

## PERSPECTIVES

# Predicting the identity and impact of future biological invaders: a priority for aquatic resource management

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**Abstract:** The identification and risk assessment of potential biological invaders would provide valuable criteria for the allocation of resources toward the detection and control of invasion threats. Yet, freshwater biologists have made few attempts at predicting potential invaders, apparently because such efforts are perceived to be costly and futile. We describe some simple, low-cost empirical approaches that would facilitate prediction and demonstrate their use in identifying high-risk species from an important donor region: the Ponto-Caspian (Black, Caspian, and Azov seas) basin. This region is the source of several freshwater organisms already invading North America, including the zebra mussel (*Dreissena polymorpha*), quagga mussel (*Dreissena bugensis*), ruffe (*Gymnocephalus cernuus*), and round goby (*Neogobius melanostomus*). Based on a thorough literature review, we identify 17 additional Ponto-Caspian animals that have recent invasion histories and are likely to be transported overseas in ship ballast water; moreover, their broad salinity tolerance could allow them to survive an incomplete ballast-water exchange. These results suggest that, unless current vectors are more effectively controlled, the Great Lakes - St. Lawrence River system and other North American inland waterways will continue to receive and be impacted by invasive Eurasian species.

**Résumé :** L'identification des espèces susceptibles de devenir envahissantes et l'évaluation des risques qu'elles peuvent poser permettraient de définir des critères utiles pour l'affectation de ressources à la détection et à l'élimination des espèces nuisibles. Jusqu'ici, pourtant, les biologistes des eaux douces n'ont guère consacré de temps à cette question, de telles études paraissant être considérées comme coûteuses et inutiles. Nous décrivons ici des méthodes de prévision empiriques, simples et peu coûteuses et nous montrons comment les utiliser pour identifier les espèces à fort potentiel de nuisibilité d'une région qui peut être une importante source de ce genre d'organismes : le bassin pontocaspien (comprenant la mer Noire, la mer Caspienne et la mer d'Azov). C'est en effet de cette région que proviennent plusieurs des espèces qui ont déjà envahi les eaux douces nord-américaines et notamment la moule zébrée (*Dreissena polymorpha*), la moule quagga (*Dreissena bugensis*), la grémille (*Gymnocephalus cernuus*) et le gobie arrondi (*Neogobius melanostomus*). Dans une revue documentaire approfondie, nous avons relevé 17 autres espèces animales d'origine pontocaspienne qui ont récemment envahi d'autres régions et qui pourraient vraisemblablement être transportées jusqu'ici dans l'eau de ballast des bateaux arrivant d'outremer; de plus, comme ces espèces tolèrent des conditions de salinité très variées, elles pourraient survivre dans une eau de ballast incomplètement changée. Ces résultats donnent à penser qu'à défaut d'un contrôle plus rigoureux des vecteurs actuels, de nouvelles espèces envahissantes continueront d'être introduites d'Eurasie et de provoquer des dégâts dans le bassin des Grands Lacs et du Saint-Laurent, ainsi que dans d'autres bassins hydrographiques de l'intérieur des terres en Amérique du Nord.

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## Introduction

One of the most pervasive and ecologically damaging effects of human activities is the widespread movement of species beyond their natural range. In most countries,  $10^2$ - $10^4$  nonindigenous species have been documented and their numbers are increasing (Lodge 1993). In North America, hundreds

of exotic plants and animals have become established in aquatic habitats during this century (e.g., Mills et al. 1993a, 1996; Cohen and Carlton 1998). Biological invasions will continue to occur, particularly as expanding global trade increases the volume of flora and fauna that is shuttled from one geographic realm to another (e.g., in the ballast water of ships; Carlton and Geller 1993). The aquarium industry, for example,

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**Table 1.** Some hypothesized general attributes of invasive aquatic species (based on Ehrlich 1986; Groves and Burdon 1986; Lodge 1993; Morton 1979, 1997).

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1. Abundant and widely distributed in original range
  2. Wide environmental tolerance
  3. High genetic variability
  4. Short generation time
  5. Rapid growth
  6. Early sexual maturity
  7. High reproductive capacity
  8. Broad diet (opportunistic feeding)
  9. Gregariousness
  10. Possessing natural mechanisms of rapid dispersal
  11. Commensal with human activity (e.g., ship ballast-water transport)
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has deliberately moved thousands of foreign species into North America, paving the way for many unintentional introductions (Welcomme 1984).

Typically, only a small proportion (<10%) of introduced species cause significant impacts (Williamson and Fitter 1996), but some of these have had enormous ecological and economic consequences (OTA 1993). Advance information on invasive and potentially harmful organisms would provide valuable criteria for control measures, such as quarantines and import restrictions (Groves and Burdon 1986; Willan 1987; Jenkins 1996), for allocating resources to maximize detection and for guiding decisions about proposed introductions (e.g., Townsend and Winterbourn 1992). Yet, despite the ecological and economic damage caused by exotics such as the sea lamprey (*Petromyzon marinus*), purple loosestrife (*Lythrum salicaria*), Eurasian watermilfoil (*Myriophyllum spicatum*), zebra mussel (*Dreissena polymorpha*), and others (OTA 1993; Mills et al. 1993a), there have been few formal attempts at forecasting unplanned invasions in North American freshwater habitats (but see Mandrak 1989; Mills et al. 1993b). This is likely the result of what Rejmanek (1996) described as a "widespread pessimism regarding the prospect of predicting which species are likely to become successful invaders." Such pessimism may have led administrators to ignore the warning of consultants contracted by the Canadian government in 1980 to study the occurrence of foreign organisms in ship ballast water; the consultants reported the transport of living veliger larvae to the Great Lakes in European vessels and predicted the establishment of the zebra mussel in North America (Bio-Environmental Services Ltd. 1981).

Clearly, the science and management of exotic species need to become more proactive to prevent or mitigate invasion threats. In this perspective, we propose that limited, but valuable predictions of the invasion success of different aquatic organisms can be made using documented information. We suggest a few simple, low-cost approaches that would facilitate the identification of potential future aquatic invaders.

### Guidelines for identifying potential aquatic invaders

Because any organism can potentially expand its population when introduced into a favorable environment, it would be impractical to construct a comprehensive list of potential

invaders based solely on environmental tolerances. A more cost-effective strategy is to identify species with exceptionally high invasion and impact potential. Using concepts currently being developed in both marine and terrestrial invasion biology (e.g., Forcella et al. 1986; Carlton 1996; Mack 1996; Rejmanek 1996), we suggest the following guidelines for such a selection process.

#### 1. Identify potential donor regions and dispersal pathways of future invaders

An essential first step toward predicting invasions is the identification of a potential geographic donor region. Active donor "hot spots" may be identified by their disproportionate numerical contribution to the floras and faunas of various recipient regions using updated species lists (e.g., Mills et al. 1993a 1996; Cohen and Carlton 1998). Regions with similar climates may have a higher potential of successfully exchanging species, although predictions based on this assumption have had varied success (Mack 1996). Potential donor regions may also be identified by large-scale shipping patterns. The global dispersal of aquatic organisms has been achieved primarily through transoceanic shipping (Williams et al. 1988; Carlton and Geller 1993), with ports acting as distribution hubs (Morton 1987; Willan 1987). Therefore, because the bulk of international trade is carried by ships, regions with growing economies should be considered as potential future donors of exotic species.

The presence of strong dispersal pathways and vector activity between the potential donor and target regions may indicate a high probability of future invasion. For example, repeated ballast-water discharges by European shipping using the St. Lawrence Seaway have resulted in the establishment of numerous species of exotic algae, invertebrates, and fishes in the Great Lakes; in fact, over 30% of all invasions in the Great Lakes have occurred following the opening of the Seaway (Mills et al. 1993a). Similarly, an increase in the net tonnage of ships arriving from East Asian ports over the past three decades has coincided with introductions of a variety of Asian invertebrates into Pacific North American estuaries (Cordell et al. 1992; Cohen and Carlton 1998). Therefore, Carlton (1996) suggested that an analysis of shipping traffic from regions containing known invaders such as the zebra mussel (e.g., the Great Lakes) or the Japanese crab *Hemigrapsus sanguineus* (e.g., Long Island Sound) could help predict where these species will next invade. While the probability of future North American invasions should be reduced by recent U.S. and Canadian regulations requiring oceanic exchange of ballast water, not all ships comply and incomplete ballast-water exchanges are common (Locke et al. 1993). Because organisms with saline-tolerant life stages could survive an incomplete ballast-water exchange and remain in the residual water or tank bottom sediments (Carlton 1985; Carlton and Geller 1993; Locke et al. 1993), it is likely that ships will continue to introduce new aquatic species into North America.

#### 2. Select potential invaders using biological criteria

After having identified a potential donor region, a pool of probable invaders could be selected based on a general biological profile of invasive species. Some hypothesized attributes of successful aquatic invaders are listed in Table 1. Few of these generalizations have been confirmed by rigorous

**Table 2.** Ponto-Caspian fauna established in the Great Lakes – St. Lawrence River system (data from Mills et al. 1993a; Witt et al. 1997; Zaranko et al. 1997).

Taxon	Species	Common name	Year of discovery	Mode of invasion
Cnidarians	<i>Cordylophora caspia</i>	Hydroid	1956	Unknown
Amphipods	<i>Echinogammarus ischnus</i>	Gammarid amphipod	1995	Ship ballast water
Bivalves	<i>Dreissena polymorpha</i>	Zebra mussel	1988	Ship ballast water
	<i>Dreissena bugensis</i>	Quagga mussel	1989	Ship ballast water
Fishes	<i>Cyprinus carpio</i>	Common carp	1879	Intentional introduction
	<i>Gymnocephalus cernuus</i>	Ruffe	1987	Ship ballast water
	<i>Neogobius melanostomus</i>	Round goby	1990	Ship ballast water
	<i>Proterorhinus marmoratus</i>	Tubenose goby	1990	Ship ballast water

statistical and experimental studies, and each has exceptions (Simberloff 1989; Lodge 1993); however, they apply well to a wide variety of invasive organisms and thus provide a useful basis for prediction. For example, a species with high genetic variability, wide tolerance limits, and natural mechanisms for rapid dispersal (e.g., the zebra mussel; Garton and Haag 1991) is more likely to colonize a large geographic range (Ehrlich 1986; Groves and Burdon 1986). Studies on herbaceous plants have shown that the size of the current distribution of a species is often a good predictor of invasiveness (Forcella et al. 1986; Roy et al. 1991; Rejmanek 1996). In fact, a large range is possessed by many invasive freshwater plants and animals, e.g., water hyacinth (*Eichornia crassipes*) (Groves and Burdon 1986), brown trout (*Salmo trutta*) (MacCrimmon et al. 1970), the cladoceran *Daphnia lumholzi* (Have1 et al. 1995), the hydrobiid snail *Potamopyrgus antipodarum* (Zaranko et al. 1997), and the Asiatic clam *Corbicula fluminea* (Morton 1997).

The most consistent attribute of an invasive species is human commensalism. Most successful invaders, particularly major pest species, use dispersal mechanisms that involve human activity (Ehrlich 1986; Groves and Burdon 1986; Morton 1979, 1997). Many invasive bivalves and crustaceans possess planktonic larvae that are more easily transported in ship ballast water (Morton 1979; Carlton 1985; Carlton and Geller 1993). Moreover, recent introductions of the amphipod *Echinogammarus ischnus* (Witt et al. 1997) and round goby (*Neogobius melanostomus*) (Jude et al. 1995) demonstrate that at least some organisms that lack a true planktonic stage can be transported by this mechanism. We recommend that profile-based predictions focus on the ability of an organism to exploit ballast-water transport and that particular attention be given to euryhaline organisms that are either planktonic (pelagic) or have planktonic life stages or behaviours.

### 3. Use invasion history as a predictive criterion

More reliable predictions can be made by assuming that invasive species will continue to invade elsewhere if conditions permit and opportunities arise (Daehler and Strong 1993; Carlton 1996). This premise can be combined with the previous profile-based approach by focusing on species that have an invasion history and an ability to interface with human-mediated dispersal mechanisms, particularly transoceanic shipping. Predictive power can be further enhanced by considering only species that have recently invaded sites (new potential donor regions) from which subsequent dispersal to the

target region is more likely. Using this method, Mills et al. (1993b) successfully predicted the invasion of the Great Lakes by *P. antipodarum*, a snail with an extensive invasion history in Europe; it was recently reported from Lake Ontario (Zaranko et al. 1997). Similarly, *Limnoperna fortunei*, an Asian freshwater mussel that is currently expanding its range in both the Western Pacific and South America, is predicted to become established in North America (Ricciardi 1998).

### Application to predicting invasions: the Great Lakes - Ponto-Caspian example

To demonstrate these approaches, we have selected the Great Lakes - St. Lawrence River as the target region and the Ponto-Caspian (Black, Caspian, and Azov seas) basin as a potential donor region. The former has been colonized by >140 exotic species, of which more than half are of Eurasian origin (Mills et al. 1993a; Witt et al. 1997; Zaranko et al. 1997). The Ponto-Caspian basin possesses a diverse endemic fauna (Mordukhai-Boltovskoi 1979a), is linked to North America by extensive shipping traffic (Locke et al. 1993; Mills et al. 1993a), and is the source of numerous invasive animals characterized by a broad ecological adaptability derived from having evolved under extremely variable hydrological and saline conditions (Zenkevitch 1963). Several Ponto-Caspian species are already established in the Great Lakes system (Table 2); with perhaps one exception, tubenose goby (*Proterorhinus marmoratus*), each of these has had a previous invasion history. Most (75%) were introduced by ballast water within the last 15 years. In fact, several ballast-water introductions of Eurasian fauna into the Great Lakes in the 1970s and 1980s had established a pattern of invasion prior to the arrival of the zebra mussel (Mills et al. 1993a). A focused search of other species likely to use this pathway would have identified the zebra mussel as a probable invader on the basis of its rapidly expanding European range, life history traits that facilitate ballast-water transport (i.e., planktonic larvae, wide salinity tolerance), and occurrence in estuarine waters where shipping traffic is frequent.

Using recent European literature (published after 1960) and Ponto-Caspian species lists provided by Mordukhai-Boltovskoi (1979a), we applied a combination of our predictive approaches to identify a pool of potential North American invaders. We considered 82 euryhaline macroinvertebrates that are endemic to freshwater regions of the Caspian Sea basin. From these, we selected species that belong to taxonomic

**Table 3.** Ponto-Caspian fauna predicted to invade the Great Lakes - St. Lawrence River system.

Taxon	Species	Common name	Literature source <sup>a</sup>
Polychaetes	<i>Hypania invalida</i>	Polychaete worm	9, 10, 11, 14, 15, 16, 23
Amphipods	<i>Corophium curvispinum</i>	Corophiid amphipod	1, 4, 6, 7, 10, 11, 17, 19, 20, 21, 22, 23
	<i>Corophium sowinskyi</i>	Corophiid amphipod	7, 10, 11, 15
	<i>Dikerogammarus haemobaphes</i>	Gammarid amphipod	6, 9, 10, 11, 16
	<i>Dikerogammarus villosus</i>	Gammarid amphipod	10, 11, 13, 16
	<i>Pontogammarus obesus</i>	Gammarid amphipod	6, 7, 10, 11
	<i>Pontogammarus robustoides</i>	Gammarid amphipod	6, 10, 11, 16
	<i>Obesogammarus crassus</i>	Gammarid amphipod	6, 7, 10, 11
Mysids	<i>Limnomysis benedeni</i>	Mysid shrimp	10, 11, 12, 16
	<i>Paramysis intermedia</i>	Mysid shrimp	10, 11, 12, 18
	<i>Paramysis lacustris</i>	Mysid shrimp	3, 10, 11, 12
	<i>Paramysis ullskyi</i>	Mysid shrimp	10, 11, 12, 18
	<i>Hemimysis anomala</i>	Mysid shrimp	10, 11, 24
Bivalves	<i>Hypanys (Monodacna) colorata</i>	Cardiid clam	8, 10, 11, 12, 15, 23
Fishes	<i>Clupeonella caspia</i>	Tyulka; Caspian kilka	5, 10, 11, 12
	<i>Benthophilus stellatus</i>	Starry goby	10, 11, 12, 23
	<i>Neogobius fluviatilis</i>	Monkey goby	2, 10, 11, 12, 23

<sup>a</sup>Sources of information used in our literature survey: 1, Bachmann et al. 1997; 2, Biro 1972; 3, Bondarenko and Yablonskaya 1979; 4, Bortkevitch 1987; 5, Hoestland 1991; 6, Jazdzewski 1980; 7, Jazdzewski and Konopacka 1988; 8, Kogan 1970; 9, Lvova et al. 1996; 10, Mordukhai-Boltovskoi 1964; 11, Mordukhai-Boltovskoi 1979a; 12, Mordukhai-Boltovskoi 1979b; 13, Musko 1989; 14, Nagy 1979; 15, Pirogov et al. 1991; 16, Pligin and Yemel'yanova 1989; 17, Pygott and Douglas 1989; 18, Tarasov 1996; 19, Taylor and Harris 1986; 20, Tittizer et al. 1995; 21, van den Brink et al. 1993; 22, van der Velde et al. 1994; 23, Zenkevitch 1963; 24, Salemaa and Hietalahti 1993.

groups whose life history stages are likely to survive oceanic transport in ship ballast water (cf. Carlton 1985; Carlton and Geller 1993; Locke et al. 1993). From the resulting set (59 species), we identified those that had a documented invasion history, i.e., recent evidence of having successfully invaded habitats outside their natural range; for species that were introduced deliberately into new basins during stocking programs, we required evidence of unintentional secondary spread. Species that are currently invasive in Europe but that were judged unlikely to be transported in ship ballast water (e.g., the crayfish *Astacus leptodactylus*; Holdich and Reeve 1991) were rejected. Other groups (e.g., copepods, cladocerans) were not considered because of taxonomic inconsistencies or insufficient information on invasion history. Our survey (meant primarily to be illustrative rather than comprehensive) revealed 17 Ponto-Caspian invertebrates that have high invasion potential and are likely to survive an incomplete ballast-water exchange and thus should be considered as probable future immigrants to the Great Lakes (Table 3).

### High-risk species: potential impact of Ponto-Caspian fauna

Can we predict the ecological impact of a Great Lakes' invasion by any of these species? An effective approach toward predicting the impact of an invader is to identify patterns in multiple, spatially independent invasions (e.g., Ricciardi et al. 1995, 1996, 1997; Grosholz and Ruiz 1996). While correlative analyses are often limited by a scarce amount of comparable quantitative data, descriptive information on the impacts of previous invasions may still provide a basis for useful predictions, although with a high degree of uncertainty (e.g., Grosholz and Ruiz 1996; Moyle and Light 1996). Simple, but

powerful predictions may result by assuming that invaders will cause significant impacts in the target region if they have already done so in other regions (e.g., Forcella et al. 1986; Townsend and Winterbourn 1992; Ricciardi et al. 1995; Grosholz and Ruiz 1996). Arguably, this approach would have identified Eurasian invaders like the zebra mussel, ruffe (*Gymnocephalus cernuus*), and *Bythotrephes* as species of high impact potential prior to their arrival in North America. Therefore, we searched the literature for evidence of ecosystem alterations by our 17 Ponto-Caspian invertebrates or closely related species. Recognizing that these results are both speculative and subjective, our review suggests that each of the following species would have a significant ecological impact in the Great Lakes - St. Lawrence River system

#### **Corophium spp.**

The suspension-feeding amphipods *Corophium curvispinum* and *Corophium sowinskyi* inhabit fresh and brackish waters of lakes and rivers (Taylor and Harris 1986) and have been spreading across Europe since ca. 1900, using newly constructed canals and shipping traffic to enter adjacent river basins (Jazdzewski 1980). Both species live in massive networks of mud tubes constructed on stable substrata. In the 1980s *C. curvispinum* invaded the Rhine, colonizing hundreds of kilometres of the river and establishing enormous densities (100 000 – 750 000·m<sup>-2</sup>) within only a few years (van der Brink et al. 1993). Similar high densities (>100 000·m<sup>-2</sup>) have been recently recorded in other European rivers (Tittizer et al. 1995; Bachmann et al. 1997). By fixing thick layers (1-4 cm) of mud to the surfaces of stones, *C. curvispinum* displaced filter-feeding caddisflies (*Hydropsyche* sp.) and the zebra mussel from the Dutch Lower Rhine: zebra mussel larvae were

denied suitable settling surfaces, and adult mussels were smothered to death by muddy encrustations (van der Velde et al. 1994). Competition for particulate food may also have occurred. Reductions in total organic carbon and suspended material in the lower Rhine have been attributed to the explosive population growth and filtration activity of the amphipod (van den Brink et al. 1993). These observations suggest that the introduction of Ponto-Caspian corophiids could significantly alter littoral communities and food webs in North American river systems.

### Mysids

Mysid shrimp are diverse and abundant in shallow littoral areas of Ponto-Caspian deltas and estuaries (Mordukhai-Boltovskoi 1964, 1979a). A few species have demonstrated high invasion potential. Recognized as an important food item for fish, *Hemimysis anomala* and *Paramysis* spp. (*P. lacustris*, *P. intermedia*, *P. ullskyi*) have been intentionally transplanted, with remarkable success, into numerous lakes and reservoirs in Eurasia and the Baltic Peninsula, in which they have rapidly formed dense populations (Mordukhai-Boltovskoi 1964, 1979a). Another mysid, *Limnomysis benedeni*, was accidentally introduced into Dnieper reservoirs (Pligin and Yemel'yanova 1989) and has also spread 1700 km up the Danube River. These species have continued to expand their ranges in recent decades (Mordukhai-Boltovskoi 1979a, 1979b; Salemaa and Hietalahti 1993; Tarasov 1996).

Ponto-Caspian mysids differ strikingly from their North American relatives by their adaptation to shallow, warm waters; for example, the metabolic rate of *P. lacustris* at 20°C is similar to that of cold-water mysids at 10°C (Bondarenko and Yablonskaya 1979). This being the case, *Paramysis* and others could potentially invade a large number of North American lakes that are currently devoid of mysids. Their impact in these lakes would likely include a reduction of zooplankton (with concomitant negative effects on planktivorous fishes and higher consumers; cf. Spencer et al. 1991) and biomagnification of contaminants at higher trophic levels through a lengthening of the food chain; PCB and mercury levels in pelagic fishes have been shown to be higher in North American lakes containing mysids than in mysid-free lakes (Rasmussen et al. 1990; Cabana et al. 1994).

### *Clupeonella caspia*

Three fishes from the Ponto-Caspian region, the ruffe, round goby, and tubenose goby, were introduced into the Great Lakes by ballast-water discharge in the 1980s (Mills et al. 1993a; Jude et al. 1995). Additional species that may arrive in the future include a Caspian herring, the "tyulka" (*Clupeonella caspia*). This pelagic planktivore is a fast-growing, eurythermal, and euryhaline species that has historically inhabited coastal waters of the Black and Caspian seas, but has expanded its range throughout the Volga, Don, and Kama rivers in recent decades (Hoestland 1991). In Volga River reservoirs, the tyulka is reported to have become abundant and suppressed native fishes (Mordukhai-Boltovskoi 1979b). It is capable of extreme population fluctuations, and mass winter mortalities in reservoirs have been reported (Hoestland 1991). We predict that the tyulka would cause reductions of native planktivores (e.g., coregonids, shiners, yellow perch (*Perca flavescens*)) in the Great Lakes system, similar to the observed impacts of

another introduced clupeid, the alewife (*Alosa pseudoharengus*) (Brandt et al. 1987). The tyulka poses the added threat of invading lakes that are currently devoid of important pelagic forage fish, which could result in increased contaminant levels in piscivores, an effect already documented for introduced smelt (Vander Zanden and Rasmussen 1996).

### Conclusion: using predictive approaches as an early-warning system

We have demonstrated how simple, low-cost approaches could be used to identify species with high invasion and impact potential. In spite of any perception that "the worst is over" (i.e., all significant invaders have already arrived), our results suggest that the Great Lakes - St. Lawrence River system and other North American inland waterways will continue to receive and be impacted by invasive Eurasian fauna.

Because the ecological and economic costs of invasion are high (OTA 1993), resources should be allocated towards prevention. Preventative measures depend on advance knowledge of invasion threats, which can be gained from careful monitoring of information networks (e.g., literature, the internet, symposia), and the application of the guidelines we have described. Such endeavors would be aided greatly by the development of a broadly accessible electronic inventory of aquatic invaders, with information about their life history, habitat requirements, dispersal patterns, and methods of control. Even when invasion is imminent, advance knowledge could prepare us for dealing with the ecological and technological impacts that may follow. Given the detrimental effects of invasive aquatic organisms on fisheries, biodiversity, outdoor recreation, and water supply systems (e.g., Morton 1979, 1997; Kaufman 1992; Lodge 1993; Mills et al. 1993a; OTA 1993), the identification of future invaders should be a common priority among scientists and policy makers.

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