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EDITORS



CURRENT DISTRIBUTIONAL STATUS OF SEVEN INVASIVE EXOTIC FISHES IN THE PENINSULA OF BAJA CALIFORNIA

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The current distributional status of seven invasive exotic fish species (*Gambusia affinis*, *Poecilia latipinna*, *Poecilia reticulata*, *Xiphophorus hellerii*, *Cyprinus carpio*, *Lepomis cyanellus* and *Tilapia* sp. cf. *zillii*) for the continental waters of the Baja California Peninsula was documented. This study was based on specimens collected between 1977 and 2011 for 109 sites, as well as records of species reported in the literature. In the oasis ecosystems of Baja California Sur is notable the impacts of the redbelly tilapia (*T. sp. cf. zillii*) and guppy (*P. reticulata*) on the endemic populations of the Baja killifish (*Fundulus lima*), while in the Lower Río Colorado basin of Baja California both redbelly tilapia and sailfin molly (*P. latipinna*) have decimated the remnant populations of the desert pupfish (*Cyprinodon macularius*).

Keywords: exotic fish, invasive fish, impacts, Baja California Peninsula.

1. INTRODUCTION

One of the main threats affecting the stability and integrity of the fish communities in the arid and semiarid regions of northern Mexico is the introduction of exotic or nonnative fishes (Contreras-Balderas *et al.* 2008). In Mexico at least 113 exotic fish species have been reported (Contreras-Balderas *et al.* 2008), number that will be increasing if programs of control and eradication of exotics are not timely implemented. The stability of the freshwater ecosystems with low species richness become chaotic when invasive exotic species (high competitive and ecological plasticity) are stocked, particularly in small wetland habitats as springs and oases, where its native biota that has evolved in isolation for thousandths of years and lacking competitive strategies and no predation are displaced or eliminated by this advantage interaction (Douglas *et al.* 1994).

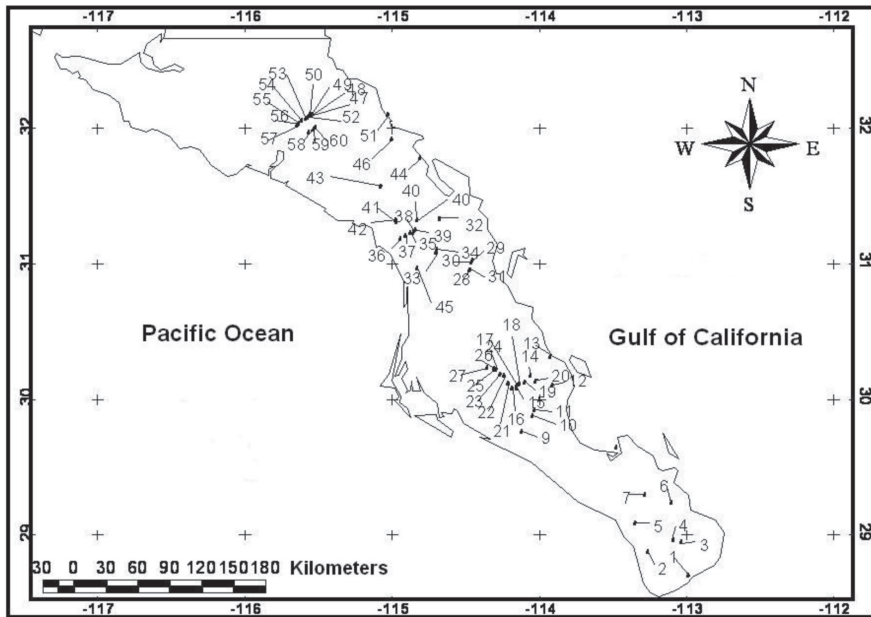
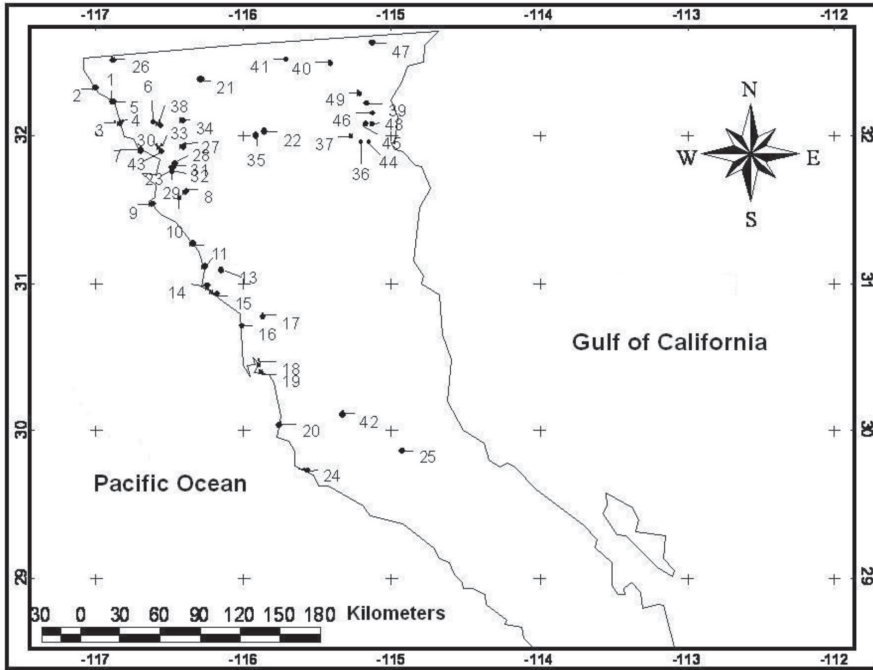
The homogenization of the biota in a geographic region is the result of the gradual elimination of the native species and its replacement by those exotics, which originates a loss of the biodiversity and changes in the function of the ecosystem (Mack *et al.* 2000, McKinney and Lockwood 1999, Marchetti *et al.* 2001, Rahel 2002). From a regional point of view, 17 exotic fish species has been reported for Baja California (Ruiz-Campos and Contreras-Balderas 1987, Ruiz-Campos *et al.* 2000) and six species for Baja California Sur (Ruiz-Campos *et al.* 2002, Ruiz-Campos 2012). Varela-Romero *et al.* (2002) evaluated the impact of exotic redbelly tilapia (*Tilapia* sp. cf. *zillii*) on the native populations of the desert pupfish *Cyprinodon macularius* in different sites of the lower Colorado River basin of Sonora and Baja California. These authors consigned the extirpation of the native pupfish for several historic sites of its distribution in Baja California (cf. Follett 1960, Hendrickson and Varela 1989). Likewise, Ruiz-Campos *et al.* (2006, 2008) evaluated the impact of redbelly tilapia on the distribution and abundance of the endemic Baja California killifish *Fundulus lima* in the oases of the San Ignacio and La Purísima of Baja California Sur, determining the virtual elimination of the endemic fish in the type locality of oasis San Ignacio.

The aim of this work is to document the distribution of seven exotic fish species and their impacts on the native fish fauna in the Baja California Peninsula, based on records with voucher specimens from scientific collections or records that been referred to in the literature during a period of 34 years.

2. MATERIAL AND METHODS

The records of distribution for the seven exotic species documented in this study were based on voucher specimens (cf. Appendix 1) that have been collected by the authors during a period of 34 years (1977 to 2011) in 109 sites through the Peninsula of Baja California, Mexico (see Figures 1 and 2, Appendix 2). The fish were captured using different types of fishing gears according to the habitat of each species. In shallow habitats (< 1.5 m deep) active (seine of 6 m long x 1.5 m height x 1/8 and 1/16 inches mesh size) and passive (minnow-traps) capture methods were used; while in those sites deeper than 1.5 m experimental gillnets (with 6 m-panels with mesh sizes of 0.5, 1.5, 3 and 4 inches) and cast nets were used. Electrofishing equipment (Smith-Root 15-C P.O.W.) was used for shallow habitat with low salinity (< 0.5 ppt), such as in the headwaters of streams (Sierra San Pedro Mártir).

Samples for each collected fish were fixed in field with a 10% formalin solution and transported to laboratory for analysis and identification. After seven days, the fish samples were washed with water during 1 day, and finally preserved with 50%



FIGURES 1 & 2. Collecting sites in the State of Baja California, Mexico (see details on toponomy in Appendix 2) / Collecting sites in the State of Baja California Sur, Mexico (see details on toponomy in Appendix 2).

ethanol. Voucher specimens were deposited in the following Fish Collections: Facultad de Ciencias, Universidad Autónoma de Baja California (UABC); Departamento de Investigación Científica, Universidad de Sonora (DICTUS); and Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León (UANL).

The voucher specimens of fish species collected in the study area previous to 1991 were examined in the following museums: Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León (UANL) at Monterrey, NL (Mexico); Centro Interdisciplinario de Ciencias Marinas (CICIMAR) at La Paz, BCS (Mexico); and Museo Regional de Historia Natural-Universidad Autónoma de Baja California Sur (UABCS) at La Paz, BCS.

Scientific and common names and taxonomical arrangement of the species follows to Eschmeyer (1998). For each species a synopsis is provided that includes the following information: *Common name*: common names of the species both in English and Spanish based on Nelson *et al.* (2004). *Native range*: native distribution range of the species based on published records. *Previous records*: those records referred to in publications or in museum records prior to 1991. *Recent records*: those collection records supported with voucher specimens deposited in the UABC Fish Collection or with visual reports, all of them carried out during samplings after 1991. Other information appears in parenthesis. *Comments*: information regarding to the non-native distribution of the taxon, as well as documentation of the impact of this exotic species on the distribution and abundance of the native fish fauna.

3. RESULTS AND DISCUSSION

The following seven invasive exotic species documented here, represent those species with higher distributional representation in the Baja California Peninsula.

Family Poeciliidae

Gambusia affinis (Baird & Girard, 1853)

COMMON NAME: Mosquito Fish / pez mosquito.

NATIVE RANGE: Atlantic and Gulf of Mexico drainages from south New Jersey to Mexico; Mississippi river basin from central Indiana and Illinois, USA south through the Gulf of Mexico drainages and northern Veracruz (Álvarez del Villar 1970: III; Page and Burr 1991: 235).

PREVIOUS RECORDS. Baja California: Río Hardy at Meganito (3.4 km north El Mayor); Río Colorado at 6.4 km downstream the junction with Río Hardy, at Pongo de Abajo, 24.1 km south El Mayor, and 40.2 km above the mouth (Follett 1960: 227); Río Tijuana (3.2 km E Tijuana); a stream 23 km SE Tecate *ca.* Valle de

Las Palmas (CAS-119067, 119246); Ojos Negros 42 km E Ensenada (CAS-119247); Arroyo Guadalupe (= La Misión) at valley of Santa Rosa and town of La Misión, and Arroyo San Simón S San Quintín (Follett 1960: 227). Baja California Sur: Arroyo at Santiago and Arroyo San José del Cabo (Follett 1960: 227); Ojo de Agua de La Rosita at San Antonio, Ojo de Agua at San Bartolo, Arroyo La Tinaja [= El Túnel, Caduaño], and Presa (dam) Juárez *ca.* Todos Santos (Contreras-Balderas and Escalante-Cavazos 1984: 113).

RECENT RECORDS. Baja California: Arroyo Alamar at Cañón del Padre; irrigation channel at Ejido Sinaloa (Varela *et al.* 2002: 162); mouth of Arroyo Cantamar (= El Médano); mouth of Arroyo El Descanso; mouth of Arroyo La Misión, La Misión town; Rancho Santa Rosa; Rancho Korodaki; Arroyo San Miguel; stream between Piedras Gordas and Las Minas; Emilio López Zamora dam; Arroyo San Carlos at Agua Caliente and Las Hamacas; streams of Las Animas, Santo Tomás, Seco [ca. Colonet], San Telmo, Santo Domingo (mouth) and Rancho El Divisadero; Arroyo El Rosario (lower part). Baja California Sur: Arroyo La Tinaja *ca.* Miraflores and Arroyo Boca de la Sierra at the base of the San Bernardino canyon (cf. Ruiz-Campos *et al.* 2002: 150).

COMMENTS: This livebearer fish was introduced in northwestern Mexico for the control of mosquito, becoming an invasive species due to its high tolerance and competitive capacity to extreme environmental factors. There are two sources of distribution of mosquito fish in the Baja California Peninsula, one in the northwestern (Ruiz-Campos *et al.* 2000: 77) and the second at south of La Paz (Ruiz-Campos *et al.* 2002: 151). In northwestern Baja California is considered a current competitor of the native threespine stickleback *Gasterosteus aculeatus*, in the coastal streams of El Descanso, Santo Domingo and El Rosario (Ruiz-Campos *et al.* 2000: 77).

Poecilia latipinna (LeSueur, 1821)

COMMON NAME: Sailfin Molly / topote velo negro.

NATIVE RANGE: Atlantic and Gulf of Mexico coastal drainages, from Cape Fear drainage, North Carolina, to Veracruz, Mexico (Fuller *et al.* 1999: 309).

PREVIOUS RECORDS. Baja California: Río Hardy and Río Colorado (Hendrickson and Varela-Romero 1989: 480). Baja California Sur: None.

RECENT RECORDS. Baja California: Río Hardy at campo Mosqueda, Río Colorado at Ejido Yucumuri, irrigation channel between Ejido Nayarit and Sonora (Varela-Romero *et al.*, 2002: 162), Río El Mayor at Campo Sonora, and Laguna Salada at El Paraíso fishery camp; Baja California Sur: None.

COMMENTS: The sailfin molly is one of many exotic fishes that have been introduced in the waters of the lower Colorado River of California and Arizona (Dill

and Cordone 1997: 124) and dispersed into the Mexican part of the basin. In the Ciénaga de Santa Clara (Sonora) this fish competes with endangered desert pupfish (*Cyprinodon macularius*) for space and food (Varela-Romero *et al.* 2002: 161).

Poecilia reticulata Peters, 1859

COMMON NAME: Guppy / gupi.

NATIVE RANGE: West Indies and northern South America, from west Venezuela to Guyana Guyana (Fuller *et al.* 1999: 312).

PREVIOUS RECORDS. Baja California: None. Baja California Sur: Presa (dam) Juárez at Todos Santos (UANL-2569 [303]) (Contreras-Balderas and Escalante-Cavazos 1984: 114).

RECENT RECORDS. Baja California: Arroyo Cataviña (near Cataviña); and Arroyo Santa Gertrudis at Misión de Santa Gertrudis. Baja California Sur: Arroyo San José del Cabo; Arroyo Las Pocitas (two localities: Pozas del Vado and Rancho El Caracol); Arroyo San Pedro (seven localities: San Basilio, Pozo del Iritú, Rancho Merecuaco, Rancho Los Arados, Rancho El Caporal, and San Pedro de La Presa); Arroyo Bebelamas [three localities: Poza Honda (Rancho San Lucas), Rancho El Frijolito and Rancho San Antonio de la Montaña]; Arroyo San Luis (three localities: Misión de San Luis Gonzaga, Presa Higuajil and Rancho Las Cuedas); Arroyo La Zorra near Rancho Viejo; Arroyo San Javier at Misión de San (Francisco) Javier; Arroyo Comondú (two localities: San Miguel de Comondú and San José de Comondú); Arroyo La Purísima (seven localities: La Purísima, near San Gregorio estuary, San Isidro, El Pilón, Carambucho, La Purísima-San Juanico road, and Ojo de Agua); Arroyo La Purísima Vieja at Paso Hondo; Oasis La Purísima Vieja; Río Mulegé (dam); Arroyo Boca de Magdalena at San José de Magdalena; Arroyo San Joaquín (three localities: San Joaquín, El Sauzal and San Zacarías); Arroyo San Ignacio [eight localities: Oasis San Ignacio (two localities: spring and dam), Rancho El Tizón, Lake Side, San Lino, Poza Larga, Laguna Roberts, San Zacarías and Rancho San Sabas]; and San Gregorio stream at Sierra San Francisco.

COMMENTS: It is the most invasive exotic fish in the freshwater bodies in the central and southern Baja California Peninsula, from Arroyo Cataviña (Baja California) to Arroyo San José del Cabo (Baja California Sur). From its first detection in 1977 at the tip of the Peninsula in Arroyo San José del Cabo (Ruiz-Campos and Contreras-Balderas 1987: 112), its dispersal to other inland waters has been enough quick and favored by the stocking via anthropogenic. The presence of the guppy in very remote sites of the Sierra de San Francisco (Rancho San Gregorio) was previously reported by Ruiz-Campos *et al.* (2002: 151).

Xiphophorus hellerii Heckel, 1848

COMMON NAME: Green Swordtail / cola de espada.

NATIVE RANGE: Middle America from Río Nantla, Veracruz (Mexico), to north-western Honduras (Page and Burr 1991: 234; Fuller *et al.* 1999: 316).

PREVIOUS RECORDS: None.

RECENT RECORDS. Baja California: None. Baja California Sur: Arroyo San Pedro at San Basilio and San Pedro de la Presa; Arroyo San Ignacio at the spring, El Tizón, bridge, Poza Larga, San Lino (front to Rice and Beans), Paso Los Pinos [between Los Corralitos and San Sabas] and San Sabas; and Arroyo San Joaquín at El Sauzal.

COMMENTS: The green swordtail is syntopical with the native Baja California killifish *Fundulus lima* through the Río San Ignacio (except for locality of Los Corralitos) (Ruiz-Campos *et al.* 2006: 506) and Río San Pedro de La Presa (Ruiz-Campos *et al.* 2002: 151). The abundance of the green swordtail has been pretty decimated in the spring of San Ignacio due to the presence of other exotic competitor (redbelly tilapia) from 1996 (Ruiz-Campos *et al.* 2006: 508).

Family Cyprinidae

Cyprinus carpio Linnaeus, 1758

COMMON NAME: Common Carp / carpa común.

NATIVE RANGE: Eurasia (Page and Burr 1991: 64).

PREVIOUS RECORDS. Baja California: Río Colorado and its tributaries (Follett 1960: 227), as well as Laguna Salada (= Maquata) at La Playita (Ruiz-Campos and Contreras-Balderas 1987: 110). Baja California Sur: None.

RECENT RECORDS. Baja California: Channel tributary to Laguna Salada; Río Colorado at Campo Gabriel and near the junction with Río Hardy. Baja California Sur: Río San Ignacio at the spring, bridge, Poza Larga, Los Corralitos and San Sabas (Ruiz-Campos *et al.* 2006: 506).

COMMENTS: The presence of this Eurasian cyprinid in Baja California was first documented by Follett (1960: 227) for the Río Colorado and its tributaries in the Mexicali valley. In Baja California Sur, common carp was stocked into the San Ignacio oasis in 1973 to promote rural fish farming (Ruiz-Campos *et al.* 2002: 150). In both cases, the consumption of this fish is little frequent due to the bad flavor of its flesh and the feasibility to obtain fresh fish from the San Ignacio coastal lagoon. A specimen (UABC-1361) weighting 3.5 kg was caught using gillnet near the spring of the San Ignacio oasis on 26 October 2002. Two common morphs have been detected in the Peninsula of Baja California, the “mirror morph” in the Río San Ignacio and the “normally scaled morph” in the lower Colorado River basin (Ruiz-Campos 2012: 105).

Family Centrarchidae

Lepomis cyanellus Rafinesque, 1819

COMMON NAME: Green Sunfish / pez sol.

NATIVE RANGE: Native to Great Lakes, Hudson Bay, and Mississippi River basins from New York and Ontario to Minnesota and South Dakota, and south to Gulf of Mexico drainages, including the Rio Grande basin and northern Mexico (Page and Burr 1991: 267).

PREVIOUS RECORDS. Baja California: Río Tijuana, 3.2 km E Tijuana; a stream *ca.* Valle de Santa Rosa at 32.2 km S [sic] Ensenada (Follett 1960: 228); and Arroyo San Miguel (= Guadalupe or La Misión, CAS-19405). Baja California Sur: None.

RECENT RECORDS. Baja California: Arroyo El Descanso (mouth and adjacent lagoon); mouth of Arroyo La Misión; Arroyo San Antonio de las Minas at Rancho Kodoraki and Rancho La Fortuna; Arroyo Doña Petra at Rancho Madrigal; Rancho Tierra Santa; Rancho Santa Rosa; Charco Escondido [Parque Nacional Constitución 1857]; Arroyo San Carlos at Rancho Las Hamacas and Rancho Alamitos; Arroyo Santo Tomás at Ejido Ajusco and La Bocana Santo Tomás; mouth of Arroyo San Telmo; and Arroyo Santo Domingo at Rancho El Divisadero. Baja California Sur: None.

COMMENTS: The non-native presence of green sunfish in the streams of the Mediterranean region of Baja California was first reported by Follett (1960: 228) for the Santa Rosa valley (a tributary to Arroyo Guadalupe) on the basis of a personal communication via Dr. Carl L. Hubbs. This exotic centrarchid is a possible predator of the native threespine stickleback (*Gasterosteus aculeatus*) in the mouth of the Río El Descanso and its adjacent lagoon (Sánchez-González *et al.* 2001: 192).

Family Cichlidae

Tilapia sp. cf. *zillii* (Gervais, 1848)

COMMON NAME: Redbelly Tilapia / tilapia panza roja.

NATIVE RANGE: Tropical and subtropical Africa, Near East; West Africa through Chad basin to Nile, Lake Albert, and Lake Turkana into Israel and Jordan Valley. This cichlid has been widely introduced by the man in many regions of the world, even the same African continent (Fuller *et al.* 1999: 451; Moyle 2002: 415).

PREVIOUS RECORDS: None.

RECENT RECORDS. Baja California: Río El Mayor at Campo Sonora; irrigation channel between Ejido Nayarit and Ejido Sonora (Varela-Romero *et al.* 2002: 159); Presa (dam) Emilio López Zamora, and Arroyo San Juan de Dios at Rancho El Saucito. Baja California Sur: Oasis San Ignacio at spring, El Tizón, Lake Side, bridge (entry to San Ignacio town), San Lino (adjacent to Hotel Rice and Beans),

Poza Larga, Rancho Los Estribos, Lagunita de Roberts, Rancho Los Corralitos, and Rancho San Sabas. Arroyo Cadejé at Cadejé (F. Reynoso-Mendoza, unpublished data); Arroyo Boca de Magdalena at San José de Magdalena; Arroyo San Martín at Rancho La Vinorama [Sierra de Guadalupe]; Arroyo La Purísima at San Isidro, El Pílon, bridge of Carambucho, La Purísima, Carambucho [= Cuba], Presa (dam) Carambucho, and Ojo de Agua; Oasis La Purísima Vieja; La Purísima Vieja at Paso Hondo; Arroyo Comondú at San Miguel de Comondú; Arroyo San Javier at Misión de San [Francisco] Javier; Higuajil dam; Poza Honda [Rancho San Lucas] and Rancho El Frijolito; Arroyo Bebelamas [Río Bramonas basin] at Rancho San Antonio de la Montaña; Arroyo San Luis at Misión de San Luis Gonzaga and Rancho Las Cuedas; Arroyo San Pedro at San Pedro de La Presa, San Basilio, Pozo del Iritú, Rancho Merecuaco, Rancho Los Arados and Rancho Tres Pozas; Arroyo La Soledad at El Quelele; and Arroyo San José del Cabo (Dr. Alejandro Maeda-Martínez, pers. comm.).

COMMENTS: Redbelly tilapia is one of the most invasive exotic fishes in the inland waters of the Peninsula of Baja California (Ruiz-Campos *et al.* 2002: 151, 2006: 506; Varela-Romero *et al.* 2002: 164) and southwestern U.S.A. (Dill and Cordone, 1997: 201). In the Lower Colorado River basin, this fish is the main cause of the decreasing in abundance and distribution of the desert pupfish populations, *Cyprinodon macularius* (Schoenherr 1988: 115; Varela-Romero *et al.* 2002: 164); likewise, in the oases of Baja California Sur has caused the extirpation of the endemic Baja California killifish (*Fundulus lima*) in the localities of Misión de San Javier (cuenca Río San Javier), Las Cuedas (cuenca Río San Luis), Poza Honda (cuenca Río Bebelamas), Misión de San Luis Gonzaga (Cuenca Río San Luis) and San Pedro de La Presa (cuenca Río San Pedro) (see Figure 2; Ruiz-Campos 2012: 129). The redbelly tilapia was first stocked into the at San Ignacio oasis in 1995 by a person from the adjacent town, but without considering the severe ecological effects that this event would generate a few years later. Previous to the introduction of redbelly tilapia, the Baja California killifish was the dominant fish in the spring habitat with relative abundances between 70 and 97% (Alaníz-García 1995: 22); however ten years later, this situation was reverted to favor the redbelly tilapia, which exhibit relative abundances as high as 84–94% (Ruiz-Campos *et al.* 2008: 29).

4. GENERAL CONSIDERATIONS

The invasion of non-native aquatic species to new areas should be considered a process that involves three steps: initial dispersal, establishment, and radiation (Elton 1958). In each step exists selective pressures operating on the survival of organisms in

order to diminish of successive way the total pool of species and increase the success of invasion (Williamson 1996). In this sense, several hypotheses have been proposed to explain the patterns of invasion by exotic species in the aquatic ecosystems. The first hypothesis (human activity) makes reference to the steps of initial invasion, establishment and radiation; while the second hypothesis (biotic acceptance) predicts that the establishment of nonnative species will be higher for rich areas in native species, where the abiotic conditions are favorable for both; and finally, the third hypothesis (biotic resistance) explains that the success of the invasion decreases in relation to the species richness in the community (cf. Elton 1958, Gido and Brown 1999, Leprieur *et al.* 2008) and the time of accumulation of species.

One of the aquatic ecosystems of the northwestern Mexico more strongly impacted by the introduction of exotic fishes is the lower Rio Colorado basin, where at least 23 species have been recorded (Ruiz-Campos *et al.*, 2012). This high number of exotic fishes is resulting of the accumulation of species by almost a century through the active dispersal from the reservoirs and irrigation channels of Arizona. Significant fluctuations in the base flow of the Colorado River has generated the extinction of fish species associated to conditions of high levels of current flows (discharge) such as the endemics, *Xyrauchen texanus*, *Gila elegans* and *Ptychocheilus lucius* (Rinne and Minckley 1991; Varela-Romero and Hendrickson 2009) as well as the establishment of exotic fishes tolerant to these hydrological changes such as red shiner, sailfin molly, mosquito fish and redbelly tilapia (Varela-Romero *et al.* 2002), all of them have dispersed into the agriculture irrigation channels in the Mexicali valley. In this same basin, but in spring and wetland habitats, the abundance of the desert pupfish *Cyprinodon macularius* has been dramatically decreased in those historic distribution localities (Follett 1960, Hendrickson and Varela-Romero 1989, Varela-Romero *et al.* 2002, Miller *et al.* 2005), mainly by competition with redbelly tilapia and sailfin molly interaction (Varela-Romero *et al.* 2002).

Based on the niche theory (Chase and Leibold 2003), two species occurring on the same space and time cannot have identical realized niches because one would be excluding the other. Exotic species with ample potential niches such as occur with invasive species, which trend to become dominant forms when introduced in systems containing species with specialized ecological niches. Thus, significant alterations in the habitat conditions of the native species will promote the expression of potential niches of the exotic species with high environmental tolerance. The oases of Baja California Sur, characterized by the low diversity of native fish fauna, contain endemic fishes as the Baja California killifish (*Fundulus lima*) and Baja freshwater clingfish (*Gobiesox juniperoserrai*), as well as forms of marine or peripheral derivation such as *Awaous banana*, *Eleotris picta*, *Gobiomorus maculatus*, *Dormitator latifrons*,

and *Agonostomus monticola* (Follett 1960, Ruiz-Campos *et al.* 2002, Ruiz-Campos 2010).

This native fish taxocenosis has been strongly modified and decimated by the introduction of exotic fishes, especially of redbelly tilapia. In Baja California Sur, the first introduction of redbelly tilapia occurred in 1986 for the Río Purísima basin (Ruiz-Campos *et al.* 2002). This exotic species was repeatedly stocked into others basins causing the extirpation of the endemic killifish and peripheral fishes in the oases of San Javier, San Pedro de la Presa, Las Cuedas, Paso Iritú, San Luis Gonzaga (Ruiz-Campos 2012), and most recently at Poza Honda (Ruiz-Campos, obs. pers.).

In spite of that the eradication of invasive exotic fishes in the oases of the Baja California Peninsula is virtually impossible, one strategy that might reduce and mitigate the impacts of the exotic species on the natives is the implementation of a permanent program of removing for exotic fishes using active and passive capture techniques.

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APPENDIX 1

Examined material of exotic fishes from the Peninsula of Baja California, Mexico. The collecting sites for voucher specimens followed by catalog numbers and number of specimens in square brackets.

Poecilia reticulata

BAJA CALIFORNIA: Arroyo *ca.* Cataviña (UABC-726 [42], 877 [75]), La Bocana at Cataviña (UABC-1350 [3]). BAJA CALIFORNIA SUR: Río San José del Cabo at San José del Cabo (UABC-754 [1]); Presa (dam) Juárez at Todos Santos (UANL-2569 [303]); Arroyo Las Pocitas at Poza del Vado (UABC-1563 [65], 1575 [20]) and Rancho El Caracol (UABC-1564 [11], 1576 [24], 1577 [50], 1582 [99], 1592 [9]); Arroyo San Pedro at San Basilio (UABC-780 [39]), Pozo del Iritú [Encinas] (UABC-784 [69], 1574 [14]), Rancho Merecuaco (UABC-793 [50]), Rancho Los Arados (UABC-1583 [8]), San Pedro de La Presa (UABC-1317 [42], 1321 [31], 1419 [1], 1485 [6]); Arroyo El Caporal at Rancho El Caporal (UBC-1307 [50]); Arroyo Bebelamas at Poza Honda [Rancho San Lucas] (UABC-746 [37], 2359 [62]), Rancho El Frijolito (UABC-749 [71], 2357 [42]) and San Antonio de la Montaña (UABC-1311 [18]); Arroyo San Luis [dam] at Misión de San Luis Gonzaga (UABC-752 [196], 757 [23], 1579 [19]), Presa Higuajil (UABC-742 [2]) and Rancho Las Cuedas (UABC-1301 [62], 1578 [30], 1586 [34]); Arroyo La Zorra *ca.* Rancho Viejo (UABC-1483 [117]); Arroyo San Javier [dam] at Misión de San [Francisco] San Javier (UABC-822 [170], 823 [61], 912 [7], 2354 [24], 2355 [6]); Arroyo Comondú at San Miguel de Comondú (UABC-765 [339]) and San José de Comondú (UABC-763 [149], 764 [162]); Arroyo La Purísima *ca.* San Gregorio estuary (UABC-2158 [2], San Isidro (UABC-727 [5], La Purísima [dam and bridge] (UABC-761 [48], 827 [1]), El Pilón (UABC-1501 [1]), Carambucho [Cuba] (UABC-760 [16], 828 [1], 1529 [1]), Presa (dam) Carambucho (UABC-761 [48], 827 [1]), Puente (bridge) Carambucho (UABC-1533 [12]), and Ojo de Agua (UABC-1467 [25], 1580 [22]); La Purísima Vieja at Paso Hondo (UABC-1466 [7], 1554 [19]); Río Mulegé [dam] (UABC-146 [83], 907 [7]); Arroyo Boca de Magdalena at San José de Magdalena (UABC-737 [18], 908 [26]); Arroyo San Joaquín at San Joaquín (UABC-733 [81], El Sauzal (UABC-734 [11], 1474 [76]) and San Zacarías (UABC-075 [36]); Oasis San Ignacio at spring (UABC-080 [51], 936 [26], 1306 [58], 2129 [2]), El Tizón (UABC-1536 [7]), Lake Side (UABC-1437 [39], 1496 [2]), San Lino at front of Hotel Rice and Beans (UABC-1527 [19]), Poza Larga (UABC-1314 [18], 1447 [76], 1457 [40], 1503 [2], 2133 [1]), Laguna Roberts (UABC-1497 [32]), San Sabas (UABC-1456 [40], 1502 [4]); Arroyo San Gregorio at Sierra San Francisco (UABC-725 [138]); and Arroyo Santa Gertrudis at Santa Gertrudis Mission.

Gambusia affinis

BAJA CALIFORNIA: an unnamed stream *ca.* Valle de Las Palmas (CAS-119067, 119246) and Ojos Negros (CAS-119247), Arroyo Alamar at Cañón del Padre (UABC-1351 [1]); mouth of Arroyo El Descanso (UABC-409 [14], 411 [710]) and its adjacent lagoon (UABC-435 [7], 481 [6], 996 [27]); Arroyo La Misión (mouth: UABC-216 [2], 487 [7], UANL-13720 [8]; town: UABC-050 [3], 073 [9]) and tributaries at Rancho Santa Rosa UABC-376 [65], 875 [14]) and Rancho Korodaki [= fall of Agua Caliente] (UABC-1297 [29]); Arroyo San Miguel [= El Carmen] (UABC-201 [10], 488 [99]); unnamed stream between Piedras Gordas and Las Minas (UABC-1356 [3]); Presa (dam) Emilio López Zamora (UABC-1593 [1]); Arroyo San Carlos at ranches of Las Hamacas (UABC-932 [7]) and Agua Caliente [hot spring] (UABC-954 [3]); Arroyo Las Animas (UABC-1360 [54]); Arroyo Santo Tomás [Ejido Ajusto] (UABC-605 [2]), Arroyo Seco [ca. Colomet] (UABC-317 [56]), Arroyo San Telmo (UABC-169 [61], 312 [315], 471 [26]), Arroyo Santo Domingo (mouth, UABC-166 [1], 310 [9]; and Rancho El Divisadero, UABC-455 [112], 592 [30], 1026 [12]); Arroyo El Rosario (UABC-160 [2], 162 [30], 309 [14], 320 [56], 458 [130], 462 [12], 584 [32], 892 [3], 959 [1], 1024 [7], 2094 [13], 2096 [15], 2100 [1], 2109 [1]); Río Colorado at tributary channel of Laguna Salada (USON-174 [1]); Río Hardy at campo Mosqueda (USON-191 [114]); Río Colorado at Ejido Yucumuri [Campo Escondido] (USON-196 [347]); Río Hardy at Campo Mosqueda [La Cabaña] (USON-204 [1098]); La Laguna Salada at El Paraíso fishery camp (USON-209 [27]; a channel effluent to agricultural lands at S Ejido Nayarit (USON-214 [28]). BAJA CALIFORNIA SUR: Ojo de Agua de La Rosita (UANL-2543 [44]), Ojo de Agua de San Bartolo (UANL-2547 [383]), Arroyo La Tinaja *ca.* Miraflores (UANL-2553 [49], UABC-751 [88]) and Arroyo Boca de la Sierra (UABC-767 [29]); Presa (dam) Juárez *ca.* Todos Santos (UANL-2568 [75]).

Poecilia latipinna

BAJA CALIFORNIA: Río El Mayor at Campo Sonora (UABC-100 [46], 135 [7], 136 [15]); Río Hardy at campo Mosqueda (USON-192 [224]; Río Hardy Campo Mosqueda at La Cabaña (USON-205 [1941]); Río Colorado at Ejido Yucumuri (USON-197 [13], 953 [57]); La Laguna Salada at El Paraíso fishery camp (USON-210 [1]);]; and channel effluent to agricultural lands at S Ejido Nayarit (USON-215 [1802], 921 [9], 929 [19], 966 [45], 989 [68]).

Cyprinus carpio

BAJA CALIFORNIA: Channel effluent to Laguna Salada (UABC-117 [8]), Río Colorado *ca.* 60 m (UABC-222 [1]), 100 m (UABC-108 [1]), and 800 m (UABC-414 [2]) before the junction with Río Hardy; and Río Colorado at Campo Gabriel

(UABC-951 [2]). BAJA CALIFORNIA SUR: Río San Ignacio at Ojo de Agua (UABC-076 [1], 721 [1], 1361 [1]; Contreras-Balderas, 1999: 33), bridge of Río San Ignacio (UABC-1449 [2], 1537 [2]), Poza Larga (UABC-1300 [3], 1428 [23], 1506 [11], 1538 [3], 1608 [15]), Los Corralitos (UABC-1453 [2], 1551 [2]), 2121 [5], and San Sabas (UABC-1550 [1]).

Lepomis cyanellus

BAJA CALIFORNIA: Arroyo El Descanso (adjacent lagoon, UABC-177 [1]), mouth of Arroyo La Misión (UABC-865 [1]); Arroyo San Antonio de las Minas at Rancho Kodoraki (G. Ruiz-Campos, pers. obs.) and at Rancho La Fortuna (UABC-2051 [25]), Arroyo Doña Petra at Rancho Madrigal (UABC-1491 [1]), Rancho Tierra Santa (UABC-183 [16], 665 [33]); Rancho Santa Rosa (UABC-377 [4], 876 [1]); Charco Escondido [Parque Nacional Constitución 1857] (UABC-1488 [1]), Arroyo Santo Tomás at Ejido Ajusco (UABC-224 [2]) and La Bocana Santo Tomás (UABC-452 [1]); and mouth of Arroyo San Telmo (UABC-311 [6]).

Tilapia sp. cf. zillii

BAJA CALIFORNIA: Río El Mayor at Campo Sonora (UABC-109 [17], 119 [1]); Presa (dam) Emilio López Zamora (UABC-1037); Arroyo San Juan de Dios at El Saucito (UABC- 1653 [188]); and irrigation channel between Ejido Nayarit and Ejido Sonora (USON-990 [7]). BAJA CALIFORNIA SUR: Arroyo Las Pocitas at Rancho El Cantil (UABC-2363 [3], Arroyo La Soledad at Rancho El Quelele (UABC-2246[6]), Arroyo San Pedro at San Pedro de La Presa (UABC-1322 [5], 1329 [1], 1423 [224]), San Basilio (UABC-783 [18], 1424 [12]), Pozo del Iritú (UABC-788 [13], 1562 [11], 1573 [16]), Rancho Merecuaco (UABC-792 [4]), Rancho Los Arados (UABC-1572 [16], 1584 [23]) and Rancho Tres Pozas (UABC-795 [3]); Arroyo San Luis at Misión de San Luis Gonzaga (UABC-739 [13], 1571 [15], 1585 [23]) and Rancho Las Cuedas (UABC-744 [3], 750 [5], 1303 [39], 1570 [13], 1587 [17]); Arroyo Bebelamas [Bramonas basin] at Rancho San Antonio de la Montaña (UABC-1310 [60]), Poza Honda [Rancho San Lucas] (UABC-747 [126], 2358 [13]) and Rancho El Frijolito (UABC-748 [1], 2360 [81]); Presa (dam) Higuajil (UABC-741 [18]); Arroyo San Javier at Misión de San [Francisco] Javier (UABC-819 [3], 820 [73], 821 [22], 911[13], 1545 [92], 2356 [4]); Arroyo Comondú at San Miguel de Comondú (UABC-766 [1]); La Purísima Vieja at Paso Hondo (UABC-1546 [39], 1558 [57]), Oasis La Purísima Vieja (UABC-1547 [22], 1557 [5]), Arroyo La Purísima ca. San Gregorio estuary (UABC-2157 [14]), San Isidro (UABC-728 [2]), El Pilón (UABC-1441 [30], 1482 [3], 1511 [277]), bridge of Carambucho (UABC-1531 [8]), La Purísima (UABC-762 [90], 825 [34]), Carambucho [= Cuba] (UABC-759 [38], 826 [8], 1299 [2], 1528 [2]), Presa

(dam) Carambucho (UABC-1302 [15], 1408 [39], 1415 [33], 1440 [15], 1523 [43]), and Ojo de Agua (UABC-1406 [11], 1410 [27], 1412 [7], 1420 [41], 1427 [2], 1429 [10], 1439 [3], 1510 [36]), 1548 [1]); Arroyo San Martín at Rancho La Vinorama [Sierra de Guadalupe] (UABC-738 [1]); Oasis San Ignacio at spring (UABC-942 [10], 1304 [30], 1469 [149], 1495 [127], 2091 [28]), El Tizón (UABC-1442 [78], 1534 [21]), Lake Side (UABC-1459 [86], 1521 [14]), San Ignacio [bridge of] (UABC-1443 [1], 1444 [4]), San Lino [front of Hotel Rice and Beans] (UABC-1525 [18]), Poza Larga (UABC-1494 [1], 1509 [82], 1520 [14], 1581 [11], 2130 [10], 2131 [73], 2132 [25]), Rancho Los Estribos (UABC-1411 [30], 1414 [26]), Lagunita de Roberts (UABC-1519 [19]), Rancho Los Corralitos (UABC-1454 [2], 1455 [30], 1507 [4], 1552 [1], 2085 [63], 2086 [81], 2087 [71]), Rancho Los Pinos (UABC-2084 [44], 2088 [26], 2089 [23], 2090 [51]) and Rancho San Sabas (UABC-1493 [2], 1508 [15], 1522 [4], 1549 [1]).

APPENDIX 2

Toponymy and geographical coordinates of the collecting sites for exotic fish species in the Peninsula of Baja California, Mexico.

Baja California:

1. Bocana Arroyo Cantamar (= Médano). 32°13'44.2" N, 116°55'21.5" W.
2. Bocana Arroyo El Descanso (= La Posta). 32°12'09.3" N, 116°54'47.8" W.
3. Bocana Arroyo La Misión (= Guadalupe). 32°05'32.0" N, 116°52'50.0" W.
4. Poblado La Misión. 32° 5'45" N; 116° 51'30" W.
5. Arroyo Guadalupe at Rancho Santa Rosa (= El Salto). 32°13'43.9" N, 116°55'21.6" W.
6. Arroyo Guadalupe at Rancho Tierra Santa (Ejido El Porvenir). 32°05'00.0" N, 116°37'00.0" W.
7. Bocana Arroyo San Miguel (= El Carmen), Ensenada. 31°54'05.8" N, 116°43'48.4" W.
8. Arroyo Las Ánimas at Ejido Uruapan. 31°37'00.0" N, 116°26'00.0" W.
9. Bocana Arroyo Santo Tomás. 31°32'12.9" N, 116°39'28.0" W.
10. Arroyo Santo Tomás at Ejido Ajusco. 31°35'00.0" N, 116°28'00.0" W.
11. Bocana Arroyo San Vicente. 31°15'54.3" N, 116°22'51.7" W.
12. Bocana Arroyo El Salado (*ca.* Loma Linda). 31°06'35.5" N, 116°17'50.4" W.
13. Arroyo Seco *ca.* Colonet. 31°05'56.1" N, 116°10'58.9" W.
14. Bocana Arroyo San Rafael *ca.* Punta Colonet. 30°58'08.1" N, 116°16'29.8" W.
15. Bocana Arroyo San Telmo *ca.* Punta San Telmo. 30°56'29.5" N, 116°14'57.6" W.
16. Bocana Arroyo Santo Domingo *ca.* San Ramón. 30°42'53.6" N, 116°02'31.6" W.
17. Arroyo Santo Domingo at Rancho El Divisadero. 30°46'21.4" N, 115°54'19.5" W.

18. Bocana Arroyo San Simón (*ca.* Ejido El Papalote). 30°27'04.1" N, 115°55'36.3" W.
19. Bocana Arroyo San Simón (1 km above Hotel La Pinta). 30°24'24.1" N, 115°54'24.3" W.
20. Bocana Arroyo El Rosario. 30°02'32.5" N, 115°47'15.6" W.
21. Arroyo Neji *ca.* Ejido Neji. 32°23'00.0" N, 116°19'00.0" W.
22. Laguna Hanson, Sierra Juárez. 32°02'00.0" N, 115°54'00.0" W.
23. Arroyo San Carlos at Rancho Alamitos. 31°46'00.0" N, 116°31'00.0" W.
24. Bocana Arroyo San Fernando, Ensenada. 29°43'33.7" N, 115°38'49.6" W.
25. Arroyo Cataviña *ca.* Cataviña. 29°52'4.5776" N, 114°56'59.989" W.
26. Arroyo Alamar, Cuenca del Río Tijuana. 32°31'27.5" N, 116°54'46.8" W.
27. Arroyo (unnamed) between Piedras Gordas and Las Minas. 31°55'46.1" N, 116°27'04.7" W.
28. Arroyo San Carlos at Rancho Las Hamacas. 31°47'51.6" N, 116°30'02.4" W.
29. Arroyo San Carlos at Balneario [swimming pool] Agua Caliente. 31°46'0" N, 116°31'0" W.
30. Presa (dam) Emilio López Zamora. 31°54'08.5" N, 116°35'37.8" W.
31. Arroyo Guadalupe at Rancho Korodaki. 32° 06'15.8" N, 116° 27'03.4" W.
32. Charco Escondido, Parque Constitución 1857. 32°00'10.8" N, 115°56'50.52" W.
33. Arroyo San Antonio de las Minas, San Antonio de las Minas. 21°58'32.2" N, 116°37'55.4" W.
34. Río Colorado *ca.* junction with Río Hardy. 32° 6'0" N; 115° 13'45" W.
35. Río Hardy *ca.* junction with Río Colorado. 32° 6'0" N; 115° 14'15" W.
36. Channel effluent to Laguna Salada. 31° 58'N; 115° 13'W.
37. Río El Mayor at Campo Sonora. 32° 0'4" N; 115° 18'0" W.
38. Represa (dam) at Rancho Tierra Santa, Ejido El Porvenir. 32°5'0" N; 116°37'0" W.
39. Río Pescadores at Rancho Caimán. 32°13'30"N, 115°11'30"W.
40. Canal Cerro Prieto o Solfataras (= Pacífico). 32°30'N, 115°27'W.
41. La Playita, northwestern edge of Laguna Salada. 32°31'0" N, 115°45'0" W.
42. Arroyo San Juan de Dios at El Saucito. 30° 06'51.8" N, 115° 21'18.9" W.
43. Arroyo Cañón de Doña Petra at Rancho Madrigal. 31°55'20.9"N, 116°36'13.4"W.
44. Río Colorado, kilometer num. 76, Mexicali-San Felipe freeway, under the bridge. 31°56'N, 115°12'W.
45. Río Hardy at campo Mosqueda. 32°5'N, 115°12'W.
46. Río Hardy at La Cabaña *ca.* Campo Mosqueda., 32°8'N, 115°11'W.
47. La Laguna Salada at El Paraíso fishery camp, km. num. 23, Mexicali-Tijuana freeway. 32°38'N, 115°39'W.
48. Río Colorado at Ejido Yucumuri (Campo Escondido), km. num. 67, Mexicali-San Felipe freeway. 32°5'N, 115°10'W.

49. Irrigation channel between Ejido Nayarit and Ejido Sonora. 32°17'41.3"N., 115°15'20.5"W.

50. Arroyo Santa Gertrudis at Mission of Santa Gertrudis

Baja California Sur:

1. Arroyo [Ojo de Agua] at San José del Cabo. 23°03'32.0" N, 109°41'28.8" W.
2. Arroyo San Venancio at San Venancio. 23°16'48.6"N, 110°02'7.3" W.
3. Arroyo La Tinaja (El Aguajito) ca. Miraflores. 23°21'59.4" N, 109°45'19.2" W.
4. Arroyo Boca de La Sierra on the basis of San Bernardino canyon ca. Miraflores. 23°23'10.6" N, 109°49'11.7" W.
5. Presa Juárez ca. Todos Santos. 23°32'44.4" N, 110°08'44.1" W.
6. Ojo de Agua de San Bartolo. 23°44'11.0" N, 109°50'25.0" W.
7. Ojo de Agua de La Rosita at San Antonio. 23°48'20.1"N, 110°03'41" W.
8. Arroyo Las Pocitas at Pocitas del Vado. 24°23'N, 111°06'W.
9. Arroyo Las Pocitas at Rancho El Caracol. 24°32'N, 111°01'W.
10. Arroyo Las Pocitas at Rancho El Cantil. 24°35'29.4" N, 110°59'32.9" W.
11. Arroyo La Soledad at El Quelele. 24 48'37.5" N, 110 50'32.5" N.
12. Arroyo Los Dolores at Misión de Santa Dolores. 25 04'27.1" N, 110°51'40.1" W.
13. Arroyo La Presa at La Presa de Toris [= Toris de La Presa]. 24°54'N, 111°02'W.
14. Arroyo San Pedro at Pozo del Iritú [= Rancho Encinas]. 24°46'55.0" N, 111°09'02.4" W.
15. Arroyo San Pedro at Rancho Los Arados. 24°47'06.5" N, 111°11'07.2" W.
16. Arroyo San Pedro at Rancho Merecuaco. 24°48'25.2" N, 111°09'03.6" W.
17. Arroyo San Pedro at Rancho Tres Pozas, entre El Carracito [sic] y El Ciruelo. 24°48'58.1" N, 111°07'33.0" W.
18. Arroyo San Pedro at San Basilio, antes de la confluencia con Arroyo La Presa. 24°50'13.1" N, 111°04'37.4" W.
19. Arroyo San Pedro at San Pedro de La Presa. 24°51'N, 110°59'W.
20. Arroyo San Pedro at Rancho El Caporal. 24 49'47.5" N, 111 13'09.5" W.
21. Arroyo San Luis at Rancho Las Cuedas. 24°53'59.4" N, 111°14'58.7" W.
22. Arroyo San Luis at Misión de San Luis Gonzaga. 24°54'34.8" N, 111°17'21.5" W.
23. Arroyo Bebelamas at Poza de la Caguama [Rancho San Antonio de la Montaña]. 24 57'33.8" N, 111 19'21.1" W.
24. Arroyo Bebelamas at Rancho El Frijolito [= El Frijol]. 24°57'29.0" N, 111°19'06.0" W.
25. Arroyo Bebelamas at Rancho San Lucas (Poza Honda). 24°57'44.6" N, 111°20'17.9" W.

26. Arroyo San Luis at Presa Higuajil. 24°58'22.7" N, 111°23'37.2" W.
27. Arroyo San Javier (dam and spring) at Misión de San [Francisco] Javier. 25°52'07.0" N, 111°32'49.0" W.
28. Arroyo La Zorra, 2 km above Rancho Las Parras). 25°57'20.2" N, 111°31'06.8" W.
29. Arroyo San Javier at Rancho Viejo. 25°56'30.3" N, 111°32'05.1" W.
30. Arroyo San Javier at El Carrizal (between Los Hornos y Chula Vista ranches). 25°52'31.0" N, 111°32'38.5" W.
31. Arroyo La Tasajera between Canipolé and Uña de Gato, Loreto. 26°20'46.1" N, 111°47'12.5" W. [dry strambed].
32. Arroyo Comondú at San Miguel de Comondú. 26°01'57.6" N, 111°49'58.3" W.
33. Arroyo Comondú at San José de Comondú. 26°03'32.4" N, 111°49'29.3" W.
34. Arroyo La Purísima at San Isidro. 26°12'29.4" N, 112°02'26.6" W.
35. Arroyo La Purísima at the ford of the La Purísima-San Juanico road. 26°09'32.2" N, 112°07'42.2" W
36. Arroyo La Purísima at La Purísima. 26°10'58.7" N, 112°05'18.5" W.
37. Arroyo La Purísima at Carambucho [= Cuba]. 26°12'58.6" N, 112°01'12.9" W.
38. Arroyo La Purísima at Presa (dam) Carambucho. 26°14'19.8" N, 112°00'03.6" W.
39. Arroyo La Purísima at Ojo de Agua. 26°19'24.2" N, 111°59'09.7" W.
40. Arroyo La Purísima Vieja at La Purísima Vieja. 26°18'39.9" N, 112°09'43.8" W.
41. Arroyo La Purísima Vieja at Paso Hondo. 26°20'08.2" N, 112°09'48.2" W.
42. Arroyo San Martín at Rancho La Vinorama, between El Tule and Martín ranches. 26°38'14" N, 112°17'27" W.
43. Río Mulegé between the bridge and the mouth. 26°53'54" N, 111°57'58" W.
44. Ojo de Agua del Río Mulegé (above the dam). 25°53'12.5" N, 111°59'12.1" W.
45. Arroyo Boca de Magdalena at San José de Magdalena. 27°04'08.7" N, 112°12'07.9" W.
46. Oasis San Ignacio at spring. 27°17'48.3" N, 112°52'55.1" W.
47. Arroyo San Ignacio at El Tizón. 27°17'53.2" N, 112°53'12.3" W.
48. Arroyo San Ignacio at Lake Side. 27°17'56.0" N, 112°53'39.0" W.
49. Arroyo San Ignacio at bridge of access to the town of San Ignacio. 27°17'51.3" N, 112°53'50.8" W.
50. Arroyo San Ignacio at San Lino [front to Hotel Rice and Beans]. 27°17'52.1" N, 112°54'17.6" W.
51. Arroyo San Ignacio at Poza Larga. 27°16'26.1" N, 112°54'46.5" W.
52. Arroyo San Ignacio at Rancho Los Estribos. 27°15'40.2" N, 112°55'40.9" W.
53. Arroyo Sam Ignacio en Poza Roberts. 27°14'43.6" N, 112°57'31.6" W.
54. Arroyo San Ignacio at Los Corralitos. 27°13'01.9" N, 112°59'16.9" W.
55. Arroyo San Ignacio at Paso Los Pinos. 27°12'37.3" N, 112°59'54.8" W.

56. Arroyo San Ignacio at San Sabas. $27^{\circ}11'51.8''$ N, $113^{\circ}00'09.3''$ W.
57. Arroyo San Joaquín at San Zacarías. $27^{\circ}08'N$, $112^{\circ}54' W$.
58. Arroyo San Joaquín at El Sauzal. $27^{\circ}10'N$, $112^{\circ}52' W$.
59. Arroyo San Joaquín at San Joaquín. $27^{\circ}11'N$, $112^{\circ}51' W$.
60. Arroyo San Gregorio at Rancho San Gregorio, Sierra San Francisco. $27^{\circ}40'35.5''$ N, $113^{\circ}01'02.8'' W$.

Exploring Mexico's northwest, the Baja California Peninsula, its surrounding oceans, its islands, its rugged mountains, and rich seamounds, one feels diminished by the vastness and the greatness of the landscape while consumed by a sense of curiosity and awe. In a great natural paradox, we see the region's harsh arid nature molded by water through deep time, and we feel that its unique lifeforms have been linked to this desert and sea for thousands of years, as they are now.

These landscapes of fantasy and adventure, this territory of surprising, often bizarre growth-forms and of immense natural beauty, has inspired a wide array of research for over two centuries and continues to inspire the search for a deeper knowledge on the functioning, trends, and conservation status of these ecosystems in both land and ocean.

This book offers a compilation of research efforts aimed at understanding this extraordinary region and preserving its complex richness. It is a synthesis of work done by some exceptional researchers, mostly from Mexico, who indefatigably explore, record, and analyze these deserts and these seas to understand their ecological processes and the role of humans in their ever-changing dynamics.

Elisabet V. Wehncke



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