Mummichog (*Fundulus heteroclitus*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, March 2020
Revised, March 2020
Web Version, 6/23/2020

Organism Type: Fish
Overall Risk Assessment Category: Uncertain

Photo: Smithsonian Environmental Research Center. Licensed under Creative Commons Attribution 2.0 Generic. Available: https://commons.wikimedia.org/wiki/File:Fundulus_heteroclitus_RR_08-11-19_0580_(48547991467).jpg (March 2020)

1 Native Range and Status in the United States

Native Range

From Froese and Pauly (2020):

"Western Atlantic: Gulf of St. Lawrence to northeast Florida, USA."

From Gonzalez et al. (2009):

"The geographical distribution of the Mummichog ranges from southwestern Newfoundland to northeastern Florida (Able and Felley 1986), while the Gulf Killifish [*Fundulus grandis*] ranges from northeastern Florida southward to the coasts of Mexico (Duggins et al. 1989)."

The majority of sources identified the native range of *Fundulus heteroclitus* as the Atlantic Coast of North America from Newfoundland, Canada, south to northeastern Florida (e.g. Gisbert and López 2007; Fuller 2020), while a few cite Bigelow and Schroeder (1951) stating that the native

range extends into the Gulf of Mexico, to the Texas coastline or further into Mexico. There is a second species, *F. grandis*, which has a range from southern Florida, along the Gulf Coast to Mexico (see Relyea (1983) for a discussion of *Fundulus* species). According to Relyea (1983) these two species could be easily misidentified. This ERSS will follow the majority of the literature in considering the range of *F. heteroclitus* as having a southern limit in northeastern Florida. Observations along the Gulf Coast or in Mexico will be considered to be misidentifications of *F. grandis* unless otherwise noted as introductions of *F. heteroclitus*.

Status in the United States

From Fuller (2020):

"Native Range: Marine, brackish, and occasionally freshwaters from the Gulf of St. Lawrence to northeastern Florida (Robins and Ray 1986)."

"[Nonnative range:] Previously established or locally established in New Hampshire and Pennsylvania (Scarola 1973; Trautman 1981). Denoncourt et al. (1975a) reported only two specimens from Sandy Run, and one specimen from the Juniata River [Pennsylvania]. Established in the lower Susquehanna and Delaware drainages (Denoncourt et al., 1978)."

According to Fuller (2020), *Fundulus heteroclitus* has been reported as non-native in the following States (years of reports and watersheds given after State name):

- Michigan (2012; Detroit)
- New Hampshire (1973; Merrimack River)
- North Carolina (2020; Waccamaw)
- Pennsylvania (1934–1981; Beaver, Brandywine-Christina, Lehigh, Lower Susquehanna, Lower Susquehanna-Swatara, Schyulkill, Shenango, Upper Juniata, Upper Ohio)

From Froese and Pauly (2020):

"Alvin Seale brought the fish to Hawaii upon the authorization of the Government of the Hawaiian Islands in 1905."

Froese and Pauly (2020) list *F. heteroclitus* as established in Hawaii.

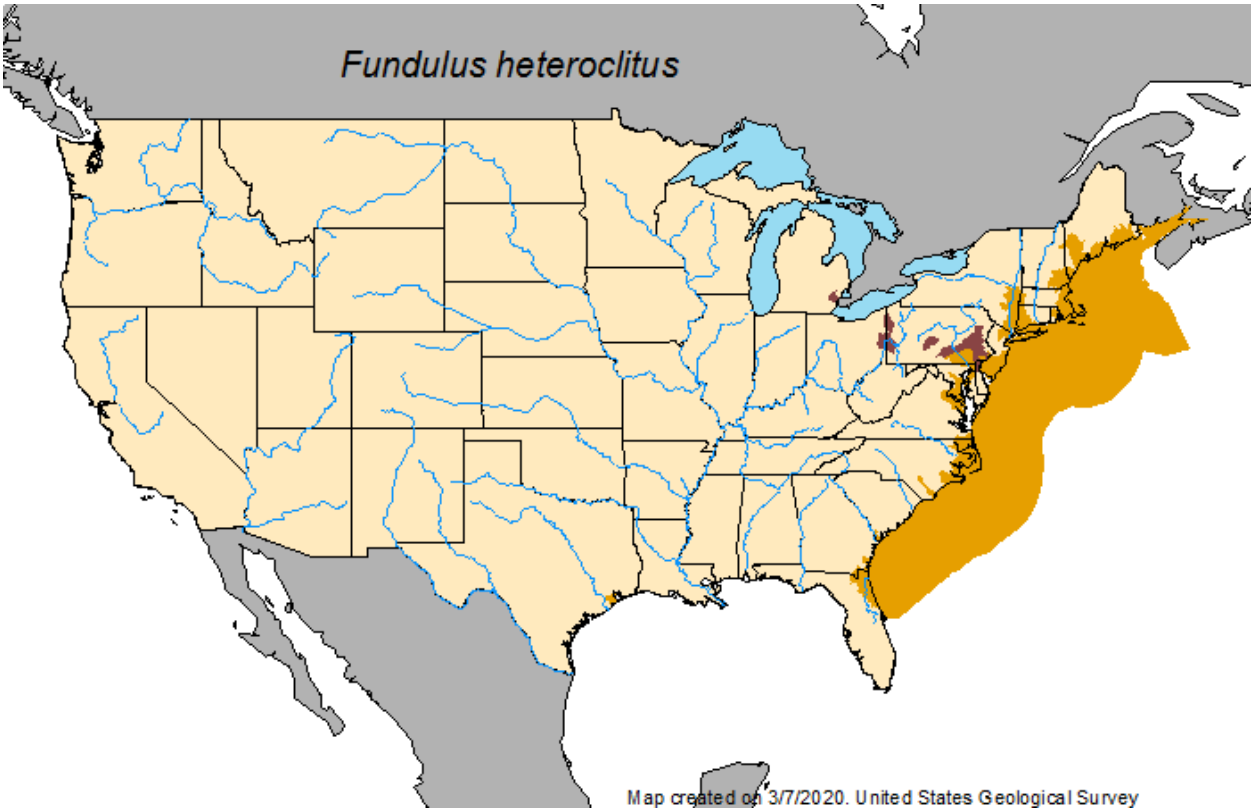

Figure 1. Map of the contiguous United States showing the native (orange) and nonnative (red) ranges of *Fundulus heteroclitus* by watershed. Map from Fuller (2020).

From Chesapeake Bay Program (2020):

"Mummichogs are often sold to fishermen as live bait."

Means of Introductions in the United States

From Fuller (2020):

"This species was introduced into ponds in New Hampshire, apparently via bait bucket release (Scarola 1973). It was transferred to far western Pennsylvania from the Delaware River drainage of the eastern part of the state (Raney 1938, cited in Trautman 1981), possibly as a baitfish. The other collections in Pennsylvania are believed to be bait bucket introductions (Denoncourt et al. 1975a, 1978)."

From Froese and Pauly (2020):

"mosquito control [in Hawaii]"

Remarks

This ERSS was previously published in November 2016. Revisions were completed to incorporate new information and conform to updated standards.

From Froese and Pauly (2020):

"Two subspecies were previously recognized: *Fundulus heteroclitus heteroclitus* and *Fundulus heteroclitus macrolepidotus* [Page and Burr 2011]."

Information included in this ERSS pertains to the whole species, *Fundulus heteroclitus*, unless otherwise noted.

From Dawley (1992):

"All-female hybrids of the killifishes *Fundulus heteroclitus* and *Fundulus diaphanus*, known from two sites in Nova Scotia, Canada, are shown to reproduce clonally."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

According to Fricke et al. (2020), *Fundulus heteroclitus* (Linnaeus 1766) is the current valid name for this species.

From ITIS (2020):

Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Deuterostomia
Phylum Chordata
Subphylum Vertebrata
Infraphylum Gnathostomata
Superclass Actinopterygii
Class Teleostei
Superorder Acanthopterygii
Order Cyprinodontiformes
Suborder Cyprinodontoidei
Family Fundulidae
Genus *Fundulus*
Species *Fundulus heteroclitus* (Linnaeus, 1766)

Size, Weight, and Age Range

From Froese and Pauly (2020):

"Maturity: L_m ?, range 4 - ? cm
Max length : 15.0 cm TL male/unsexed; [Huber 1996]; common length : 8.9 cm TL male/unsexed; [Hugg 1996]; max. reported age: 4 years [Kottelat and Freyhof 2007]"

Environment

From Froese and Pauly (2020):

"Marine; freshwater; brackish; benthopelagic; non-migratory. […] 10°C - 24°C [Baensch and Riehl 1995] [assumed to be the recommended aquarium temperature]"

From Taybi et al. (2020):

"However, it [*Fundulus heteroclitus*] can survive in a hypersaline waters compared to *G. holbrooki*, with a maximum of 2,757 g/l (2,760.15 ppm) recorded at the Moulouya mouth […]."

Climate

From Froese and Pauly (2020):

"Temperate; […] 52°N - 28°N, 82°W - 57°W"

Distribution Outside the United States

Native

Much of the native range of *Fundulus heteroclitus* is contained within the United States. See section 1 for a full description.

From Froese and Pauly (2020):

"Western Atlantic: Gulf of St. Lawrence […]."

Introduced

According to Froese and Pauly (2020) *Fundulus heteroclitus* has been introduced and is probably established in the Philippines.

From Blanco-Garrido and Clavero (2016):

"The mummichog was apparently introduced to southern Iberian Peninsula [Portugal and Spain] in the early 1970s, although the introduction date remains unclear and could be older. When first collected in 1973, the mummichog was thought to be a yet unknown Iberian cyprinodontiform, and was even described as a new species, with the name of *Valencia lozanoi* (Gómez-Caruana et al., 1984), being finally synonymized with *F. heteroclitus* (Fernández-Delgado et al., 1986). Those first Spanish records came from the Guadalquivir marshes, although the species was recorded soon after (1974) in the Guadiana estuary, more than 100 km of coastline away. The mummichog was then located in the marshes of Cádiz Bay in 1983, becoming an abundant species from there to the Guadiana estuary at the end of 1980's (Fernández-Delgado et al., 1989). The species was reported from the Barbate marshes in 1996, although it might have been present there since around 1993 (Gutiérrez-Estrada et al., 1998; […]). In 2005 the mummichog was first recorded in the Mediterranean Sea basin, being captured in the Ebro Delta (Gisbert & López,

2007), where it has apparently succeeded in establishing self-sustained populations (López et al., 2012)."

"In 1996, the Barbate marshes constituted the southern limit of the Iberian range of the mummichog. Gutiérrez-Estrada et al (1998) sampled two sites in the Cachón River, a small watercourse reaching the Atlantic some 7 km to the south-east, but did not find the species there […]. The Cachón River enters the sea through a narrow mouth that is usually blocked by a sandbar during summers […]. In this situation, anoxia and fish mortality episodes are frequent. One of such episodes started on July 31st 2016 and lasted up to August 4th, when the sandbar was artificially broken and the river was connected to the sea […]. The inspection of the beached dead fishes revealed a high prevalence of mummichog. Individuals of both sexes were found in high numbers and covering a wide range of sizes (22-100 mm, total length), indicating the existence of a well-established population."

From Taybi et al. (2020):

"We found it [*F. heteroclitus*] for the first time in Morocco and Northern Africa at the Moulouya River mouth"

"In , the distribution of *F. heteroclitus* seems to be limited to the Oriental region so far, from the wetlands of Ain Chabbak to the mouth of the Moulouya River […]."

Means of Introduction Outside the United States

From FAO (2020):

"mosquito control"

Short Description

From Froese and Pauly (2020):

"Distinguished from nearly identical species *Fundulus grandis* by having the following characters: more convex upper profile; dark bars alternating with silvery interspaces on side; small ocellus at rear of dorsal fin of male; and each mandible with 4 pores [Page and Burr 2011]."

From Relyea (1983):

"Meristic data, […] are as follows: pelvic fin rays 6-6; branchiostegal rays 5 + 5; dorsal fin rays 10-15 (mode = 12); anal fin rays 9-12 (mode = 11); branched caudal rays 14-21, usually 16-18; caudal peduncle circumferential scales 17-22, usually 19-20; and pectoral fin rays 16-21 (mode = 18-19)."

"Mature males in life are colored blue to olive dorsally, shading to a lighter olive ventro-laterally. The ventral region is bright yellow in breeding males (hence the common name yellow bellied cobbler). Small, light spots occur on the body, especially posteriorly. The median fins are blue with light spots, and have a yellow or orange margin. Pelvic and pectoral fins are also

yellow or orange. An ocellus occurs in the dorsal fin of males, but this is obscured by increasing pigmentation in the dorsal fin as the fish matures […]."

Biology

From Froese and Pauly (2020):

"Occurs in saltwater marshes, tidal creeks and nearby fresh water [Page and Burr 2011]. A resident intertidal species with homing behavior [Gibson 1999]. Adults are mainly found in saltwater marshes and in tidal creeks. They may leave tide pools if aquatic conditions become inhospitable [Martin and Bridges 1999]. They also enter fresh water to a limited extent [Robins and Ray 1986]. Not a seasonal killifish. They breathe air when out of water [Martin and Bridges 1999]."

"Deposits eggs in the shells of *Modiolus demissus* [Balon 1975]."

"Omnivorous feeder, food includes small crustaceans, polychaetes, insect larvae and vegetable matter. Preyed upon by kingfishers, small mammals, brook trout and bullfrogs."

From NatureServe (2020):

"Spawns spring through summer or early fall. May spawn 8 or more times during season; peaks coincide with high spring tides. Eggs hatch only when eggs are inundated, usually on spring tides (in about 7-8 days). Usually sexually mature in 2nd year, some in 1st year (Abraham 1985)."

"Summer density of individuals longer than 40 mm may range from 0.35-6.04/ sq m in certain estuaries. Individuals longer than 60 mm maintained summer range of 36-38 m along bank of tidal creek; some moved up to 375 m (Abraham 1985). Preyed on by many species of fishes and wading birds; blue crab is a major predator of adults in some salt marshes. Predation by adult mummichogs and xanthid crabs may contribute to the high mortality of larvae and juveniles (Kneib 1986)."

"Mummichogs are common in salt marsh flats, estuaries, and tidal creeks, especially where there is abundant submergent and emergent vegetation. Adults use intertidal zone only when it is flooded; young remain on marsh even at low tide, inhabiting shallow puddles (Kneib 1986). They occasionally enter freshwater streams and rivers (Lee et al. 1980, Page and Burr 2011). Individuals may burrow into bottom mud in winter. Spawning occurs in fresh, brackish, or saltwater; generally in estuarine and salt marsh environments. Eggs are laid in various sites at levels reached only by high spring tides; usually in sand in New England populations and in *Spartina alterniflora* or empty *Geukensia demissa* shells in Middle Atlantic and southern populations (Taylor 1986). Eggs normally incubate in air (aerial incubation apparently is essential for survival), not submerged until next spring tide. Abrupt decreases in salinity (e.g. due to spring freshets) may decrease fertilization success and increase larval mortality in local populations (Able and Palmer 1988)."

"Feeds at surface, mid-water, and off bottom mainly on various invertebrates, also algae and detritus. Feeds mainly at high tide during daylight, but also feeds opportunistically (Abraham 1985)."

Human Uses

From Froese and Pauly (2020):

"Aquarium: commercial"

"Difficult to maintain in aquariums [Huber 1996]."

"mosquito control"

From Kent et al. (2009):

"Other fishes commonly used in biomedical research include […] mummichog (*Fundulus heteroclitus*) […] for toxicology and oncology (Bailey et al., 1996; Hawkins et al., 2003; Law, [2001]; Walter and Kazianis, 2001; Winn, 2001)."

From Chesapeake Bay Program (2020):

"Mummichogs are often sold to fishermen as live bait."

Diseases

***Fundulus heteroclitus* is susceptible to two OIE-reportable diseases (OIE 2020), *Aphanomyces invadens* and viral haemorrhagic septicaemia virus.**

From Johnson et al. (2004):

"We explored the infectivity of *A. invadans* (WIC strain) when inoculated into four commonly occurring species: Atlantic menhaden, striped killifish, *Fundulus majalis* (Walbaum), mummichog *F. heteroclitus* (L.), and hogchoker, *Trinectes maculatus* (Bloch & Schneider). […] Mummichogs experienced a lower prevalence of lesions compared with the other species. Lesions appeared as reddened/purple areas under the skin along the dorsal surface, with some exhibiting curvature of the vertebral bone starting just behind the dorsal fin, an injection point […]. At no time did lesions develop into frank open ulcers, as did infections in menhaden and killifish. Mortality in mummichogs was low; less than half of those that developed lesions died […]. At the end of the experiment, many of the infected mummichogs appeared to be recovering from the lesions […]"

From Gagné et al. (2007):

"Viral haemorrhagic septicaemia virus (VHSV) was isolated from mortalities occurring in populations of mummichog, *Fundulus heteroclitus*, stickleback, *Gasterosteus aculeatus aculeatus*, brown trout, *Salmo trutta*, and striped bass, *Morone saxatilis*, in New Brunswick and Nova Scotia, Canada."

According to Poelen et al. (2014) *Fundulus heteroclitus* can be the host to *Cyclustra ralli, Homolometron pallidum, Agamonema immanis, Argulus funduli, Ergasilus lizae, Ergasilus manicatus, Ergasilus funduli, Kudoa funduli, Myxobolus funduli, Sessilina* sp., *Trichodina tenuidens, Livoneca ovalis, Trichodina domerguei, Neoechinorhynchus rostratus, Gyrodactylus stephanus, Fundulotrema prolongis, Gyrodactylus prolongis, Salsuginus hetercliti, Gyrodactylus foxi, Swingleus ancistrus, Contracaecum robustum, Stephanostomum tenue, Crepidostomum cooperi, Gonocercella trachinoti, Clinostomum complanatum, Echinochasmus schwartzi, Lasiotocus minutus, Otobothrium cysticum, Posthodiplostomum minimum, Phagicola diminuta, Proteocephalus macrocephalus, Dichelyne bullocki, Neoechinorhynchus cylindratus, Cyclustera ibisae, Glossocercus caribaensis, Philometra overstreeti, Paratenuisentis ambiguus, Cosmocephalus obvelatus, Paracuaria adunca, Southwellina hispida, Glossocercus aurita, Neoechinorhynchus rutili, Myzobdella lugubris, Eustrongylides* sp., *Psedoterranova decipiens, Contracaecum rudolphii, Fundulotrema porterensis,* and *Fundulotrema foxi*.

Threat to Humans

From Froese and Pauly (2020):

"Harmless"

3 Impacts of Introductions

From Froese and Pauly (2020):

"Introduction has caused the decline of native species and near extinction of *Aphanius baeticus* in southwestern Spain [Kottelat and Freyhof 2007]."

From Elvira (1995):

"Reasons for decline [of *Aphanius iberus*] and present threats: Habitat destruction (desiccation) water pollution and potential competition with introduced exotic toothcarps *Gambusia holbrooki* (Agassiz, 1859) and *Fundulus heteroclitus* (Linnaeus, 1766)."

From Gisbert and López (2007):

"In the Ebro River delta, the only potential estuarine species to be affected by the introduction of *F. heteroclitus* could also be the endemic *A. iberus*. Local populations of another cyprinodontoid species such as *V. hispanica*, which is considered as critically endangered (IUCN, 2006), however, might be also threatened if *F. heteroclitus* were able to disperse into freshwater habitats. On the Atlantic coast of the Iberian Peninsula *F. heteroclitus* inhabits a wide range of salinities, but prefers the most saline sites, usually >25 (Gutiérrez-Estrada *et al.*, 1998). Other authors, however, have reported that this species is unaffected by salinity and it has been reported in freshwater habitats (Weisberg, 1986)."

"Although *F. heteroclitus* is considered a rather sedentary species with a small home range (Kneib, 1984), the capture of these specimens in an open aquatic environment (Alfacs Bay)

suggests that a further range expansion in the Ebro River delta may occur, as was reported for the south-western *F. heteroclitus* populations (Bernardi *et al.*, 1995). Thus, further research must be focused on the habitat preference and potential effects of the introduced *F. heteroclitus* on native fish populations from the Ebro River delta."

From Gutiérrez-Estrada et al. (1998):

"If mummichog were outcompeting other species, the mechanisms of this potential exclusion have not been directly evaluated and remain unknown. However, direct predation does not seem to be a factor because *F. heteroclitus* consumes only invertebrates and plants in the study area (Hernando, 1975; Arias & Drake, 1986). Also, the competition for food does not seem to be a decisive factor due to the enormous productivity of the areas where it is found. Therefore, perhaps, the competition for space could be the best explanation for this apparent segregation observed for mummichog and other fish species in the study area."

"It is difficult to evaluate the precise ecological consequences of the mummichog introduction in southern Iberia, especially due to the fact that the original environmental conditions existing in the area where it was introduced are unknown. However, it is probable that some effects may have been negative. Some local fish species may have been displaced, and there have been probable economic losses in traditional prawn fishery yields which are known to be heavily consumed by mummichog (Arias & Drake, 1986). On the other hand *F. heteroclitus* is consumed in large quantities by very important commercial fish species, such as large *Sparus aurata* and *Dicentrarchus labrax* (Arias, pers. comm.). Also, mummichog seems to have a positive effect on some endangered birds, like spoonbills (*Platalea leucorodia*), storks (*Ciconia ciconia*) and several ardeids (*Ardea* sp. *Egretta garzetta*, etc.) (Delecourt, pers. comm.). Clearly, the potential impacts of *F. heteroclitus* in the environmentally rich tidal wetlands of south-western Spain should be further investigated."

From Taybi et al. (2020):

"Nevertheless, the idea that alien fishes have driven the Moroccan population of a native *Aphanius* species to extinction is also possible, especially in eastern Morocco, where *G. holbrooki* and *F. heteroclitus* have invaded all suitable hydrosystems, from the fresh continental waters of rivers and springs, to brackish and salty waters of coastal lagoons and wetlands."

4 History of Invasiveness

Fundulus heteroclitus has been introduced and become established in the Iberian Peninsula, Morocco, and to inland waters outside of its native range on the east coast of the United States. In parts of its introduced range in southwestern Spain it may have contributed to the decline of native species and near extinction of *Aphanius baeticus*. The supporting literature behind the reports of impacts were not available in English. Only one statement did not frame the impact in terms of a potential impact or an impact in conjunctions with another introduced species. Thus, the history of invasiveness for *F. heteroclitus* is Data Deficient.

5 Global Distribution

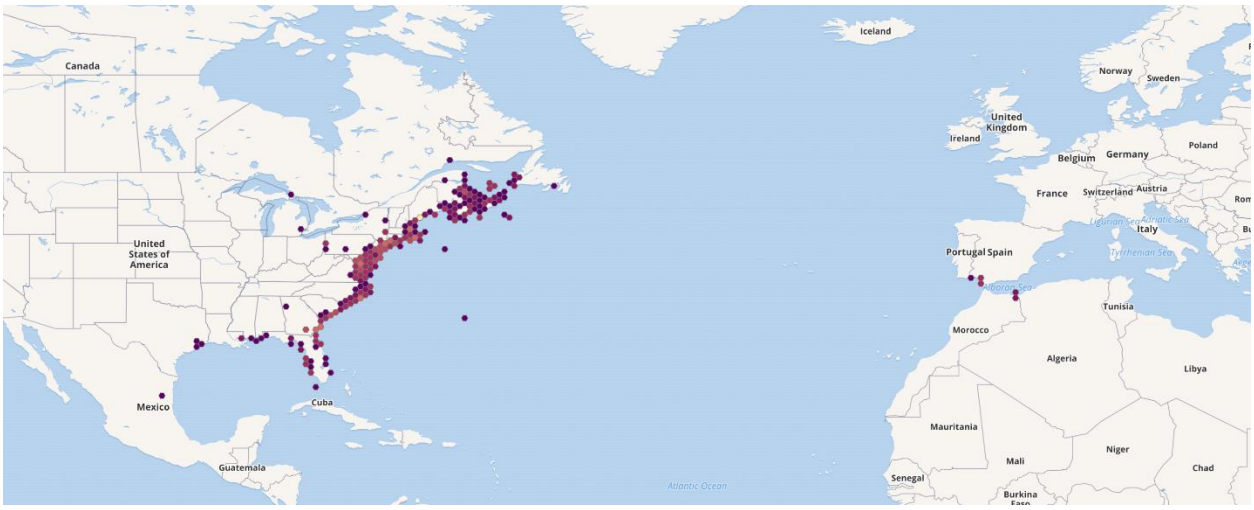

Figure 2. Known global distribution of *Fundulus heteroclitus*. Observations are reported from North America in Mexico, the United States, and Canada, and Spain, Portugal, and Morocco. The different shades of purple for the dots indicate concentrations of observations with lighter shades indicating a higher number of observations from that location. Map from GBIF Secretariat 2020. The points located in Bermuda, off the coast of New England, and between Lakes Superior and Huron could not be verified as established populations, and therefore were not included in the climate match. The points along the Gulf Coast are considered to be misidentifications of *Fundulus grandis* and were not used to select source points for the climate match (see section 1 for discussion of ranges of *F. heteroclitus* and *F. grandis*).

Exact locations for population in the Philippines could not be verified and were therefore not used as source locations for the climate match. Because the climate matching analysis is not valid for marine waters, no marine occurrences were used in the climate matching analysis.

6 Distribution Within the United States

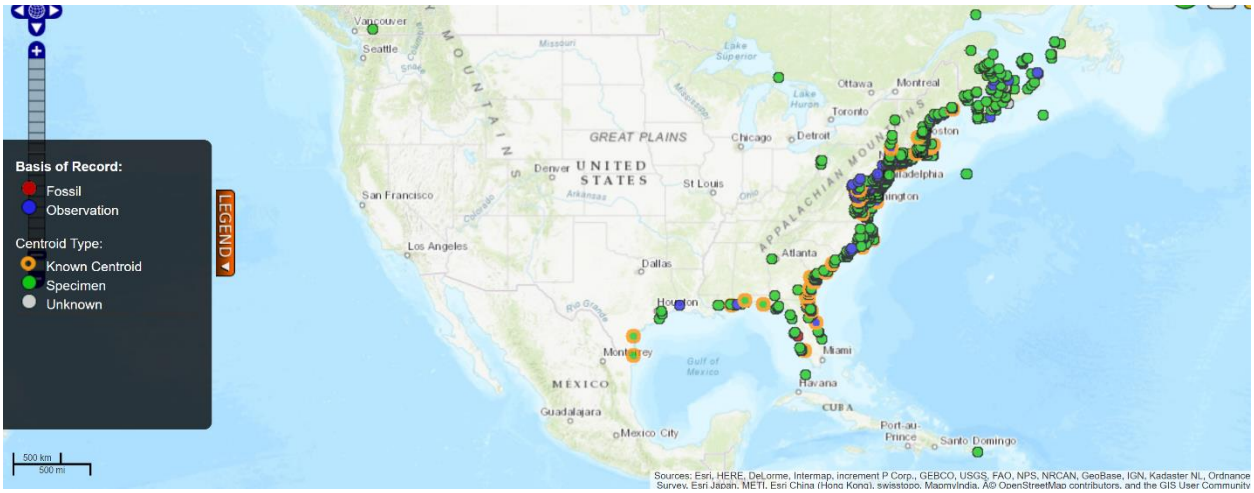

Figure 3. Known distribution of *Fundulus heteroclitus* in the United States. Map from BISON (2020). The points located on the west coast near Seattle, between Lake Superior and Huron, and in Puerto Rico could not be verified and therefore were not included in the climate match. The points along the Gulf Coast are considered to be misidentifications of *Fundulus grandis* and were not used to select source points for the climate match (see section 1 for discussion of ranges of *F. heteroclitus* and *F. grandis*).

No records of observations could be found for the reported introduced population in Hawaii. Because the climate matching analysis is not valid for marine waters, no marine occurrences were used in the climate matching analysis.

7 Climate Matching

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2018; 16 climate variables; Euclidean Distance) was high throughout much of the eastern contiguous United States, which was expected as the species is native to many coastal rivers from Maine to northern Florida. The climate match was also high in the Midwest, along the Gulf Coast into eastern Texas, and in much of California, which are outside the native range of the species. The climate match was low for the northernmost Plains States, Pacific Northwest, much of the Rocky Mountains, and most of Texas. Everywhere else had a medium match, including inland areas of the south from northwest South Carolina to eastern Louisiana. The Climate 6 score for the contiguous United States was 0.422, high (scores of 0.103 or greater are classified as high). Most States had a high individual Climate 6 score except for Idaho, North Dakota, Nevada, Oregon, and Washington, which had low individual scores, and Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming, which had medium individual scores.

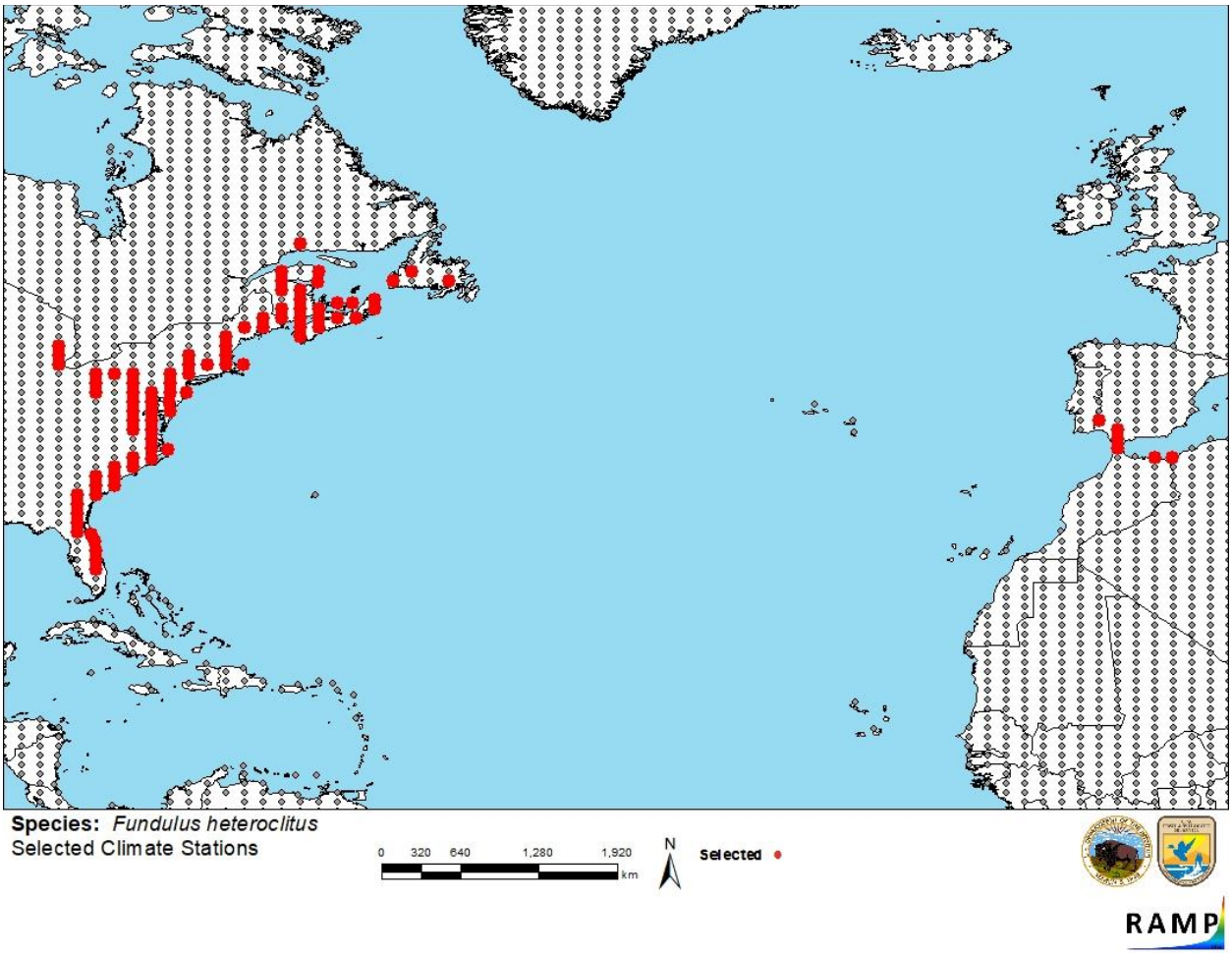

Figure 4 RAMP (Sanders et al. 2018) source map showing weather stations in North America, Europe, and Africa selected as source locations (red; United States, Canada, Spain, Portugal, Morocco); and non-source locations (gray) for *Fundulus heteroclitus* climate matching. Source locations from BISON (2020) and GBIF Secretariat (2020). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

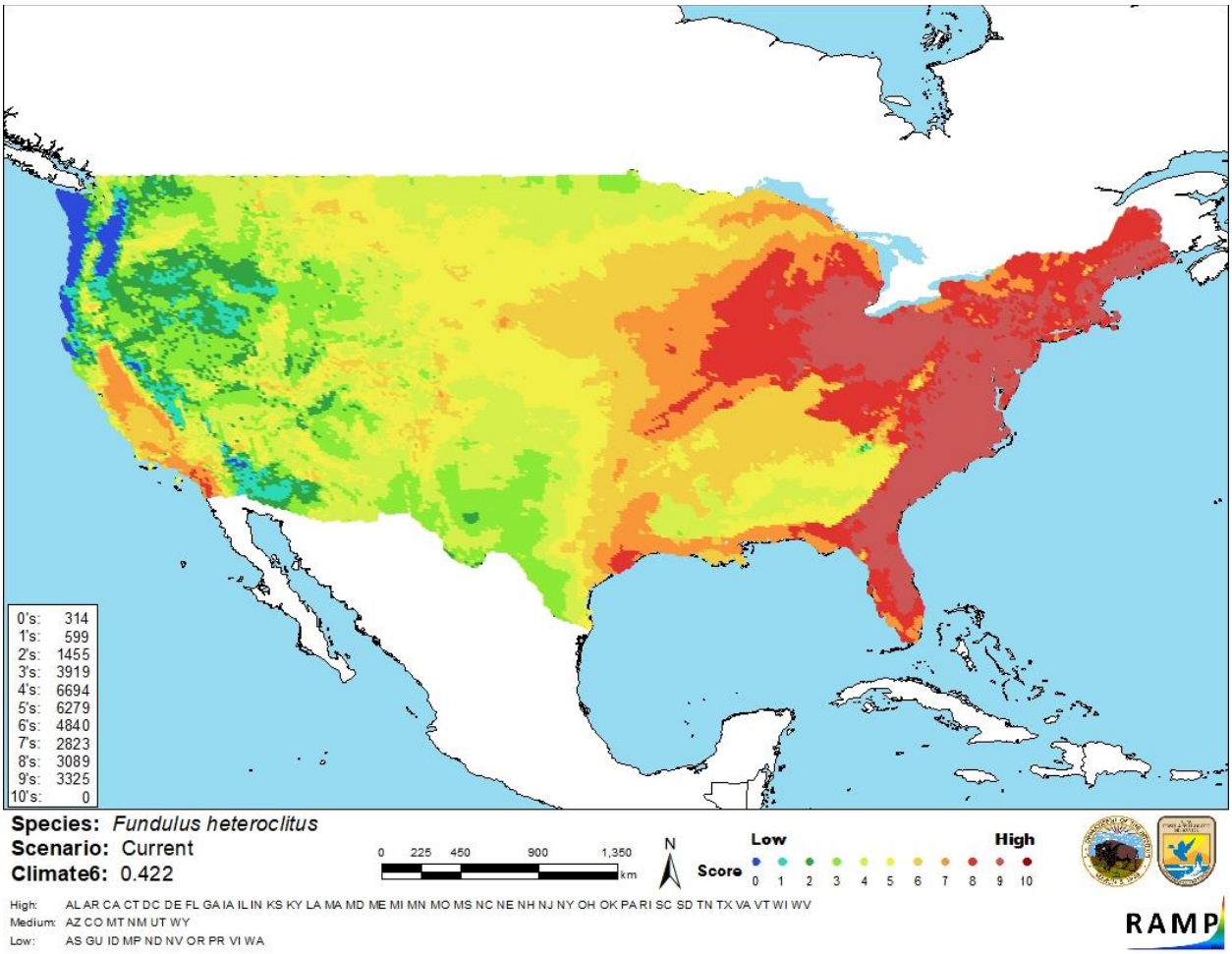

Figure 5. Map of RAMP (Sanders et al. 2018) climate matches for *Fundulus heteroclitus* in the contiguous United States based on source locations reported by BISON (2020) and GBIF Secretariat (2020). Counts of climate match scores are tabulated on the left. 0/Blue = Lowest match, 10/Red = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

8 Certainty of Assessment

Fundulus heteroclitus is a well-known, well-studied species. Peer-reviewed scientific literature was available regarding most aspects of the species' biology and ecology. Reports of potential impacts were found in peer-reviewed literature and a concrete statement of abundance reductions and a near extinction from a book but the information behind those reports could not be

accessed. Due to that there was not enough scientifically defensible information regarding the history of invasiveness. Some databases also reported observations that, according to the range of the species reported in the majority of the literature, are mostly likely the results of misidentifications of a closely related species. The certainty of assessment for *F. heteroclitus* is low, primarily due to the lack of information on scientifically documented impacts of introduction.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Mummichog (*Fundulus heteroclitus*) is native to the Atlantic coast of the United States and Canada. The species is typically found in estuarine habitats, but does have populations in freshwater sections of coastal rivers. It can survive well in freshwater, where it has been introduced for mosquito control or as bait. Bait bucket introductions have likely led to established populations in inland United States, outside of the species' native range, and *F. heteroclitus* has been reported in the Detroit River in the Great Lakes as well as in many places in Pennsylvania. It was also reported as introduced to Hawaii in the early 1900s. This species has been introduced and has spread along the southern coast of the Iberian Peninsula. It was also recently reported to be introduced and established in northeast Morocco. This species is reported to hybridize with *Fundulus diaphanous*, another species of killifish native to the United States. The history of invasiveness is Data Deficient. There are reports of impacts to native species in the Iberian Peninsula, particularly reductions in abundance, potentially to the point of endangering the existence of a population. However, many of those statements were framed as potential impacts, impacts in conjunction with other introduced species, or the information those statements were derived from could not be found. The climate match for the contiguous United States is high with most of the eastern United States and parts of the Gulf Coast having a high match. Much of the Midwest and West had medium to low matches except for much of California, which had high matches. The certainty of assessment is low due to the lack of detailed information available regarding the species impacts of introductions. The overall risk category for this species is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 4): Data Deficient**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Low**
- **Remarks, Important additional information: Susceptible to infection by two OIE-reportable diseases, *A. invadans* (epizootic ulcerative syndrome) and viral haemorrhagic septicaemia virus**
- **Overall Risk Assessment Category: Uncertain**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 11.

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