



## Checklist and analysis of completeness of the reef fish fauna of the Revillagigedo Archipelago, Mexico

MANON FOURRIÈRE<sup>1,2,5</sup>, HÉCTOR REYES-BONILLA<sup>1</sup>, ARTURO AYALA-BOCOS<sup>3</sup>,  
JAMES KETCHUM<sup>4</sup> & JUAN CARLOS CHÁVEZ-COMPARAN<sup>5</sup>

<sup>1</sup>Universidad Autónoma de Baja California Sur. Departamento Académico de Biología Marina. Carretera al sur km. 5.5., Col. El Mezquitito. CP 23080, La Paz, B.C.S., México. E-mail: [manon.fourriere@gmail.com](mailto:manon.fourriere@gmail.com); [hreyes@uabcs.mx](mailto:hreyes@uabcs.mx)

<sup>2</sup>International Studies in Aquatic Tropical Ecology (ISATEC-Master candidate), Bremen University, Fachbereich 02. Postfach 33 04 40. 28334 Bremen, Germany

<sup>3</sup>Ecosistemas y Conservación: Proazul Terrestre A.C. Camineros 196, Fracc. del Sol. C.P. 23076 La Paz, B.C.S. Mexico

<sup>4</sup>Pelagios-Kakunjá, A.C. Sinaloa 1540. Col. Las Garzas. CP 23070. La Paz, B.C.S., México

<sup>5</sup>Universidad de Colima. Facultad de Ciencias Marinas. Carretera Manzanillo-Barra de Navidad km 20. Manzanillo, Col. México

<sup>6</sup>Corresponding author

### Abstract

This paper presents an updated checklist of cartilaginous and bony fishes from the Revillagigedo Archipelago reefs and nearby areas (Tropical Eastern Pacific). To compile this list, we gathered data from field surveys between 1994 and 2015, from an exhaustive literature review, and by consulting museum collections and databases. With these records we estimated the completeness of the local fish inventory using four non-parametric rarefaction methods. We report a total of 389 species in 102 families; 235 of these are reef fish that occur in the Eastern but also in the Central Pacific, and 13 species were identified as endemic to the archipelago. A non-parametric statistical model predicts that the expected number of reef fish present at Revillagigedo should be  $244.3 \pm 3.2$  species, which is 9 species more than the observed richness, and this difference was statistically significant ( $p = 0.02$ ). That predictive model estimates that about 96% of the total richness of reef fish from the archipelago is known. Comparisons of the completeness of the inventory at Revillagigedo to that reported for the fish fauna of the Eastern Pacific and worldwide, showed that the quality of the sampling effort is remarkably high, in spite of the geographic isolation of the archipelago.

**Key words:** Eastern Tropical Pacific, oceanic islands, endemism, inventory, ichthyofauna

### Resumen

Se presenta un listado actualizado de los peces cartilaginosos y óseos de los arrecifes y zonas cercanas al Archipiélago de Revillagigedo (Pacífico oriental). Para elaborar la lista se realizaron censos entre los años 1994 y 2015, y se condujo una revisión bibliográfica y de colecciones y bases de datos de museos. Con estos registros se llevó a cabo un análisis de la comprehensividad del elenco sistemático de los peces del archipiélago utilizando cuatro modelos no paramétricos. Se reporta un total de 389 especies de 102 familias; de estas, 235 son peces arrecifales y solo 13 especies son endémicas del archipiélago. Con las pruebas no paramétricas se estimó que el número esperado de especies arrecifales presentes en Revillagigedo es de  $244.3 \pm 3.2$ , lo que implica que se ha registrado cerca del 96% de la riqueza total de este grupo en la localidad. Comparando la calidad del inventario ictiofaunístico de las islas Revillagigedo con el reportado para la fauna de peces del Pacífico oriental en general, y para arrecifes en otras partes del mundo, se observó que en el archipiélago el esfuerzo de muestreo y su calidad han sido altas, a pesar de la dificultad logística para realizar estudios en la zona.

**Palabras clave:** Pacífico oriental tropical, Islas oceánicas, Endemismo, Inventario, Ictiofauna

## Introduction

The Revillagigedo Archipelago is located in the tropical eastern Pacific, approximately 400 km southwest of the southwestern tip of the Baja California Peninsula (Brattstrom, 1990), and is politically administered by México. The archipelago is composed of four volcanic islands (Socorro, Clarión, San Benedicto and Roca Partida, in order of size), that emerge from a depth of 3500 m, along the eastern edge of the Clarión fracture zone (Castellanos & Ortega-Rubio, 1994). From a marine zoogeography perspective, the islands are considered as a part of the Oceanic Island Province (*sensu* Robertson & Cramer, 2009), although most researchers place them in the Panamic Province (Spalding *et al.*, 2007).

Because of the archipelago's strategic importance, there is a permanent presence of the Mexican Navy on Socorro and Clarión Islands. Furthermore, the islands are part of a biosphere reserve (Anonymous, 2004) and have a local staff responsible for management. These initiatives and the access to local facilities have allowed researchers to conduct a continuous program to characterize the terrestrial fauna of the Revillagigedo Islands (Castellanos & Ortega-Rubio, 2004). However, the situation with the marine ecosystems is different since no well-equipped boats are available. Consequently, the increase in knowledge and accumulation of data have been slower. In spite of this, there is fairly good information available about the composition of floras and faunas, and among the most recent (post 1990) relevant papers are those of León-Tejera *et al.* (1996) and Serviere-Zaragoza *et al.* (2007) for macroalgae, Glynn *et al.* (1996) and Ketchum & Reyes-Bonilla (2001) for corals, Mille-Pagaza *et al.* (1994), Emerson (1995) and Reyes-Bonilla (1999) for molluscs, and Mille-Pagaza *et al.* (2003) and Hernández-Aguilera (2002) for decapod crustaceans. Additionally, Bautista-Romero *et al.* (1994) and Mille-Pagaza *et al.* (2002) published a detailed checklist that incorporated a number of groups of macroinvertebrates.

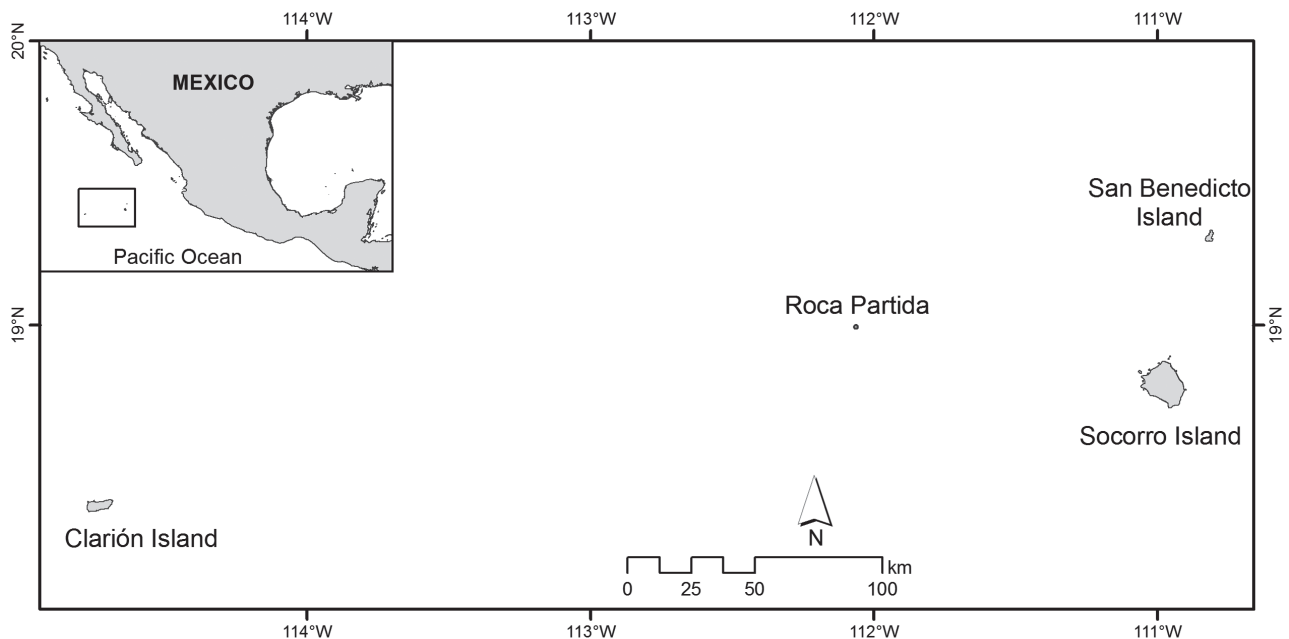
With regard to the ichthyofauna, the first publications date back to the late 19th and early 20th centuries (Jordan & McGregor, 1899; Snodgrass & Heller, 1905). Records accumulated over time and by the 1990s more than 150 species had been reported (Allen & Robertson, 1996). Later, papers from Castro-Aguirre & Balart (2002), Robertson & Cramer (2009) and Chávez-Comparán *et al.* (2010) reported between 83 and 212 species of reef fish. Robertson & Allen (2015) recorded a total of 320 species, although only 292 of them were confirmed. This reference includes typical reef taxa such as Muraenidae, Serranidae and Chaetodontidae, but also pelagic species of Carcharhinidae, Exocoetidae and Carangidae. These publications made evident that the archipelago's fish fauna is mostly composed of species from the Panamic Province, with elements of circumtropically distributed species, a number of transpacific species, and a relatively high proportion of endemics (between 4.2% and 5.2%). Unfortunately, because of the archipelago's remoteness and the relatively low effort dedicated to characterize its fish fauna, there is still much to learn about it.

The particular location of the Revillagigedo Islands in a transitional zone where the California and Costa Rica currents converge (Fiedler & Talley, 2006) makes the archipelago an interesting setting for marine fauna because of the combination of species from different biogeographic regions. Also, the islands are recognized as key stepping stones for the colonization of (Ketchum & Reyes Bonilla, 1997, 2001; Lessios & Robertson, 2006), and reef fish are no exception to this pattern (Robertson *et al.*, 2004; Robertson & Allen, 2015). Because of the importance of the archipelago, and fueled by the interest to generate better information about its fish communities, this paper presents an updated checklist of the cartilaginous and bony fishes observed or collected at the Revillagigedo Archipelago and its surroundings. To perform this task, we started by taking the most recent compilations, correcting the nomenclature of the cited species where necessary, and introduced new information obtained from field observations, and from confirmed reports of specimens deposited in collections in the United States. Finally, all the information was used to analyze the completeness of the reef fish inventory of the islands, using a series of non-parametric rarefaction methods.

## Material and methods

This fish checklist of the Revillagigedo Archipelago was compiled in several steps. We started with the most recent formally published list of Castro-Aguirre & Balart (2002), which was then modified as follows. First, we carried out a bibliographic review of all papers published from 2003 to 2015 on the ichthyofauna of the islands in refereed journals, technical books, and from the list included in the Management Plan of the Biosphere Reserve

(Anonymous, 2004). Second, we confirmed the taxonomic status of all species using the *Catalog of Fishes* (Eschmeyer & Fricke, 2015a: <http://researcharchive.calacademy.org/research/ichthyology/catalog>), in order to eliminate synonyms and generate a list of valid names.



**FIGURE 1.** Location of the Revillagigedo Archipelago, in the tropical eastern Pacific.

In parallel, we conducted field surveys at the four islands of the archipelago in December 1994, May 1995, February–May 1999, April 2010, February, April and December 2012 and January–March 2013, carrying out between 15 and 77 dives per visit. In the first three years we recorded abundance and identity of the fishes sighted at time intervals of 30–45 minutes. In 2010, 2012 and 2013 visual censuses were performed along belt transects of 25 x 4 m (77 transects in 2010, 27 in 2012 and 28 in 2013, surveying during each visit an area between 2700 m<sup>2</sup> and 7700 m<sup>2</sup>). Transects were run for 8–16 m, and for 16–24 m at each site. In 2012 and 2013 we also conducted 32 observation dives during which the occurrence of all fish species was recorded. The identification of species observed in the field was done from illustrations in Allen & Robertson (1994), Gotshall (1998), Humann & De Loach (2004), and Robertson & Allen (2015).

The last undertaking was to gather information from electronic and in-house sources. This entailed consulting curators and visits to collections at institutions in the United States of America, as well as carrying out internet searches on international databases of geographical distribution of marine taxa. In both instances we selected only the records of fishes that were explicitly mentioned as seen or had been collected at the Revillagigedo Archipelago, or within a 50 km radius from the centre of each island. The specimens are housed at the following institutions: National Museum of Natural History, Smithsonian Institution (USNM, Washington), Los Angeles Natural History Museum (LACM, Los Angeles), and the Scripps Institution of Oceanography (SIO, San Diego). To make the checklist as inclusive as possible, the selection of reports was independent of the method of collection, depth or year. It is important to note that most of the species referred to in these museum records had previously been reported in scientific publications or had been visually confirmed during our field surveys. As in previous cases, the nomenclature of the taxa was confirmed from the *Catalog of Fishes* (Eschmeyer & Fricke, 2015a). If a record was dubious because of the rareness of the species in the eastern Pacific or for other reasons, we consulted the museum's curator for confirmation and placed them in a separate table (Table 3).

Although in reef studies it is usual to restrict faunal inventories to shallow-water and benthic species (e.g. Castro-Aguirre & Balart, 2002), we decided to include pelagic and deep water species in this checklist. With the steep topography of the island it is common to observe many of these species close to the reefs or near the surface during the night very close to the coastline. However, because of the difference in the quality of the available information for these groups, and conscious that the data for reef fishes is usually much better than for pelagic or deep water species (Eschmeyer *et al.*, 2010), we listed them separately: one for reef fishes (Table 1) and another for

non-reef species (brackish water, pelagic and deep-water fish; Table 2). We used the list of reef taxa to build a matrix of species versus the data from museums, field surveys and literature (a total of 20 different data sources that were used as sampling units; Mora *et al.*, 2008) for the estimates of completeness of the fish fauna (a proxy for total gamma diversity; Reyes-Bonilla *et al.*, 2008). This was done for the entire reef fauna and for each of the 16 families represented by at least 5 species in the checklist. The analyses were carried out using Primer ver. 6.0 software, and the non-parametric methods of Chao 2, Jackknife 1, Jackknife 2, and Bootstrap (with 1000 permutations). These procedures were selected as they are suitable for information of species presence and absence, and have been demonstrated to be accurate estimators of richness (Dixon, 2001). Further details of the techniques are provided by Gotelli & Colwell (2011).

With the values obtained by these methods we calculated the average and standard deviation of the expected richness in total and for each reef fish family, and analyzed the differences between these data and the observed species diversity. We applied two procedures. The first, described by Sokal & Rohlf (2012), assumes that the data follow a normal distribution, and uses a modified Student's t-test to compare individual values of estimated against expected values. The second assumes that the data are non-parametric. This was done by resampling the data from the results of the four methods used to assess completeness of the inventory 1000 times, and comparing the expected figure and its confidence interval, to the actual number. We considered the difference as significant if the known species richness had a probability of occurrence of less than 5% (Dixon, 2001).

## Results

We confirmed the occurrence of 389 species of marine fish off the Revillagigedo Archipelago, in 254 genera, 102 families, 27 orders, and 2 classes (Tables 1 and 2). Of these, we observed 151 species in the field, while the literature review yielded 345 species reported for the island, and 247 records came from museums; the numbers do not add to 389 because many species have appeared in at least two information sources or were seen or directly recorded after dives by the authors. The most speciose families were the Carangidae (23), Serranidae (21), Exocoetidae (20), Muraenidae (19), Labridae (16), Carcharhinidae (14), Pomacentridae (14), Scombridae (14), and Myctophidae (13). From a habitat perspective, 235 (60.41%) are considered as reef fish, while 154 species (39.59%) are brackish water, deep water or pelagic species. In addition, we found 10 more taxa that have been reported to occur in the archipelago, but that we consider doubtful as their distribution does not normally include the Revillagigedo Islands. Because their identification has not been confirmed yet, they are listed in Table 3.

This study also confirmed that the Revillagigedo Archipelago has 13 endemic species of fishes (3.3% of the total, and 5.5% of the reef taxa): *Axoclinus multicinctus* Allen & Robertson, 1992, *Acanthemblemaria mangognatha* Hastings & Robertson, 1999, *Dactyloscopus insulatus* Dawson, 1975, *Enneanectes exsul* Rosenblatt, Miller & Hastings, 2013, *Gobiesox aethus* (Briggs, 1951), *Gobiesox canidens* (Briggs, 1951), *Hypsoblennius proteus* (Krejsa, 1960), *Labrisomus socorroensis* Hubbs, 1953, *Lythrypnus insularis* Bussing, 1990, *Rypticus courtenayi* McCarthy, 1979, *Serranus socorroensis* Allen & Robertson, 1992, and *Tomicodon absitus* Briggs, 1955, as well as the undescribed species *Xyrichtys* species B, pictured by D. Gotshall.

Although over 90% of the species in Tables 1 and 2 were confirmed either to be present in the field, or are referred to in scientific publications, there are 7 reef taxa and 28 deep-water or pelagic fishes which were recorded exclusively from museum collections. To these 35 museum-only records, we added eight families to the checklist (Nemichthyidae, Bathylaconidae, Gonostomatidae, Sternoptychidae, Stomiidae, Trachipteridae, Melamphidae, and Oplegnathidae) that have not previously been reported for the archipelago, most likely because they represent deep water species.

Robertson & Allen (2015) noted 28 fishes as potentially present in the area, but with no confirmed records. We establish the presence of 4 of these from museum collections (Table 1): *Bregmaceros bathymaster* Jordan & Bollman, 1890 (SIO-63820), *Remora brachyptera* (Lowe, 1839) (SIO-73375), *Scarus compressus* (Osburn & Nichols, 1916) (LACM-31782.033), *Synodus lacertinus* Gilbert, 1890 (LACM-31782.001), and of *Carcharhinus longimanus* (Poey, 1861) from field observation (1994-1999 and 2012). This means that at least 24 other reef fish may be resident of the islands, but their presence is still unsubstantiated.

Estimates obtained by non-parametric methods indicate that the expected richness of reef fish is higher than the 235 confirmed to date species (Table 1), with values fluctuating between 241.5 (Chao 2) to 247.8 (Jackknife 2) species, with an average of  $244.3 \pm 3.2$  (s.d.) species. This assessment suggests that the local inventory represents 96.1% of the expected total richness and that approximately 9 fish species may be still unreported for the archipelago. Analyzing the data at a lower taxonomic level, the total richness reported for each family represented

**TABLE 1.** Checklist of reef fishes of the Revillagigedo Archipelago.

Key to museums: **USNM**) National Museum of Natural History, Smithsonian Institution; **SIO**) Scripps Institution of Oceanography, San Diego; **LACM**) Natural History Museum of Los Angeles.

References: **1)** Snodgrass & Heller 1905; **2)** Schmitt & Schultz 1940; **3)** Bautista-Romero *et al.* 1994; **4)** Castro-Aguirre & Balart 2002; **5)** CONANP-SEMARNAT 2004; **6)** Robertson & Allen 2006; **7)** Chávez-Comarán *et al.* 2010; **8)** IOC of UNESCO 2010; **9)** Robertson & Allen 2015 (\*Unconfirmed species); **10)** GBIF 2011; **11)** Froese & Pauly 2015; **12)** Eschmeyer & Fricke 2015b.

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<b>Phylum CHORDATA</b>						
<b>Clase CHONDRICHTHYES</b>						
<b>Order LAMNIFORMES</b>						
<b>Family Lamnidae</b>						
<i>Carcharodon carcharias</i> (Linnaeus, 1758)						3, 4, 5, 6, 11
<b>Order CARCHARHINIFORMES</b>						
<b>Family Carcharhinidae</b>						
<i>Carcharhinus albimarginatus</i> (Rüppell, 1837)	+		+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 9, 12
<i>Carcharhinus galapagensis</i> (Snodgrass & Heller, 1905)	+		+	+	SIO, USNM, LACM	4, 5, 6, 8, 9, 12
<i>Carcharhinus leucas</i> (Müller & Henle, 1839)						3, 4, 5, 6, 8, 9
<i>Carcharhinus limbatus</i> (Müller & Henle, 1839)	+				SIO, LACM	3, 4, 5, 6, 8, 9, 11
<i>Galeocerdo cuvier</i> (Péron & Lesueur, 1822)	+		+	+	SIO	3, 4, 5, 6, 8, 9, 11, 12
<i>Triaenodon obesus</i> (Rüppell, 1837)	+		+	+		4, 5, 6, 8, 9, 11
<b>Family Sphyrnidae</b>						
<i>Sphyrna lewini</i> (Griffith & Smith, 1834)	+		+	+	LACM	3, 4, 6, 8, 9
<b>Order MYLIOBATIFORMES</b>						
<b>Family Dasyatidae</b>						
<i>Dasyatis diptera</i> (Jordan & Gilbert, 1880)					LACM	8, 9
<i>Dasyatis longa</i> (Garman, 1880)			+	+	SIO, LACM	5, 6, 8, 7, 9, 11
<b>Family Myliobatidae</b>						
<i>Aetobatus narinari</i> (Euphrasen, 1790)						4, 5, 6, 8, 9
<i>Manta birostris</i> (Walbaum, 1792)						3, 4, 5, 6, 8, 9, 11
<i>Mobula tarapacana</i> (Philippi, 1892)	+		+	+	SIO	4, 6, 8, 9
<b>Order ECHINORHINIFORMES</b>						
<b>Family Echinorhinidae</b>						

.....continued on the next page



TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Echinorhinus cookei</i> Pietschmann, 1928						6, 8, 9
<b>Order TORPEDINIFORMES</b>						
<b>Family Narcinidae</b>						
<i>Narcine entemedor</i> Jordan & Starks, 1895	+	+		+	SIO, LACM	5, 6, 8, 7, 9
<b>Clase ACTINOPTERYGII</b>						
<b>Order ANGUILLIFORMES</b>						
<b>Family Muraenidae</b>						
<i>Anarchias galapagensis</i> (Seale, 1940)					SIO, LACM	6, 8, 9
<i>Echidna nebulosa</i> (Ahl, 1789)						4, 6, 8, 9
<i>Echidna nocturna</i> (Cope, 1872)	+					1, 4, 5, 6, 8, 9, 12
<i>Enchelycore octaviana</i> (Myers & Wade, 1941)	+			+	LACM	5, 6, 8, 9
<i>Gymnomuraena zebra</i> (Shaw, 1797)	+	+	+	+		4, 5, 6, 8, 7, 9
<i>Gymnothorax castaneus</i> (Jordan & Gilbert, 1883)	+	+	+	+	SIO, LACM	4, 5, 6, 8, 7, 9, 10, 11
<i>Gymnothorax dovii</i> (Günther, 1870)	+				LACM	3, 4, 5, 6, 8, 9
<i>Gymnothorax flavimarginatus</i> (Rüppell, 1830)						4, 5, 6, 8, 9, 11
<i>Gymnothorax panamensis</i> (Steindachner, 1876)					SIO, LACM	3, 4, 5, 6, 8, 9, 11, 12
<i>Gymnothorax pictus</i> (Ahl, 1789)						1, 4, 5, 6, 8, 9, 11, 12
<i>Gymnothorax undulatus</i> (Lacepède, 1803)						4, 5, 6, 8, 9, 11
<i>Muraena argus</i> (Steindachner, 1870)						4, 6, 8, 9
<i>Muraena clepsydra</i> Gilbert, 1898						4, 6, 8, 9
<i>Muraena lentiginosa</i> Jenyns, 1842					LACM	3, 4, 5, 6, 8, 7, 9
<i>Uropterygius macrocephalus</i> (Bleeker, 1864)	+			+	SIO, LACM	3, 4, 5, 6, 8, 9, 11, 12
<i>Uropterygius polystictus</i> Myers & Wade, 1941						4
<i>Uropterygius versutus</i> Bussing, 1991						5, 6, 8, 9
<i>Scuticaria tigrina</i> (Lesson, 1828)	+	+	+	+	LACM	4, 5, 6, 8, 7, 9, 11
<b>Family Ophichthidae</b>						
<i>Ichthyapus selachops</i> (Jordan & Gilbert, 1882)					LACM	5, 6, 8, 9, 11
<i>Myrichthys pantostigmus</i> Jordan & McGregor, 1898	+	+				1, 5, 6, 8, 7, 9, 11, 12

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Paraletharchus opercularis</i> (Myers & Wade, 1941)					LACM	5, 6, 8, 9
<b>Family Congridae</b>						
<i>Ariosoma gilberti</i> (Ogilby, 1898)					SIO	8, 9
<i>Heteroconger digneti</i> (Pellegriin, 1923)						8,9
<i>Paraconger californiensis</i> Kanazawa, 1961					SIO, LACM	5, 6, 8, 9
<i>Paraconger similis</i> (Wade, 1946)						8, 9, 11
<b>Order AULOPIFORMES</b>						
<b>Family Synodontidae</b>						
<i>Synodus lacertinus</i> Gilbert, 1890					LACM	8, 9*
<b>Order OPHIDIIFORMES</b>						
<b>Family Ophidiidae</b>						
<i>Brotula ordwayi</i> Hildebrand & Barton, 1949					LACM	8, 9
<b>Family Bythitidae</b>						
<i>Grammonus diagrammus</i> (Heller & Snodgrass, 1903)					LACM	5, 6, 8, 9
<b>Order LOPHIIFORMES</b>						
<b>Family Antennariidae</b>						
<i>Antennarius commerson</i> (Lacepède, 1798)						5, 6, 8, 9
<i>Antennarius sanguineus</i> (Gill, 1863)					SIO, LACM	4, 5, 6, 8, 9
<i>Antennatus strigatus</i> (Gill, 1863)					LACM	4, 5, 6, 8, 9
<b>Order MUGILIFORMES</b>						
<b>Family Mugilidae</b>						
<i>Chaenomugil proboscideus</i> (Günther, 1861)					SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 9, 10, 11, 12
<i>Mugil curena</i> Valenciennes, 1836						
<i>Mugil setosus</i> Gilbert, 1892					SIO, LACM	1, 3, 4, 5, 6, 8, 9, 12
<i>Xenomugil thoburni</i> (Jordan & Starks, 1896)					SIO, USNM, LACM	1, 2, 4, 5, 6, 8, 9, 11, 12
<b>Order ATHERINIFORMES</b>						
<b>Family Atherinopsidae</b>					USNM	4
<i>Atherinella eriarcha</i> Jordan & Gilbert, 1882					SIO, LACM	3, 4, 5, 6, 8, 9, 11, 12

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<b>Order BELONIFORMES</b>						
<b>Family Belontiidae</b>						
<i>Tylosurus crocodilus fodiator</i> Jordan & Gilbert, 1882					SIO	8, 9, 12
<i>Tylosurus acus melanotus</i> (Bleeker, 1850)						5, 6, 8, 9, 11
<i>Tylosurus pacificus</i> (Steindachner, 1876)					USNM, LACM	8, 9
<b>Order BERYCIFORMES</b>						
<b>Family Holocentridae</b>						
<i>Myripristis berndti</i> Jordan & Evermann, 1903	+		+	+		5, 6, 8, 9
<i>Myripristis clarionensis</i> Gilbert, 1897		+			SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<i>Neoniphon suborbitalis</i> (Gill, 1863)	+		+	+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 12
<i>Myripristis leiognathus</i> Valenciennes, 1846	+		+	+	LACM	4, 5, 6, 8, 7, 9, 11
<i>Plectrypops lima</i> (Valenciennes, 1831)	+		+		SIO, LACM	5, 6, 8, 9
<b>Order GASTEROSTEIFORMES</b>						
<b>Family Syngnathidae</b>						
<i>Bryx veleronis</i> Herald 1940					SIO, LACM	4, 5, 6, 8, 9, 11
<i>Doryrhamphus excisus paulus</i> Kaup, 1856	+				SIO, LACM	3, 4, 5, 6, 8, 9, 11, 12
<b>Family Aulostomidae</b>						
<i>Aulostomus chinensis</i> (Linnaeus, 1766)	+		+	+	SIO, LACM	3, 4, 5, 6, 8, 9, 11
<b>Family Fistulariidae</b>						
<i>Fistularia commersonii</i> Rüppell, 1838	+	+	+	+	SIO, LACM	4, 5, 6, 8, 7, 9
<b>Order SCORPAENIFORMES</b>						
<b>Family Scorpaenidae</b>						
<i>Pontinus vaughani</i> Barnhart & Hubbs, 1946					SIO, LACM	4, 5, 6, 8, 9, 11
<i>Scorpaena histrio</i> Jenyns, 1840						4, 6, 8, 7, 9
<i>Scorpaena mystes</i> Jordan & Starks, 1895	+	+	+	+		4, 5, 6, 8, 7, 9, 11
<i>Scorpaenodes xyris</i> (Jordan & Gilbert, 1882)		+			SIO, LACM	1, 3, 4, 5, 6, 8, 9, 11, 12

.....continued on the next page



TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field Observation (2010)	Field observation (2012-2013)	Museum records	References
<b>Order PERCIFORMES</b>						
<b>Family Serranidae</b>						
<i>Alphestes immaculatus</i> Breder, 1936				+	SIO	8, 9
<i>Alphestes multiguttatus</i> (Günther, 1867)						4
<i>Cephalopholis colonus</i> (Valenciennes, 1846)	+	+	+	+	SIO, LACM	3, 4, 5, 6, 8, 7, 9, 11, 12
<i>Cephalopholis panamensis</i> (Steindachner, 1876)	+	+	+	+	USNM, LACM	4, 8, 7, 9
<i>Dermatolepis dermatolepis</i> (Boulenger, 1895)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<i>Diplectrum euryplectrum</i> Jordan & Bollman, 1890					USNM	8, 9
<i>Epinephelus anologus</i> Gill, 1863					LACM	1, 2, 4, 5, 6, 8, 7, 9, 11, 12
<i>Epinephelus cifuensis</i> Lavenberg & Grove, 1993					SIO	6, 8, 9
<i>Epinephelus clippertonensis</i> Allen & Robertson, 1999		+	+	+		6, 8, 9, 11
<i>Epinephelus quinquefasciatus</i> (Bocourt, 1868)	+		+	+	SIO	6, 9
<i>Epinephelus labriformis</i> (Jenyns, 1840)	+	+	+	+	SIO, USNM, LACM	1, 2, 3, 4, 5, 6, 8, 7, 9, 10, 12
<i>Hyporhamphus niphobles</i> (Gilbert & Starks, 1897)					SIO	
<i>Mycteroperca jordani</i> (Jenkins & Evermann, 1889)						3, 5, 6, 8, 9
<i>Mycteroperca prionura</i> Rosenblatt & Zahuranec, 1967						5
<i>Pronotoگرامmus multifasciatus</i> Gill, 1863						1, 5, 6, 8, 9, 12
<i>Pseudogramma thaumasia</i> (Gilbert, 1900)					LACM	8, 9
<i>Rypticus courtenayi</i> McCarthy, 1979					SIO, LACM	4, 5, 6, 8, 7, 9, 11, 12
<i>Rypticus nigripinnis</i> Gill, 1861			+	+	USNM, LACM	8, 9
<i>Serranus aequidens</i> Gilbert, 1890					USNM	
<i>Serranus socorroensis</i> Allen & Robertson, 1992					SIO, USNM, LACM	4, 5, 6, 8, 9, 11
<b>Family Opistognathidae</b>						
<i>Opisthognathus punctatus</i> Peters, 1869					SIO	8, 9
<i>Opisthognathus rhomaleus</i> Jordan & Gilbert, 1882					SIO	5, 6, 8, 9, 11
<i>Opisthognathus rosenblatti</i> Allen & Robertson, 1991						8, 9

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<b>Family Priacanthidae</b>						
<i>Cookeolus japonicus</i> (Cuvier, 1829)					SIO	4, 5, 6, 8, 9, 11
<i>Heteropriacanthus cruentatus</i> (Lacepède, 1801)	+			+	USNM, LACM	1, 3, 4, 5, 6, 8, 9, 11, 12
<i>Priacanthus alalaua</i> Jordan & Evermann, 1903					LACM	4, 5, 6, 8, 9, 11
<i>Pristigenys serrula</i> (Gilbert, 1891)						4, 5, 6, 8, 9, 11
<b>Family Apogonidae</b>						
<i>Apogon atricaudus</i> Jordan & McGregor, 1898	+		+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 9, 11, 12
<i>Apogon dovii</i> Günther, 1862						8, 9
<i>Apogon guadalupensis</i> (Osburn & Nichols, 1916)		+			LACM	4, 5, 6, 8, 7, 9
<i>Apogon retrosella</i> (Gill, 1862)		+			SIO	8, 9, 12
<b>Family Malacanthidae</b>						
<i>Caulolatilus princeps</i> (Jenyns, 1840)					LACM	4, 5, 6, 8, 9, 11
<i>Caulolatilus affinis</i> Gill, 1865						9
<b>Family Echeineidae</b>						
<i>Echeneis naucrates</i> Linnaeus, 1758						3, 5, 6, 8, 9
<b>Family Carangidae</b>						
<i>Alectis ciliaris</i> (Bloch, 1787)					LACM	5, 6, 8, 9
<i>Carangoides orthogrammus</i> (Jordan & Gilbert, 1882)	+			+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 9, 11, 12
<i>Caranx lugubris</i> Poey, 1860	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 11, 12
<i>Caranx melampygus</i> Cuvier, 1833	+	+	+	+	SIO, USNM, LACM	1, 2, 3, 5, 6, 8, 7, 9, 12
<i>Caranx sexfasciatus</i> Quoy & Gaimard, 1825	+		+	+	LACM	1, 2, 3, 4, 5, 6, 8, 9, 12
<i>Elagatis bipinnulata</i> (Quoy & Gaimard, 1825)	+				SIO, LACM	4, 5, 6, 8, 7, 9, 11
<i>Seriola lalandi</i> Valenciennes, 1833				+		8, 9
<i>Trachinotus stilbe</i> (Jordan & McGregor, 1898)	+			+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 9, 12
<i>Uraspis helvola</i> (Forster, 1801)	+		+	+	SIO, LACM	4, 5, 6, 8, 9
<b>Family Lutjanidae</b>						
<i>Hoplopagnus guentherii</i> Gill, 1862				+		8, 9

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Lutjanus argentiventris</i> (Peters, 1869)	+					5, 6, 8, 9
<i>Lutjanus inermis</i> (Peters, 1869)		+				7
<i>Lutjanus peru</i> (Nichols & Murphy, 1922)					SIO, LACM	5, 6, 8, 9
<i>Lutjanus viridis</i> (Valenciennes, 1846)		+	+	+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 11, 12
<b>Family Gerreidae</b>						
<i>Diapterus brevirostris</i> (Cuvier, 1830)						5, 6, 8, 9
<b>Family Haemulidae</b>						
<i>Anisotremus interruptus</i> (Gill, 1862)	+			+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 12
<i>Anisotremus taeniatus</i> Gill, 1861		+		+	USNM	8, 9
<i>Orthopristis chalcus</i> (Günther, 1864)						
<b>Family Sparidae</b>						
<i>Calamus brachysomus</i> (Lockington, 1880)						8, 9
<b>Family Sciaenidae</b>						
<i>Pareques</i> species A						5, 6, 8, 9
<b>Family Mullidae</b>						
<i>Mulloidichthys dentatus</i> (Gill, 1862)	+	+	+	+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 12
<i>Pseudupeneus grandisquamis</i> (Gill, 1863)						5, 6, 8, 9
<b>Family Kyphosidae</b>						
<i>Girella nigricans</i> (Ayres, 1860)					USNM	8, 12
<i>Kyphosus vaigiensis</i> (Gill, 1862)		+		+		1, 4, 5, 6, 8, 7, 9, 12
<i>Kyphosus elegans</i> (Peters, 1869)	+	+	+	+	SIO, LACM	1, 3, 5, 6, 8, 7, 9, 12
<i>Kyphosus sectatrix</i> (Jordan & Gilbert, 1882)	+	+	+	+	SIO, LACM	1, 3, 5, 6, 8, 7, 9, 12
<i>Kyphosus ocyurus</i> (Jordan & Gilbert, 1882)		+		+	SIO	4, 5, 6, 8, 9
<b>Family Chaetodontidae</b>						
<i>Chaetodon humeralis</i> Günther, 1860		+			LACM	8, 7, 9
<i>Chaetodon meyeri</i> Bloch & Schneider, 1801						5, 6, 8, 9
<i>Forcipiger flavissimus</i> Jordan & McGregor, 1898	+	+	+	+	SIO, USNM, LACM	4, 5, 6, 8, 7, 9, 11, 12

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Forcipiger longirostris</i> (Broussonet, 1782)					SIO, LACM	1, 3, 12
<i>Johnrandallia nigrostris</i> (Gill, 1862)	+	+	+	+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 12
<i>Prognathodes falcifer</i> (Hubbs & Rehnitz 1958)	+		+	+		4, 5, 6, 8, 9
<b>Family Pomacanthidae</b>						
<i>Holacanthus clarionensis</i> Gilbert, 1890	+	+	+	+	SIO, USNM, LACM	1, 3, 5, 6, 8, 7, 9, 10, 11, 12
<i>Holacanthus passer</i> Valenciennes, 1846	+		+	+		6, 8, 9
<i>Pomacanthus zonipectus</i> (Gill, 1862)				+		6, 8, 9
<b>Family Kuhliidae</b>						
<i>Kuhlia mugil</i> (Forster, 1801)					SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 11, 12
<b>Family Cirrhitidae</b>						
<i>Cirrhitichthys oxycephalus</i> (Bleeker, 1855)	+	+	+	+	SIO, LACM	4, 5, 6, 8, 7, 9, 10
<i>Cirrhitus rivulatus</i> Valenciennes, 1846	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 12
<i>Oxyrrhites typus</i> Bleeker, 1857						4, 6, 8, 9
<b>Family Pomacentridae</b>						
<i>Abudefduf declivifrons</i> (Gill, 1862)						6, 8, 9
<i>Abudefduf troschelii</i> (Gill, 1862)		+			SIO, USNM, LACM	4, 5, 6, 8, 7, 9, 10, 11, 12
<i>Azurina hirundo</i> Jordan & McGregor, 1898	+	+	+	+	SIO	4, 5, 6, 8, 7, 9, 11, 12
<i>Chromis alta</i> Greenfield & Woods, 1980	+				SIO	5, 6, 8, 9
<i>Chromis atrilobata</i> Gill, 1862		+	+	+	LACM	3, 4, 5, 6, 8, 9
<i>Chromis limbaughi</i> Greenfield & Woods, 1980						5, 6, 8, 9
<i>Hypsypops rubicundus</i> (Girard, 1854)						8, 9, 12
<i>Microspathodon bairdii</i> (Gill, 1862)	+				SIO, LACM	1, 3, 4, 5, 6, 8, 9, 11, 12
<i>Microspathodon dorsalis</i> (Gill, 1862)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<i>Stegastes acapulcoensis</i> (Fowler, 1944)						4, 6, 8, 9
<i>Stegastes flavilatus</i> (Gill, 1862)	+	+	+	+	LACM	3, 4, 5, 6, 8, 9, 12

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Stegastes leucurus</i> (Gilbert, 1892)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<i>Stegastes rectifraenum</i> (Gill, 1862)		+			LACM	3, 4, 5, 6, 8, 9, 10
<i>Stegastes redemptus</i> (Heller & Snodgrass, 1903)	+	+			SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<b>Family Labridae</b>						
<i>Bodianus diplotaenia</i> (Gill, 1862)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 12
<i>Halichoeres adustus</i> (Gilbert, 1890)			+	+	USNM	1, 4, 5, 6, 8, 7, 9, 11, 12
<i>Halichoeres chierchiae</i> Di Caporiacco, 1948		+		+		8, 9
<i>Halichoeres dispilus</i> (Günther, 1864)		+		+		4, 8, 7, 9
<i>Halichoeres insularis</i> Allen & Robertson, 1992		+	+	+	USNM, LACM	4, 5, 6, 8, 7, 9, 11
<i>Halichoeres melanotis</i> (Gilbert, 1890)	+			+		4, 8, 7, 9
<i>Halichoeres nicholsi</i> (Jordan & Gilbert, 1882)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 11
<i>Halichoeres notospilus</i> (Günther, 1864)	+		+	+	LACM	1, 3, 4, 5, 6, 8, 7, 9, 12
<i>Iniistius pavo</i> (Valenciennes, 1840)	+					3, 4, 5, 6, 8, 9
<i>Novaculichthys taeniourus</i> (Lacepède, 1801)	+	+				3, 4, 5, 6, 8, 9
<i>Stethojulis bandanensis</i> (Bleeker, 1851)						3, 4, 5, 6, 8, 9
<i>Thalassoma grammaticum</i> Gilbert, 1890	+	+		+	SIO, USNM, LACM	1, 5, 6, 8, 7, 9, 12
<i>Thalassoma lucasanum</i> (Gill, 1862)	+	+	+	+	SIO, LACM	3, 4, 5, 6, 8, 7, 9, 10, 12
<i>Thalassoma lutescens</i> (Lay & Bennett, 1839)					SIO, USNM, LACM	3, 4, 10
<i>Thalassoma virens</i> Gilbert, 1890	+	+	+	+	SIO, USNM, LACM	1, 4, 5, 6, 8, 7, 9, 10, 12
<i>Xyrichtys</i> species B						5, 6, 8, 9
<b>Family Scaridae</b>						
<i>Scarus compressus</i> (Osburn & Nichols, 1916)	+				LACM	8, 7, 9*
<i>Scarus ghobban</i> Forsskål, 1775		+				5, 7
<i>Scarus perrico</i> Jordan & Gilbert, 1882		+			SIO	9
<i>Scarus rubroviolaceus</i> Bleeker, 1847	+	+	+	+	SIO, LACM	4, 5, 6, 8, 7, 9, 11, 12
<i>Calotomus carolinus</i> (Valenciennes, 1840)	+	+	+	+	SIO	1, 4, 5, 6, 8, 7, 9, 11, 12

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Nicholsina denticulata</i> (Evermann & Radcliffe, 1917)	+	+		+	USNM	7, 8, 9
<b>Family Tripterygiidae</b>						
<i>Axoclinus multicinctus</i> Allen & Robertson, 1992	+				SIO, USNM, LACM	4, 5, 6, 8, 9, 11
<i>Enneanectes exsul</i> Rosenblatt, Miller & Hastings, 2013						5, 6, 8, 9, 12
<b>Family Dactyloscopidae</b>						
<i>Dactyloscopus insulatus</i> Dawson, 1975					SIO, LACM	4, 5, 6, 8, 9, 11, 12
<i>Girella semicinctus</i> Gilbert, 1890					SIO, LACM	4, 5, 6, 8, 9
<i>Myxodagnus opercularis</i> Gill, 1861					SIO, LACM	4, 5, 6, 8, 9, 12
<b>Family Blenniidae</b>						
<i>Entomacrodus chioscticus</i> (Jordan & Gilbert, 1882)					SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 9, 10, 11, 12
<i>Hypsoblennius proteus</i> (Krejsa, 1960)					SIO, USNM, LACM	4, 5, 6, 8, 9, 11, 12
<i>Ophioblennius steindachneri</i> Jordan & Evermann, 1898	+	+	+		SIO, USNM, LACM	3, 4, 5, 6, 8, 9
<i>Plagiotremus azaleus</i> (Jordan & Bollman, 1890)	+	+	+	+	LACM	4, 5, 6, 8, 9
<b>Family Labrisomidae</b>						
<i>Malacotenus mexicanus</i> Springer, 1959						7
<i>Labrisomus multiporosus</i> Hubbs, 1953						3, 4, 5, 6, 8, 9
<i>Labrisomus socorroensis</i> Hubbs, 1953					SIO, LACM	3, 5, 6, 8, 9, 11, 12
<i>Labrisomus xanti</i> Gill, 1860					LACM	3, 4, 5, 6, 8, 9
<b>Family Chaenopsidae</b>						
<i>Acanthemblemaria mangonatha</i> Hastings & Robertson, 1999					USNM	5, 9
<b>Family Gobiessocidae</b>						
<i>Gobiesox adustus</i> Jordan & Gilbert, 1882					LACM	1, 5, 6, 8, 9, 12
<i>Gobiesox aethus</i> (Briggs, 1951)					SIO	4, 5, 6, 8, 9, 12
<i>Gobiesox canidens</i> (Briggs, 1951)					SIO	3, 4, 5, 6, 8, 9, 12
<i>Tomicodon absitus</i> Briggs, 1955					SIO	3, 4, 5, 6, 8, 9, 12
<i>Tomicodon eos</i> (Jordan & Gilbert, 1882)					SIO	12
<i>Tomicodon petersii</i> (Garman, 1875)					LACM	
<i>Tomicodon zebra</i> (Jordan & Gilbert, 1882)					SIO	8, 9, 12

.....continued on the next page



TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<b>Family Gobiidae</b>						
<i>Bathygobius ramosus</i> Ginsburg, 1947					SIO, USNM, LACM	3, 4, 5, 6, 8, 9, 10, 12
<i>Coryphopterus urosphilus</i> Ginsburg, 1938		+			SIO	4, 5, 6, 8, 7, 9, 12
<i>Lythrypnus insularis</i> Bussing, 1990					LACM	3, 4, 5, 6, 8, 9, 11
<i>Lythrypnus pulchellus</i> Ginsburg, 1938					LACM	4, 9
<i>Lythrypnus zebra</i> (Gilbert, 1890)					LACM	1, 3, 5, 6, 8, 9, 12
<b>Family Schindleriidae</b>						
<i>Schindleria praematura</i> (Schindler, 1930)					SIO, LACM	8, 9*
<b>Family Ephippidae</b>						
<i>Chaetodipterus zonatus</i> (Girard, 1858)					USNM	8
<b>Family Zancidae</b>						
<i>Zanclus cornutus</i> (Linnaeus, 1758)	+	+	+	+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<b>Family Acanthuridae</b>						
<i>Acanthurus nigricans</i> (Linnaeus, 1758)	+	+	+	+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<i>Acanthurus triostegus</i> (Linnaeus, 1758)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 11, 12
<i>Acanthurus xanthopterus</i> Valenciennes, 1835	+	+	+	+	SIO	4, 6, 8, 7, 9
<i>Ctenochaetus marginatus</i> (Valenciennes, 1835)	+	+	+	+	SIO	5, 6, 8, 7, 9
<i>Prionurus laticlavus</i> (Valenciennes, 1846)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<i>Prionurus punctatus</i> Gill, 1862	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12
<b>Order PLEURONECTIFORMES</b>						
<b>Family Bothidae</b>						
<i>Bothus leopardinus</i> (Günther, 1862)					LACM	1, 5, 6, 8, 7, 9, 12
<i>Bothus mancus</i> (Broussonet, 1782)					SIO, LACM	3, 4, 5, 6, 8, 7, 9, 11
<b>Order TETRAODONTIFORMES</b>						
<b>Family Balistidae</b>						
<i>Balistes polylepis</i> Steindachner, 1876	+	+		+	SIO, USNM, LACM	3, 4, 5, 6, 8, 7, 9, 12
<i>Canthidermis maculata</i> (Bloch, 1786)				+		4, 5, 6, 8, 9

.....continued on the next page

TABLE 1. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Melichthys niger</i> (Bloch, 1786)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 11, 12 8, 9
<i>Melichthys vidua</i> (Richardson, 1845)						7
<i>Pseudobalistes naufragium</i> (Jordan & Starks, 1895)						
<i>Sufflamen verres</i> (Gilbert & Starks, 1904)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 11, 12
<i>Xanthichthys mento</i> (Jordan & Gilbert, 1882)	+	+	+	+	SIO, USNM, LACM	1, 5, 6, 8, 7, 9, 11, 12
<b>Family Monacanthidae</b>						
<i>Aluterus monoceros</i> (Linnaeus, 1758)				+		5, 6, 8, 9
<i>Aluterus scriptus</i> (Osbeck, 1765)	+	+	+	+	SIO, LACM	1, 3, 4, 5, 6, 8, 7, 9, 12
<i>Cantherhines dumerilii</i> (Hollard, 1854)	+	+	+	+	SIO, LACM	3, 4, 5, 6, 8, 9, 11, 12
<b>Family Ostraciidae</b>						
<i>Lactoria diaphana</i> (Bloch & Schneider, 1801)					SIO, LACM	4, 6, 8, 9, 12
<i>Ostracion meleagris</i> Shaw, 1796	+	+	+	+	SIO, LACM	3, 4, 5, 6, 8, 7, 9, 12
<b>Family Tetraodontidae</b>						
<i>Arothron hispidus</i> (Linnaeus, 1758)	+					4, 5, 6, 8, 9
<i>Arothron meleagris</i> (Anonymous, 1798)	+	+	+	+	SIO, USNM, LACM	1, 3, 4, 5, 6, 8, 7, 9, 10, 12
<i>Canthigaster punctatissima</i> (Günther, 1870)	+	+	+	+	SIO, LACM	3, 4, 5, 6, 8, 7, 9, 12
<i>Guentheridia formosa</i> (Günther, 1870)					USNM	
<i>Sphoeroides lobatus</i> (Steindachner, 1870)						5, 6, 8, 7, 9
<b>Family Diodontidae</b>						
<i>Chilomycterus reticulatus</i> (Linnaeus, 1758)			+	+	SIO	5, 6, 8, 9
<i>Diodon eydouxii</i> Brisout de Barneville, 1846						5, 6, 8, 9
<i>Diodon holocanthus</i> Linnaeus, 1758	+	+	+	+	SIO, USNM, LACM	4, 5, 6, 8, 7, 9
<i>Diodon hystrix</i> Linnaeus, 1758	+	+	+	+	LACM	1, 3, 4, 5, 6, 8, 7, 9, 12

**TABLE 2.** Checklist of non-reef fishes of the Revillagigedo Archipelago.

Key to museums: **USNM**) National Museum of Natural History, Smithsonian Institution; **SIO**) Scripps Institution of Oceanography, San Diego; **LACM**) Natural History Museum of Los Angeles.  
References: **1)** Snodgrass & Heller 1905; **2)** Schmitt & Schultz 1940; **3)** Bautista-Romero *et al.* 1994; **4)** Castro-Aguirre & Balart 2002; **5)** CONANP-SEMARNAT 2004; **6)** Robertson & Allen 2006; **7)** Chávez-Comarán *et al.* 2010; **8)** IOC of UNESCO 2010; **9)** Robertson & Allen 2015 (\*Unconfirmed species); **10)** GBIF 2011; **11)** Froese & Pauly 2015; **12)** Eschmeyer & Fricke 2015b.

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<b>Phylum CHORDATA</b>						
<b>Clase CHONDRICHTHYES</b>						
<b>Order ORECTOLOBIFORMES</b>						
<b>Family Rhincodontidae</b>						
<i>Rhincodon typus</i> Smith, 1828	+			+		3, 4, 5, 6, 8, 9, 11
<b>Order LAMNIFORMES</b>						
<b>Family Alopiidae</b>						
<i>Alopias pelagicus</i> Nakamura, 1935						6, 9*
<i>Alopias superciliosus</i> Lowe, 1841						3, 5, 6, 9*
<i>Alopias vulpinus</i> (Bonnaterre, 1788)						5, 6
<b>Family Triakidae</b>						
<i>Galeorhinus galeus</i> (Linnaeus, 1758)					LACM	5, 6, 8, 9
<b>Family Lamnidae</b>						
<i>Isurus oxyrinchus</i> Rafinesque, 1810						4, 5, 6, 8, 9*, 11
<b>Order CARCHARHINIFORMES</b>						
<b>Family Scyliorhinidae</b>						
<i>Cephalurus cephalus</i> (Gilbert, 1892)						4, 8
<i>Galeus piperatus</i> Springer & Wagner, 1966						4
<i>Parnaturus xanthurus</i> (Gilbert, 1892)						4
<b>Family Carcharhinidae</b>						
<i>Carcharhinus altimus</i> (Springer, 1950)					LACM	4, 5, 6, 8, 9, 11
<i>Carcharhinus brachyurus</i> (Günther, 1870)						4, 5, 6, 8, 9, 11
<i>Carcharhinus falciformis</i> (Müller & Henle, 1839)	+		+	+	LACM	4, 5, 6, 8, 9, 11

.....continued on the next page

TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Carcharhinus longimanus</i> (Poey, 1861)	+			+		3, 4, 5, 6, 8, 9*
<i>Carcharhinus obscurus</i> (Lesueur, 1818)	+					3, 4, 5, 6, 8, 9, 11
<i>Nasolamia velox</i> (Gilbert, 1898)						5, 6, 8, 9, 11
<i>Prionace glauca</i> (Linnaeus, 1758)						4, 5, 6, 9*, 11
<i>Rhizoprionodon longurio</i> (Jordan & Gilbert, 1882)						4, 5, 6, 8, 9, 11
<b>Family Sphyrnidae</b>						
<i>Sphyrna media</i> Springer, 1940						3, 5
<i>Sphyrna tiburo</i> (Linnaeus, 1758)						4, 5, 6, 8, 9, 11
<i>Sphyrna zygaena</i> (Linnaeus, 1758)						4, 5, 6, 8, 9*
<b>Order MYLIOBATIFORMES</b>						
<b>Family Dasyatidae</b>						
<i>Pteroplatytrygon violacea</i> (Bonaparte, 1832)						5, 6, 8, 9
<b>Family Myliobatidae</b>						
<i>Mobula japanica</i> (Müller & Henle, 1841)						4, 9*
<b>Clase ACTINOPTERYGII</b>						
<b>Order ANGUILLIFORMES</b>						
<b>Family Nemichthyidae</b>						
<i>Avocettina bowersii</i> (Garman, 1899)					SIO	
<b>Order CLUPEIFORMES</b>						
<b>Family Engraulidae</b>						
<i>Cetengraulis mysticetus</i> (Günther, 1867)						5, 6, 8, 9
<b>Family Clupeidae</b>						
<i>Etrumeus acuminatus</i> (Gilbert, 1890)						3, 5
<i>Sardinops sagax</i> (Jenyns, 1842)					USNM, LACM	4, 5, 6, 8, 9
<b>Order ARGENTINIFORMES</b>						
<b>Family Bathylacnidae</b>						

.....continued on the next page

TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Bathylagoides nigrigenys</i> (Parr, 1931)					SIO	
<b>Order STOMIIFORMES</b>						
<b>Family Gonostomatidae</b>						
<i>Cyclothone acclinidens</i> Garman, 1899					SIO	
<i>Diplophos proximus</i> Parr, 1931					SIO	
<i>Diplophos taenia</i> Günther, 1873					SIO, LACM	
<b>Family Sternoptychidae</b>						
<i>Argyropelecus lychnus</i> Garman, 1899					SIO, LACM	
<b>Family Phosichthyidae</b>						
<i>Vinciguerria lucetia</i> (Garman, 1899)					SIO, LACM	12
<b>Family Stomiidae</b>						
<i>Bathophilus filifer</i> (Garman, 1899)					SIO, LACM	
<i>Idiacanthus antrostomus</i> Gilbert, 1890					SIO	
<i>Stomias atriventer</i> Garman, 1899					SIO, LACM	
<b>Order MYCTOPHIFORMES</b>						
<b>Family Myctophidae</b>						
<i>Bolinichthys longipes</i> (Brauer, 1906)					SIO	
<i>Bolinichthys pyrosobolus</i> (Alcock, 1890)					LACM	
<i>Diaphus anderseni</i> Tåning, 1932					LACM	
<i>Diaphus pacificus</i> Parr, 1931					SIO	
<i>Diogenichthys laternatus</i> (Garman, 1899)					SIO, LACM	
<i>Gonichthys coco</i> (Cocco, 1829)					LACM	8
<i>Gonichthys tenuiculus</i> (Garman, 1899)					SIO	
<i>Hygophum atratum</i> (Garman, 1899)					SIO, LACM	8
<i>Hygophum reinhardtii</i> (Lütken, 1892)					LACM	8, 12
<i>Lampanyctus omostigma</i> Gilbert, 1908					SIO	

.....continued on the next page

TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Myctophum aurolaternatum</i> Garman, 1899					LACM	8
<i>Nannobranchium idostigma</i> (Parr, 1931)					SIO	
<i>Nannobranchium ritteri</i> (Gilbert, 1915)					LACM	8
<b>Order LAMPRIFORMES</b>						
<b>Family Lophotidae</b>						
<i>Eumecichthys fiski</i> (Günther, 1890)					LACM	4
<b>Family Trachipteridae</b>						
<i>Desmodema polystictum</i> (Ogilby, 1898)					LACM	
<b>Order GADIFORMES</b>						
<b>Family Bregmacerotidae</b>						
<i>Bregmaceros bathymaster</i> Jordan & Bollman, 1890					SIO	5, 6, 8, 9*
<b>Family Moridae</b>						
<i>Laemonema vercundum</i> (Jordan & Cramer, 1897)					SIO, USNM, LACM	8, 12
<b>Family Merlucciidae</b>						
<i>Merluccius productus</i> (Ayres, 1855)						8, 9
<b>Order LOPHIIFORMES</b>						
<b>Family Ogcocephalidae</b>						
<i>Dibranchius spongiosa</i> (Gilbert, 1890)					LACM	8, 11, 12
<b>Order ATHERINIFORMES</b>						
<b>Family Atherinopsidae</b>						
<i>Atherinops affinis</i> (Ayres, 1860)						9*
<b>Order BELONIFORMES</b>						
<b>Family Exocoetidae</b>						
<i>Cheilopogon atrisignis</i> (Jenkins, 1903)					LACM	3, 4, 5, 6, 8, 9, 11, 12
<i>Cheilopogon dorsomacula</i> (Fowler, 1944)						9*
<i>Cheilopogon heterurus</i> (Rafinesque, 1810)					LACM	3, 5

.....continued on the next page



TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Cheilopogon papilio</i> (Clark, 1936)						4, 5, 6, 8, 9, 11
<i>Cheilopogon pinnatibarbatus californicus</i> (Bennett, 1831)					USNM, LACM	4, 5, 6, 8, 9, 11
<i>Cheilopogon spilonotopterus</i> (Bleeker, 1865)					SIO, LACM	4, 5, 6, 8, 9, 11, 12
<i>Cheilopogon unicolor</i> (Valenciennes, 1847)					LACM	
<i>Cheilopogon xenopterus</i> (Gilbert, 1890)					USNM, LACM	1, 3, 4, 5, 6, 8, 9, 12
<i>Cypselurus angusticeps</i> Nichols & Breder, 1935						4, 5, 6, 8, 9, 11
<i>Cypselurus callopterus</i> (Günther, 1866)					SIO	8, 9
<i>Cypselurus sinus</i> (Valenciennes, 1847)	+				SIO	
<i>Exocoetus monocirrhus</i> Richardson, 1846					SIO, LACM	4, 5, 6, 8, 9
<i>Exocoetus volitans</i> Linnaeus, 1758						1, 4, 5, 6, 8, 9
<i>Hirundichthys marginatus</i> (Nichols & Breder, 1928)					SIO, LACM	4, 5, 6, 8, 9
<i>Hirundichthys oxycephalus</i> (Bleeker, 1853)					LACM	
<i>Hirundichthys rondeletii</i> (Valenciennes, 1847)						9*
<i>Hirundichthys speculiger</i> (Valenciennes, 1847)						4, 5, 6, 8, 9
<i>Oxyporhamphus micropterus</i> (Valenciennes, 1847)					SIO, LACM	4, 5, 6, 8, 9
<i>Prognichthys sealei</i> Abe, 1955						4
<i>Prognichthys tringa</i> Breder, 1928						4, 5, 6, 8, 9
<b>Family Hemiramphidae</b>						
<i>Euleptorhamphus viridis</i> (Van Hasselt, 1823)					SIO, USNM, LACM	4, 5, 6, 8, 9, 12
<i>Hemiramphus saltator</i> Gilbert & Starks, 1904						4, 5, 6, 8, 9
<b>Family Belontiidae</b>						
<i>Ablennes hians</i> (Valenciennes, 1846)						4, 6, 8, 9
<i>Platybelone pterura</i> (Leusueur, 1821)					SIO, USNM, LACM	3, 4, 5, 6, 8, 9, 11, 12
<i>Strongylura exilis</i> (van Hasselt, 1823)					LACM	3, 4, 5, 6, 8, 9, 10
<b>Family Scomberesocidae</b>						
<i>Cololabis saira</i> (Brevoort, 1856)						3, 4, 5, 11

.....continued on the next page

TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<b>Order CYPRINODONTIFORMES</b>						
<b>Family Fundulidae</b>						
<i>Fundulus parvipinnis</i> Girard, 1854						8, 9*
<b>Order STEPHANOBERYCFIFORMES</b>						
<b>Family Melamphaidae</b>						
<i>Melamphaes spinifer</i> Ebeling, 1962					SIO	
<i>Poromitra oscitans</i> Ebeling, 1975					SIO	
<i>Scopeloberyx robustus</i> (Günther, 1887)					SIO	
<i>Scopelogadus bispinosus</i> (Gilbert, 1915)					SIO	
<b>Order GASTEROSTEIFORMES</b>						
<b>Family Syngnathidae</b>						
<i>Syngnathus auliscus</i> (Swain, 1882)					SIO	8, 9
<b>Family Fistulariidae</b>						
<i>Fistularia corneta</i> Gilbert & Starks, 1904					SIO, LACM	4, 5, 6, 8, 9, 11
<b>Family Triglidae</b>						
<i>Bellator loxias</i> (Jordan, 1897)						5, 6, 8, 9
<i>Prionotus albirostris</i> Jordan & Bollman 1890						9*
<b>Order PERCIFORMES</b>						
<b>Family Nematistiidae</b>						
<i>Nematistius pectoralis</i> Gill, 1862						4
<b>Family Coryphaenidae</b>						
<i>Coryphaena equiselis</i> Linnaeus, 1758					SIO, LACM	1, 4, 5, 6, 8, 9
<i>Coryphaena hippurus</i> Linnaeus, 1758						4, 5, 6, 8, 9
<b>Family Echenidae</b>						
<i>Phtheichthys lineatus</i> (Menzies, 1791)					LACM	5, 6, 8, 9
<i>Remora australis</i> (Bennett, 1840)						5, 6, 9*
<i>Remora brachyptera</i> (Lowe, 1839)					SIO	3, 4, 5, 6, 8, 9*

.....continued on the next page

TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Remora osteochir</i> (Cuvier, 1829)						5, 6, 9*
<i>Remora remora</i> (Linnaeus, 1758)	+		+	+	USNM, LACM	5, 6, 8, 9, 12
<i>Remorina albescens</i> (Temminck & Schlegel, 1850)						5, 6, 8, 9, 12
<b>Family Carangidae</b>						
<i>Carangoides otrynter</i> (Jordan & Gilbert, 1883)					LACM	5, 6, 8, 9
<i>Caranx caballus</i> Günther, 1868	+		+	+	SIO, LACM	3, 4, 5, 6, 8, 9, 12
<i>Caranx caninus</i> Günther, 1867					USNM	5, 6, 8, 9
<i>Chloroscombrus orqueta</i> Jordan & Gilbert, 1883						8, 9
<i>Decapterus macarellus</i> (Cuvier, 1833)				+	SIO, LACM	4, 5, 6, 8, 9
<i>Decapterus muroadsi</i> (Temminck & Schlegel, 1844)					SIO, LACM	4, 5, 6, 8, 9, 11
<i>Hemicaranx zelotes</i> Gilbert, 1898						5
<i>Naucrates ductor</i> (Linnaeus, 1758)					LACM	4, 5, 6, 8, 9
<i>Selar crumenophthalmus</i> (Bloch, 1793)					SIO, LACM	1, 4, 5, 6, 8, 7, 9
<i>Selene peruviana</i> (Guichenot, 1866)					SIO, LACM	
<i>Seriola rivoliana</i> Valenciennes, 1833	+			+	SIO, USNM, LACM	5, 6, 8, 9, 12
<i>Trachurus symmetricus</i> (Ayres, 1855)						3, 5
<i>Uraspis secunda</i> (Poey, 1860)					SIO, LACM	
<b>Family Lobotidae</b>						
<i>Lobotes pacificus</i> Gilbert, 1898					LACM	8, 9
<b>Family Sciaenidae</b>						
<i>Cynoscion xanthurus</i> Jordan & Gilbert, 1882					LACM	
<b>Family Luvaridae</b>						
<i>Luvarus imperialis</i> Rafinesque, 1810						4, 5, 6, 9*
<b>Family Sphyraenidae</b>						
<i>Sphyraena argentea</i> Girard, 1854					SIO	5, 6, 8, 9
<b>Family Gempylidae</b>						
<i>Gempylus serpens</i> Cuvier, 1829					LACM	4, 5, 6, 8, 9

.....continued on the next page

TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Lepidocybium flavobrunneum</i> (Smith, 1843)						4, 6, 9*
<i>Neolotus tripes</i> Johnson, 1865						4, 5
<b>Family Trichiuridae</b>						
<i>Lepidopus fitchi</i> Rosenblatt & Wilson, 1987					LACM	4, 6
<i>Trichiurus lepturus</i> Linnaeus, 1758						5
<b>Family Scombridae</b>						
<i>Acanthocybium solandri</i> (Cuvier, 1832)	+			+	SIO, USNM	3, 4, 5, 6, 8, 9
<i>Axius thazard brachydorax</i> Collette & Aadland, 1996					LACM	4, 5, 6, 8, 9
<i>Axius rochei eudorax</i> Collette & Aadland, 1996						9*
<i>Euthynnus affinis</i> (Cantor, 1849)					SIO	5, 6, 8, 9
<i>Euthynnus lineatus</i> Kishinouye, 1920	+					3, 4, 5, 6, 8, 9
<i>Katsuwonus pelamis</i> (Linnaeus, 1758)						1, 3, 4, 5, 6, 8, 9
<i>Sarda chilensis</i> (Cuvier, 1832)						3, 4, 5, 6, 8, 9
<i>Sarda orientalis</i> (Temminck & Schlegel, 1844)						5, 6, 8, 9
<i>Scomber australasicus</i> Cuvier, 1832					SIO	4, 5, 6, 8, 9, 11
<i>Scomber japonicus</i> Houttuyn, 1782						5, 6, 8, 9, 12
<i>Thunnus alalunga</i> (Bonnaterre, 1788)					SIO	3, 5, 6, 8, 9
<i>Thunnus albacares</i> (Bonnaterre, 1788)	+		+	+		3, 4, 5, 6, 8, 9
<i>Thunnus obesus</i> (Lowe, 1839)						5, 6, 8, 9
<i>Thunnus orientalis</i> (Temminck & Schlegel, 1844)						3, 5, 6
<b>Family Xiphiidae</b>						
<i>Xiphias gladius</i> Linnaeus, 1758						3, 4, 5, 6, 9*
<b>Family Istiophoridae</b>						
<i>Istiophorus platypterus</i> (Shaw, 1792)			+	+		4, 5, 6, 8, 9
<i>Istiompax indica</i> (Cuvier, 1832)						4, 5, 6, 9
<i>Kajikia audax</i> (Philippi, 1887)						3, 5, 6, 8, 9
<i>Makaira nigricans</i> Lacepède, 1802						3, 4, 5, 6, 9

.....continued on the next page

TABLE 2. (Continued)

	Field observation (1994-1999)	Field observation (2007)	Field observation (2010)	Field observation (2012-2013)	Museum records	References
<i>Tetrapturus angustirostris</i> Tanaka, 1915						4, 5, 6, 9*
<b>Family Centrolophidae</b>						
<i>Schedophilus haedrichi</i> Chirichigno F., 1973						5, 6, 9*
<b>Family Nomeidae</b>						
<i>Cubiceps pauciradiatus</i> Günther, 1872					LACM	5, 6, 8, 9*
<i>Nomeus gronovii</i> (Gmelin, 1789)						5, 6, 8, 9
<i>Psenes sio</i> Haedrich, 1970						9*
<b>Order PLEURONECTIFORMES</b>						
<b>Family Paralichthyidae</b>						
<i>Citharichthys gilberti</i> Jenkins & Evermann, 1889					SIO	8, 9
<i>Syacium latifrons</i> (Jordan & Gilbert, 1882)						9*
<i>Syacium ovale</i> (Günther, 1864)					LACM	5, 6, 8, 9
<b>Family Soleidae</b>						
<i>Aseraggodes herrei</i> Seale, 1940					SIO, LACM	5, 6, 8, 9
<b>Family Cynoglossidae</b>						
<i>Symphurus atramentatus</i> Jordan & Bollman, 1890					LACM	8, 9
<i>Symphurus leei</i> Jordan & Bollman, 1890					USNM	
<b>Order TETRAODONTIFORMES</b>						
<b>Family Tetraodontidae</b>						
<i>Lagocephalus lagocephalus</i> (Linnaeus, 1758)					LACM	4, 6, 8, 9
<b>Family Molidae</b>						
<i>Mola mola</i> (Linnaeus, 1758)						4, 5, 6, 8, 9
<i>Ranzania laevis</i> (Pennant, 1776)						4, 5, 6, 8, 9

by five or more species was very similar to that expected by the non-parametric methods (usually less than 5% or 1 species in difference; Fig. 2, Table 4), an indication that the particular checklist for the archipelago might be complete. The only exception was the family Serranidae for which current richness is five species less than the expected richness calculated by the models (Fig. 2, Table 4).

**TABLE 3.** Checklist of doubtful fishes of the Revillagigedo Archipelago.

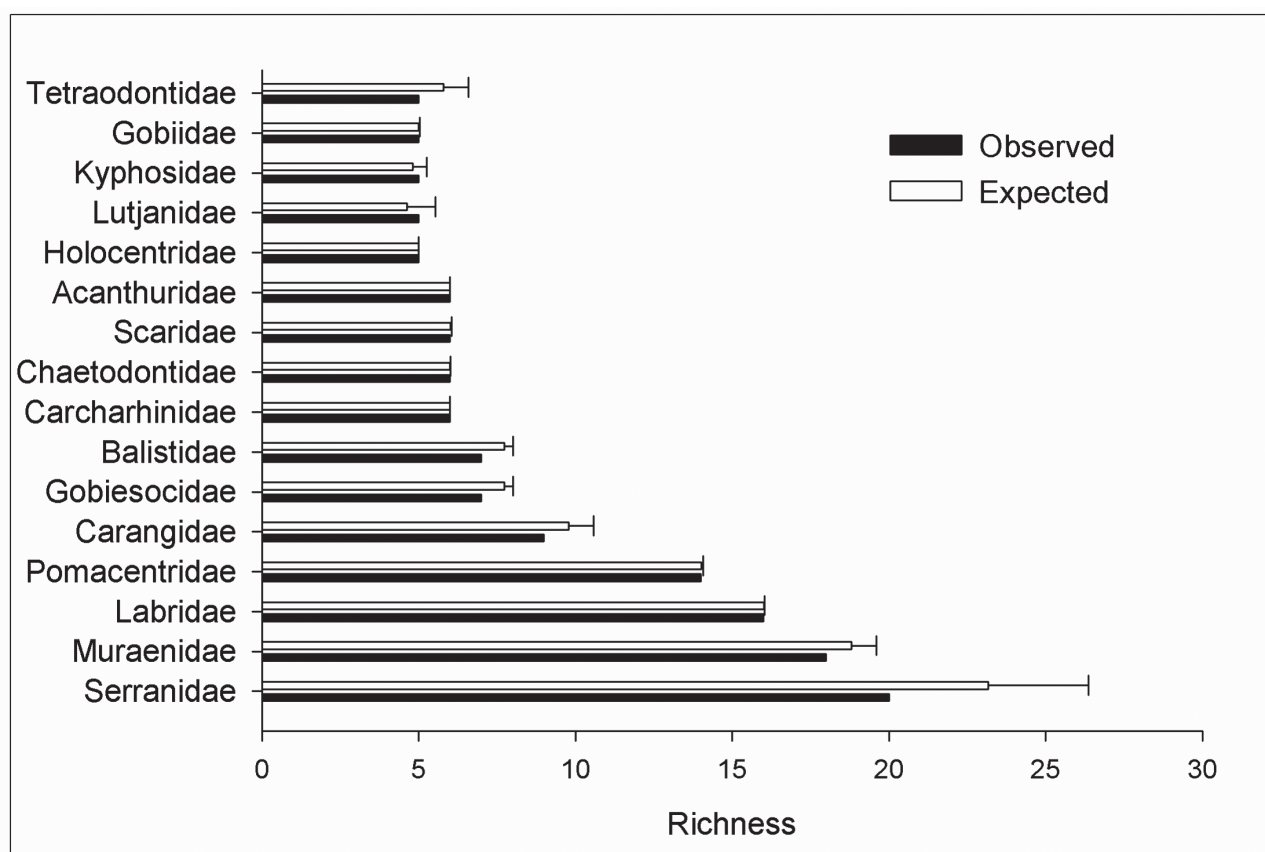
Key to museums: **USNM**) National Museum of Natural History, Smithsonian Institution; **SIO**) Scripps Institution of Oceanography, San Diego; **LACM**) Natural History Museum of Los Angeles.

References: **1)** Snodgrass & Heller 1905; **2)** Schmitt & Schultz 1940; **3)** Bautista-Romero *et al.* 1994; **4)** Castro-Aguirre & Balart 2002; **5)** CONANP-SEMARNAT 2004; **6)** Robertson & Allen 2006; **7)** Chávez-Comparán *et al.* 2010; **8)** IOC of UNESCO 2010; **9)** Robertson & Allen 2015 (\*Unconfirmed species); **10)** GBIF 2011; **11)** Froese & Pauly 2015; **12)** Eschmeyer & Fricke 2015b.

	Field observation (1994–1999)	Museum records	References
<b>Phylum CHORDATA</b>			
<b>Clase CHONDRICHTHYES</b>			
<b>Order CARCHARHINIFORMES</b>			
<b>Family Carcharhinidae</b>			
<i>Carcharhinus plumbeus</i> (Nardo, 1827)		USNM-118395	4, 5, 6, 9*, 11
<b>Clase ACTINOPTERYGII</b>			
<b>Order PERCIFORMES</b>			
<b>Family Serranidae</b>			
<i>Rypticus bicolor</i> Valenciennes, 1846		SIO 70-394, USNM-41259.5226862	3, 5, 12(CAS 1777)
<b>Family Haemulidae</b>			
<i>Orthopristis cantharinus</i> (Jenyns, 1840)		USNM-131407	
<b>Family Embiotocidae</b>			
<i>Embiotoca jacksoni</i> Agassiz, 1853			12 (SU 5918)
<b>Family Pomacentridae</b>			
<i>Abudefduf concolor</i> (Gill, 1862)			4, 12 (CAS 1771)
<b>Family Labridae</b>			
<i>Halichoeres semicinctus</i> (Ayres, 1859)			12 (SU 10455)
<b>Family Chaenopsidae</b>			
<i>Acanthemblemaria hancocki</i> Myers & Reid, 1936			3, 5, 6, 8, 11
<i>Acanthemblemaria macrospilus</i> Brock, 1940	+		4, 11, 12 (CAS (SU) 58566)
<b>Family Gobiidae</b>			
<i>Lythrypnus rhizophora</i> (Heller & Snodgrass, 1903)		USNM-348758	8, 12 (CAS (CH) 1231)
<b>Order PLEURONECTIFORMES</b>			
<b>Family Paralichthyidae</b>			
<i>Citharichthys xanthostigma</i> Gilbert, 1890		USNM-131431	

Finally, the statistical analyses using the Student t-test and the bootstrap show that of the 16 families analyzed, only Balistidae and Gobiiesocidae showed significant differences between the expected and observed richness (Table 4). In both cases the statistical model predicts that at least one species of each family is to be expected to be found at the islands in the future.





**FIGURE 2.** Observed species richness of fish families at the Revillagigedo Archipelago, and expected value (average and standard deviation), according to four non parametric methods applied on data from Table 1.

**TABLE 4.** Results of the statistical analyses to determine completeness of the inventory of reef fishes of Revillagigedo Archipelago (families selected if with 5 or more species at the site). In gray, tests depicting significant differences between expected and observed values. If SD = 0.00, it represents a true value of less than 0.001.

Family	Observed richness	Expected richness (mean ± SD)	Student t	p	Bootstrap p
Holocentridae	5	5.00 ± 0.00	0.488	0.708	0.7010
Lutjanidae	5	4.63 ± 0.89	0.395	0.697	0.692
Kyphosidae	5	4.82 ± 0.44	0.355	0.631	0.644
Tetraodontidae	5	5.78 ± 0.80	0.955	0.352	0.405
Gobiidae	5	5.01 ± 0.02	0.486	0.711	0.704
Carcharhinidae	6	6.00 ± 0.00	0.487	0.710	0.702
Chaetodontidae	6	6.00 ± 0.01	0.489	0.706	0.699
Scaridae	6	6.02 ± 0.04	0.485	0.712	0.705
Acanthuridae	6	6.00 ± 0.00	0.487	0.631	0.641
Gobiesocidae	7	7.73 ± 0.27	2.589	0.017	0.039
Balistidae	7	7.73 ± 0.28	2.558	0.019	0.042
Carangidae	9	9.79 ± 0.80	0.977	0.341	0.395
Pomacentridae	14	14.02 ± 0.05	0.490	0.705	0.688
Labridae	16	16.01 ± 0.02	0.463	0.727	0.711
Muraenidae	18	18.80 ± 0.79	0.978	0.3410	0.395
Serranidae	20	23.17 ± 3.20	1.556	0.173	0.233
TOTAL	235	244.33 ± 3.24	2.538	0.017	0.038

## Discussion

The 389 species of fishes recorded for the Revillagigedo Archipelago greatly increases the number of species reported in previous checklists (176 species in Robertson & Allen, 2006; 228 species in Castro-Aguirre & Balart, 2002; 212 species in Robertson & Cramer, 2009; and 292 in Robertson & Allen, 2015). The increase is mostly due to the fact that we included pelagic and deep water taxa in this review, many of which were not considered in previous studies as they were focused mostly on coastal rocky reefs. We included these fishes in the present paper (even if they do not inhabit the reefs) because the steepness of the bottom in the archipelago results in pelagic fishes usually interacting with reef taxa, either at cleaning stations or as a food resource (Vetter *et al.*, 2008). However, it is important to note that because of the little information available for pelagic and deep water fishes, we separated their records (Table 2) from those of typical reef species (Table 1), and analyzed only the latter (Figure 2). In this way, we avoided overestimating the expected richness because the methods used to evaluate it depend on the number of species with single records (Table 2).

Even when considering only reef taxa, Table 1 lists 235 species, which is still a higher figure compared to the number reported by other authors (a maximum of 220 species reported by Robertson & Allen in 2015). We suggest that this increase could be a result of the more intense sampling effort in the field made by the authors in the past decade, a more thorough literature review, and the fact that this study incorporated validated museum data.

The total gamma diversity of 389 species at the Revillagigedo Archipelago (Table 1 and 2) is high compared with that known for other oceanic islands of the eastern Pacific (Robertson & Cramer, 2009; Robertson & Allen, 2015): 197 species were reported at Clipperton Island (Fourrière *et al.*, 2014), 203 at Malpelo Island, Colombia (Robertson & Cramer, 2009) and 259 at Cocos, Costa Rica (Robertson & Cramer, 2009). These differences can be explained from principles of island biogeography because several islands of the Revillagigedo Archipelago have a large coastal perimeter, which increases the probability for larvae or vagrant adults coming from other regions to arrive to the area. Furthermore, the Revillagigedo Islands are under the direct influence of several currents (Fiedler & Talley, 2006), a situation that would augment the larval pool of colonizers. Finally, it is important to note that, as the reef fish richness in Galápagos, Ecuador (363 species; Robertson & Cramer, 2009) is similar to that of the Revillagigedos, and both archipelagos are much larger than the other oceanic islands of the eastern Pacific (that have less richness), we suggest that there is a clear species-area relationship, as has been shown for the Gulf of California (Thomson & Gilligan, 2002).

The local endemism of the islands (13 species) is 3.3% taking into consideration the full species list, or 5.5 % if only reef taxa are considered. The latter value is intermediate among oceanic islands of the eastern Pacific (data from Robertson & Cramer, 2009), as it is lower than at the Galápagos (>8%), and higher than at Cocos (4.6%), and Malpelo Islands (2.5%). In general, most endemics of the Revillagigedos belong to families that are comprised of small bodied fishes with demersal eggs (Blennidae, Chaenopsidae, Gobiidae, Gobiessocidae, Tripterygiidae; 8 of 13 species), and their speciation probably results from the combination of short generation times (typical of small fishes), larval strategies, and possible geographic isolation (Riginos & Victor, 2001; Robertson, 2001; Helfman *et al.*, 2009).

Regarding the completeness of the species inventory, non-parametric methods [analysis] show that the observed number of 235 species is 9 species less than the expected richness (Table 1) and this difference is significant (Table 4). This model estimates that about 96% of the total richness of reef fish from the archipelago is known. This percentage is higher than that proposed by Zapata & Robertson (2007), who from accumulation functions conclude that the lists of marine shorefishes of the eastern Pacific are 85% to 88% complete, and of the 80% of the inventory proposed worldwide by Mora *et al.* (2008). These observations show that although Revillagigedo is an isolated area, the sampling effort is of very high quality.

Focusing on the 16 reef fish families with 5 or more species, 14 of them show no difference between the expected richness and that currently observed (Fig. 2, Table 4). This implies that the surveys carried out to date have been sufficient to register most of the species present at the Revillagigedo Archipelago. One factor that might have helped to complete the inventory is that, as the topography of the islands is relatively homogeneous, the number of habitats may be relatively limited, which would place an upper limit in local richness. On the other hand, in the two families in which statistical differences were found between expected and observed richness (Balistidae and Gobiessocidae), the difference is less than one species, meaning that even in these cases, the model estimates that the species listings are almost complete. Note also that in all cases the occurrence of an extra 1 or 2

species in the inventory is feasible as the number of taxa reported for these families in the eastern Pacific is larger (Robertson & Allen, 2015). Notwithstanding this, it will be necessary to get more information to confirm if the calculations are correct.

In conclusion, in this paper we present a list of 389 species for the Revillagigedo Archipelago (235 of them resident in shallow reef habitats), which represents an increment of 21.6 % comparing with the most detailed available checklist. The number of taxa is higher than of any other oceanic island in the eastern Pacific Ocean other than the Galápagos, and may result of the large size of the islands and their geographic position that allow colonization from diverse biogeographical regions. Statistical predictions of the completeness of the reef fish inventory showed that the currently known richness is about 4% lower to that expected, but nevertheless, that the listing of all but two speciose families seems to be complete.

## Acknowledgements

We thank Vivianne Solís (Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México) for the invitation to join their expeditions to the archipelago in 1997. The staff and divers of the live aboards “Rocio del Mar” “Sea Escape” and “Nautilus Explorer” provided support and transportation to the archipelago. This study was supported with funds from Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (HJ017, to HRB). Sarahí Gómez, Ollin González, Nuria Torrejón, Fernando Aranceta, David Petatán and Luis Drew, students and technicians of the laboratory, collaborated by collecting data in the field and elaborating the map. We also thank E. Balart, Dr. Ross Robertson, John McCosker, M. Murtaugh, E. Madrid, W. Holleman and an anonymous reviewer who really improved the manuscript with their comments. We also would like to thank Rick Feeney from Natural History Museum of Los Angeles County, Phil Hastings and H.J. Walker from Scripps Institution of Oceanography, Dave Catania from California Academy of Sciences and Anthony Harold from the Grice Marine Laboratory who help to corroborate the identification of several of the specimens from the museums.

## References

- Allen, G.R. (2008) Conservation hotspots of biodiversity and endemism for Indo-Pacific coral reef fishes. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 18, 541–556.  
<http://dx.doi.org/10.1002/aqc.880>
- Allen, G.R. & Robertson, D.R. (1994) *Fishes of the tropical eastern Pacific*. University of Hawaii Press, Honolulu, 322 pp.
- Baums, I.B., Boulay, J.N., Polato, N.R. & Hellberg, M.E. (2012) No gene flow across the eastern Pacific barrier in the reef-building coral *Porites lobata*. *Molecular Ecology*, 21, 5418–5433.  
<http://dx.doi.org/10.1111/j.1365-294X.2012.05733.x>
- Bautista-Romero, J., Reyes-Bonilla, H., Lluch-Cota, D.B. & Lluch-Cota, S.E. (1994) Aspectos generales sobre la fauna marina. In: Ortega-Rubio, A. & Castellanos-Vera, A. (Eds.), *La Isla Socorro, Reserva de la Biosfera Archipiélago de Revillagigedo, México*. Centro de Investigaciones Biológicas del Noroeste, La Paz, pp. 247–264.
- Bellwood, D.R. & Meyer, C.P. (2009) Searching for heat in a marine diversity hotspot. *Journal of Biogeography*, 36 (4), 569–576.  
<http://dx.doi.org/10.1111/j.1365-2699.2008.02029.x>
- Brattstrom, B.H. (1990) Biogeography of the Island Revillagigedo, Mexico. *Journal of Biogeography*, 17 (2), 177–183.  
<http://dx.doi.org/10.2307/2845325>
- Castellanos, A. & Ortega-Rubio, A. (1994) Características generales. In: Ortega-Rubio, A. & Castellanos-Vera, A. (Eds.), *La Isla Socorro, Reserva de la Biosfera Archipiélago de Revillagigedo, México*. Centro de Investigaciones Biológicas del Noroeste, La Paz, pp. 19–29.
- Castro-Aguirre, J.L. & Balart, E.F. (2002) La ictiofauna de las Islas Revillagigedo y sus relaciones zoogeográficas, con comentarios acerca de su origen y evolución. In: Lozano-Vilano, M.L. (Ed.), *Libro jubilar en honor del Dr. Salvador Contreras Balderas*. Universidad Autónoma de Nuevo León, Monterrey, pp. 153–170.
- Chávez-Comparán, J.C., Patiño-Barragán, M., Calderón-Riveroll, G., Lezama-Cervantes, C., Lara-Chávez, B., Ibarra-Casillas, M. & Bautista-Laureano, S. (2010) Lista de peces generada por censos visuales submarinos en la Isla Socorro Colima, México. *Revista Cubana de Investigaciones Pesqueras*, 27, 72–78.
- CONANP–SEMARNAT (2004) *Programa de conservación y manejo Reserva de la Biosfera Archipiélago de Revillagigedo, México*. Secretaría de Medio Ambiente y Recursos Naturales, México D.F., 219 pp.

- Dixon, P.M. (2001) The bootstrap and the jackknife: describing the precision of ecological indices. In: Scheiner, S.M. & Gurevitch, J. (Eds.), *Design and analysis of ecological experiments*. Oxford University Press, Oxford, pp. 267–288.
- Emerson, W.K. (1995) A zoogeographic summary of the marine mollusks of the Revillagigedo Island (tropical eastern Pacific Ocean). *The Festivus*, 27 (1), 3–18.
- Eschmeyer, W.N. & Fricke, R. (2015a) *Catalog of Fishes: Genera, Species, References*. Available from: <http://research.calacademy.org/research/ichthyology/catalog/fishcatmain.asp/> (accessed 30 December 2015)
- Eschmeyer, W.N. & Fricke, R. (2015b) Guide to fish collections. Available from: <http://research.calacademy.org/research/ichthyology/collection/index.asp> (accessed 30 December 2015)
- Eschmeyer, W.N., Fricke, R., Fong, J.D. & Polack, D.A. (2010) Marine fish diversity: history of knowledge and discovery (Pisces). *Zootaxa*, 2525, 19–50.
- Fiedler, P.C. & Talley, L.D. (2006) Hydrography of the eastern tropical Pacific: A review. *Progress in Oceanography*, 69 (2–4), 143–180.  
<http://dx.doi.org/10.1016/j.pocean.2006.03.008>
- Fourri re, M., Reyes-Bonilla, H., Rodr guez-Zaragoza, F.A. & Crane, N. (2014) Fishes of Clipperton Atoll, Eastern Pacific: Checklist, endemism and analysis of completeness of the inventory. *Pacific Science*, 68 (3), 375–395.  
<http://dx.doi.org/10.2984/68.3.7>
- Froese, R. & Pauly, D. (2015) FishBase. Available from: <http://www.fishbase.org/> (accessed 11 January 2013)
- Glynn, P.W., Veron, J.E.N. & Wellington, G.M. (1996) Clipperton Atoll (eastern Pacific): oceanography, geomorphology, reef-building coral ecology and biogeography. *Coral Reefs*, 15 (2), 71–99.  
<http://dx.doi.org/10.1007/BF01771897>
- Gotshall, D. (1998) *Sea of Cortez marine animals: a guide to the common fishes and invertebrates Baja California to Panama*. Sea Challengers, Monterey, 110 pp.
- Gotelli, N.J. & Colwell, R.K. (2011) Estimating species richness. In: Magurran, A.E. & McGill, B.J. (Eds.), *Biological diversity: frontiers in measurement and assessment*. Oxford University Press, Oxford, pp. 39–54.
- Helfman, G.S., Collette, B.B., Facey, D.E. & Bowen, B.W. (2009) *The Diversity of Fishes: Biology, Evolution, and Ecology*. Wiley-Blackwell, UK, 736 pp.
- Hern ndez-Aguilera, J.L. (2002) Crust ceos del Archipi lago de Revillagigedo (Stomatopoda y Decapoda, de Thalassinidea a Brachyura), Pac fico oriental tropical. In: Hendrickx, M.E. (Eds.), *Contribuciones al estudio de los crust ceos del Pac fico este*. Instituto de Ciencias del Mar y Limnolog a, UNAM. Mazatl n, pp. 301–315.
- Hobbs, J.P.A., Jones, G.P., Munday, P.L., Connolly, S.R. & Srinivasan, M. (2011) Biogeography and the structure of coral reef fish communities on isolated islands. *Journal of Biogeography*, 39 (1), 130–139.  
<http://dx.doi.org/10.1111/j.1365-2699.2011.02576.x>
- Humann, P. & DeLoach, N. (2004) *Reef fish identification. Baja to Panama*. New World Publication, Jacksonville, 343 pp.
- Intergovernmental Oceanographic Commission (IOC) of UNESCO (2010) The Ocean Biogeographic Information System Web. Available from: <http://www.iobis.org> (accessed 10 March 2010)
- Jordan, D.S. & McGregor, R.C. (1899) List of fishes collected at the Revillagigedo Archipelago and neighboring islands. *Reports of the United States Fisheries Commission*, 24, 271–284.
- Ketchum, J.T. & Reyes Bonilla, H. (1997) Biogeography of hermatypic corals of the Archipi lago Revillagigedo, M xico. *Proceeding of the 8th International Coral Reef Symposium*, Panam  1, 471–476
- Ketchum, J.T. & Reyes-Bonilla, H. (2001) Taxonom a y distribuci n de los corales hermat picos (Scleractinia) del Archipi lago de Revillagigedo, M xico. *Revista de Biolog a Tropical*, 49 (3–4), 803–848.
- Leis, J.M., Sweatman, H.P.A. & Reader, S.E. (1996) What the pelagic stages of coral reef fishes are doing out in blue water: daytime field observations of larval behavioural capabilities. *Marine and Freshwater Research*, 47 (2), 401–411.  
<http://dx.doi.org/10.1071/MF9960401>
- Leon-Tejera, H., Serviere-Zaragoza, E. & Gonz lez-Gonz lez, J. (1996) Affinities of the marine flora of the Revillagigedo Islands, Mexico. *Hydrobiologia*, 326–327 (1), 159–168.  
<http://dx.doi.org/10.1007/BF00047801>
- Lessios, H.A. & Robertson, D.R. (2006) Crossing the impassable: genetic connections in 20 reef fishes across the eastern Pacific barrier. *Proceedings of the Royal Society of London, series B*, 273 (1598), 2201–2208.  
<http://dx.doi.org/10.1098/rspb.2006.3543>
- Magurran, A.E. (2004) *Measuring biological diversity*. Oxford University Press-Blackwell, Oxford, 215 pp.
- Mille-Pagaza, S.R., P rez-Chi, A. & Holgu n-Qu iones, O. (1994) Malacologic benthic fauna of the Socorro Island littoral, Revillagigedo, Mexico. *Ciencias Marinas*, 20, 467–486.  
<http://dx.doi.org/10.7773/cm.v20i4.979>
- Mille-Pagaza, S.R., Carrillo-Laguna, J., P rez-Chi, A. & S nchez-Salazar, M.E. (2002) Abundancia y diversidad de los invertebrados litorales de isla Socorro, Archipi lago Revillagigedo, M xico. *Revista de Biolog a Tropical*, 50, 97–106.
- Mille-Pagaza, S.R., P rez-Chi, A. & S nchez-Salazar, M.E. (2003) Littoral decapods of Socorro Island, Revillagigedo Archipelago, Mexico. *Revista de Biolog a Tropical*, 51, 175–182.
- Mora, C., Chittaro, P.M., Sale, P.F., Kritzer, J.P. & Ludsin, S.A. (2003) Patterns and processes in reef fish diversity. *Nature*, 421, 933–936.  
<http://dx.doi.org/10.1038/nature01393>



- Mora, C., Tittensor, D.P. & Myers, R.A. (2008) The completeness of taxonomic inventories for describing the global diversity and distribution of marine fishes. *Proceedings of the Royal Society of London, series B*, 275 (1631), 149–155.  
<http://dx.doi.org/10.1098/rspb.2007.1315>
- Riginos, C. & Victor, B.C. (2001) Larval spatial distributions and other early life-history characteristics predict genetic differentiation in eastern Pacific blennioid fishes. *Proceedings of the Royal Society of London, series B*, 268, 1931–1936.  
<http://dx.doi.org/10.1098/rspb.2001.1748>
- Robertson, D.R. (2001) Population maintenance among tropical reef fishes: Inferences from small-island endemics. *Proceedings of the National Academy of Sciences of the United States of America*, 98, 5667–5670.  
<http://dx.doi.org/10.1073/pnas.091367798>
- Robertson, D.R. & Allen, G.R. (2006) Shore fishes of the Tropical Eastern Pacific: an Information System. CD-ROM. Smithsonian Tropical Research Institute, Balboa, Panama.
- Robertson, D.R. & Cramer, K. (2009) Shore fishes and biogeographic subdivisions of the Tropical Eastern Pacific. *Marine Ecology Progress Series*, 380 (1–17), 1–17.  
<http://dx.doi.org/10.3354/meps07925>
- Robertson, D.R. & Allen, G.R. (2015) Shorefishes of the tropical Eastern Pacific. Smithsonian Tropical Research Institute, Balboa, Panama. Available from: <http://www.stri.org/sfstep/> (accessed 11 January 2013)
- Reyes-Bonilla, H. (1999) Additions to the summary of marine mollusks of the Islas Revillagigedo (tropical Eastern Pacific Ocean, Mexico). *Festinus*, 31, 31–40.
- Reyes-Bonilla, H. (2003) Coral reefs of the Pacific coast of Mexico. In: Cortes, J. (Ed.), *Latin American coral reefs*. Elsevier, Amsterdam, pp. 331–344.  
<http://dx.doi.org/10.1016/B978-044451388-5/50015-1>
- Schmitt, W.L. & Schultz, L.P. (1940) List of the fishes taken on the Presidential Cruise of 1938. *Smithsonian Miscellaneous Collections*, 98, 1–10.
- Servière-Zaragoza, E., Riosmena-Rodríguez, R., León-Tejera, H., & González-González, J. (2007) Distribución espacial de macroalgas marinas en las Islas Revillagigedo, México. *Ciencia y Mar*, 11, 3–13.
- Snodgrass, R.E. & Heller, E. (1905) Papers from Hopkins–Stanford Galapagos expedition, 1898–1899. XVII. Shore fishes of the Revillagigedo, Clipperton, Cocos and Galapagos islands. *Proceedings of the Washington Academy of Sciences*, 6, 333–427.
- Sokal, R.R. & Rohlf, F.J. (2012) *Biometry: the principles and practice of statistics in biological research*. 4th ed. Freeman, New York, 937 pp.
- Spalding, M.D., Fox, H.E., Allen, G.R., Davidson, N., Ferdaña, Z.A., Finlayson, M., Halpern, B.S., Jorge, M.A., Lombana, A., Lourie, S.A., Martin, K.D., McManus, E., Molnar, J., Recchia, C.A. & Robertson, J. (2007) Marine ecoregions of the world: a bioregionalization of coastal and shelf areas. *Bioscience*, 57 (7), 573–583.  
<http://dx.doi.org/10.1641/B570707>
- Thomson, D.A. & Gilligan, M.R. (2002) Rocky shore fishes. In: Case, T.J., Cody, M.L. & Ezcurra, E. (Eds.), *A new island biogeography of the Sea of Cortes*. Oxford University Press, Oxford, pp. 154–189.
- Vetter, R., Kohin, S., Preti, A., McClatchie, S. & Dewar, H. (2008) Predatory interactions and niche overlap between mako shark, *Isurus oxyrinchus* and jumbo squid, *Dosidicus gigas*, in the California Current. *California Cooperative Oceanic Fisheries Investigations Reports*, 49, 142–156.
- Victor, B.C. & Wellington, G.M. (2000) Endemism and the pelagic larval duration of reef fishes in the eastern Pacific Ocean. *Marine Ecology Progress Series*, 205, 241–248.  
<http://dx.doi.org/10.3354/meps205241>
- Zapata, F.A. & Robertson, D.R. (2007) How many species of shorefishes are there in the tropical eastern Pacific? *Journal of Biogeography*, 34 (1), 38–51.  
<http://dx.doi.org/10.1111/j.1365-2699.2006.01586.x>