U.S. Fish & Wildlife Service

Round Goby (*Neogobius melanostomus*)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, June 2019
Revised, September 2019
Web Version, 11/18/2019

Photo: E. Engbretson, USFWS. Public domain. Available: https://digitalmedia.fws.gov/digital/collection/natdiglib/id/5112/rec/2. (June 2019).

1 Native Range and Status in the United States

Native Range

From Fuller et al. (2019):

"Eurasia including Black Sea, Caspian Sea, and Sea of Azov and tributaries (Miller 1986)."

From Freyhof and Kottelat (2008):

"Native: Azerbaijan; Bulgaria; Georgia; Iran, Islamic Republic of; Kazakhstan; Moldova; Romania; Russian Federation; Turkey; Turkmenistan; Ukraine"

Status in the United States

From Fuller et al. (2019):

"Already spread to all five Great Lakes, with large populations in Lakes Erie and Ontario. Likely to find suitable habitat throughout Lake Erie and in all Great Lakes waters at depths less than 60 m (USEPA 2008). Established outside of the Great Lakes basin in 1994 (Dennison, personal communication), and in 2010 spread into the lower Illinois River (K. Irons, Illinois Natural History Survey, Champaign, IL, personal communication)"

"Round Goby was considered extremely abundant in the St. Clair River in 1994. Short trawls made in Lake Erie in October 1994 turned up 200 individuals. Frequent trawling in 1995 collected over 3,000 individuals near Fairport Harbor, Ohio (Knight, personal communication). Densities in Calumet Harbor exceed 20 per square meter (Marsden and Jude 1995). Gravid females and different size classes have been found in Lake Erie (T. Cavender, Ohio State University, Columbus, OH, personal communication). In Lake Superior, primarily established in Duluth-Superior Harbor and lower St. Louis River, and absent from the remainder of the western portion of the lake (Bergstrom et al., 2008)"

From Charlebois et al. (2001):

"The round goby […] has spread to all the Great Lakes and several of their tributaries, into three inland rivers in Michigan (Flint, Shiawassee, and Saginaw), […] and down the Chicago Sanitary and Shipping Canal en route to the Mississippi River (Steingraeber *et al.* 1996)."

From Merry et al. (2019):

"In August 2018, during annual round goby monitoring, a participating bottom trawling crew from the Missouri Department of Conservation captured one round goby (43 mm TL) in the Alton reach of the Illinois River near Grafton, Illinois at approximately river kilometer 2.1 (38.96933, -90.45245). This capture is roughly 52 rkm [river kilometers] downstream of the 2017 capture. Additionally a participating bottom trawling crew from the U.S. Fish and Wildlife Seivice [*sic*] captured one round goby (61 mm TL) in Pool 26 of the Mississippi River near its confluence with the Illinois River at approximately river kilometer 350.3 (38.96753, -90.42326). This is the first round goby capture reported in the Mississippi River."

Based on a search of the literature and major online aquarium retailers, there is no evidence that this species is in trade in the United States.

Means of Introductions in the United States

From Fuller et al. (2019):

"Introduced into the Great Lakes from the Black Sea via freighter ballast. Spread to Lake Superior by freighters operating within the Great Lakes. Round Goby distribution in the Baltic Sea was partially determined by shipping activity, thus it is likely the same applies to the Great Lakes populations (Kotta et al. 2016)."

From Merry et al. (2018):

"Downstream drift of larval round goby may explain the expansion of the range of round goby in the lower Illinois River despite the lack of preferred habitat."

From Kornis et al. (2012):

"Dams may ultimately limit inland range expansion, although humans have helped the species bypass dams *via* accidental introduction in several inland lakes and rivers, including […] the Flint and Shiawassee Rivers in Michigan (D. Jude & J. Janssen, unpubl. data). Bait-bucket transfer (due to anglers or bait store operators who capture their own bait and fail to identify and remove *N. melanostomus*) is the presumptive mechanism of dispersal upstream of dams."

Remarks

A previous version of this ERSS was published online in 2014.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2019):

"Kingdom Animalia
 Subkingdom Bilateria
  Infrakingdom Deuterostomia
   Phylum Chordata
    Subphylum Vertebrata
     Infraphylum Gnathostomata
      Superclass Actinopterygii
       Class Teleostei
        Superorder Acanthopterygii
         Order Perciformes
          Suborder Gobioidei
           Family Gobiidae
            Genus *Neogobius*
             Species *Neogobius melanostomus* (Pallas, 1814)"

From Fricke et al. (2019):

"Current status: Valid as *Neogobius melanostomus* (Pallas 1814). Gobiidae: Gobiinae."

Size, Weight, and Age Range

From Froese and Pauly (2019):

"Max length : 24.6 cm TL male/unsexed; [Skora et al. 1999]; max. reported age: 6 years [Sokolowska and Frey 2009]"

Environment

From CABI (2019):

"*N. melanostomus* is eurythermal and euryhaline species [*sic*]. It can withstand very low level of dissolved oxygen."

From Froese and Pauly (2019):

"Marine; freshwater; brackish; demersal; amphidromous [McDowall 1997]; depth range 0 - 30 m [Skora et al. 1999]."

"Prefer shallow, brackish waters but also occur in fresh waters [Skora et al. 1999] […]. Can tolerate a temperature range of 0 to 30°C, but mainly thrive in warm temperate waters; able to tolerate low oxygen content waters for several days [Skora et al. 1999]."

From Freyhof and Kottelat (2008):

"To 50-60 m deep in Black Sea during winter."

Climate/Range

From Froese and Pauly (2019):

"Temperate; […] 60°N - 36°N, 18°E - 58°E"

Distribution Outside the United States

Native

From Fuller et al. (2019):

"Eurasia including Black Sea, Caspian Sea, and Sea of Azov and tributaries (Miller 1986)."

From Freyhof and Kottelat (2008):

"Native: Azerbaijan; Bulgaria; Georgia; Iran, Islamic Republic of; Kazakhstan; Moldova; Romania; Russian Federation; Turkey; Turkmenistan; Ukraine"

Introduced

From CABI (2019):

"In the Baltic Sea basin *N. melanostomus* started its invasion probably from the late 1980s, when in 1990 few individuals 3-4 years old have been found for the first time in the Gulf of Gdansk (the Baltic Sea, Poland) (Skóra and Stolarski, 1993).The species soon spread along the Polish coast (Sapota, 2004) but also entered the Vistula River as far as 130km upstream from the mouth (Kostrzewa and Grabowski, 2002). It has been recently reported from several other places in the southern coastal waters of the Baltic Sea (Ojaveer, 2006) and in the North Sea basin (Van Beek, 2006). […] *N. melanostomus* invasion to the Baltic Sea was preceeded by its previous expansion in the Volga River system e.g. in the late 1980s it was found in the Moscow River basin (tributary of the upper stretch of the Volga) (Pinchuk et al., 2003)."

"Its presence in North America was first recorded in 1990 in the St Clair River at Sarnia (Ontario) (Jude et al., 1992)."

"The expansion along the Danube River farther upstream from the Iron Gate (suggested border of its natural range in the Danube) is also observed (Simonovic et al., 1998; Wiesner et al., 2000; Guti et al., 2003; Stránai and Andreji, 2004)."

From Charlebois et al. (2001):

"The round goby […] has spread to all the Great Lakes and several of their tributaries, […] into an inland river in Ontario (Running Creek; E. Holm, Royal Ontario Museum, personal communication) […]"

From Kornis et al. (2012):

"Relatively new populations have been found in the western Baltic Sea along the coast of Germany (Sapota, 2004) and the eastern Baltic Sea along the coasts of Latvia and Estonia [Gulfs of Riga and Finland; Ojaveer (2006)]. It has also been captured along the southern coasts of Sweden and Finland (Björklund & Almqvist, 2010), in the Lek River, Netherlands (van Beek, 2006), in the Orda Estuary in the west Baltic (Czugała & Woźniczka, 2010), and in the Scheldt River and Albert Canal in Belgium (Verreycken *et al.*, 2011)."

According to Froese and Pauly (2019), *N. melanostomus* is established outside its native range in the countries of Sweden, Lithuania, Denmark, Austria, Belarus, Germany, Finland, Czech Republic, and Belgium; establishment in the Netherlands is probable.

Means of Introduction Outside the United States

From CABI (2019):

"The most probable route of *N. melanostomus* migration to the southern part of Baltic Sea is the so-called northern corridor (Bij de Vaate et al., 2002) consisting the [*sic*] Volga River, Rybinsky Reservoir, lakes Ladoga and Onega connected by artificial canals with the Gulf of Finland

(Sapota, 2004). Its introduction to the Baltic Sea is usually related to ballast-water transport (Sapota, 2004) and possibly as eggs attached to the hulls of barges."

"It is supposed that the expansion of *N. melanostomus* in the Danube may be the result of natural migration encouraged by water transport and human-mediated alteration of river banks e.g. rip-rap habitats and other harbour artificial substrates seem to be preferred [*sic*] by *N. melanostomus* for shelter (Ahnelt et al., 1998; Wiesner, 2005)."

From Corkum et al. (2004):

"The round goby may have migrated naturally to the Gulf of Gdansk along a river route from the Black Sea through the Dnieper, Pripet, Pina, Kanal Krolewski, Bug, and Vistula or a longer route from the Caspian Sea to the Gulf of Finland through the Volga, Rybinskoe Reservoir, and the Onega and Ladoga lakes (Skora and Stolarski 1993)."

From Freyhof and Kottelat (2008):

"Accidentally arrived in […] lowermost Rhine (Netherlands) in 2004 with ballasts water in ships."

From Kornis et al. (2012):

"Dams may ultimately limit inland range expansion, although humans have helped the species bypass dams *via* accidental introduction in several inland lakes and rivers, including Lake Simcoe and the Trent–Severn waterway in Ontario (Borwick & Brownson, 2006), [and] Rice Lake in Ontario (J. Borwick, pers. comm.) […]. Bait-bucket transfer (due to anglers or bait store operators who capture their own bait and fail to identify and remove *N. melanostomus*) is the presumptive mechanism of dispersal upstream of dams."

Short Description

From CABI (2019):

"*N. melanostomus* is small, up to 25 cm in total length. Its pelvic fins form a very characteristic suction disc on the ventral surface. The pelvic disc is 0.6-0.8 times the abdomen length. The body is scaled on the parietal region, nape, back, throat, abdomen, pectoral fin peduncles, and one quarter of the gill covers. The head is wide (as or wider than deep) and relatively big (22-23% of body length). Eyes are large and protrude slightly from the top of the head. The angle of the jaw is below the anterior quarter of the eye. The lower jaw is not prominent. The anterior dorsal fin has 5-7 spines, usually 6, and the posterior dorsal fin has one spine and 13-16 soft rays. The anal fin has one spine and 11-14 soft rays. The pectoral fins have 17-20 soft rays. *N. melanostomus* lacks a gas bladder and chemoreceptors. Neuromasts are present throughout the body and head. *N. melanostomus* lacks a visible lateral line. Males are larger than females. Both sexes have an erectile urogenital papilla between the anus and the base of the anal fin. Coloration: yellowish-grey, with lateral blotches; first dorsal fin with large black spot in posterior part; breeding males are almost black and their median fins are more elongated and white-edged (Pinchuk et al., 2003)."

Biology

From Corkum et al. (2004):

"Round gobies are voracious feeders of benthic organisms with larger specimens (>7 cm) feeding on nonindigenous dreissenids (Ray and Corkum 1997). The diet of the round goby includes amphipods, chironomids, cladocerans, crayfish, dragonflies, dreissenids, isopods, mayflies, fish eggs, and larvae. Diggins et al. (2002) showed that diet choice of the round goby varied as a function of substrate type (bare, stones, gravel) and light intensity (ambient, turbid, dark). In this laboratory study, consumption of amphipods (*Echinogammarus ischnus*) declined with increasing substrate complexity; whereas, the proportion of dreissenids in the diet increased. Round goby predation on grazing invertebrates enhanced algal biomass as evidenced by increased chlorophyll *a* concentrations in a field study (Kuhns and Berg 1999)."

From Kornis et al. (2012):

"*Neogobius melanostomus* are multiple spawners, typically spawning every 3–4 weeks from April through to September in its native range (Charlebois *et al*., 1997). Spawning is cued by water temperature (9–26° C), however, and both gravid females and breeding-coloured males have been captured as late as November in the Detroit River (MacInnis & Corkum, [2000]) due to prolonged warm water temperatures. Males mature at age 3 or 4 years and females at age 2 or 3 years in its native range (Miller, 1986), but both sexes may mature up to a year earlier in the Great Lakes based on findings from the upper Detroit River (MacInnis & Corkum, [2000]). Males guard nests and may not feed during spawning, suggesting most males die after one spawning season (Charlebois *et al*., 1997), although this has yet to be confirmed. Up to 10 000 eggs from four to six females may be present in a nest, and fertilization and hatching rates are as high as 95% (Charlebois *et al*., 1997). Eggs and larvae are relatively large (3·2 mm diameter) compared to other gobiid species […]; as a result, a single female produces relatively few eggs (328–5221 in native range) (Kovtun, 1978). Fecundity was lower in the Detroit River than in the native range (mean 198 eggs per female with a positive linear relationship between number of eggs and L_S [length from nose tip to end of caudal peduncle]), but greater than most native competitor species (MacInnis & Corkum, [2000]). *Neogobius melanostomus* hatch at *c*. 5 mm total length (L_T), with […] well-developed fins and digestive system […] (Leslie & Timmins, 2004)."

"*Neogobius melanostomus* spawn, feed and hide in hard substrata and are typically most abundant in rocky habitats. Tethering experiments in sandy habitat with and without shelters indicated that open habitats (sand and mud) posed a higher risk of predation than sheltered habitat (cobble and boulder) (Belanger & Corkum, 2003) and several field surveys found *N. melanostomus* prefers rocky substrata (Ray & Corkum, 2001; Young *et al*., 2010). Nonetheless, soft substrata are utilized by *N. melanostomus* and abundance may be similar on soft and hard substrata in some areas (Johnson *et al*., [2005]; Taraborelli *et al*., 2009). Thus, mud and sand habitat are not resistant to invasion and the lack of a hard substratum will not prevent colonization, although *N. melanostomus* will probably colonize hard before soft substrata."

Human Uses

From Froese and Pauly (2019):

"Due to its large size, it has a major commercial value in some areas, especially in Azov Sea. It is usually salted, dried and consumed with beer [Patzner et al. 2011]."

"Fisheries: commercial; aquarium: commercial; bait: occasionally"

Diseases

According to Kornis et al. (2012), *N. melanostomus* is a host of viral haemorrhagic septicaemia virus, an OIE-reportable disease (OIE 2019).

From Kornis et al. (2012):

"The parasite fauna of *N. melanostomus* has received close attention in both its native and invaded range. At least 94 species of parasites are known for *N. melanostomus* (Kvach & Stepien, 2008), but new parasite records emerge as the species increases its range (Kosuthova *et al*., 2009; Francová *et al*., 2011; Pazooki *et al*., 2011). In the introduced Eurasian and North American populations, *N. melanostomus* has often acquired local parasites; thus far it has not been reported to harbour invasive parasites into invaded areas (Muzzal *et al*., 1995; Camp *et al*., 1999; Rolbiecki, 2006; Kvach & Stepien, 2008; Francová *et al*., 2011). […] Trematodes are the most common parasitic group of *N. melanostomus* (Kvach & Stepien, 2008), but cestodes (French *et al*., 2005) and acanthocephalans (Kvach & Stepien, 2008), among other groups, are also commonly found. Larger and older *N. melanostomus* usually have more parasites than younger fish (Ozer, 2007), but parasite prevalence and abundance is generally low (Camp *et al*., 1999)."

"*Neogobius melanostomus* is also a known host of viral haemorrhagic septicaemia virus (VHSV) in the Great Lakes (Al-Hussinee *et al*., 2011). While there is no evidence linking consumption of *N. melanostomus* to VHSV occurrence in predatory fishes, VHSV can be transmitted to predators through the gut following ingestion of an infected prey item (Meyers & Winton, 1995). Given the growing importance of *N. melanostomus* as prey for piscivorous fishes, further research into the incidence of VHSV in *N. melanostomus* is warranted."

Threat to Humans

From Froese and Pauly (2019):

"Potential pest"

From Fuller et al. (2019):

"Walleye anglers in Detroit report that at times, all they can catch are gobies, which eagerly attack bait (Marsden and Jude 1995)."

"The invasion of Round Goby into Lake Erie has had very real environmental and economic impacts. Beginning in 2004, The State of Ohio has closed the Smallmouth Bass fishery in Lake Erie during the months of May and June, due to high predation rates by gobies on nests affecting recruitment. […] The months of May and June normally account for 50 percent of the total Smallmouth Bass catch in Lake Erie so there will be a considerable loss in funds generated by recreational fishers (National Invasive Species Council 2004)."

3 Impacts of Introductions

From Corkum et al. (2004):

"The round goby negatively affects the recruitment of native fishes in the Great Lakes. For example, Chotkowski and Marsden (1999) showed in laboratory studies that round gobies fed on eggs and fry of lake trout, *Salvelinus namaycush*. Field studies confirmed that round gobies feed on eggs of lake sturgeon, *Acipenser fulvescens*, probably reducing hatching success of these native fishes (J. Nichols, USGS, Ann Arbor, pers. comm.). In Ohio, anglers are permitted to catch and release smallmouth bass during the spawning period. When bass are removed from nests, the round gobies consumed exposed smallmouth bass embryos (G. Steinhart, Ohio State University, pers. comm.). The combined angling and gobiid predation pressure could represent a substantial recruitment loss of smallmouth bass in Lake Erie."

"Round goby predation on grazing invertebrates enhanced algal biomass as evidenced by increased chlorophyll *a* concentrations in a field study (Kuhns and Berg 1999)."

From Fuller et al. (2019):

"The numbers of native fish species have declined in areas where the Round Goby has become abundant (Crossman et al., 1992). This species has been found to prey on darters, other small fish, and Lake Trout eggs and fry in laboratory experiments. They also may feed on eggs and fry of sculpins, darters, and Logperch (Marsden and Jude, 1995) and have also been found to have a significant overlap in diet preference with many native fish species. French and Jude (2001) suggested that Round Goby competes with Rainbow Darter (*Etheostoma caeruleum*), Logperch (*Percina caprodes*), and Northern Madtom (*Noturus stigmosus*) for small macroinvertebrates; however, Burkett and Jude (2015) found that gobies exhibited little diet overlap with most small benthic fishes."

"Mottled Sculpins (*Cottus bairdi*) have been particularly affected since the establishment of *N. melanostomus* (Marsden and Jude 1995). This is almost certainly due to competition with sculpins for spawning sites in large Round Goby (greater than 100 mm), for space in medium Round Goby (60-100 mm) and for food in small Round Goby (less than 60 mm) (Janssen and Jude 2001). Janssen and Jude (2001) argued that the main cause of the dramatic decline in the native Mottled Sculpin population is due to nesting interference with Round Goby; the other competition factors having a less severe impact, although they acknowledge the need for further research on food competition. Adults aggressively defend spawning sites and occupy prime spawning areas, keeping natives out (Marsden and Jude 1995; Dubs and Corkum 1996). Laboratory experiments have shown that the more aggressive *N. melanostomus* will evict *C. bairdi* from rock shelters that are being used for spawning or daytime predator evasion

(Dubs and Corkum 1996). In trials where gobies were introduced into tanks with Mottled Sculpin residents, the gobies approached and chased the resident sculpin (Dubs and Corkum 1996). When sculpin were released into resident Round Goby tanks, the sculpin were chased and bitten (Dubs and Corkum 1996). Sculpin did not exhibit any aggressive behavior towards the gobies in any scenario (Dubs and Corkum 1996). In Calumet Harbor, there has been an absence of Mottled Sculpin nests and fish aged 0 since 1994, coinciding with *N. melanostomus* establishment (Janssen and Jude 2001). *Neogobius melanostomus* and *C. bairdi* both take daytime refuge from predators under rocks, emerging to feed nocturnally (Dubs and Corkum 1996). This space competition could displace *C. bairdi* into deeper and unprotected spaces where they can easily be predated. Competition for food between *N. melanostomus* and *C. bairdi* occurs most heavily when they are young (less than 60 mm), due to the overlap of an arthropod diet at this age (Janessen and Jude 2001)."

"*Neogobius melanostomus* introductions may also be a vector for the spread of avian botulism. The change in behavior of infected gobies make them preferred prey items to piscivorous birds (Yule et al. 2006). At Lake Erie, botulism infected birds had been feeding more on Round Goby compared to uninfected birds (Corkum et al. 2004). Increased abundance of Round Goby in the diet of double-crested cormorant (*Phalacrocorax auritus*) may reduce chick growth and reproductive success, due to a lower energy density compared to other native fishes (Ruetz et al. 2009), and thus could provide some control over cormorant populations (Van Guilder and Seefelt 2013). Round Goby may provide an entry point for polychlorinated biphenyls (PCBs) into trophic webs. Macksasitorn et al. (2015) found a weak correlation between sediment and goby tissue PCB concentrations, with smaller gobies having higher PCB concentration."

"Not all impacts of the introduced Round Goby are negative. Round Gobies comprise the majority of the diet for Lake Erie water snakes (*Nerodia sipedon insularum*), and the abundance of gobies has been credited for the increase in population size, increased growth rates, and larger body size of the snakes (King et al. 2006). Due to their increase in abundance, the Lake Erie water snake was removed from the federal Endangered Species List in 2011. In addition, round gobies provide an abundant food source for several sportfishes including walleye (Taraborelli et al. 2010), yellow perch (Truemper and Lauer 2005), and largemouth/smallmouth bass (Steinhart et al. 2004; Taraborelli et al. 2010). Round goby became the primary food resource for smallmouth bass in New York waters of Lake Erie following invasion, with a marked decrease in crayfish consumption, and bass had a larger length-at-age in the post-invasion period (Crane and Einhouse 2016). Jacobs et al. (2017) used stable isotope analysis to examine Lake Sturgeon (*Acipenser fulvescens*) in Lake Ontario and lower Nigara River pre- and post-invasion of Round Goby, finding an increased trophic position with age, an increased rate of δ^{15}N enrichment, and a marked importance of Round Goby in Lake Sturgeon diets in the post-invasion period. Jacobs et al. (2017) suggest that high abundance of this novel food source has altered Lake Sturgeon feeding ecology and may have increased population growth and success."

"Walleye anglers in Detroit report that at times, all they can catch are gobies, which eagerly attack bait (Marsden and Jude 1995)."

"The invasion of Round Goby into Lake Erie has had very real environmental and economic impacts. Beginning in 2004, The State of Ohio has closed the Smallmouth Bass fishery in Lake

Erie during the months of May and June, due to high predation rates by gobies on nests affecting recruitment. […] The months of May and June normally account for 50 percent of the total Smallmouth Bass catch in Lake Erie so there will be a considerable loss in funds generated by recreational fishers (National Invasive Species Council 2004)."

From Kornis et al. (2012):

"*Neogobius melanostomus* threatens several species with conservation concerns. In several species-at-risk hotspots in Ontario tributaries, recently established *N. melanostomus* populations threaten seven endangered species (one fish and six mussels) in addition to 16 non-endangered benthic fish species (Poos *et al*., 2010). *Neogobius melanostomus* is also abundant in several tributaries occupied by species listed as critically imperilled or imperilled in Wisconsin, including three species of mussel and three species of aquatic insect (M. S. Kornis, pers. obs.). Mussel species are affected both through direct predation and indirectly through reduced availability of native fish hosts required by some mussel species for their glochidia larvae (Poos *et al*. 2010)."

"In the Baltic Sea, *N. melanostomus* primarily competes with the commercially important flounder *Platichthys flesus* L. 1758, evidenced by strong similarities in diet and a negative correlation between *P. flesus* and *N. melanostomus* abundance (Karlson *et al*., 2007). *Neogobius melanostomus* also restricts habitat utilization and therefore food availability to *P. flesus* (Karlson et al., 2007). Three-spined stickleback *Gasterosteus aculeatus* L. 1758 abundance in the Gulf of Gdansk was also negatively correlated with *N. melanostomus* abundance, indicating a shift from pelagic to benthic forage fishes as *N. melanostomus* populations increase in size (Corkum *et al*., 2004)."

"It is yet unknown how *N. melanostomus* parasite loads may affect species predating on *N. melanostomus*, although (Robinson *et al*. 2009) it [*sic*] makes a loose association between *N. melanostomus* diet and *Contracaecum* sp. parasitism in double-crested cormorants *Phalacrocorax auritus*."

4 Global Distribution

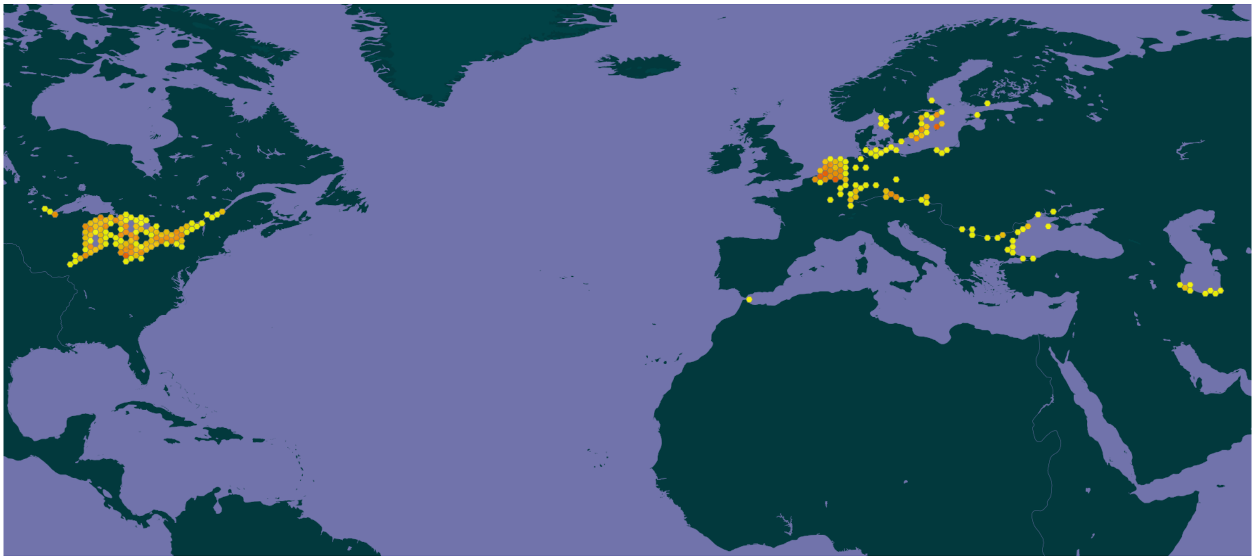

Figure 1. Known global distribution of *Neogobius melanostomus*. Map from GBIF Secretariat (2019). A point in Morocco was excluded from climate matching analysis because it may represent an incorrectly identified specimen. No georeferenced occurrences were available for parts of the established range in Azerbaijan, Georgia, Kazakhstan, Turkmenistan, Lithuania, Latvia, and Belarus.

5 Distribution Within the United States

Figure 2. Known distribution of *Neogobius melanostomus* in the United States. Map from Fuller et al. (2019). Orange diamonds represent established populations of *N. melanostomus*; yellow diamonds represent populations with an "unknown" designation. The point near Binghamton, New York, represents a "failed" population of *N. melanostomus*.

6 Climate Matching

Summary of Climate Matching Analysis

The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.531, indicating a high overall climate match. (Scores of 0.103 and greater are classified as high.) The climate match was highest from the inland Northeast United States across to the upper Midwest, including areas where *N. melanostomus* is already established. The climate match was also high in the Great Basin, Columbia Plateau, and in scattered locations in the Rocky Mountains. The rest of the contiguous United States had a medium climate match, except for the Southeast, the Pacific Northwest, and part of the Southwest, where the climate match was low. The States of Alabama, Florida, Georgia, Louisiana, Mississippi, Rhode Island, South Carolina, and Texas had low climate scores; Kentucky, North Carolina, and Tennessee had medium climate scores; the remaining 37 States in the contiguous United States had high climate scores.

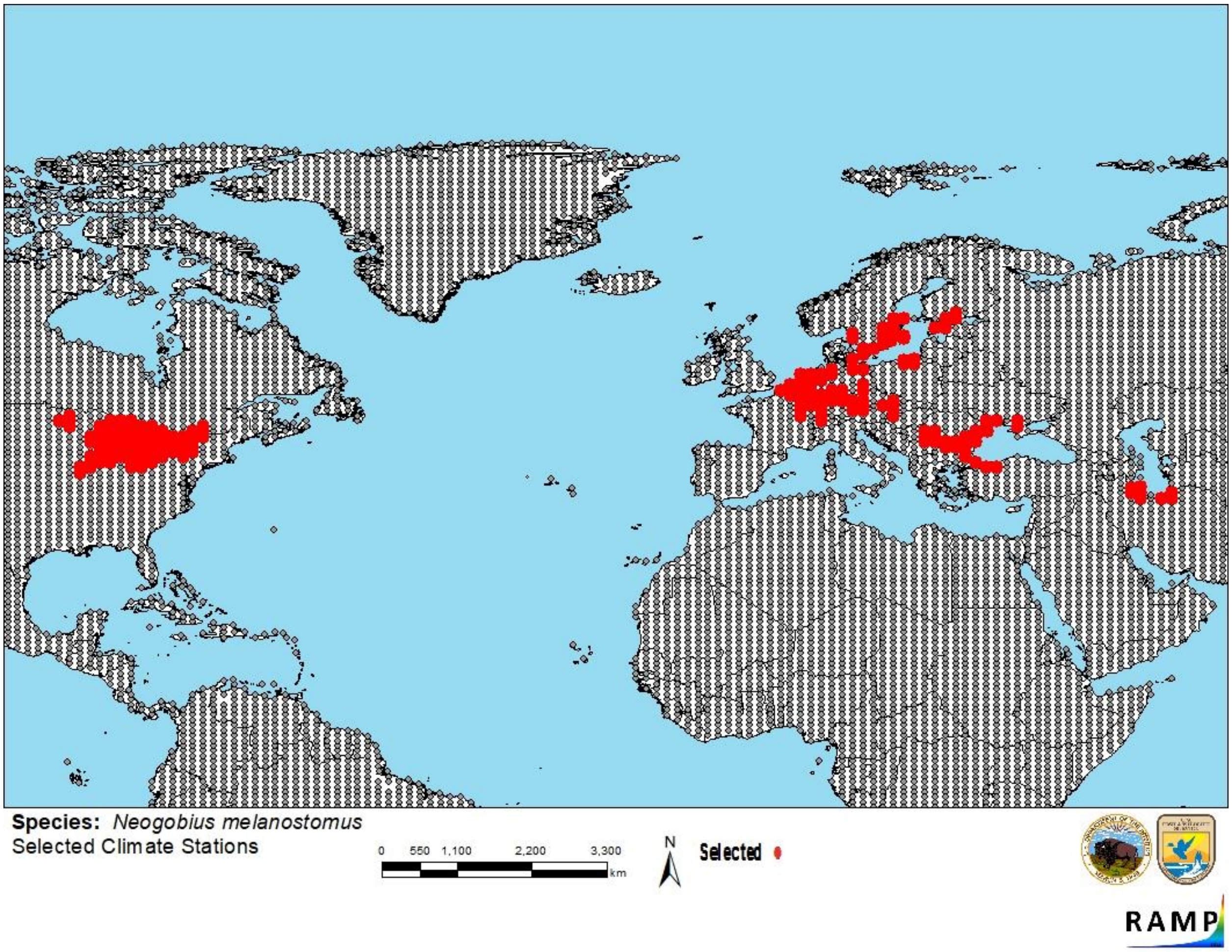

Figure 3. RAMP (Sanders et al. 2018) source map showing weather stations selected as source locations (red; United States, Canada, Iran, Turkey, Ukraine, Moldova, Bulgaria, Romania, Serbia, Slovakia, Czech Republic, Hungary, Austria, Germany, Switzerland, France, Belgium, Netherlands, Denmark, Sweden, Poland, Estonia, Finland) and non-source locations (gray) for *Neogobius melanostomus* climate matching. Source locations from GBIF Secretariat (2019).

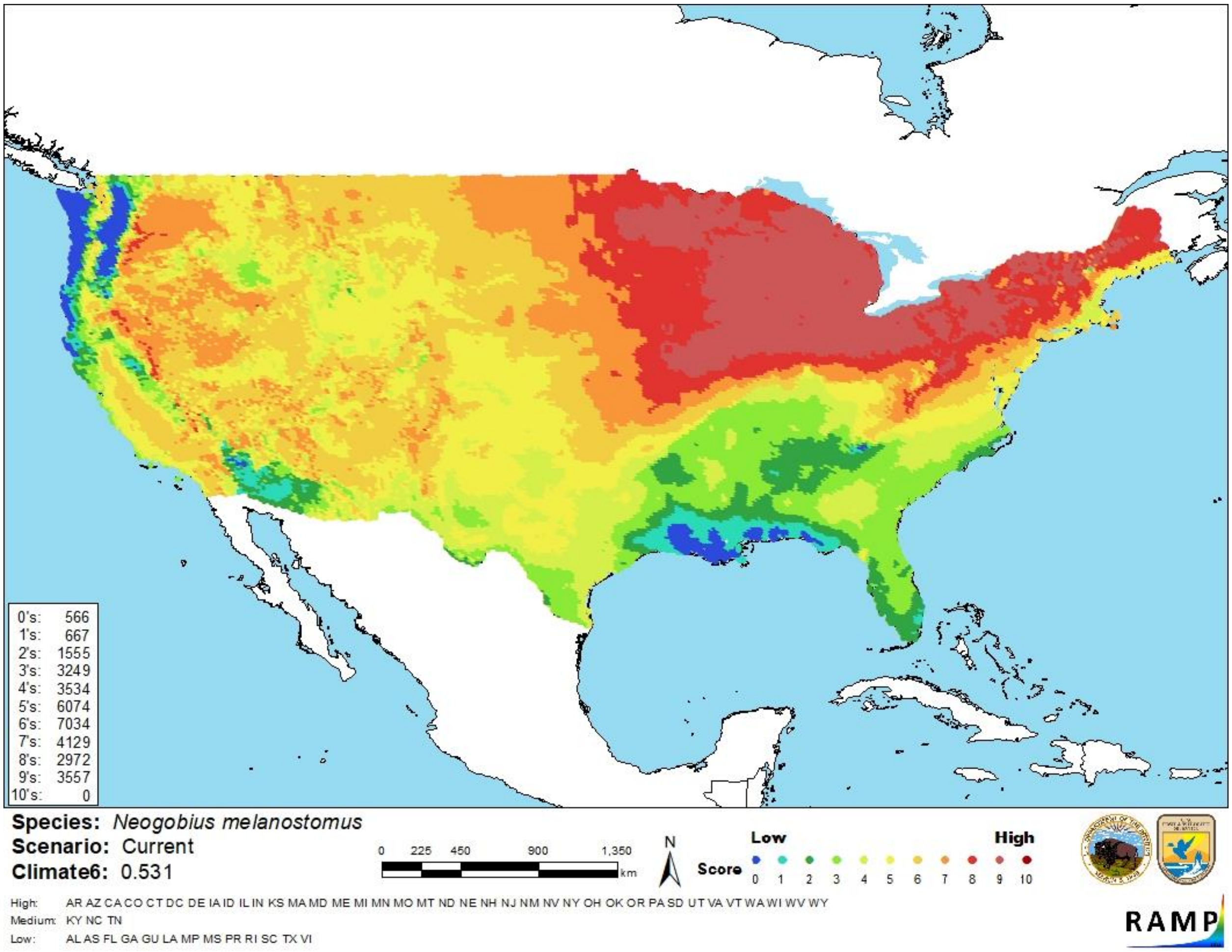

Figure 4. Map of RAMP (Sanders et al. 2018) climate matches for *Neogobius melanostomus* in the contiguous United States based on source locations reported by GBIF Secretariat (2019). 0 = Lowest match, 10 = Highest match.

The "High", "Medium", and "Low" climate match categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

There is adequate documentation of the biology, ecology, distribution, and history of invasion of *Neogobius melanostomus*. The negative impacts of *N. melanostomus* introduction outside of its native range have been well-documented in the scientific literature. No further information is needed to assess the risk this species poses to the contiguous United States. Certainty of this assessment is high.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Neogobius melanostomus, the Round Goby, is a freshwater fish species native to the Black, Azov, and Caspian Sea basins. This species has been introduced to Europe and North America through accidental transport in ships' ballast water. Once introduced, it disperses primarily via rivers and canals, although it is sometimes transported as bait. *N. melanostomus* has a broad established distribution in the Great Lakes basin and the Illinois River. It has recently been found in the Mississippi River. History of invasiveness is high. Where introduced, *N. melanostomus* competes aggressively for food and habitat with native fish species and preys on native mussels, including several species that are endangered or of conservation concern. The species can serve as a vector for avian botulism and is a host of viral haemorrhagic septicaemia, an OIE-reportable disease. Competition with sport fish has resulted in economic losses in Ohio. *N. melanostomus* has a high climate match with the contiguous United States, with the highest match occurring in the Northeast and Great Lakes. The certainty of this assessment is high because of the abundance of information on negative impacts of introduction. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks: Host of viral haemorrhagic septicaemia virus, an OIE-reportable disease.**
- **Overall Risk Assessment Category: High**

9 References

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