Vanden Berghe E., M. Brown, M.J. Costello, C. Heip, S. Levitus and P. Pissierssens (Eds). 2004. p. 115-124
Proceedings of 'The Colour of Ocean Data' Symposium, Brussels, 25-27 November 2002
IOC Workshop Report 188 (UNESCO, Paris). x + 308 pp.
– also published as VLIZ Special Publication 16

Informational resources on aquatic alien species in Europe on the internet: present developments and future perspectives

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Abstract

During the last two decades rates of invasions of European inland and coastal waters by alien species increased significantly. The development of an internet-based informational resources database on aquatic invasive species is considered as one of the most important mechanisms of information exchange within the scientific community. These resources may provide comprehensive information for management of aquatic invasive species in Europe, as well as for scientific and educational purposes. At present, the online informational resources on aquatic alien species from Europe are located in several online national, regional and global databases and information systems. However, at present the available online information is generally not sufficient for management purposes, such as prevention of new introductions, or control and eradication of the established invasive alien species. Future development of the internet resources on aquatic alien species in Europe should consider the integration in the developing global network of online interoperable databases and information systems. Priority should be given to the development of the interlinked regional information hubs, which should provide comprehensive information on aquatic alien species, including regional alien species directories with species-specific entries, and online access to the datasets of geo-referenced monitoring data. The development of species-specific entries for regional directories can be conducted by the European experts, including participants of the European Research Network of the Aquatic Invasive Species (ERNAIS).

Keywords: Invasive alien species; Aquatic ecosystems; Databases; Information systems; Internet resources.

Introduction

During the last decades the invasion rates of alien species[1] into European inland and coastal waters increased significantly. A number of alien species arrived in Europe from other parts of the world with ship ballast water and as hull fouling. The breaking of natural barriers between water basins by the construction of canals in the 19th and 20th centuries resulted in the spread of hundreds of alien species. Headlong intentional introductions also contributed to the number of invaders, including invasive and pathogen organisms. Currently several hundreds of species are considered as alien in the Mediterranean Sea (Galil, 2000; Galil and Zenetos, 2002). It is believed that about 100 aquatic invaders occur in the Baltic Sea, with 56 species first recorded during 1950-2002 (Baltic Alien Species Database, 2001; Leppäkoski *et al.*, 2002a). In the Black Sea, 59 species are considered as alien, including 49 species introduced during the last 50 years (Zaitsev and Öztürk, 2001). In many cases introductions of invasive species have caused significant losses in marine, estuarine and inland water biodiversity and economy in Europe (Leppäkoski *et al.*, 2002b).

The development of open databases and information systems on invasive alien species is essential for the effective international cooperation in data and expertise sharing, and provides support for management and control efforts. Internet-based information systems may serve as the main tool for the wide dissemination of information on taxonomy, biology, environmental impacts and possible control measures of invasive species. International law requires governments and other relevant organizations to support the creation and maintenance of the databases, information systems and interoperable distributed network of databases for the compilation and dissemination of information on alien species for the use in the context of any prevention, introduction, monitoring and mitigation activities. The 6th Conference of the Parties of the Convention on Biological Diversity agreed that a Clearing-house mechanism will be useful to facilitate scientific and technical cooperation on invasive species issues, and notified the Global Invasive Species Programme (GISP, 1999) as an international thematic focal point for alien species under the clearing-house mechanism, and calls on Parties, countries and relevant organizations to contribute to the creation and maintenance of the global information network, in particular to ensure effective international cooperation and expertise sharing (Decision VI/23, 2002).

Currently relevant international organizations and working groups are actively working on the development of open informational resources on aquatic alien species in Europe (GloBallast, 2001; Gollasch, 2002; Olenin *et al.*, 2002; Panov *et al.*, 2002). These resources may provide comprehensive information for the management of invasive alien species in European inland and coastal waters, as well as for scientific and educational purposes, and form a 'European hub' of the global invasive species informational network. The goal of the present paper is to overview the existing online informational resources on aquatic alien species in Europe, and to discuss perspectives of their further development.

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[1] The following definitions are used: (i) 'alien species' refers to a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce; (ii) 'invasive alien species' means an alien species whose introduction and/or spread threatens biological diversity (iii) 'introduction' refers to the movement by human agency, indirect or direct, of an alien species outside of its natural range (past or present) (Decision VI/23, 2002).

Global Informational Resources

ISSG Global Invasive Species Database

The Global Invasive Species Database was developed by the IUCN/SSC Invasive Species Specialist Group (ISSG) as part of the Global Invasive Species Programme (GISP, 1999). It provides global information on invasive alien species to agencies, resource managers, decision-makers, and interested individuals. The database focuses on invasive species that threaten biodiversity and covers all taxonomic groups from micro-organisms to animals and plants. Species information is supplied by expert contributors from around the world and includes: species' biology, ecology, native and alien range, references, contacts, links and images. Currently it includes searchable entries for 100 of 'World's Worst Invasive Alien Species', which consider both aquatic invasive species of European origin (fishhook waterflea *Cercopagis pengoi*, zebra mussel *Dreissena polymorpha*, green crab *Carcinus maenas*, common carp *Cyprinus carpio*, brown trout *Salmo trutta*), and harmful aquatic species, intentionally or unintentionally introduced into European inland and coastal waters from other regions (Pacific sea weed *Caulerpa taxifolia*, Japanese kelp *Undaria pinnatifida*, Atlantic ctenophore *Mnemiopsis leidyi*, Chinese mitten crab *Eriocheir sinensis*, Western mosquitofish *Gambusia affinis*, large-mouth bass *Micropterus salmoides*, common tilapia *Oreochromis mossambicus*). These informational resources are linked to the Baltic Sea Alien Species Database, Caspian Sea Biodiversity Database and the Regional Biological Invasions Center Information System (see the following chapter) (ISSG Global Invasive Species Database).

The FAO Database on Introductions of Aquatic Species (DIAS)

The FAO database on introductions of aquatic species currently contains about 3,150 records of introductions of freshwater and marine fishes, and other taxa, and can be queried through the Search Form. The database includes records of species introduced or transferred from one country to another. Coverage of accidental introductions of organisms (e.g. through ship ballast waters) is not complete and records on this topic have been generally entered only when important impacts on fisheries or on the environment have been caused (introduction of *Mnemiopsis leidyi* to the Black Sea, for instance).

Global Information System on Fishes (FishBase)

Global Information System on Fishes (FishBase) is one of the most comprehensive online informational resources on freshwater and marine fishes. FishBase was developed at the International Center for Living Aquatic Resources Management (ICLARM) in collaboration with the Food and Agriculture Organization of the United Nations (FAO) and with the support from the European Commission. FishBase is a relational database, which contains practically all fish species known to science (more than 25,000 species), including information on invasive European species (round goby *Neogobius melanostomus*, ruffe *Gymnocephalus cernuus* etc.), and fish species, alien for the European waters (Amur sleeper *Perccottus glenii*, stone morone *Pseudorasbora parva* and other). Species-specific entries include comprehensive information on fish species distribution, morphology, biology, references and links to other relevant internet sources of information (Froese and Pauly, 2002). However, detailed information on the

distribution of invasive fish species in European waters, their invasion history and environmental impacts is not available in FishBase.

Global Ballast Water Management Programme (GloBallast) Information Resource

Comprehensive information of ballast water management is available at the Global Ballast Water Management Programme (GloBallast) website, which represents the global clearinghouse on ballast water management. The GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast) is assisting developing countries to reduce the transfer of harmful aquatic organisms and pathogens in ship ballast water, implement the IMO ballast water guidelines and prepare for the new IMO ballast water convention. The GloBallast website includes detailed information and links to other open sources of information on legislation, available ballast water treatment technologies, and provides reviews and links to the main online national, regional and national databases and information systems on aquatic alien species (GloBallast, 2002).

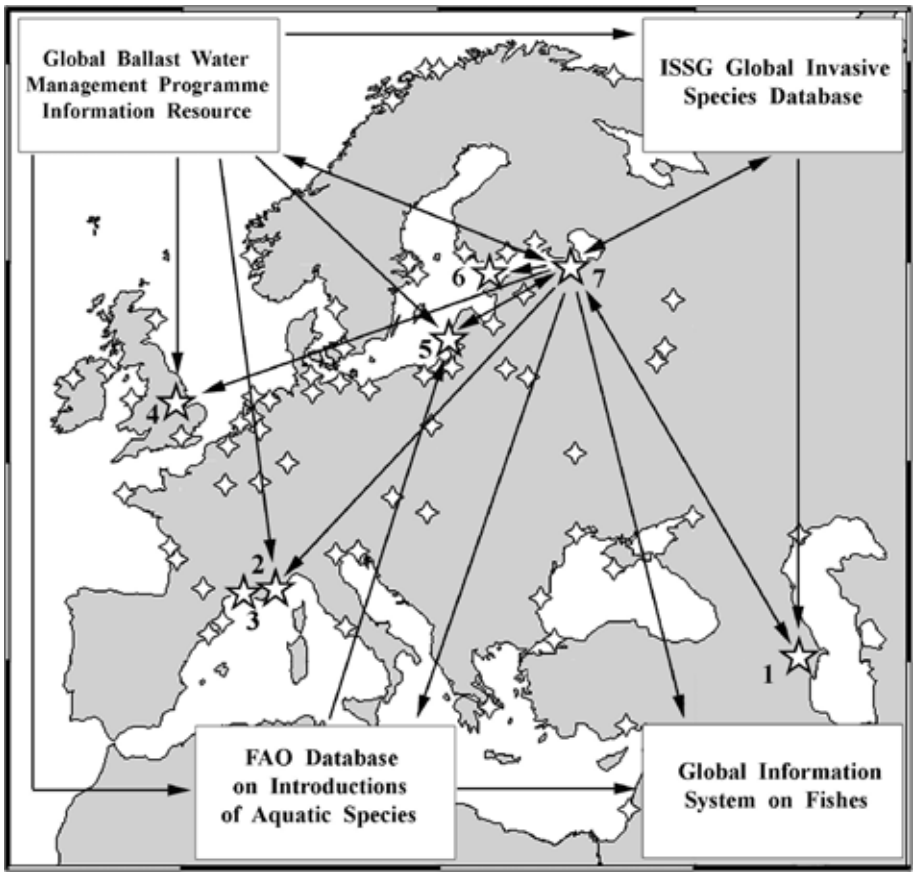

Fig. 1. Location of the main national and regional internet resources on aquatic alien species in Europe and links between them and with global online resources (1- Caspian Sea Biodiversity Database, 2- CIESM Atlas of Exotic Species, 3-Caulerpa taxifolia Database, 4- Directory of Non-native Marine Species in British Waters, 5- Baltic Sea Alien Species Database, 6- Marine Alien Species of Estonia Website, 7- Regional Biological Invasions Center Information System; small asterisks indicate ERNAIS sites).

National and Regional Informational Resources

Internet resources on aquatic alien species in the United Kingdom

Directory of Non-native Marine Species in British Waters

The Directory of Non-native Marine Species in British Waters, hosted on the website of the Joint Nature Conservation Committee (JNCC), includes entries on 53 species, alien for British coastal waters. The species-specific entries include data on species taxonomy, dates of introduction, origin, method of introduction, rates of spread, brief description of distribution, effects on the environment and control methods. The list of alien species includes such invasive organisms as the Japanese brown alga *Sargassum muticum*, the East Asian parasitic nematode *Anguillicola crassus*, the Atlantic polychaete *Marenzelleria viridis*, the New Zealand mud snail *Potamopyrgus antipodarum*, the Japanese oyster *Crassostrea gigas*, the North Atlantic clam *Mya arenaria*, the West Atlantic crab *Rhythropanopeus harrisii* and the Chinese mitten crab *Eriocheir sinensis* (Directory of Non-native Marine Species in British Waters).

The Chinese Mitten Crab homepage

The Chinese Mitten Crab homepage, hosted by the Natural History Museum, represents a useful online information source on the Chinese mitten crab *Eriocheir sinensis*. It includes detailed information on the taxonomy of this invasive species, the description of its life history with pictures of its life cycle, its distribution in North America, Europe and Great Britain (illustrated by maps), information on environmental problems, associated with this species introduction (The Natural History Museum, 2002).

Biological Records Centre (BRC) website

The Biological Records Centre (BRC) website, hosted by the Center for Ecology and Hydrology (CEH), is the national custodian of data on the distribution of wildlife in the British Isles, and provides online access to the data on the distribution of species via a sophisticated information system (The National Biodiversity Network Gateway). This system gives access to the National Biodiversity Network species dictionary and 10-km distribution maps. The pilot version includes data from the BRC database (including data on native and introduced crayfish) and several other data sets (including data on some marine invasive species) (The Biological Records Centre).

Marine Alien Species of Estonia website

The Marine Alien Species of Estonia website, hosted by the Estonian Marine Institute in Tallinn, includes standardized entries on 12 alien species, established in Estonian coastal waters, with information on species identification, natural range, invasion history in the Baltic Sea, distribution and population dynamics, ecological and economic impact, list of references. Alien species divided in three main subgroups by lifestyle: plankton (three species, including invasive

Ponto-Caspian fishhook waterflea *Cercopagis pengoi*), benthic invertebrates (six species, including invasive Ponto-Caspian zebra mussel *Dreissena polymorpha*, New Zealand mud snail *Potamopyrgus antipodarum*, Chinese mitten crab *Eriocheir sinensis*, Atlantic polychaete *Marenzelleria viridis*), and fishes (four species, including the invasive Ponto-Caspian round goby *Neogobius melanostomus*) (Marine Alien Species of Estonia).

The Caulerpa taxifolia *website*

The *Caulerpa taxifolia* website (information system) is located at the University of Nice-Sophia Antipolis (France), and provides distributional maps, information on environmental impacts and images of this extremely invasive Pacific macroalgae ('killer alga'), which possesses a very high potential to spread and replace native species.

CIESM Atlas of Exotic Species

The International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) Atlas of Exotic Species includes detailed description of 125 alien species of mollusks, 55 species of alien crustaceans and 91 alien fish species that invaded the Mediterranean Sea. The list of alien species includes several highly invasive species (the Pacific gastropod *Rapana venosa*, the West Atlantic crabs *Rhythropanopeus harrisii* and *Callinectes sapidus*, the Chinese mitten crab *Eriocheir sinensis*). Individual species entries include species images, their diagnostic features, biological information, references and distribution maps (CIESM, 2001).

Caspian Sea Biodiversity Database

The demonstration version of the Caspian Sea Biodiversity Database (CSBD) has been developed during 2001-2002 in the frameworks of the UNDP Caspian Environment Programme (CEP), and posted on the CEP website in June 2002. The CSBD consists of English and Russian versions, and currently includes entries on 36 aquatic species, both native (30 species) and alien (6 species) for the Caspian Sea ecosystem (Caspian Sea Biodiversity Database, 2002). Alien species in the CSBD are represented by three unintentionally introduced zooplankton organisms: the Mediterranean diatom alga *Rhizosolenia calcar-avis*, the Atlantic copepod *Acartia tonsa*, the Atlantic ctenophore *Mnemiopsis leidyi*, and three intentionally introduced organisms: the Atlantic-Mediterranean clam *Abra ovata*, and two fish species, *Liza aurata* (Atlantic-Mediterranean), and *Liza saliens* (Mediterranean). The CSBD also includes entries on two native species, considered as highly invasive outside the Ponto-Caspian Region, the cladoceran *Cercopagis pengoi* (fishhook waterflea) and fish *Neogobius melanostomus* (round goby). Entries in the database include information on species taxonomy, their distribution and biology, references and illustration of organisms. Entries on *Cercopagis* and *Mnemiopsis* include internet-links to entries on these species in the Regional Biological Invasions Center Information System (see below).

Baltic Sea Alien Species Database

An internet database on aquatic alien species in the Baltic Sea area was developed as an initiative of the Baltic Marine Biologists´ Working Group on Non-indigenous Estuarine and Marine Organisms in 1997; in 2000 a new concept of the online database appeared with support received from the Baltic Marine Environment Protection Commission (HELCOM). At present the database represents an interactive user-friendly tool, which includes several information retrieving options. The database species directory contains individual species entries. An entry includes the complete taxonomy of a species and available comments, complementing and specifying the Database features (year of introduction, ecological impact, etc.). The database search tool is a direct way to retrieve information according to the major features. It allows the retrieval of data by a single feature (i.e. by 'Taxon') or by combined features (i.e. 'Taxon' and 'Origin' and 'Ecological impact'), including multiple selections of items within any feature. A list of species, retrieved according to the selected criteria, is linked to relevant individual entries on species and references (Baltic Sea Alien Species Database, 2002; Olenin *et al.*, 2002), which include individual entries on such invasive Ponto-Caspian species as fishhook waterflea *Cercopagis pengoi* and the round goby *Neogobius melanostomus*. Some species-specific entries are hosted by the Regional Biological Invasions Center Information System (see below), the entry for the zebra mussel, *Dreissena polymorpha*, for instance.

Regional Biological Invasions Center Information System

The Regional Biological Invasions Center Information System (RBIC), hosted by the Zoological Institute of the Russian Academy of Sciences in St. Petersburg, is a new concept of the Group on Aquatic Alien Species (GAAS) website, which initially opened in 1999 (Panov, 1999). Currently RBIC is serving as the regional clearinghouse on invasive alien species (both aquatic and terrestrial), and as a web portal, providing access to the internet-based information resources on invasive species research and management in Europe and worldwide (Fig. 1) (Regional Biological Invasions Center, 2001a). The development of the Geographic Information System 'INVADER' as an international database on the internet is one of the RBIC priorities. Currently a demonstration version of GIS 'INVADER', with comprehensive geo-referenced information on the distribution of the Ponto-Caspian invasive cladoceran *Cercopagis pengoi* in Europe and North America, is available online (Regional Biological Invasions Center, 2001b). Online geo-referenced distribution maps of selected aquatic invasive species, including the Atlantic ctenophore *Mnemiopsis leidyi*, the Ponto-Caspian mussel *Dreissena polymorpha* and the cladoceran *Cercopagis pengoi*, along with detailed descriptions of their taxonomy, invasion histories, biology, environmental impacts are available at the RBIC Illustrated Database of the Aquatic Invasive Species of Europe, interlinked with the Baltic Sea Alien Species Database, the Global Invasive Species Database and the Caspian Sea Biodiversity Database (Regional Biological Invasions Center, 2001c). Entry on *Mnemiopsis leidyi* provides an example of a comprehensive and user-friendly online information system on the aquatic invasive species, linked to other internet-based sources of information (Shiganova and Panov, 2002). Entry on *Mnemiopsis* in the RBIC Illustrated Database is already serving as open information system on *Mnemiopsis* for the Ponto-Caspian Region, updated on a regular basis.

The RBIC portal is also supporting web pages of some international working groups and networks, including the developing European Research Network on Aquatic Invasive Species, the Caspian Environment Program Regional Invasive Species Advisory Group and SIL Working

Group on Aquatic Invasive Species (Regional Biological Invasions Center, 2001d), and serving as a regional information hub for the developing global invasive species informational network (for more information on the global network see the online Report of the Joint Convention on Biological Diversity/Global Invasive Species Programme Informal Meeting on Formats, Protocols and Standards for Improved Exchange of Biodiversity-related Information 2002, and Report of the Workshop on Development of Nordic/Baltic Invasive Species Information Network 2002). RBIC is interlinked with the United States Geological Survey Nonindigenous Species Information Resource, which has been established as a central repository for accurate and spatially referenced biogeographic accounts of alien (nonindigenous) aquatic species, and represents American information hub of the global invasive species informational network.

Recommendations

At present, the online informational resources on aquatic alien species in Europe are located in several online national, regional and global databases and information systems, briefly described above. These informational resources are already linked within the World Wide Web, with the Regional Biological Invasions Center Information System (RBIC) serving as a regional web portal (Fig. 1). However, at present available online information is not sufficient for management purposes, such as prevention of new introductions, or control and eradication of the established invasive alien species. Probably only in the case of the invasive ctenophore *Mnemiopsis leidyi*, available information in the interlinked Global Invasive Species Database, Caspian Sea Biodiversity Database and RBIC is sufficient enough for the elaboration of adequate control measures in the Ponto-Caspian Region, as well as for undertaking preventive management options in the potential regions-recipients of this harmful species (in the Baltic Sea Region, for instance).

Future development of the internet resources on aquatic alien species in Europe should consider the integration in the developing global network of online interoperable databases and information systems (see Introduction). Priority should be given to the development of the interlinked regional information hubs, like those serving the Nordic/Baltic Region (interlinked Baltic Sea Alien Species Database and RBIC) and Mediterranean Sea (CIESM Atlas of Exotic Species). The creation of other regional information hubs is needed, specifically for the Ponto-Caspian Region. Its biodiversity and fisheries are threatened by alien species introductions. They represent an important donor area of aquatic invasive species for European inland and coastal waters and worldwide. These regional information hubs should provide comprehensive information on aquatic alien species, including regional alien species directories with species-specific entries, and online access to the datasets of geo-referenced monitoring data. Timely access to such open geo-referenced data, using already available internet and GIS technologies (like demonstrated at the RBIC and Biological Records Centre websites) may ensure service of the regional information hubs as effective management tools (early warning systems, for instance). The development of species-specific entries for regional directories can be conducted by the relevant European experts, whose contact information and area of expertise is available in the online database of the European Research Network of the Aquatic Invasive Species (ERNAIS) (Regional Biological Invasions Center, 2001). The timely incorporation of geo-referenced data from aquatic alien species monitoring into open national and regional databases is a challenging goal and the elaboration of effective mechanisms of achievement of this goal should be considered as one of the future priorities in the process of the development of online informational resources on aquatic alien species in Europe.

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