Racer Goby (*Babka gymnotrachelus*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, 2014
Revised, April 2017 and November 2018
Web Version, 9/18/2019

Photo: Y. Kvach. Licensed under CC BY-SA 3.0. Available: https://commons.wikimedia.org/wiki/File:Racer_goby_from_the_Bug_River_4.jpg. (November 2018).

1 Native Range and Status in the United States

Native Range

From Freyhof and Kottelat (2008):

"Black, Azov and Caspian Sea basins."

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

From Baker et al. (2018):

"Ponto-Caspian basin, Aral Sea, Marmara Sea (N[ei]lson and Stepien 2009[b], Stepien and Tumeo 2006)."

From Grabowska (2005):

"The native distribution of Ponto-Caspian gobiids encompasses brackish lagoons of the Black, Azov and Caspian seas as well the lower courses of associated river catchments (i.e. Danube, Dniester, Eastern Bug, Dnieper, Don; Miller, 2003)."

Status in the United States

From Baker et al. (2018):

"Not established in North America, including the Great Lakes"

There is no indication that this species is in trade in the United States.

Means of Introductions in the United States

From Baker et al. (2018):

"Potential pathway(s) of introduction: Transoceanic shipping (ballast water)"

Remarks

A previous version of this ERSS was published in 2014.

From Medvedev et al. (2013):

"Among species of the genus *Neogobius* sensu Berg, 1949, that fell into the phyletic lineage "Ponticola," two subgenera were earlier singled out: *Babka* with the Racer goby *Gobius gymnotrachelus* Kessler, 1857, as the type species and *Ponticola* with *G. ratan* Nordmann, 1840, as the type species. Berg (1949) considered that the Racer goby should be placed into a separate genus *Mesogobius* with the Knout goby *M. batrachocephalus* (Pallas, 1814). This merging was proved to be groundless by Vasil'eva and Bogachik (1991), and the craniological differences of *Gobius gymnotrachelus* from the species included in the subgenus *Ponticola* were considered as the evidence for separating it into the subgenus *Babka* of the genus *Gobius* (Vasil'eva, [1992]). A number of researchers raised the taxonomic status of the monotypical subgenus *Babka* up to the generic level (Neilson and Stepien, [2009b]; Freyhof, 2011)."

From Baker et al. (2018):

"Synonyms and Other Names:
Neogobius gymnotrachelus, *Gobius burmeisteri* Kessler, 1877, *G. gymnotrachelus* Kessler, 1857, *G. macropus* De Filippi, 1863, *Mesogobius gymnotrachelus* (Kessler, 1857), *M. g. otschakovinus* Zubovich, 1925"

Synonyms listed above, as well as the valid scientific name, *Babka gymnotrachelus*, were used to search for information for this report.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From WoRMS (2018):

"Animalia (Kingdom) > Chordata (Phylum) > Vertebrata (Subphylum) > Gnathostomata (Superclass) > Pisces (Superclass) > Actinopterygii (Class) > Perciformes (Order) > Gobioidei (Suborder) > Gobiidae (Family) > Gobiinae (Subfamily) > *Babka* (Genus) > *Babka gymnotrachelus* (Species)"

From Fricke et al. (2018):

"Current status: Valid as *Babka gymnotrachelus* (Kessler 1857). Gobiidae: Gobiinae."

Size, Weight, and Age Range

From Froese and Pauly (2018):

"Maturity: Lm ?, range 6 - ? cm
Max length : 16.2 cm TL male/unsexed; [Berg 1965]; max. reported age: 5 years [Kottelat and Freyhof 1972]"

From Grabowska (2005):

"Males were on average about 23.3% longer and 53.8% heavier than females. The smallest female with mature gonads was 58 mm TL (estimated age 2+ years), and males were sexually mature at 59 mm TL (age of 1+ years)."

Environment

From Froese and Pauly (2018):

"Freshwater; brackish; benthopelagic. […] 4°C - 20°C [Baensch and Riehl 1991; assumed to be recommended aquarium temperature range]"

"[…] inhabits mostly fresh- and brackish waters with low salinity (<2%)."

From Baker et al. (2018):

"It can tolerate a broad range of environmental conditions; its thermal range is -1 - 30°C (Moskal'kova 1996) and its lethal dissolved oxygen threshold is 0.4 – 1.3 mg/L (Charlebois et al. 1997)."

Climate/Range

From Froese and Pauly (2018):

"Temperate; […] 49°N - 40°N, 25°E - 54°E"

Distribution Outside the United States

Native

From Freyhof and Kottelat (2008):

"Black, Azov and Caspian Sea basins."

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

From Baker et al. (2018):

"Ponto-Caspian basin, Aral Sea, Marmara Sea (N[ei]lson and Stepien 2009[b], Stepien and Tumeo 2006)."

From Grabowska (2005):

"The native distribution of Ponto-Caspian gobiids encompasses brackish lagoons of the Black, Azov and Caspian seas as well the lower courses of associated river catchments (i.e. Danube, Dniester, Eastern Bug, Dnieper, Don; Miller, 2003)."

Introduced

From Baker et al. (2018):

"*Babka gymnotrachelus* has extended its geographical distribution to include the Baltic Sea basin (Danilkiewicz 1998). *Babka gymnotrachelus* has been observed in the Yantra River of the Danube, Bulgaria (Vassilev et al. 2008). *Babka gymnotrachelus* was first collected in the Almer Grube from the Upper Danube River, Germany in May 2011 (Haertl et al. 2012). It was first observed in 1995 in the middle section of Bug River, which is a tributary of the Vistula River in Poland (Grabowska and Grabowski 2005). It was first reported in Slovakia in 1999 and is now invasive after locally expanding its range from the Danube delta (Košco et al. 2010). It has been observed in the River Vistula (Marszal et al. 2004)."

From Grabowska (2005):

"In Poland, the racer goby was first recorded in the middle section of the Western Bug river basin, a tributary of the River Vistula, in 1995 (Danilkiewicz, 1996). Racer goby spread rapidly down the Western Bug, and by at least 2000 it had reached the lower River Vistula (Kostrzewa and Grabowski, 2001), with more recent records as far down as 175 km from the river's mouth (J. Grabowska pers. obs.)."

From Borcherding et al. (2011):

"[…] establishments in Serbia, Hungary (Guti, 2006), Slovakia, (Kautman, 2001; Jurajda et al., 2005) and Vienna, Austria by the late 1990s (Wiesner, 2005)."

From Haertl et al. (2012):

"Racer gobies were now discovered and photographed from a backwater of the Upper Danube River at Regensburg, and from a groyne head habitat in the Danube main channel at Mariaposching, Germany […] A closer examination confirmed their preliminary identification and prompted a re-examination of the specimen that was reported as the first record of *B. gymnotrachelus* in Germany (see Borcherding et al. 2011)."

"Previously reported records of this species from the German River Rhine are male *Neogobius fluviatilis* (Pallas, 1841), or possibly hybrids between different benthophiline goby species."

From Zogaris et al. (2019):

"The discovery of the racer goby *Babka gymnotrachelus* in the transboundary Evros river basin, collected on September 10th 2018 at two locations very close to the Greek-Bulgarian and Greek-Turkish borderlines, is reported. This is a new addition to the non-native ichthyofauna of Greece and the Aegean Sea drainages […] Boat-based electrofishing sampling, following the EU Water Framework Directive monitoring program, provides first evidence of what is presumed to be a recently established population; most of the 13 collected specimens are juveniles and the species has not yet been located in the river's tributaries."

The current status of *B. gymnotrachelus* in Germany could not be confirmed.

Means of Introduction Outside the United States

From Baker et al. (2018):

"The Main-Danube Canal is one of the main dispersal routes for invasive Ponto-Caspian species to move into Central Europe (Leuven et al. 2009). […] Its increased distribution in Europe has been attributed to canal construction and shipping (Kalchhauser et al. 2013)."

From Grabowska (2005):

"The most probable route of migration taken by the racer goby is via the Pripyat-Bug Canal system, which was built at the end of the 18th century."

"[…] the reasons for these relatively rapid expansions are a subject of debate involving both direct and indirect human factors (e.g. ballast water transport, hulls fouling, dam and reservoir construction, and climate change). However, gobies possess biological traits that may facilitate range expansion (Ehrlich, 1989) – attributes of a so-called 'perfect colonist' that are important in establishing a viable, self-sustaining population (Moyle and Light, 1996)."

From Zogaris et al. (2019):

“We hypothesize that the probable vector for invasion [of Greece] is the accidental transfer through fish stocking practices from the Danubian/Black Sea catchments to the Evros's Bulgarian artificial dam reservoirs.”

Short Description

From Froese and Pauly (2018):

“Dorsal spines (total): 7 - 8; Dorsal soft rays (total): 14-18; Anal spines: 1; Anal soft rays: 12 - 16. This species is distinguished from its congeners entering freshwater in Europe by the following characters: irregular position and shape of diagonal bars on body; first branched ray of second dorsal about as long as penultimate ray; no scales on midline of nape, in front of preoperculum; pelvic-disc fraenum with small rounded lobes and the length is less than 1/6 of width at base; scales in midlateral series 54-62 + 2-3; posterior part of first dorsal without black spot [Kottelat and Freyhof 1972].”

From Grabowska (2005):

“Males were in dark spawning colouration, with enlarged cheek areas and prolonged dorsal fins forming a veil, […].

Biology

From Froese and Pauly (2018):

“Occurs in brackish- and fresh-water habitats with low salinity (< 2 ppt); lagoons and lakes; large rivers to small, fast-flowing streams; on sand or mud bottom; mainly in well vegetated or high-complexity habitats. Abundant in backwaters and still channels [Kottelat and Freyhof 1972]. Longevity is 4-5 years; spawns for the first time at 2 years; spawning season in April to June, occasionally until mid-August; females may repeat spawning during a season; usually spawns for a single season. Males guard eggs until hatching; with adhesive eggs deposited on stones, shells and aquatic plants [Kottelat and Freyhof 1972]. Feeds on crustaceans (esp. Corophiid amphipods), aquatic insects (mostly chironomid larvae), polychaetes, also small fish and mollusks [Miller 1986].”

From Baker et al. (2018):

“This species feeds at night and its diet is composed of soft-bodied benthic invertebrates such as chironomid larvae and amphipods (Grabowska and Grabowski 2005). *Babka gymnotrachelus* exhibits plasticity and opportunism in its feeding behavior, and feeds on what is readily available.”

“*Babka gymnotrachelus* exhibits territorial and aggressive behavior towards other fishes, but is less aggressive than the round goby, another fish native to the Ponto-Caspian (Polaçik et al. 2008).”

From Grabowska (2005):

"Specialized reproductive behaviour (nest construction and parental care of eggs) and an extended spawning period increase the probability that racer goby can successfully establish self-sustaining populations in novel environments."

Human Uses

From Baker et al. (2018):

"This fish is not commercially valuable and is an insignificant part of the fishing industry in the Caspian basin (Azizova 1962, Pinchuk et al. 2003). *Babka gymnotrachelus* is not recreationally or medically valuable."

Diseases

No OIE-reportable diseases (OIE 2019) have been documented for this species.

From WoRMS (2018):

"Host of *Ergasilus gobiorum* Markevich & Sukhnenko, 1967 […]"

"Host of *Gyrodactylus proterorhini* Ergens, 1967 […]"

From Baker et al. (2018):

"*Babka gymnotrachelus* is a host for several European parasites including the trematode *Cryptocotyle concavum*, the acanthocephalan *Pseudoechinorhynchus* (Najdenova 1974, Smirnov 1986), the monogenean *Gyrodactylus proterorhini*, the digenean *Bucephalus polymorphus*, and the ciliate *Trichodina domerguei* (Kvach and Mierzejewska 2011, Mierzejewska et al. 2011, Mierzejewska et al. 2012, Mierzejewska et al. 2014). *Dreissena polymorpha* is an intermediate host for *Bucephalus polymorphus* and are eaten by gobies. Pike and perch that prey on gobies may be infected."

Threat to Humans

From Froese and Pauly (2018):

"Harmless"

3 Impacts of Introductions

From Baker et al. (2015):

"If introduced, *Babka gymnotrachelus* may potentially compete with native Great Lakes species for food (Holcík 1991). As a non-native fish in the Danube River, *Babka gymnotrachelus* exhibits a strong dietary overlap with some native fishes (Copp et al. 2008). In a laboratory experiment, *Babka gymnotrachelus* exhibited competitive and aggressive behavior towards *Cottus gobio* when feeding (Kakareko et al. 2013). […] In the Baltic basin, *Babka gymnotrachelus* avoids resource competition with native fishes through spatial segregation while foraging (Grabowska and Grabowski 2005, Kakareko et al. 2003)."

From Grabowska et al. (2010):

"The negative impact of alien fish species on native ecosystems in Poland is still speculative rather than proved and needs further studies. One group of threats is related to their foraging behavior. It is usually expected that aliens may compete with indigenous fish species for food resources […] The high dietary overlap between native percid fishes and the invading Ponto-Caspian gobies were found in the Danube (Copp et al. 2008). There are not too many studies considering that problem in Polish waters while those dealing with it did not reveal diet overlap e.g. between racer goby and native perch and ruff in the Vistula River (Grabowska & Grabowski 2005). The non-native species are also often blamed for predation on eggs and fry of native ones and due to that decrease of their reproduction success. This kind of prey was not often found in the diet of racer goby and monkey goby in the Włocławski Reservoir (Kostrzewa & Grabowski 2003, Grabowska & Grabowski 2005, Kakareko et al. 2005)."

From Jermacz et al. (2015):

"We video-recorded fish behaviour for 2 h in single-species and mixed-species pairs in the presence of single shelters at three flow velocities: 0, 10 (a velocity preferred by the racer goby) and 30 $cm \cdot s^{-1}$ (a velocity greater than preferred by the racer goby) to determine whether the invader can deprive the native species [European bullhead, *Cottus gobio*] of its shelter. At the flow of 0 and 10 $cm \cdot s^{-1}$, the racer goby exhibited aggressive behaviour towards bullhead, and this restricted the time spent by the bullhead in the shelter. Moreover, although the flow of 30 $cm \cdot s^{-1}$ inhibited racer goby aggression, the time spent by the bullhead in the shelter in interspecific competition was still reduced when compared to intraspecific controls. Our results suggest that under natural conditions, the racer goby displace bullheads from their shelters even at flow velocities greater than optimal for the racer goby."

"The bullhead allowed conspecifics to enter the shelter and was unable to defend a shelter against racer goby intruders. It was also unable to enter the shelter inhabited by a goby. The racer goby, on the other hand, showed a remarkably different behaviour, effectively defending its shelter against competitors, as well as easily displacing the bullhead individuals from the shelters occupied by them."

From Kakareko et al. (2016):

“This underwater study in the River Brda revealed a significant inverse relationship between the invading racer goby and small native European bullheads in the areas inhabited by both species. This suggests that the invader may be adversely affecting small bullheads where racer goby are present. However, the results also reveal that the two species are partitioning habitat (substratum type, shelter type and water velocity), which indicates that in this large lowland river, the intensity of adverse competitive interactions between the species may be lower than suggested by laboratory experiments (Kakareko et al. 2013).”

“European bullhead was most abundant in areas of the River Brda with fast-flowing water and coarse substrata, where they make use of stones of various sizes as shelters. No significant effects of Ponto-Caspian racer goby were observed on large bullheads, which occupied boulder crevices with the highest water velocities, areas almost entirely devoid of the invading racer gobies. The range of habitats used by large European bullheads in the River Brda was clearly narrower than that of the invading racer goby, and this could be interpreted to mean that the invading racer goby has affected the native species’ abundance and habitat use. However, because the remainder of this river system has been invaded by the racer goby, it was not possible to determine whether or not this is the case.”

“Although we observed a clear habitat segregation between the racer goby and large specimens of European bullhead in the River Brda, most pronounced in the case of water velocity, this was not the case of small bullheads. The latter displayed a significant habitat overlap with small gobies with regard to shelter type, and they were inversely related with both large and small gobies in shared areas, suggesting that the competition for refuges between the fish is likely and the alien species may adversely affect small European bullheads. Experimental data suggest (Jermacz et al. [2015]) that the racer goby is more aggressive than the resident European bullhead and, if equal in size, the former won the competition for the shelter. Thus, racer gobies are likely to exert a negative impact on the recruitment of small European bullheads by monopolising parts of the river with intermediate water velocities over stony or gravely substrata.”

“The occurrence of small bullheads in the River Brda was inversely correlated to the presence of gobies and to the presence of large conspecifics, which suggests that if they are displaced from their present habitats by the invaders, they could face increased intraspecific competition.”

4 Global Distribution

Figure 1. Known global distribution of *Babka gymnotrachelus*, reported from eastern and central Europe. Map from GBIF Secretariat (2019). Occurrences reported from Germany were not used in the climate matching analysis because establishment of *B. gymnotrachelus* in the country could not be confirmed. No georeferenced occurrences were available from GBIF Secretariat (2019) for parts of the species established range in Austria, Azerbaijan, Georgia, Greece, Hungary, Iran, Kazakhstan, Moldova, Russia, Slovakia, Turkmenistan, or Ukraine. (Some georeferenced occurrences were obtained from other sources to perform the climate matching analysis.)

5 Distribution Within the United States

This species has not been reported as introduced or established in the United States.

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 0.217, indicating a high overall climate match. (Scores of 0.103 or greater are classified as high.) The climate match was highest in the Great Lakes region. The Interior West had patches of high match as well. The most significant areas of low match were located in the Southeast, the Southwest, and the Pacific Northwest. Much of the rest of the contiguous United States had a medium climate match.

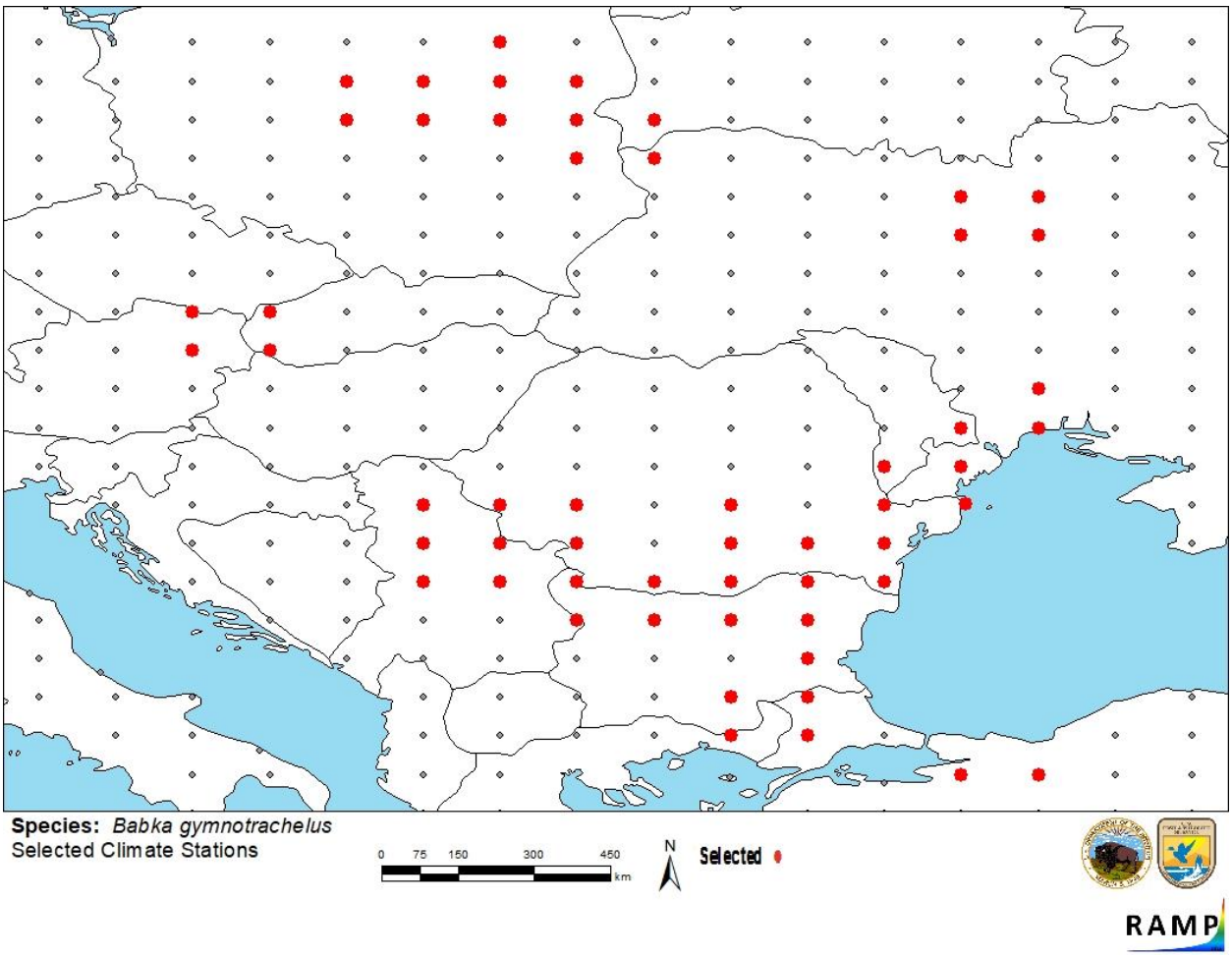

Figure 2. RAMP (Sanders et al. 2018) source map showing weather stations selected as source locations (red; Austria, Slovakia, Serbia, Romania, Bulgaria, Greece, Turkey, Moldova, Poland, Ukraine) and non-source locations (gray) for *Babka gymnotrachelus* climate matching. Source locations from GBIF Secretariat (2019), with additional locations from Wiesner (2005; Austria), Neilson and Stepien (2009a; Ukraine), and Zogaris et al. (2019; Greece).

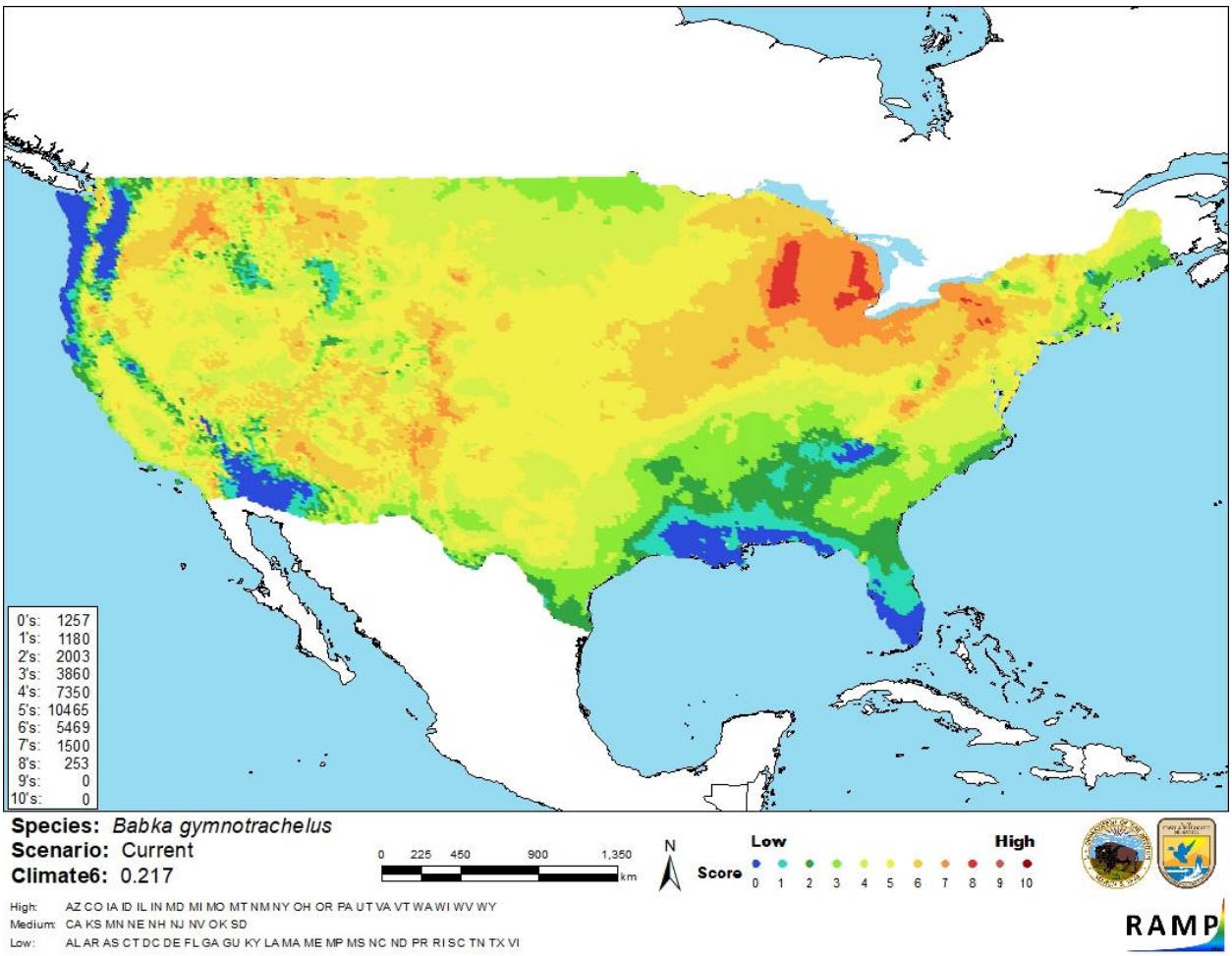

Figure 3. Map of RAMP (Sanders et al. 2018) climate matches for *Babka gymnotrachelus* in the contiguous United States based on source locations reported by GBIF Secretariat (2019), with additional locations from Wiesner (2005; Austria), Neilson and Stepien (2009a; Ukraine), and Zogaris et al. (2019; Greece). 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

Babka gymnotrachelus has been introduced to and established in several European countries, but there are few georeferenced occurrences reported from the native range in eastern Europe and western Asia. Negative impacts from introductions of this species are suggested in the scientific literature, but impacts that have been demonstrated in the laboratory have not yet conclusively been shown to occur in natural settings. Certainty of this assessment is low.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Babka gymnotrachelus, Racer Goby, is a fish native to the Black Sea, Sea of Azov, and Caspian Sea basins and tributaries in Eastern Europe. It inhabits fresh and brackish waters. Nonnative populations have established in the Danube River and the Baltic Sea basins, including in the countries of Austria, Hungary, Slovakia, Serbia, and Poland. There is also evidence of recent range expansion into Greece. Shipping is the primary pathway for *B. gymnotrachelus* introduction, although fish stocking may also contribute. There are no reports of this species being introduced in the United States. There are concerns about the possible invasiveness of *B. gymnotrachelus* in its introduced range, but there is no conclusive evidence of negative impacts in natural settings. History of invasiveness is classified as "None Documented." More evidence is needed to determine the impacts of introduction of this species, so the certainty of this assessment is low. *B. gymnotrachelus* has an overall high climate match with the contiguous United States, and a particularly high match in the Great Lakes region. Overall risk to the contiguous United States is uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 3): None Documented**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): Low**
- **Overall Risk Assessment Category: Uncertain**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

Baker, E., H. Siersma, and J. Li. 2018. *Babka gymnotrachelus* (Kessler, 1857). U.S. Geological Survey, Nonindigenous Aquatic Species Database, Gainesville, Florida, and NOAA Great Lakes Aquatic Nonindigenous Species Information System, Ann Arbor, Michigan. Available: https://nas.er.usgs.gov/queries/greatlakes/FactSheet.aspx?SpeciesID=46&Potential=Y&Type=2&HUCNumber=. (November 2018).

Borcherding, J., S. Gertzen, and S. Staas. 2011. First record of Pontian racer goby, *Babka gymnotrachelus* (Gobiidae: Teleostei), in the River Rhine, Germany. Journal of Applied Ichthyology 27:1399-1400.

Freyhof, J., and M. Kottelat. 2008. *Babka gymnotrachelus*. The IUCN Red List of Threatened Species 2008: e.T188118A8643960. Available: http://www.iucnredlist.org/details/188118/0. (April 2017).

Fricke, R., W. N. Eschmeyer, and R. van der Laan, editors. 2018. Catalog of fishes: genera, species, references. Available: http://researcharchive.calacademy.org/research/ichthyology/catalog/fishcatmain.asp. (November 2018).

Froese, R., and D. Pauly, editors. 2018. *Babka gymnotrachelus* (Kessler, 1857). FishBase. Available: https://www.fishbase.de/summary/Babka-gymnotrachelus.html. (November 2018).

GBIF Secretariat. 2019. GBIF backbone taxonomy: *Babka gymnotrachelus*, Kessler, 1857. Global Biodiversity Information Facility, Copenhagen. Available: https://www.gbif.org/species/5788062. (November 2018).

Grabowska, J. 2005. Reproductive biology of racer goby *Neogobius gymnotrachelus* in the Włocławski Reservoir (Vistula River, Poland). Journal of Applied Ichthyology 21(4):296-299.

Grabowska, J., J. Kotusz, and A. Witkowski. 2010. Alien invasive fish species in Polish waters: an overview. Folia Zoologica 59(1):73-85.

Haertl, M., A. F. Cerwenka, J. Brandner, J. Borcherding, J. Geist, and U. L. Schliewen. 2012. First record of *Babka gymnotrachelus* (Kessler, 1857) from Germany. Spixiana 35(1):155-159.

Jermacz, Ł., J. Kobak, A. Dzierżyńska, and T. Kakareko. 2015. The effect of flow on the competition between the alien racer goby and native European bullhead. Ecology of Freshwater Fish 24:467-477.

Kakareko, T., J. Kobak, M. Poznańska, Ł. Jermacz, and G. H. Copp. 2016. Underwater evaluation of habitat partitioning in a European river between a non-native invader, the racer goby and a threatened native fish, the European bullhead. Ecology of Freshwater Fish 25:60-71.

Medvedev, D. A., P. A. Sorokin, V. P. Vasil'ev, N. V. Chernova, and E. D. Vasil'eva. 2013. Reconstruction of phylogenetic relations of Ponto-Caspian gobies (Gobiidae, Perciformes) based on mitochondrial genome variation and some problems of their taxonomy. Journal of Ichthyology 53(9):702-712.

Neilson, M. E., and C. A. Stepien. 2009a. Escape from the Ponto-Caspian: evolution and biogeography of an endemic goby species flock (Benthophilinae: Gobiidae: Teleostei). Molecular Phylogenetics and Evolution 52:84-102.

OIE (World Organisation for Animal Health). 2019. OIE-listed diseases, infections and infestations in force in 2019. World Organisation for Animal Health, Paris. Available: http://www.oie.int/animal-health-in-the-world/oie-listed-diseases-2019/. (August 2019).

Sanders, S., C. Castiglione, and M. H. Hoff. 2018. Risk Assessment Mapping Program: RAMP, version 3.1. U.S. Fish and Wildlife Service.

Wiesner, C. 2005. New records of non-indigenous gobies (*Neogobius* spp.) in the Austrian Danube. Journal of Applied Ichthyology 21:324-327.

WoRMS. 2018. *Babka gymnotrachelus*. *In* World Register of Marine Species. Available: http://www.marinespecies.org/aphia.php?p=taxdetails&id=1016384. (November 2018).

Zogaris, S., A. Ntakis, and R. Barbieri. 2019. The racer goby, *Babka gymnotrachelus* (Kessler, 1857) invades the Evros river: evidence of recent establishment in Greece. Knowledge and Management of Aquatic Ecosystems 420:13.

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Azizova. 1962. [*Source did not provide full citation for this reference*.]

Baensch, H. A., and R. Riehl. 1991. Aquarien atlas, volume 3. Mergus, Verlag für Naturund Heimtierkunde, Melle, Germany.

Berg, L. S. 1949. Ryby presnykh vod SSSR i sopredel'nykh stran. Ch. 3. Akademii Nauk SSSR, Moscow.

Berg, L. S. 1965. Freshwater fishes of the U.S.S.R. and adjacent countries, volume 3, 4th edition. Israel Program for Scientific Translations Ltd, Jerusalem. (Russian version published 1949).

Charlebois, P. M., J. E. Marsden, R. G. Goettel, R. K. Wolfe, D. J. Jude, and S. Rudnika. 1997. The round goby *Neogobius melanostomus* (Pallas): a review of European and North American literature. Illinois Natural History Survey Special Publication 20.

Copp, G. H., V. Kovác, I. Zweimüller, A. Dias, M. Nascimento, and M. Balážová. 2008. Preliminary study of dietary interactions between invading Ponto-Caspian gobies and some native fish species in the River Danube near Bratislava (Slovakia). Aquatic Invasions 3(2):193-200.

Danilkiewicz, Z. 1996. *Babka łysa* (gołogłowa), *Neogobius gymnotrachelus* (Kessler, 1857) Perciformes, Gobiidae – nowy gatunek w ichtiofaunie zlewiska Morza Bałtyckiego. [The racer goby, *Neogobius gymnotrachelus* (Kessler, 1857) Perciformes, Gobiidae – a new species in the Baltic Sea Basin]. Kom. Ryb. 2:27-29.

Danilkiewicz, Z. 1998. *Babka szczupla*, *Neogobius fluviatilis* (Pallas, 1811), Perciformes, Gobiidae – nowy, pontyjski element w ichtiofaunie zlewiska Morza Baltyckiego. Fragmenta Faunistica 41(21):269-277.

Ehrlich, P. R. 1989. Attributes of invaders and the invading processes: vertebrates. Pages 315-328 *in* J. A. Drake, H. A. Mooney, F. di Castri, R. H. Groves, F. J. Kruger, M. Rejmánek, and M. Williamson, editors. Biological invasions: a global perspective. SCOPE 37. John Wiley and Sons, New York.

Freyhof, J. 2011. Diversity and distribution of freshwater gobies from the Mediterranean, the Black and Caspian Seas. Ch. 2.6 *in* R. A. Patzner, J. L. Van Tassell, M. Kovacic, and B. G. Kapoor, editors. The biology of gobies. CRC Press, Taylor and Francis Group, Scientific Publications, Enfield, New Hampshire.

Grabowska, J., and M. Grabowski. 2005. Indications on the diel feeding activity in early summer of racer goby *Neogobius gymnotrachelus* (Gobiidae) – a new invader in the Baltic Basin. Journal of Applied Ichthyology 21:282-286.

Guti, G. 2006. First record of racer goby *Neogobius gymnotrachelus* (Pallas, 1811) in the Hungarian section of the Danube. Opuscula Zoologica (Budapest) 35:83-84.

Holcík, J. 1991. Fish introductions in Europe with particular references to its central and eastern part. Canadian Journal of Fisheries and Aquatic Sciences 48:13-23.

Jermacz, Ł., J. Kobak, A. Dzierzynska, and T. Kakareko. 2015. The effect of flow on the competition between the alien racer goby and native European bullhead. Ecology of Freshwater Fish 24(3):467-477.

Jurajda, P., J. Cerny, M. Polacik, Z. Valova, M. Janac, R. Blazek, and M. Ondrackova. 2005. The recent distribution and abundance of non-native *Neogobius* fishes in the Slovak section of the River Danube. Journal of Applied Ichthyology 21:319-323.

Kalchhauser, I., P. Mutzner, P. E. Hirsch, and P. Burkhardt-Holm. 2013. Arrival of round goby *Neogobius melanostomus* (Pallus, 1814) and bighead goby *Ponticola kessleri* (Günther, 1861) in the High Rhine (Switzerland). BioInvasions Records 2(1):79-83.

Kakareko, T., J. Żbikowski, and J. Żytkowicz. 2005. Diel partitioning in summer of two syntopic neogobiids from two different habitats of the lower Vistula River, Poland. Journal of Applied Ichthyology 21:292-295.

Kakareko, T., J. Zbikowski, and M. Kowalska. 2003. Trophic relationships between the invasive gobiid of genus *Neogobius*, and small percids in the littoral zone of the Wloclawski Reservoir. Acta Hydrobiol. (Suppl.) 6:29-38. (In Polish.)

Kakareko, T., J. Kobak, J. Grabowska, L. Jermacz, M. Przybylski, M. Poznanska, D. Pietraszewski, and G. H. Copp. 2013. Competitive interactions for food resources

between invasive racer goby *Babka gymnotrachelus* and native European bullhead *Cottus gobio*. Biological Invasions 15(11):2519-2530.

Kautman, J. 2001. The first occurrence of *Neogobius gymnotrachelus* in the Slovak Danube. Folia Zoologica 50:79-80.

Košco, J., L. Košuthová, P. Košuth, and L. Pekárik. 2010. Non-native fish species in Slovak waters: origins and present status. Biologia 65(6):1057-1063.

Kostrzewa, J., and M. Grabowski. 2001. The racer goby, *Neogobius gymnotrachelus* (Kessler, 1857) (Gobiidae, Perciformes) – a new species in the Vistula River. Przegląd Zoologiczny 45:101-102. (In Polish.)

Kostrzewa, J., and M. Grabowski. 2003. Oportunistic feeding strategy as factor promoting the expansion of racer goby (*Neogobius gymnotrachelus* Kessler, 1857) in the Vistula basin. Lauterbornia 48:91-100.

Kottelat, M., and J. Freyhof. 1972. Handbook of European freshwater fishes. Publications Kottelat, Cornol and Freyhof, Berlin.

Kvach, Y., and K. Mierzejewska. 2011. Non-indigenous benthic fishes as new hosts for *Bucephalus polymorphus* Baer, 1827 (Digenea: Bucephalidae) in the Vistula River basin, Poland. Knowledge and Management of Aquatic Ecosystems 400:02.

Leuven, R. S. E. W., G. Van der Velde, I. Baijens, J. Snijders, C. Van der Zwart, H. J. R. Lenders, and A. Bij de Vaate. 2009. The river Rhine: a global highway for dispersal of aquatic invasive species. Biological Invasions 11:1989-2008.

Marszal, L., Zieba, G., Przybylski, M., Grabowska, J., and Kaczkowski, Z. 2004. Monitoring of the ichthyofauna of the Skrwa Prawa river system. Scientific Annual of the Polish Anglers Association 17:77-98.

Mierzejewska, K., A. Martyniak, T. Kakareko, K. Stanczak, and P. Hliwa. 2011. *Gyrodactylus proterorhini* Ergens, 1967 (Monogenoidea, Gyrodactylidae) in gobiids from the Vistula River – the first record of the parasite in Poland. Parasitology Research 108(5):1147-1151.

Mierzejewska, K., Y. Kvach, M. Wozniak, A. Kosowska, and J. Dziekonska-Rynko. 2012. Parasites of an Asian fish, the Chinese Sleeper *Perccottus glenii*, in the Wloclawek Reservoir on the Lower Vistula River, Poland: in search of the key species in the host expansion process. Comparative Parasitology 79(1):23-29.

Mierzejewska, K., Y. Kvach, K. Stanczak, J. Grabowska, M. Wozniak, J. Dziekonska-Rynko, and M. Ovcharenko. 2014. Parasites of non-native gobies in the Wloclawek Reservoir on the lower Vistula River, first comprehensive study in Poland. Knowledge and Management of Aquatic Ecosystems 414:01.

Miller, P. J. 1986. Gobiidae. Pages 1019-1085 *in* P. J. P. Whitehead, M.-L. Bauchot, J. C. Hureau, J. Nielsen, and E. Tortonese, editors. Fishes of the North-eastern Atlantic and the Mediterranean, volume 3. UNESCO, Paris.

Miller, P. J. 2003. The freshwater fishes of Europe. Vol. 8/I Mugilidae, Atherinidae, Atherionopsidae, Blennidae, Odontobutidae, Gobiidae 1. AULA-Verlag, Wiesbaden, Germany.

Moskal'kova, K. I. 1996. Ecological and morphophysiological prerequisites to range extension in the round goby *Neogobius melanostomus* under conditions of anthropogenic pollution. Journal of Ichthyology 36(8):584-590.

Moyle, P. B., and T. Light. 1996: Biological invasions of freshwater: empirical rules and assembly theory. Biological Conservation 78:149-161.

Najdenova, N. N. 1974. Parasite fauna of fishes of the goby family from the Black and Azov seas. Naukova Dumka, Kiev, Ukraine.

Neilson, M. E., and C. A. Stepien. 2009b. Evolution and phylogeography of the tubenose goby genus *Proterorhinus* (Gobiidae: Teleostei): evidence for new cryptic species. Biological Journal of the Linnean Society 96:664-684.

Pinchuk, V. I., E. D. Vasil'eva, V. P. Vasil'ev, and P. J. Miller. 2003. *Neogobius gymnotrachelus* (Kessler, 1857). Pages 265-279 *in* P. J. Miller, editor. The freshwater fishes of Europe, volume 8/I Mugilidae, Atherinopsidae, Blenniidae, Odontobutidae, Gobiidae 1. Aula-Verlag, Wiesbaden, Germany.

Polaçik, M., M. Janáç, T. Trichkova, M. Vassilev, and P. Jurajda. 2008. The distribution and abundance of the *Neogobius* fishes in their native range (Bulgaria) with notes on the non-native range in the Danube River. Large Rivers 18:193-208.

Smirnov, A. I. 1986. Pisces: Perciformes, Scorpaeniformes, Pleuronectiformes, Gobiesociformes, Lophiiformes. Fauna Ukraine 8(5). Naukova Dumka, Kiev, Ukraine.

Stepien, C. A., and M. A. Tumeo. 2006. Invasion genetics of Ponto-Caspian gobies in the Great Lakes: a 'cryptic' species, absence of founder effects, and comparative risk analysis. Biological Invasions 8:61-78.

Vasil'eva, E. D. 1992. The morphology of the skull and taxonomic position of goby *Gobius gymnotrachelus* (Gobiidae, Pisces). Vestnik Moskovskogo Universiteta, Seriya 16: Biologiya 2:46-50.

Vasil'eva, E. D. and T. A. Bogachik. 1991. The morphology of the skull of the knout goby *Mesogobius batrachocephalus* (Pallas) (Gobiidae, Pisces) and its position in the system

of Gobiidae family. Bulletin of Moscow Society of Naturalists. Biological Series 96(3):27-36.

Vassilev, M. V., T. A. Trichkova, D. Ureche, I. Stoica, K. Battes, and M. T. Zivkov. 2008. Distribution of gobiid species (Gobiidae, Pisces) in the Yantra River (Danube basin, Bulgaria). Proceedings of the Anniversary Scientific Conference of Ecology 1:163-172.