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The round goby, *Neogobius melanostomus*, a fish invader on both sides of the Atlantic Ocean

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Abstract

During the past decade, a bottom-dwelling, aggressive, multiple-spawning fish, the round goby (Gobiidae: *Neogobius melanostomus*), has spread from its native region in the Ponto-Caspian throughout Europe and to the Laurentian Great Lakes in North America. An international workshop, held at the Hel Marine Station, Poland, was organized to summarize population features of the round goby. Common fish predators of round gobies in the Great Lakes and in native regions are obligate and facultative benthic fishes and occasionally, pelagic fishes. In contrast, the main predator of the round goby in the Gulf of Gdansk is the Great Cormorant (*Phalacrocorax carbo*). In the Great Lakes, round gobies have lead to the decline of mottled sculpin (*Cottus bairdi*) and logperch (*Percina caprodes*) and reduced the hatching success of native fishes by feeding on their eggs. In the Gulf of Gdansk, round gobies have increased in abundance, while three-spined sticklebacks (*Gasterosteus aculeatus*) have declined. Round gobies have a broad diet throughout their range; larger specimens are molluscivores. There are fewer species of parasites and lower infection rates of round gobies in recently colonized areas than in native areas. Overall, newly colonized round gobies in brackish waters and lakes are smaller, mature earlier, have a male biased operational sex ratio and are more short-lived compared with round gobies from marine (native) habitats.

Introduction

A bottom-dwelling fish, the round goby, *Neogobius melanostomus* (Pallas 1811) of the family Gobiidae and native to the Ponto-Caspian region, was first discovered in June 1990 in both the Baltic Sea (Skora and Stolarski 1993) and the Laurentian Great Lakes (Jude et al. 1992). Eggs, juveniles, or adults of *N. melanostomus* were likely transported to both the Gulf of Gdansk in the Baltic Sea and the Great Lakes in North America by ballast water of foreign vessels presumed to have originated from the Ponto-Caspian region. 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). In North America, *N. melanostomus* spread to all five Great Lakes in five years (http: // nas.er.usgs.gov/fishes/images/goby_map.jpg). Similarly, the round goby spread quickly to the western part of the Gulf of Gdansk from Puck Bay in Poland.

Ecologists have summarized features that have enhanced invasions including descriptions of successful

colonizers (high fecundity, wide tolerance of abiotic factors), impact (economic and ecological), and habitats prone to invasion (i.e. accessible corridors between habitats, climatically matched regions, and disturbed environments) (Elton 1958; Lodge 1993; Ricciardi and MacIsaac 2000). Reasons for the proliferation of *N. melanostomus* are their tolerance of a wide range of environmental factors; a broad diet; aggressive behaviour; an ability of the round goby to spawn repeatedly throughout the spring, summer, and autumn; parental care by males to facilitate successful recruitment; and large body size compared with species of a similar benthic lifestyle (Charlebois et al. 1997; MacInnis and Corkum 2000a). Concerns about the round goby include: (1) their ability to transfer contaminants through the food web; (2) their detrimental effects on native species; (3) their ability to proliferate owing to their multiple-spawning habits; (4) the potential expansion of round gobies by anglers using bait buckets; and (5) economic costs of gobies as by-catch in nets of commercial fishers in countries that lack a market for the fish.

Three scientific meetings have been organized to summarize research on the round goby. In 1996, the first round goby conference was held in Chicago, Illinois, USA. The following year, Charlebois et al. (1997) published a review of European and North American literature on the round goby. The document included abstracts of presentations presented at the Chicago meeting. In 1999, the second round goby meeting was held in conjunction with the International Association of Great Lakes Research in Cleveland, Ohio, USA. Several papers, presented at the Cleveland meeting, were published as a special round goby section in the Journal of Great Lakes Research (Charlebois et al. 2001). In 2001, a third round goby meeting (an international workshop), held at the Hel Marine Station in Poland, was organized by Mariusz R. Sapota and Krzysztof E. Skora. Workshop participants were asked to summarize population features and current research on *N. melanostomus* in various geographical regions.

This paper summarizes the findings presented at the Hel Marine Station workshop. Specifically, we identified current research activities on the fish invader, compared similarities and differences of round goby populations located on either side of the Atlantic Ocean, and presented research needs and directions for scientists studying the effect of an invader on aquatic ecosystems.

Current research activities

North America (The Laurentian Great Lakes)

Two species of gobiids, the round goby, *N. melanostomus* (Pallas) and tubenose goby *Proterorhinus marmoratus* (Pallas) are found in the Laurentian Great Lakes (Jude et al. 1992). Unlike the wide-spread round goby, the tubenose goby is limited in distribution to the St Clair River, Lake St Clair, Detroit River, and sites along the north shore of western Lake Erie.

The founding source population of the round goby in North America is unknown, but populations collected from the Gulf of Gdansk and from Varna, Bulgaria (Black Sea) have been eliminated (Dougherty et al. 1996; Dillon and Stepien 2001). North American populations, however, are closely related genetically, suggesting a common geographic origin (Dillon and Stepien 2001).

Fisheries managers are concerned that the round goby may move from the Great Lakes basin south to the Mississippi River basin where the goby may adversely affect native biota. Baited minnow traps have been used to monitor the rate of round goby movement (about 25 km/yr) en route to the Mississippi River from Lake Michigan, a distance of 536 km (Steingraeber and Thiel 2000). An electrical barrier was constructed on the Des Plaines River, Illinois, to reduce the risk of nonindigenous fishes from moving between the Great Lakes and Mississippi River basins, but the round goby moved downstream from the barrier before it was energized (April 2002). However, the electric barrier may help to reduce the transfer between basins of other nonindigenous species such as the bighead (*Hypophthalmichthys nobilis*) and silver (*Hypophthalmichthys molitrix*) carp, which are now moving north to the Great Lakes and are within 25 km of the barrier.

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).

Because round gobies feed on benthic organisms that are exposed to contaminated sediments and are preyed upon by various sport and commercial fishes, the fish diet of humans is a health concern. Morrison et al. (2000) measured PCB congener concentrations in aquatic biota and sediment in western Lake Erie before and after the invasion by round gobies. Predicted changes in PCB concentration in fish were smaller than those from measured increases in sediment between study years owing to the resuspension of buried contaminated sediments from turbulence caused by higher wind speeds (Morrison et al. 2000).

Several agencies have monitored both movement by the round goby and their contribution to the diet of predators in Lake Erie. The round goby first entered Lake Erie in 1993 and by 1999 had spread throughout the lake. The round goby contributes substantially to the diet of smallmouth bass (*Micropterus dolomieu*), stonecat (*Noturus flavus*), burbot (*Lota lota*), and yellow perch (*Perca flavescens*), but is a minor component in the diet of walleye (*Stizostedion vitreum*) and white bass (*Morone chrysops*) (T. Johnson, Ontario Ministry of Natural Resources, Wheatley, pers. comm.). Recent declines in the catch rates of the round goby from trawl surveys in the central and western basins of Lake Erie may be attributed to increased consumption of the round goby by predators (C. Knight, Ohio Department of Natural Resources, Fairport Harbor, pers. comm.).

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.

Results from trawling studies in the St Clair River indicate that the decline of mottled sculpin, *Cottus bairdi*, and logperch, *Percina caprodes*, coincided with the presence of the round goby (Jude et al. 1995; Janssen and Jude 2001). On the basis of behavioural interactions between mottled sculpins and the aggressive round goby, Dubs and Corkum (1996) predicted that the round goby would induce mottled sculpins to desert nearshore habitats and be forced into deeper habitats where the sculpins would be more susceptible to large predators. More recently, Janssen and Jude (2001) indicated that recruitment failure of mottled sculpins resulted from spawning interference by the round goby.

Belanger et al. (2003) showed that olfactory sensory neurons (OSN) are distributed throughout the peripheral olfactory organ of the round goby. The presence of accessory nasal sacs suggests that the round goby may regulate the flow of odorants over ONS, likely through a pumping mechanism linked to gill ventilation (Belanger et al. 2003). Murphy et al. (2001) showed that electro-olfactogram responses and gill ventilation rates increased when round goby were exposed to the putative pheromone estrone, 17β-estradiol-3β-glucuronide, and etiocholanolone. Also, gill ventilation increases were observed in reproductive round goby exposed to gonadal tissue extracts from reproductive females (Belanger 2002). These findings show that gill ventilation in the round goby is useful for testing olfactory recognition of putative pheromones and could be linked to sexual attraction between male and female round gobies, and between round gobies and embryos of native fishes.

Researchers have suggested a possible link between the round goby and botulism, *Clostridium botulinum* type E, a disease of wild migratory birds (H. Domske, New York Sea Grant and E. Obert, Pennsylvania Sea Grant, pers. comm.). In Lake Erie, incidence of *C. botulinum* type E toxin has been reported in Common Loon (*Gavia immer*), Herring Gull (*Larus argentatus*), Ring-billed Gull (*Larus delawarensis*), Long-tailed Duck (*Clangula hyemalis*), and Red-breasted Merganser (*Mergus serrator*) (J. Robinson, Environment Canada, pers. comm.). These botulism-infected birds had a higher incidence of round goby in their guts than did uninfected birds (D. Campbell, University of Guelph, unpubl. data). It is possible that low dissolved oxygen concentrations combined with a temperature inversion stressed round goby to such a degree that they floated to the surface

and drifted shoreward, enabling birds to feed on fish. At this stage, more research is needed to confirm the link, if any, between gobies and botulism in fish eating birds.

The Baltic Sea

There are six species of gobiids found along the Polish coast of the Baltic Sea including the common goby, *Pomatoschistus microps*; the sand goby, *Pomatoschistus minutus*; the black goby, *Gobius niger*; the two-spotted goby, *Gobiusculus flavescens*; the transparent goby, *Aphya minuta*; and the round goby, *N. melanostomus* (Horackiewicz and Skora 1998). Of these species, the two-spotted goby and transparent goby are rare in the region (Horackiewicz and Skora 1998). Since the round goby was first reported near the Port of Hel in June 1990 (Skora and Stolarski 1995), the species has increased in density and biomass from the outer part of Puck Bay to the inner shallow Puck Lagoon then to the open part of the Gulf of Gdansk (Figure 1). In 1999, round gobies were first caught in the Vistula Lagoon (east of the Gulf of Gdansk) (Borowski 1999). Salinity values in the Vistula Lagoon range from 0‰ to 2‰; salinity values in Puck Bay and the South Baltic Sea are about 7‰. By early summer 1999, fishers reported round gobies at Rugia Island, Germany (H. Winkler, University of Rostock, unpubl. data). In May 2003, the round goby had been reported at several locations along the north coast of Germany, west to Rostock (K. Skora, University of Gdansk, unpubl. data).

Sapota (2001a,b) documented the change in biomass and density of fishes (three-spined stickleback, *Gasterosteus aculeatus*; common goby, sand goby, round goby) that dominated nearshore areas of Puck Bay, 1995–1999. Although *G. aculeatus* dominated (up to 99%) samples from Puck Bay lagoon in 1995 and 1997, the round goby represented about 25% by number in 1999 with highest abundance during summer months. Because of differences in diet (three-spined stickleback is omnivorous; round goby is molluscivorous) and habit (three-spined stickleback is pelagic; round goby is benthic), the two species will likely continue to co-occur in the lagoon. However, in outer Puck Bay, the round goby may compete for food with flounder, *Platichthys flesus* (another molluscivore), and for space with other Gobiidae (especially *P. microps*, *P. minutus*, *G. niger*) and the eelpout (*Zoarces viviparus*). It seems unlikely that the semi-pelagic,

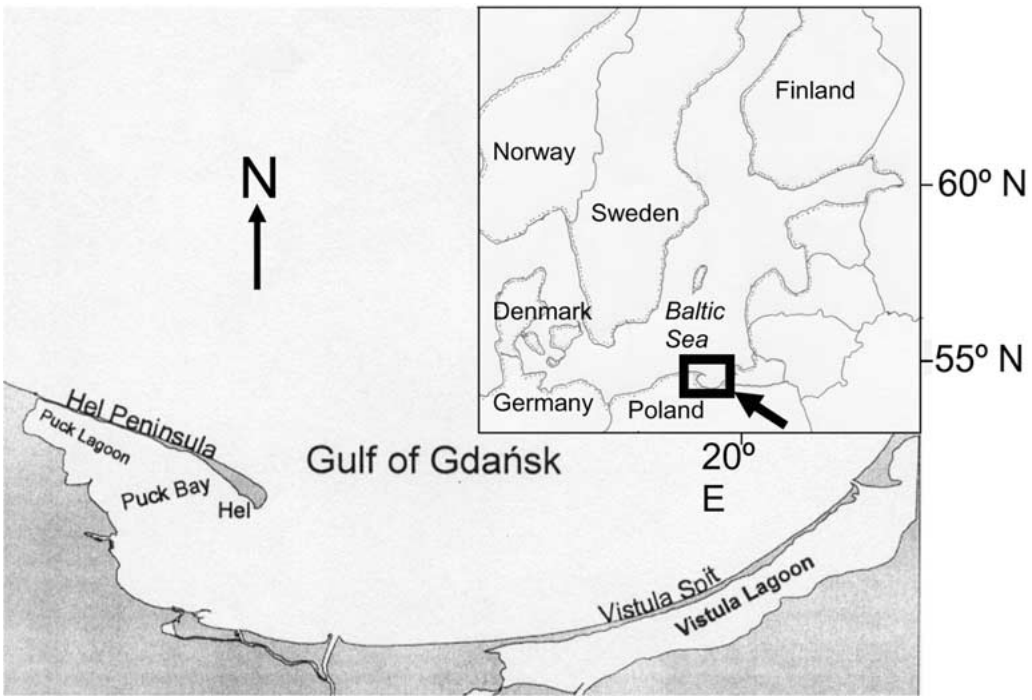

Figure 1. Sites of the round goby invasion in the Gulf of Gdansk.

schooling two-spotted goby would compete with the benthic round goby. However, if substrate sites are limiting, there is a potential for competitive interactions between the two species because the two-spotted goby, like the round goby, uses hard substrate (mussel shells) for nests (J. Bjelvemark, Göteborg University, pers. comm.). Preliminary laboratory results showed that diel activity patterns differed between the diurnal round goby and the nocturnal eelpout when the species co-occurred (K. Skora, University of Gdansk, unpubl. data).

Although fish predators on round gobies in the Gulf of Gdansk are unknown, Great Cormorants (*Phalacrocorax carbo*) feed predominately (72%) on the round goby (Bzoma and Stempniewicz 2001). In 1999, Great Cormorants in the Gulf of Gdansk consumed about 900 tonnes of fish and round goby were especially abundant prey from June to August (Bzoma and Stempniewicz 2001).

Parasites of the round goby

Yuriy Kvach (Odessa University, pers. comm.) analysed the parasites of the round goby from the Puck Bay, Poland. Only four species of freshwater parasites were observed in the round goby including trematodes (*Diplostomum* spp.) and a crustacean (*Ergasilis* sp.). The round goby infection rate, from samples collected near Hel (on the border of Puck Bay), was low (4–8%) compared with an infection rate of 20% in round gobies collected throughout most of the inner region of Puck Lagoon. In contrast, Kvach documented 52 species of parasites in round gobies collected from the northwestern region of the Black Sea where the infection rate is up to 90–100% (depending on location). The endemic parasites of these round gobies are typically marine and brackish water, although 14 species of freshwater parasites have been identified from round gobies collected from the Black Sea (Pronin et al. 1997). In North America, 76% (35/46) of round gobies were infected with one or more parasites and of the 10 species of parasites found, nine species were freshwater. *Diplostomum spathacum* (a species common in the Baltic, but more typical of freshwater in the Ponto-Azov basin: Chernyshenko 1957; Koval 1962) was the most common parasite occurring in 65% of the round gobies collected from the St Clair River region in North America (Pronin et al. 1997). Overall, there are fewer species of parasites and lower infection rates of the round goby in recently colonized areas than in native areas (i.e. the Black Sea). However, Pronin et al. (1997) suggest that the low parasitic load of the mollusc, *Dreissena polymorpha*, a major prey of the round goby diet in North America, accounts for the low parasitic infection rate of the round goby in the Great Lakes.

Alternative reproductive strategies of the round goby in freshwater and marine habitats

Successful colonists typically have a short generation time, high fecundity, and high growth (Lodge 1993). Svetlana Rudnicka (Institute of Fisheries, Bulgaria, unpubl. data) compared morphological features of round goby from samples ($n = 128$ fish) obtained from brackish water (4.5–7.8‰) and more marine (15–17‰) habitats near Varna, Bulgaria. Size of round gobies, designated as 'normal' were larger in marine habitats compared with 'dwarf' forms in brackish water and fish in freshwater (Figure 2). The dwarf morph was similar to the size-at-age of the round goby in the Detroit River of the Laurentian Great Lakes (MacInnis and Corkum 2000b). The Detroit River study was conducted in 1996, just 3 years after the fish had first been reported in the river. Rudnicka also reported differences in other morphological features between morphs including pelvic fin length (dwarf: 28.4 mm, normal 22.3 mm), interorbital width compared with head width (dwarf 16.2%, normal 21.2%), gonadosomatic index (dwarf 11.2, normal 7.6), and relative batch fecundity (dwarf 52.6, normal 37.5). Overall, round gobies from brackish waters and lakes (new colonizers) were smaller, matured earlier and were more short-lived

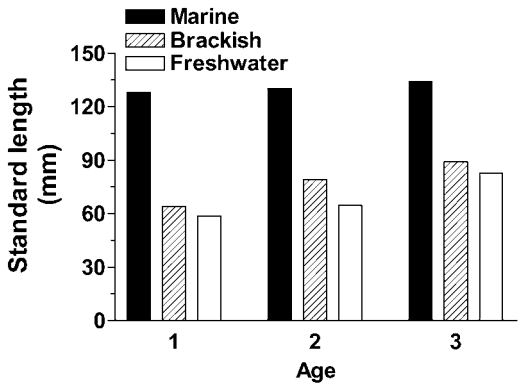

Figure 2. Standard length (mm) of the round goby at ages 1, 2, and 3 in marine and brackish waters (S. Rudnicka, Institute of Fisheries, Bulgaria), and in freshwater habitats (MacInnis and Corkum 2000b).

compared with the same species from marine (native) habitats. The dwarf morph directs more of its energy to reproduction than does the normal morph. The longer suctorial fused pelvic fin of dwarf forms may contribute to its attachment to the substrate (perhaps contributing to a more benthic or less mobile habit than the normal morph) or to secure its body to nests more effectively than normal morphs when releasing gametes (S. Rudnicka, Institute of Fisheries, Bulgaria, pers. comm.). The narrower interorbital width to head width ratio offers an advantage of upward vision in the dwarf morph, possibly to better avoid predation than the normal morph (S. Rudnicka, Institute of Fisheries, Bulgaria, pers. comm.). Earlier, Sozer (1941) documented differences between size-at-age between dwarf and normal forms of the round goby, suggesting that higher salinity of marine environments stimulated growth. However, salinity in the Gulf of Gdansk is similar to brackish waters observed by Rudnicka, yet round gobies in the Gulf of Gdansk are among the largest of the round gobies found (Skora and Stolarski 1993). Thus, salinity alone cannot account for differences between dwarf and normal morphs.

New records of the round goby in Europe

The Danube is the second longest river (after the Volga River) of Europe, linking (through additional canals) the Black and North seas. Thus, the waterway serves as a link across a continent over which invaders may travel. Christian Wiesner (Universität für Bodenkultur, pers. comm.) reported the occurrence of round gobies in the slow-flowing side channels of the mainstem Danube River in Vienna, Austria. There were three new species of *Neogobius* at this study site including *N. melanostomus*, the rarer *Neogobius kessleri* (bighead goby), and *Neogobius gymnotrachalus* (racer goby) (Ahnelt et al. 2001). These fish co-occurred with *P. marmoratus* (tubenose goby) and a sculpin, *Cottus gobio*. Zooplankton (*Bosmina longirostris*) and ostracods were common in the diet of small round gobies (TL < 5 cm), whereas *Gammarus*, dreissenids, and gastropods were common in stomachs of the larger size classes (TL > 5 cm) of fish. Simonovic et al. (1998) earlier reported the occurrence of the round goby in sections of the Danube that flow through Serbia and Yugoslavia. Recently, the round goby has continued to expand in this region of the Danube where the species co-occurs with *Neogobius fluviatilis*, *Neogobius gymnotrachelus*, *N. kessleri*, and *P. marmoratus* (Simonovic et al. 2001). Here, the round goby is a molluscivore feeding mainly on the zebra mussel, *D. polymorpha.*

Similarities and differences in round goby populations located on either side of the Atlantic Ocean

Many features of the round goby are common to populations on both sides of the Atlantic Ocean including their benthic habits, male parental care, dwarf morphs, and associated reproductive habits in freshwater habitats, fast dispersal ability, ontogenetic diet shifts, competition with other benthic fishes, parasitic fauna, and migration to deeper waters in winter months. However, certain attributes of round goby populations, associated fauna, and habitats differ between regions where the species has invaded (Table 1).

Fish predators of the round goby in the Laurentian Great Lakes include obligate benthivores (e.g. *A. fulvescens*, *N. flavus*), facultative benthivores

Table 1. Differences in round goby populations that have invaded the Laurentian Great Lakes and the Baltic Sea (Gulf of Gdansk).

Attribute	Gulf of Gdansk	Laurentian Great Lakes
Predators	Great Cormorant	Several fishes, waterfowl
Salinity	Low salinity	Freshwater
Available substrate	Sand	Rocks (preferred)
Nest sites limiting	Yes	No
Operational sex ratio	Male biased (3 : 1)	Male biased (6 : 1)
Other gobiids	*A. minuta* *G. niger* *G. flavescens* *P. microps* *P. minutus*	*P. marmoratus*

(e.g. *Aplodinotus grunniens*, *M. dolomieu*), and occasionally pelagic fishes (e.g. *S. vitreum*, *P. flavescens*) (T. Johnson, Ontario Ministry of Natural Resources, pers. comm.). Fishes representing the same feeding guilds prey on round goby in the native Black Sea including obligate benthivores (e.g. *Acipenser* sp., *Platichthys flesus luscus*) and pelagic fishes (e.g. *P. fluviatilis*, *Salmo salar*, *Stizostedion lucioperca*) (V. Zamorov, Odessa National University, pers. comm.). However, fish predators are not common in the shallow, slightly saline waters of Puck Bay and the Gulf of Gdansk and no fish has been found to feed on round gobies in this region (Skora 1993). Instead, Great Cormorants prey on the invader.

Male round goby defend and maintain nests in which many females deposit eggs. The nests are associated with hard substrates. Most juvenile and adult round goby prefer rocky substrates, but the fish also are found in fine gravel and sandy substrates in which they may burrow (Ray and Corkum 2001). Although sand substrates predominate in the Gulf of Gdansk, hard structures such as rocks and logs are found nearshore and it is in these habitats where round gobies nest. Multiple nests are often found under hard substrates or in shelters. For example, 13 round goby nests have been observed under one board (with nests located a few centimetres apart), suggesting that nest sites are likely limiting in the Gulf of Gdansk (J. Samsel, Ocean Instruments Ltd, pers. comm.). Similarly, multiple nests are found on hard substrates in the Great Lakes (Wickett and Corkum 1998). The male : female ratio in Puck Bay is about 3 : 1 (K. Skora, University of Gdansk, unpubl. data). The operational sex ratio (about 6 : 1) is even more male biased in the Great Lakes (L.D. Corkum, University of Windsor, unpubl. data).

In the Great Lakes basin, round gobies are typically confined to lakes and connecting channels (e.g. Detroit and St Clair rivers) or navigational waterways (e.g. the Calumet Sag Channel near Chicago). The presence of the round goby at upstream locations in Michigan rivers within the basin likely has occurred by bait bucket transfer rather than migration upstream (Jude 2001). Jude (2001) reported that round gobies did not penetrate long distances upstream because the fish were limited by a variety of factors. In the Gulf of Gdansk, the round goby has been observed to migrate 40 km upstream of Vistula River (K. Skora, University of Gdansk, unpubl. data).

The invasion of the round goby has resulted in diet shifts among predators and changes in food web structure. In the Gulf of Gdansk, cormorants have shifted their diet from eel (*Anguilla anguilla*) and sprat (*Spratus spratus*) to the round goby, resulting in increases in eel and sprat (Bzoma and Stempniewicz 2001). Increases in planktivorous sprat have resulted in a reduction of zooplankton and a corresponding increase in algal biomass. Researchers in North America using enclosures (cages) in field experiments reported that round gobies grazing on invertebrates resulted in enhanced algal biomass (Kuhns and Berg 1999). Other food web changes are likely to occur in the transfer of energy and contaminants by the round goby. This process may result in enhanced fish production and/or human health concerns if contaminant levels in sport and commercial fishes increase.

Research needs

Because the round goby has spread so quickly in Europe and North America and the effect of the invader in new environments is not yet realized, colleagues at the workshop identified the following research needs:

1. Clear documentation of methods and gear (types of nets and comparable mesh sizes) used to collect fish (fyke nets were preferred in nearshore areas).
2. Agreement on common techniques (e.g. use of total length rather than standard length).
3. Global distribution map of the round goby (and other invaders). Vadim E. Panov and colleagues at the Zoological Institute, St Petersberg, Russia have developed GIS software for the registration of aquatic invasive species and creation of interactive distribution maps. Demonstration versions of GIS 'INVADER' are available at the internet web site, http://www.zin.ru/projects/invasions. This web site may be an avenue to document the global distribution of the round goby. In North America, invading species are documented by the United States Geological Survey at the web site: http://nas.er.usgs.gov/fishes.
4. Development of taxonomic keys for larval stages of *Neogobius* species.
5. Mapping of shipping routes to determine likely dispersal routes of round goby throughout the world.
6. The founding source population of *N. melanostomus* (for the Great Lakes and the Gulf of Gdansk) should be identified through genetic analysis. Distinct

morphometric analyses are needed for comparison with populations from the Ponto-Caspian region.
7. The Hel Marine Station, Poland, was suggested to serve as a housing facility for reprints.
8. The organization of periodic workshops on the round goby was suggested at a venue that would enable researchers of modest means to participate.

Clearly, co-operative efforts are needed by researchers and their institutions to conduct long-term ecological studies on the effects of the round goby on aquatic ecosystems. Workshops on the round goby, such as the one held at the Hel Marine Station, serve to enhance such collaborative efforts.

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