Ponto-Caspian gobies (*Babka gymnotrachelus, Proterorhinus marmoratus, Neogobius melanostomus*)

- Freshwater fishes from the Ponto-Caspian region.
- Not yet present in GB but invasive in other parts of Europe.
- Likely to have serious impacts on native biodiversity, through predation and competition with fish and other freshwater species.
- Could also have significant impacts on commercial fisheries through predation of stock.

Neogobius melanostomus Source: Michal Grabowski

History in GB

Not yet recorded in GB but invasive in parts of Europe including the Netherlands. Climatic conditions within parts of the risk assessment area (particularly England, south of Birmingham and Leeds) are suitable for the establishment of these species. *P. marmoratus* and *B. gymnotrachelus* are more likely to establish riverine populations, while *N. melanostomus* is more successful in lakes, streams and brackish waters.

Native distribution

Native to Sea of Azov, Black sea and Caspian basins.

[map not available]

Distribution in GB

Not yet recorded in GB.
N. melanostomus is invasive in parts of Europe, including the Netherlands. *P. marmoratus* has been reported in Germany and the Netherlands, and *B. gymnotrachelus* in Poland and Austria.

Impacts

Environmental

- Greatest impacts likely to be on native fish and other freshwater species through predation and competition for food and spawning habitat.
- Native species affected could include those of high conservation status such as white-clawed crayfish and swan mussel.
- Can cause substantial changes to food webs.
- May act as a vector of various parasites and viruses, including viral haemorrhagic septicaemia virus although this risk is low.

Economic

- May have significant impacts on commercial fisheries due to predation of fish stock.

Social

- *N. melanostomus* is a nuisance to anglers, known to take bait.
- May accumulate toxic substances (including mercurcy) by eating bivalves. These could possibly be passed on to humans if game fish which prey on Ponto-Caspian gobies are consumed.

Introduction pathways

Ballast water - most of the long distance introductions of Ponto-Caspian gobies are believed to have occurred via this route.
Contaminant of fish imports - Ponto-Caspian gobies are not readily accessible as part of the ornamental trade but may be accidentally imported with other species.

Spread pathways

Contaminant of fish stock - although fish movement is regulated, officers are unlikely to be familiar with Ponto-Caspian gobies, especially if juvenile.
Natural - Ponto-Caspian gobies are generally sedentary with limited home ranges but some individuals can occasionally move longer distances, e.g. 2km in seven months.

Summary

	Risk	Confidence
Entry	MODERATELY LIKELY	MEDIUM
Establishment	VERY LIKELY	VERY HIGH
Spread	RAPID	HIGH
Impacts	MASSIVE	MEDIUM
Conclusion	HIGH	HIGH

Information about GB Non-native Species Risk Assessments

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species where there is often a lack of firm scientific evidence. It also strongly promotes the use of good quality risk assessment to help underpin this approach. The GB risk analysis mechanism has been developed to help facilitate such an approach in Great Britain. It complies with the CBD and reflects standards used by other schemes such as the Intergovernmental Panel on Climate Change, European Plant Protection Organisation and European Food Safety Authority to ensure good practice.

Risk assessments, along with other information, are used to help support decision making in Great Britain. They do not in themselves determine government policy.

The Non-native Species Secretariat (NNSS) manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. Risk assessments are carried out by independent experts from a range of organisations. As part of the risk analysis process risk assessments are:

- Completed using a consistent risk assessment template to ensure that the full range of issues recognised in international standards are addressed.
- Drafted by an independent expert on the species and peer reviewed by a different expert.
- Approved by an independent risk analysis panel (known as the Non-native Species Risk Analysis Panel or NNRAP) only when they are satisfied the assessment is fit-for-purpose.
- Approved for publication by the GB Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAP.

To find out more about the risk analysis mechanism go to: www.nonnativespecies.org

Common misconceptions about risk assessments

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted:

- Risk assessments consider only the risks posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Risk assessments are about negative impacts and are not meant to consider positive impacts that may also occur. The positive impacts would be considered as part of an overall policy decision.
- Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based.
- Completed risk assessments are not final and absolute. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Draft risk assessments are available for a period of three months from the date of posting on the NNSS website*. During this time stakeholders are invited to comment on the scientific evidence which underpins the assessments or provide information on other relevant evidence or research that may be available. Relevant comments are collated by the NNSS and sent to the risk assessor. The assessor reviews the comments and, if necessary, amends the risk assessment. The final risk assessment is then checked and approved by the NNRAP.

*risk assessments are posted online at: http://www.nonnativespecies.org/index.cfm?pageid=143
comments should be emailed to nnss@apha.gov.uk

Rapid Risk Assessment of: Ponto-Caspian gobies
Author: Prof. R.E. Gozlan

Version: Draft 1 (*July 2012*), NNRAP 1st review (*Feb 2013*), Peer Review (*Aug 2014)*, Draft 2 (*Nov 2016*), NNRAP 2nd review (*Nov 2016*), Draft 3 (*Feb 2017*)
Signed off by NNRAP: November 2016
Approved by Programme Board: June 2019
Placed on NNSS website: July 2019

GB Non-native species Rapid Risk Assessment (NRRA)

Introduction:

The rapid risk assessment is used to assess invasive non-native species more rapidly than the larger GB Non-native Risk Assessment. The principles remain the same, relying on scientific knowledge of the species, expert judgement and peer review. For some species the rapid assessment alone will be sufficient, others may go on to be assessed under the larger scheme if requested by the Non-native Species Programme Board.

Guidance notes:

- We recommend that you read all of the questions in this document before starting to complete the assessment.
- Short answers, including one word answers, are acceptable for the first 10 questions. More detail should be provided under the subsequent questions on entry, establishment, spread, impacts and climate change.
- References to scientific literature, grey literature and personal observations are required where possible throughout.

1 - What is the principal reason for performing the Risk Assessment? (Include any other reasons as comments)

Response: To assess the risk associated with this species in Great Britain
The three species *B. gymnotrachelus; P. marmoratus; N. melanostomus* have been widely introduced outside their native range (number of introductions in separate countries are 2, 6 and 11 respectively) and some have formed invasive populations within the introduced range in particular in North America. Due to the geographic proximity and commercial links between the native range of these fishes and GB, there is a high chance of introduction of these species in GB and therefore there is an urgent need to perform a RA. It is important to be aware that within a country several introductions could have taken place. For example, *N. melanostomus* has been introduced to no fewer than 24 systems (Lake Superior, Lake Michigan, Lake Huron, Lake Erie, Lake Ontario, Lake Simcoe, Lake Cayuga, Lake Onondaga, Lake St. Clair, Rice Lake, Illinois River, Flint River, Shiawassee River, and scores of Great Lakes tributaries in North America; the Baltic Sea, the Kattegat, the Aegean Sea, Lek River (Netherlands), Scheldt River (Belgium), Danube River, Vistula River, Dnieper River, Dniester River, Don River, and Moscow river in Europe. Here, 'introduced' is used to indicate a non-native population and 'invasive' to indicate that the introduced population also has deleterious effects.

2 - What is the Risk Assessment Area?

Response: Great Britain (i.e. England, Scotland, Wales and their islands)
Great Britain will be evaluated as the RAA including freshwater, brackish and salt water.

3 - What is the name of the organism (scientific and accepted common; include common synonyms and notes on taxonomic complexity if relevant)?

Response:

1- *Proterorhinus marmoratus* (Tubenose Goby) (Pallas, 1814); According to Stepien and Tumeo (2006) the name should be changed to *Proterorhinus semilunaris* (Heckel 1837).

2- *Neogobius gymnotrachelus* (Racer Goby) is now known as *Babka gymnotrachelus* (Kessler, 1857) (see also Stepien and Tumeo 2006; Ohayon and Stepien 2007; Neilson and Stepien 2009). The species is related to a monotypic genus Babka, which was previously considered as a subgenus of the Neogobius genus.

3- *Neogobius melanostomus* (Round Goby) (Pallas, 1814)

4 - Is the organism known to be invasive anywhere in the world?

Response: Yes, all three have been invasive within their introduced range and in particular in the gulf of Gdansk (Poland) and in the Great Lakes (USA). Although *N. melanostomus* is invasive throughout its introduced range, including the Baltic Sea (i.e. Gulf of Gdansk) and the Great Lakes, *B. gymnotrachelus* and *P. marmoratus* are not. Both species have only been invasive in parts of their introduced range. *B. gymnotrachelus* is a problematic invader in several European inland rivers, especially the Danube and Rhine Rivers and in several rivers of the Baltic Basin but not in the proper Baltic Sea. *P. marmoratus* has established a population in a few areas of the Laurentian Great Lakes (USA) although it has not become invasive.

5 - What is the current distribution status of the organism with respect to the Risk Assessment Area?

Response: None of the three species have yet been introduced to GB

6 - Are there conditions present in the Risk Assessment Area that would enable the organism to survive and reproduce? Comment on any special conditions required by the species?

Response: The climatic and habitat condition in the RAA are fairly similar to the environmental conditions found in the native range (e.g. Sea of Azov, Black Sea and Caspian basins) and across the introduced range (e.g. Austria, Netherland, Poland, USA). Therefore there is no reason why if introduced in the RRA, these species of fish would not establish. All three species have invasive potential for all freshwater habitats in Great Britain but only *N. melanostomus* has established invasive populations in brackish habitats. Despite the three species inhabiting high salinity areas in their native range (up to 40.6 PSU in areas of the Caspian Sea, Kazancheev 1981), saltwater in their native range derives from CaSO4 and not NaCl as in the ocean (Strayer & Smith 1993). Even *N. melanostomus*, which has a substantial invasive population in the brackish parts of the Baltic Sea (average salinity of 8 PSU, Højerslev et al. 1996), dies within 48 hours of exposure to oceanic salinities (30 PSU of NaCl, Ellis & MacIsaac 2009).

7 - Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment Area or sufficiently similar for the organism to survive and thrive?

Response: Yes (see above)

8 - Has the organism established viable (reproducing) populations anywhere outside of its native range (do not answer this question if you have answered 'yes' to question 4)?

Response:

9 - Can the organism spread rapidly by natural means or by human assistance?

Response: Yes it has proved to be very invasive almost everywhere it has been introduced. Long distance introductions are believed to be human assisted (e.g. ballast water) but others are the result of natural colonisation (e.g. in the Danube).

10 - Could the organism itself, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment Area?

Response: Yes. They particularly impact recreational fishing and therefore cause economic and social harm in GB. Specifically, Ponto-Caspian gobies can negatively affect sport fish and commercially harvested fish through egg predation (Kornis et al. 2012); negatively affect native mussel populations through predation; compete with native fishes reliant on benthic invertebrates for food (Balshine et al. 2005); compete for spawning habitat with native fishes that spawn on rocky substrate (Janssen & Jude 2001); contribute to increased bioaccumulation of contaminants (e.g., mercury, PCBs) to predatory fishes consumed by humans (Azim et al. 2011) and can serve as vectors of several fish and bird diseases such as botulism (Yule et al. 2006) and viral hemorrhagic septicaemia (Cornwell et al. 2011).

Entry Summary

Estimate the overall likelihood of entry into the Risk Assessment Area for this organism (comment on key issues that lead to this conclusion).

Response: ***moderately likely***

Confidence: ***moderate***

Comments (include list of entry pathways in your comments):
These species are not readily in the ornamental trade and this would limit any hobbyist's interest. It could, however, be imported for research purposes and escape into the wild. This is a low probability but is nonetheless a potential route of entry in particular as this species is increasingly scrutinised among the scientific community. These Ponto-Caspian gobies do not represent an interest to the angling community, which will reduce the chance of the species being actively introduced in GB through that pathway.

Therefore the most likely route of introduction is accidental either 1) through a contaminant of fish imports or as 2) part of ballast water from a ship (Gherardi 2007; Karatayev *et al.*2008, Kornis *et al*. 2012). So far most of the long distance introductions of Ponto-Caspian gobies are believed to have taken place as a contaminant of ballast water (2) rather than fish stock movements (1). In addition, the fish import legislation in GB is a documented and controlled route, which would limit the likelihood of introduction.

In view of the recent change in ballast management policy by the International Maritime Organisation (www.IMO.org), the risk of Ponto-Caspian goby introduction in GB through ballast water should be reduced (although these regulations are not currently in force). After more than 14 years of complex negotiations between IMO Member States, the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) was adopted by consensus at a Diplomatic Conference held at IMO Headquarters in 2004. The Convention will require all ships to implement a Ballast Water and Sediments Management Plan. All ships will have to carry a Ballast Water Record Book and will be required to carry out ballast water management procedures to a given standard. Parties to the Convention are given the option to take additional measures, which are subject to criteria set out in the Convention and to IMO guidelines. Recent laboratory experiments found that all *N. melanostomus* died within 48 h when subject to a salinity of 30 (Ellis and MacIsaac 2009). This suggests that current ballast water exchange regulations, during which ballast tanks are filled with ocean water (NaCl) for c. 5 days, may prevent future *N. melanostomus* introduction events through this pathway. However, based on the annual volume of maritime transactions between the Caspian Sea region and GB and the risk of having a percentage of ships not applying the guidelines, the ballast pathway as an entry route for Ponto-Caspian goby introduction in GB remains a risk.

NB: Some governments and ship owner associations are pushing the International Maritime Organization for ferry boat exemptions to comply with the ballast water exchange regulations (online news article from 14 August 2014: http://worldmaritimenews.com/archives/134018/denmark-pushes-for-ballast-water-exemptions/). Ferry boats using ballast could pose a moderate risk if such exemptions were granted. For instance, there are two ferries that run from Rotterdam, Belgium to Great Britain and both boats operate out of the mouth of the Lek River where *N. melanostomus* was discovered in 2004 (van Beek 2006).

Establishment Summary

Estimate the overall likelihood of establishment (comment on key issues that lead to this conclusion).

Response: ***very likely***

Confidence: ***very high***

Comments (state where in GB this species could establish in your comments, include map if possible):

There is a good match between the climatic conditions within the native range (e.g. Sea of Azov, Black Sea and

Caspian basins) and the RAA when we look in terms of the number of months above a threshold temperature (12ºC). This way we account not for the range of minimum maximum temperature but the number of degree-days received over the year. However, this is probably less suitable in the higher part of GB in a line above Birmingham-Leeds and in Wales as the number of months above 12 ºC goes down to about 3 months. We have noticed with our current climate model research that this limits the possibility of similar species establishing to the north (Flether et al. 2016). In addition, for round goby, Ng and Gray (2011) found that cold temperatures limit their growth and that their optimum energetic is around 26ºC (Kornis *et al.* 2012). That said , relatively recent population 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 (Ojaveer 2006) as well as along the southern coasts of Sweden and Finland (Björklund and Almqvist 2010), Poland and Belarus (Grabowska *et al*. 2010, Semenchenko *et al*. 2011).

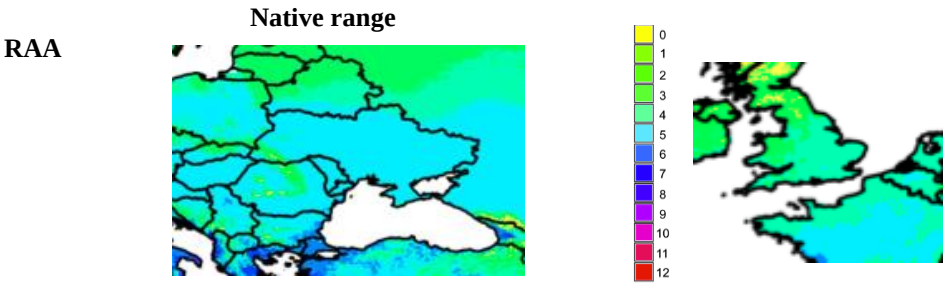

Figure 1: Map of the number of months above 12ºC.

All three species have a reproductive strategy based on nest guarding males, which ensures a maximum chance of survival of the offspring. The reproductive season starts when water temperatures are between 9–26oC (Grabowska et al. 2010, Semenchenko et al. 2011, Kornis et al. 2012). This extremely large temperature tolerance makes all three species well adapted to GB and in particular to England. This coupled with batch spawning with a reproduction every 3-4 weeks, makes the colonisation process fairly rapid. All three species have similar modes of reproduction and tolerance with regards to habitat. These three species of Ponto-Caspian gobies are extremely tolerant to a range of environmental parameters and can be found in brackish as well as freshwater habitats from ponds, lakes, and large rivers to small, fast-flowing streams. In terms of substrate they can be found on sand, mud or pebbles (i.e typically most abundant in rocky habitats). Generally, their populations reach maximum densities in sheltered areas with abundant macrophyte growth (Kocovsky et al. 2011; Kornis et al. 2012).

In conclusion, based on the biological needs and the current environmental conditions in GB, there is no reason to believe that any of these three species of Ponto-Caspian gobies would have any difficulty establishing large populations rapidly after introduction. However, *P. marmoratus* and *B. gymnotrachelus* may have the best ability of the three species to establish truly riverine populations (Grabowska et al. 2008), whilst *N. melanostomus* has had the most success globally, invading lakes, streams, and brackish waters.

Spread Summary

Estimate overall potential for spread (comment on key issues that lead to this conclusion).

Response: ***rapid***

Confidence: ***high***

Comments (include list of spread pathways in your comments):
The bulk of scientific literature about Ponto-Caspian goby spread in their introduced range refers to *N. melanostomus* (Kornis *et al.* 2012). Long distance spread is likely to result from human transport using bait-bucket transfer, in particular upstream catchment as weirs and dams would prevent natural colonisation. However, it has been shown that they are, in general, sedentary species (Björklund and Almqvist 2010) with limited home ranges (circa $5 \pm 1{\cdot}2$ m^2, see Ray and Corkum 2001) but that some individuals can occasionally move distances of about 2 km in seven months (Wolfe & Marsden, 1998). In effect, river colonisation seems to follow a 'stratified dispersal' that includes a combination of diffusion over short distances by most individuals and long-distance colonisation by migrant individuals with estimates ranging between 500m/years up to 4km/years (Bronnenhuber *et al.* 2011).

However, the main risk of spread in GB will result from a contaminant during the movement of fish stock. Although, a site permit or supplier permit under the Keeping and Introduction of Fish (England and River Esk Catchment Area) Regulations 2015 is required for any fish movement within the country, officers are unlikely to be familiar with Ponto Caspian gobies at the start of the colonisation process especially if these are juvenile stages.

In conclusion based on empirical data about Ponto Caspian gobies speed of spread in their newly invaded habitat, I would expect a similar situation to take place in the RAA and at least in England.

Impact Summary

Estimate overall severity of impact (comment on key issues that lead to this conclusion)

Response: ***very high***

Confidence: ***moderate***

Comments (include list of impacts in your comments):
There are a range of potential impact associated with the introduction of Ponto Caspian gobies in the RAA. However, the greater impact is likely to be seen from competition with native species through resource competition, spawning interference and displacement of native species to sub-optimal habitats (Dubs and Corkum 1996, Janssen and Jude 2001, Bergstrom and Mensinger 2009, Poos *et al*. 2010). Typically, these gobies are very aggressive species (in particular *N. melanostomus*) and will displace, harass and prey on small native fish species. These target native species could typically be minnows *Phoxinus phoxinus*, bullhead *Cottus gobio*, stone loach *Barbatula barbatula*, flounder *Platichthys flesus*, and three-spined stickleback *Gasterosteus aculeatus* (Karlson *et al*. 2007, Corkum *et al*. 2004) but could also include species of high conservation status such as the native white-clawed crayfish *Austropotamobius pallipes* or the freshwater Swan Mussel *Anodonta cygnea*. Diets are influenced by habitat, time of day and age/body size of individuals and could be essentially zooplankton when juvenile or benthic invertebrates, small fishes and the eggs and larvae of large fishes (Kornis *et al.* 2012). For example, in lentic habitats where population of molluscs could be abundant, they usually represent the primary diet component of *N. melanostomus*. Ponto-Caspian gobies feed at all times of day with diet changing on a daily basis (Carman *et al*. 2006).

In addition, species such as *N. melanostomus* has often led to deep change within the foodweb. It affects the upper part of the foodweb as it represents an abundant source of prey for predatory fishes and fish-eating birds (Jakubas 2004) and at the bottom as at some locations, predation on Ephemeroptera, Plecoptera and Trichoptera has contributed to invertebrate community shifts (reduced Shannon diversity; see Krakowiak and Pennuto, 2008). This Ponto Caspian goby diet can facilitate bioaccumulation of toxic substances (e.g. mercury, polychlorinated biphenyls [PCB] and polychlorinated naphthalenes [PCN]) to upper levels of the food web (Ng and Gray 2009). Although there is less published information on *P. marmoratus* and *B. gymnotrachelus*, there is some evidence that they also generate similar impacts as *N. melanostomus*.

A range of parasites such as *Gyrodactylus proterorhini* found in invasive goby populations in Poland (Mierzejewska *et al.* 2011) and viruses have been associated with Ponto-Caspian gobies such as for example the viral haemorrhagic septicaemia virus (VHSV) in the Great Lakes (Al-Hussinee *et al*. 2011). However, overall the introduced population of Ponto-Caspian gobies are less parasitized than the native ones (Kvach and Stepien 2008, Gendron *et al*. 2012).

Climate Change

What is the likelihood that the risk posed by this species will increase as a result of climate change?

Response: ***low***

Confidence: *high*

Comments (include aspects of species biology likely to be effected by climate change (e.g. ability to establish, key impacts that might change and timescale over which significant change may occur):

Due to the current distribution of Ponto-Caspian gobies and the range of climatic conditions already encountered by this species across its introduced range (e.g. from Finland to Greece), the projected climate change scenario for GB is well within the current climatic tolerance of the species. Therefore, there is high confidence that the likelihood of the risk of introduction and establishment posed by these species being modified as a result of climate change is extremely low. The only aspect that climate change could add to Ponto Caspian goby invasion, is the fact that GB native communities may be weakened as a result of an increase in temperature and rainfall, allowing gobies to establish more easily. However, the level of uncertainty is far greater than our current understanding of goby biological plasticity.

Conclusion

Estimate the overall risk (comment on the key issues that lead to this conclusion).

Response: *high*

Confidence: *high*

Comments:
Based on our current understanding of ecological impact of these three species across their current invasive range and the future risk of introduction in GB, the overall risk posed by these gobies is high. The outcome will mostly rest on the risk of this species to be introduced to GB, with ballast water representing the main introduction pathway. When introduced, any of these three species would have the capacity to establish and rapidly colonise freshwater and brackish systems within the RAA with may be a greater risk in England. Ecological impact on native communities is likely to be observed not long after their initial establishment in particular if *N. melanostomus* as it is the larger and most aggressive of all three.

Management options (brief summary):

1 - Has the species been managed elsewhere? If so, how effective has management been?

Response:
Where introduced Ponto Caspians have form large populations in open systems of large closed systems (e.g. large lakes) which prevent its eradication. For example, an attempt to eradicate *N. melanostomus* took place after early detection in Pefferlaw Brook, a small tributary to Lake Simcoe, Ontario, Canada, after its introduction was confirmed in 2004. *N. melanostomus* was thought to represent a serious threat to Lake Simcoe's angling industry (Kurji et al. 2006) and in 2005 a rotenone treatmeant was applied to a 5 km stretch of Pefferlaw Brook with the goal of eradicating *N. melanostomus*. However, several *N. melanostomus* were captured months after treatment and the species invaded Lake Simcoe despite intense seining efforts to remove remaining *N. melanostomus* from the brook.

Other management options for control include intensive trapping, electric barriers to upstream movement, flow velocity barriers to upstream movement, bottom-release formulations of piscicides (Bayluscide or antimycin), stocking predators, and commercial harvest in the case of large populations. Aside from the electric barrier (used in the Chicago River, USA; Steingraeber & Thiel 2000), none of these options have actually been used to manage a Ponto-Caspian goby population and testing methods for Ponto-Caspian goby management remains an urgent research need. Thus, management efforts have focused on prevention campaigns towards aquatic invaders in general as well as early detection and eradication efforts in smaller systems (Kornis *et al.* 2012). This has had little effect in the Great Lakes or even in Europe as no early warning systems were in place at the start of the invasion. This is not to say that in the case of our RAA these prevention campaigns would not work.

2 - List the available control / eradication options for this organism and indicate their efficacy.

Response:

To locally reduce goby densities among invasive populations, it would probably require a large, sustained effort on the scale of a commercial fishery. When established it will be difficult to control/eradicate these species. In lakes, bottom trawling might provide an effective sampling technique (Clapp *et al.* 2001) but in rivers electrofishing, for example, would require the operator to search for gobies on the bottom, as they lack a swim bladder and do not float when electrofished (Kornis and Vander Zanden 2010).

The most cost effective option might be the use of traps, although Diana *et al.* (2006) have identified a great efficiency variability, which appeared to be heavily influenced by season. There are other management options such as the use of piscicide (rotenone) in some small closed water systems (already successfully used to eradicate local populations of *Pseudorasbora parva* in the UK (Britton *et al.* 2010).

However, a law that makes it illegal to transport Ponto Caspian gobies would be most efficient in preventing human-mediated spread.

3 - List the available pathway management options (to reduce spread) for this organism and indicate their efficacy.

Response:
There is an urgent need to set up an early warning system in GB targeted to geographical locations representing a high risk of non-native species introduction (e.g. ports with high shipping traffic from the Ponto-Caspian area, the Baltic Sea and the Great Lakes or ferry destinations from the Lek river and arriving in the port of Hull). As soon as the first population of gobies is identified, then, an intense depletion sampling should be operated. At the same time leaflet information on the ecological risk associated with the spread of these species should be distributed among the angling community. Finally, specific attention (and training of relevant officer) should be made for the presence of gobies as a contaminant of fish import consignments.

4 - How quickly would management need to be implemented in order to work?

Response:
If introduced, the initial distribution is likely to be limited to a few locations. The sooner these locations are identified and controlled, the better chance of success authorities will have in controlling the long-term presence of Ponto Caspian gobies in GB and its potential spread. If populations are relatively small the chance of eradication or efficient control would currently be high and therefore should represent a priority.

References

Provide here a list of the references cited in the course of completing assessment

List:

Al-Hussinee L., Lord S., Stevenson R.M.W., Casey R.N., Groocock G.H., Britt K.L. Kohler K.H., Wooster G.A., Getchell R.G., Bowser P.R. and Lumsden J.S. (2011). Immunohistochemistry and pathology of multiple Great Lakes fish from mortality events associated with viral hemorrhagic septicemia virus type IVb. *Diseases of Aquatic Organisms*, 93: 117-127.

Azim M.E., Kumarappah A., Bhavsar S.P., Backus S.M. and Arhonditsis G. (2011) Detection of the spatiotemporal trends of mercury in Lake Erie fish communities: a Bayesian approach. *Environmental Science and Technology*, 45: 2217-2226.

Balshine S, Verma A, Chant V, Theysmeyer T (2005) Competitive interactions between round gobies and logperch. *J. Great Lakes Research*, 31:68-77.

Bergstrom M.A. and Mensinger A.F. (2009). Interspecific resource competition between the invasive round goby and three native species: logperch, slimy sculpin, and spoonhead sculpin. *Transactions of the American Fisheries Society*, 138: 1009-1017.

Björklund M. and Almqvist G. (2010). Rapid spatial genetic differentiation in an invasive species, the round goby *Neogobius melanostomus* in the Baltic Sea. *Biological Invasions*, 12: 2609–2618.

Britton J.R., Davies G.D. and Brazier M. (2010b). Towards the successful control of the invasive *Pseudorasbora parva* in the UK. *Biological Invasion*,12:125-131.

Bronnenhuber J.E., Dufour B.A., Higgs, D.M. and Heath D.D. (2011). Dispersal strategies, secondary range expansion and invasion genetics of the nonindigenous round goby, *Neogobius melanostomus*, in Great Lakes tributaries. *Molecular Ecology*,20:1845–1859.

Carman S.M., Janssen J., Jude, D.J. and Berg M.B. (2006). Diel interactions between prey behaviour and feeding in an invasive fish, the round goby, in a North American river. *Freshwater Biology*, 51: 742–755.

Clapp D.F., Schneeberger P.J., Jude D.J., Madison G. and Pistis C. (2001). Monitoring round goby (*Neogobius melanostomus*) population expansion in eastern and northern Lake Michigan. *Journal of Great Lakes Research*, 27: 335–341.

Corkum L.D., Sapota M.R. and Skora K.E. (2004). The round goby, *Neogobius melanostomus*, a fish invader on both sides of the Atlantic Ocean. *Biological Invasions*, 6:173–181.

Cornwell E.R., Eckerlin G.E., Getchell R.G., Groocock G.H., Thompson T.M., Batts W.N., Casey R.N., Kurath G., Winton J.R., Bowser P.R., Bain M.B. and Casey J.W. (2011) Detection of viral hemorrhagic septicaemia virus by quantitative reverse transcription polymerase chain reaction from two fish species at two sites in Lake Superior. *J. Aquatic Animal Health* 23(4): 207-217.

Diana C.M., Jonas J.L., Claramunt R.M., Fitzsimons J.D. and Marsden J.E. (2006). A comparison of methods for sampling round goby in rocky littoral areas. *North American Journal of Fish Management*, 26: 514–522.

Dubs D.O.L. and Corkum, L.D. (1996). Behavioural interactions between round gobies (*Neogobius melanostomus*) and mottled sculpins (*Cottus bairdi*). *Journal of Great Lakes Research*, 22: 838–844.

Ellis S. and MacIsaac H.J. (2009). Salinity tolerance of Great Lakes invaders. *Freshwater Biology*, 54: 77–89.

Fletcher D.H., Gillingham P., Britton. J.R., Blanchet. S. and Gozlan. R.E. (2016) Predicting global invasion risks: a management tool to prevent future introductions. *Scientific Reports* 6: 26316.

Gendron A.D., Marcogliese D.J. and Thomas M. (2012). Invasive species are less parasitized than native competitors, but for how long? The case of the round goby in the Great Lakes-St. Lawrence Basin. *Biological*

Invasions, 14: 367-384

Grabowska J., Pietraszewski D. and Ondračková M. (2008) Tubenose goby *Proterorhinus marmoratus* (Pallas, 1814) has joined three other Ponto-Caspian gobies in the Vistula River (Poland). *Aquatic Invasions*, 3(2): 261-265.

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

Gherardi F. (2007). Biological Invaders in Inland Waters: Profiles, Distribution and Threats. Book Series: Invading Nature - Springer Series in Invasion Ecology, Vol 2 Publisher: Springer, Dordrecht, Netherlands

Højerslev N.K., Holt N. and Aarup T. (1996) Optical measurements in the North Sea-Baltic Sea transition zone: On the origin of the deep water in the Kattegat. *Continental Shelf Research*, 16:1329-1342.

Jakubas D. (2004). The response of the grey heron to a rapid increase of the round goby. *Waterbirds*, 27: 304–307.

Janssen J. and Jude D.J. (2001). Recruitment failure of mottled sculpin *Cottus bairdi* in Calumet Harbor, southern Lake Michigan, induced by the newly introduced round goby *Neogobius melanostomus*. *Journal of Great Lakes Research*, 27: 319–328.

Karatayev Alexander Y., Mastitsky Sergey E., Burlakova Lyubov E. *et al*. (2008). Past, current, and future of the central European corridor for aquatic invasions in Belarus. *Biological Invasions*, 10: 215-232.

Karlson A.M.L., Almqvist G., Skora K.E. and Appelberg M. (2007). Indications of competition between non-indigenous round goby and native flounder in the Baltic Sea. *ICES Journal of Marine Science*, 64: 479–486.

Krakowiak P.J. and Pennuto C.M. (2008). Fish and macroinvertebrate communities in tributary streams of eastern Lake Erie with and without round gobies (*Neogobius melanostomus*, Pallas 1814). *Journal of Great Lakes Research*, 24: 675–689.

Kocovsky P.M., Tallman J.A., Jude D.J. *et al*. (2011). Expansion of tubenose gobies *Proterorhinus semilunaris* into western Lake Erie and potential effects on native species. *Biological Invasions*, 13: 2775-2784.

Kornis M.S. and Vander Zanden M.J. (2010). Forecasting the distribution of the invasive round goby (*Neogobius melanostomus*) in Wisconsin tributaries to Lake Michigan. *Canadian Journal of Fisheries and Aquatic Sciences*, 67: 553–562.

Kornis M.S. (2011) Distribution, impact, and life histories of round gobies in the Laurentian Great Lakes and their tributaries: lessons for invasion biology. Ph.D. Dissertation, University of Wisconsin-Madison, USA. 176 pp.

Kornis M.S., Mercado-Silva N., Vander Zanden M.J. (2012). Twenty years of invasion: a review of round goby *Neogobius melanostomus* biology, spread and ecological implications. *Journal of Fish Biology*, 80: 235-285.

Kurji K., Payne M., Doyle H. and LaMarca J. (2006) The lesser evils of battling round goby infiltration. *Canadian Medical Association Journal*, 174:1557.

Kvach Y. and Stepien C.A. (2008). Metazoan parasites of introduced round and tubenose gobies in the Great Lakes: Support for the "Enemy Release Hypothesis". *Journal of Great Lakes Research*, 34: 23-35.

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

Neilson M.E. and Stepien C.A. (2009). Escape from the Ponto-Caspian: Evolution and biogeography of an endemic goby species flock (Benthophilinae: Gobiidae: Teleostei). *Molecular Phylogenetics and Evolution*, 52(1): 84-102. doi:10.1016/j.ympev.2008.12.023

Ng, C.A. and Gray K.A. (2009). Tracking bioaccumulation in aquatic organisms: a dynamic model integrating life history characteristics and environmental change. *Ecological Modelling*, 220: 1266–1273.

Ng C.A. and Gray K.A. (2011). Forecasting the effects of global change scenarios on bioaccumulation patterns in great lakes species. *Global Change Biology*, 17: 720-733.

Ohayon J.L. and Stepien C.A. (2007). Genetic and biogeographic relationships of the racer *goby Neogobius gymnotrachelus* (Gobiidae: Teleostei) from introduced and native Eurasian locations. *Journal of Fish Biology*, 71 (Supp. C): 360-370.

Ojaveer H. (2006). The round goby *Neogobius melanostomus* is colonizing the NE Baltic Sea. *Aquatic Invasions*, 1:44–45.

Poos M., Dextrase, A.J., Schwalb A.N. and Ackerman J.D. (2010). Secondary invasion of the round goby into high diversity Great Lakes tributaries and species at risk hotspots: potential new concerns for endangered freshwater species. *Biological Invasions*, 12: 1269–1284.

Ray W.J. and Corkum L.D. (2001). Habitat and site affinity of the round goby. *Journal of Great Lakes Research*, 27: 329–334.

Sapota, M. R. (2004). The round goby (*Neogobius melanostomus*) in the Gulf of Gdánsk – a species introduction into the Baltic Sea. *Hydrobiologia*, 514: 219–224.

Semenchenko V., Grabowska J., Grabowski M., Rizevsky V. and Pluta M. (2011). Non-native fish in Belarusian and Polish areas of the European central invasion corridor. *Oceanological and Hydrobiological Studies*, 40: 57-67.

Steingraeber M.T. and Theil P.A. (2000) The round goby (*Neogobius melanostomus*): another unwelcome invader in the Mississippi River Basin. Transactions of the 65th North American Wildlife and Natural Resources Conference (McCabe RE and Loos SE, eds.), pp. 328-344. Wildlife Management Institute, Washington, DC, USA.

Strayer D.L. and Smith L.C. (1993) Distribution of the zebra mussel (*Dreissena polymorpha*) in estuaries and brackish waters. In Zebra Mussels: Biology, Impacts, and Control (Nalepa TA and Scholloesser DW, eds.), pp. 715-727. Lewis Publishers, Ann Arbor, Michigan, USA.

Stepien, C. A. & Tumeo, M. A. (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.

Van Beek G.C.W. (2006) The round goby *Neogobius melanostomus* first recorded in the Netherlands. *Aquatic Invasions*, 1:42-43.

Wolfe R.K. and Marsden J.E. (1998). Tagging methods for the round goby (*Neogobius melanostomus*). *Journal of Great Lakes Research*, 24:731–735.

Yule A.M., Barker I.K., Austin J.W. and Moccia R.D. (2006) Toxicity of Clostridium botulinum Type E neurotoxin to Great Lakes fish: implications for avian botulism. *Journal of Wildlife Diseases, 42:479-493.*