



Freshwater fish at risk or extinct in México

A checklist and review

Salvador Contreras-Balderas¹, Patricia Almada-Villela², María de Lourdes Lozano-Vilano³ & María Elena García-Ramírez³

¹Universidad Autónoma de Nuevo León, A.P. 504, San Nicolás, N.L., México, 66450 (E-mail: saconbal@axtel.net);

²Cambridge, UK (E-mail: patricia_almada@hotmail.com); ³Universidad Autónoma de Nuevo León, A.P. 425, San Nicolás, N.L., México, 66450 (E-mail: marlozan@ ccr.dsi.uanl.mx)

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Contents

Abstract	page 241
Resumen	241
Introduction	242
Material and methods	242
Results and discussion	243
Corrections	244
Conclusions	244
Acknowledgements	244
References	244
Appendices	246

Key words: extinctions, fishes, freshwater, México, risk

Abstract

The Mexican freshwater fish that are at risk or extinct are listed by family, state, basin/region, and causes of risk. Of the 506 known species, 168 are at some level of risk, and 25 are believed to be extinct. States with the most reports are: Chihuahua (46); Coahuila (35); Nuevo León (20); Sonora (19); Durango (18); and Tamaulipas (15). With the exception of Sonora, these states are largely located in the Río Bravo region, and are all arid or semiarid. Most extinctions have occurred in Nuevo León (8) and Coahuila (7). The main causes of risk reported are: habitat reduction or alteration (86); water depletion (83); presence of exotics (76); small or declining population (73); and small habitat (57). All of which result in very local endemism. These causes of risk develop easily when the distribution is small. The critical factor is aridity, which is associated with desertization. Water conflicts were to be expected, and the result is resource non sustainability.

Resumen

Los peces mexicanos de agua dulce en riesgo se enlistan por familia, estado, cuenca/región, y causas. De las 506 especies conocidas, 169 se encuentran en algún nivel de riesgo, y 25 se consideran extintas. Los estados con mas reportes son Chihuahua (46), Coahuila (35), Nuevo León (20), Sonora (19), Durango (18), and Tamaulipas (15), y excepto por Sonora son principalmente partes de la región del Río Bravo, y todos son áridos o semiáridos. La mayoría de las extinciones han sucedido en Nuevo León (8), y Coahuila (7). Las principales causas de riesgo hasta donde se sabe han sido reducción o alteración de hábitat (86), abatimiento de agua (83), presencia de exóticos (76), población pequeña o en reducción (73), y localidades o hábitats pequeños (57) los cuales equivalen a endemismos muy locales. Estas causas se desarrollan fácilmente cuando la distribución es pequeña. Todo junto, el aspecto crítico es la aridez, asociada aquí a la desertificación, donde los conflictos por el agua eran de esperarse, y de exhibirse no sustentabilidad del recurso.

Introduction

The issue of species at risk has been gaining public attention in recent years, following the Rio Declaration on Biodiversity. The freshwater fauna is one of the critical groups under consideration with reference to controversial issues regarding freshwater worldwide. In México, the first call for fish was that of Miller (1961), when only 11 species were listed. Since then, the numbers have increased continuously: 33 at risk and 7 extinct (Contreras-Balderas, 1969); 41 at risk (Contreras-Balderas, 1972, 1985); 60 at risk (Deacon et al., 1979); 122 at risk (Williams et al., 1989); 114 at risk (Contreras-Balderas, 1990); 138 at risk (Castro-Aguirre and Balart, 1993); 7 extinct (Contreras-Balderas, 1969); 13 extinct (Castro-Aguirre and Balart, 1993); and 15 extinct (Harrison and Stiassny, 1999). In this paper, the numbers of species at risk or extinct are 169 and 25 respectively. Recent explorations of some smaller regions, have revealed a wider distribution of certain endemics. However, these endemics either endure equivalent risk conditions, so no change in status has resulted e.g., la Media Luna-Rio Verde basin (Aguilera-González, et al., pers. com.), or they have been reported as approaching or being extinct e.g., Parras (Contreras-Balderas and Maeda-Martínez, 1985) and Southern Nuevo León (Contreras-Balderas and Lozano-Vilano, 1996).

Differences in counts arise from differing levels of exploration and knowledge, extinction criteria, and viewpoints. National listings usually reflect the situation at national levels, where a species population may be highly endangered. International listings reflect the full range of the species, which may not be endangered. Changes in status are also affected by the invalidation/revalidation of species. Our baseline was that the total number of known Mexican freshwater fish species is 506.

The causes of risk in North America, including México, have already been considered (Contreras-Balderas, 1976; Contreras-Balderas et al., 1976; Deacon et al., 1979; Williams et al., 1989). However, a wider explanation of the situation has been presented concerning aridity, habitat impairment, water depletion, exotics, pollution, small or declining population, and poor regional management, all of which have reduced the sustainability of some regions (Contreras-Balderas and Lozano-Vilano, 1993).

From the legal standpoint, Mexico has already developed an official listing of species at risk (NOM

059-ECOL-1994), which is in revision. The requirements for listing species were not defined in the original version. Additionally, in the revision, the governmental and technical Committee in charge call for an evaluation of the risk. Since México has not had a program for financing appropriate assessments of species at risk, this condition can hardly be fulfilled. One important addition to the revised NOM is that species considered extinct by experts, are listed as possibly extinct. In the event that such species are rediscovered, they would be given legal protection status immediately.

As in other parts of the world, we suffer from a very limited supply of experts, time, funds, and interest in at risk species, hence, information about species has to be derived from other programs. México has to rely on information from the few specialists with countrywide experience or local expert opinions about the highly endemic species in order to compile the list. Since 1964, one of the authors of this paper (SCB) has had the opportunity to investigate the status of species and inspect most of the arid or warmer regions of Mexico, and has kept an listing, updated as often as is feasible. It is important to have this kind of listing as a dynamic tool to generate the data required to propose a species for a legal level of protection, especially given the new requirements for assigning such status in Mexico. This type of listing may provide: guidelines for regional or local evaluation; indicators of relative environmental integrity or health; criteria for protection or restoration; ecosystem status; and an assessment of the extent of tasks or programs needed to conserve biodiversity. The listing of extinct species is a means of warning against increasing threats and destructive actions, and may put an end to thoughtless destruction of habitat and species.

Materials and methods

We relied mainly on our own collections and/or observations. Records of specimens examined are housed in the Laboratory and Fish Collection, Universidad Autónoma de Nuevo León. Literature records and comments were considered when providing dates of last collection or observation, or status comments. Status of species is given as Endangered (E), or Threatened (T), as defined in the Endangered Species Act (1973), and as Special Concern (SC) as defined by Deacon et al. (1979) and applied by Williams

et al. (1989). The abbreviations used for the states are: Baja California (BC), Baja California Sur (BCS), Coahuila (COA), Chiapas (CHA), Chihuahua (CHI), Durango (DGO), = Guerrero, Guanajuato (GTO), Jalisco (JAL), México (MEX), Michoacán (MIC), Nayarit (NAY), Oaxaca (OAX), Puebla (PUE), Querétaro (QUE), Quintana Roo (QUI), Sinaloa (SIN), Sonora (SON), San Luis Potosí (SLP), Tabasco (TAB), Tamaulipas (TAM), Veracruz (VER), Yucatán (YUC), and Zacatecas (ZAC). The aridity of these states is common knowledge. Comments include the main known causes of risk or reasonable information on the type of risk, numbered as follows:

1. Habitat reduction or alteration.
2. Water depletion (surface or underground).
3. Overexploitation.
4. Rarity of the species (numbers or localities).
5. Small locality or habitat (e.g., springs or small basins).
6. Exotic species present in the same habitat or locality.
7. Pollution.
8. Small or declining population (usually in consequence of causes 1, 2, 4, 6, or 7).
9. Hybridization.

We omitted the majority of references included in the works cited.

Results and discussion

The distribution of the At Risk fish species in México, which is important for protection schemes, is far from random. Northern Mexican desert states contain most of the species (Table 1). Species At Risk listings are shown in Appendix 1 and listing of Extinct species appears in Appendix 2.

A rapid review of the lists shows that arid and semiarid basins, often with heavy population and/or development have the highest incidence of fish species At Risk or Extinct, as shown in Table 3. The Pluvial Río Bravo region, comprising the interior drainages Casas Grandes, Santa María, Santa Clara, Bavícora, Bustillos, Mexicanos, Nazas, Aguanaval, Parras, Llanos del Salado, and the Pacific basin headwaters, has a dry climate most of the year, and the waters have been depleted. Some of these basins drain states with higher numbers of species At Risk or Extinct (Durango, Chihuahua, Coahuila, Nuevo León, and Tamaulipas). These states are basically arid, and contain 77 At Risk and 16 Extinct species. In these

Table 1. State distribution of freshwater fish species at risk (endangered, threatened, and special concern) or extinct in México due to aridity, as defined in text. Species shared by different states causes the sum of columns to be higher than the actual count of species considered

State	Spp. at risk	Spp. extinct	Climate
Baja California	6	–	Arid
Baja California Sur	2	–	Arid
Coahuila	35	7	Arid
Colima	1	–	
Chiapas	7	–	
Chihuahua	46	2	Arid
Distrito Federal	–	3	
Durango	18	2	Semiarid
Guanajuato	3		Semiarid
Jalisco	3	3	
México	2	3	
Michoacán	9	2	
Morelos	1	–	
Nayarit	2	–	
Nuevo León	20	8	Semiarid
Oaxaca	6	–	Semiarid
Puebla	4	–	Semiarid
Quintana Roo	8	–	
San Luis Potosí	10	–	Semiarid
Sinaloa	2	–	
Sonora	19	–	Arid
Tabasco	3	–	
Tamaulipas	15	3	Semiarid
Veracruz	5	1	
Yucatán	6	–	Tropical semiarid
Zacatecas	1	–	Arid
Total	167	25	

areas, it is possible to consider some subareas separately, such as Parras and Southern Nuevo León, with seven and six extinct species and the Valley of México (Distrito Federal, México), where three cyprinid species became Extinct (Miller et al., 1989), and nearly all other species have disappeared, although some survive scarcely in the Lerma basin (Díaz-Pardo et al., 1993). This basin is heavily polluted and in very poor condition. Its species are at High Risk and we may have to add some additional species to the Extinct listing in the near future.

Given that some fish are shared by more than one region, state or basin, and are subject to more than one

cause of risks, the numbers in the tables do not equal the total number of species listed in them.

Corrections

The cyprinodontid species, *Cyprinodon* spp. from Sandia, Nuevo León, reported in Williams et al. (1989) based on contributions of SCB, cited in WCMC (1994), and in Espinoza-Pérez et al. (1996), and inadvertently cited both as *Cyprinodon* spp.; they were described by Lozano-Vilano and Contreras-Balderas (1993) and cited under their published names by WCMC (1996). The inclusion of some species as Extinct by Castro-Aguirre and Balart (1993) referred to México only (some of them survive in the US). They included some species that are unknown in México (e.g., *Hybopsis gracilis*), are not At Risk yet (e.g., *Notropis stramineus* (= *N. ludibundus*)), or do not exist (e.g., *Catemaco aguirrepequeno* (nomen nudum)).

Conclusions

A large proportion of the Mexican freshwater fish fauna ($n = 506$) is regarded as At Risk (169) or Extinct (25), and the number has increased constantly since the first report in 1961 (Contreras-Balderas, 1999; 2000). The Río Bravo, in both pluvial and sensu stricto, is the most endangered ecosystem, and has experienced the most extinctions. However, small extensions like Parras, or Southern Nuevo León, record more extinctions than the Río Bravo. The states with the highest number of reports are Chihuahua (45), Coahuila (35), Nuevo León (20), Sonora (20), Durango (18), and Tamaulipas (15). With the exception of Sonora, these states are largely located in the Río Bravo region, and are all arid or semiarid. Most extinctions have occurred in Nuevo León (8) and Coahuila (7). The main causes of risk have been habitat reduction or alteration (86), water depletion (83), exotics present (74), population reduction (63), and small locality or habitat (6), which results in very local endemism. The first two causes of risk are often followed by the fourth cause and all develop readily when the range is small. The critical factor is aridity, which is associated with desertization. The increasing trend in fish species At Risk will continue, unless Mexico finds a way to use water and aquatic resources in a sustainable way.

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References

- De Buen, F. (1956) El primer representante (*Notropis moralesi* nov. sp.) de la familia cyprinidae en la fauna neotropical. *Anales del Instituto de Biología, Universidad Nacional Autónoma de México* **26**(2), 527–541.
- Castro-Aguirre, J.L. and Balart, E.F. (1993) La ictiología en México: Pasado, presente y futuro. *Revista de la sociedad Mexicana de historia natural. Vol. Especial XLIV*, 327–343.
- Chernoff, B. and Miller, R.R. (1986) Fishes of the *Notropis calientis* complex with a key to the southern shiners. *COPEIA* **1986**(1), 170–183.
- Cochran, P.A., Lyons, J. and Merino-Rábago, E. (1996) Notes on the biology of the Mexican lampreys *Lampetra spadicea* and *L. geminis* (Agnatha: Petromyzontidae). *Ichthyol. Explor. Freshwaters* **7**(2), 173–180.
- Contreras-Balderas, S. (1969) Perspectivas de la ictiofauna en las zonas Áridas del Norte de México. *Memorias, primer simposio internacional de aumento en la producción de alimentos en zonas Áridas. ICASALS, Texas Tech. Publ.* **3**, 394–304.
- Contreras-Balderas, S. (1972) *Lista Anotada de Los Peces Amenazados de Extinción en México*. Resumen Memorias Segundo Congreso Nacional de Zoología. Monterrey, México.
- Contreras-Balderas, S. (1976) *Impacto Ambiental de Obras Hidráulicas*. Plan Nacional Hidráulico, Secretaría de Recursos Hidráulicos, México.
- Contreras-Balderas, S. (1990) Lista Anotada de Especies de Peces Mexicanos en Peligro o Amenazados de Extinción. In: Camarillo, J.L. and Rivera, F. (eds.), *Áreas Naturales Protegidas en México y Especies en Peligro de Extinción*. Universidad Nacional Autónoma de México, México, pp. 211–217.
- Contreras-Balderas, S. (1999) Acuicultura, ictiodiversidad, transfaunación acuática y peces en Riesgo en México. *Memorias, Cuarta Reunión Nacional de Redes de Investigación en Acuicultura, México* **1**, 97–102.
- Contreras-Balderas, S. (2000) Biodiversidad en las Aguas Continentales de México. In: Secretaría del Medio Ambiente, Recursos Naturales y Pesca, México. *Estado de Salud de la Acuicultura IV*, 1–13.

- Contreras-Balderas, S. and Lozano-Vilano, M. L. (1993) Water, endangered fishes, and development perspectives in North-eastern Mexico. *Conservation Biology* **8**(2), 379–387.
- Contreras-Balderas, S. and Lozano-Vilano, M. L. (1994) *Cyprinella alvarezdelvillari*, a new cyprinid fish Río Nazas of México, with a key to the *Lepida* clade. *COPEIA* **1994**(4), 897–906.
- Contreras-Balderas, S. and Lozano-Vilano, M. L. (1996) Survival status of the Sandia and Potosí Valleys endemic pupfishes and crayfishes from the Mexican plateau in Nuevo León, Mexico, with Comments on Associated Extinct Snails. *Ichthyol. Explor. Freshwaters* (Germany) **7**(1), 33–40.
- Contreras-Balderas, S. and Maeda-Martínez, A. (1985) Estado actual de la ictiofauna nativa de la Cuenca de Parras, Coah., Méx., con notas sobre algunos invertebrados. *Memoria, VIII Congreso Nacional de Zoología, México* **1**, 59–69.
- Contreras-Balderas, S. and Rivera-Teillery, R. (1973) *Notropis aguirrepequeñoi*, especie nueva endémica del Río Soto la Marina, Tamaulipas, México (Pisces: Cyprinidae). *Publicaciones Biológicas, Instituto de Investigaciones Científicas* **1**(2), 9–23.
- Contreras-Balderas, S. and Verduzco-Martínez, J.A. (1977) *Dionda mandibularis*, a new cyprinid fish endemic to the Upper Rio Verde, San Luis Potosí, Mexico, with comments on related species. *San Diego Soc. Nat. Hist., Trans.* **18**(16), 259–266.
- Contreras-Balderas, S., Landa-Salinas, V., Villegas-Gaytán, T. and Rodríguez-Olmos, G. (1976) Peces, piscicultura, presas, polución, planificación pesquera y Monitoreo en México, o la danza de las P. Simposio sobre pesquerías en Aguas Continentales (Tuxtla Gutiérrez, Chiapas). *Memorias, Simposio sobre Pesquerías en Aguas Continentales, México* **1**, 315–346.
- Deacon, J.E., Kobetich, G., Williams, J.D. and Contreras-Balderas, S. (1979) Fishes of North America endangered, threatened, or of special concern. *Fisheries* **4**(2), 29–44.
- Díaz-Pardo, E., Godínez-R., M.A., López-L., E. and Soto-G., E. (1993) Ecología de los peces de la cuenca del Río Lerma, México. *Anales de la Escuela Nacional de Ciencias Biológicas, Instituto Politécnico Nacional, Méx.* **39**, 103–127.
- Espinoza-Pérez, H. and Castro-Aguirre, J. L. (1996) A new freshwater clingfish (Pisces: Gobiessocidae) from Baja California Sur, México. *Bull. Southern Cal. Acad. Sci.* **95**, 120–126.
- Harrison, I.J. and M.L.J. Stiassny (1999) Chapter 12:271-331. The quiet crisis a preliminary listing of the freshwater fishes of the world that are extinct or “missing in action”. In: McPhee, R. (ed.), *Extinctions in Near Time*. Kluwer Acad./Plenum Publ.
- Hendrickson, D.E. and Varela-R., A. (1989) Conservation status of desert pupfish, *Cyprinodon macularius*, in México and Arizona. *COPEIA* **1989**(2), 478–483.
- Humphries, J.M. (1984) *Cyprinodon verecundus*, n. sp., a fifth species of pupfish from Laguna Chichankanab. *COPEIA* **1984**(1), 58–68.
- Humphries, J.M. and Miller, R.R. (1981) A remarkable species flock of pupfishes, genus *Cyprinodon*, from Yucatán, México. *COPEIA* **1981**(1), 52–64.
- Lozano-Vilano, M.L. and Contreras-Balderas, S. (1993) Four new species of *Cyprinodon* from Southern Nuevo León, Mexico, with a Key to the *C. eximius* complex (Teleostei: Cyprinodontidae). *Ichthyol. Explor. Freshwaters* (Germany) **4**(4), 295–308.
- Lozano-Vilano, M.L. and Contreras-Balderas, S. (1996) Extinction of most Sandia and Potosí Valleys (Nuevo León, México) endemic pupfishes, crayfishes, and snails. *Ichthyol. Explor. Freshwaters* (Germany) **7**(1), 33–40.
- Lozano-Vilano, M.L. and Contreras-Balderas, S. (1999) *Cyprinodon bobmilleri*: New species of pupfish from Nuevo León, México (Pisces: Cyprinodontidae). *COPEIA* **1999**(2), 382–387.
- Mayden, R.L. and Hillis, D.M. (1990) Natural history and systematics of the largemouth shiner, *Cyprinella bocagrande* (Teleostei: Cypriniformes), with comments on conservation status. *COPEIA* **1990**(4), 1004–1011.
- Miller, R.R. (1961) Man and the changing fish fauna of the American Southwest. *Pap. Mich. Acad. Sci.* **46**(1960), 365–404.
- Miller, R.R. (1963) Extinct, rare, and endangered American freshwater fishes. *XVI International Congress of Zoology* **8**, 4–11.
- Miller, R.R., Williams, J.D. and Williams, J.E. (1989) Extinctions of North American fishes during past century. *Fisheries* **14**(6), 22–38.
- Minckley, W.L. and Minckley, C.O. (1986) *Cyprinodon pachycephalus*, a new species of pupfish (Cyprinodontidae) from the Chihuahuan Desert of Northern Mexico. *COPEIA* **1986**(1), 184–192.
- Norris, S.M. and Minckley, W.L. (1997) Two new species of *Etheostoma* (Osteichthyes: Percidae) from Central Coahuila, Northern Mexico. *Ichthyol. Explor. Freshwaters* **8**(2), 159–176.
- Ruiz-Campos, G., Contreras-Balderas, S., Lozano-Vilano, M.L., González-G., S. and Alanís-G., J. (2000) Ecological and distributional status of the continental fishes of Northwestern Mexico. *Bull. Southern Cal. Acad. Sci.* **99**(2), 59–90.
- Ruiz-Campos, G., Castro-Aguirre, J.L., Contreras-Balderas, S., Lozano-Vilano, M.L., González-Aguilera, A.F. and Sánchez-G., S. (in press) Distribution and status of fishes of Oases in Baja California Sur, Mexico. *Reviews in Fish Biology and Fisheries* **0**(0), 00–00.
- Walsh, S.J. and Gilbert, C.R. (1995). New species of troglotic catfish of the genus *Prietella* (Siluriformes: Ictaluridae) from Northeastern Mexico. *COPEIA* **1995**(4), 850–861.
- WCMC (1994) *1994 IUCN Red List of Threatened Animals*. International Union for Conservation of Nature, Great Britain.
- WCMC (1996) *1994 IUCN Red List of Threatened Animals*. International Union for Conservation of Nature, Great Britain.
- Williams, J.E., Johnson, J.A., Hendrickson, D.A., Contreras-Balderas, S., Williams, J. D., Navarro-Mendoza, M., McAllister, D.E. and Deacon, J.D. (1989) Fishes of North America endangered, threatened, or of special concern: 1989. *Fisheries* **14**(6), 2–20.

Appendix 1. Checklist of freshwater fish at risk in México, derived from literature and confirmed by inspection by at least one of the authors where no literature is cited

Family	Species	Common name	Status	Risks	Range	Comments
Petromyzonidae	<i>Lampetra géminis</i>	Lamprea Jacona	E	1+++; 5+++; 8	MIC	1 refuge locality Parque Morelos.
	<i>Lampetra spadicea</i>	Lamprea Chapala	E	1+, 2+, 6, 7, 8	MIC	Low numbers (Cochran et al., 1996).
	<i>Lampetra tridentata</i>	Lamprea Pacífico	E	4+++	BCN	Collected twice only (Ruiz-Campos et al., 2000).
Acipenseridae	<i>Scaphyrhynchus platyrhincus</i>	Esturión	E	4+++	CHI	Not seen in 126 years (Mayden et al., 1992).
Lepisosteidae	<i>Lepisosteus oculatus</i>	Catán pinto	T	1+++	TAM, NLE	Collected only at 4–5 localities since 1980.
	<i>Atractosteus spatula</i>	Catán lagarto	SC	1+++	TAM	Very scarce.
Cyprinidae	<i>Agosia chryso-gaster</i>	Pupo Sonora	T	1++	SON	
	<i>Algansea aphanea</i>	Juil Ayutla	T	4	JAL	
	<i>Algansea avia</i>	Juil Tepic	T	4	NAY	
	<i>Algansea barbata</i>	Juil Lerma	E	7+++	MEX	Highly altered conditions (Díaz-Pardo et al., 1993).
	<i>Algansea popoche</i>	Popoche	T	3+, 7+	JAL	Very scarce since 1963.
	<i>Cyprinella divarzelvillari</i>	Sardinita La Concha	E	5+++; 6	DGO	Inhabits 10 km of spring/river only (Contreras-Balderas and Lozano-Vilano, 1994). Lost 95% of its population in 1996 after a storm.
	<i>Cyprinella bocagrande</i>	Sardinita Bocagrande	E	5+++; 6	CHI	Single locality, exotics present (Mayden and Hillis, 1990).
	<i>Cyprinella formosa</i>	Sardinita Guzmán	T	1+++	CHI	
	<i>Cyprinella garmani</i>	Sardinita Mayrán	T	1+++	DGO	
	<i>Cyprinella latrensis</i>	Sardinita rojiazul	SC	1+++; 2+, 6+++; 7, 8	CHI, DGO, COA, NLE, TAM	Reduced populations. Exotic in Rio Colorado.
	<i>Cyprinella ornata</i>	Sardinita negra	T	8++	CHI, DGO	
	<i>Cyprinella panarcys</i>	Sardinita Conchos	E	1, 8+	CHI	
	<i>Cyprinella proserpina</i>	Sardinita Pecos	E	5+++	COA	Inhabits single springs/river only. Lost 80% of its population/habitat.
	<i>Cyprinella rutila</i>	Sardinita San Juan	T	1+, 2, 6, 7, 8	NLE	Heavy pollution, dewatering.
	<i>Cyprinella santamariae</i>	Sardinita Santa María	E	1+, 2, 6, 7, 8	CHI	
	<i>Cyprinella xanthicara</i>	Sardinita Cuatro Ciénegas	E	6, 8	COA	Exotics present.
	<i>Cyprinella</i> sp.	Sardinita Saúz	E	1+++; 2+++; 5	CHI	Dewatered basin.
<i>Cyprinella</i> sp.	Sardinita Santa Clara	E	1+, 2++	CHI	Dewatered basin.	
<i>Cyprinella</i> sp.	Sardinita Bavícora	E	1+++; 2+++; 5	CHI	Dewatered basin.	
<i>Dionda diaboli</i>	Carpita diabla	E	1, 2, 5, 6	COA	Disappeared in 2 localities, 1 surviving.	
<i>Dionda dichroma</i>	Carpita bicolor	T	1, 6	SLP		
<i>Dionda episcopa</i>	Carpita Pecos	E	5, 6	COA	Scarce in single habitat known.	
<i>Dionda mandibularis</i>	Carpita quijarona	E	1, 6	SLP	Scarce (Contreras-Balderas and Verdusco-Martínez, 1977; Aguilera-González et al., pers. com., 1996).	
<i>Dionda melanops</i>	Carpita manchada	E	1+, 2, 6, 7, 8	NLE	Highly polluted and dewatered habitats.	
<i>Dionda</i> sp.	Carpita Cuatro Ciénegas	E	6	COA	Exotics present.	
<i>Exrarius aestivalis</i>	Carpa de lunares	T	1+, 2, 6, 7, 8	CHI, COA, NLE, TAM	Highly polluted and dewatered.	
<i>Gila conspersa</i>	Carpa manchada	SC	2, 8+++	DGO		
<i>Gila ditaenia</i>	Carpa sonorensis	T	1+, 2, 8	SON		
<i>Gila elegans</i>	Carpa elegante	E	1+, 2++	SON		
<i>Gila eremica</i>	Carpa negra	SC	1+, 2, 8	SON		
<i>Gila intermedia</i>	Carpa Gila	E	1+, 2++	SON		
<i>Gila modesta</i>	Carpa Saltillo	E	1+++; 2+++	COA		
<i>Gila nigrescens</i>	Carpa Chihuahua	T	1, 2+, 8+++	CHI, DGO	Survives in 1 of 12 localities known.	

Appendix 1. Continued

Family	Species	Common name	Status	Risks	Range	Comments
	<i>Gila purpurea</i>	Carpa Yáqui	E	1, 2+, 8	SON	Extirpated before 1963 (Miller, 1961, 1963).
	<i>Gila robusta</i>	Carpa aletas redondas	SC	1, 2+, 8	SON	Single locality.
	<i>Gila</i> sp.	Carpa Iturbide	E	5+++	NLE	Not collected in México in last 50 years.
	<i>Hybognathus amarus</i>	Sardina Chamizal	E	1+, 2+, 6	CHI, COA, NLE, TAM	Few localities known (Contreras-Balderas et al., MS).
	<i>Hybopsis inelidae</i>	Carpa Río Verde	E	5+++	OAX	Collected only in 1956 (De Buen, 1956).
	<i>Hybopsis moralesi</i>	Carpa Tepelmeme	E	5+	OAX	Formerly abundant (Contreras-Balderas and Rivera-Tejilery, 1973)
	<i>Notropis aguirrepequenoi</i>	Carpa Pílon	SC	5+	TAM	now scarce.
	<i>Notropis amabilis</i>	Carpa texana	T	1+, 2+, 6	CHI, COA, NLE, TAM	
	<i>Notropis braytoni</i>	Carpa lamaulipeca	T	1+, 2+, 6	CHI, COA, NLE, TAM	
	<i>Notropis cummingsi</i>	Carpa Balsas	T	4+, 6, 7	MIC	
	<i>Notropis chihuahua</i>	Carpa Chihuahua	T	1+, 2+, 6	CHI, DGO	
	<i>Notropis jemezianus</i>	Carpa Bravo	T	1+, 2+, 6	CHI, COA, NLE, TAM	
	<i>Psychocheilus luctus</i>	Carpa gigante del Colorado	E	1+, 2+, 6	SON, BCN	Extirpated before 1963 (Miller, 1961, 1963).
	<i>Rhinichthys cobitis</i>	Carpa locha	E	1+, 2+, 6	SON	Extirpated before 1963 (Miller, 1961, 1963).
	<i>Rhinichthys osculatus</i>	Carpa pinta	E	1+, 2+, 6	SON	Extirpated before 1963 (Miller, 1961, 1963).
Catostomidae	<i>Carpiodes carpio</i>	Matalote blanco	SC	1+, 2+, 6	CHI, COA, NLE, TAM	
	<i>Catostomus bernardini</i>	Matalote Yaqui	SC	1, 2, 6	CHI, SON	
	<i>Catostomus cahita</i>	Matalote cahita	T	1, 2, 6	CHI	
	<i>Catostomus conchos</i>	Matalote Conchos	T	1, 2, 6, 8+	CHI	
	<i>Catostomus insignis</i>	Matalote Sonora	E	1+, 2+, 6	SON	Extirpated before 1963 (Miller, 1961, 1963).
	<i>Catostomus leopoldi</i>	Matalote Bavispe	SC	1+, 2	CHI	
	<i>Catostomus nebuliferus</i>	Matalote Nazas	T	1+, 2+, 6	DGO	
	<i>Catostomus wigginsi</i>	Matalote Opata	T	1+, 2+, 6	SON	
	<i>Cycleptus elongatus</i>	Matalote azul	T	1+, 2+, 6, 8+	CHI, COA, NLE, TAM	
	<i>Ictiobus bubalus</i>	Cuino blanco	T	1+, 2+, 6, 8+	CHI, COA, NLE, TAM	
	<i>Ictiobus niger</i>	Cuino negro	T	1+, 2+, 6, 8+	CHI, COA, NLE, TAM	
	<i>Pantosteus plebeius</i>	Matalote Tarahumara	T	1, 2, 6, 8+	SON, CHI, COA, TAM	
	<i>Scartomyzon congestum</i>	Matalote gris	T	1, 2, 6, 8+	COA, NLE, TAM	
	<i>Xyrauchen texanus</i>	Matalote jorobado	E	1+, 2+, 6	SON, BCN	Extirpated from México before 1963 (Miller, 1963).
Characidae	<i>Asyanax armandoi</i>	Sardinita Péñjamo	T	5+++	CHA	
	<i>Asyanax jordani</i>	Sardina ciega	SC	5+	SLP	
	<i>Bramocharax caballeri</i>	Pepesca Catemaco	E	3+, 5, 6	VER	Single locality, exotics present, overexploited.
Itetaluridae	<i>Itetalurus australis</i>	Bagre Pánuco	T	8	SLP	
	<i>Itetalurus lupus</i>	Bagre montaña	T	1, 2, 6, 8	COA, NLE	
	<i>Itetalurus mexicanus</i>	Bagre Río Verde	T6, 8	SLP		
	<i>Itetalurus pricei</i>	Bagre Yáqui	T	1, 2, 6, 8+	RT	
	<i>Prietella hundbergi</i>	Bagre ciego duende	E	5+++	TAM	Very rare (Walsh and Gilbert, 1995).
	<i>Prietella phreatophila</i>	Bagre ciego Múzquiz	E	5+	COA	Dewatered habitats.
Aritidae	<i>Potamarius nelsoni</i>	Bagre lacandón	SC	4	CHA	

Appendix 1. Continued

Family	Species	Common name	Status	Risks	Range	Comments
Pimelodidae	<i>Rhamdia guatemalensis depressa</i>	Juil yucateco	SC	5+++	YUC	Single locality
	<i>Rhamdia guatemalensis decolor</i>	Juil Motul	SC	5+++	YUC	Single locality
	<i>Rhamdia guatemalensis sacrificii</i>	Juil de cenote	SC	5+++	QUI	Single locality
	<i>Rhamdia guatemalensis sdygaea</i>	Juil San Isidro	SC	5+++	YUC	Single locality
	<i>Rhamdia maatsuyanensis</i>	Juil ciego Olmecca	T	5+++	VER	Single locality
	<i>Rhamdia reddelli</i>	Juil ciego Mixteco	T	5+++	OAX	Single locality
	<i>Rhamdia zongolizensis</i>	Juil ciego Oaxaca	T	5+++	OAX	Single locality
Salmonidae	<i>Oncorhynchus chrysogaster</i>	Trucha dorada mexicana	E	1, 6, 9	CHI, DGO	Hybridization with rainbow trout.
	<i>Oncorhynchus mykiss nelsoni</i>	Trucha San Pedro Mártir	SC	5	BCN	Stable (Ruiz-Campos et al., 2000), restricted range.
	<i>Oncorhynchus</i> sp. A.	Trucha Yaqui	SC	4, 6	CHI, DGO, SON	Exotic trout introduced.
	<i>Oncorhynchus</i> sp. B	Trucha Mayo	SC	4, 6	CHI	Exotic trout introduced.
Bythiidae	<i>Ogilbia pearsei</i>	Dama blanca	E	5+++	YUC, QUI	Very rare.
Atherinidae	<i>Chirostoma bartoni</i>	Charal La Caldera	E	2, 5+++	GTO	Single locality dried.
	<i>Chirostoma promelas</i>	Blanco pico negro	E	1+++; 2+++; 8	JAL	Highly altered conditions (Díaz-Pardo, et al. 1993).
	<i>Poblana alchichica</i>	Charal Alchichica	E	5+++; 8	PUE	Single locality.
	<i>Poblana ferdebueni</i>	Charal Almoleya	E	5+++; 8	PUE	Single locality.
	<i>Poblana letholepis</i>	Charal La Preciosa	E	5+++; 8	PUE	Single locality.
	<i>Poblana squamata</i>	Charal Quechulac	E	5+++; 8	PUE	Single locality.
	<i>Rivulus robustus</i>	Almirante	E	4+++	VER, TAB	Very rare.
Profundulidae	<i>Profundulus hildebrandi</i>	Escamudo San Cristóbal	E	1+++; 2+++; 7	CHA	Population reduced 95%.
Fundulidae	<i>Fundulus lima</i>	Sardimilla de Oasis	E	5+, 6	BCS	Population reduction and exotics (Ruiz-Campos et al., this volume).
	<i>Lucania interioris</i>	Sardimilla Cuatro Ciénegas	E	4+++; 6, 8	COA	Single locality.
Poeciliidae	<i>Gambusia ahvarezi</i>	Guayacón San Gregorio	E	5+++	CHI	Single locality.
	<i>Gambusia eurystoma</i>	Guayacón El Azufre	T	5+++	TAB	Single locality.
	<i>Gambusia huartadoi</i>	Guayacón Dolores	E	5+++	CHI	Single locality.
	<i>Gambusia longispinis</i>	Guayacón Cuatro Ciénegas	E	5+++	COA	Few localities.
	<i>Gambusia senilis</i>	Guayacón manchado	SC	1, 2, 6, 7 8++	CHI	
	<i>Gambusia speciosa</i>	Guayacón amarillo	E	1, 2, 6, 7 8++	NLE; COA	
	<i>Gambusia</i> sp. A	Guayacón pinto	E	5	CHI	Single locality.
	<i>Gambusia</i> sp. B	Guayacón San Diego	E	5	CHI	Single locality.
	<i>Poecilia latipunctata</i>	Molly Tamesí	E	6, 7, 8+++	TAM	Populations reduced 99%.
	<i>Poecilia sulphuraria</i>	Molly El Azufre	T	5+++	TAB	Single habitat reduced and impacted.
	<i>Poecilia velifera</i>	Molly de Vela	T	3+++; 4	YUC	
	<i>Poeciliopsis latidens</i>	Guatopote del Fuerte	T	8+++	SIN	
	<i>Poeciliopsis occidentalis</i>	Guatopote Sonora	T	1, 2+++; 6, 8++	SON	
	<i>Priapella compressa</i>	Guayacón Palenque	T	4+++; 8++	CHA	
<i>Priapella olmeca</i>	Guayacón olmeca	T	5++	VER		

Appendix 1. Continued

Family	Species	Common name	Status	Risks	Range	Comments	
	<i>Xiphophorus clemenciae</i>	Espada Clemencia	T	8+++	OAX	Habitat wide, but impacted.	
	<i>Xiphophorus couchianus</i>	Platy Monterrey	E	1+++; 2+++; 5+++; 6; 8+++	NLE	Extirpated in 5 of its 7 spring habitats.	
	<i>Xiphophorus gondoni</i>	Platy Cuatro Ciénegas	E	5+++; 6+++; 8	COA	Single locality with exotics.	
	<i>Xiphophorus meyeri</i>	Platy Múzquiz	E	1+++; 2+++; 5+++; 8+++	COA	Single habitat dewatered 95%.	
	<i>Xiphophorus milleri</i>	Espada Catemaco	E	5+++; 6; 8	VER	Introduced exotics.	
Goodeidae	<i>Allotoca dugesi</i>	Tiro	T	1+++	MIC, JAL, GTO		
	<i>Ateniobius toweri</i>	Mexcalpique colazul	E	2+; 6+++	SLP		
	<i>Girardinichthys multiradiatus</i>	Mexcalpique Lermense	T	1+++; 2+++; 8+++	RL	Highly altered conditions (Díaz-Pardo et al., 1993).	
	<i>Girardinichthys viviparus</i>	Mexcalpique azteca	E	1+++; 2+++; 8+++	VM	Remaining habitat almost nil.	
	<i>Characodon audax</i>	Mexcalpique Toboso	T	1+++; 2+++; 5	DGO	Habitat reduction.	
	<i>Characodon lateralis</i>	Mexcalpique arcoiris	E	1+++; 2+++; 5	DGO	Habitat reduction.	
	<i>Hubbsina turneri</i>	Cherehuita	E	1+++; 2+++; 5	MIC	Survives in 1 of 2 known areas (Moncayo, com. pers.).	
	<i>Skiffia bilineata</i>	Tiro rayado	T	1+++; 2+++; 5	MIC, JAL, GTO	Highly altered conditions (Díaz-Pardo et al., 1993).	
	<i>Skiffia lernae</i>	Tiro Lerma	T	1+++; 2+++; 5	LCH	Highly altered conditions (Díaz-Pardo et al., 1993).	
	<i>Xenoporphus captivus</i>	Mexcalpique viejo	E	2+++; 5+++; 8	SLP	Habitat impacted, reduced 90%.	
	Cyprinodontidae	<i>Cualac tessellatus</i>	Cachorrillo Media Luna	E	2+; 6; 8+++	SLP	Habitats dewatered, exotics (Aguilera-González et al., com. pers.).
		<i>Cyprinodon atrorus</i>	Cachorrillo Bolsón	T	6+++	COA	Few localities.
		<i>Cyprinodon beltrani</i>	Cachorrillo lodero	E	2+++; 6	QUI	Single locality (Humphryes and Miller, 1981).
<i>Cyprinodon bifasciatus</i>		Cachorrillo Cuatro Ciénegas	T	1+++; 6	COA	Few localities.	
<i>Cyprinodon bobmilleri</i>		Cachorrillo San Ignacio	T	5+++	NLE	Single locality impacted (Lozano-Vilano and Contreras-Balderas, 1999).	
<i>Cyprinodon eremus</i>		Cachorrillo Sonoyta	E	1; 2; 4; 5; 6; 8;	SON	Scarce, with abundant exotics (Hendrickson and Varela, 1989).	
<i>Cyprinodon eximius</i>		Cachorrillo Conchos	T	1; 2; 6; 7; 8	CHI	Population reduction.	
<i>Cyprinodon fontinalis</i>		Cachorrillo Carbonera	E	2+++; 5+++; 6	CHI	Single locality.	
<i>Cyprinodon labiosus</i>		Cachorrillo cangrejero	E	2+++; 6	QUI	Single locality (Humphryes and Miller, 1981).	
<i>Cyprinodon maculatus</i>		Cachorrillo escamudo	E	2+++; 5+++; 6	CHI	Single locality.	
<i>Cyprinodon maya</i>		Cachorrillo gigante	E	1+++; 2+++; 8	SON	Extirpated before 1963 (Miller, 1961, 1963).	
<i>Cyprinodon nazas</i>		Cachorrillo Mayrán	E	2+++; 6	QUI	Single locality (Humphryes and Miller, 1981).	
<i>Cyprinodon pachycephalus</i>		Cachorrillo cabezón	T	1+++; 2+++; 8	DGO	Dewatered basin.	
<i>Cyprinodon sinus</i>		Cachorrillo boxeador	E	2+++; 5+++; 6	CHI	Single locality (Minckley and Minckley, 1986).	
<i>Cyprinodon verucundus</i>		Cachorrillo dorsal larga	E	2+++; 6	QUI	Single locality (Humphryes and Miller, 1981).	
<i>Cyprinodon</i> sp.		Cachorrillo Santa Rosa	E	1+++; 2+++	CHI	Single locality.	
<i>Cyprinodon</i> sp.		Cachorrillo Bustillos	E	1+++; 2+++	CHI	Dewatered basin.	
<i>Cyprinodon</i> sp.		Cachorrillo Ojo Caliente	E	1+++; 2+++	CHI	Single locality.	
<i>Cyprinodon</i> sp.		Cachorrillo Saúz	E	1+++; 2+++	CHI	Dewatered basin.	
Gasterosteidae		<i>Gasterosteus aculeatus</i>	Espinocho	T	1+; 2+; 8+++	BCN	Threatened (Ruiz-Campos et al., 2000).
Synbranchidae	<i>Ophisternon infernale</i>	Anguila ciega	T	1+; 4+; 8+++	YUC, QUI	Very rare.	

Appendix 1. Continued

Family	Species	Common name	Status	Risks	Range	Comments
Percidae	<i>Etheostoma australe</i>	Dardo Conchos	E	1++, 2++, 6, 8	CHI	
	<i>Etheostoma grahami</i>	Dardo Río Bravo	T	1++, 2++, 6, 8	NLE, COA	
	<i>Etheostoma lugoi</i>	Dardo Cuatro Ciénegas	E	1++, 2++, 6, 8	COA	Scarce (Norris and Minckley, 1997).
	<i>Etheostoma potisi</i>	Dardo Tarahumara	T	1++, 2++, 6, 8	ST	Single locality.
	<i>Etheostoma</i> sp.	Dardo Peñón Blanco	SC	1, 2, 4, 6	DGO	Nearly extirpated in México.
Centrarchidae	<i>Percina macrolepidida</i>	Perca escamuda	T	1++, 2++, 6, 8	COA	Few localities.
	<i>Micropterus</i> sp.	Robalito cieneguense	E	5, 6	COA	Few localities.
	<i>Lepomis</i> sp.	Mojarra pechiroja	E	5, 6	COA	Few localities.
Cichlidae	<i>Cichlasoma bartoni</i>	Mojarra caracolera	E	6, 8+++	SLP	Population reduction.
	<i>Cichlasoma grammodes</i>	Mojarra Chiapa de Corzo	SC	1++, 8	CHA	
	<i>Cichlasoma hartwegi</i>	Mojarra Río Grande	SC	1++, 8	CHA	
	<i>Cichlasoma labridens</i>	Mojarra huasteca	E	6, 8+++	SLP	Population reduction.
	<i>Cichlasoma minckleyi</i>	Mojarra Cuatro Ciénegas	T	6, 8	COA	Exotics present.
	<i>Cichlasoma sokoloffi</i>	Mojarra Misala	SC	1++, 8	CHA	
Gobiessocidae	<i>Gobiesox fluvialis</i>	Cucharita de río	SC	4++	SIN, COL, COA, MIC, NAY, CHI, ZAC	
	<i>Gobiesox juniperoserrai</i>	Cucharita Baja California	E	5+++	BCS	Scarce, single locality (Espinoza-Pérez and Castro-Aguirre, 1996).
	<i>Gobiesox mexicanus</i>	Cucharita mexicana	SC	4++	GRO, OAX	

1 = Habitat alteration, 2 = Water depletion, 3 = Overexploitation, 4 = Rarity, 5 = Small locality, 6 = Exotics present, 7 = Pollution, 8 = Population reduction, 9 = Hybridization.
+ = Intensity.

Appendix 2. Extinct freshwater fish of México

Family	Species	Common name	State	Comments	
Cyprinidae	<i>Evarra bustamantei</i>	Carpita Bustamante	DFE, MEX	Valley of México dried before 1983 (Miller et al., 1989).	
	<i>Evarra eigenmanni</i>	Carpita Eigenmann	DFE, MEX	Valley of México dried around 1983 (Miller et al., 1989).	
	<i>Evarra tlahuacensis</i>	Carpita Tlahuac	DFE, MEX	Valley of México dried around 1983 (Miller et al., 1989).	
	<i>Gila</i> sp. A	Carpa Gordá Parras	COA	Last seen in 1968 (Contreras-Balderas and Maeda, 1985).	
	<i>Gila</i> sp. B	Carpa Flaca Parras	COA	Last seen in 1968 (Contreras-Balderas and Maeda, 1985).	
	<i>Hybopsis amecae</i>	Carpita Ameca	JAL	Last collected in 1969 (Chernoff and Miller, 1986).	
	<i>Hybopsis autidion</i>	Carpita Durango	DGO	Not seen in 40 years (Chernoff and Miller, 1986).	
	<i>Notropis orca</i>	Carpita fantasma	CHI, COA, NLE	Last collected in 1975 (SCB).	
	<i>Notropis saladonis</i>	Carpita Salado	COA, NLE	Last seen in 1968 (SCB).	
	<i>Notropis s. sinus</i>	Carpita narizona	CHI, COA, NLE	Last seen in México in 1968 (not seen).	
	<i>Synpodon signifer</i>	Carpita Parras	COA	Not seen in 97 years (Miller et al., 1989).	
	Atherinidae	<i>Chirostoma charari</i>	Charal tarasco	MIC	Harrison and Stiassny (1999) unresolved.
		<i>Chirostoma compressum</i>	Charal	MIC	Harrison and Stiassny (1999) unresolved.
Poeciliidae	<i>Priapella bonita</i>	Guayacán bonito	VER	Not recorded in 97 years.	
Goodeidae	<i>Ameca splendens</i> *	Guayacán esplendoroso	JAL	No recent information.	
	<i>Characodon garmani</i> *	Tiro Parras	COA	Collected only in 1880 (Miller et al., 1989).	
	<i>Skiffia francescae</i> *	Tiro dorado	JAL	Disappeared in single locality.	
Cyprinodontidae	<i>Cyprinodon abarezi</i> *	Cachorrito Potosí	NLE	Habitat dried in 1994 (Contreras-Balderas and Lozano-Vilano, 1996).	
	<i>Cyprinodon ceciliae</i>	Cachorrito Cecilia	NLE	Habitat dried. Not collected since 1990 (Contreras-Balderas and Lozano-Vilano, 1996).	
	<i>Cyprinodon inmemoriam</i>	Cachorrito recuerdo	NLE	Habitat dried in 1986 (Contreras-Balderas and Lozano-Vilano, 1996).	
	<i>Cyprinodon lanifasciatus</i>	Cachorrito Parras	COA	Last collected in 1903 (Contreras-Balderas and Maeda-Martínez, 1985).	
	<i>Cyprinodon longidorzalis</i> *	Cachorrito dorsal larga	NLE	Habitat dried in 1994 (Contreras-Balderas and Lozano-Vilano, 1996).	
	<i>Cyprinodon meeki</i> *	Cachorrito Mezquital	DGO	Not collected since 40 years ago.	
	<i>Cyprinodon veronicae</i> *	Cachorrito Verónica	NLE	Habitat dried in 1996 (unpub.).	
	<i>Megapsilon aporus</i> *	Cachorrito enano	NLE	Habitat dried in 1994 (Contreras-Balderas and Lozano-Vilano, 1996).	

Cualac tessellatus, listed as by Harrison and Stiassny (1999) was surviving locally, although its habitat being reduced and exotics present (Aguilera-González et al., com-pers.).

* Indicates surviving in captivity.

