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An annotated checklist of marine fishes from the Sanctuary of Bahía Chamela, Mexico with occurrence and biogeographic data

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Abstract
An annotated checklist of marine fishes of the Sanctuary of Islands and Islets of Bahía Chamela in the central Mexican Pacific is presented. Records of fish species were obtained by different methods including visual census, sampling with anesthetics, fisherman-nets, and trawling with a biological dredge. Additional records were obtained from natural history collections and publications. The list comprises 196 species in 64 families and 141 genera. The Carangidae is the most speciose family with 11 species, followed by the Labridae with 10 and the Pomacentridae with nine. Fourteen species are endemic in Mexican Pacific waters, but none is restricted to Bahía Chamela. The most dominant species recorded during underwater surveys were Epinephelus labriformis, Stegastes flavilatus, and Halichoeres dispilus. Most species are of tropical affinities distributed throughout the tropical eastern Pacific (123), eastern Pacific (23), and Mexican Pacific (14). Other species are known from the eastern and Indo-Pacific regions (18), eastern Pacific and western Atlantic oceans (2), and some are circumtropical (9). A new record of the Gulf Brotula Ogilbilia ventralis is provided for the Bahía Chamela and its geographical distribution is extended to Mexican central Pacific.

Keywords
Species richness, Ichthyofauna, eastern Pacific, systematic list, biogeographic affinity
Introduction

The study of fish diversity along the Mexican Pacific coasts started two centuries ago by naturalists and scientists who studied rich collections from some now-memorable expeditions (Gilbert 1890, Jordan et al. 1895, Breder 1926, 1927, 1928, 1936, Fowler 1944). Today the estimated number of recorded marine species along these coasts is 1,121, with the Gulf of California exhibiting the highest species richness (van der Heiden and Findley 1988, Hastings et al. 2010, Espinosa-Pérez 2014). However, there are still many areas and habitats (bays, estuaries, mangroves, reefs, littoral zones, deep-water realm) in the Mexican tropical Pacific where proper fish inventories are missing.

Fishes are an important marine group from an ecological and economic point of view. The destruction and pollution of many habitats and the overexploitation of fishes have affected marine ecosystems with the consequent loss of environmental services. For this reason, the implementation of Marine Protected Areas (MPAs) has begun to be a common practice in conservation and a useful fisheries management tool (Roberts et al. 2001, Edgar 2011). However, the design of an effective MPA requires information about the diversity of species inhabiting an area and its connectivity with other areas (Halpern and Warner 2003, Costello et al. 2010).

In the Mexican Pacific, there are some well-inventoried MPAs. For instance, there are well-documented checklists of fishes inhabiting Isla Guadalupe Biosphere Reserve (Reyes-Bonilla et al. 2010), an important area for the reproduction of the white shark off the Baja California peninsula. MPAs inside the Gulf of California include the Bahía de Los Ángeles Biosphere Reserve (Viesca-Lobatón et al. 2008, Mascareñas-Osorio et al. 2011), a seasonal sanctuary for the whale shark; Loreto Marine Park (Campos-Dávila et al. 2005, Rife et al. 2013); National Park Archipiélago of Espíritu Santo (Aburto-Oropeza and Balart 2001, Arreola-Robles and Elorduy-Garay 2002, Rodríguez-Romero et al. 2005); Gulf of California Islands (Del Moral-Flores et al. 2013); Cabo Pulmo National Park (Alvarez-Filip et al. 2006), where sound management has restored the fish biomass (Aburto-Oropeza et al. 2011); Isla Isabel National Park (Galván-Villa et al. 2010); and Islas Marias Biosphere Reserve (Erisman et al. 2011). Others include the Archipiélago de Revillagigedo Biosphere Reserve (Jordan and McGregor 1899, Castro-Aguirre and Balart 2002, Chávez-Comparán et al. 2010), Islas Marietas National Park (Solís-Gil and Jiménez-Quiroz 2004, García-Hernández et al. 2014), and Bahías de Huatulco National Park (Ramírez-Gutiérrez et al. 2007, López-Pérez et al. 2010, Juárez-Hernández et al. 2013) in the central and southern Mexican Pacific. However, many of the MPAs from the Mexican central Pacific are lacking inventories of marine fishes. One of these is the Sanctuary of Bahía Chamela located along the coast of Jalisco; it comprises eight islands and four islets dispersed along the bay.

The Sanctuary of Bahía Chamela was the first marine sanctuary in Mexico and has been protected since 2002 (Miranda et al. 2011). This sanctuary is home to species of restricted distribution and endemic fauna and flora. However, scarce information about fish diversity of the sanctuary is available. Only two previous lists of fishes of this bay are found reporting 59 and 80 species for the mainland coastline and for the
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Material and methods

Study area. The Bahía Chamela is located in the middle coastline area of Jalisco state on the central Mexican Pacific (19°32’N; 105°06’W) (Figure 1). The bay is located between two major oceanic systems: the Gulf of Tehuantepec and the Gulf of California. The extent of the bay is 28 km from Punta Chamela to Punta Rivas (south to north). The sanctuary includes eight islands called as Pajarera, Cocinas, Mamut, Colorada, San Pedro, San Agustín, San Andrés, and La Negra, and four islets as Los Anegados, El Novillo, La Mosca, and Submarino (CONANP 2008). All of these islands and islets are included in the Marine Priority Region No. 38 of sites for conservation of the National Commission for Knowledge and Use of Biodiversity of Mexico (CONABIO). The continental coast of the bay presents sandy beaches to the northern side and shallow plains and rocky beaches to the south. The islands and islets are of continental origin with similar age and composition throughout the region (possibly from the Cretaceous) (Schaaf 2002). The two larger islands have rocky and sandy beaches, while the smaller islands and the islets have rocky intertidal zones sometimes with vertical steep slopes. The depth of the bay varies between 10 and 25 m, decreasing dramatically in the proximity of the coastline and the islands.

Sampling effort and data analysis. Records of fish species were made by visual census and obtained from analyses of collection reports and materials and available publications. Records in situ were made using underwater visual census from 2007 to 2012 according to the technique described by English et al. (1994). Each transect covered an area of 100 m² (50 m × 2 m) and was conducted by a single diver. Cryptic fishes and other specimens were collected from 2007 to 2015 with a 10% anaesthetic solution of clove oil diluted in ethanol, with a fisherman-net, and with a biological dredge. All collected specimens were deposited in the fish collection of the Laboratory of Marine Ecosystems and Aquaculture (LEMA-CPE), Centro Universitario de Ciencias Biológicas y Agropecuarias, Universidad de Guadalajara (Zapopan, Mexico), except specimen of Chaenopsis sp. that was deposited in the Marine Vertebrate Collection (SIO), Scripps Institution of Oceanography, University of California (San Diego, USA). Records obtained from publications included only those that were identified to species level and excluded any questionable records that we could not confirm as species known to occur in the Mexican Pacific.

The nomenclature for species level, family designations, and systematic were updated following Eschmeyer (2015). Distributions and biogeographic affinities for species are
based on Thomson et al. (2000), Hastings and Springer (2009), Erisman et al. (2011), Mascareñas-Osorio et al. (2011), and Robertson and Allen (2015), using the following categories: CT = Circumtropical (distributed throughout the tropics of the world), EP = eastern Pacific (including tropical and temperate regions), EP+ATL = eastern Pacific and western Atlantic oceans (occurs in both oceans), EP+IP = eastern Pacific and Indo-Pacific regions (occurs in both regions), MEX = Mexican waters of the Pacific (including the Gulf of California and outer coast of Baja California), and TEP = tropical eastern Pacific (extends from south of Magdalena Bay, Baja California to Cabo Blanco in northern Peru, includes the Gulf of California and offshore islands as Revillagigedo, Clipperton, Cocos, Malpelo, and the Galápagos). For a description of the structure of fish assemblages, the species recorded between 2007 and 2012 through visual census were classified in five categories using the frequency of occurrence: D = Dominant (> 80% of census), A = Abundant (61-80%), C = Common (41-60%), U = Uncommon (21-40%), and R = Rare (< 21%).

Results and discussion

Species richness. A list of 196 species, 141 genera, and 64 families of marine fishes from the Bahía Chamela is presented (Table 1). In comparison with previous studies
Table 1. Checklist of fishes from the Sanctuary of Bahía Chamela, Mexico. The list is arranged systematically by class, orders, and families according to Eschmeyer (2015). Record designation: V = visual record (2007–2009); C = collected specimen (2007-2015); SIO = records of the Scripps Institution of Oceanography; R1 = Espinoza-Pérez et al. (2002); R2 = Galván-Villa (2015). Frequency of occurrence: D = dominant; A = abundant; C = common; U = uncommon; R = rare. Biogeographical affinity: CT = Circumtropical; EP = Eastern Pacific; EP+ATL = Eastern Pacific and Atlantic oceans; EP+IP = Eastern Pacific and Indo-Pacific; MEX = Mexican waters of the Pacific; TEP = Tropical Eastern Pacific. IUCN Categories: EN = Endangered; VU = Vulnerable; DD = Data deficient; NT = Near threatened; LC = Least concern; NE = Not evaluated. - = No data.

| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|--------------------|---------|---------------------|----------------------------------------|--------------------------|---------------------------|-----------------|
| CHONDRICHTHYES     |         |                     |                                        |                          |                           |                 |
| Carcharhiniformes  | Sphyrnidae | *Sphyrna lewini* (Griffith & Smith, 1834) | R1 | - | - | CT | EN |
| Rajiformes         | Narcinidae | *Diplobatis ommata* (Jordan & Gilbert, 1890) | V | - | R | TEP | VU |
|                    | Rhinobatidae | *Rhinobatos glaucostigma* Jordan & Gilbert, 1883 | SIO, R1 | SIO 70-238 | - | TEP | DD |
|                    | Rhinobatos | *Rhinobatos leucorhynchus* Günther, 1867 | V | R | TEP | NT |
|                    | *Zapteryx xyster* Jordan & Evermann, 1896 | V, SIO | SIO 70-237 | R | TEP | DD |
| Myliobatiformes    | Gymnuridae | *Gymnura marmorata* (Cooper, 1864) | R1 | - | - | TEP | LC |
|                    | Myliobatidae | *Aetobatus narinari* (Euphrasen, 1790) | V, R2 | - | R | CT | NT |
|                    | *Urobatis concentricus* Osburn & Nichols, 1916 | V, R2 | - | R | MEX | DD |
| Urotrygonidae      | *Urobatis halleri* (Cooper, 1863) | SIO, R1 | SIO 70-237 | - | TEP | LC |
|                    | *Urotrygon munda* Gill, 1863 | R1 | - | TEP | DD |
|                    | *Urotrygon rogersi* (Jordan & Starks, 1895) | SIO | SIO 70-238 | - | TEP | DD |
| ACTINOPTERYGII     | Albuliformes | *Albula pacifica* (Beebe, 1942)† | R1 | - | - | EP | NE |
| Anguilliformes     | Congridae | *Ariosoma gilberti* (Ogilby, 1898) | SIO | SIO 70-237 | - | TEP | LC |
|                    | *Paraconger californiensis* Kanazawa, 1961 | V, SIO | SIO 70-235 | R | TEP | LC |
| CLASS/Order/Family | Species                                                                 | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|-------------------|------------------------------------------------------------------------|----------------------------------------|------------------------|--------------------------|-----------------|
| Clupeiformes      | Harengula thrissa (Jordan & Gilbert, 1882)                            | SIO                                    | R1                     | TEP                      | LC              |
|                   | Lile stolifera (Jordan & Gilbert, 1882)                               | -                                      | -                      | -                        | LC              |
| Gadiformes        | Bythitidae                                                             |                                        |                        |                          |                 |
|                   | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Ophidiiformes     | Antennatus coccineus (Lesson, 1831)                                   | C, SIO                                 |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |
| Bythitidae        | Bythitidae                                                             |                                        |                        |                          |                 |

**Species and Catalog Numbers:**

- Gymnomuraena zebra (Shaw, 1797)
- Gymnomuraena carteri (Jordan & Gilbert, 1883)
- Muraenidae Jenyns, 1842
- Apterichthys kieriana (Myers & Wade, 1859)
- Ophichthys tricolor (Kemp, 1850)
- Quassirpus nobile (Kemp, 1890)
- Gymnothorax castaneus (Jordan & Gilbert, 1883)
- Muraena lentiginosa Jenyns, 1842
- Ophichthys triserialis (Kaup, 1856)
- Quassirpus nothochir (Gilbert, 1890)
- Ophichthys triserialis (Kaup, 1856)
- Clupeidae Harengula thrissa (Jordan & Gilbert, 1882)
- Pliosteostoma lutipinnis (Jordan & Gilbert, 1882)
- Clupeidae Lile stolifera (Jordan & Gilbert, 1882)
- Engraulidae Anchoa ischana (Jordan & Gilbert, 1890)
- Anchoa scofieldi (Jordan & Culver, 1895)
- Synodontidae Synodus evermanni Jordan & Bollman, 1890
- Synodus lacertinus Gilbert, 1890
- Synodus scituliceps Jordan & Gilbert, 1890
- Synodus sechurae Hildebrand, 1946
- Bregmacerotidae Bregmacerotus badynae Jordan & Bollman, 1890
- Bythitidae Ogilbura hopkinsi, Muller, Schwartzman & Nielsen, 2005
- Bythitidae Ogilbura tricolor, Hildebrand, 1946
- Bythitidae Ogilbura yunnanensis Ancey, 1913
- Bythitidae Parabrotulidae Walker & Rosenblatt, 1988
- Batrachoidiformes Antennatus coccineus (Less, 1831)
- Antennatus scituliceps (Hildebrand, 1946)
- Antennatus sechurae (Hildebrand, 1946)
- Harengula thrissa (Jordan & Gilbert, 1882)
- Pliosteostoma lutipinnis (Jordan & Gilbert, 1882)
- Anchoa ischana (Jordan & Gilbert, 1882)
- Anchoa scofieldi (Jordan & Culver, 1895)
- Synodus evermanni Jordan & Bollman, 1890
- Synodus lacertinus Gilbert, 1890
- Synodus scituliceps Jordan & Gilbert, 1890
- Synodus sechurae Hildebrand, 1946
- Bregmacerotus badynae Jordan & Bollman, 1890
- Ogilbura hopkinsi, Muller, Schwartzman & Nielsen, 2005
- Ogilbura tricolor, Hildebrand, 1946
- Ogilbura yunnanensis Ancey, 1913
- Parabrotulidae Walker & Rosenblatt, 1988
- Antennatus coccineus (Less, 1831)
- Antennatus scituliceps (Hildebrand, 1946)
- Antennatus sechurae (Hildebrand, 1946)
| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|-------------------|---------|--------------------|--------------------------------------|-------------------------|--------------------------|-----------------|
| **Gobiesociformes** | *Arcos erythrops* (Jordan & Gilbert, 1882) | C, SIO | LEMA-PE74, SIO 70-167 | - | MEX | LC |
| | *Gobiesox adustus* Jordan & Gilbert, 1882 | SIO | SIO 70-167 | - | TEP | LC |
| | *Gobiesox papillifer* Gilbert, 1890 | C | LEMA-PE95 | - | TEP | LC |
| **Atheriniformes** | *Atherinella eriarcha* Jordan & Gilbert, 1882 | SIO, R1 | SIO 70-167 | - | TEP | LC |
| **Beloniformes** | *Ablephara hians* (Valenciennes, 1846) | C, SIO | LEMA-PE60, SIO 70-166 | - | CT | NE |
| | *Platybelone argalus* (Lesueur, 1821) | R1 | - | - | CT | LC |
| | *Tilournus fodiator* Jordan & Gilbert, 1882 | R1 | - | - | CT | LC |
| **Beryciformes** | *Myripristis leiognathus* Valenciennes, 1846 | V, SIO, R2 | SIO 70-167 | R | TEP | LC |
| | *Sargocentron suborbitalis* (Gill, 1863) | V, R2 | - | U | TEP | LC |
| **Syngnathiformes** | *Fistularia commersonii* Rüppel, 1838 | V, SIO, R2 | SIO 70-167 | R | EP+IP | NE |
| | *Hippocampus ingens* Girard, 1858 | C | LEMA-PE99 | - | EP | VU |
| **Scorpaeniformes** | *Pomacentrus sp. 1* \( ^{\dagger} \) | C | LEMA-PE132 | - | - | - |
| | *Pomacentrus sp. 2* \( ^{\ddagger} \) | C | LEMA-PE136 | - | - | - |
| | *Scorpaena mystes* Jordan & Starks, 1895 | V, C, R2 | LEMA-PE102 | R | EP | LC |
| | *Scorpaena sonora* Jenkins & Evermann, 1889 | SIO | SIO 70-238 | - | MEX | LC |
| | *Scorpaenodes xyris* (Jordan & Gilbert, 1882) | C, SIO | LEMA-PE112, 114, 115, SIO 70-167 | - | EP | LC |
| **Perciformes** | *Prionotus stephanophrys* Lockington, 1881 | SIO | SIO 70-168 | - | TEP | LC |
| **Epinephelidae** | *Alphestes immaculatus* Breder, 1936 | V, R2 | - | U | TEP | LC |
| | *Cephalopholis panamensis* (Steindachner, 1877) | V, R2 | - | C | TEP | LC |
| | *Dermatolepis dermatolepis* (Boulenger, 1895) | V | - | R | EP | LC |
| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|--------------------|---------|--------------------|----------------------------------------|-------------------------|--------------------------|-----------------|
| **Serranidae**     | Epinephelus labriformis (Jenyns, 1840) | V, SIO, R2 | SIO 70-167 | D | EP | LC |
|                    | Paranthias colonus (Valenciennes, 1846) | V | - | R | TEP | LC |
|                    | Rypicus bicolor Valenciennes, 1846 | V, SIO | SIO 70-167 | R | TEP | LC |
|                    | Rypicus nigripinnis Gill, 1861 | V | - | R | TEP | LC |
| **Apogonidae**     | Apogon pacificus (Herre, 1935) | V, SIO | SIO 70-167 | R | EP | LC |
|                    | Apogon retrocella (Gill, 1862) | V, SIO, R2 | SIO 70-167 | R | TEP | LC |
| **Carangidae**     | Canthax caballus Günther, 1868 | V, R2 | - | R | EP | LC |
|                    | Canthax sexfasciatus Quoy & Gaimard, 1825 | V, R1 | - | R | EP+IP | LC |
|                    | Carangoides otryner (Jordan & Gilbert, 1883) | C | LEMA-PE56 | - | EP | LC |
|                    | Carangoides vinctus (Jordan & Gilbert, 1882) | R1 | - | - | TEP | LC |
|                    | Chloroscombrus orquesta Jordan & Gilbert, 1883 | R1 | - | - | EP | LC |
|                    | Gnathanodon species (Forskal, 1775) | V, R1 | - | R | EP+IP | NE |
|                    | Hemicaranx leucurus (Günther, 1864) | R1 | - | - | TEP | LC |
|                    | Oligoplites saurus (Bloch & Schneider, 1801) | R1 | - | - | TEP | NE |
|                    | Selene brevoortii (Gill, 1863) | C | LEMA-PE103 | - | EP | LC |
|                    | Trachinotus patiens Cuvier, 1832 | R1 | - | - | TEP | LC |
|                    | Trachinotus rhodopus Gill, 1863 | C, R1 | LEMA-PE108, 113 | - | EP | LC |
| **Lutjanidae**     | Hoplolagus guentherii Gill, 1862 | V, R1 | - | R | TEP | LC |
|                    | Lutjanus argentiventris (Peters, 1869) | V, R1, R2 | - | U | TEP | LC |
|                    | Lutjanus colorado Jordan & Gilbert, 1882 | R1 | - | - | TEP | LC |
|                    | Lutjanus guttatus (Steindachner, 1869) | V, R1, R2 | - | R | EP | LC |
|                    | Lutjanus inermis (Peters, 1869) | V | - | R | TEP | LC |
|                    | Lutjanus novemfasciatus Gill, 1862 | V, C, R1, R2 | LEMA-PE119, 120 | R | TEP | LC |
|                    | Lutjanus viridis (Valenciennes, 1846) | V, R2 | - | R | TEP | LC |
| **Gerreidae**      | Diapterus peruavus (Cuvier, 1830) | R1 | - | - | TEP | LC |
|                    | Eucinostomus doulii (Gill, 1863) | SIO | SIO 70-237 | - | TEP | LC |
|                    | Eucinostomus gracilis (Gill, 1862) | SIO, R1 | SIO 70-237 | - | TEP | LC |
|                    | Gerres simillimus Regan, 1907 | V, R1 | - | - | TEP | LC |
| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|--------------------|---------|---------------------|----------------------------------------|-------------------------|--------------------------|------------------|
| Haemulidae         | Anisotremus taeniatus Gill, 1861 | SIO | SIO 70-167 | - | TEP | LC |
|                    | Haemulon flaviguttatum Gill, 1862 | V, SIO, R1, R2 | SIO 70-167 | U | EP | LC |
|                    | Haemulon maculicauda (Gill, 1862) | V, SIO, R2 | SIO 70-167 | U | TEP | LC |
|                    | Haemulon secofasciatum Gill, 1862 | V, R2 | - | R | TEP | LC |
|                    | Haemulon scudderii Gill, 1862 | R1 | - | - | TEP | LC |
|                    | Haemulon steindachneri (Jordan & Gilbert, 1882) | V, R1, R2 | - | U | TEP | LC |
|                    | Microlepidotus brevippinnis (Steindachner, 1869) | V, SIO, R2 | SIO 70-167 | R | TEP | LC |
|                    | Pomadasys macracanthus (Günther, 1864) | R1 | - | - | TEP | LC |
|                    | Pomadasys panamensis (Steindachner, 1876) | R1 | - | - | TEP | LC |
| Sciaenidae         | Cynoscion nannus Castro-Aguirre & Arizú-Martínez, 1976 | SIO | SIO 70-168 | - | TEP | LC |
|                    | Pareques fuscovittatus (Kendall & Radcliffe, 1912) | V, SIO | SIO 70-167 | R | MEX | LC |
|                    | Umbrina xanti Gill, 1862 | R1 | - | - | TEP | LC |
| Polynemidae        | Polydactylus approximans (Lay & Bennett, 1839) | R1 | - | - | TEP | LC |
| Mullidae           | Mullloidichthys dentatus (Gill, 1862) | V, R2 | - | C | TEP | LC |
|                    | Pseudupeneus grandisquamis (Gill, 1863) | V, R1 | - | R | TEP | LC |
| Kyphosidae         | Kyphosus vaigiensis (Quoy & Gaimard, 1825) | V, R2 | - | R | EP | NE |
|                    | Kyphosus elegans (Peters, 1869) | V, R1, R2 | - | R | TEP | LC |
|                    | Chaetodon humeralis Günther, 1860 | V, R1, R2 | - | A | EP | LC |
|                    | Johnrandallia nigroirostris Gill, 1862 | V, SIO, R2 | SIO 70-167 | U | TEP | LC |
| Pomacanthidae      | Holocanthus passer Vaillant, 1846 | V, SIO, R2 | SIO 70-167 | C | TEP | LC |
|                    | Pomacanthus zoniceps (Gill, 1862) | V, R2 | - | R | TEP | LC |
|                    | Abudefduf declivesron (Gill, 1862) | V | - | R | TEP | LC |
|                    | Abudefduf trocheii (Gill, 1862) | V, R2 | - | U | TEP | LC |
| Pomacentridae      | Chromis atriobata Gill, 1862 | V, SIO, R2 | SIO 70-167 | U | TEP | LC |
|                    | Microspathodon bairdii (Gill, 1862) | V, R2 | - | R | TEP | LC |
|                    | Microspathodon dorsalis (Gill, 1862) | V, SIO, R2 | SIO 70-167 | A | TEP | LC |
|                    | Stegastes acapulcoensis (Fowler, 1944) | V, R2 | - | A | TEP | LC |
|                    | Stegastes flavilatus (Gill, 1862) | V, SIO, R2 | SIO 70-167 | D | TEP | LC |
| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|--------------------|---------|--------------------|----------------------------------------|-------------------------|---------------------------|------------------|
| **Stegastes leucorus** (Gilbert, 1892) | V, R2 | - | R | MEX | VU |
| **Stegastes rectifilatum** (Gill, 1862) | V, R2 | - | R | TEP | LC |
| **Cirrhitidae** | **Cirrhites oxycephalus** (Bleeker, 1855) | V | - | R | TEP | NE |
| **Cirrhites rivulatus** Valenciennes, 1846 | V | - | C | TEP | LC |
| **Mugilidae** | **Mugil carema** Valenciennes, 1836 | V, R1, R2 | - | R | EP+ATL | NE |
| **Chaenomugil proboscideus** (Günther, 1861) | R1 | - | - | TEP | LC |
| **Labridae** | **Bodianus diplotenia** (Gill, 1862) | V, SIO, R2 | SIO 70-167 | C | TEP | LC |
| | **Halichoeres chierchiae** Di Caporiacco, 1948 | V, R1, R2 | - | C | TEP | LC |
| | **Halichoeres dispilus** (Günther, 1864) | V, C, SIO, R2 | LEMA-PE93, 127, 128 SIO 70-167 | D | TEP | LC |
| | **Halichoeres melanotis** (Gilbert, 1890) | V, R2 | - | R | TEP | LC |
| | **Halichoeres nicholsi** (Jordan & Gilbert, 1882) | V, SIO, R2 | SIO 70-167 | A | TEP | LC |
| | **Halichoeres notospilus** (Günther, 1864) | V, R2 | - | U | TEP | LC |
| | **Iniistius pavo** (Valenciennes, 1840) | C | LEMA-PE133 | - | EP+IP | LC |
| | **Novaculichthys taeniourus** (Lacepède, 1801) | V, R2 | - | R | EP+IP | LC |
| | **Thalassoma grammaticum** Gilbert, 1890 | V, R2 | - | R | EP+IP | LC |
| | **Thalassoma lucasanum** (Gill, 1862) | V, R2 | - | C | TEP | LC |
| **Scaridae** | **Nicholsia denticulata** (Evermann & Radcliffe, 1917) | V, R2 | - | R | EP | LC |
| | **Scarus ghobban** Forsskål, 1775 | V, R2 | - | R | EP+IP | LC |
| | **Scarus perrico** Jordan & Gilbert, 1882 | V, R2 | - | R | TEP | LC |
| **Dactyloscopidae** | **Axoclinus storeae** (Brock, 1940) | V, C | - | R | MEX | LC |
| | **Eumeanectes carinalis** (Jordan & Gilbert, 1882) | C, SIO | LEMA-PE121 SIO 70-167 | - | TEP | LC |
| | **Eumeanectes glenae** Rosenblatt, Miller & Hastings, 2013 | V, SIO | SIO 70-167 | R | MEX | NE |
| | **Eumeanectes macrops** Rosenblatt, Miller & Hastings, 2013 | SIO | SIO 70-167 | - | MEX | NE |
| **Dactyloscopidae** | **Dactyloscopus anmis** Miller & Briggs, 1962 | C | LEMA-PE78 | - | TEP | LC |
| | **Gillellus arenicola** Gilbert, 1890 | C | LEMA-PE117 | - | TEP | LC |
| **Labrisomidae** | **Labrisomus xanti** (Gill, 1860) | V | - | R | MEX | LC |
| | **Malcocetus ebiisi** Springer, 1959 | V, C, SIO, R2 | LEMA-PE100, 107 SIO 70-167 | R | TEP | LC |
| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|--------------------|---------|--------------------|--------------------------------------|------------------------|--------------------------|-----------------|
| Malacoctenidae     | Malacoctenus mexicanus (Springer, 1959) | C, SIO | LEMA-PE98, SIO 70-167 | LC | TEP | LC |
|                   | Malacoctenus polyporosus (Cope, 1877) | V, C | LEMA-PE110 | LC | TEP | LC |
|                   | M. tetranemus Cope, 1877 | C, SIO | LEMA-PE96, 109, SIO 70-167 | LC | TEP | LC |
|                   | Starksia spinipenis Al-Uthman, 1960 | V, C, SIO | LEMA-PE118, SIO 70-167 | LC | TEP | LC |
|                   | Paraclinus tanygnathus Rosenblatt & Parr, 1969 | C | LEMA-PE101, 106, 111 | LC | TEP | LC |
| Chaenopsidae       | Chaenopsys syr | C | LEMA-PE14-41 | LC | TEP | LC |
|                   | Corbiculiceps bohleri Stephens, 1963 | C, SIO | LEMA-PE84, 85 | LC | TEP | LC |
|                   | E. myersi Stephens, 1963 | C | LEMA-PE80, 86, 104, SIO 70-167 | LC | TEP | LC |
|                   | Protemblemaria bicirrus (Hildebrand, 1946) | C | LEMA-PE90, 105 | LC | TEP | LC |
| Blenniidae         | Entomacrodus chiostictus (Jordan & Gilbert, 1882) | C | LEMA-PE137 | LC | TEP | LC |
|                   | Hypsoblennius brevipinnis (Günther, 1861) | C | LEMA-PE89 | LC | TEP | LC |
|                   | Ophioblennius steindachneri (Jordan & Evermann, 1898) | V, SIO, R2 | SIO 70-167 | LC | TEP | LC |
|                   | Plagiotremus azaleus (Jordan & Bollman, 1890) | V, SIO, R2 | SIO 70-167 | LC | TEP | LC |
| Eleotridae          | Eleotris picta Kner, 1859 | R1 | - | LC | TEP | LC |
|                   | Hypoepibulus leuciscus (Günther, 1861) | V, SIO, R2 | SIO 70-167 | LC | TEP | LC |
|                   | P. elongatus (Jordan & Evermann, 1898) | C | LEMA-PE90, 105 | LC | TEP | LC |
|                   | Plagiotremus azaleus (Jordan & Bollman, 1890) | V, SIO, R2 | SIO 70-167 | LC | TEP | LC |
| Gobiidae           | Coryphopterus urospilus Ginsburg, 1859 | V, C, SIO, R2 | LEMA-PE88, 116, SIO 70-167 | LC | TEP | LC |
|                   | Ctenogobius sagittula (Günther, 1862) | C | LEMA-PE89 | LC | TEP | LC |
|                   | Elacatinus puncticulatus Ginsburg, 1859 | V, C, SIO, R2 | LEMA-PE88, 116, SIO 70-167 | LC | TEP | LC |
|                   | Gymnoeleotris seminuda (Günther, 1898) | V | LEMA-PE88 | LC | TEP | LC |
| Microdesmidae      | Microdesmus dipus Ginsburg, 1859 | V | LEMA-PE88 | LC | TEP | LC |
| Microdesmidae      | Microdesmus dipus Ginsburg, 1859 | C, SIO | LEMA-PE88, 82 | LC | TEP | LC |
| Microdesmidae      | Microdesmus dipus Ginsburg, 1859 | C, SIO | LEMA-PE88, 82 | LC | TEP | LC |
| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|--------------------|---------|--------------------|---------------------------------------|-------------------------|---------------------------|-----------------|
| Ephippidae         | Chaetodipterus zonatus (Girard, 1858) | R1 | - | - | EP | LC |
| Zanclidae          | Zanclus cornutus (Linnaeus, 1758) | V, R2 | - | R | EP+IP | NE |
| Acanthuridae       | Acanthurus sancobusus Valenciennes, 1835 | V, R1 | - | R | EP+IP | LC |
|                    | Prionurus punctatus Gill, 1862 | V, R2 | - | R | TEP | LC |
| Sphyraenidae       | Sphyraena ensis Jordan & Gilbert, 1882 | C, R1 | LEMA-PE129 | - | TEP | LC |
| Scombridae         | Euthynnus lineatus Kishinouye, 1920 | V | - | R | EP+IP | LC |
| **Pleuronectiformes** |         |                  |                                        |                         |                           |                 |
| Paralichthyidae    | Cycloptera sp.‡ | C | LEMA-PE130 | - | - | - |
|                    | Eropus crososus Jordan & Gilbert, 1882 | R1 | - | - | EP+ATL | NE |
|                    | Eropus sp.‡ | C | LEMA-PE123a | - | - | - |
|                    | Syacium latifrons (Jordan & Gilbert, 1882) | SIO | SIO 70-238 | - | TEP | LC |
|                    | Syacium ovale (Günther, 1864) | SIO | SIO 70-237 | - | TEP | LC |
|                    | Syacium sp.‡ | C | LEMA-PE124 | - | - | - |
| Bothidae           | Bothus constellatus (Jordan, 1889) | SIO | SIO 70-237, 238 | - | EP+IP | NE |
|                    | Monolene dubiosa Garman, 1899 | SIO | SIO 70-168 | - | TEP | LC |
| Cynoglossidae      | Symphurus atramentosus Jordan & Bollman, 1890 | SIO | SIO 70-237 | - | TEP | LC |
|                    | Symphurus leei Jordan & Bollman, 1890 | C, SIO | LEMA-PE122, SIO 70-235 | - | TEP | LC |
|                    | Symphurus melanurus Clark, 1936 | C | LEMA-PE131 | - | TEP | LC |
|                    | Symphurus sp.‡ | C | LEMA-PE123b, 125, 126 | - | - | - |
| Tetraodontiformes   |         |                  |                                        |                         |                           |                 |
| Balistidae         | Balistes polylepis Steindachner, 1876 | V, R2 | - | R | EP+IP | LC |
|                    | Pseudobalistes nasutus (Jordan & Starks, 1895) | V, R2 | - | R | TEP | LC |
|                    | Sufflamen verres (Gilbert & Starks, 1904) | V, R2 | - | C | TEP | LC |
| Monacanthidae      | Aluterus scriptus (Osbeck, 1765) | V, R2 | - | R | CT | NE |
| Ostraciidae        | Canthervines intermedii (Holland, 1854) | V | - | R | EP+IP | NE |
|                    | Ostracion meleagris Shaw, 1796 | V, R2 | - | R | EP+IP | NE |
| CLASS/Order/Family | Species | Record designation | Catalog number of collected specimens | Frequency of occurrence | Bio-geographical affinity | IUCN Categories |
|--------------------|---------|-------------------|--------------------------------------|-------------------------|--------------------------|-----------------|
| Tetraodontidae     | Arothron hispidus (Linnaeus, 1758) | V | - | R | EP+IP | NE |
|                    | Arothron meleagris (Anonymous, 1798) | V, R1, R2 | - | U | EP+IP | NE |
|                    | Canthigaster punctatissima (Günther, 1870) | V, R2 | - | R | TEP | LC |
|                    | Sphoeroides annulatus (Jenyns, 1842) | V, SIO, R1, R2 | SIO 70-238 | R | EP | LC |
|                    | Sphoeroides lobatus (Steindachner, 1870) | V, SIO, R2 | SIO 70-237, 238 | R | TEP | LC |
| Diodontidae        | Chilomycterus reticulatus Linnaeus, 1758 | V, R2 | - | R | CT | NE |
|                    | Diodon holocarthus Linnaeus, 1758 | V, SIO, R2 | SIO 70-167 | C | CT | NE |
|                    | Diodon bystrix Linnaeus, 1758 | V, R1, R2 | - | R | CT | NE |

† Considered as Albula nemoptera by Espinoza-Pérez et al. (2002), designated as Albula pacifica by Pfeiler (2008).
‡ These individuals represent juveniles too small to be accurately identified.
§ This individual is an undescribed species previously found in Costa Rica.
(Espinoza-Pérez et al. 2002, Galván-Villa 2015), the richness of the bay increased in this study by more than 240% (by 117 species). The jacks (Carangidae) represent the most diverse family, with 11 species and 8 genera, followed by the wrasses (Labridae) with 10 species and 5 genera, and damselfishes (Pomacentridae) and grunts (Haemulidae) each with 9 species and 4 genera. Eighteen families are represented by only one species. No endemic species for Bahía Chamela were found but 14 endemic species for the Mexican Pacific are recorded here.

The fish species richness of Bahía Chamela (196 species) is greater than in other surveyed MPAs of the Mexican Pacific, including Bahía de Los Ángeles (93 species), Bahía Loreto (66), Cabo Pulmo (62), and Isla Isabel (118) in the Gulf of California (Campos-Dávila et al. 2005, Alvarez-Filip et al. 2006, Galván-Villa et al. 2010, Viesca-Lobatón et al. 2008, Mascareñas-Osorio et al. 2011); Islas Marietas (46) (Solís-Gil and Jiménez-Quiroz 2004) in the central Mexican Pacific; and Bahías de Huatulco (112) in the southern Mexican Pacific (López-Pérez et al. 2010). Only three species (Hippocampus ingens, Holacanthus passer, Pomacanthus zonipectus) occurring in the bay have been designated with special protection category by the Mexican Official Norm 059-ECOL-2010. Furthermore, in the red list of the International Union for Conservation of Nature (IUCN 2015) three species are assessed as vulnerable (Diplobatis ommata, H. ingens, Stegastes leucorus) and one as endangered (Sphyrna lewini) (Table 1).

Fifty-four percent of the species was recorded using visual census. The composition of the fish assemblage of the bay is characterized mainly by rare species (72%). Three species are categorized as dominant: Epinephelus labriformis, Stegastes flavilatus, and Halichoeres dispilus; these species are widely distributed along the Mexican Pacific and are recognized as important in the reef-fish assemblage structure for this bay and other MPAs of the Mexican Pacific because of their high abundance and biomass (Galván-Villa 2015). Another four species are categorized as abundant: Chaetodon humeralis, Microspathodon dorsalis, Stegastes acapulcoensis, and Halichoeres nicholsi; nine as common, and 13 as uncommon. The number of species inhabiting the bay may increase after checking additional details of some of the collected specimens and published records. Additions may include undescribed species, juvenile stages from different species, or records from publications with erroneous determinations. For example, a single female individual of chaenopsid pike-blenny (Chaenopsis sp.) that was collected from sandy bottom of the bay corresponds to an undescribed species distributed from Mexico to Costa Rica (Hastings pers obs). Also three individuals of Pontinus (sp. 1 and sp. 2) were collected, but due to their small size (< 2 cm), the identification of species was not possible. They probably correspond to P. furcirhinus or P. sierra, as both species have been recorded in the area (Robertson and Allen 2015). Another five juvenile individuals of flounders (Paralichthyidae) and eight tonguefishes (Cynoglossidae) collected by the biological dredge from sandy bottoms were not identified to species level. Future careful taxonomic work on these and other specimens would increase the number of species recorded from the bay.

**Biogeographic affinity.** Most fish species recorded in Bahía Chamela are widely distributed in the tropical eastern Pacific (123 spp = 66%) (Figure 2). Twenty-three
species occur in the eastern Pacific, and 18 occur in both eastern and Indo-Pacific waters. Fourteen species are endemic in Mexican waters of the Pacific. One specimen of the Gulf Brotula, *Ogilbia ventralis*, was collected with clove oil anesthetic from under rocks, depth 6 m at the islet Novillos (Figure 3). This record represents a southern range extension for this species, known previously from the Gulf of California and southern part of the outer Baja peninsula. Bahía Chamela is the type locality for a second *Ogilbia* species, *O. boydwalkeri* (Møller et al. 2005). The festive drum fish, *Pareques fuscovitattus*, is the only endemic species in the Mexican Province (Robertson and Allen 2015). Nine species are circumtropical, and another two (*Mugil curema* and *Eiropus crosotus*) occur in both the eastern Pacific and western Atlantic regions. Seven undetermined or non-described species were excluded from the analysis of biogeographic affinity.

Previous studies considered *Haemulon steindachneri* (Haemulidae) to occur in both eastern Pacific and western Atlantic oceans, although recently molecular analysis found that these two populations belong to different species, so the valid distribution
of this nominal species is the TEP (Rocha et al. 2008). Future review of other species that reportedly occur in both oceans is important to define valid distributions. Finally, according to Robertson and Cramer (2009), the fish richness of Bahía Chamela is most similar to that of the Panama biogeographic province, but there is an important contribution of species from the Gulf of California and outer Baja peninsula and a few species from other oceans.

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