Frontiers in Ecology and the Environment

Assessing the global threat of invasive species to marine biodiversity

Jennifer L Molnar, Rebecca L Gamboa, Carmen Revenga, and Mark D Spalding

Front Ecol Environ 2008; 6, doi:10.1890/070064

Assessing the global threat of invasive species to marine biodiversity

Jennifer L Molnar[1*], Rebecca L Gamboa[1], Carmen Revenga[2], and Mark D Spalding[3]

Although invasive species are widely recognized as a major threat to marine biodiversity, there has been no quantitative global assessment of their impacts and routes of introduction. Here, we report initial results from the first such global assessment. Drawing from over 350 databases and other sources, we synthesized information on 329 marine invasive species, including their distribution, impacts on biodiversity, and introduction pathways. Initial analyses show that only 16% of marine ecoregions have no reported marine invasions, and even that figure may be inflated due to under-reporting. International shipping, followed by aquaculture, represent the major means of introduction. Our geographically referenced and publicly available database provides a framework that can be used to highlight the invasive taxa that are most threatening, as well as to prioritize the invasion pathways that pose the greatest threat.

Front Ecol Environ 2008; 6, doi:10.1890/070064

Invasive species have transformed marine habitats around the world. The most harmful of these invaders displace native species, change community structure and food webs, and alter fundamental processes, such as nutrient cycling and sedimentation. Alien invasives have damaged economies by diminishing fisheries, fouling ships' hulls, and clogging intake pipes. Some can even directly impact human health by causing disease (Ruiz *et al.* 1997). Although only a small fraction of the many marine species introduced outside of their native range are able to thrive and invade new habitats (Mack *et al.* 2000), their impact can be dramatic.

The impacts of invasions may be seen locally, but the drivers of biological invasion are, to an increasing degree, global. Unfortunately, there is a paucity of information on invasive species at the global scale. The Convention on Biological Diversity (CBD) has identified the need for "compilation and dissemination of information on alien species that threaten ecosystems, habitats, or species, to be used in the context of any prevention, introduction and mitigation activities" (CBD 2000). Most data have been compiled at local, national, or regional scales (Ricciardi *et al.* 2000). Data that do exist often do not have consistent formats or definitions, and are therefore not easily comparable (Crall *et al.* 2006). Many datasets also lack information regarding ecological and economic impacts, and are therefore unable to inform risk assessments or to catalyze effective policies across national borders.

Once alien species become established in marine habitats, it can be nearly impossible to eliminate them (Thresher and Kuris 2004). Interception or removal of pathways are probably the only effective strategies for reducing future impacts (Carlton and Ruiz 2005). With limited funds, establishing priorities is key, so that money allocated for prevention of invasions is well spent. Prioritizing actions requires knowing which species are likely to be most harmful to native ecosystems (Byers *et al.* 2002), current distributions of these species, and how they are likely to be transported to new regions.

This paper describes a new effort to quantify the geographic distribution of the threat of invasive species to marine biodiversity worldwide. We present an analytical framework that allows users to capitalize on existing information by: (1) integrating data from diverse sources in a uniform manner; (2) systematically scoring the threat of each alien species to native biodiversity; (3) collecting information by geographic units (marine ecoregions), so that data can be summarized and analyzed with other datasets at this scale; and (4) documenting introduction pathways for each species. Using the information compiled to date, we also present some initial findings from this dataset. This is not an exhaustive analysis, but illustrates the utility of the database, and provides some

In a nutshell:

- Marine invasive species are a major threat to biodiversity, and have had profound ecological and economic impacts
- Developing effective prevention strategies requires global information, but most datasets are local or regional
- A new database, containing a simple, quantified threat-scoring index and introduction pathways classification, provides a critical tool for objectively comparing marine invasions worldwide
- Initial results confirm earlier assessments of the primary importance of shipping and aquaculture as introduction pathways and of the high levels of invasion in the temperate regions of Europe, North America, and Australia

[1]*The Nature Conservancy, Seattle, WA 98101* [*]*(jmolnar@tnc.org);* [2]*The Nature Conservancy, Arlington, VA 22203;* [3]*The Nature Conservancy, Newmarket CB8 8AW, UK*

new insight into patterns and processes of global marine invasions.

Scope of the assessment

This assessment is focused on the global distribution patterns and impacts of alien species on native species and habitats in the coastal marine environment. Species that primarily occur in and modify human-managed waters (eg aquaculture) have been included, but only their impacts on native biodiversity are documented.

There are multiple ways to define "invasive species" (Lodge *et al.* 2006). Recognizing the limitations and practical needs of a global study, we use a broad definition that includes any species reported to have become established outside of its native range (Richardson *et al.* 2000; Rejmánek *et al.* 2002). This differs from the narrower definition used for public policy purposes, which requires that the species cause negative economic, environmental, or public health impacts (eg US Federal Executive Order 13112 1999; McNeely *et al.* 2001), but it allows incorporation of information from a broader array of data sources. We devised a threat scoring system to indicate the magnitude of species' ecological impact and invasive potential within the global framework.

We report non-native occurrences by ecoregion, using a biogeographic classification recently developed for marine coastal environments (www.nature.org/MEOW; Spalding *et al.* 2007). Ecoregions are widely used for conservation planning and strategic analysis by major conservation NGOs (Olson *et al.* 2001). Marine ecoregions have been defined as "areas of relatively homogeneous species composition, quite clearly distinct from adjacent systems" (Spalding *et al.* 2007). They are contained within marine realms, which are defined as large areas of ocean in which biota share a similar evolutionary history due to isolation or other factors (Spalding *et al.* 2007). We selected these units of analysis because they are global in scale and commensurate with the resolution of the data in a way that is useful for ecologically guided, regional risk assessment. Additional research was often necessary to convert data reported by political units (eg countries, states) into biogeographic terms.

We developed our data collection methods to allow consistent documentation of information across taxa and habitats. Related ongoing assessments of terrestrial and freshwater invasive species will be reported elsewhere.

Database development

We collected information on marine invasive species from a variety of sources and compiled the information in a geographically referenced database. In addition to non-native distributions by marine ecoregion, we documented habitat types, native distributions, and introduction pathways for each species. We also collected detailed information about the threat that each species posed to native biodiversity, using the scoring system described below. A description of our data collection methods is provided in WebPanel 1.

Input data were restricted to published sources or otherwise highly credible, publicly available datasets, with a robust scientific framework; all sources are referenced in the database. We initially targeted datasets that covered broad spatial scales and taxonomic groups. Regional, national, and some sub-national datasets, along with literature and internet resources, were used to supplement data gaps and provide information at a finer scale. Data collection is ongoing. The database is available online (www.nature.org/marineinvasions) and will be updated periodically.

Threat scoring system

The number of alien species in a habitat does not indicate the level of threat posed to native biota or the damage already done. Many species establish in a new habitat with few disruptions, whereas others alter entire ecosystems or put native species at risk of extinction. We developed a threat-scoring system, based on several existing threat classification systems (Cal-IPC 2003; Salafsky *et al.* 2003; NatureServe 2004), to capture information on the threat posed by alien species.

Each invasive species was assigned a score (where data allowed) for the following categories: ecological impact, geographic extent, invasive potential, and management difficulty (Panel 1).

The "ecological impact" score measures the severity of the impact of a species on the viability and integrity of native species and natural biodiversity. For example, the green alga, *Caulerpa taxifolia*, was assigned the highest ecological impact score (4), based on its ability to outcompete native species and reduce overall biodiversity (Jousson *et al.* 2000). The sea slug, *Godiva quadricolor*, was conservatively assigned a lower score (2), because its only known impact is feeding on one taxon – other sea slugs – with no wider effects documented (Hewitt *et al.* 2002).

The ecological impact score was assigned globally for each species, not for specific occurrences. For consistency, this score reflects the most damaging documented impacts, although geographic variation and diversity of impacts were also noted where available. Where impact information was ambiguous, we were conservative and assigned a lower score. Because we are assessing the ecological impacts of invasive species, we have, to date, only included species for which we found documentation of ecological impacts, or lack thereof. We did not track how many species were excluded due to this criterion. We believe that the most harmful species are also the best documented, so that even at this stage, our work has a representative coverage of these most harmful species.

Species not captured in our database probably have relatively low ecological or economic impact and may include microorganisms whose introductions are largely unrecorded and whose impacts remain poorly understood (Drake *et al.* 2007). "Geographic extent" captured the scale of each species' invasive range. It was defined relative to ecoregion size, instead of by absolute units (eg area, length of coastline), to allow use across marine, freshwater, and terrestrial environments. "Invasive potential" is an estimate of the magnitude of the current or recent rate of spread and the potential for future spread after introduction to new habitats. The "management difficulty" score indicates the effort required to reverse the threat, remove the species, and/or manage its presence.

Threat scores were necessarily semi-quantitative, but they correspond to categories that differ substantially in threat level, with clearly defined parameters for assigning individual scores (WebPanel 1). This enabled us to include a broad range of information and to use the same categorical scoring across marine, freshwater, and terrestrial habitats.

Panel 1. Threat scoring system

Each species in our assessment was assigned a score for each of the following categories (where data allowed), to indicate the magnitude of the threat it poses to native biodiversity. The scoring system was devised so that it could be applied consistently to different types of species and to those living in marine, freshwater, and terrestrial habitats.

Ecological impact

4 – Disrupts entire ecosystem processes with wider abiotic influences
3 – Disrupts multiple species, some wider ecosystem function, and/or keystone species or species of high conservation value (eg threatened species)
2 – Disrupts single species with little or no wider ecosystem impact
1 – Little or no disruption
U – Unknown or not enough information to determine score

Geographic extent

4 – Multi-ecoregion
3 – Ecoregion
2 – Local ecosystem/sub-ecoregion
1 – Single site
U – Unknown or not enough information to determine score

Invasive potential

4 – Currently/recently spreading rapidly (doubling in < 10 years) and/or high potential for future rapid spread
3 – Currently/recently spreading less rapidly and/or potential for future less rapid spread
2 – Established/present, but not currently spreading and high potential for future spread
1 – Established/present, but not currently spreading and/or low potential for future spread
U – Unknown or not enough information to determine score

Management difficulty

4 – Irreversible and/or cannot be contained or controlled
3 – Reversible with difficulty and/or can be controlled with significant ongoing management
2 – Reversible with some difficulty and/or can be controlled with periodic management
1 – Easily reversible, with no ongoing management necessary (eradication)
U – Unknown or not enough information to determine score

Pathways

To consistently document introduction information in our database, we needed a classification of marine, terrestrial, and freshwater species pathways that would allow for the capture and summary of data with various levels of detail. We based our framework on the outline developed by the US National Invasive Species Council's Pathways Team (Campbell and Kriesch 2003; revised by Lodge *et al.* 2006). This team developed "a system for evaluating the significance of invasive species pathways" into and within the US, broadly defining pathways as "any means that allows entry or spread of an invasive species" (Campbell and Kriesch 2003). Although this system includes routes of introduction that others may consider to be vectors (Carlton and Ruiz 2005) and categories are not always mutually exclusive, it allows the practical categorization of commonly reported information on pathways and vectors. We modified this system slightly, to better fit a global assessment and made category adjustments to allow effective gathering of data by species (Panel 2).

Using this framework, we documented all known and likely pathways for each species in our database. We only included pathways to new habitats, not methods for local dispersal. We were not geographically specific (eg we recorded that a particular species could be carried in ballast water, but not the specific ports between which it traveled). We documented additional introduction information, including whether the introduction of a species via a pathway was intentional or accidental.

Assessing the extent and impact of invasive species

We have compiled information from over 350 data sources. The database now includes 329 marine invasive species, with at least one species documented in 194 ecoregions (84% of the world's 232 marine ecoregions; Figure 1). The dominant groups of species in our database are crustaceans (59 species), mollusks (54), algae (46), fish (38), annelids (31), plants (19), and cnidarians (17).

We scored all 329 species for ecological impact and geographic extent. The mean ecological impact score was 2.55 (SD = 1.04) – halfway between "disrupts single species with little or no wider ecosystem impact" and "dis-

Panel 2. Pathways framework

We used this framework to document known and likely pathways for each marine species in our assessment. It was adapted from the National Invasive Species Council Invasive Species Pathway Team, with "pathways" defined broadly as "any means that allows entry or spread of an invasive species" (Campbell and Kriesch 2003). This outline has been summarized to highlight sub-pathways for marine species; see WebPanel 2 for full outline with all sub-pathways.

Transportation-related pathways

- Modes of transportation
  - Air transportation
  - Freshwater/marine transportation
    - Ballast and/or fouling
      - Ballast water and sediments
      - Hull/surface fouling
    - Stowaways in holds
    - Superstructures/structures above the water line
    - Dredge spoil material
    - Canals that connect waterways
  - Land/terrestrial transportation
- Items used in shipping process
  - Containers – both exterior and interior
  - Packing materials
- Tourism/travel/relocation
- Mail/internet/overnight shipping companies

Commerce in living organisms pathways

- Live seafood trade
- Livestock
- Aquaculture and mariculture activities
  - Enclosed facilities
  - Stocking in open water
- Pet, aquarium, and water garden trade
- Bait industry
- Biocontrol
- Nurseries/garden/landscaping
- Agricultural and forestry species trade
- Plants and plant parts as food
- Other animal trade
- Other plant trade

Other human-assisted pathways

- Ecosystem disturbance
- Climate change

Natural spread

rupts multiple species, some wider ecosystem function". Most species have been found in multiple ecoregions (mean geographic extent score of 3.98, SD = 0.19). We scored 324 species for invasive potential, with a mean score of 2.05 (SD = 1.03; "established/present…high potential for future spread"). The 268 species scored for management difficulty had a mean of 3.56 (SD = 0.71), indicating that most are difficult if not impossible to remove or control.

A primary driver for the development of this assessment was to provide a means of distinguishing relatively low-impact invasive species from those with potentially severe detrimental effects. We defined "harmful" invasive species as those having ecological impact scores of 3 or 4 (disrupting multiple species or wider ecosystems). Using this definition, 57% of species in our database are harmful, ranging from 47% of cnidarians to 84% of plants (Figure 2). The database also allows a geographic perspective; Figure 1 shows the number of harmful invasive species by ecoregion.

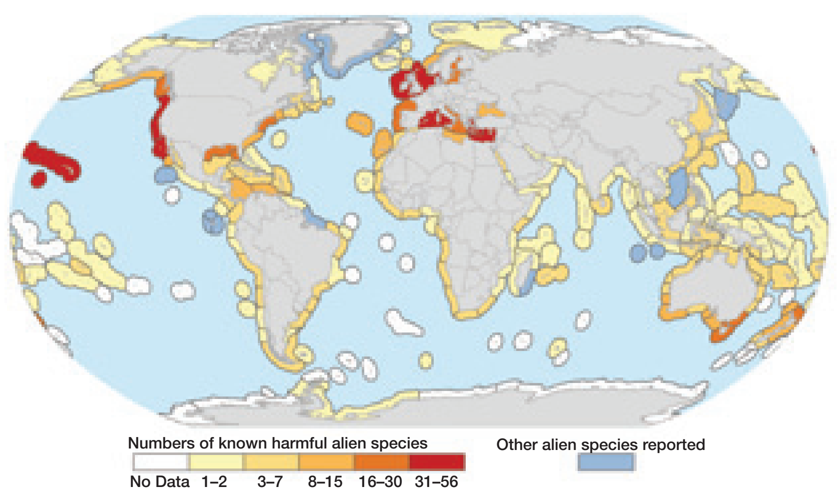

Figure 1. Map of the number of harmful alien species by coastal ecoregion, with darker red shades indicating a greater number of species with high ecological impact scores (3 or 4). Ecoregions in which only less harmful species have been documented are shown in dark blue.

Our data reveal high levels of invasion in the following ecoregions: Northern California, including San Francisco Bay (n = 85 species, 66% of which are harmful), the Hawaiian Islands (73, 42%), the North Sea (73, 64%), and the Levantine Sea in the eastern Mediterranean (72, 50%). Realms that feature the highest degree of invasion are the Temperate Northern Atlantic (240, 57%), Temperate Northern Pacific (123, 63%), and Eastern Indo-Pacific (76, 45%). The least invaded realms are the Southern and Arctic Oceans (1, 100%, and 9, 56%, respectively).

We documented known or likely pathways for all 329 marine invasive species, with a mean of 2.0 pathways per species (SD = 1.1). More than 80% of species were introduced unintentionally. The most common pathway for marine species in the database was shipping (ballast and/or fouling; 228 species, 57% of which are harmful). Of the 205 species with more detailed shipping pathway information, 39% are known to have been, or are likely to have been transported only by ship fouling, 31% are transported only by ballast, and 31% are transported by either ship fouling or ballast. The aquaculture industry is the next most common pathway (134 species, 64% of which are harmful; Figure 3).

To demonstrate regional variation, key pathways into the most heavily invaded ecoregions were determined by aggregating the known and likely pathways of species recorded in those ecoregions (Table 1). While shipping pathways are generally dominant, aquaculture is an important conduit for invasions on the west coast of the US, while the Suez Canal is a key pathway into the eastern Mediterranean.

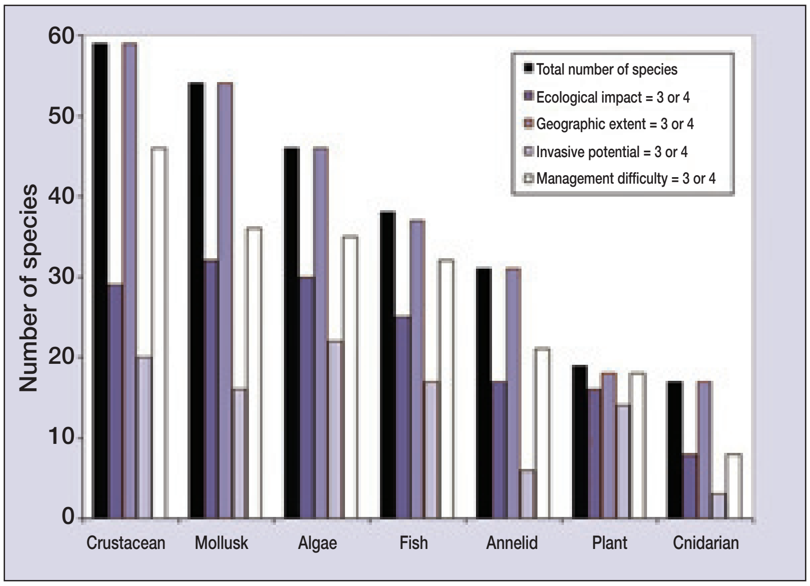

Figure 2. Number of species in the dominant groups that fall into the highest two categories (3 or 4) of each threat score.

Among the 359 data sources compiled to date, 47% are from peer-reviewed literature, 33% are from other published reports, 11% are from existing databases and atlases, and 3% are from unpublished reports (a list of database sources is provided in WebPanel 3). Most species were initially entered into our database using other databases and atlases, which, in almost every case, were compiled from the peer-reviewed literature and/or by regional experts. Additional information was obtained from the literature and reports. The accuracy of the patterns we found is dependent, in part, on the reliability of the data sources we used. Of course, even with reliable sources it is probable that, over time, corrections will be required. Necessary amendments may include incorporation of new studies or correction of errors from original field assessments, but environmental, evolutionary, or stochastic changes may also necessitate revision of the information in our database. For example, a heretofore benign, non-native species could invade a new niche and become a greater threat, or a native species could adapt to consume or out-compete an invader.

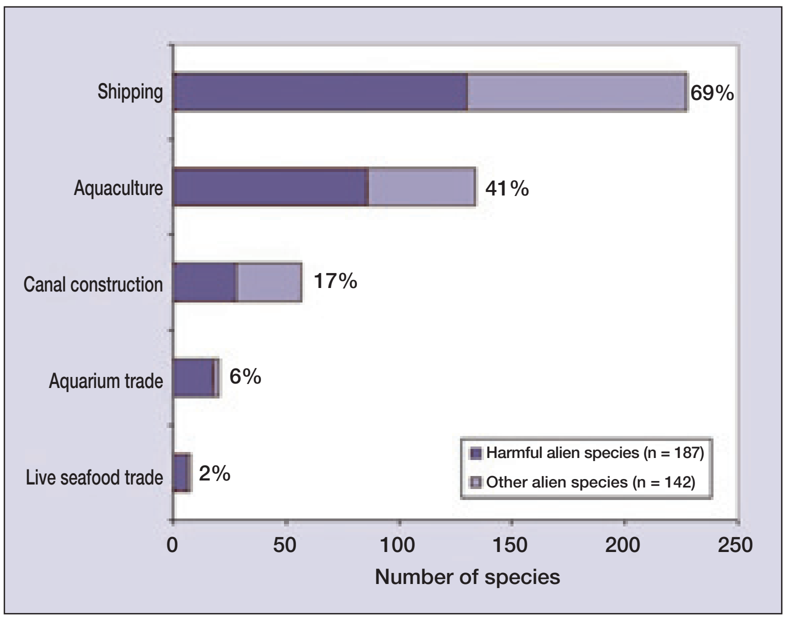

Figure 3. Number of marine alien species known or likely to be introduced by the most common human-assisted pathways, with the proportion scored as high ecological impact (3 or 4) shown in a darker shade. Percent of total number of species in assessment (n = 329) is indicated.

Identifying research and information needs

We documented more information on well-studied regions (eg US, Europe, Australia) than on other areas. Regions with a small number of invasions reported may contain few, if any, invasive species, but it is likely that at least some of these gaps are the result of a lack of research, monitoring, and/or public reporting of information.

A large number of ecological and economic impacts of alien species have been documented by others in regions identified as highly invaded on our map (eg San Francisco Bay, Cohen and Carlton 1998; Hawaiian Islands, Smith *et al.* 2003; North Sea, Eno *et al.* 1997; Mediterranean Sea, Galil 2006). It is probable that alien species are also affecting regions that appear, on our map, to be less invaded. To see if shipping data could act as a proxy indicator for identifying areas where invasions may have gone undetected, we compared our data on harmful species introduced via shipping in well-

Table 1. Key pathways for most invaded ecoregions

Ecoregion	*Number of harmful species (% of total)*	*Pathways (% of harmful species)*[*]
Northern California	56 (66%)	Shipping (71%); aquaculture (71%)
North Sea	47 (64%)	Shipping (83%); aquaculture (57%)
Western Mediterranean	43 (66%)	Shipping (77%); aquaculture (55%)
Oregon, Washington, Vancouver	41 (65%)	Aquaculture (73%); shipping (68%)
Levantine Sea	36 (50%)	Canal (61%); shipping (58%)
Puget Trough/Georgia Basin	35 (64%)	Aquaculture (74%); shipping (69%)
Celtic Seas	33 (66%)	Shipping (76%); aquaculture (67%)
Aegean Sea	31 (53%)	Shipping (55%); canal (52%)
Southern California Bight	31 (72%)	Shipping (81%); aquaculture (71%)
Hawaiian Islands	31 (42%)	Shipping (68%); aquaculture (39%)

[*]*Species may be known or likely to be transported via more than one pathway*

studied regions (US excluding Alaska, temperate Europe, Australia, New Zealand) with separate shipping indicators (number of ports and shipping cargo volume) in a recent year (2003) by ecoregion (Halpern unpublished). We found statistically significant correlations between these shipping indicators and the number of harmful species reported (using a generalized linear model for number of ports – number of harmful species: $t = 6.94$, SE = 0.0019, df = 32; for shipping cargo volume – number of harmful species: $t = 5.81$, SE = 5.2×10^{-10}, df = 32). Thus, the magnitude of shipping activities could potentially predict the risk for harmful invasions. These shipping measures do not account for the origin of incoming ships, susceptibility to invasion, changes in shipping patterns and volume (Drake and Lodge 2004), or variation in quarantine standards and shipping operations. Should such refinements to shipping data become available, it is likely that even stronger relationships would be observed.

Given the correlation between shipping indicators and harmful invasions, regions with high port traffic but few reported invasions probably contain more marine invaders than we have documented. Notably, we would expect this to include east and southeast Asia. Data may not have been collected in these regions, or results may not be easily available to researchers in other parts of the world. It is our hope that the establishment of global data repositories or networks on invasive species (eg Global Invasive Species Information Network; www.gisinetwork.org) will encourage more detailed research and the release of additional information.

Together with more thorough geographic coverage, better reporting of ecological impacts would help to close the most substantial and immediate information gaps. Our database includes only those species with documented ecological impacts. Several hundred invasive species known to exist in places like the Mediterranean Sea (Mooney and Cleland 2001) and San Francisco Bay (Cohen and Carlton 1998) were excluded because impact information was not reported. These particular systems are already highly invaded, but a more complete assessment of impacts would improve understanding of likely effects in other regions where those species are found. We are making our database freely available online, to encourage further submissions; this will improve reporting and refine our knowledge of global invasion patterns.

Conservation and policy applications

Using data collected in this assessment, we can identify global patterns and draw preliminary conclusions that may be applied to conservation and policy efforts. Here, we discuss several ways in which our database could be used to inform policy decisions.

Informing regional strategies

The database allows us to examine patterns of the known presence of marine invasive species and the distribution of their threat. The number of harmful species in each ecoregion provides an indication of the level of degradation from past invasions as well as, perhaps, the pressure from future invasions. This information could help policy makers to understand the trade-offs as they choose how to implement decisions and invest resources.

Prioritizing pathways for prevention efforts

Identification of the most common pathways for introduction of harmful marine species (Figure 3) can inform and support international policies aimed at preventing such introductions. Our results, based on the largest dataset compiled to date, clearly confirm earlier studies (eg Ruiz *et al.* 1997; Minton *et al.* 2005) and point to shipping as a major global pathway. This provides a powerful, objective argument in support of ongoing efforts to improve ballast water management practices (eg International Maritime Organization's Ballast Water Convention and Management Programme; http://globallast.imo.org). Even so, the major impacts of ship-fouling species suggest that ballast water agreements alone may be insufficient. We also confirm earlier studies describing the role of aquaculture operations in marine invasions (eg Naylor *et al.* 2001). Stricter, industry-wide control measures could be developed and legal and enforcement structures strengthened to restrict intentional and accidental introductions of harmful species.

Our assessment data can also be used by policy makers in specific regions (Table 1). For example, in the two ecoregions that extend along the coastlines of Oregon and Washington State, including the Puget Sound, aquaculture is the most common pathway for introduction (71% of non-native marine species documented in these ecoregions were introduced by aquaculture). Most of these introductions probably occurred accidentally, through oyster farming (with introduced species hitchhiking on shells or equipment). Of the 33 species known to be associated with oyster farming, 55% are harmful, and most are difficult if not impossible to remove or control (26 of 28 species scored for management difficulty received a score of 3 or 4). In this region, policy makers and conservation practitioners should be working with the aquaculture industry to prevent any future invasions, by improving practices and perhaps limiting new operations.

Our data could inform biosecurity measures by helping to identify species that have not yet invaded an ecoregion or realm but have had considerable impact in similar habitats elsewhere. Our use of biogeographic units will be of value in identifying "similar" vulnerable ecoregions, and more refined data about ship movements and habitat suitability would further support such work (see Hayes *et al.* 2002).

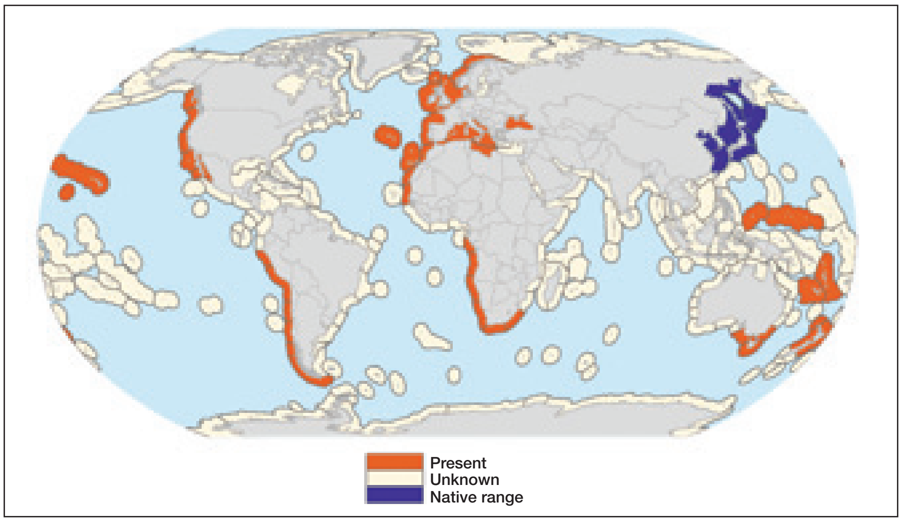

Figure 4. *The Pacific oyster* (Crassostrea gigas) *has been intentionally released and cultured in coastal waters around the world. It can dominate native species and destroy habitat (ecological impact = 3). The map shows its distribution; its invasive range is indicated in red, its native range in blue.*

Informing introduction decisions

Species are often introduced to new habitats for their economic benefits or to meet development needs (eg aquaculture). There may be an initial economic gain, but if a species becomes invasive, it can cause serious, unforeseen economic and ecological damage. These risks of invasion have often not been factored into decisions on species introductions (Naylor *et al.* 2001).

Our impact scores offer guidance on the merits of these intentional introductions. For example, oysters have been deliberately introduced into coastal waters worldwide, to be cultured for food. One species in particular, *Crassostrea gigas*, has been introduced in at least 45 ecoregions (Figure 4). Its high ecological impact score (3) should cause decision makers and regulators to reconsider plans for introduction of this oyster into new areas. While its harvest brings economic gains, the ecological impact of introductions of this species are potentially dramatic. Oysters play a role in many estuarine ecosystem processes; altering their abundance or distribution causes complex changes. Furthermore, when oyster populations are supplemented with alien oysters, other alien species can piggyback on their shells (Ruesink *et al.* 2005). Global information about distribution and impacts could inform risk assessments and decisions about whether, and how, species should be introduced in the future.

Conclusions

The new invasive species database provides a powerful tool for understanding the patterns and processes of marine invasions. The current data holdings already represent the most comprehensive collection of information on marine invasions worldwide. By quantifying impacts and describing pathways of invasion, our data framework improves our ability to assess threats and impacts and allows valid and consistent assessments between locations, habitats, or taxonomic groups. Work is continuing to expand this assessment of marine invasive species and similar analyses are underway for terrestrial and freshwater species.

Initial findings confirm earlier studies and point to shipping and aquaculture as the most critical pathways for marine invasions globally. At the same time, regional differences in dominant pathways are highlighted.

The information we have compiled can begin to inform the large-scale strategies necessary to prevent future introductions. This global perspective allows researchers and regulators to better consider where and how invasive species are likely to be introduced and invade in the future. This can help to inform risk assessments and decisions about potential future introductions, as well as the development of species- and pathway-specific regulations and geographically targeted policies.

We have also identified some disparities in information resources on marine invasive species. In particular, there is clearly under-reporting of both microorganisms and low-impact invasive species, and there appears to be a geographic gap in our knowledge regarding large parts of east Asia, where invasions are highly likely, but little published information exists. We hope that these observations may catalyze and encourage efforts to make decentralized data available and direct future research efforts.

Acknowledgements

The authors thank the following people for their help and advice: P Kareiva, JM Randall, EC Underwood, A Holt, FT Campbell, JM Hoekstra, MD Jennings, TM Boucher, and A Pierpoint. CD Canham and TH Tear provided useful feedback on an early draft. We also thank BS Halpern for the use of unpublished data and JC Robertson for creating the maps.

References

Byers JE, Reichard S, Randall J, *et al.* 2002. Directing research to reduce the impacts of non-indigenous species. *Conserv Biol* **16**: 630–40.

Cal-IPC (California Invasive Plant Council). 2003. Criteria for categorizing invasive non-native plants that threaten wildlands. www.cal-ipc.org/ip/inventory/pdf/Criteria.pdf. Viewed 23 Mar 2005.

Campbell F and Kriesch P. 2003. Final report by the National Invasive Species Council's Invasive Species Pathways Team of the Prevention Working Group. www.invasivespeciesinfo.gov/council/wrkgrps.shtml. Viewed 30 Aug 2006.

Carlton JT and Ruiz GM. 2005. Vector science and integrated vector management in bioinvasion ecology: conceptual frameworks. In: Mooney HA, Mack RN, McNeely JA, *et al.* (Eds). Invasive alien species: a new synthesis. Washington, DC: Island Press.

CBD (Convention on Biological Diversity). 2000. Alien species that threaten ecosystems, habitats or species, as adopted by Conference of the Parties 5 Decision V/8. http://cbd.int/decisions/cop-04.shtml?id=7150&lg=0&m=COP-04. Viewed 23 Feb 2007.

Cohen AN and Carlton JT. 1998. Accelerating invasion rate in a highly invaded estuary. *Science* **279**: 555–58.

Crall AW, Meyerson LA, Stohlgren TJ, *et al.* 2006. Show me the numbers: what data currently exist for non-native species in the USA? *Front Ecol Environ* **4**: 414–18.

Drake JM and Lodge DM. 2004. Global hot spots of biological invasions: evaluating options for ballast-water management. *P Roy Soc Lond B Bio* **271**: 575–80.

Drake LA, Doblin MA, and Dobbs FC. 2007. Potential microbial bioinvasions via ships' ballast water, sediment, and biofilm. *Mar Pollut Bull* **55**: 333–41.

Eno NC, Clark RA, and Sanderson WG (Eds.) 1997. Non-native marine species in British waters: a review and directory. Peterborough, UK: Joint Nature Conservation Committee.

Galil BS. 2006. Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea. *Mar Pollut Bull* **55**: 314–22.

Hayes KR, McEnnulty FR, and Sliwa C. 2002. Identifying potential marine pests – an inductive approach. Final report for Environment Australia, National Priority Pests Project. www.issg.org/database/species/reference_files/Hayes,%20K.R%20et%20al.,%202002.pdf. Viewed 9 Jan 2007.

Hewitt CL, Martin RB, Sliwa C, *et al.* (Eds). 2002. National Introduced Marine Pest Information System. http://crimp.marine.csiro.au/nimpis. Viewed 7 Jul 2005.

Jousson O, Pawlowski J, Zaninetti L, *et al.* 2000. Invasive alga reaches California. *Nature* **408**: 157–58.

Lodge DM, Williams S, MacIsaac HJ, *et al.* 2006. Biological invasions: recommendations for US policy and management. *Ecol Appl* **16**: 2035–54.

Mack RN, Simberloff D, Lonsdale WM, *et al.* 2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Ecol Appl* **10**: 689–710.

McNeely JA, Mooney HA, Neville LE, *et al* (Eds). 2001. A global strategy on invasive alien species. Gland, Switzerland and Cambridge, UK: World Conservation Union.

Minton MS, Verling E, Miller AW, and Ruiz GM. 2005. Reducing propagule supply and coastal invasions via ships: effects of emerging strategies. *Front Ecol Environ* **3**: 304–08.

Mooney HA and Cleland EE. 2001. The evolutionary impact of invasive species. *P Natl Acad Sci USA* **98**: 5446–51.

NatureServe. 2004. An invasive species assessment protocol: evaluating non-native plants for their impact on biodiversity. www.natureserve.org/library/invasiveSpeciesAssessmentProtocol.pdf. Viewed 4 Aug 2005.

Naylor RL, Williams SL, and Strong DR. 2001. Aquaculture – a gateway for exotic species. *Science* **294**: 1655–56.

Olson DM, Dinerstein E, Wikramanayake ED, *et al.* 2001. Terrestrial ecoregions of the world: a new map of life on earth. *BioScience* **51**: 933–38.

Rejmánek M, Richardson DM, Barbour MG, *et al.* 2002. Biological invasions: politics and the discontinuity of ecological terminology. *Bull Ecol Soc Am* **83**: 131–33.

Ricciardi A, Steiner WWM, Mack RN, and Simberloff D. 2000. Toward a global information system for invasive species. *BioScience* **50**: 239–44.

Richardson DM, Pysek P, Rejmánek M, *et al.* 2000. Naturalization and invasion of alien plants: concepts and definitions. *Divers Distrib* **6**: 93–107.

Ruesink JL, Lenihan HS, Trimble AC, *et al.* 2005. Introduction of non-native oysters: ecosystem effects and restoration implications. *Annu Rev Ecol Evol Syst* **36**: 643–89.

Ruiz GM, Carlton JT, Grosholz ED, and Hines AH. 1997. Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent, and consequences. *Am Zool* **37**: 621–32.

Salafsky N, Salzer D, Ervin J, *et al.* 2003. Conventions for defining, naming, measuring, combining, and mapping threats in conservation. Bethesda, MD: Foundations of Success. http://fosonline.org/images/Documents/Conventions_for_Threats_in_Conservation.pdf. Viewed 7 Sep 2004.

Smith JE, Conklin EJ, Hunter CL, and Smith CM. 2003. The impact of invasive algae on biodiversity and coral cover in Hawaii. In: Pederson J and Moll R (Eds). Proceedings of the Third International Conference on Marine Bioinvasions. La Jolla, CA: California Sea Grant.

Spalding MD, Fox HE, Allen GR, *et al.* 2007. Marine ecoregions of the world: a bioregionalization of coast and shelf areas. *BioScience* **57**: 573–83.

Thresher RE and Kuris AM. 2004. Options for managing invasive marine species. *Biol Invas* **6**: 295–300.

US Federal Executive Order 13112. 1999. Invasive species. 12 Apr 1999. http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=1999_register&docid=99-3184-filed.pdf. Viewed 21 Mar 2007.

WebPanel 1. Data collection methods

We have developed a data framework in which we document information about individual invasive species, including their non-native range extent, threat to native biodiversity, and introduction pathways. Building on existing datasets, we have integrated information from a wide variety of sources and developed a geographically referenced Microsoft Access database of marine invasive species.

Our aim was to enable efficient and consistent data collection through effective design of the database and criteria (described below). To aid in this, we used database fields common to other data collection efforts wherever possible (eg IUCN SSC's Global Invasive Species Database [GISD], www.issg.org/database). This allowed us to collect data from those sources more efficiently, and will make it easier for others to incorporate our data into their work.

We present data only on marine species in this publication, but we are collecting data on freshwater and terrestrial species in parallel efforts, using consistent methods.

Information about data collected in our database and how we made decisions on documenting information is provided below. The database is available at http://conserveonline.org/workspaces/global.invasive.assessment.

General species information

We collected data on species that are established outside of their native range and have the potential to impact native species and biodiversity. Species that occur in and impact human-dominated habitats (eg aquaculture) have been included, but only their impact on natural habitats and native biodiversity has been recorded.

We documented basic information about each species, including:

- Scientific name
- Common name
- Whether the species lives in marine, freshwater, and/or terrestrial habitats
- Higher taxonomic group (list based on "organism type" in GISD):
    - Algae
    - Ascidian
    - Bacterium
    - Bryozoan
    - Ectoprocta
    - Fungus
    - Invertebrate – annelid
    - Invertebrate – arthropod – crustacean
    - Invertebrate – arthropod – insect
    - Invertebrate – arthropod – other
    - Invertebrate – cnidarian
    - Invertebrate – ctenophore
    - Invertebrate – echinoderm
    - Invertebrate – mollusk
    - Invertebrate – mollusk (snail)
    - Invertebrate – platyhelminth
    - Invertebrate – porifera (sponges)
    - Nematode
    - Plant
    - Protozoa
    - Tunicate
    - Vertebrate – amphibian
    - Vertebrate – bird
    - Vertebrate – fish
    - Vertebrate – mammal
    - Vertebrate – reptile
    - Virus

References

In an index of references, we noted bibliographic citation information and the type of documentation for each source.

Type of documentation – measure of reliability of data used to score, based on Cal-IPC (2003)

- *Peer review (PR)* – published, peer-reviewed scientific evidence or floras/faunas
- *Report (RE)* – non-peer-reviewed, published documents and reports
- *Compilations (COMP PR/RE)* – source that is a compilation of data from PR and RE sources (eg existing databases of invasive species)
- *Expert opinion (EO)* – confirmed, unpublished observations by a qualified professional
- *Anecdotal (AN)* – unconfirmed, anecdotal information

Geography and habitat

In addition to non-native occurrences by ecoregion (described below), we collected descriptive information about distribution and habitats for each species, where data allowed. References for these data were documented.

- *Origin* – description of the native range of a species
- *First introduction* – description of the first reported introduction for which we found evidence
- *Non-native distribution by country and other geographic units* – Our focus was on documenting non-native ranges by ecoregion, but many data sources reported distributions using different units. We have captured this information in text fields.
- *Habitat description* – text field describing the habitats in which a species is found

WebPanel 1. Data collection methods – *Continued*

- *Habitat* – Species were noted as living in one or more of the marine habitats in the following list. To maintain consistency with existing databases, we based it on the habitat list in the GISD and included some additional marine habitat classes. This is not a formal classification of marine or coastal habitats, and we would also point out that the habitat classes are not mutually exclusive – many are nested or overlapping. Where relevant we documented multiple habitats for species:

  - o Aquaculture facilities
  - o Brackish water
  - o Coastland
  - o Estuaries/bays
  - o Intertidal zones
  - o Marine habitats
  - o Shallow lagoons
  - o Benthic
  - o Canals
  - o Coral reefs
  - o Fouling communities
  - o Mangroves
  - o Rocky habitats
  - o Wetlands

Non-native occurrence by ecoregion

We have documented the non-native range of each species, defining non-native occurrences as ecoregions in which a species is established outside of its native range (marine ecoregions: www.nature.org/MEOW; Spalding *et al.* 2007). Reference(s) were included for each ecoregional occurrence.

As a rough indicator of the reliability of these data, we also noted whether an ecoregional occurrence was within the geographic scope of references used. For example, if a database of invasive species in the Mediterranean Sea states that a species is also found in the Philippines, we included that occurrence in the database, but noted that it was outside of the geographic scope of the data source (until we can confirm the occurrence with a source from that region).

Threat scores

Species were assigned a score for each of the following (where data allowed) to indicate the magnitude of the threat that it poses to native biodiversity: "ecological impact", "geographic extent", "invasive potential", and "management difficulty".

Our four threat scores are based on systems proposed by Salafksy *et al.* (2003), NatureServe (2004), and California Invasive Plant Council (Cal-IPC 2003). The following chart roughly compares the criteria of each to our scores:

The categories used to assign each score were devised so that they can be applied consistently to different types of species and to those living in marine, freshwater, and terrestrial habitats.

Scores were assigned globally for each species, not for specific occurrences. For consistency, we used the worst documented case to score a species. If data were ambiguous, we were conservative in assigning higher scores.

Below are descriptions of how we scored the threat of species and collected supporting data.

Ecological impact

Ecological impact measures the severity of the impact of a species on the viability and integrity of native species and natural biodiversity. The following information was captured in the database:

Score

4 – Disrupts entire ecosystem processes with wider abiotic influences

3 – Disrupts multiple species, some wider ecosystem function, and/or keystone species or species of high conservation value (eg threatened species)

2 – Disrupts single species with little or no wider ecosystem impact

1 – Little or no disruption

U – Unknown or not enough information to determine score

Text Description – succinct description to support score, including, if data allowed, description of the wider abiotic influences, ecosystem and species disruptions, and including geographic variation in impact if applicable

Sources – cited documentation for score and descriptive text

Species were scored based on the worst documented case, with conditions in that case noted in the text description field. Occurrences and conditions where there was less of an impact are described in the text description as well.

We were conservative in assigning higher scores when data were ambiguous. For example, if a species is known

	Salafsky et al.	*NatureServe*	*Cal-IPC*
Ecological impact	Severity/synergism	Ecological impact	Ecological impact
Geographic extent	Scope	Current distribution and abundance	Ecological amplitude and distribution
Invasive potential	Timing/likelihood	Trend in distribution and abundance	Invasive potential
Management difficulty	Reversibility	Management difficulty	na
Type of documentation	na	na	Level of documentation

WebPanel 1. Data collection methods – *Continued*

to have economic impacts (eg fouling ship hulls), but its impacts in natural habitats have not been studied, we would assign it a low ecological impact score, pending more available data. Potential but unverified impacts were noted in the text description.

Some examples of the types of impacts that we assigned to each of the categories:

4 – Causing large scale changes such as: altering community structure, causing localized to widespread extinctions, altering native level of activity (eg clogging waterways, altering natural topography)
3 – Disrupting changes impacting more than a small number of species without causing localized extinctions, competition with threatened or keystone species, changing balance in ecosystem
2 – Causing minor impact to a species or species group with no wider known impacts and without causing extinctions
1 – Established, but little or no known impact; may be long-term resident, coexisting with native species

Geographic extent

Geographic extent measures the current extent of the species outside of its native range. The following information was captured in the database:

Score
4 – Multi-ecoregion
3 – Ecoregion
2 – Local ecosystem/sub-ecoregion
1 – Single site
U – Unknown or not enough information to determine score

Distribution within non-native range – locally patchy, locally pervasive, regionally patchy, regionally pervasive (approximate division between local/regional is ecoregion)

Text description – succinct description to support score

Sources – cited documentation for score and descriptive text

These categories were developed to indicate order of magnitude differences in non-native range, using a system that can be applied across marine, freshwater, and terrestrial habitats. We distinguished between the categories using the following criteria:

4 – Spans three or more ecoregions, cross continental, trans-oceanic
3 – Established in no more than two adjoining ecoregions
2 – More than one occurrence within one ecosystem
1 – Single locality

As an additional description of the non-native distribution of a species, we noted the following, if data allowed:

Locally patchy – sightings or small communities established in localized area
Locally pervasive – dominant to similar flora/fauna in localized community
Regionally patchy – small, independent populations spanning two or more ecoregions
Regionally pervasive – dominant characteristics within all/most regional occurrences

Invasive potential

Invasive potential measures current/recent rate of spread and potential for future spread once introduced in a new habitat. The following information was captured in the database:

Score
4 – Currently/recently spreading rapidly (doubling in < 10 years) and/or high potential for future rapid spreading
3 – Currently/recently spreading less rapidly and/or potential for future, less rapid spreading
2 – Established/present, but not currently spreading and high potential for future spreading
1 – Established/present, but not currently spreading and/or low potential for future spreading
U – Unknown or not enough information to determine score

Text description – succinct description to support score and other information (eg description of dispersal methods, past invasions, and geographic variation)

Sources – cited documentation for score and descriptive text

We used both quantitative and qualitative descriptions of the spread of invasive species in a new habitat to assign a score. We distinguished between the categories using the following criteria:

4 – Species has spread/invaded rapidly (doubling in < 10 years) after past introductions, indicating that it is likely to spread quickly after new invasions
3 – Species has spread/invaded after past introductions and/or is likely to after new invasions, but not quickly enough to be scored a "4"

WebPanel 1. Data collection methods – *Continued*

2 – Species has not yet spread/invaded into the habitat in which it has been introduced, but it has characteristics/traits that indicate it is likely to spread/invade
1 – Species has not – and is not likely to in the future – spread/invade once introduced

Management difficulty
Management difficulty measures effort required to reverse the threat and/or remove the species. The following information was captured in the database:

Score
4 – Irreversible and/or can not be contained or controlled
3 – Reversible with difficulty and/or can be controlled with significant ongoing management
2 – Reversible with some difficulty and/or can be controlled with periodic management
1 – Easily reversible, with no ongoing management necessary (eradication)
U – Unknown or not enough information to determine score

Text description – succinct description to support score

Sources – cited documentation for score and descriptive text

We used information about past or ongoing eradication and control efforts. We distinguished between the categories using the following criteria:

4 – No known successful form of complete removal, eradication, or control
3 – Removal and/or control require significant resources and effort; complete removal may require routine scheduled maintenance on regular basis
2 – Removal and/or control do not require significant resources and effort, but seasonal controls and monitoring may be required
1 – Known occurrences have been easily detected and eradicated; no recurrence or spread after eradication

Pathways
We documented all known and likely introduction pathways for each species in our database, adapting a list of "pathways" developed by the US National Invasive Species Council's Invasive Species Pathways Team (Campbell and Kriesch 2003; refined by Lodge *et al.* 2006). Their task was "developing a system for evaluating the significance of invasive species pathways" with "pathways" defined broadly as "any means that allows entry or spread of an invasive species" (Campbell and Kriesch 2003). Although this system includes routes of introduction that are elsewhere classed as vectors (Carlton and Ruiz 2005) and categories are not always mutually exclusive, it allows the practical categorization of commonly reported information on pathways and vectors. We modified this system slightly, to better fit a global assessment and made category adjustments to allow effective gathering of data by species.

A summary of the marine pathways used is in Panel 2, and our full pathways list is provided in WebPanel 2.

The following information was captured in the database for each species:

Pathway – This field captured how a species is brought to new habitats (not local dispersal after it has been introduced). We documented all known and likely pathways for each species. The field was populated from the list of pathways described above (Panel 2, WebPanel 2)

For each pathway of a species, the following was also documented (as data allowed):

Introduction – describes the release itself (after a species travels on a pathway to a new habitat)

- Intentional – deliberate release, authorized or not
- Accidental – unintentional release, hitchhiker
- Not human assisted – natural migration

Documented – this field allowed us to distinguish between pathways that are known for a species, and those that are likely (eg due to habitat, species vulnerabilities)
- Known – documented case(s)
- Probable – likely pathway for a species and/or for specific introduction
- Possible – potential pathway (eg based on species physiology)

Cause – describes the driver of an invasion on a pathway (eg specific industries, food resource, ornamentation)

This type of field has been used in other databases to specifically describe the cause of one introduction, but it is difficult to repeat this level of detail in a global database. We are capturing typical/known modes of introduction, instead of the details of one introduction. For example, for the introduction of a diatom via the "ballast water" pathway, we usually can not get enough detailed information to narrow the cause to the type of ship/industry.

WebPanel 1. Data collection methods – *Continued*

Description – text field to capture details about introductions (eg specific cases)

References – documented for each species' pathway

References

Cal-IPC (California Invasive Plant Council). 2003. Criteria for categorizing invasive non-native plants that threaten wildlands. www.cal-ipc.org/ip/inventory/pdf/Criteria.pdf. Viewed 23 Mar 2005.

Campbell F and Kriesch P. 2003. Final report by the National Invasive Species Council's Invasive Species Pathways Team of the Prevention Working Group. www.invasivespeciesinfo.gov/council/wrkgrps.shtml. Viewed 30 Aug 2006.

Lodge DM, Williams S, MacIsaac HJ, *et al*. 2006. Biological invasions: recommendations for US policy and management. *Ecol Appl* **16**: 2035–54.

NatureServe. 2004. An invasive species assessment protocol: evaluating non-native plants for their impact on biodiversity. www.natureserve.org/library/invasiveSpeciesAssessmentProtocol.pdf. Viewed 4 Aug 2005.

Salafsky N, Salzer D, Ervin J, *et al*. 2003. Conventions for defining, naming, measuring, combining, and mapping threats in conservation. Bethesda, MD: Foundations of Success. http://fosonline.org/images/Documents/Conventions_for_Threats_in_Conservation.pdf. Viewed 7 Sep 2004.

Spalding MD, Fox HE, Allen GR, et al. 2007. Marine ecoregions of the world: a bioregionalization of coast and shelf areas. *BioScience* **57**: 573–83.

WebPanel 2. Alien species pathway framework

Adapted from NISC Invasive Species Pathway Team's outline (Campbell and Kriesch 2003)

I. Transportation-related pathways
- A. Modes of transportation
  - 1. Air transportation
    - a) Wheel wells
    - b) Cabin
    - c) Cargo holds
  - 2. Freshwater/marine transportation
    - a) Ballast and/or fouling
      - (1) Ballast water and sediments
      - (2) Hull/surface fouling
    - b) Stowaways in holds
    - c) Superstructures/structures above the waterline
    - d) Dredge spoil material
    - e) Canals that connect waterways
  - 3. Land/terrestrial transportation
    - a) Cars, trucks, buses, ATVs, etc
    - b) Construction equipment and firefighting equipment
    - c) Trains, subways, metros, monorails
    - d) Hikers, horses, pets
- B. Items used in shipping process
  - 1. Containers – both exterior and interior
  - 2. Packing materials
    - a) Wood packing materials
    - b) Seaweed
    - c) Other plant materials
    - d) Sand/earth
- C. Tourism/travel/relocation
  - 1. Travelers themselves
  - 2. On baggage and gear
  - 3. Transported pets/plants and animals transported for entertainment
  - 4. Travel consumables
- D. Mail/internet/overnight shipping companies

II. Commerce in living organisms pathways
- A. Live seafood trade
- B. Livestock
- C. Aquaculture and mariculture activities
  - 1. Enclosed facilities
  - 2. Stocking in open water
- D. Pet, aquarium, and water garden trade
- E. Bait industry
- F. Biocontrol
- G. Nurseries/garden/landscaping
  - 1. Whole plants
  - 2. Plant parts
- H. Agricultural and forestry species trade
  - 1. Whole plants
  - 2. Plant parts
- I. Plants and plant parts as food
- J. Other animal trade
- K. Other plant trade
  - 1. Whole plants
  - 2. Plant parts

III. Other human-assisted pathways
- A. Ecosystem disturbance
  - 1. Short-term disturbances that facilitate introduction
  - 2. Long-term disturbances that facilitate introduction
- B. Climate change

IV. Natural spread

WebPanel 3. Marine data sources in database

In general, "databases and atlases" were the initial sources of species that we included in our database. We then used "articles and reports" and "other web sources" to supplement species information on occurrences, pathways, and threat scoring. We have not included all the information available in each of the local datasets listed.

Databases and atlases

Database/atlas name	*Access information*
IUCN-ISSG's Global Invasive Species Database	www.issg.org/database
FishBase	www.fishbase.org
FIGIS: FAO's Fisheries Global Information System	www.fao.org/fi/figis/
AquaInvader: Database of Aquatic Invasive Species of Europe	www.zin.ru/rbic/projects/aquainvader/searchmain.asp
NAS: USGS's Nonindigenous Aquatic Species Database	http://nas.er.usgs.gov
NIMPIS: Australia's National Introduced Marine Pest Information System	www.marine.csiro.au/crimp/nimpis/
CIESM Atlas of Exotic Species in the Mediterranean	www.ciesm.org/atlas/
NEMESIS: Smithsonian Environmental Research Center's National Exotic Marine and Estuarine Species Information System	http://invasions.si.edu/nemesis/
NatureServe Explorer	www.natureserve.org/explorer/
Australia Weed Database	www.weeds.org.au
Invasive Plants of Canada Project	www.plantsincanada.com/
CERC's Introduced Species Summary Project	www.columbia.edu/itc/cerc/danoff-burg/invasion_bio/inv_spp_summ/invbio_plan_report_home.html
Gulf States Marine Fisheries Commission's Non-Native Aquatic Species Summaries	http://nis.gsmfc.org/nis_alphabetic_list.php
Baltic Sea Alien Species Database	www.ku.lt/nemo/alien_species_directory.html
Invasive species in the Pacific northwest	Boersma PD, Reichard SE, and Van Buren AN. 2006. Seattle, WA: University of Washington Press
Intertidal Marine Invertebrates in the Puget Sound	www.nwmarinelife.com/
Exotic Aquatics on the Move: A Joint Project of National Sea Grant Network and Geographic Education Alliances	www.iisgcp.org/EXOTICSP/
Caspian Sea Biodiversity Database	www.caspianenvironment.org/biodb/eng/main.htm
AlgaeBase	www.algaebase.org/
Belgian Forum on Invasive Species' Harmonia Database	http://ias.biodiversity.be
APIRS Online: The Database of Aquatic, Wetland, and Invasive Plants	http://plants.ifas.ufl.edu/search80/NetAns2/
Great Lakes Aquatic Nonindigenous Species List	www.glerl.noaa.gov/res/Programs/invasive/anscommon052703.html
NOBANIS: North European and Baltic Network on Invasive Species	www.nobanis.org/Factsheets.asp
JNCC's Non-native marine species in British waters: a review and directory	www.jncc.gov.uk
MarLIN: The Marine Life Information Network for Britain and Ireland	www.marlin.ac.uk/
Invasive Aliens in Northern Ireland	www.habitas.org.uk/invasive
Government of Western Australia – Dept of Fisheries: Introduced Marine Aquatic Invaders – A Field Guide	www.fish.wa.gov.au/docs/pub/IMPMarine/index.php?0506
Alien Species in Swedish Sea Areas / Frammande Arter / Svenska Hav – Sweden	www.frammandearter.se/
Alien and Invasive Algae in Hawai`i	www.botany.hawaii.edu/GradStud/smith/websites/m-kupeke.htm
Marine Algae of Hawai`i	www.hawaii.edu/reefalgae/invasive_algae/
Invasive Species of Long Island Sound	www.seagrant.uconn.edu/INVID.HTM
Harmful Plankton Project: The user-friendly guide to harmful phytoplankton in EU waters	www.liv.ac.uk/hab/Data%20sheets/p_mini.htm
University of California–Davis, Agriculture and Natural Resources Database	http://ucce.ucdavis.edu/datastore/datareport.cfm?searcher=&surveynumber=182&reportnumber=42&Submit.x=58&Submit.y=13

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Ahyong S	Range extension of two invasive crab species in eastern Australia: *Carcinus maenas* (Linnaeus) and *Pyromaia tuberculata* (Lockington)	2005		*Mar Pollut Bull* **50**: 460–62
Ahyong ST *et al.*	First Mediterranean record of the Indo-West Pacific mantis shrimp, *Clorida albolitura* Ahyong and Naiyanetr, 2000 (Stomatopoda, Squillidae)	2006	www.aquaticinvasions.ru/2006/AI_2006_1_3_Ahyong_Galil.pdf	*Aquatic Invasions* **1**: 191–93
Akyol O *et al.*	First confirmed record of *Lagocephalus sceleratus* (Gmelin, 1789) in the Mediterranean Sea	2005		*J Fish Biol* **66**: 1183–86
Aligizaki K *et al.*	The presence of the potentially toxic general *Ostreopsis* and *Coolia* (Dinophyceae) in the North Aegean Sea, Greece	2006		*Harmful Algae* **5**: 717–30
Andreakis N *et al.*	*Asparagopsis taxiformis* and *Asparagopsis armata* (Bonnemaisoniales, Rhodophyta): genetic and morphological identification of Mediterranean populations	2004		*Eur J Phycol* **39**: 273–83
Andrews JD	Effects of tropical storm Agnes on epifaunal invertebrates in Virginia estuaries	1973		*Chesapeake Sci* **14**: 223–34
Armonies W	What an introduced species can tell us about the spatial extension of benthic populations	2001	www.int-res.com/articles/meps/209/m209p289.pdf	*Mar Ecol-Prog Ser* **209**: 289–94
Ashton G *et al.*	Global distribution of the alien marine amphipod *Caprella mutica*	2004	http://66.165.102.189/pdf/24Friday/A/fri_a_e_am/Gail_Ashton.pdf	13th International Conference on Aquatic Invasive Species
Ashton G *et al.*	Rapid assessment of the distribution of marine non-native species in marinas in Scotland	2006	www.aquaticinvasions.ru/2006/AI_2006_1_4_Ashton_etal_1.pdf	*Aquatic Invasions* **1**: 209–13
Avent SR	Distribution of *Eurytemora americana* (Crustacea, Copepoda) in the Duwamish River estuary, Washington		www.ocean.washington.edu/people/oc549/savent/projects/duwamish.htm	Unpublished report: University of Washington, School of Oceanography
Bachelet G *et al.*	Invasion of the eastern Bay of Biscay by the nassariid gastropod *Cyclope neritea:* origin and effects on resident fauna	2004	www.int-res.com/articles/meps2004/276/m276p147.pdf	*Mar Ecol-Prog Ser* **276**: 147–59
Bailey RJE *et al.*	Predatory interactions between the invasive amphipod *Gammarus tigrinus* and the native opossum shrimp *Mysis relicta*	2006		*J North Am Benthol Soc* **25**: 393–405
Bailey-Brock JH	A new record of the polychaete *Boccardia proboscidea* (Family Spionidae), imported to Hawai`i with oysters	2000	www.uhpress.hawaii.edu/journals/ps/PS541.html	*Pac Sci* **54**: 27–30
Baker P *et al.*	Nonindigenous marine species in the greater Tampa Bay ecosystem	2004	http://dl.nwrc.gov/net_prod_download//public/gom_net_pub_products/DOC/Tech-02-04-Invasives.pdf	Tampa Bay Estuary Program Technical Publication # 02-04
Bakir K *et al.*	Contribution to the knowledge of alien amphipods off the Turkish coast: *Gammarposis togoensis* (Schellenberg, 1925)	2007	*www.aquaticinvasions.ru/2007/AI_*2007_2_1_Bakir_etal.pdf	*Aquatic Invasions* **2**: 80–82
Ballesteros E *et al.*	Mortality of shoots of *Posidonia oceanica* following meadow invasion by the red alga *Lophocladia lallemandii*	2007		*Bot Mar* **50**: 8–13
Band-Schmidt CJ *et al.*	Culture studies of *Alexandrium affine* (Dinophyceae), a non-toxic cyst forming dinoflagellate from Bahia Concepcion, Gulf of California	2003		*Bot Mar* **46**: 44–54

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Barse AM	Distribution of the swim bladder nematode, *Anguillicola crassus*, among Chesapeake Bay American eels, *Anguilla rostrata*	1999	www.sdafs.org/meetings/99sdafs/physio/barse1.htm	From the 1999 Southern Division of the American Fisheries Society Midyear Meeting held in Chattanooga, Tennessee
Bellemo G *et al.*	First report of a filamentous species of *Desmarestia* (Desmarestiaceae, Fucophyceae) in the Lagoon of Venice (Italy, Mediterranean Sea)	2001		*Bot Mar* **44**: 541–45
Bij de Vaate A *et al.*	Geographical patterns in range extension of Ponto-Caspian macroinvertebrate species in Europe		http://article.pubs.nrc-2002cnrc.gc.ca/ppv/RPViewDoc?_handler_=HandleInitialGet&journal=cjfas&volume=59&calyLang=eng&articleFile=f02-098.pdf	*Can J Fish Aquat Sci* **59**: 1159–74
Bilecenoglu M *et al.*	Range extension of three lessepsian migrant fish (*Fistularia commersoni, Sphyraena flavicauda, Lagocephalus suezensis*) in the Mediterranean Sea	2002		*J Mar Biol Ass UK* **82**: 525–26
Bilecenoglu M *et al.*	Range expansion of silverstripe blaasop, *Lagocephalus sceleratus* (Gmelin 1789), to the northern Aegean Sea	2006		*Aquatic Invasions* **1**: 289–91
Bjaerke MR *et al.*	Effects of temperature and salinity on growth, reproduction and survival in the introduced red alga *Heterosiphonia japonica* (Ceramiales, Rhodophyta)	2004		*Bot Mar* **47**: 373–80
Blua A	Caspian: influx of killer jellyfish threatens fish stocks	2004	www.rferl.org/featuresarticle/2004/06/d4beb0c9-eaec-4030-b330-e93fb974c99f.html	Radio Free Europe
Bolch CJS	A review of the molecular evidence for ballast water introduction of the toxic dinaflagellates *Gymnodinium catenatum* and the *Alexandrium* "tamarensis complex" to Australia	2007		*Harmful Algae* **6**: 465–85
Bolton TF *et al.*	Chemical mediation of sperm activity and longevity in the solitary ascidians *Ciona intestinalis* and *Ascidiella aspersa*	1996	www.biolbull.org/cgi/reprint/190/3/329.pdf	*Biol Bull* **190**: 329–35
Bosa CR *et al.*	Peracarids associated to worm reefs of *Phragmatopoma caudata* (Kröyer) (Polychaeta, Sabellariidae) from Caiobá beach, Matinhos, Paraná	2002		*Rev Bras Zool* **19**: 135–47
Branham JM *et al.*	Coral-eating sea stars *Acanthaster planci* in Hawai`i	1971		*Science* **172**: 1155–57
Bravo I *et al.*	Resting cysts of the toxigenic dinoflagellate genus *Aledandrium* in recent sediments from the Western Mediterranean coast, including the first description of cysts of *A kutnerae* and *A peruvianum*	2006		*Eur J Phycol* **41**: 293–302
Brock BJ	On some south Australian *Caulerpa* species	2005	www.mlssa.asn.au/journals/2005Journal.htm	Marine Life Society of South Australia Inc 2005 Journal
Brunetti R and Mastrototaro F	The non-indigenous stolidobranch ascidian *Polyandrocarpa zorritensis* in the Mediterranean: description, larval morphology and pattern of vascular budding	2004	www.mapress.com/zootaxa/2004f/z00528f.pdf	*Zootaxa* **528**: 1–8
Burton D	Control of colonial hydroid macrofouling by free-field ultrasonic radiation	1984		*Science* **223**: 1410–11

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Bushek D	Seasonal abundance and occurrence of the Asian isopod *Synidotea laevidorsalis* in Delaware Bay, USA	2006	www.hsrl.rutgers.edu/PDFs/Isopod.pdf	*Biological Invasions* **00**: 1–6
Calcinai B *et al.*	Dispersal and association of two alien species in the Indonesian coral reefs: the octocoral *Carijoa riisei* and the demosponge *Desmapsamma anchorata*	2004		*J Mar Biol Ass UK* **84**: 937–41
California Regional Water Quality Control Board: San Francisco Bay Region	Prevention of exotic species introductions to the San Francisco Bay Estuary: a total maximum daily load report to USEPA	2000	www.swrcb.ca.gov/rwqcb2/download/Tmdl.pdf	California Regional Water Quality Control Board San Francisco Bay Region
Cannicci S	Racing across the Mediterranean – first record of *Percnon gibbesi* (Crustacea: Decapoda: Grapsidae) in Greece	2006	www.mba.ac.uk/jmba/pdf/5300.pdf	JMBA2 – Published online
Cardigos F *et al.*	Non-indigenous marine species of the Azores	2006		*Helgol Mar Res* **60**: 160–69
Carlton JT	Introduced invertebrates of San Francisco Bay	1979	www.estuaryarchive.org/archive/conomos_1979	In: Conomos TJ (Ed) San Francisco Bay: the urbanized estuary
Carlton JT	Introduced marine and estuarine mollusks of North America: an end-of-the-20th-century perspective	1992	www.sgnis.org/publicat/papers/jsr11_2.pdf	*J Shellfish Res* **11**: 489–505
Castilla JC *et al.*	Recent introduction of the dominant tunicate, *Pyura praeputialis* (Urochordata, Pyuridae) to Antofagasta,Chile	2002		*Mol Ecol* **11**: 1579–84
Castilla JC *et al.*	Down under the southeastern Pacific: marine non-indigenous species in Chile	2005	www.bio.puc.cl/caseb/pdf/prog6/Castilla%20etal_Biological%20invasions_2005.pdf	*Biol Invasions* **7**: 213–32
Cevik C *et al.*	A new record of an alien jellyfish from the Levantine coast of Turkey – *Cassiopea andromeda* (Forsskal, 1775)	2006	www.aquaticinvasions.ru/2006/AI_2006_1_3_Cevik_etal.pdf	*Aquatic Invasions* **1**: 196–97
Ceviker D *et al.*	Three alien molluscs from Iskenderun Bay (SE Turkey)	2006	www.aquaticinvasions.ru/2006/AI_2006_1_2_Ceviker_Albayrak.pdf	*Aquatic Invasions* **1**: 76–79
Chase C *et al.*	Marine bioinvasions fact sheet: New England marine bioinvaders		http://massbay.mit.edu/resources/pdf/case-studies.pdf	Sea Grant Fact Sheet
Chester RH	Destruction of Pacific coast corals by the sea star *Acanthaster planci*	1969		*Science* **165**: 280–83
Cho TO *et al.*	*Antithamnion nipponicum* (Ceramiaceae Rhodophyta), incorrectly known as *A pectinatum* in western Europe, is a recent introduction along the North Carolina and Pacific coasts of North America	2007		*Eur J Phycol* **40**: 323–35
CIESM	Alien marine organisms introduced by ships in the Mediterranean and Black Seas	2002	hwww.ciesm.org/online/monographs/Istanbul02.pdf	CIESM Workshop Monographs n 20
Çinar ME	Serpulid species (Polychaeta: Serpulidae) from the Levantine coast of Turkey (eastern Mediterranean), with special emphasis on alien species	2006	www.aquaticinvasions.ru/2006/AI_	*Aquatic Invasions* **1**: 233–40

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Çinar ME *et al.*	Temporal changes of soft-bottom zoobenthic communities in and around Alsancak Harbor (Izmir Bay, Aegean Sea), with special attention to the autecology of exotic species	2006	www.blackwell-synergy.com/doi/abs/10.1111/j.1439-0485.2006.00102.x	*Mar Ecol* **27**: 229
Çinar ME *et al.*	New records of alien species on the Levantine coast of Turkey	2006	www.aquaticinvasions.ru/2006/AI_2006_1_2_Cinar_etal.pdf	*Aquatic Invasions* **1**: 84–90
Cohen AN	Nonindigenous aquatic species in a United States estuary: a case study of the biological invasions of the San Francisco Bay and Delta	1995	www.anstaskforce.gov/Documents/sfinvade.htm	A report for the US Fish and Wildlife Service and the National Sea Grant College Program Connecticut Sea Grant
Cohen AN	An exotic species detection program for Puget Sound	2004	www.sfei.org/bioinvasions/Reports/2004-PugetSoundESDP380.pdf	Report for Puget Sound Action Team, Olympia, Washington
Cohen AN *et al.*	Washington State Exotics Expedition 2000: a rapid survey of exotic species in the shallow waters of Elliott Bay, Totten and Eld Inlets, and Willapa Bay	2000	http://faculty.washington.edu/cemills/WSX2000.pdf	
Cohen AN *et al.*	A rapid assessment survey of exotic species in sheltered coastal waters	2002	www.sfei.org/bioinvasions/Reports/2002-2000SoCalifsurvey_384.pdf	Project Report for the Southern California Exotics Expedition 2000
Coles SL *et al.*	Nonindigenous species introductions on coral reefs: a need for information	2002	http://hbs.bishopmuseum.org/pdf/56(2)p191-209.PDF	*Pac Sci* **56**: 191–209
Collin R *et al.*	Research note: *Crepidula convexa* Say, 1822 (Caenogastropoda: Calyptraeidae) in Washington State, USA	2006		*Am Malacol Bull* **21**: 113–16
Colorni A *et al.*	Fusariosis in the shrimp *Penaeus semisulcatus* cultured in Israel	1989		*Mycopathologia* **108**: 145–47
Cook CDK *et al.*	A revision of the genus *Elodea* (Hydrocharitaceae)	1985	http://el.erdc.usace.army.mil/aqua/apis/plants/html/elodea_c.html	*Aquat Bot* **21**: 111–56
Cordell JR	Asian copepods in Pacific Northwest estuaries	1998	www.psat.wa.gov/Publications/psnotes_pdf/psnote41.pdf	Puget Sound Notes No 41
Cordell JR *et al.*	The invasive Asian copepod *Pseudodiaptomus inopinus* in Oregon, Washington, and British Columbia estuaries	1996	www.sgnis.org/publicat/cordeljr.htm	*Estuaries* **19**: 629–38
Corsini M *et al.*	Lessepsian migrant *Fistularia commersonii* from Rhodes marine area	2002		*J Fish Biol* **61**: 1061–62
Corsini M *et al.*	Lessepsian migration of fishes to the Aegean Sea: first record of *Tylerius spinosissimus* (Tetraodontidae) from the Mediterranean, and six more fish records from Rhodes	2005	http://elnais.ath.hcmr.gr/PDF/Corsini_2005.pdf	*Cybium* **29**: 347–54
Corsini M *et al.*	On the occurrence of two brachyurans, *Myra subgranulata* and *Hebstia condyliata*, on Rhodes Island (SE Aegean Sea)	2006	http://elnais.ath.hcmr.gr/PDF/MYRA%20SUBGRANULATA_HERBSTIA%20CONDYLIATA.pdf	*Crustaceana* **79**: 167–74
Corsini M *et al.*	Three new exotic fish records from the SE Aegean Greek waters	2006		*Sci Mar* **70**: 319–23
CSIRO	Marine Pests Information Sheets	2000	www.marine.csiro.au/crimp/Marine_pest_infosheets.html	

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Curiel D *et al.*	First report of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta) in the Mediterranean Sea	2002		*Bot Mar* **45**: 66–70
Currie DR	Changes to benthic communities over 20 years in Port Phillip Bay, Victoria, Australia	1999		*Mar Pollut Bull* **38**: 36–43
Currie DR *et al.*	Exotic marine pests in the Port of Geelong, Victoria	1998		Marine and Freshwater Resource Institute Report No 8
da Rocha RM *et al.*	Introduced ascidians in Paranagua Bay, Parana, southern Brazil	2005	www.scielo.br/scielo.php?script=sci_arttext&pid=S0101-81752005000400052#fig08	*Rev Bras Zool* **22**: 1170–84
Dahlberg MD	Toxicity of acrolein to barnacles (*Balanus eburneus*)	1971 1	http://estuariesandcoasts.org/cdrom/CPSC1971_12_4_282_284.pdf	*Chesapeake Sci* **12**: 282–84
D'Archino R *et al.*	Invasive marine red algae introduced to New Zealand waters: first record of *Grateloupia turuturu* (Halymeniaceae, Rhodophyta)	2007		*NZ J Mar Freshwat Res* **41**: 35–42
Daunys D *et al.*	Invasion of the North American amphipod (*Gammarus tigrinus* Sexton, 1939) into the Curonian Lagoon, Southeastern Baltic Sea	2006	www.ekoi.lt/uploads/docs/2006_1_20-26%20psl.pdf	*Acta Zool Lit* **16**: 20–26
De Blauwe H *et al.*	Extension of the range of the bryozoans *Tricellaria inopinata* and *Bugula simplex* in the north-east Atlantic ocean (Bryozoa: Cheilostomatida)	2001		*Nederlandse Faunistische Mededelingen* **14**: 103–12
de la Cruz F *et al.*	Lista actualizada de los gasteropodos de la planicie del Arrecife Lobos, Veracruz, Mexico	2006	www.udoagricola.150m.com/V6UDOAg/V6Vicencio128.pdf	*Revista UDO Agricola* **6**: 128–37
De Rincon O	Studies on selectivity and establishment of "Pelo de Oso" (*Garveia franciscana*) on metallic and non-metallic materials submerged in Lake Maracaibo, Venezuela	2003		*Anti-Corros Methods Mater* **50**: 17–24
Det Norske Veritas	Ballast Water Scoping Study	2005	www.defra.gov.uk/science/Project_Data/DocumentLibrary/ME3113/ME3113_3506_FRP.pdf	Project No 3120018
Dijkstra JA *et al.*	Distribution and ecology of four colonial ascidians: *Botryllus schlosseri, Botrylloides violaceus, Diplosoma listerianum* and *Didemnum* sp in the Gulf of Maine	2005	www.whoi.edu/page.do?pid=11421&cid=16297&c=2	2005 International Invasive Sea Squirt Conference Presentation Abstract
Dulcic J	Northernmost occurrence of *Sphoeroides pachygaster* (Tetraodontidae) in the Adriatic Sea	2002		*Bull Mar Sci* **70**: 133–39
Dulcic J *et al.*	First record of the marbled spinefoot *Siganus rivulatus* (Pisces: Siganidae) in the Adriatic Sea	2004		*J Mar Biol Ass UK* **84**: 1087–88
Dyrynda PE *et al.*	The distribution, origins and taxonomy of *Tricellaria inopinata* d'Hondt and Occhipinti Ambrogi, 1985, an invasive bryozoan new to the Atlantic	2000		*J of Nat Hist* **34**: 1993–2006
Edinger GJ *et al.* (Eds)	Marine and estuarine	2002	www.dec.state.ny.us/website/dfwmr/heritage/marine_estuarine.pdf	In: Ecological communities of New York State, 2nd edn. A revised and expanded edition of Carol Reschke's Ecological communities of New York State (draft for review)

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Eldredge LG and Smith CM (Eds)	A guidebook of introduced marine species of Hawai'i	2001	www2.bishopmuseum.org/HBS/invertguide/index.htm	Bishop Technical Report 21
Elsam	Elsam Offshore Wind Turbines - Horns Rev/Annual status report for the environmental monitoring programme	2004	www.hornsrev.dk/Miljoeforhold/miljoerapporter/HR_annual%20report%202004%20version%2011072005.pdf	
Epifanio CE	Transport of blue crab (*Callinectes sapidus)* larvae in the waters off mid-Atlantic states	1995 1		*Bull Mar Sci* **57**: 569–706
Fashchevsky B	Human impact on rivers and fish in the Ponto-Caspian Basin	2003	www.fao.org/docrep/007/ad525e/ad525e0d.htm	FAO – Proceedings of the second international symposium on the management of large rivers for fisheries
Fenner D	Biogeography of three caribbean corals (*Scleractinia*) and the invasion of *Tubastraea coccinea* into the Gulf of Mexico	2001		*Bull Mar Sci* **69**: 1175–89
Fernandes LF *et al.*	The recently established diatom *Coscinodiscus wailesii* (Coscinodiscales, Bacillariophyta) in Brazilian waters. I: remarks on morphology and distribution	2001		*Phycol Res* **49**: 89–96
Flimlin G *et al.*	Major predators of cultured shellfish	1993	http://aquanic.org/publicat/usda_rac/efs/nrac/nbull18.pdf	Northeastern Regional Aquaculture Center Bulletin No 180-1993
Flores AAV *et al.*	Postlarval stages and growth patterns of the spider crab *Pyromaia tuberculata* (Brachyura, Majidae) from laboratory-reared material	2002		*J Crust Biol* **22**: 314–27
Foster BA *et al.*	Foreign barnacles transported to New Zealand on an oil platform	1979		*N Z J Mar Freshw Res* **13**: 143–49
Foulquie M *et al.*	Regional project for the development of marine and coastal protected areas in the Mediterranean region (MedMPA)	2002	http://medmpa.rac-spa.org/pdf/Rapports/Syrie/Report_Field%20survey%20Nov.%202002%20ENG.pdf	
Galil BS	Biodiversity and invasion – how resilient is the Levant Sea?	1997	www.sviva.gov.il/Enviroment/Static/Binaries/Articals/bio_inv_1.doc	*Israel Environ Bull* **30**
Galil BS	Loss or gain? Invasive aliens and biodiversity in the Mediterranean Sea	2006		*Mar Pollut Bull* **55**: 314–22
Galil BS	Shipping impacts on the biota of the Mediterranean Sea	2006	http://ec.europa.eu/maritimeaffairs/contributions_post/18bella_galil.pdf	
Galil BS *et al.*	A sea change – exotics in the eastern Mediterranean	2002	www.biomareweb.org/downloads/exotic_med.pdf	In: Leppakoski E *et al.*(Eds). Invasive aquatic species of Europe. Netherlands: Kluwer Academic Publishers
Garci ME *et al.*	*Xenostrobus securis* (Lamarck, 1819) (Mollusca: Bivalvia): first report of an introduced species in Galacian waters	2007		*Aquacult Int* **15**: 19–24
Garono RJ	Addendum to the Deschutes River Estuary Restoration Study	2007	www.earthdesign.com/deschutes/Deschutes-Inv-Jan-2007_final.pdf	Deschutes River Estuary Restoration Feasibility Study
Gaudet D	Atlantic Salmon: a white paper	2002	www.adfg.state.ak.us/special/as/docs/as_white2002.pdf	Report to Alaska Department of Fish and Game

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	Title	Year	Website	Journal/report information
Gavio B *et al.*	*Grateloupia turuturu* (Halymeniaeae, Rhodophyta) is the correct name of the non-native species in the Atlantic known as *Grateloupia doryphora*	2002	http://72.14.253.104/search?q=cache:V3py0_0gfYQJ:morayeel.louisiana.edu/SeaweedsLab/Fredericq/Grateloupia%2520turuturu.pdf+Grateloupia+turuturu&hl=en&ct=clnk&cd=2&gl=us	*Eur J Phycol* **37**: 349–59
Giacobbe MG *et al.*	Recurrent high-biomass blooms of *Alexandrium taylorii* (Dinophyceae), a HAB species expanding in the Mediterranean	2007		*Hydrobiologia* **580**: 125–33
Godwin S *et al.*	Reducing potential impact of invasive marine species in the northwestern Hawaiian Islands Marine National Monument	2005	http://cramp.wcc.hawaii.edu/Down/loads/TR_Godwin_et_al%20_Invasives_Final%20Draft.pdf	Hawaiian Coral Reef Assessment and Monitoring Program
Gofas S *et al.*	Exotic molluscs in the Mediterranean Basin: current status and perspectives	2003		*Oceanogr Mar Biol Ann Rev* **41**: 237–77
Gokoglu M and Kaya Y	First record of *Melicertus hathor* (Penaeidae) from the Gulf of Antalya (Mediterranean Sea)	2005	www.mba.ac.uk/jmba/pdf/5177.pdf	*JMBA2 – Biodiversity Records*
Golani D	Impact of Red Sea fish migrants through the Suez Canal on the aquatic environment of the eastern Mediterranean	1998	http://environment.yale.edu/documents/downloads/0-9/103golani.pdf	Yale School of Forestry and Environmental Studies Bulletin 103
Golani D	First record of the bluespotted cornetfish from the Mediterranean Sea	2000		*J Fish Biol* **56**: 1545–47
Golani D	The Indo-Pacific striped eel catfish, *Plotosus lineatus* (Thunberg, 1787), (Osteichtyes: Siluriformes) a new record from the Mediterranean	2002		*Sci Mar* **66**: 321–23
Goren M *et al.*	A review of changes in the fish assemblages of Levantine inland and marine ecosystems following the introduction of non-native fishes	2005		*J Appl Ichthyol* **21**: 364–70
Grabowski M	Rapid colonization of the Polish Baltic Coast by an Atlantic palaemonid shrimp *Palaemon elegans* Rathke, 1938	2006	www.aquaticinvasions.ru/2006/AI_2006_1_3_Grabowski.pdf	*Aquatic Invasions* **1**: 116–23
Gribble KE *et al.*	Distribution and toxicity of *Alexandrium ostenfeldii* (Dinophyceae) in the Gulf of Maine, USA	*2005*	www.whoi.edu/redtide/labweb/publications/Gribble_etal_2005_SI.pdf	*Deep-Sea Re (2 Top Stud Oceanogr)* **52**: 2754–63
Haahti H and Kangas P (Eds)	State of the Gulf of Finland in 2004	2006	www.itameriportaali.fi/en/tietoa/itamerentila/vuosiraportit/2004/en_GB/state_of_the_gulf_of_finland_in_2004/	MERI – Report Series of the Finnish Institute of Marine Research No 55
Hadfield MG *et al.*	Metamorphic competence, a major adaptive convergence in marine invertebrate larvae	2001		*Am Zool* **41**: 1123–31
Haque A	Macrobenthic assemblages inhabiting mangrove forests and adjacent mudflats	2003	www.eicc.bio.usyd.edu.au/pubs/?DB=pubs&id=356	MSc thesis, University of Sydney
Harmelin-Vivieni ML *et al.*	The littoral fish community of the Lebanese rocky coast (eastern Mediterranean Sea) with emphasis on Red Sea immigrants	2005		*Biol Invasions* **7**: 625–37
Hart T	Maine's marine invaders	2005	www.seagrant.umaine.edu/documents/pdf/MMI05.pdf	Sea Grant Fact Sheet
Hayward BW	Faunal changes in Waitemata Harbour sediments, 1930s–1990s	1997		*J R Soc NZ* **27**: 1–20

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Herkül K *et al.*	Distribution and population characteristics of the alien talitrid amphipod *Orchestia cavimana* in relation to environmental conditions in the northeastern Baltic Sea	2006		*Helgol Mar Res* **60**: 121–26
Hickerson EL *et al.*	The state of coral reef ecosystems of the Flower Garden Banks, Stetson Bank, and other banks in the northwestern Gulf of Mexico	2005	http://ccma.nos.noaa.gov/ecosystems/coralreef/coral_report_2005/FGB_Ch8_C.pdf	
Hoagland KE	Range extensions of teredinids (shipworms) and polychaetes in the vicinity of a temperate-zone nuclear generating station	1980		*Mar Biol* **58**: 55–64
Hoffmeyer MS	Decadal change in zooplankton seasonal succession in the Bahía Blanca estuary, Argentina	2004		*J Plankton Res* **26**: 181–89
Hoffmeyer MS *et al.*	*Eurytemora americana* Williams, 1906, not *Eurytemora affinis* (Poppe, 1880), inhabits the Bahia Blanca estuary, Argentina*	2000	www.icm.csic.es/scimar/PDFs/sm64n1111.pdf	*Sci Mar* **64**: 111–13
Holdich D *et al.*	The invasive Ponto-Caspian mysid, *Hemimysis anomala*, reaches the UK	2006	www.aquaticinvasions.ru/2006/AI_2006_1_1_Holdich_etal.pdf	*Aquatic Invasions* **1**: 4–6
Hovel KA *et al.*	Planktivory as a selective force for reproductive synchrony and larval migration	1997	www.int-res.com/articles/meps/157/m157p079.pdf.	*Mar Ecol-Prog Ser* **157**: 79–95
ICES: International Council for the Exploration of the Sea	Report of the Working Group on Introductions and Transfers of Marine Organisms (WGITMO)	2007	www.ices.dk/reports/ACME/2007/WGITMO07.pdf	ICES WGITMO Report 2007
ICES: International Council for the Exploration of the Sea	ICES Working Group on Introductions and Transfers of Marine Organisms Report 200	2006	www.ices.dk/reports/ACME/2006/WGITMO06.pdf	ICES CM 2006/ACME:05
IMO: International Marine Organizations	Alien invaders – putting a stop to the ballast water hitch-hikers	1999	http://72.14.253.104/search?q=cache:mevKIw5iG4MJ:www.imo.org/includes/blastData.asp/doc_id%3D420/BALLAST%2520Alien%2520invaders%25201999.pdf+Antithamnion+nipponicum&hl=en&ct=clnk&cd=23&gl=us	
Inglis G *et al.*	Gulf Harbour Marina	2005	www.maf.govt.nz/mafnet/publications/biosecurity-technical-papers/2005-12-gulf-harbour-marina.pdf	Baseline survey for non-indigenous marine species (Research Project ZBS2000/04)
Inglis G *et al.*	Opua Marina – baseline survey for non-indigenous marine species (Research Project ZBS 2000/04)	2005	www.maf.govt.nz/mafnet/publications/biosecurity-technical-papers/2005-14-opua-marina.pdf	Biosecurity New Zealand Technical Paper No: 2005/14
Inglis G *et al.*	Dunedin Harbour (Port Otago and Port Chalmers) – baseline survey for non-indigenous marine species (Research Project ZBS2000/4)	2005	www.maf.govt.nz/mafnet/publications/biosecurity-technical-papers/2005-10-port-of-otago.pdf	Biosecurity New Zealand Technical Paper No: 2005/14
Inglis G *et al.*	Port of Lyttelton – baseline survey for non-indigenous marine species (Research Project ZBS2000/04)	2006	www.maf.govt.nz/mafnet/publications/biosecurity-technical-papers/2005-01-port-of-lyttelton.pdf	Biosecurity New Zealand Technical Paper No: 2005/01
Janas U	Distribution and individual characteristics of the prawn *Palaemon elegans* (Crustacea, Decapoda) from the Gulf of Gdansk and the Dead Vistula River	2005	http://aliens.ocean.univ.gda.pl/obce/Baltic_Aliens/Janas.pdf	*Oceanological and Hydrobiological Studies* **XXXIV**: 83–91

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Jones JB and Franklin A	Monitoring and surveillance of non-radioactive contaminants in the aquatic environment and activities regulating the disposal of wastes at sea, 1995 and 1996	1998	www.cefas.co.uk/Publications/aquatic/aemr51.pdf	Science Series: Aquatic Environment Monitoring Report No 51
Jørgensen LL and Sundet JH	Introduction, spread and potential impact of the recently introduced Red King Crab, *Paralithodes camtschaticus*, in coastal subarctic Norway	2003	www.sgnis.org/publicat/jorgsund.htm	Proceedings of the Third International Conference on Marine Bioinvasions; La Jolla, California; 2003 March 16–19
Karako S *et al.*	*Asterina burtoni* (Asteroidea; Echinodermata) in the Mediterranean and the Red Sea: does asexual reproduction facilitate colonization?	2002		*Mar Ecol-Prog Ser* **234**: 139–45
Katagan T *et al.*	An Indo-Pacific stomatopod from the Sea of Marmara: *Erugosquilla massavensis* (Kossmann, 1880)	2004		*Crustaceana* **77**: 381–83
Kennedy VS *et al.*	Maryland's oysters – research and management	1981	http://nsgd.gso.uri.edu/aqua/mdut81003.pdf	Maryland Sea Grant – Publication No UM-SG-TS-81-04
Kenny R	Effects of temperature, salinity and substrate on distribution of *Clymenella torquata* (Leidy), Polychaeta	1969	http://links.jstor.org/sici?sici=0012-9658%28196907%2950%3A4%3C624%3AEOTSAS%3E2.0.CO%3B2-0	*Ecology* **50**: 624–31
Kideys AE *et al.*	Prelimlinary report: laboratory studies on the *Beroe ovata* and *Mnemiopsis leidi* in the Caspian Sea Water	2002	www.caspianenvironment.org/mnemiopsis/mnemmenu6.htm	Caspian Environment Program
Kim M-S *et al.*	Recent introduction of *Polysiphonia morrowii* (Ceramiales, Rhodophyta) to Punta Arenas, Chile	2004		*Bot Mar* **47**: 389–94
Knight-Jones *et al.*	*Sabelliform polychaetes*, mostly from Turkey's Aegean coast	1991		*J of Nat Hist* **25**: 837–55
Kornfield IL *et al.*	Likely pre-Suez occurrence of a Red Sea fish (*Aphanius dispar*) in the Mediterranean	1976	www.nature.com/nature/journal/v264/n5583/abs/264289a0.html	*Nature* **264**: 289–91
Kozhova OM *et al.*	Spread of *Elodea canadensis* in Lake Baikal	2004		*Hydrobiologia* **259**: 203–11
Krakae M *et al.*	Native parasites adopt introduced bivalves of the North Sea	2006		*Biol Invasions* **8**: 919–25
Kufel L	Chara beds acting as nutrient sinks in shallow lakes – a review	2002		*Aquat Bot* **72**: 249–60
Lavie B *et al.*	Genetic diversity of marine gastropods: contrasting strategies of *Cerithium rupestre* and *C scabridum* in the Mediterranean Sea	1986		*Mar Ecol-Prog Ser* **28**: 99–103
Leone D	Sponge threatens coral in bay	2005	http://starbulletin.com/2005/12/10/news/story03.html	*Star Bulletin* **10** (44)
Levin LA	Drift tube studies of bay–ocean water exchange and implications for larval dispersal	1983		*Estuaries* **6**: 364–71
Ligal MZ *et al.*	Bioaccumulation of some heavy metals (Cd, Fe, Zn, Cu) in two bivalvia species (*Pinctada radiata,* Leach 1814 and *Brachidontes pharaonis* Fischer, 1870)	2005		*Turk J Vet Anim Sci* **29**: 89–93
Lilly EL *et al.*	Paralytic shellfish poisoning toxins in France linked to human-introduced strain of *Alexandrium catenella* from western Pacific: evidence from DNA and toxin analysis	2002		*J Plankton Res* **24**: 443–52

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Lim PT *et al.*	First report of *Alexandrium taylori* and *Alexandrium peruvianum* (Dinophyceae) in Malaysian waters	2005		*Harmful Algae* **4**: 391–400
Littler DS *et al.*	Report: Bonaire National Marine Park – algal survey and inventory	2006	www.mina.vomil.an/welcome/islands/downloads/Bonairealgalsurveyreport.pdf	
Lopez V and Krauss U	National and regional capacities and experiences on marine invasive species, including ballast waters, management programmes in the wider Caribbean Region: a compilation of current information	2006	www.cep.unep.org/newsandevents news/2006/report-on-marine-invasive species/	UNEP Caribbean Environment Programme Report on Marine Invasive Species
Lotan A *et al.*	Synchronization of the life cycle and dispersal pattern of the tropical invader scyphomedusan *Rhopilema nomadica* is temperature dependent	1994	www.int-res.com/articles/meps/109/m109p059.pdf	*Mar Ecol-Prog Ser* **109** 59–65
Maldonado M *et al.*	Effects of physcial factors on larval behavior, settlement and recruitment of four tropical demosponges	1996	www.int-res.com/articles/meps/138/m138p169.pdf	*Mar Ecol-Prog Ser* **138**: 169–80
Martel C *et al.*	Invasion of the marine gastropod *Ocinebrellus inornatus* on the French Atlantic coast	*2004*		*Mar Ecol-Prog Ser* **273**: 163–72
Martin A *et al.*	The fauna of anfipodos (Crustacea: Amphipoda) of coastal waters of the eastern region of Venezuela	2003		*Bulletin, Spanish Institute of Oceanography* **1**: 327–44
Martin G *et al.*	Recent changes in distribution pattern of introduced charophyte species *Chara Connivens* in Estonian coastal waters of the Baltic Sea	2003	www.sgmeet.com/mb/viewabstract2 asp?AbstractID=136&SessionID=28	Poster Abstract: Third International Conference on Marine Bioinvasions
Mastitsky SE *et al.*	The gravel snail, *Lilthoglyphus naticoides* (Gastropoda: Hydrobiidae), a new Ponto-Caspian species in Lake Lukomskoe (Belarus)	2006	www.aquaticinvasions.ru/2006/AI_2006_1_3_Mastitsky_Samoilenko.pdf	*Aquatic Invasions* **1**: 161–70
Mavruk S *et al.*	Non-native fishes in the Mediterranean from the Red Sea, by way of the Suez Canal	2007	www.springerlink.com/content/462t521t02lw8532/?p=e67e9b1bd2a64d22abacae9ab50e8a45&pi=3	*Reviews in Fish Biology and Fisheries* (early online publication)
Maximov AA *et al.*	Invasion by oligochaete *Tubificoides pseudogaster* alters soft-bottom community structure and function in the eastern Gulf of Finland	*2006*	www.msi.ttu.ee/files/0/GoFSeminar 2006Abstracts.pdf	Gulf of Finland Seminar – Abstracts
McGann M *et al.*	Invasion by a Japanese marine microorganism in western North America	2000		*Hydrobiologia* **421**: 25–30
McGann M *et al.*	Arrival and expansion of the invasive foraminifer *Trochammina hadai* Uchio in Padilla Bay, Washington: a new geologic datum	2007	gsa.confex.com/gsa/2007CD/final program/abstract_121069.htm	Cordilleran Section – 103rd Annual Meeting; 2007 May 4–6
Metropolitan Wastewater Dept – Ocean Monitoring Program	An ecological assessment of San Diego Bay: a component of the Bight '98 regional survey	2003	www.swrcb.ca.gov/rwqcb9/programs/baycleanup/SDBay%20Report.pdf	City of San Diego, California
Miller AW	Assessing the importance of biological attributes for invasion success: eastern oyster (*Crassostrea virginica*) introductions and associated molluscan invasions of Pacific and Atlantic coastal systems	2000	http://magpiedesign.com/miller/documents/MilllerAW2000 Dissertation.pdf	

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Mills CE *et al.*	Invertebrate introductions in marine habitats: two species of hydromedusae (Cnidaria) native to the Black Sea, *Maeotias inexspectata* and *Blackfordia virginica*, invade San Francisco Bay	1995		*Mar Biol* **122**: 279–88
Mito T *et al.*	Invasive alien species in Japan: the status quo and the new regulation for prevention of their adverse effects	2004	www.airies.or.jp/publication/ger/pdf/08-02-08.pdf	*Global Environmental Research* **8**: 171–91
Monti M *et al.*	First record of Ostreopsis cfr Ovata on macroalgae in the Northern Adriatic Sea	2007		*Mar Pollut Bull* **54**: 598–601
Morello EB *et al.*	The alien bivalve *Anadara demiri* (Arcidae): a new invader of the Adriatic Sea, Italy	2004	http://journals.cambridge.org.offcampus.ib.washington.edu/download.php?file=%2FMBI%2FMBI84_05%2FS0025315404010410a.pdf&code=41a99853006ac144ef0a6e06d5ccf9fa	*J Mar Biol Ass UK* **84**: 1057–64
Morton B	The marine flora and fauna of Hong Kong and Southern China V	2001		
Nguyen-Ngoc L	An autecological study of the potentially toxic dinoflagellate *Alexandrium affine* isolated from Vietnamese waters	2004		*Harmful Algae* **3**: 117–29
Ni Chualain F *et al.*	The invasive genus *Asparagopsis* (Bonnemaison-iacea, Rhodophyta): molecular systematics, morphology, and ecophysiology of Falkenbergia isolates	2004		*J Phycol* **40**: 1112–26
NOAA	Invasive marine species found on Georges Bank	2003	www.noaanews.noaa.gov/stories2003/s2125.htm	*NOAA Magazine*
Novosel M *et al.*	Ecology of an anchialine cave in the Adriatic Sea with special reference to its thermal regime	2007		*Mar Ecol* **28**: 3–9
Ojaveer H *et al.*	Ecological impact of Ponto-Caspian invaders in the Baltic Sea, European inland waters and the Great Lakes: an inter-ecosystem comparison	2002	www.biomareweb.org/downloads/ojaveer.pdf	In: Leppäkoski E *et al.* 2002. Invasive aquatic species of Europe: distribution, impacts and management
Özcan T *et al.*	The first record of the banana prawn *Fenneropenaeus merguiensis* (De Man, 1888) (Crustacea: Decapoda: Penaeidae) from the Mediterranean Sea	2006	www.aquaticinvasions.ru/2006/AI_2006_1_4_Ozcan_etal.pdf	*Aquatic Invasions* **1**: 286–88
Ozturk B *et al.*	Indo-Pacific gastropod species in the Levantine and Aegean Seas	2006	http://aquaticinvasions.ru/2006/AI_2006_1_3_Ozturk_Can.pdf	*Aquatic Invasions* **1**: 124–29
Pais A *et al.*	Westward range expansion of the Lessepsian migrant *Fistularia commersonii* (Fistulariidae) in the Mediterranean Sea, with notes on its parasites	2007		*J Fish Biol* **70**: 269–77
Pallaoro A *et al.*	First record of the *Sphyraena chrysotaenia* (Klunzinger, 1884) (Pisces, Sphyraenidae) from the Adriatic Sea	2001		*J Fish Biol* **59**: 179–82
Pancucci-Papadopoulou MA	Update of marine alien species in Hellenic waters	2005	http://elnais.ath.hcmr.gr/PDF/Update%20of%20marine%20alien%20species%20in%20Hellenic%20waters.pdf	*Medit Mar Sci* **6**
Pannell A	Treatment methods used to manage *Didemnum vexillum* in New Zealand	2007		

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Mills CE *et al.*	Invertebrate introductions in marine habitats: two species of hydromedusae (Cnidaria) native to the Black Sea, *Maeotias inexspectata* and *Blackfordia virginica*, invade San Francisco Bay	1995		*Mar Biol* **122**: 279–88
Parry GD and Cohen B	Exotic species established in Western Port, including an assessment of the status of the exotic species *Corbula gibba, Alexandrium* spp, *Gymnodinium* spp and *Undaria pinnatifida*	2001	http://72.14.253.104/search?q=cache:A-9iBCN_nBYJ:www.land.vic.gov.au/DSE/nrencm.nsf/646e9b4bba1afb2bca256c420053b5ce/7ae83a588d2ce75eca256e670017e6b0/%24FILE/report45.pdf+Alexandrium+peruvianum&hl=en&ct=clnk&cd=11&gl=us	
Paula AF *et al.*	Spatial distribution and abundance of non-indigenous coral genus *Tubastraea* (Cnidaria, Scleractinia) around Ilha Grande, Brazil	2005	www.scielo.br/pdf/bjb/v65n4/a14v65n4.pdf	*Braz J Biol* **65**: 661–73
Penna A *et al.*	*Alexandrium catenella* (Dinophyceae), a toxic ribotype expanding in the NW Mediterranean Sea	2005		*Mar Biol* **148**: 12–23
Piazzi L *et al.*	Spread of alien macroalgal species along the Tuscany coasts	2000	http://flux.ve.ismar.cnr.it/igbp/proceeding2000/GLOBEC.pdf	Global Ocean Ecosystem Dynamics (GLOBEC) – Characteristics of and variations in the Mediterranean marine ecosystem
Pierre MADL and Maricela YIP	Literature review of *Caulerpa taxifolia*	2005	www.sbg.ac.at/ipk/avstudio/pierofun/ct/caulerpa.htm	Contribution for the 31st BUFUS Newsletter, University of Salzburg – Molecular Biology, Salzburg Austria
Pipitone C *et al.*	Contribution to the knowledge of *Percnon gibbesi* (Decapoda, Grapsidae), an exotic species spreading rapidly in Sicilian waters	*2001*		*Crustac Int J Crustac Res* **74**: 1009–17
Pollard DA *et al.*	Report on Port Kembla introduced marine pest species survey	2002	www.dpi.nsw.gov.au/__data/assets/pdf_file/137166/output-41.pdf	*NSW Fisheries Final Report Series* 41
Psomadakis PN *et al.*	Additional record of *Sphoeroides pachygaster* (Pisces: Tetraodontidae) in the Tyrrhenian Sea and notes on the distribution of the species in the Mediterranean	2006	www.mba.ac.uk/jmba/pdf/5186.pdf	*JMBA2 – Biodiversity Records*
Rahimian H *et al.*	*Pseudobacciger harengulae* from the Atlantic herring *Clupea harengus*: a new host and locality record	2003		*J Helminthol* **77**: 69–75
Ray GL	Invasive marine and estuarine animals of the south Atlantic and Puerto Rico	2005	http://el.erdc.usace.army.mil/elpubs/pdf/ansrp05-5.pdf	US Army ERDCenter Report: ERDC/TN ANSRP-05-5
Ray GL	Invasive marine and estuarine animals of the Gulf of Mexico	2005	http://el.erdc.usace.army.mil/elpubs/pdf/ansrp05-4.pdf	ANSRP Technical Notes Collection (ERDC/TN ANSRP-05-4)
Rees JT *et al.*	Non-indigenous hydromedusae in California's upper San Francisco Estuary: life cycles, distribution, and potential environmental impacts*	2000	www.icm.csic.es/scimar/PDFs/sm64s1073.pdf	*Sci Mar* **64**: 73–86
Rhodes LL *et al.*	*Coolia monotis* (Dinophyceae): a toxic epiphytic microalgal species found in New Zealand (Note)	1997		*NZ J Mar Freshwat Res* **31**: 139–41

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Rodionova NV and Panov VE	Establishment of the Ponto-Caspian predatory cladoceran *Evadne anonyx* in the eastern Gulf of Finland, Baltic Sea	2006	www.aquaticinvasions.ru/2006/AI_2006_1_1_Rodionova_Panov.pdf	*Aquatic Invasions* **1**: 7–12
Rojas-Gonzalez B *et al.*	Notes on *Rhodomelaceae* (Rhodophyta) from the Canary Islands: observations on reproductive morphology and new records	2000	www.atypon-link.com/WDG/doi/pdf/10.1515/BOT.2000.015	*Bot Mar* **43**: 147–55
Rolbiecki L	The first record of parasites in *Gammarus tigrinus* Sexton, 1939 – a recent newcomer to the Gulf of Gdansk	2005		*Oceanologia* **47**: 283–87
Ruesink J *et al.*	Demographic comparisons and control strategies for high- and low-impact invaders	2004	http://abstracts.co.allenpress.com/pweb/esa2004/document/?ID=38451	2004 ESA Annual Meeting Abstract
Ruitton S *et al.*	First assessment of the *Caulerpa racemosa* (Caulerpales, Chlorophyta) invasion along the French Mediterranean coast	*2005*	www.unice.fr/LEML/Pages/Pub_LEML/Ruitton_etal_2005.pdf	*Mar Pollut Bull* **50**: 1061–68
Ruiz GM	Invasion of coastal marine communities in North America: apparent patterns, processes, and biases	2000		*Annu Rev Ecol Syst* **31**: 481–531
Russell DJ *et al.*	Host utilization during ontogeny by two pycnogonid species (*Tanystylum duospinum* and *Ammothea hilgendorfi*) on the hydroid *Eucopella everta* (Coelenterata: Campanulariidae)	1990	http://viticulture-enology.org/09/48/094880.html	*Bijdr Dierkd* **60**: 215–24
Russev vBK	Influence of some ecological factors on changes of the standing crop of zoobenthos of the Danube in the Bulgarian stretch	1972	www.iad.gs/content/library/artikel/artikel6.php?PHPSESSID=a67e9c66f51a1f0178dd34112743887f	Proceedings of the IBP–UNESCO Symposium
Sanson M *et al.*	Sublittoral and deep-water red and brown algae new from the Canary Islands	2002		*Bot Mar* **45**: 35–49
Sartoni G *et al.*	A survey of the marine algae of Milos Island, Greece	1999		*Cryptogamie: Algol* 20: 271–83
Schramm W and Nienhuis PH	Marine benthic vegetation: recent changes and the effects of eutrophication	1996		
Schwartz FJ	Tail spine characteristics of stingrays (order *Myliobatiformes*) found in the northeast Atlantic, Mediterranean, and Black Seas	2005	http://ichthyology.tau.ac.il/2005/Stingray.pdf	*Electronic Journal of Ichthyology* **1**: 1–9
Seehagen A *et al.*	The interspecific competition between *Carcinus maenas* (Linnaeus 1758) and *Hemigrapsus penicillatus* (De Haan 1835), a potential invader into German coastal waters	2001	www.sgnis.org/publicat/cmb57.htm	Proceedings of the Second International Conference on Marine Bioinvasions; New Orleans, LA; 2001 April 9–11
Sei S	First report of the occurrence of *Acartia tonsa* (Copepoda:Calanoida) in the Lesina lagoon (south Adriatic Sea–Mediterranean Sea)	2006	www.mba.ac.uk/jmba/pdf/5391.pdf	JMBA2 – Biodiversity Records
Selina MS *et al.*	First records of dinoflagellates *Alexandrium margalefi* Balech, 1994 and *A tamutum* Montresor, Beran et Jon, 2004 in the seas of the Russian Far East	*2005*		*Russian Journal of Marine Biology* **31**: 187–91
Sezgin M *et al.*	New record of a Lessepsian amphipod from the Levantine coast of Turkey: *Elasmopsus pectenicrus* (Bate 1862)	2007		*Crustaceana* **80**: 247–51
Shluker AD	State of Hawaii Aquatic Invasive Species Management Plan	2003	www.hawaii.gov/dlnr/dar/pubs/ais_mgmt_plan_final.pdf	

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	Title	Year	Website	Journal/report information
Simon-Bouhet B *et al.*	Multiple introductions promote range expansion of the mollusc *Cyclope neritea* (Nassariidae) in France: evidence from mitochondrial sequence data	2006		*Mol Ecol* **15**:1699–1711
Smayda T	Harmful algal bloom communities in Scottish coastal waters: relationship to fish farming and regional comparisons – a review: paper 2006/3	2006	www.scottishexecutive.gov.uk/Publications/2006/02/03095327/10	Scottish Executive Publications
Stafford H *et al.*	Port of Thursday Island – baseline survey for introduced marine pests	2004	www.rrrc.org.au/publications/downloads/Port-of-Thurs-Island-Baseline-Surveys-Final-300506.pdf	Final Report of the March 2004 Port-Wide Field Survey
Steele S *et al.*	Impact of the copepod *Mytilicola orientalis* on the Pacific oyster *Crassotrea gigas* in Ireland	2001		*Dis Aquat Org* **47**: 145–49
Stimson J *et al.*	Effects of herbivory, nutrient levels, and introduced algae on the distribution and abundance of the invasive macroalga *Dictyosphaeria cavernosa* in Kaneohe Bay, Hawaii	2001		*Coral Reefs* **19**: 343–57
Streftaris N *et al.*	Globalization in marine ecosystems: the story of non-indigenous marine species across European seas	2005	www.nobanis.org/files/Streftaris%20et%20al%202005.pdf	*Oceanogr Mar Biol Annu Rev* **43**: 419–53
Streftaris N *et al.*	Alien marine species in the Mediterranean – the 100 "worst invasives" and their impact	2006	www.sesame-ip.eu/doc/Streftaris_and_Zenetos_2006_100_Worst_Invasive_species_in_Mediterranean.pdf	*Medit Mar Sci* **7**: 87–118
Svavarason J	Does the wood-borer *Sphaeroma terebrans* (Crustacea) shape the distribution of the mangrove *Rhizophora mucronata?*	2002	http://wiomsa.org/pub/downloadfile.asp?fid=41	*Ambio* **31**: 574–79
Talley TS *et al.*	Habitat utilization and alteration by the invasive burrowing isopod, *Sphaeroma quoyanum*, in California salt marshes	2001	http://levin.ucsd.edu/research/Sphaeroma.pdf	*Mar Biol* **138**: 561–73
Taskin E *et al.*	First report of *Microspongium globosum* Reinke (Phaeophyceae, Myrionemataceae) in the Mediterranean Sea	2006		*Nova Hedwigia* **82**: 135–42
Terranova S *et al.*	Population structure of *Brachidontes pharaonis* (P Fisher, 1870) (Bivalvia, Mytilidae) in the Mediterranean Sea, and evolution of a novel mtDNA polymorphism	2006		*Mar Biol* **150**: 89–101
Thessalou-Legaki *et al.*	The establishment of the invasive crab *Percnon gibbesi* (H Milne Edwards, 1853) (Crustacea: Decapoda: Grapsidae) in Greek waters	2006	www.aquaticinvasions.ru/2006/AI_2006_1_3_Thessalou_etal.pdf	*Aquatic Invasions* **1**: 133–36
Torchin ME *et al.*	Parasites and marine invasions	2002		*Parasitology* **124**: 137–51
Torchin ME *et al.*	The introduced ribbed mussel (*Geukensia demissa*) in Estero de Punta Banda, Mexico: interactions with the native cord grass, *Spartina foliosa*	2005		*Biol Invasions* **7**: 607–14
Torcu H	Lessepsian fishes spreading along the coasts of the Mediterranean and the southern Aegean Sea of Turkey	2000		*Turk J Zool* **24**: 139–48
Troup C	Marine invaders	2007	www.TeAra.govt.nz/EarthSeaAndSky/OceanStudyAndConservation/MarineInvaders/en	Te Ara - the encyclopedia of New Zealand

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Tsai ML *et al.*	Desiccation resistance of two semiterrestrial isopods, *Ligia exotica* and *Ligia taiwanensis* (Crustacea) in Taiwan	1998		*Comp Biochem Physiol A Mol Integr Physiol* **119**: 361–67
Tsai ML *et al.*	Life history plasticity and reproductive strategy enabling the invasion of *Ligia exotica* (Crustacea: Isopoda) from the littoral zone to an inland creek	2001	www.int-res.com/articles/meps/210/m210p175.pdf	*Mar Ecol-Prog Ser* **210**: 175–84
Tsirika A *et al.*	A survey of the benthic flora in the National Marine Park of Zakynthos (Greece)	2005	http://elnais.ath.hcmr.gr/PDF/Tsirika-Haritonidis_2005.pdf	*Bot Mar* **48**: 38–45
Vanden Bossche J-P *et al.*	First record of the Pontocaspian invader *Hypania invalida* (Grube, 1860) (Polychaeta: Ampharetidae) in the River Meuse (Belgium)	2001	www.naturalsciences.be/institute/associations/rbzs_website/bjz/back/pdf/BJZ%20131(2)/Volume%20131(2),%20pp.%20183-185.pdf	*Belgian J Zool* **131**: 183–85
Verslyckel T *et al.*	First occurrence of the Pontocaspian invader *Hemimysisanomala* (Sars, 1907) in Belgium (Crustacea: Mysidacea)	2000	www.whoi.edu/cms/files/tverslycke/2005/1/First_occurrence_of_the_Pontocaspian_invader_Hemimysis_anomala_(SARS,_1907)_in_Belgium_(Crustacea,_Mysidacea)-_BJZ2000_1041.pdf	*Belgian J Zool* **130**: 157–58
Voultsiadou E	Demosponge distribution in the eastern Mediterranean: a NW–SE gradient	2005		*Helgol Mar Res* **59**: 237–51
Wallentinus I *et al.*	Introduced marine organisms as habitat modifiers	2007		*Mar Pollut Bull* **55**: 323–32
Webber WR *et al.*	Life history studies on New Zealand Brachyura *5. Larvae of the family Majidae	1981	www.rsnz.org/publish/nzjmfr/1981/39.php	*NZ J Mar Freshwat Res* **15**: 331–83
Wisely B	Effects of antifouling paints on settling larvae of the bryozoan *Bugula neritina* L	1963		*Aust J Mar Freshw Res* **14**: 44–59
Wittenberg R (Ed)	An inventory of alien species and their threat to biodiversity and economy of Switzerland	2005	www.nobanis.org/files/invasives%20in%20CH.pdf	CABI Bioscience Switzerland Centre report to the Swiss Agency for Environment, Forests and Landscape
Wolff WJ	Non-indigenous marine and estuarine species in the Netherlands	2005	www.marbee.fmns.rug.nl/pdf/marbee/2005-Wolf-ZoolMed.pdf	*Zool Med Leiden* **79**: 31
Woods Hole Oceanographic Institution US	Marine fouling and its prevention	1952	https://darchive.mblwhoilibrary.org/bitstream/1912/191/18/chapter+10.pdf	Contribution No 580 from the Woods Hole Oceanographic Institute
Workman ML *et al.*	Introduced yellowfin goby, *Acanthogobius flavimanus*: diet and habitat use in the lower Mokelumne River, California	2007	http://repositories.cdlib.org/jmie/sfews/vol5/iss1/art1	*San Francisco Estuary and Watershed Science* **5**: Article 1
Xu H *et al.*	The status and causes of alien species invasion in China	2006		*Biodiversity Conserv* **15**: 2892–2904
Yamamoto M *et al.*	Draft priority species – freshwater and marine	2003	http://praise.manoa.hawaii.edu/news/Priorityspecies_draft2.doc	State of Hawaii Aquatic Nuisance Species Plan
Yokes B *et al.*	Touchdown – first record of *Percnon gibbesi* (H Milne Edwards, 1853) (Crustacea: Decapoda: Grapsidae) from the Levantine coast	2006	www.aquaticinvasions.ru/2006/AI_2006_1_3_Yokes_Galil.pdf	*Aquatic Invasions* **1**: 130–32
Zenetos A *et al.*	Origin and vectors of introduction of exotic molluscs in Greek waters	2005	www.naturalsciences.be/institute/associations/rbzs_website/bjz/back/pdf/BJZ%20135(2)/Volume%20135(2),%20pp.%20279-286.pdf	*Belgian J Zool* **135**: 279–86

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Articles and reports

Author	*Title*	*Year*	*Website*	*Journal/report information*
Zettler ML *et al.*	Distribution and population dynamics of *Marenzelleria viridis* (Polychaeta, Spionidae) in a coastal water of the southern Baltic	1995		*Arch Fish Mar Res* **42**: 209–24
Zhokhov AE *et al.*	Dispersal of invading trematodes *Nicolla skrjabini* (Iwanitzky, 1928) and *Plagioporus skrjabini* Kowal, 1951 (Trematoda: Opecoelidae) in the Volga	2006		*Russ J Ecol* **37**: 363–65

Other web resources

Title	*Website*
Alaska Invasive Species Working Group: Marine Subcommittee Audio Conference	www.uaf.edu/ces/aiswg/pdf-documents/MarineMinutes-5-30-06.pdf
Aquatic Nuisance Species: European Green Crab	http://wdfw.wa.gov/fish/ans/greencrab.htm
Aukland Museum	www.aucklandmuseum.com/
Australia identifies marine pest threats (2003 media release)	www.marine.csiro.au/media/03releases/14jul03b.htm
Australia's NSW Dept of Primary Industries: Factsheets	www.dpi.nsw.gov.au/fisheries
Avian Web: Canada Geese	www.avianweb.com/canadageese.html
Battle of the Black Sea Jellies	www.imagequest3d.com/pages/general/news/blackseajellies/blackseajellies.htm
Centre for Aquatic Plant Management's Information Sheet 7: Canadian Waterweed	www.nerc-wallingford.ac.uk/research/capm/pdf%20files/7%20Canadian%20pondweed.pdf
Chesapeake Bay Program	www.chesapeakebay.net/index.cfm
Crustikon – Crustacean photographic website – Tromsø Museum – University of Tromsø (author: C d'Udekem d'Acoz)	www.imv.uit.no/crustikon/Decapoda/Decapoda2/Species_index/Hemigrapsus_penicillatus.htm
CSIRO's The Web-Based Rapid Response Toolbox	http://crimp.marine.csiro.au/NIMPIS/controls.htm
Dauphin Island Sea Lab's Dock Watch	http://dockwatch.disl.org/haveyouseen.htm
Defense scientists discover introduced marine species (2001 media release)	www.dsto.defence.gov.au/news/3308/
Ecoplan News Issue 58	www.naturebase.net/component/option,com_docman/task,doc_download/Itemid,1075/gid,324/
Elkhorn Slough Research: Least Wanted Aquatic Invaders	www.elkhornslough.org/research/aquaticinvaders/aquatic0.htm
Examples of marine invasive species introduced via the shipping industry	www.ortepa.org/pages/ei19pt5.htm
Exotic Species of San Francisco Bay	www.exoticsguide.org/
FAO Fishery and Aquaculture country profile – Bolivia	www.fao.org/fi/website/FIRetrieveAction.do?dom=countrysector&xml=FI-CP_BO.xml
FloraBase: Western Australia Flora	http://florabase.calm.wa.gov.au/
Gammarus tigrinus, a new species in the Gulf of Finland (Baltic Sea Portal)	www.itameriportaali.fi/en/tietoa/artikkelit/ihminen/en_GB/gammarus/
Government of Western Australia – Department of Fisheries	www.fish.wa.gov.au/index.php

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Other web resources

Title	*Website*
Gracilaria salicornia	http://downwindproductions.com/tours/streams/algae.html
Greater Chicago Cichlid Association	www.gcca.net/index.htm
Guide to Marine Invaders in the Gulf of Maine	www.mass.gov/czm/invasives/monitor/id.htm
HELCOM (Helsinki Commission) 1/2005 Newsletter	http://helcom.navigo.fi/stc/files/Publications/Newsletters/newsletter_01_2005.pdf
Hemigrapsus takanoi in the Eastern Scheldt	www.dochterland.org/hemigrapsus.htm
Identifying Harmful Marine Dinoflagellates: Harmful Marine Dinoflagellate Taxa	www.nmnh.si.edu/botany/projects/dinoflag/taxa.htm#Ostreopsis
Invasion of the Jellies: Unwelcome Visitors to the Black Sea	www.ocean.udel.edu/blacksea/chemistry/jellyfish.html
Jax Shells (Jacksonville, FL)	www.jaxshells.org/
Jellies Zone	http://jellieszone.com/gonionemus.htm
Marine invasive species at our door steps: Seychelles is taking early measures (author: Bijoux J)	www.mcss.sc/MCNEWS/MCNews_v2_2.htm
Maryland DNR: Harmful Algal Blooms in Maryland	www.dnr.state.md.us/Bay/hab/prorocentrum.html
MIT Sea Grant's Introduced and Cryptogenic Species of the North Atlantic	http://massbay.mit.edu/exoticspecies/exoticmaps/index.html
MLPC – *Hemimysis anomala*, shrimp	http://blog.midwestlakes.org/06-12/hemimysis-anomala-shrimp.html
Museo Di Storia Naturale – Di Venezia: *Bursatella leachi*	www.msn.ve.it/index.php?pagina=progamb_view&id=4&idprog=18
NOAA NMFS – Southwest Regional Office	http://swr.nmfs.noaa.gov/Default.htm
Non-indigenous aquatic species of concern for Alaska – Fact Sheets	www.pwsrcac.org/projects/NIS/factsheets.html
Overview of the Conservation of Australian Marine Invertebrates (Report for Environment Australia 2002)	www.amonline.net.au/invertebrates/marine_overview/chapt6aa.html
Poisonous Red Sea Pufferfish Reach Crete	www.cretegazette.com/2007-05/crete_lagocephalus_sceleratus.php
Polysiphonia Ecology: Invasions (author: S Skikne)	www.mbari.org/staff/conn/botany/reds/Sarah/ecology-invasions.htm
San Francisco Estuary Invasive *Spartina* Project	www.spartina.org/maps_findings.htm
Seastar threat grows in southern Australia (1999 media release)	www.csiro.au/files/mediarelease/mr1999/SeastarThreatGrowsInSouthernAustralia.htm
Sierra Club Comments for the US Coral Reef Task Force – 10/24/06	www.coralreef.gov/taskforce/pdf/sierra_club_usvi.pdf
Southern Ocean Amphipoda Checklist	www.naturalsciences.be/amphi/checklist.pdf
Synopsis of Infectious Diseases and Parasites of Commercially Exploited Shellfish	www.pac.dfo-mpo.gc.ca/sci/shelldis/pages/morwoy_e.htm
The Indian River Lagoon Species Inventory (Smithsonian Marine Station at Fort Pierce)	www.sms.si.edu/irLspec/index.htm
UNEP-GRID Fact Sheet: *Hemimysis anomala* GO Sars, 1907	www.grid.unep.ch/bsein/redbook/txt/hemimysa.htm
University of Michigan Museum of Zoology's Animal Diversity Web	http://animaldiversity.ummz.umich.edu/site/index.html
University of Tartu: Benthic Invertebrates	www.sea.ee/Sektorid/merebioloogia/MASE/Benthic_invertebrates.htm

(Continued)

WebPanel 3. Marine data sources in database – *Continued*

Other web resources

Title	*Website*
USGS's Florida Integrated Science Center – Gainesville	http://cars.er.usgs.gov/Nonindigenous_Species/nonindigenous_species.html
USGS's Marine Nuisance Species	http://woodshole.er.usgs.gov/project-pages/stellwagen/didemnum/
WA State Noxious Weed Control Board's Information about common cordgrass (*Spartina anglica*)	www.nwcb.wa.gov/weed_info/Written_findings/Spartina_anglica.html
Weed Information Sheet: *Hygrophila costata*	www.portstephens.local-e.nsw.gov.au/files/46654/File/Hygrophila_info_sheet.pdf
Why do jellyfish sting? (author: B Galil)	www.ocean.org.il/Eng/Focus/Jellyfish.asp

