

1.5.5.2 Overview assessment of non-indigenous species in the OSPAR maritime area

Request

Overview assessment of non-indigenous species in the OSPAR maritime area (OSPAR request 3/2009)

To prepare an overview assessment as a contribution to the QSR 2010 of information that is available within the ICES framework on:

- a) the distribution, abundance of non-indigenous species introduced into the OSPAR maritime area as a result of human activities, and;
- b) whether the presence of these species has an adverse impacts on marine ecosystems.

Where possible, graphic material should be included e.g. illustration of trends in the number of detections of new indigenous species or the number of observed established non-indigenous species or equivalent material, would be welcomed.

Source of information

ICES. 2009. Report of the Working Group on Introductions and Transfers of Marine Organisms (WGITMO 2009)

Summary

ICES analyzed data on the presence and distribution of marine non-indigenous species collated from the Delivering Alien Invasive Species Inventories for Europe database (DAISIE) and from ICES member countries. Over 160 marine species have been identified in OSPAR regions. However, it is likely that this number under represents the total number of species as long-term monitoring and recording data are not available for many species. Also, for some groups of non-indigenous species, taxonomic identification can be difficult and it is possible that some species are currently misidentified. As identification techniques become more sophisticated, it is likely that the list of non-indigenous species will increase. It is not possible to provide the information requested by OSPAR in relation to species abundance as the available data for the OSPAR maritime region are limited.

An overview assessment of distribution has been provided for seven plant species, 23 invertebrate species, and one protozoan. Of the 160 invasive species identified, these species are problematic invaders that can have human health, economic, and ecological impacts. The summarised data includes information on how the species were introduced. Aquaculture, via deliberate transfers and as attachments on imported cultured shellfish, has been a major vector of initial introductions. Ballast water from ships, hull fouling, and fishing activities are then secondary anthropogenic vectors that have moved species to other locations. Many of these species have economic impacts, e.g., as fouling organisms on aquaculture facilities or affecting harvests. In addition, fouling of hulls, docks, piers, and other man-made structures are a nuisance and incur economic costs.

Summary case studies are provided for three non-indigenous species; the Pacific oyster, the red king crab, and the leathery sea squirt. These case studies give an overview of the species and include information regarding where they were first introduced and how they have subsequently spread.

ICES Response

Introduction

A species is considered non-indigenous in an area when that area is outside the native distributional range and it has been introduced to that area by human activities. Non-indigenous species may cause unpredictable and irreversible changes to marine ecosystems at various scales. It is important to note that non-indigenous organisms may also deleteriously affect human health.

Multiple vectors exist for the introduction of new species of marine organisms into OSPAR regions, the most important being aquaculture and shipping.

Based on the available information on non-indigenous species in OSPAR areas, ICES selected species for this advice using the following basic criteria:

1. Species that have been or are spreading and for which adequate data are available;
2. Species that are likely to have human health, economic, and/or ecological impacts;

3. Species whose presence is likely due to human factors, i.e. their presence is not likely due to natural phenomena such as migration;
4. Where possible, presence of “new species” is not due to range expansion related to climate change or natural factors.

In total 31 non-indigenous species were identified including one of higher plants species, five species of algae, one species of phytoplankton, 23 species of pelagic and benthic invertebrates, and one species of protozoa (Table 1.5.5.2).

Species Distributions

Most of the non-indigenous species identified were present in two or more OSPAR regions (especially II, III, and IV). These species usually occur on the coasts of several OSPAR countries and often in adjacent seas, including the Mediterranean and Baltic Sea. Well-known examples of such species include the bay barnacle *Balanus improvisus* (Figure 1.5.5.2) and the Chinese mitten crab *Eriocheir sinensis* (Figure 1.5.5.2.2). These species have been present for 100 years or more in European waters.



Figure 1.5.5.2 Distribution of the bay barnacle *Balanus improvisus* throughout Europe and the Baltic and Caspian Seas (Olenin and Olenina, 2009 DAISIE)



Figure 1.5.5.2.1 Distribution of the Chinese mitten crab *Eriocheir sinensis* in the OSPAR region (Gollasch 2009 DAISIE).

While there is relatively good knowledge on the status of marine non-indigenous species for some OSPAR regions (e.g., II and III), until recently very little was known for other areas, especially Region V, which includes the Azores. The potential for introductions to this remote region is high considering that trans-Atlantic leisure-boat traffic to the islands has significantly increased over the last decade. Cardigos *et al.* (2006) conducted a literature review and a database query to evaluate marine benthic species introduced to the Azores. Their study classified 12 algae and 21 invertebrates as non-indigenous species, and 18 other species as cryptogenic (of obscure or unknown origin). Two species of algae, *Asparagopsis armata* and *Caulerpa webbiana*, and two ascidians, *Clavelina oblonga* and *Distaplia corolla*, were regarded as particularly invasive along the shores of the Azorean oceanic archipelago (Cardigos *et al.*, 2006).

Abundance

Because of limited and relatively sporadic data availability, ICES is presently unable to provide any reliable assessments of population abundance or biomass estimates of the studied non-indigenous species. To do so will require substantial further work based primarily on internationally standardized and targeted monitoring to obtain abundance/biomass estimates fully comparable across the whole area.

Impacts

Non-indigenous species may alter the structure and functions of marine ecosystems in various ways. The most important and widespread impacts are habitat modification and competition for food and space with native organisms. These impacts may shrink spatial distribution the native species and also reduce native abundance and biomass, resulting in outcompeting of native species (e.g., as seen for several non-indigenous plants, molluscs, crustaceans and fouling organisms, also the Pacific oyster *Crassostrea gigas*, jackknife clam/razor clam *Ensis directus*, and red-gilled mud worm *Marenzelleria* spp.) (for details see Table 1.5.5.2). Further, the common cord-grass *Spartina anglica* may change sediment trapping and alter water flow, the ctenophore *Mnemiopsis leidyi* may influence trophic interactions of commercial fish stocks, and the red-gilled mud worm *Marenzelleria* spp. may influence nutrient regeneration.

Several species of non-indigenous algae, phytoplankton, and fouling organisms may impact human activities related to utilization of marine ecosystem goods and services (e.g., by clogging fishing nets, fouling boats, and threatening oyster and aquaculture farms and their harvests). For example the protozoan *Bonamia ostreae* can cause oyster mortality and debilitation, and the ship worm *Teredo navalis* can destroy man-made wooden structures such as boats and port installations.

Special difficulties are inherent in detecting planktonic non-indigenous species, especially microorganisms. Usually such organisms are essentially “hidden from view”, unless they manifest in sufficient numbers to cause an easily observable or economically important biological effect (e.g., nuisance phytoplankton or algal blooms, or fish diseases). Furthermore, identifying the presence of these species often requires specialized preservation and storage techniques, dedicated laboratory facilities, and considerable taxonomic expertise. Consequently, the number of such species reported in OSPAR regions may be disproportionately low relative to larger-sized organisms. Because modification of plankton communities by non-indigenous species can have significant human (e.g. the leathery sea squirt – see case study) and ecosystem health impacts, ICES advises incorporating the study of microorganisms into existing and proposed research and monitoring programs with the aim of better understanding these “invisible” yet important organisms.

Case Studies

Following are three case studies of non-indigenous species that are abundant in one or more OSPAR region and have clear economic and ecological impacts. Two of these species, the Pacific oyster *Crassostrea gigas* and the red king crab *Paralithodes camtschaticus*, were deliberately introduced for commercial purposes and subsequently have thrived in their new environments. Red king crab has become an economically important species in Norway and Russia (OSPAR Region I), as has the Pacific oyster in France (OSPAR Region IV). The third species, the leathery sea squirt, *Styela clava* is a natural member of the fouling community in Asian waters, but through trans-oceanic transport on hulls of ships, has become established in Europe, and now has spread throughout OSPAR Regions II and V. This species is a nuisance because it competes for space and food with native species and also fouls ships and piers.

Pacific oyster - Case Study

The Pacific oyster, *Crassostrea gigas* was introduced throughout Europe in the 1970s for cultivation purposes to replace declining populations of the native oyster, *Ostrea edulis* and the Portuguese oyster, *Crassostrea angulata* (Ruesink *et al.*, 2005).

After its introduction to Europe, it was assumed that natural spatfall of *C. gigas* would not occur in higher latitudes (such as Britain, Netherlands and Germany) as the waters would be too cold for reproduction. However, this species has

a tolerance for a wide range of temperatures and can grow at temperatures between 4–35 °C (Nehring, 2006) and can temporarily resist very low salinities (~ 5ppt). Fecundity is high with females producing 20–100 million eggs per spawning. The free-swimming planktonic larvae can spend up to three weeks in the water column before finding a suitable clean substrate to settle on, potentially giving the species a wide dispersal range.

The Pacific oyster is now established or has been detected in Belgium, Denmark, France, Germany, Ireland, Netherlands, and UK (Ruesink *et al.*, 2005). There are also records established populations as far north as Norway and Sweden (ICES, 2008, 2009). Populations of *C. gigas* became established in the German Wadden Sea in 1991 (Nehring, 2006) and has since expanded northwards reaching the Danish Wadden Sea in 1999 (Figure 1.5.5.2.3. Reise *et al.*, 2005).

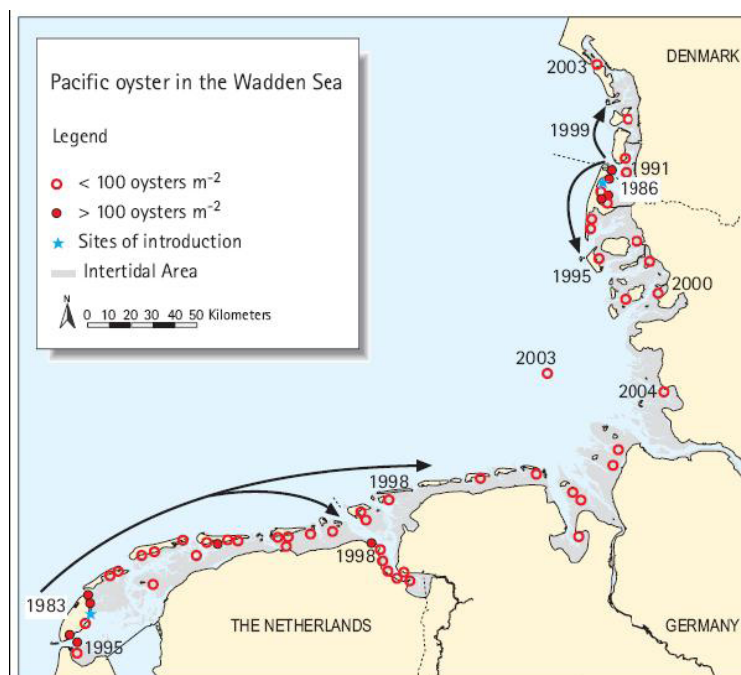


Figure 1.5.5.2.32 The Pacific oyster in the Wadden Sea. Asterisks indicate introduction sites (Texel, The Netherlands and Sylt, Germany). Years indicate first records of settlement. Circles refer to mean Pacific oyster abundance in 2003. From Reise *et al.*, 2005.

Pacific oysters form solid reefs. Their role as ecosystem engineers is particularly pronounced in soft sediment environments such as the mudflats of the Wadden Sea where hard substrate is rare except for mussel beds and oyster shells (Ruesink *et al.*, 2005; Kochmann *et al.*, 2008). In the northern German region of the Wadden Sea, *Mytilus edulis* beds are declining while populations of *C. gigas* appear to be increasing. Changing climate conditions during the last decade appear to be the primary cause of the proliferation of *C. gigas* and the decline of *M. edulis*. As yet, there is no strong evidence that these non-indigenous species have caused the decline of the native mussels (Nehls *et al.*, 2006; Nehls and Büttger, 2007). However, community structure differs between habitats created by oysters and mussels, with concomitant implications on their overall function in the marine environment (Kochmann *et al.*, 2008).

Given the Pacific oyster’s high reproductive capacity, its considerable adaptive ability allied with increasing sea temperatures, and the large standing stock of Pacific oysters in the OSPAR region, the species must now be considered a permanent constituent of the European coastal ecosystems (Nehls and Büttger, 2007). Future management strategies for these areas must consider the influence this species has on the structure and function of these marine ecosystems. The long-term impacts are unknown.

Red King Crab - Case Study

The red king crab *Paralithodes camtschaticus* was introduced into Russian waters in the 1960s and by 1976 it had migrated to Norway. The species is now found throughout coastal waters of northern Norway, where it competes with local predators, modifies habitat, and may impact the shellfish industry. A fairly comprehensive account of the red king crab in Russian and Norwegian waters is given in ICES (2005).

The native distribution range of this crab is the Okhotsk and Japan Seas, the Bering Sea, and the Northern Pacific Ocean along the Aleutian Islands. From 1961–1969, 1.5 million crab larvae, 10 000 1–3 year old juveniles, and 2609 5–15

year old adults were intentionally introduced to the areas east of Motovsky Bay at the Russian coast of the Barents Sea. (Orlov and Karpevich, 1965; Orlov and Ivanov, 1978) (Figure 1.5.5.2.4).

Red king crabs may live up to 20 years (Kurata, 1961) and can grow to a carapace length of ~220 mm and a weight of ~10 kg (Wallace *et al.*, 1949). Young larvae settle in the sublittoral zone shallower than 20 m (Marukawa, 1933). Juvenile crabs are dependent on cover the first 2 years, but later become less dependent (ICES, 2005 and references therein). Red king crabs undertake two migrations, a molting/mating migration to shallower (<60m) water in spring/summer and a feeding migration to deeper water (300–400 m) in autumn/winter. Adult crabs can potentially migrate far and quickly; Jørgensen *et al.* (2007) reported their walking speed to be 270m/h. Additionally, the pelagic larvae drift with water currents as long as they remain in the water column, and may be transported significant distances.

Food consumption and prey composition have been described for the red king crab (ICES, 2005). In the Barents Sea region red king crabs feed on bivalves and echinoderms in the spring and summer and polychaetes in the winter, competing with native crab populations. The availability of food appears to be the most important factor limiting red king crab distribution in its new environment (Gerasimova, 1997). Some changes in the diet of crabs from echinoderms to fish occurred during 1997–2000, probably due to crabs feeding on fish discarded from fishing vessels.

Since 2008 the Norwegian crab fishery is subject to two different management regimes. Inside a commercial area (east of 26° E and inside 12 nm) the crab is managed as a sustainable fishing resource. Outside this area there is an open, non-legislated fishery. The crab's population in the western part of its extended range seems not to have increased recently, indicating possible success for the open (culling) fishery. East of 26° E a TAC (Total Allowable Catch) has been proposed by the Joint Russian-Norwegian Fishery Commission. For 2009/2010 the quota is 1075 tonnes of male crabs, 110 tonnes of crabs with injuries (males), and 106 tonnes of females. This quota is calculated to correspond (approximately) to 474 000 males and 50 000 females.

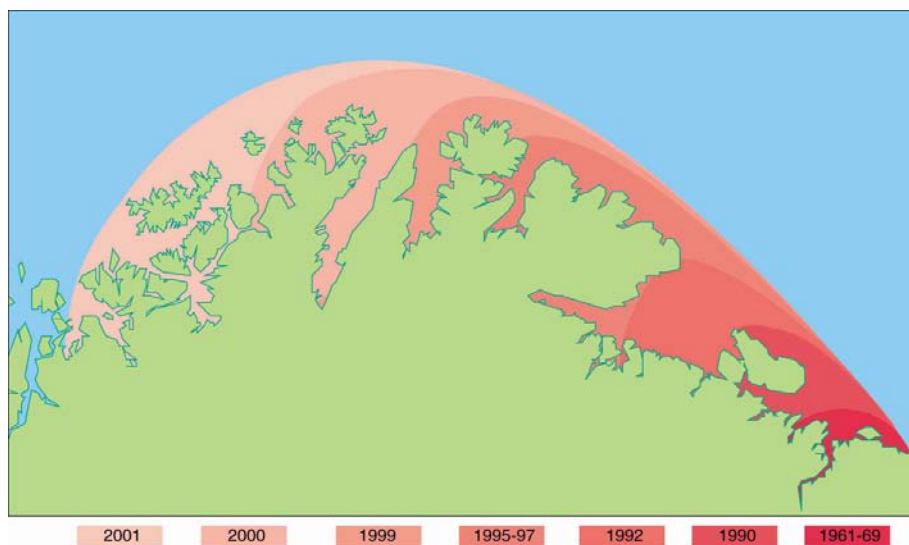


Figure 1.5.5.2.43 Estimated spread and distribution of the red king crab *Paralithodes camtschaticus* from its release region in the Barents Sea. The area shown is the northern tip of Norway. Illustration by Jan Sundet, Institute of Marine Research, Norway.

Leathery Sea Squirt - Case Study

The leathery sea squirt, *Styela clava*, was probably introduced to Europe (Figure 1.5.5.2.5) as fouling on warships during the Korean War. The species is a filter feeder occurring mainly on docks in sheltered estuaries and inlets. It is native to the Pacific coast of Asia and once introduced to Europe, it was reported on ship and leisure craft hulls. The first introduction of *S. clava* in the Mediterranean occurred in the Bassin de Thau (Davis and Davis, 2008). The species may be spread with oyster stock movements and movement of floating port structures on which *S. clava* is a fouling organism. It is a hardy species that is capable of surviving at lower salinities for short periods of time and can survive temperature fluctuations of -2°C to 23°C (Eno *et al.*, 1997; Minchin, 2009). Although the larval stage only lasts for a short period of time (24–48 hrs) introduction by ship ballast water is possible during local short voyages. The sea squirt can attain densities $> 1000/\text{m}^2$ in sheltered areas, creating a high biomass that results in competition with other filter-feeders. Young individuals often attach to larger specimens (up to 200 mm) to form clusters and thus the long-lived *S. clava* may serve as substrate for other non-indigenous species (Pederson, pers. comm.). Some humans are susceptible to respiratory problems from sprays produced from damaged tissues when removing sea squirts from oysters. Fouling of artificial structures in port regions, ranched oysters, shellfish held in hanging culture, and fish cages result in economic costs associated with maintenance. In the southern Gulf of St Lawrence, Canada, *S. clava* abundance has caused declines in cultured mussel production (Minchin, 2009).



Figure 1.5.5.2.54 Distribution of the leathery sea squirt *Styela clava* in the OSPAR region (Minchin, 2009 DAISIE).

Literature Cited

- Cardigos, F., Tempera, F., Avila, S., Goncalves, J., Colaco, A. and Santos, R.S. 2006. Non-indigenous marine species of the Azores. *Helgol Mar Res* 60: 160–169 (DOI 10.1007/s10152-006-0034-7)
- Davis, M.H., and Davis, M.E. 2008. First record of *Styela clava* (Tunicata: Ascidiacea) in the Mediterranean Region. *Aquatic Invasions*. 3(2): 125–132.
- Eno, N.C., Clark, R.A., and Sanderson, W.G. (eds) 1997. *Non-Native Marine Species in British Waters: A review and directory*. Peterborough: Joint Nature Conservation Committee, pp 152.
- Gerasimova, O.V. 1997. Analysis of king crab (*Paralithodes camtschatica*) trophic links in the Barents Sea. ICES CM 1997/GG:03. 21 pp.
- Gollasch, S. 2009. *Eriocheir sinensis* Milne-Edwards, Chinese mitten crab (Varunidae, Crustacea). In DAISE 2009. *Handbook of Alien Species in Europe*. Springer: Dordrecht. 312.
- ICES 2005. The intentional introduction of the marine red king crab *Paralithodes camtschaticus* into the Southern Barents Sea. ICES Cooperative Research Report No. 277. 18 pp.
- ICES 2008. Report of the Working Group on Introductions and Transfers of Marine Organisms (WGITMO), Copenhagen, Denmark, 12-14 March 2008. ICES CM 2008/ACOM:52; p 96.
- ICES 2009. Report of the Working Group on Introductions and Transfers of Marine Organisms (WGITMO). Washington D.C., USA. 11–13th March, 2009. ICES Submitted.
- Jørgensen T, Løkkeborg S., Ferno A., and Hufthammer M. 2007. Walking speed and area utilization of red king crab (*Paralithodes camtschaticus*) introduced to the Barents Sea coastal ecosystem. *Hydrobiologia Conference on fish telemetry No6, Sesimbra , PORTUGAL (06/2005) 2007*, vol. 582 (306 p.) [Document : 8 p.] (1 p.)
- Kochmann, J., Buschbaum, C., Volkenborn, N., and Reise, K. 2008. Shift from native mussels to alien oysters: Differential effects of ecosystem engineers. *Journal of Experimental Marine Biology and Ecology*. 364: 1–10.
- Kurata, H. 1961. On the age and growth of king crab, *Paralithodes camtschatica*. Hokkaido Suisan Shikenjo, Housiushi Geppo [Hokkaido Fish. Exp. Sta., Monthly Rep.], 18(1): 10–22.
- Marukawa, H. 1933. Taraba-gani chosa [Biological and fishery research on the Japanese king crab *Paralithodes camtschatica* (Tilesius)]. Sui Shi Ho [J. Imp. Fish. Exp. Sta., Tokyo], 4(37), 152 pp. [In Japanese with English abstract].
- Minchin, D. 2009. *Styela clava* Herdman, Asian sea-squirt (Styelidae, Ascidiacea). In DAISIE 2009. *Handbook of Alien Species in Europe*. Springer: Dordrecht. 298.
- Nehls, G., and Buttger, H. 2007. Spread of the Pacific Oyster *Crassostrea gigas* in the Wadden Sea: Causes and consequences of a successful invasion. *HARBASISNS Report*, 54 pp.
- Nehls, G., Diederich, S., Thieltges, D.W. and Strasser, S. 2006. Wadden Sea mussel beds invaded by oysters and slipper limpets: competition or climate control? - *Helgol. Mar. Res.* 60: 135–143.
- Nehring, S. 2006. NOBANIS – Invasive Alien Species Fact Sheet – *Crassostrea gigas*. – From: Online Database of the North European and Baltic Network on Invasive Alien Species - NOBANIS www.nobanis.org, Date of access 30/03/2009.
- Olenin, S., and Olenina, I. 2009. *Balanus improvisus* Darwin, bay barnacle (Balanidae, Crustacea). In DAISE 2009. *Handbook of Alien Species in Europe*. Springer: Dordrecht. 271.
- Orlov, Y. I., and Ivanov, B. G. 1978. On the introduction of the Kamchatka king crab *Paralithodes camtschatica* (Decapoda: Anomura: Lithodidae) into the Barents Sea. *Mar. Biol.*, 48(4): 373–375.
- Orlov, Y.I., and Karpevich, A.F. 1965. On the introduction of the commercial crab *Paralithodes camtschatica* (Tilesius) into the Barents Sea. In ICES Spec. Meeting 1962 to consider problems in the exploitation and regulation of fisheries for Crustacea. Ed. By Cole, H. A. (ed.) Rapp. P.-V. Réun. Cons. Int. Explor. Mer., 156: 59–61.
- Reise, K., Dankers, N., and Essink, K. 2005. Introduced Species. – In: Essink, K., Dettmann, C., Farke, H., Laursen, K., Lürßen, G., Marencic, H., and Wiersinga, W. (eds), *Wadden Sea Quality Status Report 2004*. Wadden Sea Ecosystem No. 19: 155-161.
- Ruesink, J.L., Lenihan, H.S., Trimble, A.C., Heiman, K.W., Micheli, F., Byers, J.E., and Kay, M. 2005. Introduction of non-native oysters: ecosystem effects and restoration implications. *Annual Review of Ecology, Evolution and Systematics*, 36: 643–689
- Wallace, M.M., Pertuit, C. J., and Hvatum, A. R. 1949. Contribution to the biology of the king crab, *Paralithodes camtschatica* Tilesius). U.S. Dep. Inter. Fish Wildl. Serv., Fish Leaflet, 340. 50 pp.

Table 1.5.5.2 Non-indigenous species identified as considered problematic based on reported impacts.

Taxonomic Group	OSPAR/other Region/s	Current Range Within Region/s	Probable Vectors	Location/Date of 1st report	Probable Impacts
HIGHER PLANTS					
<i>Spartina anglica</i> Common cord-grass, Townsend's grass or ricegrass	Region II, II, IV	UK, Ireland, Kattegat	Intentional planting to stop erosion, range expansion	France 1906	Habitat modification, rhizomes create monoculture stands, sediment trapping, alters water flow
ALGAE					
<i>Sargassum muticum</i> Wire weed, Jap weed, Strangle weed	Region I?, II, III, IV, Baltic, Mediterranean	West Norway to Portugal, Skagerrak, Kattegat, UK, Ireland, Portugal	Oyster imports, escape, drift range expansion	UK 1973	Algal and seaweed competition, habitat modification, clogging nets, oyster and aquaculture, propeller interference, substrate for other species in barren areas
<i>Undaria pinnatifida</i> Wakame, Japanese kelp	Region II, IV, Mediterranean	Netherlands, Belgium, France, UK, Spain, Italy	Oyster imports, range expansion, hull fouling, ballast	France (Thau Lagoon) 1971, N. France (Brittany), 1983	Space competition (annually), oysters harvest interference, fouling on boats, jetties, etc., grazed by invertebrates and ducks
<i>Gracilaria vermiculophylla</i> Asian red alga	Region II, III, SW Baltic, Mediterranean	Sweden, Denmark, Germany, Netherlands, France, Spain	Oyster import and transfers, drift range expansion, boats, dredges, fishing nets	France (Roscoff), 1996	Seaweed competition, forms mats that may smother benthic organisms, clogging nets, substrate for other species in barren areas
<i>Codium fragile</i> ssp. <i>fragile</i> Green sea fingers	Region I, II, III, IV, Mediterranean	Iceland to Portugal, Kattegat, Skagerrak, UK, Ireland, Mediterranean	Shipping, oyster movements, range expansion	Netherlands ~1900	Competition with seaweeds, forms "belt" and monoculture, habitat modification, attaches to bivalves
<i>Bonnemaisonia hamifera</i> Red alga	Region I, II, III, IV, V, Mediterranean, Baltic Sea	Southern England, Norway to the Canary Islands, Ireland, Kattegat and Belt Sea, Iceland	Shellfish import, vessel fouling, subsequently natural	England 1893	Competition, habitat alteration

Taxonomic Group	OSPAR/other Region/s	Current Range Within Region/s	Probable Vectors	Location/Date of 1 st report	Probable Impacts
PHYTOPLANKTON					
<i>Coscinodiscus walesii</i> A centric diatom	Region II, III, IV	Atlantic coast of France to Norway	Ballast water	England (Plymouth) 1977, Irish Sea 1978, Norway 1979	Has been known to form dense blooms with large amounts of mucilage, which can aggregate, sink and cover the seabed. Cause anoxic conditions. Threat to aquaculture. Inedible to most grazing zooplankton.
INVERTEBRATES					
CTENOPHORE					
<i>Mnemiopsis leidyi</i> A comb jelly	Region II, Baltic	North Sea, Kattegat	Ballast water	Netherlands, Sweden, SW Baltic, S and SW Norway 2006	Trophic impacts, competition, fish stock recruitment
POLYCHAETE					
<i>Marenzelleria</i> spp. (complex) Red gilled mud worm	Region II, III, Baltic	North and Baltic Seas	Ballast (3 separate incursions)	Scotland (Forth Estuary) 1979	Nutrient regeneration, outcompetes insects and oligochaetes, fish decline
MOLLUSCS					
<i>Crepidula fornicata</i> Slipper limpet	Region II, III, IV	Norway to Spain, UK	Introduced with <i>Crassostrea virginica</i>	UK 1872	Competition, Habitat modification
<i>Ensis directus</i> Jackknife clam, razor clam	Region II	Norway to France	Ballast water	Germany 1979	Outcompetes native bivalves, habitat modification
<i>Crassostrea gigas</i> Pacific oyster	Region II, IV	Norway to Portugal	Escaped aquaculture	France 1980s	Outcompetes native mussels (<i>Mytilus edulis</i>), habitat modification, loss of biodiversity
<i>Mya arenaria</i> Soft-shelled clam, soft clam, long-necked clam	Region I, II, III, IV	All British and Irish coasts, and from northern Scandinavia and the Faeroes to Arcachon in France	Intentional, ballast water	Europe 1245	Competition. However, this species has been established a long time and it is not known whether there have been any recent studies of the impact it has.
<i>Rapana venosa</i> Rapa whelk, veined	Region IV	Possibly established in France, not established in	Aquaculture through oyster shipments	Black Sea (Noevorossiysky Bay)	Has been found in these regions but significant adverse impact has not yet

Taxonomic Group	OSPAR/other Region/s	Current Range Within Region/s	Probable Vectors	Location/Date of 1st report	Probable Impacts
whelk		Netherlands, UK, Belgium		1940s, North Sea 2005	been recorded. However, this species is a bivalve predator and can compete with native species.
<i>Venerupis philippinarum</i> Japanese clam, Manila clam	Region II, IV	France to Spain; the Netherlands (wild populations)	Aquaculture, Suez Canal range expansion	UK 1992	Competition
<i>Teredo navalis</i> Ship worm	Region I?, II, III, IV, V	Possibly cosmopolitan except in polar regions	Hull fouling (boring)	Netherlands >1730	Destruction of wooden structures, habitat destruction
CRUSTACEANS					
<i>Eriocheir sinensis</i> Chinese mitten crab, Mitten crab, Chinese Freshwater Edible crab	Region II, III, IV	Portugal to Norway , UK, Ireland	Ballast, range expansion	Germany 1912	Habitat modification, predation, competition
<i>Hemigrapsus sanguineus</i> Asian shore crab	Region II, IV	Germany to France	Ballast, hull fouling	France 1999	Competition, habitat modification
<i>Hemigrapsus takanoi</i> Asian shore crab	Region II, IV	Germany to Spain	Ballast, hull fouling	France 1994	Competition, habitat modification
<i>Paralithodes camtschaticus</i> Red king crab	Region I	Northern Norway	Migration from early introduction	Norway 1976	Competition, predation, habitat modification
<i>Marsupenaeus japonicus</i> Kuruma prawn	Region IV	Portugal	Unknown, intentional release elsewhere	Portugal 1985	Competition
FOULING COMMUNITIES					
<i>Ficopomatus enigmaticus</i> A tubeworm	Region II, III, IV	Germany to France, Ireland	Fouling	France 1921	Competition, habitat modification
<i>Austrominius (=Elminius) modestus</i>	Region II, IV III?	Denmark to Portugal	Fouling	UK 1945	Competition, habitat modification

Taxonomic Group	OSPAR/other Region/s	Current Range Within Region/s	Probable Vectors	Location/Date of 1st report	Probable Impacts
An acorn barnacle					
<i>Caprella mutica</i> Skeleton shrimp	Region II, III, IV	Norway to Belgium	Fouling	Belgium 1998	Competition, habitat modification
<i>Telmatogeton japonica</i> A chironomid (insect)	Region II, III	Denmark to Belgium, Ireland	Fouling	Germany 1963	Competition, habitat modification
<i>Bugula stolonifera</i> A bryozoan	Region II, IV, V III?	Belgium to Spain, incl. Azores	Fouling	Netherlands 1993	Competition, habitat modification
<i>Styela clava</i> Leathery sea squirt, Asian sea squirt	Region II, III, IV	Germany to Portugal, UK, Ireland	Fouling	France 1968	Competition, habitat modification
<i>Didemnum vexillum</i> A sea squirt or tunicate	Region II, III	Netherlands, France, Ireland, UK	Fouling	Netherlands 1991	Competition, habitat modification
<i>Tricellaria inopinata</i> A bryozoan	Region II, IV	England, Spain, France, Belgium, Netherlands	Oyster import and transfers, drift range expansion, boats, dredges, fishing nets fouling	NW Spain 1996, south England 1998	Competition, habitat modification
PROTOZOA					
<i>Bonamia ostreae</i> None	Region II, III, IV	Ireland, Spain, France, Netherlands, potentially Southern England	Aquaculture	France 1976	Oyster mortality and debilitation