oceanológicas
Universidad Autónoma de Baja California, Carr.
Tijuana-Ensenada km. 107, Apartado postal 453, C.P. 22890
Ensenada, B.C., México

LUIS E. CALDERON-AGUILERA
Centro de Investigación Científica y de Educación Superior de Ensenada
Carretera Tijuana - Ensenada # 3918, Zona Playitas, C.P. 22860
Ensenada, B.C., México
Tel: +52 646 1750500, ext. 25257; Fax: +52 646
leca@cicese.mx

NADIA C. OLIVARES-BAÑUELOS
Reserva de la Biosfera Isla Guadalupe
Comisión Nacional de Áreas Naturales Protegidas
Avenida del Puerto 375, local 30
Fraccionamiento Playas de Ensenada, C.P. 22880
Ensenada, B.C., México

ABSTRACT

Guadalupe Island, off Baja California, México, is an important fishing area which also harbors high marine biodiversity. Based on field data, literature reviews, and scientific collection records, we present a comprehensive checklist of the local fish fauna, which is comprised of 328 species from 219 genera, 105 families, 30 orders, and 3 classes. Of these, 156 species represent new records. Almost half of the species (154) are from tropical waters and the remainders are typical of warm and cold temperate regions. The island is the type locality of 18 fishes, represents the range limit of 48 taxa, and has 8 endemics. A biogeographic analysis comparing Guadalupe and the Baja California Peninsula indicates that the composition of reef fishes of the island is very similar to that found at 28°N, and suggests that Cedros, San Benito islands, and Punta Eugenia, might be the key sources of tropical immigrants to Guadalupe.

INTRODUCTION

Guadalupe Island, located off the western coast of the Baja California Peninsula, has a long tradition as a fishing ground (Aguirre-Muñoz et al. 2005; Salgado-Rogel et al. 2009), and sustains many high-value fisheries, such as abalone *Haliotis* spp., lobster *Panulirus interruptus* (Randall 1840), and sea cucumber *Parastichopus parvimensis* (Clark 1913). In addition, Gallo-Reynoso et al. (2005a, b) demonstrated that the island has a key conservation significance as a breeding habitat for marine mammals, such as the Guadalupe fur seal *Arctocephalus townsendi* (Merriam 1897) and the elephant seal *Mirounga angustirostris* (Gill 1866). More recently, this location has become an important tourist attraction (Domeier and Nasby-Lucas 2007) because of the presence of white sharks, *Carcharodon carcharias* (Linnaeus 1758). For all these reasons, in 2005, the Méxican federal government recognized the biological and ecological significance of Guadalupe Island, and declared it a Biosphere Reserve (SEMARNAT 2005).

Guadalupe Island is isolated, far away from the mainland and has limited logistic facilities to conduct scientific studies. In consequence (and despite its biological importance) there is still a very limited number of papers about the ecology and composition of its marine communities. A good example of this situation is the lack of a formal checklist for many invertebrate taxa, and of the bony and cartilaginous fish fauna of this insular region. In relation to the ichthyofauna, most published listings contain only partial information from occasional visits or literature reviews (Hubbs 1960; Miller and Lea 1972; Love et al. 2005), and the few studies that have specifically targeted Guadalupe Island, are focused on particular families (Hubbs and Rechnitzer 1958; Briggs 1965; Pietsch 1969; León-Castro et al. 1993). The lack of more complete information hinders the efforts of the Biosphere Reserve managers, who require comprehensive data to set adequate baselines for monitoring possible temporal changes in community composition, caused either by anthropogenic or natural forces. Furthermore, without a detailed inventory of fish species, any biogeographic analysis of the island is limited in scope. A comparison of the fish assemblages of Guadalupe Island and the mainland has never been adequately conducted, but might elucidate population linkages between Guadalupe Island and the mainland. Such studies would be an important contribution to the "Baja to Bering" initiative, devoted to create a multinational network of marine reserves in Canada, the United States, and México (Vásárhelyi and Thomas 2008). For the reasons specified above, the objective of this paper is to present an updated systematic list of the fish fauna of Guadalupe Island, based on field data, literature reviews, and scientific collection records.

STUDY AREA

Guadalupe Island is located in the Pacific Ocean, about 260 km west of the Baja California Peninsula, México (fig. 1). It is of volcanic origin, approximately 37 x 8 km in size (total area about 254 km^2), and oriented in a north-south direction with a mountainous topography and altitudes up to 1,300 m above sea level (fig. 1). The geology, vegetation, and terrestrial fauna of Guadalupe Island are well-studied and described elsewhere (Santos-del Prado and Peters 2005). There is no significant coastal shelf, except on the south end where a shallow platform connects the island to a series of small islets, such as El Toro and El Zapato (Castro et al. 2005). Offshore, the depth increases with an average slope of 70° to the ocean floor down to 3,600 m (Gallo-Reynoso et al. 2005a). The rugged subtidal environment consists of boulders and gray-black sandy bottoms intermixed with blocks, basaltic dikes, pavements, and walls with numerous caves and hollows that provide shelter to many species, including commercially important invertebrates.

Guadalupe Island is home to a great variety of fauna and flora, including many endemic species both in land and in the sea, and for that reason it was declared as a Biosphere Reserve by the Méxican government (Garth 1958; Ferreira 1978; Santos-del Prado and Peters 2005; Espinosa-Pérez and Hendrickx 2006). The weather and oceanic conditions at Guadalupe are influenced by the California Current system, which carries water from high latitudes to the south (Castro et al. 2005). Monthly average sea surface temperature range from 14°C to 22°C (yearly average 18.7°C); the warmest months are August, September, and October when temperatures are usually > 20°C, and the coldest months are January, February, and March when temperature is typically < 17°C (Hernández-de la Torre et al. 2005). It is interesting to note that positive local temperature anomalies > 5°C have been documented in El Niño Southern Oscillation years (Durazo and Baumgartner 2002; Durazo et al. 2005), and that the southern part of the island is almost half a degree warmer than the north, evidence of the cooling effect from the California Current (CONANP 2009). The water surrounding Guadalupe Island has chlorophyll concentrations from 0.25 to 0.50 mg/m^3, with the highest production in December and January and the lowest in August and September (Venrick et al. 2003). Total primary productivity is remarkably affected in El Niño years, decreasing to very low values (Hernández-de la Torre et al. 2005).

METHODS

The process followed to construct the fish checklist of Guadalupe Island encompassed three steps. First, we conducted a field survey on the island in 2008 and 2009. Second, we gathered information from electronic and in-house scientific collections from institutions in México and the United States, encompassing records from the 1950s to 2004. Third, we conducted an extensive literature review on the fish fauna of the location of interest.

For our field survey, we visited 16 sites during a six-day visit to the island in September 2008 (fig. 1). In each location, we performed four underwater visual censuses with hookah diving equipment: two "shallow" (0–10 m) and two "deep" (10–20 m); all were conducted inside belt transects of 25 x 4 m, and the total surveyed area was 6,400 m^2. In addition, during a second two-week visit to Guadalupe in April 2009, we surveyed tide pools at the southern tip and on the west coast. All fishes observed in the field were identified on the basis of illustrations in Miller and Lea (1972), Eschmeyer et al. (1983), Gotshall (2001) and Humann (2005).

In the case of museum data, we reviewed records from eleven collections, either electronically or by direct visits to the following institutions: Universidad Autónoma de Baja California (Ensenada); Scripps Institution of Oceanography (San Diego); Los Angeles County Natural History Museum (Los Angeles); California Academy of Sciences (San Francisco); National Museum of Natural History, Smithsonian Institution (Washington, DC); American Museum of Natural History (New York); Santa Barbara Museum of Natural History (Santa Barbara); Academy of Natural Sciences of Philadelphia (Philadelphia); Museum of Comparative Zoology (Cambridge); University of Kansas Natural History Museum (Kansas City); and Tulane University (New Orleans). We only used the information from those specimens caught within 50 km of the island, independent of the fishing method, depth or year; this choice was done to have a better list of possible species, because of the steep topography of the island, it is common to observe pelagic species near the coastline (Gallo-Reynoso et al. 2005b).

Finally, to complete the checklist we made a literature review of refereed journals and technical books from libraries at Universidad Autónoma de Baja California Sur (La Paz), Centro Interdisciplinario de Ciencias Marinas (La Paz), Centro de Investigaciones Biológicas del Noroeste (La Paz), Universidad Autónoma de Baja California (Ensenada), Centro de Investigación Científica y de Educación Superior de Ensenada (Ensenada), and Scripps Institution of Oceanography (San Diego). We only took into consideration species that were reported in papers explicitly referenced to Guadalupe Island, or specifically seen or collected in the island or its surroundings (50 km away). To eliminate synonyms and generate a systematic list consisting only of valid names, we checked each taxonomic name in

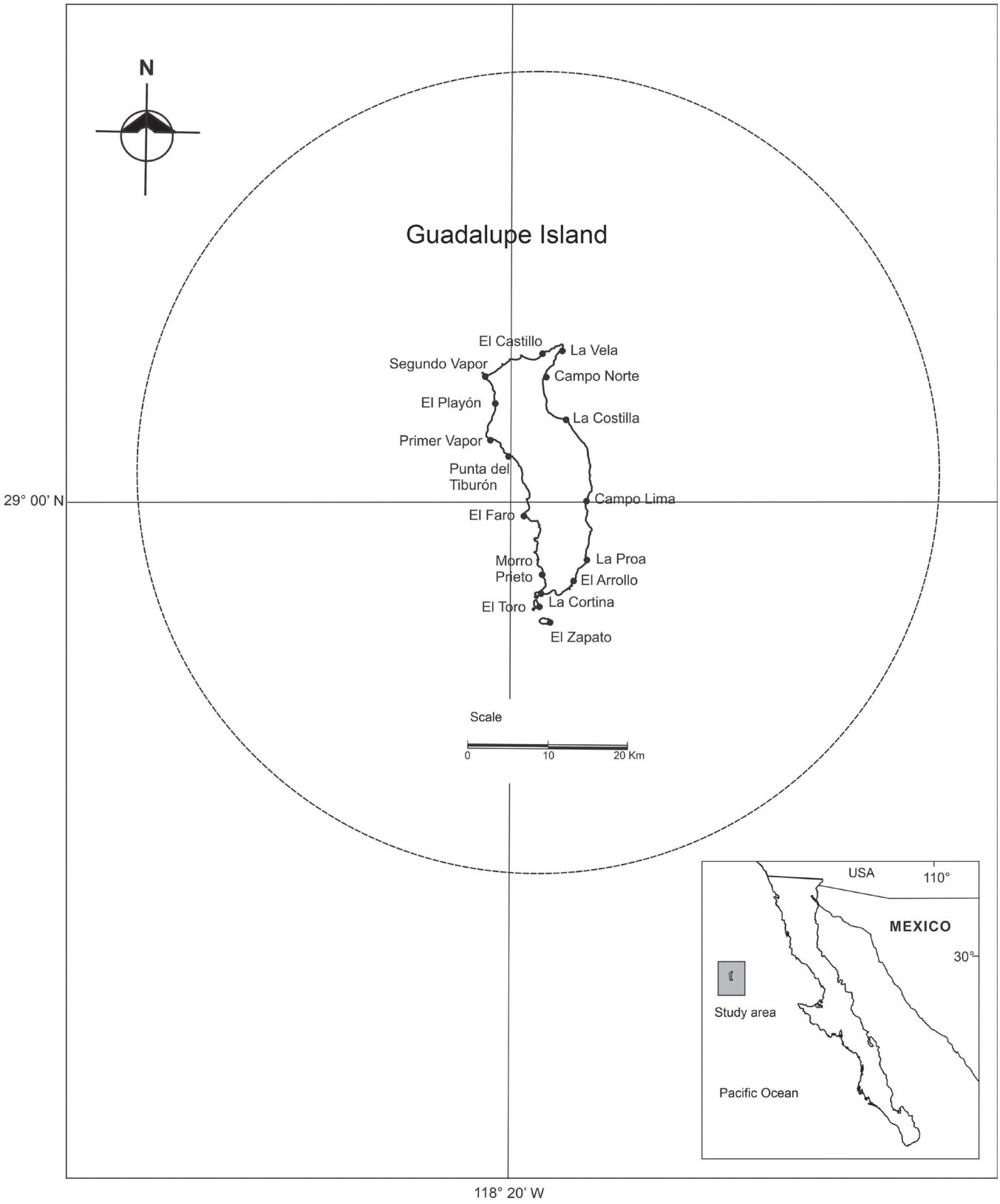

Figure 1. Locations of study area and sampling points at Guadalupe Island, Mexico. The circle indicates a 50 km radius around the island.

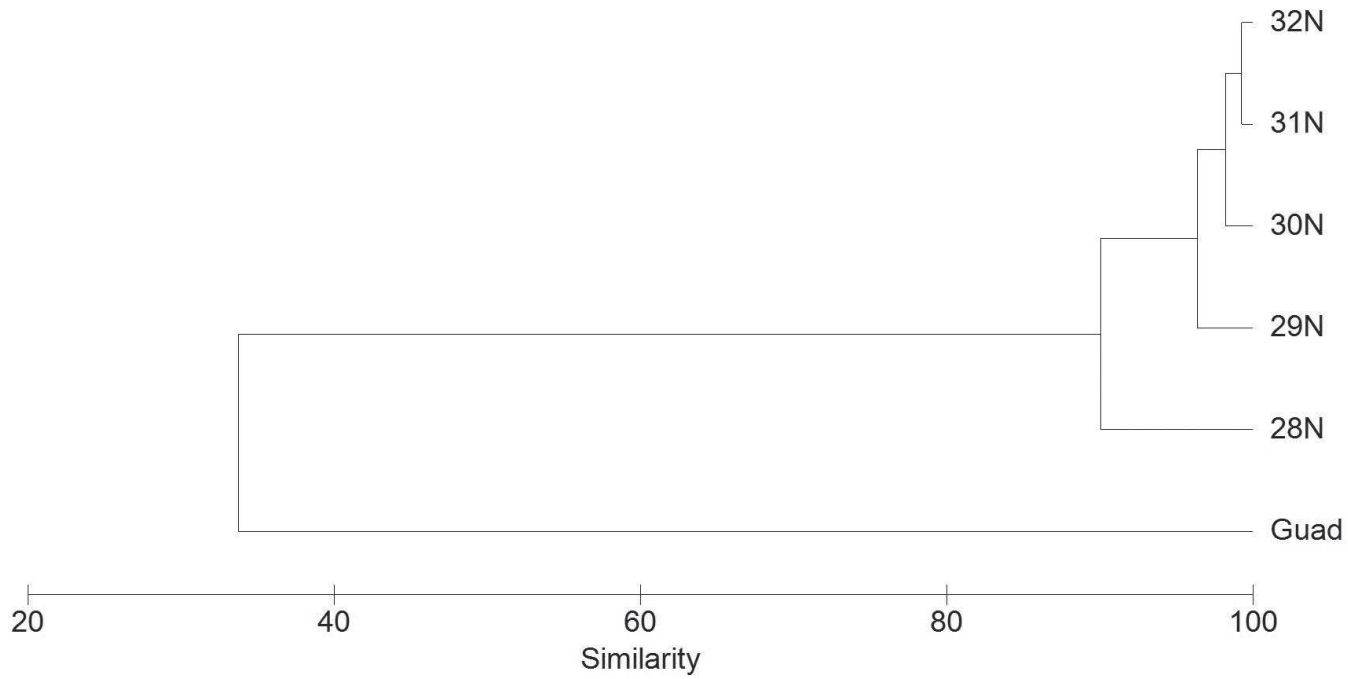

Figure 2. Dendrogram of similarity (Bray-Curtis) comparing the shallow and reef fish species of Guadalupe Island with the recorded in 1° grids of latitude of 28°N to 32°N. Specific richness per site: Isla Guadalupe: 141 species; 28°N: 327 species; 29°N: 294 species; 30°N: 280 species; 31°N: 278 species; 32°N: 280 species.

FishBase (Froese and Pauly 2009; www.fishbase.org) and the Catalog of Fishes of the California Academy of Sciences (Eschmeyer and Fricke 2009; http://research.calacademy.org/research/ichthyology/Catalog/fishcatmain.asp).

The biogeographical analysis of the data consisted of a numerical comparison of the composition of the shallow water (< 30 m depth) fish fauna among Guadalupe Island and six regions of the western Baja California peninsula. Based on published distribution data (Love et al. 2005; Allen et al. 2006; Horn et al. 2006; Robertson and Allen 2008), we constructed a matrix of the 360 species present at each latitude degree from 28°N to 32°N and on the island, and from these data we constructed a dendrogram of similitude using the Bray-Curtis coefficient and the UPGMA algorithm (Clarke and Gorley 2006). The selection of this particular group of species was born of necessity, as the most detailed occurrence records for fishes in the west coast of Baja California pertain to those distributed in rocky reefs and at depths safe for divers (Pondella et al. 2005; Robertson and Allen 2008).

RESULTS

Based on our field surveys, museum records, and literature review, we identified 328 species of marine fishes off Guadalupe Island from 219 genera, 105 families, 30 orders, and 3 classes (tab. 1). The island is the type locality for 18 species (5.5% of the fauna) and it also marks the northern or southern distributional limit for 23 and 25 species, respectively. Of the 328 documented species, 154 (46.9%) have tropical affinity and the remainder (174) are representative of temperate and cold waters. From a bathymetric perspective, 184 species (56.1%) are typically from deep (> 30 m) or pelagic waters while the remaining 144 (43.9%) are reef or shallow water fishes. Finally, Guadalupe Island has 8 endemic fishes (2.4% of the total, but 5.5% if the number refers only to rocky reef taxa): *Eptatretus fritzi* (Wisner and McMillan 1990), *Rimicola sila* (Briggs 1955), *Syngnathus insulae* (Fiitzsce 1980), *Psednos anoderkes* (Chernova and Stein 2002), *Psednos griseus* (Chernova and Stein 2002), *Psednos mexicanus* (Chernova and Stein 2002), *Psednos pallidus (*Chernova and Stein 2002) and *Brachyistius aletes* (Tarp 1952).

The literature review yielded 173 species reported for the island, while we observed 38 species in the field, and 269 records came from museums. Considering only unpublished information (data from collections and field work), Table 1 includes a total of 155 new records of fish species for Guadalupe Island, from 117 genera, 62 families, 24 orders, and 2 classes. Among the newly registered species are typical tropical reef or shallow water species, such as the leopard grouper *Mycteroperca rosacea* (Streets 1877), the large banded blenny *Ophioblennius steindachneri* (Jordan and Evermann 1898), the bullseye pufferfish *Sphoeroides annulatus* (Jenyns 1842), and the redtail triggerfish *Xanthichthys*

TABLE 1
Systematic list of the cartilaginous and bony fishes of Guadalupe Island, Baja California, Mexico. Classification according to Eschmeyer and Fricke (2009).

	Field observation (2008)	Museum data	References	Distribution area and bathymetric range	Notes
Phylum CHORDATA					
Clase MYXINI					
Order MIXINIFORMES					
Family Myxinidae					
Eptatretus deani (Evermann and Goldsborough, 1907)			13, 14	C, D	Southern limit
Eptatretus fritzi Wisner and McMillan, 1990		SIO	14, 18	E, D	Type location
Eptatretus stoutii (Lockington, 1878)		SIO		C, D	
Clase ELASMOBRANCHII					
Order HETERODONTIFORMES					
Family Heterodontidae					
Heterodontus francisci (Girard, 1855)	+	SIO, LACM	13, 28	C, S	
Order LAMNIFORMES					
Family Lamnidae					
Carcharodon carcharias (Linneus, 1758)	+		4, 28	C, S	
Isurus oxyrhynchus Rafesinque, 1810			28	T, S	
Lamna ditropis Hubbs and Follett, 1947			28	C, S	
Order CARCHARHINIFORMES					
Family Scyliorhinidae					
Cephaloscyllium ventriosum (Garman, 1880)		SIO, LACM	13, 28	T, S	
Family Triakidae					
Mustelus californicus Gill, 1864			28	C, S	
Triakis semifasciata Girard, 1855			28	C, S	
Family Carcharhinidae					
Carcharhinus leucas Muller and Henle, 1839			28	T, S	
Carcharhinus longimanus (Poey, 1861)			28	T, S	
Carcharhinus obscurus (Lesueur, 1818)			28	T, S	
Galeocerdo cuvier (Peron and Lesueur, 1822)			28	T, S	
Prionace glauca (Linneus, 1758)			28	C, S	
Family Sphyrnidae					
Sphyrna sp.			28	T, S	
Order SQUALIFORMES					
Family Dalatiidae					
Isistius brasiliensis (Quoy and Gaimard, 1824)			14, 18, 28	T, S	Northern limit
Somniosus pacificus Bigelow and Schroeder, 1944			28	C, S	
Family Squalidae					
Squalus acanthias Linneus, 1758			28	C, S	
Family Echinorhinidae					
Echinorhinus cookei Pietschmann, 1928			28	T, S	
Order TORPEDINIFORMES					
Family Torpedinidae					
Torpedo californica Ayres, 1855	+	SIO		C, S	⋆
Order RAJIFORMES					
Family Arhynchobatidae					
Bathyraja trachura (Gilbert, 1832)		USNM, AMNH	10, 13, 14	C, D	Southern limit
Family Myliobatidae					
Manta birostris (Walbaum, 1792)			13, 15	T, S	
Mobula japanica (Müler and Henle, 1841)		SIO	3	T, S	
Mobula thurstoni (Lloyd, 1908)			13, 15	T, S	
Myliobatis californica Gill, 1865	+	SIO		T, S	⋆
Clase ACTINOPTERYGII					
Order ANGUILLIFORMES					
Family Chlopsidae					
Thalassenchelys coheni Castle and Raju, 1975		LACM	14	C, D	Southern limit
Family Muraenidae					
Gymnothorax mordax (Ayres, 1859)	+	SIO	13, 14	C, S	
Gymnothorax panamensis (Steindachner, 1876)		SIO	14	T, S	Northern limit
Family Ophichthidae					
Scytalichthys miurus (Jordan and Gilbert, 1882)			14	T, S	Northern limit
Family Congridae					
Ariosoma gilberti (Ogilby, 1898)		SIO		T, D	⋆
Gnathophis cinctus (Garman, 1899)		SIO, LACM	13, 15	T, S	
Family Derichthyidae					
Derichthys serpentinus Gill, 1884		LACM		T, D	
Family Nemichthyidae					

Avocettina bowersi Garman, 1899		SIO		T, D	⋆
Avocettina infans (Günther, 1878)		SIO, LACM		C, D	⋆
Nemichthys larseni Nielsen and Smith, 1978		SIO		C, D	⋆
Nemichthys scolopaceus Richardson, 1848		SIO, LACM		T, D	⋆
Family Serrivomeridae					
Serrivomer sector Garman, 1899		SIO, LACM		T, D	⋆
Family Nettastomatidae					
Facciolella gilbertii (Garman, 1899)		LACM		T, D	⋆
ORDER SACCOPHARYNGIFORMES					
Family Cyematidae					
Cyema atrum Günther, 1878		SIO, LACM	17	T, D	⋆
Family Eurypharyngidae					
Eurypharynx pelecanoides Vaillant,1882		SIO, LACM		T, D	⋆
Family Saccopharyngidae					
Saccopharynx lavenbergi Nielsen and Bertelsen, 1985		SIO		T, D	⋆
Order CLUPEIFORMES					
Family Clupeidae					
Sardinops sagax (Jenyns, 1842)	+	SIO	13, 28	C, S	
Family Engraulidae					
Engraulis mordax Girard, 1854		SIO	19	C, S	
Pseudobathylagus milleri (Jordan and Gilbert, 1898)		SIO, LACM		C, D	⋆, Southern limit
Order OSMERIFORMES					
Family Microstomatidae					
Nansenia crassa Lavenberg, 1965		LACM		T, S	⋆
Family Opisthoproctidae					
Bathylychnops exilis Cohen, 1958			14	C, D	Southern limit
Macropinna microstoma Chapman, 1939		SIO		C, D	
Dolichopteryx longipes (Vaillant, 1888)		LACM		C, D	Southern limit
Family Bathylagidae					
Bathylagoides nigrigenys (Parr, 1931)		SIO		T, D	⋆
Bathylagus wesethi Bolin, 1938		SIO, LACM	22	C, D	
Bathylagus stilbius (Gilbert, 1890)		SIO, LACM		C, D	⋆
Lipolagus ochotensis (Schmidt, 1938)		SIO, LACM		C, D	⋆
Family Alepocephalidae					
Alepocephalus tenebrosus Gilbert, 1892		LACM	14	C, D	Southern limit
Bajacalifornia burragei Townsend and Nichols, 1925		LACM		T, D	⋆
Bathylaco nigricans Goode and Bean, 1896		LACM		C, D	⋆
Mirorictus taaningi Parr, 1947		SIO		T, D	⋆
Narcetes stomias (Gilbert, 1890)		LACM		T, D	⋆
Talismania bifurcata (Parr, 1951)		SIO, LACM		C, D	⋆
Family Platytroctidae					
Holtbyrnia latifrons Sazonov, 1976		SIO		T, D	⋆
Holtbyrnia macrops Maul, 1957		LACM		T, D	⋆
Holtbyrnia melanocephala (Vaillant, 1888)		LACM		C, D	⋆, New record eastern Pacific
Maulisia mauli Parr, 1960		LACM		T, D	⋆, New record eastern Pacific
Mentodus facilis (Parr, 1951)		LACM		T, D	⋆
Mirorictus taningi Parr, 1951		LACM		T, D	⋆
Sagamichthys abei Parr, 1953		SIO, LACM		T, D	⋆
Order STOMIIFORMES					
Family Gonostomatidae					
Cyclothone acclinidens Garman, 1899		SIO, LACM		T, D	⋆
Cyclothone atraria Gilbert, 1905		SIO, LACM		C, D	⋆
Cyclothone braueri Jespersen and Tåning, 1926		LACM		T, D	⋆
Cyclothone microdon (Günther, 1878)		SIO		T, D	
Cyclothone pallida Brauer, 1902		SIO, LACM		T, D	⋆
Cyclothone pseudopallida Mukhacheva, 1964		SIO, LACM		C, D	⋆
Cyclothone signata Garman, 1899		SIO, LACM		C, D	⋆
Gonostoma atlanticum Norman, 1930		LACM		T, D	⋆
Family Sternoptychidae					
Argyropelecus affinis Garman, 1899		SIO, LACM	17	T, D	
Argyropelecus hemigymnus Cocco, 1829		SIO, LACM		T, D	⋆
Argyropelecus intermedius Clarke, 1878		LACM		T, D	⋆
Argyropelecus lychnus Garman, 1899		SIO, LACM		T, D	⋆
Argyropelecus sladeni Regan, 1908		LACM		C, D	⋆
Danaphos oculatus (Garman, 1899)		SIO, LACM		T, D	⋆
Sternoptyx diaphana Hermann, 1781		SIO, UKNHM, LACM		C, D	⋆
Sternoptyx obscura Garman, 1899		SIO, LACM	17	T, D	⋆
Sternoptyx pseudobscura Baird, 1971		LACM		C, D	⋆
Valenciennellus tripunctulatus (Esmark, 1871)		SIO		T, D	⋆
Family Phosichthyidae					

Ichthyococcus irregularis Rechnitzer and Böhlke 1958	SIO, SBMNH, LACM		C, D	⋆
Vinciguerria lucetia (Garman, 1899)	SIO, UKNHM, LACM		T, D	⋆
Vinciguerria nimbaria (Jordan and Williams, 1895)	SIO, CAS		T, D	⋆
Vinciguerria poweriae (Cocco, 1838)	SIO		T, D	⋆
Woodsia nonsuchae (Beebe, 1932)	SIO, LACM		T, D	⋆
Family Stomiidae				
Aristostomias scintillans (Gilbert, 1915)	SIO, LACM		C, D	⋆
Bathophilus flemingi Aron and McCrery, 1958	LACM		C, D	⋆
Borostomias panamensis Regan and Trewavas, 1929	SIO, LACM		T, D	⋆
Chauliodus macouni Bean, 1890	SIO, LACM		C, D	⋆
Chauliodus sloani Bloch and Schneider, 1801	SIO		T, D	⋆
Idiacanthus antrostomus Gilbert, 1890	SIO, LACM		T, S	⋆
Photonectes margarita (Goode and Bean, 1896)	LACM		T, D	⋆
Stomias atriventer Garman, 1899	SIO, LACM	17	T, D	
Order AULOPIFORMES				
Family Scopelarchidae				
Benthalbella dentata (Chapman, 1939)	LACM	14	C, D	Southern limit
Rosenblattichthys volucris (Roffen, 1966)	SIO, LACM		C, D	⋆
Scopelarchus guentheri Alcock, 1896	LACM		C, D	⋆
Family Notosudidae				
Scopelosaurus adleri (Fedorov, 1967)	LACM		C, D	⋆
Scopelosaurus harryi (Mead, 1953)	LACM		C, D	⋆
Family Synodontidae				
Synodus lucioceps (Ayres, 1855)	SIO		C, D	⋆
Synodus scituliceps Jordan and Gilbert, 1882		14	C, S	Northern limit
Family Bathysauridae				
Bathysaurus mollis Günther, 1878		14	C, D	Southern limit
Family Paralepididae				
Lestidiops ringens (Jordan and Gilbert, 1880)	SIO, LACM		C, D	⋆
Family Anotopteridae				
Anotopterus pharao Zugmayer, 1911	LACM		T, D	⋆
Family Evermannellidae				
Evermannella ahlstromi Johnson and Glodek, 1975	LACM		T, D	⋆
Order MYCTOPHIFORMES				
Family Neoscopelidae				
Scopelengys tristis Alcock, 1890	SIO, LACM		C, D	⋆
Family Myctophidae				
Bolinichthys longipes (Brauer, 1906)	SIO, LACM		T, D	⋆
Bolinichthys pyrsobolus (Alcock, 1890)	LACM		T, D	⋆, New record eastern Pacific
Ceratoscopelus townsendi (Eigenmann and Eigenmann, 1889)	SIO, LACM		T, D	⋆
Diaphus theta Eigenmann and Eigenmann, 1890	SIO, LACM		C, D	⋆
Diogenichthys atlanticus (Taning, 1928)	SIO, LACM		T, D	⋆
Diogenichthys laternatus (Garman, 1899)	SIO, LACM		T, D	⋆
Gonichthys tenuiculus (Garman, 1899)	SIO, LACM		T, D	⋆
Hygophum atratum (Garman, 1899)	SIO, LACM		T, D	
Hygophum hanseni (Tåning, 1932)	LACM		T, D	⋆
Hygophum reinhardtii (Lütken, 1892)	SIO, LACM		T, D	
Lampadena urophaos (Paxton, 1963)	SIO, LACM		T, D	⋆
Lampanyctus festivus Tåning, 1928	SIO		T, D	⋆
Lampanyctus steinbecki Bolin, 1939	SIO		T, D	⋆
Lampanyctus tenuiformis (Brauer, 1906)	SIO		T, D	⋆
Loweina rara (Lütken, 1892)	SIO, CAS, LACM		T, D	⋆
Myctophum nitidulum Garman, 1899	SIO, LACM		C, D	⋆
Nannobrachium bristori Zahuranec, 2000	SIO		T, D	⋆
Nannobrachium hawaiiensis Zahuranec, 2000	SIO		C, D	⋆
Nannobrachium idostigma (Parr, 1931)	SIO, LACM		T, D	⋆
Nannobrachium regale (Gilbert, 1892)	SIO, LACM		C, D	⋆
Nannobrachium ritteri Gilbert, 1915	SIO, LACM		C, D	⋆
Notolychnus valdiviae (Brauer, 1904)	SIO, LACM		T, D	⋆
Notoscopelus resplendens (Richardson, 1845)	LACM		T, D	⋆
Parvilux ingens Hubbs and Wisner, 1964	SIO, LACM	14	C, D	Southern limit; type location
Protomyctophum crockeri (Bolin, 1939)	SIO, LACM		C, D	⋆
Stenobrachius leucopsarus (Eigenmann and Eigenmann, 1890)	LACM		C, D	⋆
Stenobrachius nannochir (Gilbert, 1890)	LACM		C, D	⋆
Simbolphorus californiensis Eigenmann and Eigenmann, 1889	SIO, LACM		C, D	⋆
Taaningichthys paurolychnus Davy, 1972	SIO, LACM		T, D	⋆
Tarletonbeania crenularis (Jordan and Gilbert, 1880)	LACM		C, D	⋆
Triphoturus mexicanus (Gilbert, 1890)	SIO, LACM	17	C, D	
Order LAMPRIFORMES				
Family Trachipteridae				

Desmodema lorum Rosenblatt and Butler, 1977	LACM		C, S	⋆
Order GADIFORMES				
Family Macrouridae				
Albatrossia pectoralis (Gilbert, 1892)	SIO		C, D	⋆
Coryphaenoides acrolepis (Bean, 1884)		13, 14, 15	C, D	Southern limit
Coryphaenoides armatus (Hector, 1875)	SIO		T, D	⋆
Coryphaenoides yaquinae Iwamoto and Stein, 1974	SIO		C, D	⋆
Mesobius berryi Hubbs and Iwamoto, 1977	LACM		T, D	⋆
Family Moridae				
Antimora microlepis Bean, 1890	SIO		C, D	⋆
Antimora rostrata (Günther, 1878)		2	T, D	
Family Melanonidae				
Melanonus zugmayeri Norman, 1930	LACM		C, D	⋆
Order OPHIDIIFORMES				
Family Ophidiidae				
Chilara taylori (Girard, 1858)	SIO		T, D	⋆
Lamprogrammus niger Alcock, 1891	LACM		T, D	⋆
Family Bythitidae				
Cataetyx rubrirostris Gilbert, 1890	LACM		C, D	
Grammonus diagrammus (Heller and Snodgrass, 1903)	SIO	13, 15	T, S	
Order BATRACHOIDIFORMES				
Family Batrachoidiidae				
Porichthys sp.		28		
Order LOPHIIFORMES				
Family Caulophrynidae				
Caulophryne pelagica (Brauer, 1902)		14	T, D	Northern limit
Family Oneirodidae				
Bertella idiomorpha Pietsch, 1973	CAS	21	C, D	Type location
Chaenophryne melanorhabdus Regan and Trewavas, 1932	LACM		T, D	⋆
Oneirodes acanthias (Gilbert, 1915)	SIO, LACM		C, D	⋆
Oneirodes basili Pietsch, 1974		14	C, D	Southern limit; type location
Phyllorhinichthys micractis Pietsch, 1969	LACM	14, 16, 20	C, D	Northern limit; type location
Family Gigantactinidae				
Gigantactis savagei Bertelsen, Pietsch, and Lavenberg, 1981	LACM		C, D	⋆
Order GOBIESOCIFORMES				
Family Gobiesocidae				
Gobiesox eugrammus Briggs, 1955	SIO, CAS	10, 13, 14, 15, 28	C, S	Type location
Gobiesox maeandricus (Girard, 1858)		13, 14, 15	C, S	Southern limit
Gobiesox rhessodon Smith, 1881	SIO	13, 15, 26	C, S	
Rimicola eigenmanni (Gilbert, 1890)	SIO		C, S	⋆
Rimicola sila Briggs, 1955		10, 14, 18	E, S	Type location
Order ATHERINIFORMES				
Family Atherinopsidae				
Atherinops affinis (Ayres, 1860)	CI-UABC, SIO, AMNH	8, 10, 13	C, S	
Atherinopsis californiensis Girard, 1854	SIO, LACM		C, S	⋆
Order BELONIFORMES				
Family Scomberesocidae				
Cololabis saira (Brevoort, 1856)	SIO, LACM		C, S	⋆
Family Exocoetidae				
Cheilopogon pinnatibarbatus (Bennett, 1831)	SIO	28	C, S	
Order BERYCIFORMES				
Family Anoplogastridae				
Anoplogaster cornuta (Valenciennes, 1833)	LACM		T, D	⋆
Order STEPHANOBERYCIFORMES				
Family Melamphidae				
Melamphaes acanthomus Ebeling, 1962	SIO, LACM		T, D	⋆
Melamphaes indicus Ebeling, 1962	LACM		T, D	⋆
Melamphaes janae Ebeling, 1962	SIO		T, D	⋆
Melamphaes longivelis Parr, 1933	SIO		T, D	⋆
Melamphaes lugubris Gilbert, 1891	SIO, LACM		C, D	⋆
Melamphaes parvus Ebeling, 1962	SIO, CAS, LACM	25	C, D	Type location
Poromitra crassiceps (Günther, 1878)	SIO, LACM		T, D	⋆
Scopeloberyx microlepis (Norman, 1937)	SIO		T, D	⋆
Scopeloberyx opisthopterus (Parr, 1933)	SIO		T, D	⋆
Scopeloberyx robustus (Günther, 1887)	SIO, LACM		T, D	⋆
Scopelogadus mizolepis (Günther, 1878)	SIO, LACM		T, D	⋆
Order CETOMIMIFORMES				
Family Barbourisiidae				
Barbourisia rufa Parr, 1945	SBMNH		C, D	⋆
Family Cetomimidae				

Ditropichthys storeri (Goode and Bean, 1895)		LACM		T, D	⋆
Gyrinomimus myersi Parr, 1934		SIO		T, D	⋆
Order SYNGNATHIFORMES					
Family Centriscidae					
Macrorhamphosus gracilis (Lowe, 1839)		SIO		T, S	⋆
Family Syngnathidae					
Syngnathus exilis (Osburn and Nichols, 1916)		SIO		C, D	⋆
Syngnathus insulae Fiitzsce, 1980		SIO	14, 18	E, S	Type location
Syngnathus leptorhynchus Girard, 1854		LACM		C, S	⋆
Order SCORPAENIFORMES					
Family Sebastidae					
Sebastolobus altivelis Gilbert, 1896		SIO, LACM		C, D	
Family Scorpaenidae					
Scorpaena guttata Girard, 1854	+	SIO, TUMNH, LACM	10, 13, 15	T, S	
Scorpaena histrio Jenyns, 1840		SIO	14	T, S	Northern limit
Scorpaena mystes Jordan and Starks, 1895	+			T, S	
Sebastes chlorostictus (Jordan and Gilbert, 1880)		CI-UABC, SIO	11, 13	C, D	
Sebastes constellatus (Jordan and Gilbert, 1880)		CI-UABC, SIO	11, 13	C, S	
Sebastes elongatus Ayres, 1859		CI-UABC, SIO	13	C, S	
Sebastes ensifer Chen, 1971		CI-UABC, SIO	11, 13	C, D	
Sebastes eos (Eigenmann and Eigenmann, 1890)		CI-UABC, SIO	13, 14	C, D	
Sebastes helvomaculatus Ayres, 1859			8	C, D	
Sebastes hopkinsi (Cramer, 1895)		SIO	6, 13, 14, 15	C, S	Southern limit
Sebastes lentiginosus Chen, 1971		SIO	14	C, S	Southern limit
Sebastes levis (Eigenmann and Eigenmann, 1889)	+	CI-UABC	13, 14, 15	C, D	
Sebastes macdonaldi (Eigenmann and Beeson, 1893)		CI-UABC, SIO	13	C, D	
Sebastes melanostomus (Eigenmann and Eigenmann, 1890)		CI-UABC, SIO	13	C, D	
Sebastes miniatus (Jordan and Gilbert, 1890)		CI-UABC, SIO	13	C, S	
Sebastes notius Chen, 1971		CI-UABC, SIO	11, 13, 14	T, D	Northern limit; type location
Sebastes ovalis (Ayres, 1862)		CI-UABC, SIO	13	C, D	Southern limit
Sebastes paucispinis Ayres, 1854		SIO	13, 14	C, S	
Sebastes rosaceus Girard, 1854		CI-UABC	11, 13	C, S	
Sebastes rosenblatti Chen, 1971		CI-UABC, SIO	11, 13	C, D	
Sebastes rufus (Eigenmann and Eigenmann, 1890)		SIO	13, 14, 15	C, D	
Sebastes simulator Chen, 1971		CI-UABC, SIO	11, 13, 14, 15,	C, D	
Sebastes umbrosus (Jordan and Gilbert, 1882)		CI-UABC, SIO	11, 13	C, S	
Scoepaenodes xyris (Jordan and Gilbert, 1882)	+	SIO	13, 14, 15	T, S	
Family Cottidae					
Chitonotus pugetensis (Steindachner, 1876)		SIO	15	C, S	
Clinocottus analis (Girard, 1858)	+	SIO, CAS	15	C, S	
Icelinus cavifrons Gilbert, 1890		SIO	7, 13, 15	C, S	
Ruscarius creaseri (Hubbs, 1926)		SIO	13, 15	C, S	
Family Liparidae					
Paraliparis rosaceus Gilbert, 1890		SIO	14	T, D	
Paraliparis ulochir Gilbert, 1896		SIO		C, D	⋆
Psednos anoderkes Chernova and Stein, 2002		SIO	14	E, D	Type location
Psednos griseus Chernova and Stein, 2002			14	E, D	Type location
Psednos mexicanus Chernova and Stein, 2002		LACM	14	E, D	Type location
Psednos pallidus Chernova and Stein, 2002		SIO	14	E, D	Type location
Order PERCIFORMES					
Family Howellidae					
Howella brodiei Ogilby, 1899		LACM		T, D	⋆
Family Polyprionidae					
Stereolepis gigas Ayres, 1859			15	T, S	
Family Serranidae					
Epinephelus labriformis (Jenyns, 1840)	+			T, S	⋆, Northern limit
Mycteroperca rosacea (Streets, 1877)	+	LACM		T, S	⋆, Northern limit
Mycteroperca xenarcha Jordan, 1888		SIO	15	T, S	
Paralabrax auroguttatus Walford, 1936		SIO		C, D	⋆
Paralabrax clathratus (Girard, 1854)	+	CI-UABC, SIO, AMNH	13, 23, 28	C, S	
Paralabrax nebulifer (Girard, 1854)			13, 15	C, S	
Pronotogrammus multifasciatus Gill, 1863		SIO		T, D	⋆
Family Priacanthidae					
Heteropriacanthus cruentatus (Lacepe`de, 1801)		SIO	14, 15	T, S	Northern limit
Priacanthus alalaua Jordan and Evermann, 1903			24, 28	T, S	Northern limit
Family Apogonidae					
Apogon atricaudus Jordan and McGregor, 1898		SIO	14	T, S	
Apogon guadalupensis (Osburn and Nichols, 1916)	+	SIO, AMNH	10, 13, 14, 15, 28	C, S	Type location
Family Malacanthidae					
Caulolatilus affinis Gill, 1865		SIO	14, 28	T, S	
Caulolatilus princeps (Jenyns, 1840)	+	SIO, AMNH, LACM	12	T, S	

Family Carangidae					
Decapterus muroadsi (Temminck and Schlegel, 1843)		SIO	13, 15, 26	C, S	
Elagatis bipinnulata (Quoy and Gaimard, 1825)			6	T, S	
Seriola lalandi Valenciennes, 1833	+	SIO	25, 28	T, S	
Trachurus symmetricus (Ayres, 1855)		SIO, AMNH, LACM	28	C, S	
Family Bramidae					
Brama japonica Hilgendorf, 1878			8	C, S	
Family Sparidae					
Calamus brachysomus Lockington, 1880		SIO		T, S	⋆
Family Sciaenidae					
Cynoscion sp.			28		
Genyonemus lineatus (Ayres, 1855)			28	C, S	
Pareques sp. (Gilbert, 1898)		SIO		T, S	⋆, Northern limit
Umbrina roncador Jordan and Gilbert, 1882			28	C, S	
Family Kyphosidae					
Girella nigricans (Ayres, 1860)	+	CI-UABC, SIO, CAS, AMNH, LACM	23, 28	C, S	
Kyphosus analogus (Gill, 1862)	+		18	T, S	⋆
Medialuna californiensis (Steindachner, 1876)	+	SIO, LACM	13, 15, 23	C, S	
Family Chaetodontidae					
Prognathodes falcifer (Hubbs and Rechnitzer, 1958)	+	SIO	11, 15, 28	T, S	Type location
Family Pomacantidae					
Holacanthus clarionensis Gilbert, 1891		SIO	6, 14	T, S	Northern limit
Holacanthus passer Valenciennes, 1846		SIO	14	T, S	Northern limit
Family Embiotocidae					
Brachyistius aletes (Tarp, 1952)		SIO, CAS, MCZ	10	E, S	Type location
Brachyistius frenatus Gill, 1862	+	SIO, USNM, AMNH	13, 14, 15, 23	C, S	
Embiotoca jacksoni Agassiz, 1853	+	SIO, CAS	13, 14, 15, 23, 24	C, S	
Embiotoca lateralis Agassiz, 1854	+	CAS		C, S	⋆, Southern limit
Hyperprosopon argenteum Gibbons, 1854		SIO	13, 14, 15	C, S	Southern limit
Rhacochilus toxotes Agassiz, 1854	+	SIO	14, 15	C, S	
Rhacochilus vacca (Girard, 1855)	+	SIO	7, 13, 14, 15	C, S	Southern limit
Zalembius rosaceus (Jordan and Gilbert, 1880)			13, 15	C, S	
Family Pomacentridae					
Azurina hirundo Jordan and McGregor, 1898	+	SIO	6, 10, 14, 24	C, S	
Chromis alta Greenfield and Woods, 1980			6	T, S	
Chromis atrilobata Gill, 1862			14	T, S	Northern limit
Chromis punctipinnis (Cooper, 1863)	+	SIO, AMNH	23, 28	C, S	
Hypsypops rubicundus (Girard, 1854)	+	CI-UABC, SIO, CAS, AMNH, TUMNH	13, 15, 23, 28	C, D	
Stegastes leucorus (Gilbert, 1892)	+	SIO	6, 14, 24	T, S	
Family Labridae					
Bodianus diplotaenia (Gill, 1862)		SIO	6, 14	T, S	Northern limit
Halichoeres insularis Allen and Robertson, 1992			28	T, S	Northern limit
Halichoeres nicholsi (Jordan and Gilbert, 1882)	+		6	T, S	Northern limit
Halichoeres semicinctus (Ayres, 1859)	+	CI-UABC, SIO, ANSP, TUMNH, LACM	13, 14, 15	C, S	
Oxyjulis californica (Günther, 1861)	+	SIO	23, 25	C, S	
Semicossyphus pulcher (Ayres, 1854)	+	CI-UABC, SIO, USNM, LACM	14, 15, 23, 24, 28	C, S	
Family Zoarcidae					
Melanostigma pammelas Gilbert, 1896		SIO		C, D	⋆
Pachycara bulbiceps (Garman, 1899)		SIO		C, D	⋆
Pachycara gymninium Anderson and Peden, 1988			14	C, D	Southern limit
Pachycara lepinium Anderson and Peden, 1988			14	C, D	Southern limit
Taranetzella lyoderma Andriashev, 1952			14	C, D	Southern limit
Family Pholidae					
Apodichthys anctaerosae (Gilbert and Starks, 1897)		SIO, CAS, AMNH	13, 14, 15, 18	C, S	Southern limit
Family Anarhichadidae					
Anarrhichthys ocellatus Ayres, 1855			28	C, S	Southern limit
Family Chiasmodontidae					
Kali indica Lloyd, 1909		SIO		C, D	⋆
Kali normani (Parra, 1931)		SIO	5	T, D	
Chiasmodon niger Johnson, 1864		SIO		T, D	⋆
Chiasmodon subniger Garman, 1899		SIO, LACM		T, D	⋆
Pseudoscopelus lavenbergi Melo, Walker, and Klepadlo, 2007		SIO		T, D	⋆
Family Tripterygiidae					
Enneanectes reticulatus Allen and Robertson, 1991		SIO	14	T, S	Northern limit
Enneanectes sp.			14		
Family Labrisomidae					
Alloclinus holderi (Lauderbach, 1907)	+	SIO	9, 15	C, S	
Malacoctenus ebisui Springer, 1959		SIO	14	T, S	Northern limit

Malacoctenus gigas Springer, 1959		SIO		T, S	⋆
Malacoctenus zacae Springer, 1959		SIO		T, S	⋆
Paraclinus integripinnis (Smith, 1880)		SIO, CAS	27	T, S	
Starksia guadalupae Rosenblatt and Taylor, 1971		SIO	14, 18	C, S	Northern limit; type location
Family Clinidae					
Gibbonsia elegans (Cooper, 1864)		SIO, USNM AMNH	10, 13, 14, 15, 30	C, S	
Gibbonsia montereyensis Hubbs, 1927		SIO, CAS, TUMNH	14, 30	C, S	Southern limit
Gibbonsia norae Hubbs, 1952			29	C, S	
Heterostichus rostratus Girard, 1854	+	CI-UABC, SIO, CAS	10, 13, 14, 15	C, S	
Family Chaenopsidae					
Chaenopsis alepidota (Gilbert, 1890)		SIO		C, S	⋆
Family Dactyloscopidae					
Gillellus semicinctus Gilbert, 1890		SIO	14	T, S	Northern limit
Family Blenniidae					
Hypsoblennius jenkinsi (Jordan and Evermann, 1896)		SIO		C, S	⋆
Ophioblennius steindachneri Jordan and Evermann, 1898		SIO	6	T, S	
Family Gobiidae					
Lythrypnus dalli (Gilbert, 1890)	+	SIO	13, 15	T, S	
Lythrypnus zebra (Gilbert, 1890)	+	SIO, TUMNH	13, 15	C, S	
Rhinogobiops nicholsii (Bean, 1882)			14	C, S	
Family Gempylidae					
Ruvettus pretiosus Cocco, 1833		SIO		C, S	⋆
Family Scombridae					
Acanthocybium solandri (Cuvier, 1832)			28	C, S	
Auxis thazard (Lacepède, 1800)			28	T, S	
Katsuwonus pelamis (Linnaeus, 1758)			28	T, S	
Scomber japonicus Houttuyn, 1782		SIO	28	C, S	
Thunnus alalunga (Bonnaterre, 1788)		SIO	13, 15	C, S	
Thunnus albacares (Bonnaterre, 1788)		SIO	13, 15, 28	T, S	
Thunnus obesus (Lowe, 1839)			1, 5	T, S	
Thunnus orientalis (Temminck and Schlegel, 1844)		SIO	7, 8, 13, 14, 15, 24, 28	T, S	
Thunnus thynnus (Linnaeus, 1758)			7,13, 15	T, S	
Family Istiophoriade					
Tetrapturus angustirostris Tanaka, 1915		SIO		T, D	⋆
Family Centrolophidae					
Icichthys lockingtoni Jordan and Gilbert, 1880		LACM		C, S	⋆
Order PLEURONECTIFORMES					
Family Paralichthyidae					
Citharichthys sordidus (Girard, 1854)		SIO, LACM		C, S	⋆
Citharichthys stigmaeus Jordan and Gilbert, 1882		SIO, LACM		C, S	⋆
Hippoglossina stomata Eigenmann and Eigenmann, 1890			13, 14, 15	C, S	
Paralichthys californicus (Ayres, 1859)		SIO		C, S	⋆
Family Pleuronectidae					
Microstomus pacificus (Lockington, 1879)		LACM	25	C, D	
Pleuronichthys coenosus Girard, 1854		SIO		C, D	⋆
Family Cynoglossidae					
Symphurus atricaudus (Jordan and Gilbert, 1880)		LACM		C, D	⋆
Order TETRAODONTIFORMES					
Family Balistidae					
Xanthichthys lineopunctatus (Hollard, 1854)				T, D	
Xanthichthys mento (Jordan and Gilbert, 1882)	+	SIO		T, S	⋆
Family Tetraodontidae					
Sphoeroides annulatus (Jenyns, 1842)		SIO		T, S	⋆
Family Molidae					
Mola mola (Linnaeus, 1758)		SIO		T, S	⋆

References: 1) Berdegué, 1956; 2) Briggs, 1965; 3) Castro-Aguirre and Espinosa-Pérez, 1996; 4) Domeier and Nasby-Lucas, 2007; 5) Godsil and Byers, 1944; 6) Gotshall, 1998; 7) Gotshall, 2001; 8) Hart, 1973, 9) Hubbs, 1954; 10) Hubbs, 1960; 11) Hubbs and Rechnitzer, 1958; 12) Johnson, 1969; 13) León Castro *et al.*, 1993; 14) Love *et al.*, 2005; 15) Miller and Lea, 1972; 16) Moser *et al.*, 1986; 17) Munz, 1958; 18) Nelson *et al.*, 2004; 19) Patton and Thomas, 1977; 20) Pietsch, 1969; 21) Pietsch, 1973; 22) Pietsch, 2004; 23) Quast, 1960; 24) Robertson and Allen, 2008; 25) Roedel, 1953; 26) Roedel and Fitch, 1952; 27) Rosenblatt and Parr, 1969; 28) Santos del Prado and Peters, 2005; 29) Stepien and Rosenblatt, 1991; 30) Stepien *et al.*, 1991.

Key to distribution range: T: Species of tropical affinity (midpoint of its distribution south of 24°N); C: Species of Cold-temperate affinity (midpoint of its distribution north of 24°N); E: Species endemic of Isla Guadalupe. Geographic ranges from Love *et al.*, (2005), Robertson and Allen (2008) and Fishbase (2009).

Key to bathymetric range: S: Shallow water species (resident from surface to 20 m deep); D: Deep water species (bathymetric limit higher than -20 m, or deeper). Data from Love *et al.*, (2005), Robertson and Allen (2008) and Fishbase (2009).

Key to museums: CI-UABC) Colección Ictiológica Universidad Autónoma de Baja California, Ensenada; SIO) Scripps Institution of Oceanography, San Diego; CAS) California Academy of Sciences, San Francisco; USNM) National Museum of Natural History, Smithsonian Institution, Washington; AMNH) The American Museum of Natural History; SBMNH) Santa Barbara Museum of Natural History, Santa Barbara; ANSP) The Academy of Natural Science of Philadelphia; MCZ) Museum of Comparative Zoology, Cambridge, Massachusetts; UKNHM) The University of Kansas Natural History Museum; TUMNH) Tulane University Museum of Natural History, Louisiana; LACM) Los Angeles Natural History Museum, Los Angeles.

Notes: Refers to records which Guadalupe Island marks the northern or southern limit of the distribution of the species, if the study area represents the type locality, or if this is a new record for the locality (⋆)

mento (Jordan and Gilbert 1882). Additionally, some new findings were from temperate environments, such as the California batray *Myliobatis californica* (Gill 1865), the California flounder *Paralichthys californicus* (Ayres 1859), and the striped seaperch *Embiotoca lateralis* (Agassiz 1854). There is even a new record from the circumglobal *Mola mola* (Linnaeus 1758). Many of the species that were newly identified on Guadalupe Island have known populations in similar or higher latitudes on the coasts of Mexico and the United States. It is also noteworthy that in this review we found out that *Xanthichthys lineopunctatus* (Hollard 1854) considered exclusive resident of the western Pacific, was collected on Guadalupe Island in the 1950s (SIO 53–173, SIO 54–219A). This record might be considered as doubtful until a more detailed review of the material is done.

The data base of the 360 shallow water fishes from the island and the peninsula demonstrated that Guadalupe has a markedly lower richness (144 species) than the continent (between 278 and 327, with higher numbers in lower latitudes). The Bray-Curtis coefficient and the dendrogram (fig. 2) showed that the Guadalupe Island ichthyofauna is most qualitatively similar to the one at the peninsular segment of 28°N, and that the likeness dropped gradually and reached its lowest value at the México-United States border (fig. 2). When we separated the fish fauna by class (elasmobranchs and bony fishes) the arrangement of the dendrograms from each one was consistent with that of Figure 2 (data not shown), and thus it was manifest that the biogeographical arrangement is followed by all kinds of fishes.

DISCUSSION

The comprehensive fish list of Guadalupe Island presented here (328 species) more than doubled the number reported in previous inventories (124, according to a poll of Gallo-Reynoso et al. 2005b; and Love et al. 2005 listings). One reason for the increase in nominal species richness is the inclusion of pelagic and deep water taxa in our review (tab. 1), as they inhabit areas that were not considered in previous studies of the island, which mostly focused on coastal rocky reefs (Hubbs and Rechnitzer 1958; Briggs 1965; Pietsch 1969; León-Castro et al.1993).

Nevertheless, the 144 shallow water reef fishes reported here still represent a small improvement to previous appraisals (124 species in total, from Gallo-Reynoso et al. 2005b; Love et al. 2005). In the group of 20 new records there are 12 tropical species and only 8 temperate ones. It is still early to affirm that this difference is an indication of asymmetrical incidence of colonization from tropical faunas or effects of global change, but the possibility opens new research avenues for the future.

The 144 species of shallow reef fishes reported here for Guadalupe (tab. 1) indicates that the island might be richer in such fishes than coastal lagoons on the Baja California Peninsula. According to the literature (Danemann and de la Cruz-Aguero 1993; Arellano et al. 1996; Rosales-Casián 1996; Galván-Magaña et al. 2000), San Ignacio has 81 species (26°N), Ojo de Liebre 58 species (28°N), and San Quintín has 90 (30°N). We suggest that the rocky substrate in the coastal waters of Guadalupe Island increases habitat heterogeneity and favors the occurrence of a higher number of fish species in relation to the cited lagoons, where large areas of soft bottom exists.

In contrast, Guadalupe reefs have less fish species than the coastal zone of southern California (34°N, 242 species, Horn et al. 2006), Magdalena Bay (24°N, on the Baja California Peninsula: 292 species, Galván-Magaña et al. 2000), and all one latitude degree bins of the peninsula from 28° to 32°N (238 to 327 species; fig. 2). The low species richness is also evident when comparing specific taxonomic groups resident in the island and the peninsula, like rays (6 on the island and 20 or more at each latitude degree on the peninsula), perchs and snappers (Lutjanidae; 1 on the island and 10 on the peninsula), and puffers (Tetraodontiformes; 3 on the island and 14 on the peninsula). The explanation for these differences is probably due to a series of factors. Isolation is one of the most feasible causes, since larval transportation and movement of adults must be more efficient in mainland reefs than to an island over 200 km away. However, there may be other reasons involved; for example, the lower latitude and larger relative size of Magdalena Bay and of the coastal sections of north Baja California might also contribute to its higher species richness compared to Guadalupe (Whittaker and Fernández Palacios 2007). Another reason for the discrepancies in fish diversity may be the disparity in habitat heterogeneity among areas. Along the peninsula it is possible to find mangrove forests, sea grasses, kelp forests, mollusk beds, and other biological features (Graham et al. 2007; Bizzarro 2008) all with relatively distinct faunas and in consequence, possibly working as enrichment factors (sources) for the reefs. In clear contrast, Guadalupe lacks kelps, extensive sea grasses beds or mangroves, and has a very narrow shelf where reefs can develop (Santos-del Prado and Peters 2005). The likeness in the bottom features might be the instrumental agent that brings about differences in fish species richness of the island and Baja California.

Shifting the perspective, it can be said that Guadalupe Island has low richness for an oceanic island in the eastern Pacific. This notion is exemplified by a comparison of fish diversity in shallow waters of Guadalupe Island (144 species) with that found in the rest of the region's

oceanic islands (Galápagos, Ecuador; Cocos, Costa Rica; Malpelo, Colombia; and Revillagigedos, México), from where Robertson and Cramer (2009) reported a range of 203 to 363 species. The one exception to this trend is Clipperton Island with only 104 species present (Robertson and Allen 2008). Guadalupe is much larger than Malpelo and most of the Revillagigedo islands (Santos-del Prado and Peters 2005), and is nearer to the coast than Galápagos or Clipperton (Robertson and Cramer 2009); from these facts we discard the idea that the smaller diversity is due to an island size effect (Whittaker and Fernández Palacios 2007), or to mere isolation. It is more possible that the dominant pattern of currents and the difference in temperatures between the islands and the nearest mainland can explain the situation. All cited tropical islands can carry colonizers from the mainland and from about the same latitude, using branches of the California and Costa Rica currents (Kessler 2006). However, Guadalupe is surrounded by colder waters than the peninsula (a condition that may form a temporal barrier for dispersal), and in addition, the movement of the California Current is southwards, also making arrival more difficult.

In Guadalupe Island only 8 endemic fish species have been documented (tab. 1); this adds to 2.4% of the total although the figure rises to 5.5% when considering only reef taxa. Relating these data to those of coastal waters of the tropical eastern Pacific coast (Robertson and Cramer 2009), endemism in Guadalupe is quite low as most areas have over 10 endemics, and the oceanic islands usually exceed 25. However, the situation changes when the number is transformed to percentage of the total fauna; in this case Guadalupe contains a relatively high proportion of endemics, only surpassed by some reefs in Panamá and the oceanic islands Clipperton, Cocos, Galápagos, Malpelo and Revillagigedos (13% endemics or more in all cases). It can be hypothesized that Guadalupe Island is relatively isolated from the mainland and that has favored the presence of some unique species; notwithstanding, the somewhat low endemism may indicate that segregation is not permanent or not as efficient, especially during El Niño years, when the presence of tropical taxa (both as larvae and adults) has been reported (Hernández-de la Torre et al. 2005).

Regarding the biogeographic aspects of the fauna, a recent paper (Pondella et al. 2005) investigated reef fish species abundance and composition in a group of eight islands off the coast of California (USA) and Baja California (México), with data obtained from a census of conspicuous fishes conducted at each site. They report a total of 84 species, remark the existence of a clear faunistic division of tropical and temperate faunas between Coronado and San Martín islands in México (approximate latitude 31°N), and point out that San Benito Island might be the northernmost limit of tropical species that are much more common at lower latitudes in the peninsula. The referred study did not include Guadalupe Island, and thus we decided to perform a similar analysis of the fish structure, but this time using absence/presence data from one degree latitude bins, from which information is more readily available (Love et al. 2005). The resulting dendrogram (based on a data set of 360 species of the island and the peninsula from 28°N to 32°N; fig. 2) shows that the qualitative differences in fish composition along the peninsula are gradual and do not seem to evidence the break mentioned by Pondella et al. (2005), probably because of the difference in data sources, or as an artifact of the tree that joined the northernmost point in the north (32°N) to the next most similar one (31°N). In addition, Guadalupe Island was more related to the 28°N bin than to northern latitudes. This finding suggests that the most probable source of faunal exchange with the peninsula might be the area around Cedros Island, San Benito Island, and Punta Eugenia (all at 28°N). This hypothesis is supported by the range extensions of over 20 tropical species for which their nearest area of occurrence was that latitude (including the flag cabrilla *Epinephelus labriformis* and the leopard grouper *Mycteroperca rosacea*; Pondella et al. 2005; Robertson and Allen 2008; tab. 1). Further phylogeographic studies between Guadalupe Island and the Baja California coast have to be conducted in order to confirm this connection.

In conclusion, Guadalupe Island has a total of 328 documented fish species (144 of them residents of reefs or shallow water), a much higher figure than previously reported. The site has a low number of reported endemics (only 8), a fact that indicates low local speciation rates, probably as a consequence of gene flow from the mainland. Notwithstanding, it has one of the highest percentages of endemism in the tropical and warm temperate eastern Pacific (5.5% of the species). Finally, the qualitative similarity between the fish fauna at Guadalupe and that present at 28°N on the Baja California Peninsula, points toward the latter as the main source for potential immigrants from tropical regions.

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