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STATUS OF INTRODUCTIONS OF NON-INDIGENOUS MARINE SPECIES TO THE NORTH ATLANTIC AND ADJACENT WATERS 1992–2002

TEN-YEAR SUMMARY OF NATIONAL REPORTS CONSIDERED AT MEETINGS OF THE WORKING GROUP ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

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Foreword

As an intergovernmental organization on marine research that also deals with fisheries, ICES was confronted early on with issues related to the introductions of non-indigenous species, particularly diseases and parasites transferred with live transport of fish and shellfish for relaying, stocking, ranching, and for fresh fish markets. During the late 1960s and early 1970s, a primary concern was the need to assess the risks associated with deliberate transfers of species. As a result, the Working Group on Introductions and Transfers of Marine Organisms (WGITMO) was launched, meeting for the first time in Conwy, Wales, 4 April 1979. Since then, the working group has met almost annually, with its 25th anniversary meeting held in Vancouver, Canada in 2003.

The first status report prepared by WGITMO on introduced species in the North Atlantic and its adjacent waters appeared in 1980. The second report, Status of Introductions of Non-Indigenous Marine Species into North Atlantic Waters 1981–1991, was published as *ICES Cooperative Research Report No. 231* in 1999. The present report continues the earlier efforts and summarizes species introductions as reported during WGITMO meetings 1992–2002 (Table F1). The list of participants at the meetings considered here is provided in Annex 1.

The national reports received during the reporting period (Table F2) were considered in detail in the preparation of this report. It should be noted that attendance at WGITMO meetings was not continuous for all ICES member countries. Canada, England and Wales, Ireland, Sweden, and the US delivered national reports to all meetings. Non-ICES member countries such as Australia and Italy also provided comprehensive information on introduced species.

In addition to intentionally imported and/or released organisms, unintentional species introductions were also of concern: Section 1 provides information on disease agents and parasites. Macroalgae and phytoplankton are dealt with in Section 2 and invertebrates in Section 3. Fish are covered in Section 4. Comprehensive annexes provide information of first records of non-indigenous species (Section 3.20; not limited to ICES member countries) and deliberate species introductions as well as live species imports and transfers (Section 4.12). Taxonomic inconsistencies (identical species named differently in national reports from different countries) could not be avoided, and so this report provides taxonomic data as submitted in the individual national reports.

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Table F1. Sequence of WGITMO meetings with meeting dates, venues, and Chairs.

YEAR	DATE	LOCATION	CHAIR	MEETING NUMBER
1992	14–17 April	Lisbon, Portugal	J. T. Carlton	14
1993	26–28 April	Aberdeen, Scotland	J. T. Carlton	15
1994	20–22 April	Mystic, CT, USA	J. T. Carlton	16
1995	10–13 April	Kiel, Germany	J. T. Carlton	17
1996	22–26 April	Gdynia, Poland	J. T. Carlton	18
1997	22–25 April	La Tremblade, France	J. T. Carlton	19
1998	25–27 March	The Hague, the Netherlands	J. T. Carlton	20
1999	14–16 April	Conwy, UK	J. T. Carlton	21
2000	27–29 March	Parnu, Estonia	J. T. Carlton	22
2001	21–23 March	Barcelona, Spain	S. Gollasch	23
2002	20–22 March	Gothenburg, Sweden	S. Gollasch	24

Table F2. National reports received at WGITMO meetings 1992–2002.

NATIONAL REPORT	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Australia							X				X
Belgium										X	X
Canada	X	X	X	X	X	X	X	X	X	X	X
Denmark		X									
England and Wales	X	X	X	X	X	X	X	X	X	X	X
Estonia								X	X	X	X
Finland	X	X	X	X	X	X		X	X	X	X
France		X	X	X		X	X	X	X	X	X
Georgia										X	
Germany			X	X	X	X	X	X	X	X	X
Ireland	X	X	X	X	X	X	X	X	X	X	X
Israel							X				
Italy							X		X	X	X
the Netherlands							X	X	X	X	
Norway	X	X	X		X	X	X	X	X	X	X
Poland		X			X	X		X	X		X
Portugal	X										
Scotland	X		X	X							
Spain	X	X								X	
Sweden	X	X	X	X	X	X	X	X	X	X	X
USA.	X	X	X	X	X	X	X	X	X	X	X
Total	**10**	**11**	**10**	**9**	**9**	**10**	**12**	**12**	**13**	**15**	**14**

1 Viruses, bacteria, fungi, and parasites

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Introduction

The introduction of fish pathogens and parasites through human-mediated activities has been a major concern worldwide. To prevent introductions of disease agents via intentional transfers of aquatic animals, governments as well as international bodies (e.g. ICES, World Organization for Animal Health (OIE)) have developed regulations, codes of practice, and guidelines.

One of the best descriptions of the introduction of a parasite through intentional fish movements is the transfer of the trematode, *Gyrodactylus salaris*. As stated by Johnsen and Jensen (1991), the parasite was transferred with Atlantic salmon smolts from Sweden to Norway. The infected smolts were placed in a hatchery, from where they were outplanted to several rivers. It is assumed that the Atlantic salmon populations in the exposed rivers declined as a result of the spread of the parasite and the damage it caused to the juvenile fish. In an effort to control the parasite, many rivers were depopulated and subsequently restocked with uninfected fish. However, because stocking only occurred with a few species (primarily Atlantic salmon), there was a significant effect not only on the target species, but on all other finfish species that were native to the depopulated rivers.

Another example of introduction of fish disease agents is described by Lightner *et al.* (1992) in various publications. The work clearly shows the spreading of shrimp diseases with the transport of infected animals. The spread of crayfish plague caused by the fungus *Aphanomyces astaci*, into and within Europe from North America, is also well documented (Bower and McGladdery, 2001, and references therein). Although crayfish native to North America are resistant to the disease, the disease has had severe impacts on some European stocks. It is thought the disease started spreading in Italy in the 1860s, following the introduction of American freshwater crayfish. The fungus was transferred to Britain in 1981 and also spread to Turkey, Greece, and Norway during the 1980s.

The spread of the bacterial fish disease furunculosis from Scotland to Norway via infected smolts is also well documented (Johnsen and Jensen, 1994). Following importation of rainbow trout from Denmark, furunculosis was first detected in Norway in 1964. By 1969, the disease appeared to be eradicated from Norwegian farms, following disease control measures. However, it was detected again in 1985, after smolts were imported from Scotland. The disease is presumed to have spread from farmed fish to wild stocks in rivers.

Hence, international codes and individual country regulations to reduce the risk of inadvertent transfer of pathogens and parasites through intentional fish movements (including shellfish and crustaceans) are essential. In general, they apply to aquaculture activities. However, regulations often fail to cover common commercial activities such as relaying and other temporary holding in fish habitat, from which the disease agents could escape and infect susceptible species in the environment.

In addition, the aquarium and display fish trade is a category of transfers that has largely been ignored despite its ability to transfer fish pathogens. A recent example is the transfer of spring viremia of carp (SVC) with ornamental koi carp from a koi supplier in West Virginia. SVC is an OIE-listed disease that can affect many carp species (e.g. common carp *Cyprinus carpio*, grass carp *Ctenopharyngodon idellus*, silver carp *Hypothalmichthys molitrix*, and bighead carp *Aristychthys nobilis*). Tracking and eradicating fish from that source to minimize impact on the US carp populations was an expensive undertaking for US regulatory authorities.

Similarly, Koi herpes virus is thought to have been transferred with Koi carp. It was first detected in Israel and is thought to have spread to Europe, Indonesia, the US, and recently Japan. Recent (October 2003) outbreaks have affected both the edible common carp and the koi industry in Japan, and are a concern to breeders in other countries (International Society for Infectious Diseases, http://www.isid.org; ProMED-mail, 3 January 2004).

1992–2002 Summary

This chapter gives a summary from 1992 to 2002 of the pathogens and parasites noted in national reports of member and guest countries making up the ICES Working Group on Introductions and Transfers (Table 1.1).

Clearly, the information is very patchy. Additional information can be obtained from the ICES Working Group on Diseases and Pathology of Marine Organisms, which records major disease occurrences, including newly emerging and exotic diseases in member countries. The reader may also wish to check for OIE reports on current fish health issues and new findings.

Table 1.1. Summary table of reported pathogens and parasites.

PATHOGEN/PARASITE	YEAR REPORTED	COUNTRY
Anguillicola crassus	1995	Germany
	1997	Germany
	1998	Germany, the Netherlands
	2001	Germany, Ireland
	2002	Germany, Ireland, Sweden
Bonamia	1995	France
	2001	Spain
Gyrodactylus salaris	1992	Norway
	1993	Finland
Haplosporidium nelsoni (MSX)	2001	USA
ISA virus	1999	UK
	2001	UK
	2002	USA
Marteilia	1995	France
	2001	Spain
Myicola orientalis and Mytilicola orientalis	1993	Ireland
	1995	Ireland
	1997	Ireland
	1998	Ireland
	2001	Ireland
Perkinsus	2001	Spain
Pseudogyrodactylus bini	2002	USA
Pseudogyrodactylus anguillarum	2002	USA
QPX	1997	Canada
Sabellid Fan worm	1998	USA
VHS virus	1995	Scotland
Vibrio vulnificus	1998	Norway

The most frequent reports concern the parasitic nematode *Anguillicola crassus*. This parasite is reported to be a natural parasite of eels in Southeast Asia. It is thought to have been introduced to Europe in the early 1980s (DeCharleroy, 1990). Its life cycle involves fish where it is a parasite of the swimbladder and a crustacean as an intermediate host. Copepod and ostracod and at least one species of snail have been reported as intermediate hosts, and it has

several fish reservoir (paratenic) hosts. This multiplicity of hosts allows it to spread significantly in new environments (information can be found on the Gulf States Marine website, http://nis.gsmfc.org/nis_factsheet.php?toc_id=9). The 1995 German report indicates that 100% of the eel population of the Elbe River was infected. However, subsequent reports from both Germany and the Netherlands suggest that the infestation rate is decreasing. At the same time, its range is thought to increase (German reports 1997, 1998). Ireland includes comments about its spread between river systems, and surmises that it may have been introduced into its freshwater systems via live-haul (viviere) trucks. Once established, it not only affects eels; it is also found in paratenic hosts including the ruffe, *Gymnocephalus cernuus*, and black goby, *Gobius niger*.

Ireland has repeatedly reported problems with *Myicola orientalis* and *Mytilicola orientalis*. The parasites now seem established in certain areas following their initial introduction with half-grown oysters from France. This demonstrates some of the problems associated with relaying live material.

Bonamia ostreae and *Marteila* sp. are recognized worldwide as parasites of oyster and have had significant impacts on oyster populations in areas where they are newly introduced (Bower, 2003). *Bonamia* is thought to have been introduced via transfers of *Ostrea edulis* to the east coast of the US and to Europe in the late 1970s (Elston *et al.*, 1986; Friedman and Perkins, 1994; Cigarría and Elston, 1997).

References

Bower, S. M., and McGladdery, S. E. 2001. Synopsis of Infectious Diseases and Parasites of Commercially Exploited Shellfish: Table of Contents. http://www-sci.pac.dfo-mpo.gc.ca/shelldis/toc_e.htm.

Cigarría, J., and Elston, R. 1997. Independent introduction of *Bonamia ostreae*, a parasite of *Ostrea edulis* to Spain. Diseases of Aquatic Organisms, 29: 157–158.

DeCharleroy, D. L., Grisez, L., Thomas, K., Belpaire, C., and Ollevier, F. 1990. The life cycle of Anguillicola crassus. Diseases of Aquatic Organisms, 8: 77–84.

Elston, R. A., Farley, C. A., and Kent, M. L. 1986. Occurrence and significance of bonamiasis in European flat oysters *Ostrea edulis* in North America. Diseases of Aquatic Organisms, 2: 49–54.

Friedman, C. S., and Perkins, F. O. 1994. Range extension of Bonamia ostreae to Maine, USA. Journal of Invertebrate Pathology, 64: 179–181.

Gulf States Marine website: Material on *Anguillicola crassus*. http://nis.gsmfc.org/nis_factsheet.php?toc_id=9.

Johnsen, B. O., and Jensen, A. J. 1991. The *Gyrodactylus* story in Norway. Aquaculture, 98(3/4): 289–302.

Johnsen, B. O., and Jensen, A. J. 1994. The spread of furunculosis in Norwegian Rivers. Journal of Fish Biology, 45(1): 47–55.

Lightner, D. V., Bell, T. A., Redman, R. M., Mohney, L. L., Natividad, J. M., Rukyani, A., and Poernomo, A. 1992. A review of some major diseases of economic significance in penaid prawns/shrimp of the Americas and Indopacific. *In* Diseases in Asian Aquaculture, pp. 57–80. Ed. by I. M. Shariff, R. P. Subsinghe, and J. R. Arthur. Fish Health Section, Asian Fisheries Society, Manila, Philippines.

Office International des Epizooties. 2002. International Aquatic Animal Health Code 2002, Paris, France. 157 pp.

2 Introductions and transfers of plants

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2.1 Introduction

The information in this section is compiled from WGITMO reports published during the period 1992–2002, as well as from literature, inasmuch as many countries have not contributed national reports. Furthermore, information on macroalgae, phytoplankton, and phanerogams has only been included generally in some of the national reports (in 75 out of 126 national reports submitted to WGITMO during the period 1992–2002), and only in one case has an introduced benthic microalga been reported (literature has not been searched for this group). In some countries, no new plant introductions have occurred. The aim was also to discover the fate of old introductions and report the current status, when information was available. The areas covered are the countries along the coasts of the North Atlantic and the Baltic Sea, including the non-Atlantic coasts of ICES member countries (in the US, the most spectacular macroalgal introductions have occurred on the Pacific coast and may well occur also on the Atlantic coast of North America), as well as the other European countries in the western Mediterranean Sea. On the other hand, information from Australia, Georgia, and Israel in WGITMO reports has not been included, except when reporting on eradication programmes and targeted risk species.

Benthic algae and phanerogams are listed by country for the different coastal areas, while phytoplankton species are dealt with by sea areas at the end of this chapter. Established species reported in the last status report (Wallentinus, 1999a) are also listed for each country, with the first record of attached plants. (It should be noted that the publication of that status report was delayed by more than six years, so many general references on introduced algae between 1992 and 1999 were not included.) Listed introductions also include species that arrived in a country by dispersal from other countries to which they were once introduced, in one way or the other.

Macroalgal introductions are summarized in Table 2.1 (at the end of this section). For full taxonomic affiliations of the species, see Guiry *et al.* (2006).

Introduced phanerogams in coastal areas are seldom reported. For each European country, a list is given, compiled by Wallentinus (2002: Appendix 1); most of these species were not included in the previous status report (Wallentinus, 1999a). However, most of them are old introductions, which grow or have the potential to grow (i.e. they may not occur along the seashores in areas where they have been introduced) at or near the sea, with only a few living submerged. The lists generally do not include species that are not naturalized, e.g. tomato plants, *Solanum lycopersicum* (Tutin *et al.*, 1972), which in most countries also can be found as adventive plants in banks of seaweeds and seagrasses cast ashore on the beaches. For North America, only tentative lists are given, and they only apply to the Atlantic coasts of southern Canada and northern US; additionally, plants introduced to San Francisco Bay are listed. Owing to time limitations, generally it has not been possible to follow up on the current status of the introduced phanerogams.

Not included in this report are all algal species brought to laboratories for small-scale, indoor studies in taxonomy, ecology, and physiology, and for maintaining algal cultures in the laboratory. Such deliberate introductions have probably been made to most universities, research laboratories, and field stations, and would fill a long list, if it were possible to assemble such a list. The same also applies to microalgae used for food in hatcheries.

2.2 Species of special concern

Some algae have been specifically mentioned in the terms of reference to or recommendations by WGITMO or the ICES/IMO/IOC SGBOSV, and status reports were received. The overall performance of these algae is summarized briefly below.

2.2.1 The Japanese kelp *Undaria pinnatifida*

The first European record of this brown alga was in Mediterranean France in 1971 following imports of oysters from Japan. Because "wakame" was a popular food item in Asian restaurants, in 1983 it was brought to the Atlantic coast of northern France (mainly around Brittany) for cultivation. Small-scale distribution of plants in the wild was already seen in 1986 in Rance (see below) and in 1987 at the Island of Ouessant (ICES, 1987; Floc'h *et al.*, 1991). For details on the history of the accidental and intentional introductions of this species in Europe and the risk that it would disperse to other areas, see the previous status report (Wallentinus, 1999a, 1999b; ICES, 2007). These two reports also show the first records of introductions to other continents (China, Taiwan, New Zealand, Australia, Argentina, Mexico, and California).

In northern France, six sites were seeded with *Undaria* in 1991, but only one showed a good harvest, amounting to under 50 tonnes. The densities were reported to be low, and it was concluded that the species had not become permanently established in the wild, except at St Malo (ICES, 1993; see however Floc'h *et al.*, 1991). A 1992 Spanish status report stated that the alga was relatively common in the Ria de Arosa, northern Spain (including on mussel rafts), at that time the only site in Spain (ICES, 1992). It was said to have a smaller impact on the environment there than *Sargassum muticum*. *U. pinnatifida* probably arrived in northern Spain through transfers of oysters from the Thau Lagoon in southern France and from farming experiments in open water conducted at a few sites in Galicia (ICES, 1993).

In 1994, a status report was delivered by France as requested in the ICES resolution C.Res. 1989/4.4. The report listed eight farming sites after 1990 with a production of between 40 to 75 tonnes fresh weight per year; two of these sites were later abandoned. It was emphasized that *U. pinnatifida* had only colonized some areas close to farming sites at St Malo and Charente Maritime, while other sites had small and fluctuating populations (see however Floc'h *et al.*, 1996); it was further emphasized that there was no ecological impact, and several grazers were eating the alga (ICES, 1994). Two other papers on *U. pinnatifida* in northern France were also discussed at that meeting (Castric-Fey *et al.*, 1993; Hay and Villouta, 1993). Castric-Fey *et al.* (1993) reported on diving surveys outside the farming area at Rance, where farming had occurred since 1983, where the first "wild" plants were recorded in 1986, and where large populations of mixed size classes (i.e. plants being present all year) were seen in 1992. By then, *U. pinnatifida* covered almost all available substrata not already occupied by the perennial *Laminaria* species. Castric-Fey *et al.* (1993) also considered the possible competition with the native annual kelp *Sacchorhiza polyschides*, but concluded that *U. pinnatifida* posed no threat to the environment. Hay and Villouta (1993) reported on the huge amount of *U. pinnatifida* cast ashore at St Malo, which were also seen at the Seaweed Symposium taking place there in 1992; the amount drifting ashore at Iles d'Oussant in the same period was much smaller.

The status report from 1996 emphasized the new establishment on the English south coast (see also Section 2.3.1.10) and the risk that it would extend its range in western Europe through e.g. shipping. It also concluded that, by then, the species had been accidentally introduced to New Zealand, Tasmania, Argentina, northern Spain, and in the Mediterranean (France and Italy), and that most of the original farms on the Atlantic coast of France, to which it was introduced deliberately, were then out of business (ICES, 1996, and references therein). The French report from 1997 stated that the natural subtidal populations had declined significantly,

especially in northern Brittany, owing to grazing by the snail *Gibbula*. This, however, was a temporary decrease, and the abundances later returned to initial levels. Furthermore, it was stated that only a few non-hibernating, natural populations were found outside longline cultures in southwestern France (ICES, 1997a, 1998). Two papers by Castric-Fey *et al.* (1999a, 1999b) gave a more detailed picture of the situation at St Malo, northern France. After only a few years, the species was established in several hectares along the shoreline and, in 1992, reached depths of 12 m. In 1994, there was a substantial but temporary, decline owing to abalone grazing, with biomasses increasing again during 1996 and 1997, and a further spread northwards to Normandy in 1997. They also mentioned that two morphological forms occurred in the area and that two generations could succeed each other during the year, making it possible to detect both young and old sporophytes in early autumn (ICES, 1999).

The first record of *U. pinnatifida* in the Netherlands was from Oosterschelde in March 1999 (ICES, 2000a). The first record in Belgium was either 1999 (Wallentinus, 1999b) or 2000 at Zeebrügge (ICES, 2001). In the Oosterschelde, dense populations were soon established, and it was spread, probably by movements of oyster pots, to Lake Grevlingen (ICES, 2001). See also Sections 2.3.1.7 and 2.3.1.8.

In the US, the species was first found established at several sites in California in 2000, the assumed vector being either hull fouling or ballast water (Silva *et al.*, 2002; ICES, 2002; see also Section 2.3.4.2).

At the Biocontrol Meeting in 1997 (ICES, 1997a, 1997b), Australian participants told about their eradication attempts with physical removal from a marine reserve area, because they considered the natural enemies to be too few to have any effect. Furthermore, nine tested herbicides had limited success on the sporophytes, although tests on the gametophytes were still to be carried out.

A review of this species' performance, dispersal, possible vectors, and potential harm or utilization was given by Wallentinus (1999b, and references therein), and more information is available in an updated Alien Species Alert Report (ICES, 2007). The extreme tolerance of the microscopic gametophytes, able to survive out of water for more than a month, was emphasized, making it a high-risk species for dispersal, because they can occupy minute crevices in ships. It was predicted that the species is able to establish in most cold and warm temperate areas worldwide, providing salinities are not below 20 psu, especially close to harbours and aquaculture sites. *U. pinnatifida* is also included in Australia's target list of unwanted species (ICES, 1998).

Engel *et al.* (2003) looked at the geographical mitochondrial gene lineages of 16 populations worldwide to elucidate the migration routes of the species. Two such studies have been published subsequently (Daguin *et al.*, 2005; Voisin *et al.*, 2005).

2.2.2 The Japweed *Sargassum muticum*

For the history of the accidental and intentional introductions of this species in Europe (the first reported record was in 1973 in southern England), see the previous status report (Wallentinus, 1999a) and Wallentinus (1999c), the latter also reporting on other areas of introduction.

A brief review of the status of its distribution in ICES countries was included in the 1992 WGITMO report (Wallentinus, 1992). At that time, its distribution extended from the south coast of Norway and the northwest coast of Sweden in the north (but not in the Baltic Sea), to Spain and Portugal in the south, except Ireland and Scotland. At that time in the Mediterranean, it had only been found in France, probably having arrived there with oysters. Off the American Pacific coast, occurrence was recorded from the northern part of British

Columbia southwards to the middle part of Mexico; there were no records from the Atlantic coasts.

In the Mediterranean, it spread to the Venice Lagoon, Italy, in 1992; the spread was slow in the first years, but at the end of the 1990s, it had outcompeted the native brown alga *Cystoseira barbata* in some areas (see also Section 2.3.3.3).

In 1995, it was recorded for the first time from Northern Ireland (ICES, 1995), where an eradication programme had started and two tonnes had been collected (ICES, 1996), albeit such efforts had proven unsuccessful in England (Critchley *et al.*, 1986). In 2001, the first plants were recorded from the west and southwest coasts of Ireland (ICES, 2002). See also Section 2.3.1.11.

In the 1990s in northern France, a progressive decline of the native kelp *Laminaria digitata* was seen (Cosson, 1999; see also Section 2.3.1.9), owing to competition from *Sargassum muticum*. Negative effects on other perennial seaweeds had also been seen in northern Spain, (e.g. Viejo, 1997; see also Section 2.3.1.12). Furthermore, a decline of other perennial species was recorded in Limfjorden, Denmark (Stæhr *et al.*, 2000; Wernberg *et al.*, 2001; see also Section 2.3.1.5).

For the expansions along the Norwegian coast, the Swedish west coast, the Danish Kattegat coast, and the German North Sea coast, see Sections 2.3.1.3, 2.3.1.4, 2.3.1.5, and 2.3.1.6.

A review of this species' performance, dispersal, possible vectors, and potential to cause harm was given by Wallentinus (1999c, and references therein). The high fecundity, monoecious life cycle with retained germlings on the parent plant, and large buoyancy were emphasized as high-risk factors, as well as its combined r and K strategies for successful establishment and growth (Farnham, 1997). Wallentinus (1999c) predicted that it was able to establish in most cold and warm temperate areas worldwide, providing that salinities are not too low because fertilization does not seem to occur below ca. 16 psu, although germlings can survive even 5–6 psu (Hales and Fletcher, 1989). *S. muticum* will also be included in Australia's target list of unwanted species (ICES, 1998).

2.2.3 The aquarium strain of the tropical green alga *Caulerpa taxifolia*

A background description of the introduction of *C. taxifolia* in the Mediterranean, first seen in 1984, as well as more general aspects of the genus, was given as an annex to the previous status report (Wallentinus, 1999a), although changes after 1992 were not included. In a status report on the distribution in the Mediterranean in 1992, the alga was stated to have spread 3 km east and 150 km west of Monaco and that it could spread to Spain and Portugal, but probably not to the UK and northwards (ICES, 1992). The status report of 1993 concluded that the area occupied was estimated to have increased by a factor of six each year and that the species can spread naturally up to 200 m along the shore annually under favourable conditions, but also that anthropogenic dispersal had occurred (ICES, 1993). The competition with the seagrass *Posidonia oceanica* was pointed out (see also e.g. Devillele and Verlaque, 1995). In 1994, the question of *Caulerpa taxifolia* in the Mediterranean being different from the normal tropical plants was raised, a strain created during its time as an aquarium cultivar, which survives temperatures as low as 7°C with growth from 13°C (ICES, 1994, and references therein). It was also stated that, at that time, *C. taxifolia* had spread to Elba and Sicily, and had also been recorded at Livorno, Italy, and at Palma de Mallorca, Spain. Scientific literature reviewed for the 1995 meeting showed that *C. taxifolia* can tolerate temperatures of 10°C for at least three months and that growth takes place between 10°C and 30°C. Evidence in the literature also pointed out that it may threaten the biodiversity in the areas of introduction and that some new toxic compounds had been isolated (ICES, 1995). At the meeting in 1996 (ICES, 1996), it was pointed out that further spread in the Mediterranean probably occurred by small boats carrying fragments, and that sexual reproduction does not

occur. In 1996, *C. taxifolia* was growing in about 3000 ha of the Mediterranean, where it had outcompeted most native species and, owing to the presence of the toxin caulerpenyne, was not grazed by most herbivores (ICES, 1997a). In 1997, the species occurred in Monaco (down to 100-m depth), France, Italy, Spain, and Croatia, and eradication was carried out when new sites with small patches were detected (ICES, 1998). Several studies were also made on its influence on biodiversity. In 1998, *C. taxifolia* was estimated to cover around 4600 ha in the Mediterranean (ICES, 1999). It was reported that, in some areas, most harbours had been colonized and functioned as dispersal centres, indicating that fishing and maritime activities were the main vectors. In the late 1990s, there were several pilot studies to use electrodes as a tool for eradication; however, efforts made in a nature reserve at Port-Cros, southern France, failed, and resulted instead in further dispersal of fragments (ICES, 2000a; Meinesz *et al.*, 2001).

In 2000, this strain of *Caulerpa taxifolia* was reported near San Diego on the Pacific coast of the US, where a substantial eradication campaign took place (ICES, 2001, 2002; Anderson, 2005; see also Section 2.3.4.2).

The Barcelona Appeal, released by the Plenary Assemblage of the Second Workshop on *Caulerpa taxifolia*, 15–17 December 1994, to alert the authorities and international organizations, was included in the WGITMO report of 1995 (ICES, 1995). The published proceedings from this meeting (Ribera *et al.*, 1996) include 50 papers on different aspects of *Caulerpa taxifolia*. The Appeal stated that the species could grow on all substrates and in all kinds of environments, as well as down to 99-m depth (although, in lower densities at these depths). The status report presented at the 1996 WG meeting pointed out that plants in certain regions can cover 100% of the seafloor, which could have a negative influence on diving and tourism. All recorded plants were male, propagating efficiently through fragmentation and possibly outcompeting other species, including the native *C. prolifera*. The question of using Caribbean sacoglossan snails of the genera *Elysia* and *Oxynoe* to control *C. taxifolia* was also raised at that time and further elaborated, with other candidates for marine biocontrol activities, resulting in the recommendation to thoroughly review at the 1997 WG meeting the various methods used to control introduced marine species (ICES, 1996). The Mediterranean sea slug, *Lobiger serradifalci*, was reported to eat *C. taxifolia* (ICES, 2000a), but later it was found that this species helped disperse *C. taxifolia* by producing fragments that could regenerate into new plants (Zuljevic *et al.*, 2001).

At the Biocontrol Meeting in 1997, Dr Meinesz and his student presented their laboratory experiments with Caribbean sacoglossan snails, which they motivated with the large area overgrown by *C. taxifolia*, making eradication by physical or chemical means impossible, as well as the fact that the native sacoglossan snails have pelagic larvae and would therefore disperse from the release areas (ICES, 1997a, 1997b; Meinesz, 1997). They concluded that it was possible to cultivate enough snails for a potential release with high efficiency (500–1000 sea slugs per m^2). Details of the species used in the experiments were also given, but a release had to wait for approval by the French authorities. That issue was much debated at an international seminar, arranged by the French Academy of Sciences in March 1997 (Anon., 1997), where other issues of *C. taxifolia* as well as of other introductions were also considered.

WGITMO has also expressed concern about this strain's further spread to other areas, owing to its easy availability through the aquarium trade or by transport as fragments on pleasure boats. ICES member countries were asked to survey where the species was displayed or was otherwise available and how the effluents from those facilities were treated (ICES, 1997a). The results of the surveys in the different countries were presented one year later (ICES, 1998). In France, it has been illegal since 1993 to trade and transfer *C. taxifolia*, and the same may apply to Spain. However, several species are available in pet shops, and sellers and consumers may not be able to distinguish between *C. taxifolia* and the legal *C. mexicana*.

Furthermore in France, *Caulerpa* is widely displayed in tropical aquaria and, because the growth is rapid, the method of discarding material may be crucial, even if the water is recycled. It was also discussed whether *C. taxifolia* and the invasive *C. racemosa* could be included in the CITES regulations Annex B Article 3(2)(d) as examples of species that may constitute a severe threat to indigenous wild flora and fauna.

At a WG meeting in Heraklion, Greece, in March 1998 (Gravez *et al.*, 2001) with the topic the invasive *Caulerpa* species in the Mediterranean (21 countries were represented), participants unanimously recommended sustained coordination among the countries to limit the spread, develop national programmes at several levels, provide better information to all potential users of coastal areas, impose a ban on marketing and usage of both *C. taxifolia* and *C. racemosa*, and avoid any use of *Caulerpa* species in aquaria, except for the native *C. prolifera* (ICES, 1998). Collections of *Caulerpa* species from the aquarium trade, mainly *C. taxifolia*, *C. racemosa*, and *C. prolifera*, have been collected in an archive in Nice, France by Professor Meinesz, to permit genetic studies of species to be moved around (ICES, 1999).

At the end of 2000, Meinesz *et al.* (2001) summarized the situation in the Mediterranean: "*Caulerpa taxifolia* is present in six countries (Croatia, France, Italy, Monaco, Spain, and Tunisia) with 103 independent areas of colonization, involving 131 km^2 of concerned area, along 191 km of coastline". They remarked that "80% of the areas colonized were along 500 km of the coastline between Toulon (France) and Genoa (Italy)", the area where the first dispersal was seen. They considered the species still to be in the expansion phase. Additional information on *Caulerpa* in the Mediterranean was given by Ribera Siguan (2002).

2.2.4 The cultivated Japanese nori *Porphyra yezoensis*

A proposal to introduce this species for farming in Cobscook Bay, Maine, was discussed at the WG meeting in 1992, at the formal request of the State of Maine, which approved the planned start in July 1992 had been approved by the State of Maine (ICES, 1992). Questions included whether *P. yezoenzis* could reproduce sexually in the wild, and whether drifting objects (including lost aquaculture equipment) could carry plants out of the bay and farther south to areas where sexual reproduction was possible, bearing in mind its high growth potential. It was recommended at the meeting that ICES continue to consider the release on the Atlantic coast of the US and its potential for spread into Canada and into southern waters.

At the meeting in 1993, a detailed outline of the commercial nori project was presented, and the WG was told that the first seeded nets had been released in Maine in August 1992 (ICES, 1993). This was based on a permit from the State of Maine, before the recommendations made by ICES in 1993. Dr Levine, representing the farming company, commented that, even if plants did reach areas south of Cape Cod with summer temperatures sufficiently high for sexual reproduction, the photoperiods with long days would have a negative effect on the release of the conchospores. Although noting that establishment may occur even farther north in thermal effluents, WGITMO considered the risk of natural reproduction to be small and, if realized, the ecological consequences would be limited.

In 1993, a site was also established in New Brunswick, Canada (ICES, 1994), but no continuation followed in 1994, owing to administrative problems (ICES, 1995). However, in 1996, the importation to New Brunswick was authorized by Canadian federal authorities, amounting to 100 nori nets originating in the Maine farming site (ICES, 1997a). During the WG meeting at Mystic Seaport in 1994, a visit was made to the cultivation site in Maine, and an annual report was received (ICES, 1994). In 1996, a request was made to introduce new axenic strains of *P. yezoensis* (see strains listed in ICES (1996)), and the discussion ended with a recommendation that, if such strains did not differ in reproductive behaviour from the one previously introduced (i.e. especially temperature demands), it would not meet objections.

However, it was noted that a more aggressive monitoring programme would then be necessary.

On the advice of WGITMO, salmon cages were inspected at the site visit in 1994 for any occurrence of the species. No attached plants were found on the cages, but plants were found on the ropes supporting the nori cultures. It was assumed that a full life cycle had not been completed (plants could have developed from asexual monospores), and empty scallop shells were spread to look for the conchocelis stage, but none was found (ICES, 1995). More shells were released during 1995, but no conchocelis stages were found, and monospores were found only in young gametophytes (ICES, 1996). In 1995, a new farming site was established and technical development made, and a polyculture system with salmon cages nearby was tested in 1996 (ICES, 1997a). Using an electrophoretic technique, three plants of *P. yezoensis* were found outside the farm area in 1996, five in 1997, and zero plants in 1998; but the risk of spreading outside the farming area was reported to be minimal, because monospores do not survive the winter season, and native *Porphyra* species were outcompeting *P. yezoensis* (ICES, 1997a, 1998, 1999, 2000a; Watson *et al.*, 2000). Whether the reported record of *Porphyra yezoensis* from Dover Point in New Hampshire (West *et al.*, 2005), much farther south on the American east coast, has anything to do with this farming is not known. The species was identified by using ITS1 and rbcL sequence, and when compared with data in GenBank, it was found to be identical to *P. yezoensis* forma *narawaensis* cultivar F-6. This was not among the strains listed as being of interest (ICES, 1996).

Concern was raised about the potential utilization of transgenic (through protoplast fusion) *P. yezoensis* or of native *Porphyra* species, and it was concluded that all such attempts were to be reported (ICES, 1996). Later, it was stated that no genetically modified strains of the *Porphyra* species would be released in US waters (ICES, 1997a, 1998). In 1999, it was reported that tetraploid *Porphyra yezoensis* had been artificially produced, having twice as high a growth rate as the diploid specimens, which could have ecological implications if released into the sea for farming. WGITMO recommended consulting WGAGFM for advice about the use of tetraploid species for farming (ICES, 1999).

During 1999, a trial of frozen seeding nets of *P. yezoensis* at an approved new farm site in Maine and under new management was unsuccessful, as a result of improper storage conditions. With that, the farming of *P. yezoensis* in Maine by the CPI/PhycoGen companies ended (ICES, 2000a).

2.2.5 Dinoflagellates of the genus *Pfiesteria*

The species *Pfiesteria piscicida* (previously called *P. piscimorte*) has a peculiar life cycle, involving as many as 24 different stages, some cysts and some amoeboids, besides motile cells; some strains have toxins known to cause fish kills and to directly affect humans (Burkholder *et al.*, 1995; Steidinger *et al.*, 1996). Zoospores have also been shown to negatively influence survival of bivalve larvae and hence may affect shellfish recruitment (Springer *et al.*, 2002). The species was first mentioned in WGITMO reports in 1993, with reference to a recent HAB meeting. In 1994, there was great concern over its potential dispersion by ballast water, and a resolution encouraged ICES member countries to develop ballast water and sediment management practices (ICES, 1994). A second species, *P. shumwayae*, with a similarly complex life cycle and toxic strains, has been described (Glasgow *et al.*, 2001) and was transferred to a new genus, *Pseudopfiesteria* (Litaker *et al.*, 2005).

Using PCR-based methods, both *P. piscicida* and *P. shumwayae* have been encountered in ballast water in ships arriving at Chesapeake Bay (9% and 18% of the samples, respectively; Doblin *et al.*, 2002). They also found the same species in water samples from NOBOB ships (16% and 24%, respectively), but only in one sample from the sediments. Considering the

wide global distribution (see below), the authors could not judge if this pattern resulted from an historical cosmopolitan spread or from anthropogenic activities such as shipping. Another possible vector could be shellfish movements, inasmuch as zoospores of *P. piscicida* have been shown to survive gut passage of molluscs by forming temporary cysts (Springer *et al.* 2002), and this possibility has been highlighted as a risk for intrastate movements of shellfish within the US (Shumway *et al.*, 2002).

In the early 2000s, cysts from the Oslofjord of both *P. piscicida* and the then newly described *P. shumwayae* were identified through 18S rDNA analysis, where the latter was identical to the American strain and only three base pares differed for the former. This difference may point to either a recent singular translocation or to a homogenous Atlantic distribution with a continuous gene flow. Species of *Pfiesteria* were later found in about 30% of the locations surveyed in southeastern Norway, especially in brackish water conditions (Jakobsen *et al.*, 2002; ICES, 2002). *P. shumwayae* has also been identified by molecular technique from estuaries around New Zealand (Rhodes *et al.*, 2002), as well as from Australia (Rublee *et al.*, 2002).

Many papers have been written on *Pfiesteria* and *Pfiesteria*-like organisms (PLO; see e.g. Steidinger *et al.*, 2001). In the early 2000s, there was fierce debate on whether the complex life cycle of the genus was accurate, and whether the species *P. shumwayae* had toxins. Litaker *et al.* (2002a, 2002b) claimed they had only found a typical dinoflagellate life cycle, while the opposing side (e.g. Burkholder and Glasgow, 2002) emphasized that the former had only used non-inducible, non-toxic strains of *P. piscicida*, which do not evolve through all stages. Furthermore, Berry *et al.* (2002) and Vogelbein *et al.* (2002) claimed that *P. shumwayae* was non-toxic and killed fish by means other than exotoxins. Discussions along these lines have continued.

2.3 Introduced benthic algae in different countries, arranged by coastal areas

2.3.1 The eastern Atlantic coasts including the North Sea, the Skagerrak, and the Kattegat

2.3.1.1 Iceland

No national reports have been delivered, and no new information has been discovered in the literature on any other macroalga having been introduced or on the current status of the two species listed below.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, 1978	None reported	*Codium fragile*, early 1970s	None reported

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in **bold** = invasive, in **bold + underlined** = highly invasive taxa.

Rumex obtusifolius	**Matricaria suaveolens**

2.3.1.2 The Faroe Islands

No national reports have been delivered, and no new information has been found in the literature on any other macroalga having been introduced or on the current status of *Bonnemaisonia hamifera*.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, 1980	None reported	None reported	None reported

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in **bold** = invasive, in **bold + underlined** = highly invasive taxa.

Rumex obtusifolius	**Matricaria suaveolens**

2.3.1.3 Norway

New introductions 1991–2002

In 1996, the red alga called *Dasysiphonia* sp. was recorded for the first time south of Bergen (60.12°N 5.10°E; Lein, 1999; ICES, 1999). According to Verlaque (2001), the species is identical to *Heterosiphonia japonica*; however, an ongoing taxonomic revision may show that this species should be removed from the genus *Heterosiphonia* (see also Bjærke and Rueness, 2004a). The most likely vector is shipping, because there are frequent routes between Bergen and the Netherlands, where it was recorded in 1994 (see Section 2.3.1.7), although ships from the Pacific cannot be ruled out entirely. During the late 1990s, the alga was fairly common in many areas around Bergen (ICES, 2000a) and was found earlier in 1997 at Florø (61.60°N 4.97°E; Lein, 1999). In 2000, it had spread rapidly both north- and southwards of Bergen and was found east of Lindesnes (58.0°N 7.1°E) on the Skagerrak coast; this goes against the currents and so could be the result of shipping activities or new introductions (ICES, 2001). In 2001, the northernmost limit was still in the district of Sogn and Fjordane (ICES, 2002). A few years later, it occurred abundantly, as a several-dm tall epiphyte from the mouth of the Oslofjord through to Sognefjord north of Bergen, its dispersal facilitated by vegetative reproduction (Bjærke and Rueness, 2004a, pers. comm.).

Hopkins (2002) also listed the red algae *Gracilaria gracilis* and *Sphaerococcus coronopifolius* as introduced in Norway. The former is a native species in northern European waters (see also Rueness, 1998), previously called *G. verrucosa*. The latter was first found in Norway in 1994 in the outer Oslofjord (ca. 59.3°N 9.5°E; Rueness 1998), and since 1990 has been seen on the Swedish west coast in the Koster area (ca. 58.9°N 11.0°E), where it is considered to be a range extension from more southern shores (Karlsson *et al.*, 1992). Thus, this species is less likely to have been introduced to Norway through human activities.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, 1902	*Fucus evanescens*, 1890s	*Codium fragile* ssp. *atlanticum*, <1895	None reported
Dasya baillouviana, 1966	*Colpomenia peregrina*, 1933	*Codium fragile* ssp. *scandinavicum*, 1929	
Polysiphonia harveyi[1], 1983	*Sargassum muticum*, 1988	*Codium fragile* ssp. *tomentosoides*, 1946	

[1] **Valid name *Neosiphonia harveyi* (Guiry *et al.*, 2006); year of first record, Bjærke and Rueness (2004b).**

Macroalgae introduced before 1991, but not listed above

The small red alga *Aglaothamnion halliae*, already seen in 1980 but not recognized at that time as an introduced species (Rueness and L'Hardy-Halos, 1991, and references therein;

recorded as *A. westbrookiae*), has been seen frequently during the past decade in southern Norway, often occurring on wooden pillars in harbour areas (Bjærke and Rueness, 2004c).

Current status of old introductions

The dispersal of *Sargassum muticum* along the Norwegian coast has been reported in all national reports delivered during the period 1992–2002 (no report in 1995). In 1992, the species was reported to have been permanently established on the Skagerrak coast (ICES, 1992), which had also been reported earlier (ICES, 1990). In 1993, it had reached the Bergen area on the Norwegian west coast (ICES, 1993, 1994), and sparse populations existed in 1995 in Hordaland (ca. 60.7°N 5–7°E), north of Bergen (ICES, 1996). In summer 1996, dense populations were found in a number of bays in Rogaland (ca. 59.2°N 5.5°E), north of Stavanger (ICES, 1997a). In 1997, *S. muticum* was found on the north side of Sognefjord (ca. 61.1°N 05°E), indicating the potential to spread even farther north (ICES, 1998). No drastic changes occurred the following years (ICES, 1999, 2000a, 2001). In the early 2000s, it had also established in the inner part of the Oslofjord, although there was no confirmation of any spread northwards (ICES, 2002).

The following status of earlier introductions was given by Rueness (1998):

Sporophytes, mainly sterile, of *Bonnemaisonia hamifera* is now one of the most common red algae and occurs along the whole coast, from the shores to deep waters, although gametophytes have only been found a few times.

Fucus evanescens (native in northern Norway), which is quite tolerant of eutrophication, is now the most common fucoid in the Oslofjord, where it can also form hybrids with *F. serratus* (Coyer *et al.*, 2002).

Codium fragile is common along the south coast of Norway, but has also spread as far north as Nord-Troms (ca. 70°N 18–20°E).

The red alga, *Neosiphonia harveyi*, now recognized to be of Japanese origin (McIvor *et al.*, 2001), spread in the 1990s and became common in the Oslofjord and along the coast up to Bergen.

Colpomenia peregrina, on the other hand, is not a common species, occurring in summer to autumn at sites that are not too exposed in the outer archipelago from Vestfold (ca. 59°N 10°E) to Nord-Trøndelag (ca. 65°N 11°E).

There was no information on the abundance of *Dasya baillouviana*, which seems to occur only along the Skagerrak coast.

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Ranunculus cymbalaria	**Cardaria draba**	Veronica austriaca	**Lactuca tatarica**
Fallopia japonica	**Eurucastrum gallicum**	**Ambrosia artemisifolia**	**Matricaria suaveolens**
Persicaria pensylvanica	**Isatis tinctoria**	**Centaurea aspera**	Senecio palustris
Rheum x rhabarbarum	Lobularia maritima	**Centaurea diffusa**	**Solidago canadensis**
Rumex confertus	Rosa rugosa	**Conyza canadensis**	***Elodea canadensis***
Frankenia pulverulenta	**Medicago arabica**	**Cotula coronopifolia**	**Polypogon monspeliensis**
Populus alba	**Lythrum hyssopifolia**	**Helianthus annuus**	**Asparagus officinalis**
Salix viminalis	Apium graveolens	**Inula britannica**	Iris sibirica
Brassica oleracea	**Datura stramomium**		

2.3.1.4 Sweden, the west coast

New introductions 1991–2002

No new introductions of macroalgae were included in the Swedish reports during the period 1992–2002. However, the Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) was stated by Athanasiadis (1996a) to have occurred in an offshore area in the middle of Bohuslän (ca. 58.5°N 11.1°E) since the early 1990s, and he indicated that there might be previous records under the name *P. fibrillosa*. Furthermore in 2003, it was recognized that the Japanese red alga "*Dasysiphonia* sp." had spread to the Koster archipelago (ca. 58.9°N 11.0°E) from Norway (see Section 2.3.1.3) already in 2002 and was then re-encountered in 2003 (Axelius and Karlsson, 2004). According to Verlaque (2001), the species is identical to *Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a); however, an ongoing taxonomic revision may show that this species should be removed from the genus *Heterosiphonia*.

Previously established (Wallentinus, 1999a)

Red algae	Brown algae	Green algae	Phanerogams
Bonnemaisonia hamifera, 1905[1]	*Fucus evanescens*, 1924	*Codium fragile* ssp. *scandinavicum*, 1932	None reported
Dasya baillouviana, 1953	*Colpomenia peregrina*, 1950	*Codium fragile* ssp. *tomentosoides*, 1938	
	Sargassum muticum, 1987		

[1] **Year changed following Kylin (1944).**

Current status of old introductions

The dispersal of *Sargassum muticum* along the Swedish west coast has been the subject of several surveys and has been included in most national reports during the period (Karlsson *et al.*, 1992; ICES, 1992, 1994, 1995, 1996, 1997a, 1998, 1999, 2000a, 2001, 2002; Karlsson and Loo, 1999). The first record, from the northern Kattegat coast (57.51°N 11.71°E), was in summer 1991 (ICES, 1992). In 1993 and 1994, although searched for, no attached plants had been found farther south, although drifting plants were frequently seen down to the middle part (ca. 57.1°N 12.3°E) of the province of Halland (ICES, 1994, 1995). In 1995, it had spread farther in the northern part of Halland, although still only drifting plants occurred farther south (ICES, 1996). The survey carried out in 1996 (Karlsson and Loo, 1999) revealed that, since 1993, *S. muticum* had spread 100 km to the south and was found at Träslövsläge (57.05°N 12.25°E), south of the city of Varberg, having also spread to the inner archipelagoes in Bohuslän (ICES, 1997a). No further changes had occurred between 1997 and 2002 (ICES, 1998, 2000a, 2001, 2002). It was especially vigorous, as well as heavily epiphytized, near the cooling water discharge at the nuclear power plant at Ringhals (57.26°N 12.10°E) in northern Halland, where it probably started to colonize already in 1992/1993 (ICES, 1997a). In the early 2000s, it was a common plant along the Skagerrak and northern Kattegat coasts, and by then had become very abundant in some areas in northern Bohuslän, causing possible decline in other fucoids (Carl-Johan Svensson, pers. comm.). Dense populations also act as barriers to water movements, which may lead to stagnation and enhancements of growth of ephemeral algae (ICES, 1997a; Jan Karlsson, pers. comm.; Inger Wallentinus, pers. obs.). The potentially toxic dinoflagellate *Prorocentrum lima* has often been encountered in large amounts on its canopies (Mats Kuylenstierna, pers. comm.).

The status of *Fucus evanescens* was studied in northern Bohuslän and in the Öresund area (Wikström *et al.*, 2002; ICES, 2002). In northern Bohuslän (ca. 58.8°N 11.2°E), there might have been a slight increase, as in the northern part of Öresund (ca. 56.3°N 12.5°E), although a decline was seen in the southern Öresund compared with the drastic increases in the 1960s–1970s. It was the fucoid tolerating most eutrophication, disappearing last, and returning first in

the southern Laholm Bay (56.43°N 12.85°E) during the 1980s (Wennberg, 1992). Its further dispersal along the Baltic coasts of Sweden may be limited because of its low fertility at salinities of 10 psu or lower (Wikström *et al.*, 2002).

A few gametophytes of *Bonnemaisona hamifera* were seen in the outer Koster archipelago (58.85°N 11.0°E) in 1999, but this is not a common phenomenon (Annelie Lindgren, pers. comm.). The southern border of the species is in the Öresund. The sporophytes, mainly sterile, are common on the northern part of the west coast, and a project has been started to look at the possible use of its halogenated metabolites as an antifouling compound (Gunnar Cervin, pers. comm.). In 1999, very large specimens of the red alga *Dasya baillouviana* were encountered at the discharge from the nuclear power plant at Ringhals, northern Halland, which is the southernmost record for Sweden (ICES, 2000a).

Phanerogams, often old introductions, all of Sweden

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Ranunculus cymbalaria	**Erucastrum gallicum**	Veronica austriaca	**Matricaria suaveolens**
Illecebrum verticillatum	**Isatis tinctoria**	**Ambrosia artemisifolia**	**Solidago canadensis**
Silene conica	Lobularia maritima	**Ambrosia psilostachya**	***Elodea canadensis***
Fallopia japonica	Rosa rugosa	**Centaurea aspera**	***Elodea nuttallii***
Persicaria pensylvanica	Astragalus arenarius	**Centaurea diffusa**	Beckmannia eruciformis
Rumex confertus	**Medicago arabica**	**Conyza canadensis**	**Polypogon monspeliensis**
Populus alba	**Lythrum hyssopifolia**	**Cotula coronopifolia**	**Polypogon viridis**
Salix viminalis	Apium graveolens	**Helianthus annuus**	**Asparagus officinalis**
Brassica oleracea	**Datura stramomium**	**Iva xanthifolia**	Iris sibirica
Cardaria draba	Calystegia pulchra	**Lactuca tatarica**	Iris versicolor

2.3.1.5 Denmark, all coasts

No new introductions of macroalgae were reported in the period 1992–2002, either in the national report (only delivered in 1993) or in the literature for that period.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, 1901	*Colpomenia peregrina*, 1939	*Codium fragile* ssp. *scandinavicum*, 1919	(*Myriophyllum sibiricum*)[1]
Dasya baillouviana, 1961	*Fucus evanescens, 1948*	*Codium fragile* ssp. *tomentosoides, 1920*	
	Sargassum muticum, 1984		

[1] ***Myriophyllum sibiricum* is to be considered a range extension; thus, it is not an introduced species.**

Macroalgae introduced before 1991, but not listed above

The Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) according to Maggs and Stegenga (1999, and references therein) occurred at Nissum Bredning (ca. 56.6°N 9.4°E), eastern Jutland already in 1980 and probably earlier (under the name *P. fibrillosa*). Its current status is not known, and *P. harveyi* was not listed in the earlier version of the checklist of Danish seaweeds (Nielsen, 2002).

According to Rosenvinge (1920), the occurrence of *Mastocarpus stellatus* at the harbour in Thisted, Limfjorden, (56.95°N 8.70°E) and at Århus (56.16°N 10.20°E) dates back to at least 1869 and 1911–1912, respectively, and was re-encountered by him in the same area, but not

elsewhere. He proposed that the species had arrived in both areas by vessels, because it only grew close to harbours. The species has now also been recorded from Fredrikshamn (57.46°N 10.52°E; Køie *et al.*, 2000). The species is native in the North Atlantic and occurs in Norway on the Skagerrak coast, as far south as Arendal (58.47°N 8.74°E).

Current status of old introductions

The only national report from Denmark during the period (ICES, 1993) listed an ongoing spread of *Sargassum muticum* in the Kattegat (see Section 2.3.1.4). In 1998, *S. muticum* was found attached also in the area south of the mouth of Limfjorden (ca. 56.9°N 10.3°E; see Section 2.3.1.4) and drifting north of Århus (Køie *et al.*, 2000). Its increased abundance in Limfjorden in the 1990s, when it became a dominant species, could be correlated with a corresponding decline of other perennial species, such as the brown algae *Fucus vesiculosus*, *Halidrys siliquosa*, and *Laminaria saccharina*, as well as of the introduced green alga *Codium fragile* (Stæhr *et al.*, 2000). They also reported that imports of both European and Pacific oysters from France had taken place in the early 1980s, which may explain the early presence in Limfjorden compared with the much later arrival on the German North Sea coast. Drift plants, however, had been seen frequently on the German North Sea coast during the 1980s (see Section 2.3.1.6). Also its phenology (as a means to interact) was thoroughly studied in Limfjorden, where *S. muticum* has invaded the habitat of *Halidrys siliquosa* and has had a negative influence through its pseudoperennial strategy on the native, truly perennial fucoid *Halidrys siliquosa* (Wernberg *et al.*, 2001).

Examinations of field-collected (the Kattegat) hybrid specimens between *Fucus evanescens* and *F. serratus*, being intermediate in morphology and dioecious, showed that they were fertile and all specimens were results of fertilization of *F. evanescens* eggs (Coyer *et al.*, 2002).

Sporophytes of *Bonnemaisonia hamifera*, mostly sterile, occur commonly on the North Sea and Kattegat coasts and also sporadically in the Belt Sea (Køie *et al.*, 2000). They also reported that *Fucus evanescens* is common on the coasts of eastern Jutland, Fyn, and Sjælland, and that *Colpomenia peregrina* has occurred since 1970 in the northern Kattegat down to Hirsholmene (57.50°N 10.62°E), eastern Jutland. According to them *Codium fragile* occurs southwards to northern Sjælland and the area north of Århus, but nothing is mentioned regarding its abundance.

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Silene conica	Lobularia maritima	**Ambrosia psilostachya**	***Elodea canadensis***
Fallopia japonica	Rosa rugosa	Artemisia stellariana	***Elodea nuttallii***
Persicaria pensylvanica	**Medicago arabica**	**Conyza canadensis**	**Polypogon monspeliensis**
Populus alba	**Lythrum junceum**	**Cotula coronopifolia**	**Spartina anglica**
Salix viminalis	**Datura stramonium**	**Helianthus annuus**	Spartina x townsendii
Cardaria draba	Calystegia pulchra	**Solidago canadensis**	Iris sibirica
Erucastrum gallicum	Veronica austriaca	**Lactuca tatarica**	Iris versicolor
Isatis tinctoria	**Ambrosia artemisifolia**	**Matricaria suaveolens**	

2.3.1.6 Germany, the North Sea coast

New introductions 1991–2002

A reintroduction of the Japanese brown alga *Sargassum muticum*, as well as the native brown alga *Ascophyllum nodosum*, was claimed to have occurred in an area near Sylt (ca. 54.8°N 8.2°E) in the North Sea, through imports of seed oysters, which had been "parked" outside the hatchery in Ireland (ICES, 1999). *S. muticum* was dispersing further at the beginning of the 2000s (ICES, 2001, 2002).

Bartsch and Kuhlenkamp (2000) reported that the red alga *Polysiphonia lanosa* was not seen growing as an epiphyte on the fucoid *Ascophyllum nodosum* on Helgoland (54.20°N 7.87°E) before the 1990s, but only occurred on drift plants. *P. lanosa* is common in the North Sea area, and the observed expansion to the island might therefore be considered a range extension rather than a new species introduction.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, ca. 1900	*Sargassum muticum*, 1988	*Codium fragile* ssp. *tomentosoides*, 1930	None reported
Mastocarpus stellatus, late 1970s			
(Porphyra yezoensis[1]*, 1984)*			

[1] **Genetically different from the Japanese material, and its identity has been doubted (Maggs and Stegenga, 1999; Bartsch and Kuhlenkamp, 2000, and references therein).**

Introductions of macroalgae before 1991, but not listed above

According to Maggs and Stegenga (1999, and references therein), the Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) was recorded on Helgoland (54.20°N 7.87°E) before 1978 (under the name *P. violacea*). Nothing is known about its current status.

Kornmann and Sahling (1983) depicted a red alga found on Helgoland since 1960, which they called *Callithamnion byssoides*, but according to Jan Rueness (pers. comm.) the alga in question is identical to *Aglaothamnion halliae*, and thus is an introduced species.

Current status of old introductions

After having been released as an ecological experiment in the late 1970s, the red alga *Mastocarpus stellatus* has become very abundant on Helgoland (Bartsch and Kuhlenkamp, 2000) and brought a decline in the littoral populations of the red alga *Chondrus crispus*, probably as a result of the better ability of *M. stellatus* to produce mycosporine-like amino acids (MAAs), which protect it from UV-B radiation (Bischof *et al.*, 2000).

In Königshafen Bay (55.05°N 8.38°E) at the Island of Sylt in the northern Wadden Sea, *Sargassum muticum*, first recorded in the area in 1993, was still a prominent part of the vegetation, both in the bay and outside some years later, and co-occurred outside the bay with the introduced green alga *Codium fragile*. The latter was also seen previously in the bay, thus having become scarcer (Schories *et al.*, 1997, and references therein). *S. muticum* became increasingly common on Helgoland during the 1990s (Bartsch and Kuhlenkamp, 2000).

Also *Bonnemaisonia hamifera* has increased in abundance, and fertile gametophytes were common at Helgoland in 1999, although *Codium fragile* ssp. *tomentosoides* only had a restricted distribution there at the time (Bartsch and Kuhlenkamp, 2000).

Phanerogams, often old introductions, all of Germany

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Chenopodium botrys	Astragalus arenarius	**Centaurea diffusa**	***Elodea canadensis***
Gypsophila scorzonerifolia	**Oenothera strica**	**Conyza canadensis**	***Elodea nuttallii***
Fallopia japonica	**Datura stramonium**	**Cotyla coronopifolia**	Beckmannia eruciformis
Brassica oleracea	Calystegia pulchra	**Iva xanthifolia**	**Spartina anglica**
Cardaria draba	**Centranthus ruber**	**Lactuca tatarica**	Spartina x townsendii
Isatis tinctoria	**Ambrosia artemisifolia**	**Matricaria suaveolens**	Typha laxmanni
Vaccinium macrocarpon	**Ambrosia psilostachya**	**Solidago canadensis**	**Iris versicolor**
Rosa rugosa			

Wolff (2005) listed *Cotula coronopifolia* as introduced to Germany already in 1739.

2.3.1.7 The Netherlands

New introductions 1991–2002

In 1993, an introduced red alga, identified as *Polysiphonia senticulosa* (might be conspecific with *P. morrowii*; see also Verlaque, 2001), was found at Gorishoek (Maggs and Stegenga, 1999) and was said to have increased to be common in winter and spring in Yerseke Oesterbank (ca. 51.3°N 4.2°E). They also predicted its spreading to other European countries. In 1999, it had spread over the entire Oosterschelde (ca. 51.4–51.7°N 3.7–4.3°E) and was one of the dominant species in Strijenham in 1998 (ICES, 2000a).

Two records of the red alga *Grateloupia doryphora* (valid name *G. turuturu*; Gavio and Fredericq, 2002) were also reported by Maggs and Stegenga (1999) from a former oyster pond at Yerseke (51.29°N 4.05°E) in 1993 and 1996. Wolff (2005) wrote that several large plants (up to 1 m) have been found subsequently, and that it occurs abundantly in some areas.

The North Pacific green alga *Ulva pertusa* was first recorded in the Dutch Delta in 1993 (Wolff, 2005) and subsequently became very common.

The first record of the red alga called *Dasysiphonia* sp. was also mentioned by Maggs and Stegenga (1999), found in a former oyster pond at Yerseke in 1994. According to Verlaque (2001) the species should be identical to *Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a); however, an ongoing taxonomic revision may show that the species should be removed from the genus *Heterosiphonia*. Wolff (2005) stated that it was common to abundant in the early 2000s.

In the late 1990s, the Pacific red alga *Gracilaria vermiculophylla* was sampled by H. Stegenga in the brackish Oostvoornse, close to Rotterdam, a species that spread to several countries on the North Sea coast in the early 2000s (Rueness, 2005).

The northwestern Pacific brown alga *Leathesia verruculiformis* has been found in Lake Grevlingen (ca. 51.8–51.9°N 3.8–4.15°E) and in the Oosterschelde since 1994, as an epiphyte on *Sargassum muticum* (ICES, 2000a).

The minute red alga *Acrochaetium balticum* was first reported from the brackish Lake Veere (ca. 51.3°N 3.4°E) in 1998, the small Mediterranean brown alga *Asperococcus scabra* in Lake Grevlingen in 1998, and the North American red alga *Agardiella subulata*, attached to shells, at Yerseke in Oosterschelde in December 1998 (ICES, 2000a).

In March 1999, for the first time in the Netherlands, 60-cm-long sporophytes of the Japanese kelp *Undaria pinnatifida* were recorded on shells in an oyster pond near Yerseke, and in May of the same year, one plant was found near Strijenham, both sites in the Oosterschelde (ICES, 2000a). There was a rapid colonization, and in some places, 5–6 ha could be found in the Oosterschelde, and plants were also washed ashore on the northern side. *U. pinnatifida* was also found in smaller densities in the saltwater Lake Grevlingen, probably transported there by oyster pots. In the Oosterschelde, it grows mainly on *Crassostera gigas*, but also on mussels, and being slippery, *U. pinnatifida* causes problems for fishers when retrieving the oysters, and requiring that the pots be cleaned before harvest (ICES, 2001).

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Dasya baillouviana, 1950	*Colpomenia peregrina*, 1920	*Codium fragile* ssp. *tomentosoides*, 1900	*Elodea canadensis*, late 1800s[2]
(*Bonnemaisonia hamifera* drift only)	*Sargassum muticum*, 1980	*Codium fragile* ssp. *atlanticum*,	*Elodea nuttallii*, early 1900s[2]
(*Asparagopsis armata* drift only)			
(*Antithamnionella sarnensis*[1] drift only)			

[1] **Valid name *A. ternifolia*; according to Maggs and Stegenga (1999), it was found attached already in 1951, but is not permanently established according to Wolff (2005).**

[2] **For time of introduction, see van der Velde *et al.* (2002).**

Macroalgae introduced before 1991, but not listed above

The red alga *Anothrichium furcellatum* was listed by Maggs and Stegenga (1999) as an introduction from the Mediterranean and was first found at Yerseke (in an oyster pond) in 1968. According to Wolff (2005), it was only temporarily established between 1950 and 1977 (the earlier date was from an unidentified herbarium specimen).

According to Maggs and Stegenga (1999), the Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) has been growing in the Netherlands since at least 1960, becoming a very common species in Oosterschelde and Lake Grevelingen on many different substrates (including cages and yacht moorings), also occurring in northern parts of the country.

The red alga *Antithamnionella spirographidis* was found near Yerseke in 1974 and, since 1993, has become rather common in the tidal Oosterschelde, but also occurs in the stagnant saline Lake Grevelingen (Maggs and Stegenga, 1999; Wolff, 2005).

Wolff (2005) listed the following benthic, mainly small algae (not listed above), also introduced before 1991 (year of first record in parentheses): the red algae – *Acrochaetium densum* (1967) and *Colaconema dasyae* (1953); the brown algae – *Botrytella* sp. (1919), *Elachista* sp. (1993), and *Myriactula* sp. (1980).

Current status of old introductions

Many papers on *Sargassum muticum* in the Netherlands were written in the 1980s (for references see Wallentinus (1999a, 1999c), although less were published in the 1990s. Den Hartog (1997) points to possible negative effects on eelgrass beds if it colonizes bare patches or on the edges. According to Wolff (2005), it is an abundant species, especially in Lake Grevlingen.

Of the previously listed introductions, Maggs and Stegenga (1999) described *Dasya baillouviana* as having expanded since 1993, now also found in stagnant brackish water (down to 10 psu), as well as in tidal areas during summer and early autumn.

No records of attached *Bonnemaisonia hamifera* or *Asparagopsis armata* in the Netherlands were mentioned by Maggs and Stegenga (1999). Wolf (2005) wrote that these species are still not established in the Netherlands.

According to references in Wolff (2005), the North American red alga *Agardiella subulata* has been fairly abundant in some areas since 1999.

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Corispermum intermedium	Rosa rugosa	**Lactuca tatarica**	**Schoenoplectus mucronatus**
Fallopia japonica	**Datura stramonium**	**Matricaria suaveolens**	**Paspalum disticum**
Populus alba	Calystegia pulchra	Senecio inaequidens	**Polypogon monspeliensis**
Cardaria draba	**Ambrosia artemisifolia**	**Solidago canadensis**	**Spartina anglica**
Lobularia maritima	**Ambrosia psilostachya**	***Elodea canadensis***	Spartina x townsendii
Vaccinium macrocarpon	**Conyza canadensis**	***Elodea nuttallii***	

The Dutch report (ICES, 1998) mentions that the dune grass *Ammophila arenaria* is widely used for planting in dune areas; although the cordgrass *Spartina* x *townsendii* no longer is planted, it has become well established. However, according to Tutin *et al.* (1980), *Ammophila arenaria* is native to the Netherlands.

Wolff (2005) listed *Cotula coronopifolia* as introduced already in 1846, occurring later in both brackish and freshwater marshes.

2.3.1.8 Belgium

Belgium is one of the few countries having plants included in the legislation on intentional introductions since 1999. By a royal decree, it may also be possible to eradicate alien nuisance species (ICES, 2001).

New introductions 1991–2002

The first record of the Japanese kelp *Undaria pinnatifida* at the marina of Zeebrügge (51.34°N 3.18°E) is dated 1999 (Wallentinus, 1999b), although the national report (ICES, 2001) gave the year 2000. A small population was established, but no spreading had occurred (ICES, 2002). It was seen as a range extension from northern France (ICES, 2001).

The Japweed *Sargassum muticum* was found attached in 1999 at Zeebrügge and Oostende (51.25°N 2.93°E), but later disappeared at the first site. It was speculated that oyster imports could be the vector (ICES, 2001).

The green alga *Codium fragile* ssp. *tomentosoides* was first seen forming dense populations in 1998–2000 at Oostende, but was not present there in 2001 or 2002, probably outcompeted by *Sargassum muticum* (ICES, 2001) or by changed water regimes (ICES, 2002).

The red alga *Antithamnionella spirographidis* was present at Oostende in 1992 and was established at Zeebrügge after 1983 (Maggs and Stegenga, 1999; ICES, 2001).

Also the red alga *Polysiphonia senticulosa* (might be conspecific with *P. morrowii*; see also Verlaque (2001)) has been reported in 2001 and 2002 from Oostende, growing where

Sargassum muticum had occurred previously. Although occurring in neighbouring the Netherlands (Section 2.3.1.7), it was not thought to have come from there, because no oysters had been imported from the Netherlands. Oysters, however, were imported from England and Atlantic France, where the species has not been recorded, and from British Columbia, which might be the source (ICES, 2002).

According to Maggs and Stegenga (1999, and references therein), the Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006) was found in Belgium (under the name *P. fibrillosa*) before 1995. The same also applies to the red alga *Antithamnionella ternifolia.*

Previously established taxa (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	(*Sargassum muticum* only as drift)	(*Codium fragile* ssp. *tomentosoides* only as drift)	None reported

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Chenopodium botrys	Lobularia maritima	**Ambrosia artemisifolia**	***Sagittaria graminea***
Corispermum intermedium	**Angelica archangelica**	**Ambrosia psilostachya**	***Elodea canadensis***
Fallopia japonica	**Datura stramonium**	**Conyza canadensis**	***Elodea nuttallii***
Populus alba	Calystegia pulchra	**Matricaria suaveolens**	**Polypogon monspeliensis**
Cardaria draba	Scutellaria hastifolia	Senecio inaequidens	**Spartina anglica**
Erucastrum gallicum	**Centranthus ruber**	**Solidago canadensis**	Spartina x townsendii

2.3.1.9 France, the Atlantic coast

New introductions 1991–2002

The red alga *Grateloupia filiformis* var. *luxurians* was first encountered at St Samson en Plougasnou (48.70°N 3.82°W), northern Brittany, in 1992, occurring at the same locations as *G. doryphora* (Cabioch *et al.*, 1997; valid name *G. turuturu*; Gavio and Fredericq, 2002). It was most probably introduced by shellfish movements, but shipping cannot be ruled out, because the species has occurred for a long time in southern England (see Section 2.3.1.10). The species was well established by the end of the 1990s.

Maggs and Stegenga (1999) reported that the red alga *Dasysiphonia* sp. was found near Roscoff (48.73°N 2.0°E), northern France, in 1995. According to Verlaque (2001), the species should be identical to *Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a), however, an ongoing taxonomic revision may show that it should be removed from the genus *Heterosiphonia*.

In 1996, a species of the red algal genus *Gracilaria* was seen as non-attached mats in several estuaries in Brittany, from Roscoff in the north to south of Lorient, but only vegetative plants were found in the field (Rueness, 2005), and it was considered a recent introduction. Cultivation and molecular analyses later showed it to be identical to the Asian species *Gracilaria vermiculophylla* (Rueness, 2005).

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Polysiphonia harveyi, 1832[1]			
Bonnemaisonia hamifera, 1898	*Colpomenia peregrina*, 1905	*Codium fragile* ssp. *tomentosoides*, 1946	None reported
Antithamnionella sarniensis[2], 1910	*Sargassum muticum*, 1976		
Antithamnionella spirographidis, 1911[1]	*Undaria pinnatifida*, 1983		
Asparagopsis armata, 1922			
Antithamnion densum, 1964[3]			
Mesothamnion caribaeum[4], 1967			
Lomentaria hakodatensis, 1984			
Caulacanthus ustulatus, 1986[5]			
Laurencia brogniartii, 1989			

[1] **For first record, see Farnham (1997); valid name *Neosiphonia harveyi* (Guiryi *et al.*, 2006).**

[2] **Valid name *A. ternifolia*.**

[3] **For first record, see Athanasiadis (1996b).**

[4] **Valid name *Pleonosporium caribaeum*.**

[5] **See Rueness and Rueness (2000) for confirmation of its Asian origin.**

Macroalgae introduced before 1991, but not listed above

The red alga *Anothrichium furcellatum* was listed by Maggs and Stegenga (1999) as an introduction from the Mediterranean, first found in northern France before 1922.

Magne (1992) reported on the minute red alga *Goniotrichopsis sublittoralis* being recorded from Roscoff, northern France, in 1975.

The red alga *Grateloupia doryphora* (valid name *G. turuturu*, Gavio and Fredericq, 2002) was first encountered at Lorient (47.45°N 3.22°W), southern Brittany, in 1989 and three years later at several sites in northern Brittany (Cabioch *et al.*, 1997). It was most probably introduced by shellfish movements, but shipping cannot be ruled out, because the species has occurred for a long time in southern England (see Section 2.3.1.10). The species was well established around Brittany at the end of the 1990s and early 2000s, also in eutrophicated areas, with fertile specimens occurring during a large part of the year (Cabioch *et al.*, 1997; Stiger *et al.*, 2003). Simon *et al.* (2001) reported on further dispersal around Brittany in the late 1990s, often occurring in marinas and growing on hulls of leisure boats, as well as on pontoons. Thus, shipping probably is a major vector.

Goulletquer *et al.* (2002) also listed the red alga *Hypnea musciformis*, a southern European and Mediterranean species, as introduced in Normandy in the 1900s. However, no more information on this introduction has been found, nor has it been listed by anyone else for the Atlantic coast of France, although Wallentinus (1999a) mentioned tank experiments with introduced specimens on Corsica.

Current status of old introductions

For further information about establishment in the wild of *Undaria pinnatifida*, see Section 2.2.1.

According to the national report (ICES, 1998), no significant changes or further dispersal of *Sargassum muticum* were found in the late 1990s, and in estuaries, high turbidity limited further spread. However, Cosson (1999) reported that *S. muticum* has caused a progressive decline of the kelp *Laminaria digitata* at two sites on the coast of Calvados (ca. 49.35°N 1.0°W), northern France, where *Laminaria digitata* has almost disappeared in some areas and

decreased in others to one-third of the biomasses in 1983. In the late 1990s, *S. muticum* could cover up to 80% of the substrate area.

In the early 1990s, *Caulacanthus ustulatus* was fairly common near Roscoff, northern France, but only rarely in a reproductive stage, so it mainly propagated vegetatively (Rueness, 1997).

Kraan and Barrington (2005, and references therein) reported that a commercial seaweed farm of *Asparogopsis armata* was set up in the mid-1990s on the Island of Ouessant, Brittany, northwestern France. In the mid-2000s, it encompassed 2 ha with 14 km cultivation ropes, with an annual yield of eight metric tonnes wet wt. Wild plants are used as seed stocks, and gametophytes propagated vegetatively. In contrast to a similar farm in Ireland (see Section 2.3.1.11), this farm site has not been included in the French national reports.

Phanerogams, often old introductions, all of France

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Eschscholzia californica	Sedum praealtum	**Angelica archangelica**	**Matricaria suaveolens**
Aptenia cordifolia	Rosa rugosa	**Hydrocotyle bonariensis**	Senecio inaequidens
Carpobrotus acinaciformis	Rosa virginiana	**Datura stramonium**	**Solidago canadensis**
Carpobrotus edulis	**Acacia cyanophylla**	Calystegia pulchra	***Elodea canadensis***
Carpobrotus glaucescens	**Acacia dealbata**	**Heliotropium curassavicum**	***Apanogeton distachyos***
Disyphema crassifolium	**Acacia karoo**	Phlomis fruticosa	Eleocharis bonariensis
Drosanthemum floribundum	**Acacia longifolia**	Hebe elliptica	Eleocharis striatula
Lampranthus falciformis	**Lupinus alboreus**	**Ambrosia artemisifolia**	**Fimbristylus annua**
Lampranthus roseus	Trifolium angulatum	**Ambrosia psilostachya**	Cortaderia selloana
Mesymbryanthemum nodiflorum	***Myriophyllum aquaticum***	**Ambrosia tenuifolia**	**Paspalum distichum**
Bassia hyssopifolia	Eucalyptus resinifer	**Aster squamatus**	**Paspalum vaginatum**
Chenopodium botrys	Eucalyptus robustus	**Baccaris halimifolia**	**Polypogon viridis**
Fallopia japonica	**Oenothera glazioviana**	**Bidens subalternans**	**Spartina alterniflora**
Ceratostigma plumbaginoides	**Oenothera rosea**	**Bidens vulgata**	**Stenotaphrum secundatum**
Malcolmia flexuosa	**Oenothera stricta**	**Conyza canadensis**	**Typha domingensis**
Malcolmia maritima	Euonymus japonicus	**Cotula coronopifolia**	Typha laxmanni
Corema album	Euphorbia polygonifolia	Helichrysum foetidum	**Fascicularia bicolor**
Escallonia macrantha	Erodium laciniatum	**Iva xanthifolia**	**Crocosmia x crocosmiiflora**
Sedum litoreum			

The national report (ICES, 1998) stated that the cordgrasses *Spartina anglica* and *S.* x *townsendii* were first introduced in Normandy in 1906, and in 1985, *Spartina anglica* was first observed in the Bay of Arcachon (ca. 44.7°N 1.1°W), southwestern France, quickly spreading. In the late 1990s, it covered hundreds of hectares. This led to a pilot eradication programme carried out in 1997, using quicklime injected in the sediments to destroy the rhizomes. The North American species *S. juncea* (according to Hitchcock, 1950, identical to a variety of *S. patens*; see below) has also occasionally been observed in this bay. Studies in 1998 showed that the quicklime was partially effective and caused a decline but not eradication of the cordgrasses; this would require concentrations far too high to be released in nature (ICES, 1999).

According to Goulletquer *et al.* (2002) *Spartina alterniflora* was introduced in Brest (48.38°N 4.53°W), Brittany, before 1960, and *S. versicolor* (probably identical to the North American species *S. patens* according to SanLeón *et al.*, 1999) in the Bay of Arcachon in 1901. SanLeón *et al.* (1999) also mapped several records of *S. patens* from the French Mediterranean coast.

2.3.1.10 United Kingdom including Wales, Scotland, the Isle of Man, and the Channel Islands

For Northern Ireland, see Section 2.3.1.11.

New introductions 1991–2002

In June 1994, the first records of attached *Undaria pinnatifida* at the Hamble estuary (ca. 50.85°N 1.3°W) in the Solent region, southern England, was confirmed (Fletcher and Manfredi, 1995; ICES, 1995, 1996). A pilot study was started in 1996 to monitor this species, by then only reported from this estuary in Solent, for its potential to spread farther and to compete with other species (ICES, 1996). Two additional locations on the south coast of England, as well as on Jersey (ca. 49.2°N 2.1°W), Channel Islands, were reported in 1996, probably representing new introductions and not range extensions (ICES, 1997a). In 1997, *U. pinnatifida* had established on still another site, close to the previous ones (ICES, 1998). A thorough review of the occurrence and ecology of *U. pinnatifida* in the UK and the North Atlantic was given by Fletcher and Farrell (1999), who stated that it mainly occurs on vertical sides of floating structures, and probably arrived in England with small boats being anchored in the marinas.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, 1890	*Fucus evanescens*, 1902	*Codium fragile* ssp. *atlanticum*, early 1800s	None reported
Antithamnionella spirographidis, 1906[1]	*Colpomenia peregrina*, 1905	*Codium fragile* ssp. *tomentosoides*, 1939	
Antithamnionella sarniensis[2], 1921	*Sargassum muticum*, 1973		
Asparagopsis armata, 1949			
Grateloupia filicina var. *luxurians*, <1947[3]			
Pikea californica, 1967			
Grateloupia doryphora[3, 4], 1969			
Agardhiella subulata, 1973			
Polysiphonia harveyi[5], 1976*			
Soliera chordalis, <1976[6]			
(*Soliera tenera*[7], 1978)			

[1] **For first record, see Maggs and Stegenga (1999).**

[2] **Valid name *A. ternifolia*.**

[3] **For first record, see references by Cabioch *et al.* (1997).**

[4] **Valid name *G. turuturu* (Gavio and Fredericq, 2002).**

[5] **Valid name *Neosiphonia harveyi* (Guiry *et al.*, 2006).**

[6] **Might be a cryptogenic species in UK (Farnham, 1997).**

[7] **According to Farnham (1997), this was a misidentification of a *S. chordalis* plant.**

*** 1908 according to Maggs and Stegenga (1999).**

Macroalgae introduced before 1991, but not listed above

Fletcher and Farrell (1999) gave 1986 as the year of the first record on the south coast of England of the small brown alga *Corynophlea umbellata*. It was found as an epiphyte on

Sargassum muticum, and Fletcher and Farrell (1999) considered this canopy alga to be the vector. They also mentioned the brown alga *Scytosiphon dotyi* on the east coast of England as an introduction; this may have been overlooked in the past, but now the year of introduction was established.

The red alga *Anothrichium furcellatum* was listed by Maggs and Stegenga (1999) as an introduction from the Mediterranean and was first recorded in 1976 in Dorset, southern England. They stated that the species seemed to be dispersing to new areas, which easily occurs by fragmentation and secondary attachment.

The red alga *Pterosiphonia pinnulata* was suggested by Maggs and Hommersand (1993) as possibly having been introduced, because only female plants occurred close to an oyster farm.

Current status of old introductions

By 1998, *Sargassum muticum* had extended its area into West Angle Bay (ca. 51.7°N 5°W), on the southwest coast of Wales (ICES, 1999), and the following year it was well established there and was also found on the Island of Lundy (ca. 51.2°N 4.7°W), and further dispersal could be predicted (ICES, 2000a). In 2001, it had moved into the Menai Strait (ca. 53.1°N 4.3°W), where it flourished (ICES, 2002).

Maggs and Stegenga (1999) described the status of several earlier introduced red algae: sporophytes of *Bonnemaisonnia hamifera* are very common, even in areas heavily grazed by sea urchins, as well as in sheltered, almost anoxic, muddy areas, where one-metre-thick beds can occur. *Grateloupia turuturu* (as *G. doryphora)*, which was also recorded in the Channel Islands in 1995, was described as spreading in southern England. The Japanese (McIvor *et al.*, 2001) red alga *Neosiphonia harveyi* is very common intertidally on different substrates (including ropes and pontoons in marinas), as well as on areas heavily grazed by *Littorina* snails. It is also frequently found on large, drifting canopy species such as the introduced *Sargassum muticum* and *Codium fragile*; the latter may even have been the vector of its introduction to Europe. The further spread of *N. harveyi* may be enhanced by all plants of *S. muticum* being carried by the currents. In southern England, *Antithamnionella spirographides* is especially common in yacht marinas, which may enhance its further dispersal in Europe. *Antithamnionella ternifolia* is common on the British Isles, particularly on artificial substrates such as ropes and marina pontoons, and easily dispersed by vegetative fragmented stolons.

There are many reports on the negative effects of the introduced *Codium fragile* on native species; however, in some areas, the native *C. tomentosum* still flourishes, as on Guernsey (ca. 49.5°N 2.6°W), where the introduced *C. fragile* ssp. *tomentosoides* is quite sparse (Trowbridge *et al.*, 2003).

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Equisetum ramosissimum	**Isatis tinctoria**	Phlomis fruticosa	***Sagittaria graminea***
Clematis flammula	Lobularia maritima	Scutellaria hastifolia	*Sagittaria rigida*
Eschscholzia californica	Malcolmia littorea	Hebe dieffenbachii	***Sagittaria subulata***
Aptenia cordifolia	Malcolmia maritima	Hebe salicifolia	***Elodea canadensis***

Table continued...

Carpobrotus acinaciformis	Vaccinium macrocarpon	Hebe x franciscana	***Elodea nuttallii***
Carpobrotus aequilaterus	Pittosporum crassifolium	Linaria arenaria	***Apanogeton distachyos***
(Carpobrotus chilensis ?)	Pittosporum tenuifolium	Veronica austriaca	Juncus subulatus
Carpobrotus edulis	Escallonia macrantha	Coprosoma repens	**Ammophila breviligulata**
Carpobrotus glaucescens	Sedum prealtum	**Centranthus ruber**	Cortaderia selloana
Disphyma crassifolium	Rosa luciae	**Ambrosia artemisifolia**	Cortaderia richardii
(Drosanthemum candens ?)	Rosa rugosa	**Ambrosia psilostachya**	**Lagurus ovatus**
Drosanthemum floribundum	Rosa virginiana	Artemisia stellariana	**Paspalum distichum**
Erepsia heteropetala	**Lupinus arboreus**	Asteriscus aquaticus	**Polypogon viridis**
Lampranthus falciformis	Tetragonobulus maritimus	**Baccharis halmifolia**	**Spartina alterniflora**
Lampranthus roseus	***Myriophyllum aquaticum***	Brachyglottis monroi	Spartina pectinata
Oscularia deltoides	***Myriophyllum verrucosum***	**Centaurea aspera**	Typha laxmanni
Ruschia caroli	**Lythrum junceum**	**Conyza canadensis**	**Fascicularia bicolor**
Atriplex halimus	Oenothera cambrica	**Cotula coronopifolia**	Ochagavia carnea
Atriplex suberecta	Oenothera fallax	Gaillardia x grandiflora	Agapanthus praecox
Fallopia japonica	**Oenothera glazioviana**	Gazania rigens	**Allium sativum**
Persicaria pensylvanica	**Oenothera rosea**	Grindelia stricta	**Kniphofia praecox**
Rheum x rhabarbarum	**Oenothera stricta**	**Helianthus annuus**	Kniphofia rufa
Rumex confertus	Griselina littoralis	**Inula britannica**	Kniphofia uvaria
Rumex cuneifolius	Euonymus japonicus	**Iva xanthifolia**	**Crocosmia crocosmiifolia**
Limonium hyblaeum	**Angelica archangelica**	**Lactuca tatarica**	Iris spuria
Tamarix gallica	**Datura stramonium**	**Matricaria suaveolens**	**Iris versicolor**
Populus alba	**Solanum laciniatum**	Olearia macrodontha	Iris x robusta
Salix viminalis	Calystegia pulchra	Senecio inaequidens	Phormium cookianum
Cardaria draba	Dichondra micrantha	**Senecio leucanthemifolius**	**Phormium tenax**
Erucastrum gallicum		**Solidago canadensis**	Yucca recurvifolia

2.3.1.11 Ireland and Northern Ireland

New introductions 1991–2002

In 1995, *Sargassum muticum* was first encountered in Strangford Lough (54.52°N 5.65°W), Northern Ireland, near bags with Pacific oyster; the plants were estimated to be 2–3 years old. Pacific oysters had been imported from Guernsey in 1988 (Boaden, 1995; ICES, 1995). The survey, carried out in 1995, resulted in the removal of about 2.5 tonnes, but plants still remained, and there were new surveys and clearings in the summer of 1996 (ICES, 1996, 1997a). New eradications took place in 1997 and the following years, but failed (ICES, 1998, 2000a). In 2001, the first plants were recorded in Bertraghboy Bay on the west coast and in Kenmare Bay (ca. 51.7°N 110°W), on the southwest coast of Ireland. They had probably been there for two years or more, and a field study was carried out in 2002. The vectors may either have been drift from England, visiting leisure crafts, or imported oysters (ICES, 2002). Plants occur mainly on sheltered to semi-exposed shores, in the mid-intertidal to upper subtidal, together with fucoids and *Laminaria saccharina* (Gallagher *et al.*, 2003).

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, 1891	*Colpomenia peregrina*, 1931	*Codium fragile* ssp. *atlanticum*, ca. 1808[3]	None reported
Asparagopsis armata, 1939*		*Codium fragile* ssp. *tomentosoides*, ca. 1950	
Cryptonemia hibernica[1], 1971			
(*Gracilaria multipartita*, only detached 1977–1981)			
Polysiphonia harveyi[2], 1980s			
Antithamnion densum, 1990			

[1] **See further references given by Wallentinus (1999a).**

[2] **Valid name *Neosiphonia harveyi* (Guiry *et al.*, 2006).**

[3] **Trowbridge (1998).**

*** Tetrasporophytes.**

Macroalgae introduced before 1991, but not listed above

Maggs and Hommersand (1993) listed the red alga *Antithamnionella spirographidis* from Cork and Down, Ireland, but no year of first record was given.

Current status of old introductions

On the Irish west coast, *C. fragile* ssp. *atlanticum* had increased in relative abundance at all tidal levels in 1999–2000, compared with a survey in 1971, while the dominance of *C. fragile* ssp. *tomentosoides* had declined. The native *C. tomentosum* constituted the same percentage of the population as it did in 1971 (Trowbridge, 2001).

In the late 1990s, trial cultivation of the introduced red alga *Asparagopsis armata* started on the west coast of Ireland for use in the cosmetics industry (ICES, 1998; Kraan and Barrington, 2005). This continued in the early 2000s, with plans to increase the longline cultivations. *A. armata* is common in the wild at some sheltered locations, and occurred in the early 2000s on the south, southwest, and west coasts of Ireland (ICES, 2002). Kraan and Barrington (2005) reported on a survey of previous records of gametophytes and tetrasporophytes along the Irish coast; gametophytes were found only within a 75-km radius from the farming sites. They considered farming in Ard Bay to be a source pool for the gametophytic populations (by fragmentation) and that, in general, temperatures are too low for sexual reproduction of this species. However, they did not consider *A. armata* to be an invasive species in the area, and even mentioned that it has increased biodiversity.

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Carpobrotus edulis	Erica terminalis	Phlomis fruticosa	***Elodea canadensis***
Lamprantus falciformis	Escalonia macrantha	Hebe salicifolia	***Elodea nuttallii***
Fallopia japonica	Rosa rugosa	Hebe x franciscana	Cortaderia selloana
Rheum x rhabarbum	**Lupinus arboreus**	**Centranthus ruber**	**Spartina anglica**
Populus alba	**Medicago arabica**	Artemisia stellariana	Spartina maritima
Salix viminalis	Hippophae rhamnoides	**Lactuca tatarica**	Spartina pectinata
Isatis tinctoria	**Onoethera glazioviana**	**Matricaria suaveolens**	Spartina x townsendii
Cardaria draba	**Datura stramonium**	Olearia macrodonta	**Crocosmia x crocosmiiflora**
Lobularia maritima	Calystegia pulchra	**Solidago canadensis**	**Phormium tenax**

2.3.1.12 Spain, the Atlantic coast including the Canary Islands

New introductions 1991–2002

Pena and Barbara (2003) reported on records of *Dasysiphonia* sp. in the harbour of A Coruña (ca. 43.4°N 8.4°W), northwestern Spain; citing a personal communication from J. Cremadas, Maggs, and Stegenga (1999), reported that a red alga very similar to *Dasysiphonia* sp. has been very common in Galicia, northern Spain, since the 1990s. According to Verlaque (2001), *Dasysiphonia* sp. should be identical to *Heterosiphonia japonica* (see also Bjærke and Rueness, 2004a); however, an ongoing taxonomic revision may show that it should be removed from the genus *Heterosiphonia*.

The brown alga *Stypopodium schimperi*, a Lessepsian immigrant in the Mediterranean, has been recorded from the Canary Islands (Sansón *et al.*, 2002). The Japanese (McIvor *et al.*, 2001) red alga *Polysiphonia harveyi* (valid name *Neospihonia harveyi*, Guiry *et al.*, 2006) was first recorded on Tenerife in 1991/1992, growing on buoys, ships' hulls, and ropes (Rojas Gonzáles *et al.*, 1994).

The red alga *Palmaria palmata* has been farmed on a large scale in northern Spain (José Rico, pers. comm.). The species occurs naturally in the area, but in quantities too low for the demand, and so farming should be seen as restocking.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Asparagopsis armata, 1920s	*Colpomenia peregrina*, <1960s	*Codium fragile* ssp. *tomentosoides*, <1957	None reported
Antithamniella sarniensis[1], 1920s	*Sargassum muticum*, 1985		
(*Dipterosiphonia dentritica**, 1960)	*Undaria pinnatifida*, 1990		
Antithamniella spirographides, <1986			
Mesothamnion caribaeum[2] late 1970s (Can. Isl.)			
Platysiphonia caribaea, late 1980s (Can. Isl.)			
Predaea huismanii, late 1980s (Can. Isl.)			
Grateloupia doryphora[3], 1990			
Grateloupia filicina var. *luxurians*, 1990			
(Pikea californica[4], 1991)			
Lomentaria hakodatensis, 1992[5]			
(*Bonnemaisonia hamifera*?)[6]			

[1] **Valid name *A. ternifolia*.**

[2] **Valid name *Pleonosporium caribaeum*.**

[3] **Valid name *Grateloupia turturu* (Gavio and Fredericq, 2002).**

[4] **According to ICES (1993), this was a misidentification.**

[5] **Listed in ICES (1992).**

[6] **See below.**

*** Probably native.**

Macroalgae introduced before 1991, but not listed above

The eastern Australian red alga *Gymnophycus hapsiphorus*, first recorded in 1989, was only found in harbours in the Canary Islands, growing on ships' hulls, buoys, ropes, etc., and so Sansón and Reyes (1995) suggested that it had most probably been introduced by shipping.

According to Sansón and Reyes (1995), the occurrence of *Grallatoria reptans* on the Canary Islands is a disjunct one, which sometimes indicates an introduction. Also *Antithamnion diminuatum*, which was recorded at the Canary Islands, is disjunct because it is a species of the southern hemisphere (Athanasiadis, 1996b).

Ruperez and Saura-Calixto (2001), and several similar papers on the utilization of Spanish seaweeds, stated that the red alga *Porphyra tenera* is a Spanish edible seaweed. However to our knowledge, this is an Indo-Pacific alga, which was also imported for farming on the US Pacific coast (Wallentinus, 1999a, and references therein). Thus, it is unclear whether *P. tenera* was introduced, intentionally or accidentally, to Spain, or whether – as seems more likely – the authors or their material suppliers do not have sufficient taxonomic knowledge to separate species within this genus.

Current status of old introductions

In 1992, there was a slight increase in the abundance of *Undaria pinnatifida*, and new populations of *Lomentaria hakodatensis* were found in Galicia (ICES, 1993; Bárbara and Cremades, 1996). Exploitation and cultivation of *U. pinnatifida* continue in northern Spain, and many papers published after 2000 describe analyses of that alga, as well as of some edible native seaweeds (e.g. Ruperez and Saura-Calixto, 2001). According to José Rico (pers. comm.), *U. pinnatifida* is farmed on the northwest coast all the way down to the bordering river with Portugal.

The ecological constraints for the establishment and abundance of *Sargassum muticum* in northern Spain have been discussed by several authors (e.g. Viejo *et al.*, 1995; Rico and Fernandéz, 1997; Viejo, 1997; Andrew and Veijo, 1998; Sanchez *et al.*, 2003). The species is patchily distributed and most abundant in sheltered areas and tide pools, but more sensitive to wave exposure, although phenotypic adaptation can occur. When a profuse colonization of *S. muticum* took place, perennial seaweeds of the leathery type (e.g. *Bifurcaria bifurcata* and *Cystoseira* spp.) were the ones most negatively affected (Viejo, 1997).

According to José Rico (pers. comm.), the green alga *Codium fragile* ssp. *tomentosoides* is only common on the northeast coast, in the Bay of Biscay, while the native species *C. tomentosum* dominates farther west. It also grows on the Canary Islands (Sansón and Reyes, 1995).

According to Diez *et al.* (2003), tetrasporophytes of the red alga *Asparagopsis armata* occurred in half of their surveyed quadrats, with a mean cover of 5%; gametophytes, on the other hand, were only found in 16% of the quadrats, with a mean cover of 0.4%. Andreakis *et al.* (2004) listed several collections of gametophytes of *A. armata* from the northern Spanish coast, but none of *A. taxiformis* (too cold). Diez *et al.* (2003) also listed *Bonnemaisonia hamifera* in 30% of the quadrats (mean cover 0.7%), so confirming the presence of the species in northern Spain (see discussion in Wallentinus (1999a)). Further, they recorded few sightings of the red algae *Antithamnionella spirographides* and *Anothrichium furcellatum* and of the brown alga *Colpomenia peregrina.*

When monitoring the harbour of A Coruña, northwestern Spain, in the early 2000s, the following previously introduced species were found: *Sargassum muticum*, *Undaria pinnatifida*, *Codium fragile*, and *Lomentaria hakodatensis* (Pena and Bárbara, 2003).

Phanerogams, often old introductions (all of Spain)

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Eschscholzia californica	**Fallopia japonica**	**Oenothera glazioviana**	**Cotula coronopifolia**
Opuntia ammophila	Populus euphratica	**Oenothera rosea**	**Helianthus annuus**
Aptenia cordifolia	Salix viminalis	Oenothera stricta	Helichrysum foetidum
Carpobrotus acinaciformis	Malcolmia flexuosa	Euonymus japonicus	**Solidago canadensis**
Carpobrotus aequilaterus	Malcolmia maritima	Euphorbia polygonifolia	***Elodea canadensis***
Carpobrotus chilensis	Sedum litoreum	**Hydrocotyle bonariensis**	Lilea scilloides
Carpobrotus edulis	**Acacia cyanophylla**	**Datura stramonium**	**Fimbrisylus ferruginosa**
Disphyma crassifolium	**Acacia cyclops**	**Heliotropium curassavicum**	Cortaderia selloana
Drosanthemum hispidum	**Acacia dealbata**	**Ageratina adenophora**	**Paspalum distichum**
Galenia secunda	**Acacia karoo**	**Ambrosia psilostachya**	**Paspalum vaginatum**
Lampranthus falciformis	**Acacia longifolia**	**Ambrosia tenuifolia**	**Spartina alterniflora**
Lampranthus multiradiatus	***Myriophyllum aquaticum***	**Aster squamatus**	**Spartina densiflora**
Tetragonia tetragonoides	Eucalyptus gomphocephalus	**Baccharis halmifolia**	**Stenotaphrum secundatum**
Atriplex semibaccata	Eucalyptus resinifer	**Bidens subalternans**	**Aloe vera**
Atriplex suberecta	Eucalyptus robustus	**Conyza canadensis**	**Phormium tenax**

The North American cordgrass *Spartina patens* was detected in Galician wetlands in 1997, also occurring at the border with Portugal, and is considered a weed that negatively affects species diversity in the upper marshes (SanLeón *et al.*, 1999). It has also been found on the Spanish Mediterranean coast, mostly under the name *S. versicolor*, which was long considered a native Mediterranean plant, but was most probably introduced long ago as packing material in on-board boxes and crates (SanLeón *et al.*, 1999).

2.3.1.13 Portugal, including the Azores

New introductions 1991–2002

Araujo *et al.* (2003) reported on records of the red alga *Grateloupia turuturu* from the northwest coast of Portugal in the early 2000s.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Asparagopsis armata, <1970	*Colpomenia peregrina*, <1970	None reported	None reported
Antithamnionella sarniensis[1], <1970	*Sargassum muticum*, 1991[4]		
Mesothamnion caribaeum[2], 1970s			
Symphyocladia marchantioides, 1971			
Antithamnionella spirographides ?			
(*Bonnemaisonia hamifera*?)[3]			

[1] **Valid name *A. ternifolia*.**

[2] **Valid name *Pleonosporium caribaeum*.**

[3] **See discussion in Wallentinus (1999a).**

[4] **Listed in ICES (1992).**

Macroalgae introduced before 1991, but not listed above

Tittley and Neto (2005) reported that both subspecies of *Codium fragile*, ssp. *tomentosoides* and *atlanticum*, occur widely in the Azores. According to Parente *et al.* (2003), it has been suggested that the occurrence of the brown alga *Endarachne binghamiae* could be the result of an introduction, because it is the only site in the North Atlantic and was first seen in 1980, but not reported until 1994. They also stated that this alga is common throughout the year on mid-tidal, rocky shores in exposed areas; only one stage with plurilocular sporangia has been seen, but no sexual reproduction.

According to Guiry *et al.* (2006), *Antithamnion pectinatum* (according to Cho *et al.* (2005), it should be *A. nipponicum*) occurs on the Azores. *A. diminuatum* is a species of the southern hemisphere, which has also been recorded from the Azores (Athanasiadis, 1996b).

Current status of old introductions

Since the early 2000s, *Sargassum muticum* has been found mainly in tide pools in the southwestern Portugal, where it can become dominant and its demography at the southernmost distribution limit in Europe has been studied (Engelen *et al.*, 2003). On the Azores, *Asparagopsis armata* is competitive, which has probably resulted in *A. taxiformis* being less common than earlier (Tittley and Neto, 2005). Andreakis *et al.* (2004) listed several collections of gametophytes of *A. armata* from the southern Portuguese coast, but none of *A. taxiformis*.

There is no information available on the current status of the other previously introduced seaweeds or whether the Japanese kelp *Undaria pinnatifida* has reached Portuguese waters. However, because *U. pinnatifida* is cultivated close to the Spanish border (Section 2.3.1.12) in the north, it can be expected to arrive in the near future, if it has not already done so.

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Eschscholzia californica	**Rumex cuneifolius**	**Oenothera stricta**	Helichrysum foetidum
Aptenia cordifolia	Salix viminalis	Hakea salicifolia	**Matricaria suaveolens**
Carpobrotus acinaciformis	Malcolmia flexuosa	**Hydrocotyle bonariensis**	***Elodea canadensis***
Carpobrotus edulis	**Acacia cyanophylla**	**Datura stramonium**	Triglochin striata
Disphyma crassifolium	**Acacia cyclops**	Dichondra micrantha	Lilaea scilloides
Drosanthemum candens	**Acacia dealbata**	**Heliotropium curassavicum**	**Cyperus brevifolius**
Lampranthus falciformis	**Acacia karoo**	Phlomis fruticosa	Cyperus congestus
Lampranthus multiradiatus	**Acacia longifolia**	Hebe salicifolia	Cortaderia selloana
Mesymbryanthemum crystallinum	Acacia sophorae	**Ageratina adenophora**	**Paspalum distichum**
Mesymbryanthemum nodiflorum	***Myriophyllum aquaticum***	**Ambrosia artemisifolia**	**Paspalum vaginatum**
Ruschia caroli	Eucalyptus resinifer	**Aster squamatus**	**Stenotaphrum secundatum**
Sesuvium portulacastrum	Eucalyptus robustus	**Conyza canadensis**	**Aloe vera**
Tetragonia tetragonoides	Oenothera affinis	**Cotula coronopifolia**	**Crocosmia x crocosmiiflora**
Fallopia japonica	**Oenothera glaziovana**	Gazania rigens	Phormium tenax
	Oenothera rosea		

According to SanLeón *et al.* (1999), the North American cordgrass *Spartina patens* occurs at several sites in Portugal.

2.3.2 The Baltic Sea coasts, inside the Kattegat and the Belt Sea areas

2.3.2.1 Sweden

New introductions 1991–2002

Large amounts of a subtropical, estuarine benthic diatom *Pleurosira leavis* f. *polymorpha* were reported from the cooling water basins at the nuclear power stations at Forsmark (60.38°N 18.25°E), southern Bothnian Sea, and Oskarshamn (57.26°N 16.49°E), the Baltic proper, probably having arrived through the stocking of eels (Jansson, 1994; ICES, 1995). The current status is not known.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	None reported	*Chara connivens*, 1950s (probably from the late 1800s[1])	*Elodea canadensis*, 1873
			(*Myriophyllum sibiricum*[2])

[1] **See Luther (1979).**

[2] ***Myriophyllum sibiricum* is to be considered a range extension; thus it is not an introduced species.**

Plants introduced before 1991, but not listed above

The submersed phanerogam *Elodea nuttallii* was first seen in Sweden at the end of the 1980s.

Current status of old introductions

The introduced *Chara connivens* has been placed on the Swedish Endangered Species Red List as a vulnerable species (Aronsson *et al.*, 1995; Gärdenfors, 2000). Field surveys in 1999, however, revealed that it was more abundant in the Öregrund archipelago (ca. 60.3°N 18.5°E) than previously believed (ICES, 2000a). The principle of red-listing introduced species has been discussed at several WG meetings (e.g. ICES, 1998, 1999).

Phanerogams, mainly old introductions

See Section 2.3.1.4.

2.3.2.2 Finland

No macroalgae are included in the national reports, and we found neither information in the literature on any introduced macroalgae, nor any information on whether the phanerogam *Elodea nuttalli* has been established in Finland (see Section 2.3.2.1).

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	None reported	None reported	*Elodea canadensis*, 1884
			(*Myriophyllum sibiricum*[1]

[1] ***Myriophyllum sibiricum* is to be considered a range extension; thus it is not an introduced species.**

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Ranunculus cymbalaria	**Cardaria draba**	Apium graveolens	**Inula britannica**
Fallopia japonica	**Isatis tinctoria**	**Datura stramonium**	**Lactuca tatarica**
Persicaria pensylvanica	Lobularia maritima	Veronica austriaca	**Matricaria suaveolens**
Rumex confertus	Rosa rugosa	**Ambrosia artemisifolia**	**Solidago canadensis**
Rumex obtusifolius	Astragalus arenarius	**Centaurea diffusa**	***Elodea canadensis***
Populus alba	Medicago arabica	**Conyza canadensis**	**Polypogon monspeliensis**
Salix viminalis	**Lythrum hyssopifolia**	**Helianthus annuus**	**Asparagus officinalis**
Brassica oleracea			

2.3.2.3 Estonia

The only macroalga included in the national reports is a reference in a paper dealing with grazing on *Chara connivens* (ICES, 2003; see below). We have found no information in the literature on any other introduced macroalgae.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	None reported	None reported	*Elodea canadensis*, 1873

Macroalgae introduced before 1991, but not listed above

There was no report on *Chara connivens* from Estonia in the paper by Luther (1979), who discussed old discharges of solid ballast as a vector. The first record for Estonia is from as late as the 1980s, as single specimens from Kihnu Island (ca. 58.1°N 24.0°E) and on the south coast of the island Saaremaa (ca. 58.2°N 22.6°E), western Estonia (Torn and Martin, 2003, and references therein); their origin, however, was not discussed. If solid ballast is considered to be the vector for the other countries around the Baltic, this species may well have been overlooked in the past. Recently, Torn *et al.* (2003) stated that *Chara connivens* is no longer rare in western Estonia, occurring both around the islands of Saaremaa and Hiumaa, as well as in bays on the mainland facing the Gulf of Riga (ca. 58.2–58.9°N 22.0–23.6°E), but not along the Gulf of Finland, in salinities from 0.5 to 6.5 psu and down to 3-m depth.

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Kask and Vaga, 1966; Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Chenopodium botrys	**Erucastrum gallicum**	**Ambrosia psilostachya**	**Solidago canadensis**
Corispermum intermedium	**Isatis tinctoria**	**Centaurea diffusa**	***Elodea canadensis***
Fallopia japonica	Rosa rugosa	**Conyza canadensis**	Beckmannia eruciformis
	Astragalus arenarius	**Helianthus annuus**	**Zizania aquatica**
Rumex confertus	**Medicago arabica**	**Iva xanthifolia**	Zizania latifolia
Populus alba	Apium graveolens	**Lactuca tatarica**	**Asparagus officinalis**
Brassica oleracea	**Datura stramomium**	**Matricaria suaveolens**	Iris sibirica
Cardaria draba			

2.3.2.4 Latvia

No national reports have been delivered, and we have found no information in the literature on any other introduced macroalgae or on the status of *Chara connivens* or *Elodea canadensis*.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	None reported	*Chara connivens*, 1922[1]	*Elodea canadensis*, 1880s?

[1] **See Luther (1979).**

Phanerogams, often old introductions

See Section 2.3.4.

2.3.2.5 Lithuania

No national reports have been delivered, and we have found no information in the literature on any introduced macroalgae or on the status of *Elodea canadensis*.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	None reported	None reported[1]	*Elodea canadensis*, 1880s?

[1] **See Luther (1979) for misidentifications of freshwater samples named *Chara connivens*.**

Phanerogams, often old introductions

See Section 2.3.4.

2.3.3 Russia, Baltic coast

The only records available of plants introduced into the Baltic coast of the USSR are the early introductions of the charophyte *Chara connivens* (recorded in the 1870s and 1920s; for references see Luther (1979)) and the phanerogam *Elodea canadensis*.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	None reported	*Chara connivens*, 1870[1]	*Elodea canadensis*, 1880s?

[1] **See Luther (1979).**

Phanerogams, often old introductions

See Section 2.3.4.

2.3.4 Baltic coasts of former Soviet Union – introduced phanerogams

We have only been able to find separate information for Estonia on introduced phanerogams, and the following table is based on information in *Flora Europea*, where the Baltic coasts of the former Soviet Union were treated collectively.

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Chenopodium botrys	**Erucastrum gallicum**	**Lactuca tatarica**	***Elodea canadensis***
Corispermum intermedium	**Datura stramonium**	**Matricaria suaveolens**	**Zizania aquatica**
Fallopia japonica	**Conyza canadensis**	**Solidago canadensis**	**Asparagus officinalis**
Cardaria draba			

2.3.5 Poland

No macroalgae are included in the national reports, and no information on new introduced macroalgae or on the status of previous introductions has been found in the literature.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	None reported	*Chara connivens*, <1865[1]	*Elodea canadensis*, 1870

[1] **See Luther (1979).**

Phanerogams, often old introductions

Established taxa occurring close to the seashore, including in low saline estuarine environments, on sand dunes, mud, and on rocks (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Chenopodium botrys	**Erucastrum gallicum**	**Ambrosia artemisifolia**	**Iva xanthifolia**
Silene conica	Lobularia maritima	**Ambrosia psilostachya**	**Lactuca tatarica**
Fallopia japonica	Rosa rugosa	**Centaurea diffusa**	**Matricaria suaveolens**
Populus alba	**Datura stramonium**	**Conyza canadensis**	**Solidago canadensis**
Cardaria draba	Calystegria pulchra		***Elodea canadensis***

2.3.6 Germany, Baltic coast

New introductions 1991–2002

The red alga *Dasya baillouviana* was found in the autumn of 2002 in the outer Kiel Bight (Athanasios Athanasiadis, pers. comm.), which is not surprising because it has occurred on the east coast of Jutland for many years (see Section 2.3.1.5 and Wallentinus, 1999a).

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
None reported	*Fucus evanescens*, 1989	*Chara connivens*, 1858	None reported

Current status of old introductions

The grazing effects on *Fucus evanescens* were described by Schaffelke *et al.* (1995). The authors stated that the species had increased in abundance since its first appearance, that it was less preferred than *F. vesiculosus* by the grazing isopod *Idothea baltica*, and that this could contribute to its increase.

Phanerogams, often old introductions

See Section 2.3.1.6.

2.3.7 The Mediterranean Sea

2.3.7.1 Spain, the Mediterranean coast

New introductions 1991–2002

In the summer of 1998, the first specimens of *Caulerpa racemosa* were found on Mallorca, demonstrating a regression in winter, but then a large increase in the summer of 1999 when it occupied 3 ha. According to Verlaque *et al.* (2000), it probably belongs to the invasive variety, which is considered a recent immigrant (Verlaque *et al.*, 2003). In 2000, it was common in the whole of Palma Bay (ca 39.5°N 2.6°E), having increased its area by approximately 20 times. Small populations had also been recorded near the port at Ibiza (38.90°N 1.45°E) and at Grao de Costellón (ca. 40°N 0°E), on the Mediterranean mainland coast (ICES, 2001).

The national report (ICES, 2001) also stated that several red algae had been increasing and spreading and were probably being transported by ships, because they were first recorded in the Balearic Islands, where leisure boat traffic is heavy. *Acrothamnion preissii*, first recorded in the Mediterranean in the 1960s (see Sections 2.3.3.2 and 2.3.3.3), was found on the coast of Mallorca in the early 1990s and was later observed on more locations, as well as on the north coast of Menorca. It forms dense tufts on the seagrass *Posidonia oceanica* and can replace the characteristic native epiphytes (ICES, 2001). The invasive red alga *Womersleyella setacea*, first seen on the French Mediterranean coast in the 1980s (Section 2.3.3.2) and spreading in Italy in the 1990s, appeared on the coasts of the Balearic Islands at Cabrera (ca. 39.1°N 2.9°E) and Menorca, as well as on the island Alboran during the early 1990s. The very dense turfs have a strong negative impact on the benthic communities and on the fishery (ICES, 2001).

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Asparagopsis armata, 1920s			
(*Dipterosiphonia dendritica*[1], 1960s)	None reported	*Caulerpa taxifolia*, 1992[2]	None reported
Bonnemaisonia hamifera, late 1980s			

[1] **Probably native.**

[2] **Listed in ICES (1993) for the Balearic Islands and said to have been eradicated (but see below).**

Macroalgae introduced before 1991, but not listed above

The red alga *Lophocladia lallemandii* was sighted at the southern Spanish Mediterranean coast in the late 1980s. In 2000, it had become quite invasive on the coast of Ibiza, where it could reach more than 100% cover, and the dense turfs produce seasonal blooms, which may affect the native flora and fauna (ICES, 2001).

Antithamnion amphigeneum, first seen on Alboran Island (35.98°N 3.01°W) in 1990, was observed spreading on the coast of Mallorca at the beginning of the 1990s and was later found in low abundances at the Medes Islands on the Catalonian coast and near Valencia (ca. 39.5°N 0.4°W; ICES, 2001), probably transported by boats.

According to references given by Cabioch *et al.* (1997), the red alga *Grateloupia doryphora* (valid name *G. turuturu*; Gavio and Fredericq, 2002) was seen on the coast of Malaga as early as 1948.

Magne (1992) reported that the minute red alga *Goniotrichopsis sublittoralis* was recorded from Mallorca in 1989.

Soto Moreno and Conde Poyales (1993) included the red alga *Antithamnionella spirographides* in the list of species occurring on Alboran Island.

According to Occhipinti Ambrogi (2002), the Atlantic/Pacific brown alga *Desmarestia viridis* was recorded from Malaga (ca. 36.7°N 4.4°E) in 1984.

Current status of old introductions

Caulerpa taxifolia had stabilized on the east coast of Mallorca (Porto Petro, Cala d'Or, Porto Colom) affecting around 60 ha along 9.4 km coast in 2000, although no records had been made on the mainland coast (ICES, 2001; Meinesz *et al.*, 2001).

Phanerogams, often old introductions

See Section 2.3.1.12.

2.3.7.2 France, the Mediterranean coast including Corsica

New introductions 1991–2002

A large number of newly introduced macroalgae, mostly having reproducing thalli and not just fragmentation, turned up in the Thau Lagoon (ca. 43.4°N 3.6°E) after 1991 (Verlaque, 2001), but these species were not included in the French national reports. In 1993 or early 1994, the Asian red alga *Chondrus giganteus* f. *flabellatus* was seen for the first time in Europe and in the Mediterranean, probably arriving by oysters, recently declared illegal, from Japan, where this alga is endemic (Verlaque and Latala, 1996; Verlaque, 2001). They also reported that it had already become common in September 1995, that all reproductive stages were seen, and further, if it should reach the Atlantic coast, it might be a threat to the commercially important carrageenophyte *Chondrus cripus*, through competition or hybridization.

Verlaque (2001) also listed several other newly introduced species. The Pacific red alga *Ahnfeltiopsis flabelliformis* was first seen in the lagoon in 1994, arriving by recent transfers of Japanese oysters and, subsequently, having a detrimental effect on native species. He gives the same year and vector for the calcareous crust *Lithophyllum yessoense*, a dominant species in Japan, outcompeting others by its grazer-resistance and strategy of peeling off the epithallus, as well as having a high capacity for thallus regeneration. Also the red alga *Prionitis patens*, endemic to Korea and Japan, was thought to have come to the lagoon with recent transfers of Japanese oysters, as had the Pacific/Indian Ocean red alga *Herposiphonia parca*. He concluded that the red algae *Grateloupia filicina* var. *luxurians* and *Polysiphonia morrowi*, new to the Mediterranean in 1997, might have come either directly from the Pacific or from aquaculture sites in Europe, the former having been introduced previously in several areas (see Sections 2.3.1.9, 2.3.1.10, and 2.3.1.12), while the latter may be conspecific with the record of *P. senticulosa* from the Netherlands (Section 2.3.1.7). The brown alga *Scytosiphon dotyi*, first seen in 1994, may also have come either way with oysters; the same applies to the brown alga *Acrothrix gracilis*, new to the Mediterranean in 1998. On the other hand, the red alga *Chondria coerulescens* must have an Atlantic origin and could have arrived with the transfer of oysters. The brown alga *Cladosiphon zosterae*, recorded in the lagoon in 1998 but already seen in Italy in the 1970s, also has an Atlantic origin and probably arrived with oyster transfers.

The red alga called *Pterosiphonia* sp., first seen in 1998 (Verlaque, 2001), was later identified as the Pacific species *P. tanakae* (Boudouresque and Verlaque, 2002). In 1998, the red alga *Heterosiphonia japonica* (which may be removed to another genus after revision) was first seen in the Mediterranean in this lagoon, and Verlaque (2001) concluded it may have come with oysters, either directly from the Pacific or from aquaculture sites in Europe, although shipping cannot be ruled out entirely (see Sections 2.3.1.3, 2.3.1.7, 2.1.3.9, and 2.3.1.12). A minute red alga *Rhodothamniella* cf. *codicola* (valid name *Acrochaetium codicolum*) was first detected in the lagoon in 1997, but may have come much earlier with the introduction of

Codium fragile, on which it is an epiphyte. However, this conclusion must await a definite identification.

Grateloupia lanceolata, a red alga endemic to China and Korea, was not recognized as an introduction in the Thau Lagoon until 1993, but probably arrived much earlier and was then mistaken for *Grateloupia turuturu* (Verlaque, 2001).

The red alga *Hypnea valentiae* is considered a Lessepsian immigrant in the eastern Mediterranean, but Verlaque (2001, and references therein) doubted this was the case for the Thau Lagoon and considered it more likely to have arrived from Asia with oysters.

Large populations of the tropical green alga *Caulerpa racemosa* were reported from Marseille, southern France, in 1997 (ICES, 1998; Verlaque *et al.*, 2000). Later morphological and molecular genetic studies have shown this invasive variety to be a recent invasion (Verlaque *et al.*, 2003).

The red *Laurencia caduciramulosa*, described from Vietnam, was recorded in 2002 at seven sites on the French south coast close to harbours (Klein and Verlaque, 2005). They suggested that it could be a secondary introduction by shipping from southern Italy, where it was first recorded 1991. Later in 1998, it was also found farther southwest. Furthermore, the disjunct dispersal in the Mediterranean, the closeness to harbours of the areas studied, and the relative low abundances point to a recent introduction to the Mediterranean of the species. So far, it is not considered invasive, although it can propagate vegetatively by small lateral branches (Klein and Verlaque, 2005).

Previously established (Wallentinus, 1999a)

Some years corrected after Verlaque (2001). Underlined species were seen in the Thau Lagoon in the late 1990s; species in **bold** have had a detrimental effect on native species in the lagoon.

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Asparagopsis armata, 1926	*Colpomenia peregrina*, 1956	*Codium fragile*, 1950s	
Porphyra yezoensis, 1975	*Undaria pinnatifida*, 1971	*Caulerpa taxifolia*, 1984	
Chrysymenia wrightii, 1978	*Laminaria japonica* 1976		
Aglaothamnion feldmanniae, 1979	*Desmarestia viridis*, 1978		
*(Dipterosiphonia dendritica**, 1979)	*Leathesia difformis*, 1979		
*(Laurencia microcladia**, 1979)	*Sargassum muticum*, 1980		
Lomentaria hakodatensis, 1979	*Sphaerotrichia divaricata*[5], 1980		
Acrothamnion preissii, 1981	*Chorda filum*, 1981		
Grateloupia doryphora[1], 1982	*Fucus spiralis*, 1987		
Polysiphonia setacea[2], 1987			
Lomentaria hakodatensis, 1979			
Antithamnion nipponicum[3], 1988			
Polysiphonia nigrescens[4], 1988			

[1] **Valid name *G. turuturu*, Gavio and Fredriques (2002).**

[2] **Valid name *Womersleyella setacea*.**

[3] **Also referred to as *A. pectinatum*.**

[4] **Valid name *P. fucoides*.**

[5] **Confirmed to be of Japanese origin (Peters *et al.*, 1993).**

***According to Ribera Siguan (2002), not an introduced species.**

Macroalgae introduced before 1991, but not listed above

Even more introductions of macroalgae to the Thau Lagoon were reported by Verlaque (2001), most of them recorded for the first time in the 1980s. The red alga *Dasya* sp. was first seen in 1984, and probably arrived there with the mass importations of oysters from Japan in the 1970s. It was later identified as *Dasya sessilis* (Boudouresque and Verlaque, 2002) and according to Verlaque (2002), it has subsequently developed abundant reproductive populations. Also the Asian red alga *Laurencia okamurae*, seen since 1984, probably came by the same vector. Verlaque (2001) also listed the red alga, *Agardiella subulata*, first seen in 1984, as probably having arrived with oyster transfers from the Atlantic coast, as well as the small red alga *Rhodophysema georgii*, first seen in 1978, but not recovered in surveys during the late 1990s. The red alga *Griffithsia corallinoides*, first seen in 1984, might have either a North Pacific or Atlantic origin. Verlaque also reported on a then not yet identified species of the red algal genus *Grateloupia* seen in 1985, which might be of Pacific origin. Also included was the red alga *Polysiphonia atlantica*, which he considered an introduction in the area through shipping or oysters, although Ribera Siguan (2002) considered it native to the Mediterranean.

The brown alga *Halothrix lumbricalis* was first seen in 1985 and could have either an Atlantic or Pacific origin, as could *Pilayella littoralis*.

Green algae, new to the Mediterranean, include the endemic Japanese species *Derbesia rhizophora*, recorded in 1984, and the Asian *Ulva pertusa*, first seen in 1984, both probably also the result of the massive import of Japanese oysters in the 1970s. A later paper by Verlaque *et al.* (2002) stated that abundant populations of *Ulva pertusa* have been seen since 1994, and that the specimens agreed well with this Asian species. *Monostroma obscurum*, seen in 1985, could have either an Atlantic or North Pacific origin and has had a detrimental effect on the native seaweeds.

Earlier introductions encompass the red algae *Polysiphonia paniculata*, seen in 1967 but not recovered in surveys during the late 1990s, and *Polysiphonia harveyi* (valid name *Neosiphonia harveyi*; Guiry *et al.*, 2006), which has probably been in the Mediterranean for a very long time, with a detrimental effect on the native seaweeds, although frequently referred to as *P. mottei*. The brown alga *Leathesia difformis*, occurring in all temperate seas, may have been there since 1905, but was not seen during the surveys in the late 1990s.

Current status of old introductions

For *Caulerpa taxifolia*, expansion was noted in the early 1990s (e.g. Boudouresque *et al.*, 1992; ICES, 1993), and no sign of regression was noted in the late 1990s. Maximum densities were found at depths between 1 and 30 m, with densities also increasing at depths below 30 m, then often exceeding 25% cover. At new locations with small patches, eradication was done by hand or with a cover leaking copper (ICES, 1998; see also Section 2.2.3). In 1998, *C. taxifolia* also began to invade dense *Posidonia* beds (ICES, 1999; see also Devillele and Verlaque, 1995). A 2000 survey covering over 21 000 ha in two bays where leisure boats are frequently moored revealed that more than 8000 ha were heavily colonized by *C. taxifolia* (ICES, 2002).

In 1992, the abundance of *Laminaria japonica* was reported to be declining (ICES, 1993), and Verlaque (2001) found no plants in the survey of the Thau Lagoon, albeit he did not look for it during winter.

On the other hand, *Porphyra yezoensis* and *Grateloupia doryphora* (valid name *G. turuturu*; Gavio and Frederique, 2002) were reported to have spread in 1992 (ICES, 1993), although Verlaque (2001) found no *Porphyra yezoenis* plants in the survey of the Thau Lagoon; again, he did not look for it during winter.

Phanerogams, often old introductions

See Section 2.3.1.9.

2.3.7.3 Italy

Through the courtesy of Professor Mario Cormaci, Rome University, we have the official list from the Ministry of the Environment for algal taxa believed to have been introduced along the Italian coasts, including the year of first record and publication. The year of first record is used, if not otherwise stated.

New introductions 1991–2002

The invasive variety of *Caulerpa racemosa* (Verlaque *et al.*, 2000, 2003) was first reported from Lampedusa Island (35.5°N 12.6°E) in 1993. In the late 1990s, the same variety also occurred in the Ionian and southern part of Sicily, Gulf of Cagliari (ca. 39.2°N 9.2°E), Gulf of Salerno (ca. 40.7°N 14.7°E), and near Genoa (44.4°N 8.9°E) in Tuscany (ICES, 1998; Verlaque *et al.*, 2000), in many places causing decline in native seaweed abundance and biodiversity (Occhipinti Ambrogi, 2002). In 1999, it had expanded rapidly as a result of fishing activities, disseminating fragments to new sites (ICES, 2000a). In 2001, it was very abundant at Lampedusa Island (ICES, 2002). Recently, it was also found near Taranto (40.5°N 17.2°E); its competition with the seagrass *Posidonia oceanica* depends on the densities of the meadows, although *Cymodocea nodosa* is more vulnerable and, in many places, is replaced by *Zostera noltii* (ICES, 1998; Occhipinti Ambrogi, 2002). According to studies by Piazzi *et al.* (2001) at the Tuscan coast, *C. racemosa* is even more invasive than *C. taxifolia*, having increased its surface area and number of patches by 285% and 121% in one year, compared with an increase of 68% and 11%, respectively, for *C. taxifolia*. The stolon growth *in situ* was also higher, with 2.03 cm day^{-1} compared with 0.97 for *C. taxifolia*.

Since 1992, *Undaria pinnatifida* and *Sargassum muticum* (the latter may have arrived earlier) have started to build up large populations in Venice (45.5°N 12.5°E; Curiel *et al.* 1998), the vectors being either shipping or mussel importations (ICES, 1996, 2000a). The development of *U. pinnatifida* has been very rapid in the centre of Venice (ICES, 2001) and, in 2004, it was very common along many of the canals in the city (Inger Wallentinus, pers. obs.). On the other hand, *S. muticum* took a longer time to disperse, but in 2001 had increased and almost outcompeted the native large brown alga *Cystoseira barbata* (ICES, 2001). In 1998, *U. pinnatifida* was found near Taranto, having arrived there by oysters imported from France (Occhipinti Ambrogi, 2002, and references therein).

The pantropic red alga *Womersleyella setacea* was first recorded at the coast of Livorno in 1986 and was collected at Lampedusa Island in 1993. During the 1990s, it spread in Italian waters and is even growing on *Caulerpa* spp., forming thick mats on the surface, which prevent settlement of other organisms (Occhipinti Ambrogi, 2002).

Cormaci *et al.* (1992) reported the following new red algae: the southern African *Botryocladia madagascariensis*, recorded in 1991 at Lampedusa Island and Sicily; the west African *Ceramium strobiliforme* from Salina Island in 1991; and the Red Sea species *Chondria pygmaea* from Catania harbour in 1991.

According to Verlaque (1994), the red alga *Asparagopsis taxiformis*, probably a Lessepsian immigrant, was recorded for the first time in Italy in the early 1990s at the Island of Elba (ca. 42.8°N 10.3°E). Later in the 1990s, it spread in the Gulf of Naples (Flagella *et al.*, 2003), with gametophytes dominating during winter, but occurring throughout the year and present at 75% of the sites assessed, but with a lower degree of cover and frequency than *Caulerpa racemosa*. Barone *et al.* (2003) reported gametophytes from western Sicily occurring there since 2000. Andreakis *et al.* (2004) and Ní Chualáin *et al.* (2004) both believed that *A. taxiformis* was

introduced in the Mediterranean and is genetically different from the clade found in the Caribbean Sea and on the Canary Islands. Andreakis *et al.* (2004) reported records from several places on the Italian west coast. However, the species is not included in the official list.

In 1994, the Asian red alga *Antithamnion pectinatum* (according to Cho *et al.*, (2005), the correct identity is *A. nipponicum*) was first found in the Venice Lagoon growing on mussels and other algae (Curiel *et al.*, 1996) and has subsequently spread widely (Occhipinti Ambrogi, 2002). Oyster movements seem to be the most likely vector. The species *A. amphigenum* was found for the first time the same year at Spezia Harbour in northwestern Italy (Rindi *et al.*, 1996).

The Asian red alga *Polysiphonia morrowii* was first recorded in spring 1999 in the lagoon south of Venice, where imported clams and fish are handled (Curiel *et al.*, 2002). One year later it had spread to several new sites in the centre of Venice (Occhipinti Ambrogi, 2002).

In 2001, the Asian red alga *Lomentaria hakodatensis* was found associated with *Sargassum muticum* in the southern sector of the Venice Lagoon (ICES, 2002). This Asian alga has occurred in Mediterranean France since 1979 (Section 2.3.3.2), as well as on the north coast of Spain since 1992 (Section 2.3.1.12) and on the Atlantic coast of France since 1984 (Section 2.31.9).

The diminutive deepwater red alga *Apoglossum gregarium* was first found in 1992 at several sites in the Tuscan archipelago, including the island of Elba, by Sartoni and Boddi (1993), who, however, doubted that it was a recent introduction, owing to its occurrence in deep water only. Nevertheless, it is included in the official list.

The official list also includes the red algae *Chondria polyrhiza*, first recorded from Cheradi Island, southern Italy in 1992; *Hypnea cornuta*, the first record from Mar Piccolo, Taranto, southern Italy, published in 2002; and the brown alga *Leathesia difformis*, the record from Venice Lagoon published in 1999. In a later paper, Cecere *et al.* (2004) described *Hypnea cornuta* as occurring both attached and as a free-floating population throughout the Mar Piccolo, and suggested that it could have arrived from the Indo-Pacific or the eastern Mediterranean, either by shipping or by transfers of mussels. Furthermore, it can propagate vegetatively by stellate branches or fragmentation.

In Venice Lagoon, the brown algae *Punctaria tenuissima* and *Ectocarpus siliculosus* var. *hiemalis* were first recorded in 1999 (Ribera Siguan, 2002, and references therein), and also an unidentified species of the genus *Sorocarpus* in 1996 (Curiel *et al.*, 1999), the latter genus recorded for the first time in the Mediterranean (not included in the official list).

The red alga *Laurencia caduciramulosa*, described from Vietnam, was first recorded from the Lachea Islands, close to Sicily, and in the harbour of Catania in 1991 (for references, see Klein and Verlaque, 2005). In 1998, it was found on Linosa Island (Peleagen Island, southeast of Italy), and Klein and Verlaque (2005) suggested that southern Italy probably was the primary introduction area in the Mediterranean.

Rindi *et al.* (2002) listed *Symphyocladia marchantioides* among red algae present in Tuscany, northwestern Italy. Besides the Azores, the species is only recorded from the southern hemisphere and the northern Pacific, and so might be an introduction. However, the species is not included in the official list.

The benthic dinoflagellate *Ostreopsis ovata*, typical for tropical to subtropical waters, has been found on the west coast of Italy (Tognetto *et al.*, 1995; Vila *et al.*, 2001), but could also be native to the area.

Italy, not an ICES member country, was not covered by the previous status reports, but for some macroalgae also occurring in other countries, records were mentioned (see below).

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Acrothamnion preissii, 1969	*Desmarestia viridis*[2], 1849	*Caulerpa taxifolia*, 1991–1992	None reported
Aglaothamnion feldmanniae, 1976			
Polysiphonia nigrescens[1, 2], 1985			

[1] **Valid name *P. fucoides*.**

[2] **Not included in the official list.**

Macroalgae introduced before 1991, but not listed above

The long list of introduced macroalgae provided with the Italian report in 2000 (ICES, 2000a), as well as additional species in the official list, is given below for earlier introductions not mentioned above. Dates of first records (or listed for Italy) are taken from: [1]the official list; [2]Occhipinti Ambrogi (2002); [3]Verlaque (1994); [4]Verlaque (2001); [5]ICES (2000a); and [6]Tutin *et al.* (1980).

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Asparagopsis armata, 1920s	*Colpomenia peregrina*, 1939[3]	*Codium fragile* ssp. *tomentosoides*, 1973[1]	*Halophila stipulacea*, <1980[6]
Soliera filiformis, 1922[1]	*Padina boergesenii*, 1963[1]	*Caulerpa scalpelliformis*[2, 5]	
Grateloupia doryphora, 1969[2]	*Scytosiphon dotyi*, <1978[1]		
Lophocladia lallemandi, 1969[1]	*Halothrix lumbricalis*, 1978[1]		
Neosiphonia harveyi, 1969[1]	*Cladosiphon zosterae*, <1975[4]		
Bonnemaisonia hamifera, 1973[1]			
Laurencia majuscula, 1983–84[1]			
Hypnea spinella, 1985[1]			
Agardhiella subulata, 1987[1]			
Laurencia chondroides, 1990[1]			
Plocamium secundatum, 1991[1]			
Acanthophora najadiformis[2, 5]			
Antithamniella spirographidis[2, 5]			
Griffithsia corallinoides[2, 5]			

Verlaque (1994, and references therein) also mapped the red alga *Antithamnion decipiens* (as *A. ogdeniae*) for the west coast of Italy in 1989, and *Hypnea cervicornis* from Syracuse, Sicily (<1988); the latter, however, could be the same record as *Hypnea spinella* listed above from the same place. According to Ribera Siguan (2002) and Athanasiadis (1996b), the red alga *Antithamnionella sublittoralis*, found in 1988 at Syracuse, Sicily, could be a recent introduction to the Mediterranean. However, it is not included in the official list. Ribera Siguan (2002) and Athanasiadis (1996b) also considered the closely related *A. elegans* (not included in the official list), which was already detected as sterile plants in the harbour of Naples in the late 1800s as an introduction from Japan, where fertile plants occur.

Current status of old introductions

In the late 1990s, *Caulerpa taxifolia* was present in the Ligurian Sea (several hectares of the Western Riviera colonized), Tuscany, and Sicily (ICES, 1998; see also Section 2.2.3). In 1999, it occurred along almost the whole northwest coast of Italy, forming large populations in the infralittoral fringe, and new records were made in the Messina Strait (ca. 38–38.4°N

15.7°E; (ICES, 2000a; Meinesz *et al.*, 2001), the latter estimating that 9415 ha was involved at the beginning of the 2000s. In areas with nutrient-enriched sediments, it is outcompeting the native seagrass *Cymodocea nodosa*, although *Posidonia* beds with high densities of seagrasses are less vulnerable (Occhipinti Ambrogi, 2002, and references therein).

According to Piazzi and Cinelli (2003), *Posidonia* meadows in northwestern Italy are almost totally dominated by the introduced turf red algae *Acrothamnion preisii* and *Womersleyella setacea.* However, the latter dominates on rocks, where it has replaced *A. preisii*, and partially also on "matte". In areas where *C. racemosa* has invaded, *W. setacea* is absent, but it does occur with *C. taxifolia*. Sampling rhizomes in *Posidonia* meadows from 21 sites in western Italy, Piazzi *et al.* (2002) showed that *W. setacea* was present at 17 sites and *A. preisii* at 10. They concluded that the functional algal diversity was high, if these two species were not present, or if they did not form dense turfs, while mainly filamentous algal species occurred if they did form turfs.

In the 1990s, the brown alga *Desmarestia viridis* was common in Chioggia (45.22°N 12.28°E), south of Venice, competing with the other two introduced large brown algae, *S. muticum* and *U. pinnatifida* (ICES, 2001).

The red alga *Lophocladia lallemandii* is buoyant, and when stranded on the beaches in large quantities, it creates a nuisance for tourism (Occhipinti Ambrogi, 2002).

Aglaothamnion feldmanniae, previously only recorded once in western Italy (see above), was found in Venice at the beginning of the 2000s (Occhipinti Ambrogi, 2002).

According to Andreakis *et al.* (2004), the occurrence of *Asparagopsis armata* in the Strait of Messina has not been recovered, and they even mentioned that it might have been a founder population that has died out because it was first seen there in 1987.

The Lessepsian seagrass *Halophila stipulacea* occupies shallow soft bottoms, being especially common in harbours (Occhipinti Ambrogi, 2002).

Phanerogams, often old introductions

Taxa occurring close to the seashore, including in low saline estuarine environments (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Aptenia cordifolia	**Acacia karoo**	**Hydrocotyle sibthorpioides**	Senecio inaequidens
Carpobrotus acinaciformis	**Acacia longifolia**	**Datura stramonium**	***Elodea canadensis***
Carpobrotus edulis	Eucalyptus gomphocephalus	Dichondria micrantha	*Halophila stipulacea*
Drosanthemum hispidum	Eucalyptus resinifer	**Heliotropium curassavicum**	**Cyperus polystachyos**
Tetragonia tetragonoides	Eucalyptus robustus	**Ageratina adenophora**	**Cyperus strigosus**
Fallopia japonica	Eucalyptus rudis	**Ambrosia artemisifolia**	**Fimbristylus annua**
Ceratostigma plumbaginoides	**Oenothera glazioviana**	**Ambrosia psilostachya**	**Paspalum distichum**
Salix viminalis	**Oenothera rosea**	**Aster squamatus**	**Paspalum vaginatum**
Malcolmia flexuosa	**Oenothera stricta**	**Centaurea diffusa**	**Stenotaphrum secundatum**
Sedum praealtum	Euonymus japonicus	**Conyza canadensis**	**Aloe vera**
Acacia cyanophylla	**Angelica archangelica**	**Cotula coronopifolia**	Iris spuria
Acacia dealbata	**Hydrocotyle bonariensis**	**Matricaria suaveolens**	

2.3.7.4 Malta

New introductions 1991–2002

The red algae *Botryocladia madagascariensis* and *Chondria pygmaea* were recorded for the first time in 1994 (Cormaci *et al.*, 1997).

Womersleyella setacea was recorded for the first time in this area in 1993 (Athanasiadis, 1997, and references therein). Nothing is known of its current status, but considering the increase and large impact in other areas (see Section 2.3.3.3), it may well show the same pattern here.

To our knowledge, there are no reports of *Caulerpa taxifolia* or *C. racemosa* from Malta for that period, although both species occur in Tunisia and southern Italy (Verlaque *et al.*, 2000; Meinesz *et al.*, 2001).

Introduced macroalgae (no years stated), not mentioned above

Following Cormaci *et al.* (1997) and Wallentinus (2002).

RED ALGAE	BROWN ALGAE	GREEN ALGAE
Asparagopsis armata	None reported	None reported
Acanthophora nayadiformis		
Lophocladia lallemandii		

Current status of old introductions

There is no information available on the current status of these introductions.

Phanerogams, often old introductions

Taxa occurring close to the seashore, including in low saline estuarine environments (Wallentinus, 2002).

Names in Italic = submerged, in **bold** = invasive taxa.

Aptenia cordifolia	Carpobrotus acinacifolia	**Carpobrotus edulis**	*Halophila stipulacea*

2.3.7.5 The western Balkan peninsula, excluding Greece

There is very little information in the literature on introduced algae from these countries, and they were not included in the previous status report.

New introductions 1991–2002

In 1994, the aquarium strain of the green alga *Caulerpa taxifolia* was first recorded close to a mooring dock at Stari Grad on Hvar Island (43.19°N 16.63°E), southern Croatia, and in 1995, it also turned up at the port of Malinska, Krk Island (ca. 45.2°N 14.7°E), northern Croatia, and in 1996 in the Barbat Channel near Dolin Island (ca. 44.3°N 14.8°E), Croatia, where boats are frequently moored (Meinesz *et al.*, 2001). They also stated that eradication attempts failed in the long run, and that *C. taxifolia* continued to spread, especially at the first site.

Verlaque *et al.* (2000) did not map any occurrences of *C. racemosa* in this area.

Previously introduced macroalgae (Wallentinus, 2002)

RED ALGAE	BROWN ALGAE
Chondria pygmea, Albania <1996	*Desmarestia viridis*, Croatia 1948[1]

[1] **Year according to Occhipinti Ambrogi (2002).**

Current status of old introductions

There is no information available on the current status of these introductions.

Phanerogams, often old introductions

Taxa occurring close to the seashore, including in low saline estuarine environments (Wallentinus, 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Carpobrotus edulis	Euonymus japonicus	**Ambrosia artemisifolia**	***Matricaria suaveolens***
Fallopia japonica	**Angelica archangelica**	**Aster squamatus**	***Elodea canadensis***
Brassica oleracea	**Datura stramonium**	**Conyza canadensis**	*Halophila stipulacea*
Acacia dealbata	**Heliotropium curassavicum**	**Helianthus annuus**	**Paspalum distichum**

2.3.7.6 Greece

New introductions 1991–2002

The red alga *Womersleyella setacea* was first recorded in spring 1992, from Sarti Reef and Pseudokopons on the Sithonia peninsula, northeastern Greece, where it formed 1–2 cm thick carpets in the sublittoral (Athanasiadis, 1997). The author also stated that fishers often visit the area and that the alga had probably arrived with infested nets. When revisiting the area in summer 1996, the author observed *W. setacea* again, but not forming mats. It has also been reported from Milos Island, southern Greece.

Verlaque (1994) did not map any occurrence in Greece of the Lessepsian brown alga *Stypopodium schimperii*, which was later found on Milos Island, southwestern Aegean Sea, in 1996 (Sartoni and De Biasi, 1999). Studying shallow-water hydrothermal vents off Milos Island, De Biasi and Aliani (2003) found it to be the most important and conspicuous species, reaching down to 41-m depth, with 25% cover at vent sites, but only 2–5% at non-vent sites.

Macroalgae introduced before 1991 (Wallentinus, 2002)

Year of first record follows mainly Athanasiadis (1987).

RED ALGAE	BROWN ALGAE	GREEN ALGAE
Lophocladia lallemandii, 1908	(*Chorda filum*?, <1899)	*Codium fragile* ssp. *tomentosoides*[2]
Acanthophora nayadiformis, < 1948		*Caulerpa racemosa*, 1956[3]
Hypnea valentiae, 1960s[1]		
Antithamnion decipiens, 1980		
Asparagopsis armata, < 1981		
Chondria polyrhiza, 1982		
Hypnea esperi, < 1985		
Hypnea spinella		
Sarconema scinaiodidis		
(*Polysiphonia fucoides*?, <1968)		

[1] **Probably a Lessepsian immigrant in the eastern Mediterranean; see Verlaque (2001) and references therein.**

[2] **After 1945, according to Zenetos *et al.* (2002).**

[3] **For first record, see below.**

Current status of old introductions

According to Verlaque *et al.* (2000), *Caulerpa racemosa* was first recorded in 1956 from the Greek Castellorizo Island, close to Turkey, and differed in variety from the recently invading taxon, but was not the same taxon as the specimens first recorded in the Mediterranean. The invasive variety, consistent with a variety endemic to southwestern Australia (Verlaque *et al.*, 2003), was first seen at Zakynthos Island (ca 37.8°N 20.9°E), on the southwest coast of Greece in 1993 (Panayotis and Montesanto, 1994; Verlaque *et al.*, 2000), growing as small patches in the beds of *Posidonia* at 25–35-m depth between the seagrass plants. Verlaque *et*

al. (2000) also stated that the invasive variety was found at Kalimnos Island (ca 37.0°N 27.0°E) in 1997, and at Crete, Samos Island, and the Gulf of Saronikes in 1998.

To our knowledge, there is no report on *Caulerpa taxifolia* from Greece.

According to Zenetos *et al.* (2002), *Codium fragile* is now common in the Aegean Sea.

Phanerogams, often old introductions

Taxa occurring close to the seashore, including in low saline estuarine environments (Wallentinus 2002).

Names in *Italic* = submerged, in **bold** = invasive taxa, in **bold + underlined** = highly invasive taxa.

Aptenia cordifolia	**Acacia cyanophylla**	**Aster squamatus**	*Halophila stipulacea*
Carpobrotus acinacifolia	**Datura strammonium**	**Conyza canadensis**	**Fimbrystulus ferruginosa**
Carpobrotus edulis	**Heliotropum curassavicum**	**Helianthus annuus**	**Paspalum distichum**
Lobularia maritima	**Ageratina adenophora**		**Aloe vera**

2.3.8 North America including the Pacific coast

2.3.8.1 Canada

Canada's new National Code on intentional introductions and transfers, in force since 2001, is unique because it also includes plants (ICES, 2002). In 1995, there were two proposals to introduce the Pacific kelp *Macrocystis integrifolia* from British Columbia to the Gulf of St Lawrence for developing a herring roe-on-kelp fishery, which were denied (ICES, 1996).

New introductions 1991–2002

In 1991, the green alga *Codium fragile* ssp. *tomentosoide* was recorded in Nova Scotia for the first time (Bird *et al.*, 1993; ICES, 1994), shipping or currents as the proposed vector; later, transfers of shellfish from the US were also suspected as a vector (ICES, 1996). In the first years there seemed to be no dispersal to other coastal areas or any sign of it being a threat to other subtidal species (ICES, 1996). However in 1996, there were many reports of findings in the Gulf of St Lawrence; it was also found attached to American oysters, *Crassostrea virginica*, at Prince Edward Island; further surveys and ecological impact studies were planned (Garbary *et al.*, 1997; ICES, 1997a). It later became a severe nuisance in oyster cultures at PEI, affecting both the oyster growing areas in up to 2-feet high mats, as well as on the suspended gears; although large amounts of plants (>100 000 pounds) were taken ashore, no decline was noted (ICES, 1998, 1999, 2002; Chapman, 1999). Treatment of oysters with 4% hydrated lime for five minutes or saturated brine for 15 minutes appeared to kill *Codium*, allowing oyster movements without spreading the alga (ICES, 1998). However, it was later determined that the efficiency was not high and that holdfasts of the alga in crevices on the shells could regrow despite the chemical treatment (ICES, 1999, 2000a), and that manual removal had no long-term effects. In 2000, a significant number of oysters became buoyant through the algal growth and were washed ashore; there was severe fouling of aquaculture lines, and some epiphytes on *Codium* caused skin irritations. There was also great concern that *C. fragile* would spread to the major oyster producing bays in PEI (ICES, 2001). An apparent jump within the PEI region to the southernmost part had occurred during 2001 (ICES, 2002).

For information about farming of the Japanese *Porphyra yezoensis* in New Brunswick, see Section 2.2.4.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Furcellaria lumbricalis, late 1800s?[1] (Atlantic coast)	*Fucus serratus*, 1800s?[1] (Atlantic coast)	None reported	*Artemisia stelleriana*, old (Atlantic coast)
Bonnemaisonia hamifera, 1948 (Atlantic coast)	*Sargassum muticum*, <1941 (Pacific coast)		*Zostera japonica*, 1969 (Pacific coast)
(*Lomentaria orcadensis*)[2] (Atlantic coast)	*Colpomenia peregrina*, 1960 (Atlantic coast)		

[1] **For references on proposed arrival time, see Wallentinus (1999a).**

[2] **According to Bird and McLachlan (1992: 122), it has only been recorded once and is considered an adventive species in the Maritimes.**

Macroalgae introduced before 1991, but not listed above

Recent studies using rbcL sequences have revealed that the red alga *Polysiphonia harveyi* (valid name *Neosiphonia harveyi* , Guiry *et al.*, 2006) is not of Atlantic origin, but was introduced from Japan and can be found from Newfoundland and southwards (McIvor *et al.*, 2001).

On the Pacific coast, the red alga *Lomentaria hakodatensis* was first recognized as an introduced species in 1967 at the northern part of the Gabriola Island (ca 49.2°N 123.8°W) in the Strait of Georgia, British Columbia (South, 1968). He also listed three other locations nearby where the alga had been collected in 1959 and 1962, as well as two sites on the Washington side of the Strait, and believed that, most probably, it had arrived by oyster imports from Japan, and not by dispersal from the southern part of North America. In the mid-1980s, it also had colonized the western shores of Vancouver Island (Hawkes and Scagel, 1986).

The same vector was supposed to have brought the Japanese red alga *Gelidium vagum* to British Columbia, where it has a restricted distribution in the area around the Hornby-Denman Islands, an area with many oyster farms and where it was recognized in the mid-1980s (Renfrew *et al.*, 1989).

Current status of old introductions

In British Columbia, there was concern about sightings of *Sargassum muticum* outside the Pendrell Sound, where it had arrived in the late 1970s (ICES, 1996). So far, no records of this species have been reported from the Canadian Atlantic coast, although temperatures in the southern parts are well within its tolerance range.

Bird and McLachlan (1992) stated that mature gametophytes of *Bonnemaisonia hamifera* are uncommon around Nova Scotia and in the outer Bay of Fundy, and that only young gametophytes have been seen in the Gulf of St Lawrence. Sporophytes, on the other hand, are locally abundant in summer, with tetraspores in autumn, and are present all year-round down to 20-m depth, but are rare in the inner Bay of Fundy. *Furcellaria lumbricalis* is common in the Gulf of St Lawrence and occasionally in the adjacent outer coasts down to 12-m depth. In the 1970s–1980s, storm-cast plants were used as an industrial resource, but drift has since declined, probably the result of movement of sand into the algal beds (Bird and McLachlan, 1992).

In Boundary Bay, British Columbia, there was an almost 17-fold increase between 1970 and 1991 in coverage of *Zostera japonica*, and it had extensively colonized formerly unvegetated tidal flats and dramatically altered the habitat structure, covering 60% of the bay's intertidal and shallow subtidal area and occurring mostly from 0 to −1.8 m (Baldwin and Lovvorn, 1994). They also stated that it provides an important feeding habitat for many migratory

waterfowl, which could remove 50% and 43% of its above- and below-ground biomass, respectively.

Phanerogams, often old introductions

It has not been possible to list all phanerogams introduced into Canada that grow or have a potential to grow at or close to the seashore. The tentative list below is mainly summarized from *The Flora of Nova Scotia* (Roland and Smith, 1969) and, although the occurrences in other provinces as well as in the US are for the most part mentioned, the list does not include species only found outside this area. Furthermore, it is not up-to-date with the new taxonomy and new species concepts, and of course, recent introductions are not included. In any case, it gives an idea of the rather large number of introductions, several of them being weeds. Most of them (118) are of European origin, while a few are Asian (5) or South American (2) plants, and some (6) are natives of other parts of North America. This "flora" also had an interesting influence on the North American species *Elodea canadensis*, introduced a long time ago in most European countries, stating that it had been planted in a pond as food for wild fowl. We have found, however, no information that it is an additional vector in Europe.

Bold denotes weeds, and **Bold + underlined** serious weeds, *Italic* submerged plants.

Atriplex sabulosa	Sedum accre	Lycium halimifolium	**Cirsium vulgare**
Chenopodium album	Sedum telephium[2]	**Solanum dulcamara**	Cnicus benedictus
Chenopodium botrys	**Filipendula ulmaria**	Solanum nigrum	**Cotula coronopifolia**
Chenopodium glaucum	**Potentilla argentea**	Convolvulus arvensis	**Helianthus annuus**
Scleranthus annuus	Potentilla reptans	Cynoglossum officinale	**Hieracium spp.**
Spergularia rubra	Prunus spinosa	Echium vulgare	**Iva frutescens**
Spergula arvensis	Rosa canina	Myosotis scorpiodes	**Iva xanhifolia**
Arenaria serpyllifolia	Rosa rugosa	Galeopsis bifida	Leontodon autumnalis
Stellaria graminea	Lathyrus pratensis	**Galeopsis trifida**	**Matricaria maritima**[7]
Stellaria media	Lotus corniculatus	**Lamium purpureum**	**Matricaria matricarioides**[8]
Polygonum arenastrum	Lotus uliginosus	Lycopus europeus	**Onopordum acanthium**
Polygonum rhaii?	Medicago falcata[3]	**Stachys palustris**	Senecio sylvaticus
Polygonum lapathifolium[1]	Melilotus altissimus	Cymbalaria muralis	Senecio squalidus
Polygonum cuspidatum	Trifolium repens	**Linaria vulgaris**	**Senecio viscosus**
Rumex domesticus	Vicia angustifolium	**Odontites serotina**[6]	**Senecio vulgaris**
Rumex crispus	Vicia cracca	**Verbascum thapsus**	**Sonchus arvensis**
Rumex acetosella	Vicia hirsuta	Veronica longifolia	**Sonchus uliginosus**[9]
Rumex obtusifolius	Vicia sepium	Veronica officinalis	**Tanacetum vulgare**
Populus alba	***Myriophyllum spicatum***[4]	**Plantago major var. intermedia**	**Taraxacum spp.**
Salix viminalis	**Lythrum salicaria**	**Plantago lanceolata**	**Tussilago farfara**
Urica urens	Epilobium hirsutum	**Galium aparine**	Juncus compressus
Cardaria draba	Erodium cicutarium	Galium verum	***Zostera japonica***[10]
Coronopus procumbens	Linum catharticum	**Acillea millefolium**	Aira praecox
Diplotaxis muralis	Millegrana radiola[5]	**Ambrosia psilostachya**	**Eragrostis megastachya**
Erucastrum gallicum	Conium maculatum	**Anthemis tinctoria**	**Phragmites communis**[11]
Lepidium campestre	**Pimpinella saxifraga**	Artemisia absinthium	**Poa annua**
Sisymbrium altissimum	Viola tricolor	Artemisia stelleriana	Poa pratensis
Thlaspi arvense	Centaurium umbellatum	**Artemisia vulgaris**	Puccinellia distans
Calluna vulgaris	**Datura stramonium**	Bellis perennis	**Asparagus officinalis**
			Iris pseudacorus

[1] **Valid name** ***Persicaria lapathifolia.***

[2] **Valid name** ***Hylotelephium telephium.***

[3] **Valid name** ***Medicago sativa* var. *falcata.***

[4] **See also Wallentinus (1999a).**

[5] **Valid name *Radiola linoides*.**

[6] **Valid name *Odontites littoralis*.**

[7] **Valid name *Tripleurospermum maritimum*.**

[8] **Valid name *Matricaria suaveolens*.**

[9] **Valid name *Sonchus arvensis* var. *glabrescens*.**

[10] **See also above and Wallentinus (1999a).**

[11] **Valid name *Phragmites australis*; often described as a cosmopolitic species, but considered to be an old introduction to North America, where there are many recent papers on its impact.**

The Atlantic dune grass *Ammophila arenaria* was introduced as a stabilizer on the Pacific coastal dunes in the 1860s and is now present from the southern border to north of Vancouver Island. Lately, it has become a species of concern, because it outcompetes the native species, as well as preventing new sand from being brought to the foredunes, which will cause the dunes to disappear (Wiedemann and Pickart, 1996).

Additionally, it can be mentioned that extremely dense and deep-growing (6.5 m) populations of fanwort, *Cabomba caroliniana*, were found in Lake Kasshabog (44.63°N 79.97°W), Ontario, probably as a result of a dumped aquarium. Other freshwater plants may have spread from gardens or aquaria, such as the floating heart, *Nymphoides peltata*, in two lakes near Burlington (ca. 43.3°N 79.8°W) and the European frog-bit, *Hydrocharis morsus ranae*, in several lakes throughout eastern Ontario (ICES, 1997a, 2001).

2.3.8.2 USA, excluding Hawaii

New introductions 1991–2002

As mentioned in Section 2.2.4, the first nets with *Porphyra yezoensis* were released in the sea in Maine during 1992 (ICES, 1993). As of 1994, no plants had been detected outside the cultivation area (ICES, 1994), but later, a few were recorded (ICES, 1997a), which, however, did not survive the winter (see also Section 2.2.4). West *et al.* (2005) reported records of *Pophyra yezoensis* from Dover Point in New Hampshire, but it is not clear if this occurrence has anything to do with the farming in Maine (*P. yezoensis* U51). The species was identified by using ITS1 and rbcL sequences, and when compared with data in GenBank, it was found to be identical to *P. yezoensis* forma *narawaensis* cultivar F-6 and strain NA4, which were not listed among those of interest for culturing in Maine (ICES, 1996). For more on the farming of the Japanese *Porphyra yezoensis* in Maine, see Section 2.2.4.

The Pacific red alga *Grateloupia doryphora* (valid name *G. turuturu*; Gavio and Fredriqs, 2002), previously introduced in several European countries, was first recognized in large amounts in the outermost parts of Narragansett Bay, Rhode Island, in 1996, and further studies were undertaken (ICES, 1997a; Villalard-Bohnsack and Harlin, 1997). However, later studies showed that, in fact, the species was present already in 1994 (Harlin and Villalard-Bohnsack, 2001; Villalard-Bohnsack and Harlin, 2001). It is supposed to have arrived by shipping, although it is not possible to say from where. In 1997, it was well established in Narragansett Bay, harbouring large numbers of the native grazing snail *Lactuna vincta*. The species was expected to spread farther south through Long Island Sound (ICES, 1998), and its seasonal dynamics, strategies, and further dispersal in the area were studied (Harlin and Villalard-Bohnsack, 2001; Villalard-Bohnsack and Harlin, 2001), the latter study revealing that, by 1999, it had spread north, east, and west in Narragansett Bay, and south along the open coast of Rhode Island Sound.

In 2000, the noxious aquaria strain of *Caulerpa taxifolia* was detected in southern California in Aqua Heionda Lagoon at Carlsbad (33.20°N 117.35°W) and in Huntington Harbor (33.67°N 118.0°W; Jousson *et al.*, 2000; Kaiser, 2000; ICES, 2001, 2002; Williams and Grosholz, 2002), the possible vector being aquaria releases. The authorities and private entities responded very quickly (e.g. Anderson, 2005) and, after less than three weeks, an

eradication programme was started, with chemical treatment with chlorine injected under PVS mats.

The first record of the Japanese kelp *Undaria pinnatifida* was detected in Los Angeles Harbor in 2000 (Silva *et al.*, 2002) and was later found at several sites in southern California. In 2001, it had been established at Santa Barbara Harbor (34.40°N 120.68°W), Cabrillo Beach at San Pedro (33.73°N 118.27°W), at Channel Islands Harbor at Oxnard (34.15°N 119.20°W), and as far north as Monterey Bay (36.60°N 121.89°W), there growing down to 25-m depth (ICES, 2002; Silva *et al.*, 2002). It had probably arrived with shipping. See also Section 2.2.1.

The non-native, Indo-Pacific green alga *Caulerpa brachypus* was first recognized in southeastern Florida in 2001, creating extensive mats overgrowing or displacing the native flora (Florida Sea Grant College Program, quoted by Walters *et al.*, 2006).

Mats of free-living Atlantic knotted wrack (*Ascophyllum nodosum* ecad *mackayi*) were found in San Francisco Bay during a survey in 2001–2002. The presumed vector was packing material, either around bait worms or seafood. Because fertile plants were seen and the wrack can also propagate by fragmentation, the small population was eradicated manually later that autumn (Miller *et al.*, 2004), and the success has been monitored further.

Previously established (Wallentinus, 1999a)

RED ALGAE	BROWN ALGAE	GREEN ALGAE	PHANEROGAMS
Bonnemaisonia hamifera, 1927 (Atlantic coast)	*Sargassum muticum*, <1947 (Pacific coast)	*Codium fragile* ssp. *tomentosoides*, 1957	*Artemisia stellariana*, old (Atlantic coast)
Lomentaria clavellosa, 1960s (Atlantic coast)		(Atlantic coast)	*Myriophyllum spicatum* (Atlantic coast, late 18th century)
Porphyra yezoensis (farmed in sea, Pacific coast ≥1984; Atlantic coast ≥1992)			*Zostera japonica*, <1957 (Pacific coast)
Polysiphonia cf. *breviarticulata*, 1982			

Macroalgae introduced before 1991, but not listed above

The Japanese red alga *Antithamnion nipponicum* (valid name, and according to Cho *et al.* (2005) *A. pectinatum* is not correct) was discovered in Long Island Sound, Connecticut/New York, in the 1980s (ICES, 1993).

The records of *Polysiphonia harveyi* from Massachusetts and Rhode Island in 2000 were mentioned as an introduction (ICES, 2002). Because the species was originally described from Connecticut in 1848 (Maggs and Stegenga, 1999, and references therein), this was astonishing. However, recent studies using rbcL sequences have revealed that *P. harveyi* is not of Atlantic origin, but was introduced from Japan, and most of the populations are the same as in Europe, although samples from North Carolina are the same haplotype as those having invaded New Zealand and California (McIvor *et al.*, 2001). It has been proposed that the species be moved from the genus *Polysiphonia* to the newly erected genus *Neosiphonia* (Choi *et al.*, 2001), which is now the valid name (Guiry *et al.*, 2006). Duffy and Harvilicz (2001) demonstrated experimentally its varying sensitivity to different grazers. Whereas grazer-free eelgrass became heavily fouled with periphyton and tunicates, eelgrass exposed to the amphipod *Gammarus mucronatus* alone was overgrown by the red alga *Neosiphonia* (*Polysiphonia*) *harveyi*, which reached a biomass equal to the total fouling mass of grazer-free controls, but was nearly absent from all other treatments including grazing by amphithoids.

According to Silva *et al.* (2002), the Japanese red alga *Gelidium vagum* has been recorded in Tomales Bay, California, probably having been brought there with Japanese oysters from

British Columbia or Washington, where it had been previously introduced (Renfrew *et al.*, 1989).

The Japanese red alga *Lomentaria hakodatensis* was first recognized as an introduced species in the late 1960s at two sites on the Washington side of the Strait of Georgia (South, 1968), and he believed that, most probably, it had arrived there by oyster imports from Japan, and not by dispersal from the southern part of North America. In the mid-1980s, it had also colonized the southern part of San Juan Islands (Hawkes and Scagel, 1986).

Ní Chualáin *et al.* (2004) suggested that the red alga *Asparagopsis armata* might be a relatively "recent" introduction to San Diego, California, because this is apparently the only known site on the American west coast, though it has been there since the early 1900s.

The following seaweeds (including year for the first record) were described by Cohen and Carlton (1995) as introduced in San Francisco Bay: the green algae *Codium fragile* ssp. *tomentosoides* (1977, common on rocks, pontoons etc.); *Bryopsis* sp. (1951, asexual reproduction only, cast ashore in large amounts); the brown alga *Sargassum muticum* (1973, common in low intertidal waters on pilings, etc.); the red algae *Callithamnion byssoides* (1978–1983, frequent or less on rocks); *Polysiphonia denudata* (1978–1983, common in drift or as epiphytes).

Current status of old introductions

The green alga *Codium fragile* ssp. *tomentosoides* has expanded in many areas. Mathieson *et al.* (2003) described it as the dominant canopy species in several places in southern Maine and New Hampshire, occurring both at disturbed sites after sea urchin grazing, as well as in kelp beds. They also reported that the Asian red alga *Neosphonia (*as *Polysiphonia*) *harveyi*, which is the dominant epiphyte on *Codium*, has had almost the same rapid expansion.

In 1989, *Zostera japonica* was the most abundant seagrass in the Padilla Bay, Washington, covering about 2900 ha in the mid- and lower intertidal flats of a total of 3200 ha of seagrass beds (Bulthuis, 1995).

The exotic Eurasian milfoil *Myriophyllum spicatum* (L.) was first reported in the Lake Pontchartrain estuary in 1978. By the early 1990s, it was established as a dominant species of submerged macrophyte, but its distribution and abundance varied considerably (Duffy and Baltz, 1998). They compared common littoral fish assemblages between two native macrophytes, *Vallisneria americana* and *Ruppia maritima* habitats, with those of *M spicatum* and unvegetated substratum to determine if milfoil influenced assemblage structure and microhabitat use by fish. Community diversity was highest in *V americana*, intermediate in unvegetated areas, and lowest in *R. maritima* and *M. spicatum*, although total abundances were higher in *M spicatum* and *R. maritima* than in *V. americana*. They thought *M. spicatum* may not have had a detectable influence on fish assemblages or abundances relative to the native macrophytes, because the high wave energy in the open system may prevent it from growing densely enough to strongly alter microhabitat characteristics.

Phanerogams, often old introductions

It has not been possible to list all phanerogams introduced into the country, growing or with a potential growth at or close to the seashore. The tentative list below is mainly summarized from *The Flora of Nova Scotia* (Roland and Smith, 1969), in which most US occurrences are mentioned. However, it does not include species introduced elsewhere that are not found in Nova Scotia. Furthermore, the book is not up to date with the new taxonomy, nor with new species concepts, and of course, recent introductions are not included. In any case, it gives an idea of the rather large number of introductions, several of them weeds, with most of them (115) being of European origin, although a few are Asian (5) or South American (2) plants, and some (2) are natives of other parts of North America.

Bold denotes weeds, and **Bold + underlined** serious weeds, *Italic* submerged plants. For species marked with *?*, it was not clearly stated whether they had also been introduced in the US, but it seems likely that they may also occur at least in the northeastern part of the US.

Fumaria officinalis?	Anagallis arvensis	Hyoscyamus niger	Bellis perennis?
Chenopodium album	Sedum accre	Lycium halimifolium	**Cirsium arvense**?
Chenopodium botrys	Sedum telephium[2]	**Solanum dulcamara**	**Cirsium vulgare**?
Chenopodium glaucum	**Filipendula ulmaria**?	Solanum nigrum	Cnicus benedictus
Scleranthus annuus	**Potentilla argentea**	Convolvulus arvensis	**Cotula coronopifolia**?
Spergularia rubra	Potentilla reptans	Cynoglossum officinale?	**Hieracium spp.**
Spergula arvensis	Prunus spinosa?	Echium vulgare?	**Iva xanhifolia**
Arenaria serpyllifolia	Rosa canina	Myosotis scorpiodes	Leontodon autumnalis
Stellaria graminea	Rosa rugosa?	Galeopsis bifida	**Matricaria maritima**[6]
Stellaria media	Lathyrus pratensis	**Galeopsis trifida**	**Matricaria matricarioides**[7]
Polygonum arenastrum	Lotus corniculatus	**Lamium purpureum**	**Onopordum acanthium?**
Polygonum rhaii?	Lotus uliginosus?	Lycopus europeus	Senecio sylvaticus
Polygonum lapathifolium[1]	Medicago falcata[3]	**Stachys palustris**	**Senecio viscosus**?
Polygonum cuspidatum?	Melilotus altissimus	Cymbalaria muralis	**Senecio vulgaris**
Rumex domesticus	Trifolium repens?	**Linaria vulgaris**	**Sonchus arvensis**
Rumex crispus	Vicia angustifolium	**Odontites serotina**[5]	**Sonchus uliginosus**[8]
Rumex acetosella	Vicia cracca?	**Verbascum thapsus**	**Tanacetum vulgare**
Rumex obtusifolius	Vicia hirsuta?	Veronica longifolia	**Taraxacum spp.**
Populus alba?	Vicia sepium	Veronica officinalis?	**Tussilago farfara**
Salix viminalis	**Myriophyllum spicatum**[4]	**Plantago major var. intermedia**	Juncus compressus?
Urica urens?	**Lythrum salicaria**	**Plantago lanceolata**	**Zostera japonica**[9]
Cardaria draba	Epilobium hirsutum	**Galium aparine**	Aira praecox
Coronopus procumbens	Erodium cicutarium?	Galium verum	**Eragrostis megastachya**?
Diplotaxis muralis	Linum catharticum	**Acillea millefolium**	**Phragmites communis**[10]
Erucastrum gallicum	Conium maculatum?	**Anthemis tinctoria**?	**Poa annua**
Lepidium campestre	**Pimpinella saxifraga**	Artemisia absinthium	Poa pratensis?
Sisymbrium altissimum	Viola tricolor?	Artemisia stelleriana	Puccinellia distans
Thlaspi arvense	Centaurium umbellatum	**Artemisia vulgaris**	**Asparagus officinalis**?
Calluna vulgaris			Iris pseudacorus

[1] **Valid name Persicaria lapathifolia.**

[2] **Valid name *Hylotelephium telephium*.**

[3] **Valid name *Medicago sativa* var. *falcata*.**

[4] **See also Wallentinus (1999a).**

[5] **Valid name *Odontites littoralis*.**

[6] **Valid name *Tripleurospermum maritimum*.**

[7] **Valid name *Matricaria suaveolens*.**

[8] **Valid name *Sonchus arvensis* var. *glabrescens*.**

[9] **See also above and Wallentinus (1999a).**

[10] **Valid name *Phragmites australis*; often described as a cosmopolitic species, but considered to be an old introduction to North America, where there are many recent papers on its impact.**

The following higher plants, many old introductions, were described by Cohen and Carlton (1995) as introduced in San Francisco Bay or the delta area farther inland (type of habitat given): *Chenopodium macrospermum* (in marshes); *Cotula coronopifolia* (salt and freshwater marshes); *Lepidium latifolium* (beaches, tidal shores, and invasive in high tidal marshes and ponds); *Limosella subulata* (intertidal flats); *Lythrum salicaria* (marshes, etc., often noxious weed), *Myriophyllum aquaticum* (mostly freshwater, but also tidal marshes); *Myriophyllum spicatum* (mainly freshwater in this area); *Polygonum patulum* (uncommon in saltmarshes);

Rorippa nasturtium-aquaticum (freshwater only); *Salsola kali* (saltmarshes and mudflats); *Spergularia media* (common in tidal marshes, flats, and on beaches); *Egria densa* (only freshwater, there highly invasive); *Eichhornia crassipes* (serious problem in freshwater); *Iris pseudacorus* (banks in delta); *Polypogon elongatus* (saltmarshes); *Potamogeton crispus* (mainly freshwater); *Spartina alterniflora* (saltmarshes and mud flats, increasing and eradication programmes); *S. anglica* (saltmarshes, less invasive than elsewhere); *S. densiflora* (saltmarshes); *S. patens* (marsh, not spreading); and *Typha angustifolia* (brackish marshes, often hybrids with the native *T. latifolia*).

The Atlantic dune grass *Ammophila arenaria* was introduced as a stabilizer on the Pacific coastal dunes in the 1860s and is now present in all western states. Lately, it has become a species of concern, because it outcompetes the native species, as well as preventing new sand from being brought to the foredunes, which will result in the dunes disappearing (Wiedemann and Pickart, 1996).

Among the more noteworthy introduced phanerogams, not included above, is the South American *Carpobrotus chilensis*, established a long time ago in the western US. This is now threatened by the much later introduced *Carpobrotus edulis*, which also forms vigorous hybrids with the former, increasing the threat (e.g. Weber and D'Antonio, 1999). Likewise, within the cordgrass genus *Spartina*, hybridization is said to constitute a threat to the shores of California, because both introduced species (e.g. the North American *S. alterniflora* and *S. densiflora* from Chile; Daehler and Strong, 1997; Kittelson and Boyd, 1997) and the hybrid may occupy zones other than the native species (e.g. Anttila *et al.*, 1998).

A more unusual introduction is that of the Asian sand sedge *Carex kobomugi*, which was accidentally introduced about 100 years ago when a ship with porcelain wrapped in this sedge stranded on the east coast in New Jersey (Wootton *et al.*, 2005). The sedge became established and was later planted intentionally in dune systems all along the east coast because of its disease- and trampling-resistant properties. There it expanded rapidly, necessitating eradication programmes (Standley, 1983; Wootton *et al.*, 2005).

2.4 Phytoplankton

The occurrence of new phytoplankton species in a sea area is even more difficult to relate to events of introductions than it is for macrophytes, because especially small organisms have often been neglected or not sampled in previous surveys. Furthermore, their taxonomic affinities have often been obscure, and so the natural distribution of many species is poorly known (see Elbrächter, 1999). Owing to limited time, it has not been possible to review all literature on phytoplankton species for new introductions, and the reporting of new species is mainly based on WGITMO reports during the period 1992–2002.

Current status of old introductions

Owing to limited time, it has not been possible to follow up on the current status of these species. Many of them, however, have become permanent members of the phytoplankton assemblages, and frequently, some also build up nuisant or toxic blooms. Some information on their current status in the North Sea was given by Elbrächter (1999).

2.4.1 The eastern Atlantic including the North Sea, the Skagerrak, the Kattegat, and Öresund

New introductions 1991–2002

Rhaphidophyceae: The potentially ichtyotoxic rhapidophycean alga *Fibrocapsa japonica* was first seen in samples from off the coast of Normandy, northern France, in October 1991 (Billard, 1992). Later the same year, it was also found in Dutch waters and the following year off Sylt on the German west coast (Elbrächter, 1999, and references therein) and is now a

regular component in North Sea coastal waters. Ribosomal DNA ITS markers were used to compare 16 different populations of the species from different parts of the world, and the North Sea did have the highest polymorphism, which could be explained by e.g. recent ballast-water-mediated mixing of previously isolated populations (Kooistra *et al.*, 2001; de Boer *et al.*, 2002).

Two other species of the genus *Chattonella*, *Ch. antiqua* and *Ch. marina*, were also recorded in Dutch waters in 1991 (Elbrächter, 1999, and references therein), the first described from Japanese waters, the second from the Indian Ocean.

In April/May 1998, a bloom of *Chattonella* cf. *verruculosa* (two morphological forms were seen) occurred along the Kattegat, the Skagerrak, and the inner North Sea coasts. The highest cell concentrations with up to 24 million cells per litre were found west of Jutland in May (e.g. Backe-Hansen *et al.*, 2001), and fish kills were reported from several areas. *C. verruculosa* was previously known only from Japan, and so transportations from other areas cannot be ruled out (ICES, 1999). It was also found during spring 1999 in small amounts at the Swedish west coast and east of Jutland, but it did not bloom (ICES, 2000a). In 2000, it bloomed along the Danish coast, but was only seen in small amounts on the Swedish west coast (ICES, 2001). However, in 2001 it did bloom in March/April on the Swedish west coast and on the Norwegian south coast, and nearly 1000 tonnes of farmed fish were killed. Retrospective analyses also showed that it had occurred in small amounts earlier than previously recorded in the 1990s (Mats Kuylenstierna, pers. comm.). A study (Tomas *et al.*, 2002), based on fine structure, pigments, and toxicity, considered Japanese and North Sea isolates to be closely related, although the American indigenous isolate *Chattnella* cf. *verruculosa* indicated another ichtyotoxic species in the genus.

Dinophyceae: The reported cysts of *Gymnodinium catenatum* from northern European waters in the mid-1990s were based on misidentification of a very similar native species (see below).

In the 1990s, there was believed to be a direct relationship between the occurrence of *Gymnodinium catenatum* in western Spain and ships arriving at the same time to Rochefort Harbour, as well as those coming from Portugal in 1994 and 1995 (ICES, 2000b). According to Blackburn *et al.* (2001), Spanish populations are quite closely related to Japanese ones.

The non-toxic *Alexandrium leei*, occurring in the western Pacific and northern Indian Ocean, was first recorded in Dutch waters in 1995 (Elbrächter, 1999, and references therein). So far it has not formed any extensive blooms.

Alexandrium taylori, which may cause PSP (but see Hallegraeff *et al.*, 2003), was found in Arcachon, France in 1994 (ICES, 2001).

The potential PSP-producer *Alexandrium minutum* was first recorded in phytoplankton samples from the Swedish west coast in June 1996, where it was abundant (ICES, 1997a), and it was again abundant in June 1997 (ICES, 1998). It was not recorded previously from the North Sea/Skagerrak area, the closest sighting being Brittany, France, although live cysts of the same species occurred in several sediment samples from Bohuslän collected in 1995 (ICES, 1997b). Elbrächter (1999) believed it to be a species distributed to these northern areas by currents from the Atlantic coasts of France, Spain, and Portugal. However, at a meeting in 2000 (ICES, 2000b), it was reported as new for the coast north of Brittany, France.

Since 1997, the following new dinoflagellates have been found on the Swedish west coast: *Alexandrium angustitabulatum* (known from New Zealand); *Discroerisma psilonereiella* (known from Kamchatka and British Columbia); and *Gyrodinium corallinum* (known from California). Whether they were new introductions or have been previously overlooked was not known, nor was the vector known if they have been introduced. *Alexandrium angustitabulatum* is a small, potentially toxic species difficult to separate from *A. minutum*,

although *Discroerisma psilonereiella* is relatively rare, but quite easy to recognize with the internal skeleton, and *Gyrodinium corallinum* is quite a large species (ICES, 2001).

Cysts of the subtropical/tropical species *Pyrodinium bahamense* were found in Portugal in the 1990s and are the first record from a European coast (Amorim and Dale, 1998).

For *Pfiesteria* spp., see Section 2.2.4.

Previously established (Wallentinus, 1999a).

Clearly non-introduced taxa as well as rang extensions are excluded.

DIATOMS	RHAPHIDOPHYCEANS	DINOFLAGELLATES
Odonthella sinensis, 1903	(*Olisthodiscus luteus*[1], 1964)	*Gymnodinium* cf. *aureolum*[3], 1966
Thalassiosira tealata, 1950	(*Heterosigma akashiwo*[2], late 1970s)	*Gymnodinium catenatum*[4], 1976
Pleurosigma planctonicum[6], 1966		(*Prorocentrum minimum*[5], 1976)
Coscinodiscus wailesii, 1977		*Ptychodiscus brevis*[7] ?
Thalassiosira punctigera, 1978		

[1] **According to Elbrächter (1999), conspecific with *Heterosigma akashiwo* and not an introduced species.**

[2] **According to Elbrächter (1999), not an introduced species.**

[3] **Valid name *Karenia mikimotoi*.**

[4] **In northern European waters, records of this species are based on misidentifications of the recently described species *G. nolleri* (see below).**

[5] **According to Elbrächter (1999), this is a "pseudo-exotic" species, being known earlier from the North Sea area under other names.**

[6] **Valid name *P. simonsenii*.**

[7] **Valid name *Karenia brevis*.**

Microalgae introduced before 1991, but not listed above

Blooms of the dinoflagellate *Prorocentrum redfieldii* have occurred in the Dutch coastal area since 1961, and sometimes also along the North Frisian coast, and might represent a new introduction from the North American Atlantic coast (Elbrächter, 1999). In the same paper, it was also mentioned that it might be conspecific with *P. triesinum*, a species recorded worldwide in coastal waters, and in that case, probably not introduced.

Reports concerning native, mainly potentially toxic species

In the national report from Norway (ICES, 1992, 1993), an exceptional bloom in 1991 in Sørfjorden of the dinoflagellate *Dinophysis acuta*, a potential DSP-producer, was reported to have been caused by ballast discharges originating in the UK. It should be pointed out, however, that this is a species native to the area.

In 1993 (ICES, 1993), there was concern over transfers of toxic dinoflagellate cysts from France to Ireland with the movements of *Crassostrea gigas*. That risk had also been pointed out by Dijkema (1992) for movements to the Netherlands.

Recently, there have been several reports of Azaspiracid shellfish toxins (AZP), which were also discussed by WGITMO (ICES, 2000a; Irish national report). The poisoning occurred for the first time in the Netherlands in 1995, after consumption of Irish mussels from Killary Harbour, and analyses of the toxin and its analogues later showed the native dinoflagellate *Protoperidinium crassipes* to be the organisms causing AZP (Yasumoto *et al.*, 2002). The toxins have also been identified in mussels from Craster, northeastern England, and Søgnefjord, southwestern Norway (James *et al.*, 2002), and those authors considered it not unlikely that the toxins also occur elsewhere in northern Europe.

In Sweden, high levels of PST were found in mussels in May 1997, coinciding with high levels of the dinoflagellates *Alexandrium ostenfeldii* and *A. tamarense* (ICES, 1998). In Nova Scotia, eastern Canada, *A. ostenfeldii* was found not to cause PSP, but to be the organism producing a new group of fast-acting, macrocyclic imine toxins called spirolides (e.g. Cembella *et al.*, 2000, 2002), which has also been found in algae from Limfjorden, Denmark, (MacKinnon *et al.*, 2002) and from the Scottish east coast (Rühl *et al.*, 2002).

At the end of 1999, Amnesic Shellfish Toxin, caused by diatoms of the genus *Pseudonitschzia*, was detected in *Pecten maximus* around the Irish west coast, some harvest areas being closed for months, and the same also occurred on the west coast of Scotland, with the most intense and extensive bloom seen there (ICES, 2000a). These species, however, are native to Europe.

The reports of cysts (no motile cells seen *in situ*) of the dinoflagellate *Gymnodinium catenatum*, a potential PSP-producer from Scandinavian and German waters (ICES, 1994, 1995, 1996, 1997a), were based on misidentifications of cysts having almost the same morphologies. The species in question was later described as *Gymnodimium nolleri* Ellegaard et Moestrup sp. nov. (Ellegaard and Moestrup, 1999; ICES, 1999) and does not produce PSP (ICES, 1996, and references therein, 1999; Ellegaard *et al.*, 1998).

2.4.2 The Baltic Sea, inside the Kattegat and the Belt Sea areas

New introductions 1991–2002

The potential PST-producing dinoflagellate *Alexandrium ostenfeldi* was recorded for the first time from the Baltic proper in a dense bloom outside the island of Öland in September 1997 (ICES, 1999).

Previously established (Wallentinus, 1999a)

DIATOMS	RHAPHIDOPHYCEANS	DINOFLAGELLATES
Odonthella sinensis, early 20th century		*Prorocentrum minimum*, 1983

Microalgae introduced before 1991, but not listed above

In 1992, there was a considerable bloom of the potentially toxic dinoflagellate *Prorocentrum minimum* in the northwestern Baltic proper, the species first recorded there in 1984 (ICES, 1994). Subsequently, it was questioned whether in fact it was introduced to the Baltic Sea (see Hajdu *et al.*, 2000), and so it may be considered cryptogenic. It occurred sparsely until 1998 (ICES, 1999).

2.4.3 The Mediterranean Sea

New introductions 1991–2002

Rhaphidophyceae: The Pacific, potentially toxic, species *Fibrocapsa japonica* was blooming along the Latium coast of Italy, Middle Tyrrhenian Sea, in summer 1999, discolouring the water close to shore brown (Bianco *et al.*, 2002). The vector was not discussed.

Dinophyceae: Recurrent blooms of the dinoflagellate *Alexandrium taylori*, which may cause PSP (but see Hallegraeff *et al.*, 2003), occurred in the late 1990s off the Catalonian coast, Spain, and off Sicily (ICES, 2001).

The potential PST-producer *Alexandrium catennella* has caused toxic blooms in central Catalonia, eastern Spain, first recorded in Barcelona harbour in 1996 and expanding (Vila *et al.*, 2001) to the Thau Lagoon, southern France, since 1998 (Laabir *et al.*, 2002). It has also been found off Sardinia, Italy (Lugliè *et al.*, 2002), where it was suggested to have been introduced by either ballast or mussel movements.

Alexandrium andersoni was seen in Italy for the first time in the late 1990s (Montresor *et al.*, 1998; Montresor *et al.*, 2000).

In the Thau Lagoon, southern France, *Alexandrium tamarense* was reported as new to the area, causing a significant bloom and was presumed to be an Asian strain (ICES, 2000b).

Previously established (Wallentinus, 1999a)

DIATOMS	RHAPHIDOPHYCEANS	DINOFLAGELLATES
		Ptychodiscus brevis[1], 1972

[1] **Valid name *Karenia brevis*.**

Microalgae introduced before 1991, but not listed above

Dinoflagellates: The potential PST-producer *Alexandrium tamarense* was first seen in the Adriatic Sea in August 1982, and *A. pseudogonyaulax* and *A. lusitanicum* in 1987. Because phytoplankton composition has been followed there for more than 100 years, they were believed to have arrived quite recently, either through ballast discharges or mussel importations and have been intensely monitored (ICES, 2000a, 2001; Occhipinti Ambrogi, 2002).

The potential PST-producer *Alexandrium minutum* was first found in Italy off the coast of Sicily in April 1990 (Giacobbe and Maimone, 1994), but is widely spread in other parts of the Mediterranean.

Motile cells of *Gonyaulax grindley* (= *Protoceratium reticulatum*) were first seen in small amounts in the early 1990s, although cysts have been found in sediment cores dating back 10 000 years BP.

2.4.4 Canadian and US coasts

Only the species mentioned in the national reports are listed here, because time did not allow a literature review.

New introductions 1991–2002

West of Vancouver Island on the Canadian west coast, the dinoflagellate *Cochliodinium polykrikoides*, only rarely encountered previously, caused a dense bloom for the first time in July 1999. The bloom killed farmed fish, and the survey found the highest concentrations close to inlets; because cargo ships from Korea (where the species frequently causes blooms) take on cargo here, the bloom could have resulted from discharge of ballast of either water or resuspended sediment containing cysts. There was great concern that the species might cause more blooms in the future (ICES, 2001).

Reports concerning native, mainly toxic species

There has been great concern over some "new" phytoplankton blooms in the US caused by the APS producer *Pseudonitzschia australis* on the Pacific coast, over the *Pfiesteria piscicida* in North Carolina and the Chesapeake Bay system, and over the small brown tide species *Aureococcus anophagefferens* (Pelagophyceae) on the Atlantic coast (ICES, 1993). However, these species are probably not introduced. The latter was also mentioned as a native species in the previous status report (Wallentinus, 1999a).

2.5 References

Amorim, A., and Dale, B. 1998. Distribution of cysts from toxic or potentially toxic dinoflagellates along the Portuguese coast. *In* Harmful Algae, pp. 64–65. Ed. by B. Reguera, J. Blanco, M. L. Fernández, and T. Wyatt. Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, Santiago de Compostela.

Anderson, L. W. 2005. California's reaction to *Caulerpa taxifolia*: A model for invasive species rapid response. Biological Invasions, 7(6): 1003–1016.

Andreakis, N., Procaccini, G., and Kooistra, W. 2004. *Asparagopsis taxiformis* and *Asparagopsis armata* (Bonnemaisoniales, Rhodophyta): genetic and morphological identification of Mediterranean populations. European Journal of Phycology, 39: 273–283.

Andrew, N. L., and Viejo, R. M. 1998. Ecological limits to the invasion of *Sargassum muticum* in northern Spain. Aquatic Botany, 60: 251–263.

Anon. 1997. Dynamique d'espèces marine invasives: application à l'expansion de Caulerpa taxifolia en Mediterranée. Actes de Colloques Septembre 1997, Académie des Sciences, Lavoiser Technique & Documentation, Paris. 382 pp.

Anttila, C. K., Daehler, C. C., Rank, N. E., and Strong, D. R. 1998. Greater male fitness of a rare invader (*Spartina alterniflora*, Poaceae) threatens a common native (*Spartina foliosa*) with hybridization. American Journal of Botany, 85: 1597–1601.

Araujo, R., Barabara, I., Santos, G., Oliviera, M., Pereira, R., and Sousa Pinto, I. 2003. Discovery of seven new seaweed records for the Portuguese coastline. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and Book of abstracts, P5–13, p. 89.

Aronsson, M., Hallingbäck, T., and Mattsson, J. E. 1995. Rödlistade växter i Sverige. ArtDatabanken, SLU, Uppsala (in Swedish).

Athanasiadis, A. 1987. A survey of the seaweeds of the Aegean Sea with taxonomic studies on species of the tribe Antithamnieae (Rhodophyta). PhD thesis, Department of Marine Botany, Göteborg University. 224 pp.

Athanasiadis, A. 1996a. Taxonomisk litteratur och biogeografi av Skandinaviska rödalger och brunalger. Algologia, Göteborg. 280 pp.

Athanasiadis, A. 1996b. Morphology and classification of the Ceramioideae (Rhodophyta) based on phylogenetic principles. Opera Botanica, 128: 1–216.

Athanasiadis, A. 1997. North Aegean marine algae. IV. *Womersleyella setacea* (Hollenberg) R. E. Norris (Rhodophyta, Ceramiales). Botanica Marina, 40: 473–476.

Athanasiadis, A., and Tittley, I. 1994. Antithamnioid algae (Rhodophyta, Ceramiaceae) newly recorded from the Azores. Phycologia, 33: 77–80.

Axelius, B., and Karlsson, J. 2004. Japanplym, ny rödalg för Sverige (*Heterosiphonia japonica* new for Sweden). Svensk Botanisk Tidskrift, 98(5): 268–273 (in Swedish with English legends).

Backe-Hansen, P., Dahl, E., and Danielssen, D. S. 2001. On the bloom of *Chattonella* in the North Sea/Skagerrak in April–May 1998. *In* Harmful Algal Blooms. Proceedings of the 9th International Conference on Harmful Algal Blooms, Hobart, Australia, 7–11 February 2000, pp. 78–81. Ed. by G. M. Hallegraeff, S. I. Blackburn, C. J. Bolch, and R. J. Lewis. Intergovernmental Oceanographic Commission of UNESCO, Paris.

Baldwin, J. R., and Lovvorn, J. R. 1994. Expansion of seagrass habitat by the exotic *Zostera japonica*, and its use by dabbling ducks and brant in Boundary Bay, British Columbia. Marine Ecology Progress Series, 103: 119–127.

Bárbara, I., and Cremades, J. 1996. Seaweeds of the Ría de A Coruna (NW Iberian Penisula, Spain). Botanica Marina, 39: 371–388.

Barone, R., Di Martino, V., and Mannino, A. M. 2003. *Asparagopsis taxiformis* (DeLile) Trevisan in Italy: distribution and reproductive strategies. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and Book of abstracts, P5–10, p. 88.

Bartsch, I., and Kuhlenkamp, R. 2000. The marine macroalgae of Helgoland (North Sea): an annotated list of records between 1845 and 1999. Helgoland Marine Research, 54: 160–189.

Berry, J. P., Reece, K. S., Baden, D. G., Haas, L. W., Ribeiro, W. L., Shields, J. D., Snyder, R. V., Vogelbein, W. K., and Gawley, R. E. 2002. Are *Pfiesteria* species toxicogenic? Evidence against production of ichtyotoxins by *Pfiesteria shumwayae*. Proceedings of the National Academy of Sciences of the United States of America, 99: 10970–10975.

Bianco, I., Congestri, R., and Albertano, P. 2002. Toxic armored dinoflagellates of the Latium coastal waters, Italy (Middle Tyrrhenian Sea). 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 29.

Bird, C. J., Dadswell, M. J., and Grund, D. W. 1993. First record of the potential nuisance alga *Codium fragile* ssp. *tomentosoides* (Chlorophyta, Caulerpales) in Atlantic Canada. Proceedings of the Nova Scotia Institute of Science, 40: 11–17.

Bird, C. J., and McLachlan, J. L. 1992. Seaweed flora of the Maritimes. 1. Rhodophyta – the red algae. Biopress Ltd, Bristol. 177 pp.

Billard, C. 1992. *Fibrocapsa japonica* (Rhaphidophyceae), planktonic marine alga reported for the first time in France. Cryptogamie Algologie, 13: 225–231 (in French).

Bischof, K., Kräbs, G., Hanelt, D., and Wiencke, C. 2000. Photosynthetic characteristics and myosporine-like amino acids under UV radiation: a competitive advantage of *Mastocarpus stellatus* over *Chondrus crispus* at the Helgoland shoreline. Helgoland Marine Research, 54: 47–52.

Bjærke, M. R., and Rueness, J. 2004a. The introduced red alga *Heterosiphonia japonica* (Ceramiales, Rhodophyta) in the eastern North Atlantic: an investigation of genetic variation with focus on ALFP fingerprinting. *In* Molecular and ecological studies on introduced marine macroalgae in Norwegian waters. PhD Thesis, University of Oslo, Paper I.

Bjærke, M. R., and Rueness, J. 2004b. RbcL sequences provide information on origin and distribution of *Neosiphonia harveyi* (Ceramiales, Rhodophyta) in Norwegian waters. *In* Molecular and ecological studies on introduced marine macroalgae in Norwegian waters. PhD Thesis, University of Oslo, Paper III.

Bjærke, M. R., and Rueness, J. 2004c. *Aglaothamnion halliae* (Ceramiales, Rhodophyta) in Scandinavian waters: Field observations and molecular data suggest a recent introduction. *In* Molecular and ecological studies on introduced marine macroalgae in Norwegian waters. PhD Thesis, University of Oslo, Paper II.

Blackburn, S. I., Bolch, C. J. S., Haskard, K. A., and Hallegraeff, G. M. 2001. Reproductive compatibility among four global populations of the toxic dinoflagellate *Gymnodinium catenatum* (Dinophyceae). Phycologia, 40: 78–87.

Boaden, P. J. S. 1995. The adventive seaweed *Sargassum muticum* (Yendo) Fensholt in Strangford Lough, Northern Ireland. Irish Naturalists' Journal, 25: 111–113.

Boudouresque, C. F., and Verlaque, M. 2002. Biological pollution in the Mediterranean Sea: invasive versus introduced macrophytes. Marine Pollution Bulletin, 44: 32–38.

Boudouresque, C. F., Meinesz, A., Verlaque, M., and Knoepffler-Peguy, M. 1992. The expansion of the tropical alga *Caulerpa taxifolia* (Chlorophyta) in the Mediterranean. Cryptogamie Algologie, 13: 144–145.

Bulthuis, D. A. 1995. Distribution of seagrasses in a north Puget Sound estuary – Padilla Bay, WA. Aquatic Botany, 50: 99–105.

Burkholder, J. M., and Glasgow, H. B. 2002. The life cycle and toxicity of *Pfiesteria piscicida* revisited. Journal of Phycology, 38: 1261–1267.

Burkholder, J. M., Glasgow, H. B., and Hobbs, C. W. 1995. Fish kills linked to a toxic ambush-predator dinoflagellate – distribution and environmental conditions. Marine Ecology Progress Series, 124: 43–61.

Cabioch, J., Castric-Fey, A., L'Hardy Halos, M. T., and Rio, A. 1997. *Grateloupia doryphora* and *Grateloupia filicina* var. *luxurians* (Rhodophyta, Halymeniaceae) from the coasts of Brittany (France). Cryptogamie Algologie, 18: 117–137 (in French with English abstract).

Castric-Fey, A., Girard, A., and L'Hardy-Halos, M. T. 1993. The distribution of *Undaria pinnatifida* (Phaeophyceae, Laminariales) on the coast of St Malo (Brittany, France). Botanica Marina, 36: 351–358.

Castric-Fey, A., Beaupoil, C., Bochain, J., Pradier, E., and L'Hardy-Halos, M. T. 1999a. The introduced alga *Undaria pinnatifida* (Laminariales, Alariaceae) in the rocky shore ecosystem of the St Malo area: Morphology and growth of the sporophyte. Botanica Marina, 42: 71–82.

Castric-Fey, A., Beaupoil, C., Bochain, J., Pradier, E., and L'Hardy-Halos, M. T. 1999b. The introduced alga *Undaria pinnatifida* (Laminariales, Alariaceae) in the rocky shore ecosystem of the St Malo area: Growth rate and longevity of the sporophyte. Botanica Marina, 42: 83–96.

Cecere, E., Petrocelli, A., and Verlaque, M. 2004. Morphology and vegetative reproduction of the introduced species *Hypnea cor*nuta (Rhodophyta, Gigartinales) in the Mar Piccolo of Taranto (Italy), Mediterranean Sea. Botanica Marina, 47: 381–388.

Cembella, A. D., Lewis, N. I., and Quilliam, M. A. 2000. The marine dinoflagellate *Alexandrium ostenfeldii* (Dinophyceae) as the causative organism of spirolide shellfish toxins. Phycologia, 39: 67–74.

Cembella, A. D., John, U., Elbrächter, M., Quilliam, M. A., Hummert, C., Luckas, B., and Medlin, L. 2002. Biogeography of *Alexandrium ostenfeldii* and spirolide toxin composition in natural compositions. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 47.

Chapman, A. S. 1999. From introduced species to invader: what determines variation in the success of *Codium fragile* ssp. *tomentosoides* (Chlorophyta) in the North Atlantic Ocean. Helgoländer Meeresuntersuchungen, 52: 277–289.

Cho, T. O., Boo, Y. W., and Fredericq, S. 2005. *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. European Journal of Phycology, 40: 323–335.

Choi, H-G., Kim, M-S., Guiry, M. D., and Saunders, G. W. 2001. Phylogenetic relationships of *Polysiphonia* (Rhodomelaceae, Rhodophyta) and its relatives based on anatomical and nuclear small-subunits rDNA sequence data. Canadian Journal of Botany, 79: 1465–1476.

Cohen, A. N., and Carlton, J. T. 1995. Nonindiginenous aquatic species in a United States estuary: a case study of the biological invasions of the San Francisco Bay and Delta. United States Fish and Wildlife Service, Washington DC. 26 pp. + 5 App.

Cormaci, M., Furnari, G., Alongi, G., Dinaro, R., and Pizzuto, F. 1992. On the occurrence in Sicily of three Florideophyceae new to the Mediterranean Sea. Botanica Marina, 35: 447–449.

Cormaci, M., Lanfranco, E., Borg, J. A., Buttigieg, S., Furnari, G., Micallef, S. A., Mifsud, C., Pizzuto, F., Scammacca, B., and Serio, D. 1997. Contribution to the knowledge of the benthic marine algae on rocky substrata of the Maltese Islands. Botanica Marina, 40: 203–215.

Cosson, J. 1999. On the progressive disappearance of *Laminaria digitata* on the coasts of Calvados (France). Cryptogamie Algologie, 20: 35–42 (in French).

Coyer, J. A., Peters, A. F., Hoarau, G., Stam, W. T., and Olsen, J. L. 2002. Hybridization of the marine seaweeds, *Fucus serratus* and *Fucus evanescens* (Heterokontophyta: Phaeophyceae) in a 100-year-old zone of secondary contact. Proceedings of the Royal Society London Series B-Biological Sciences, 269(1502): 1829–1834.

Critchley, A. T., Farnham, F. W., and Morrel, S. L. 1986. An account of the attempted control of an introduced marine alga, *Sargassum muticum*, in southern England. Biological Conservation, 35: 313–332.

Curiel, D., Marzocchi, M., and Bellemo, G. 1996. First report of fertile *Antithamnion pectinatum* (Ceramiales, Rhodophyceae) in the North Adriatic Sea (Lagoon of Venice, Italy). Botanica Marina, 39: 19–22.

Curiel, D., Bellemo, G., Marzocchi, M., Scattolin, M., and Parisi, G. 1998. Distribution of introduced Japanese macroalgae *Undaria pinnatifida, Sargassum muticum* (Phaeophyta) and *Antithamnion pectinatum* (Rhodophyta) in the Lagoon of Venice. Hydrobiologia, 385: 17–22.

Curiel, D., Bellemo, G., Iuri, M., Marzocchi, R., and Scattolin, N. 1999. First report of the genus *Sorocarpus* Pringsheim (Fucophyceae, Ectocarpaceae) in the Mediterranean. Botanica Marina, 42(1): 7–10.

Curiel, D., Bellemo, G., La Rocca, B., Scattolin, M., and Marzocchi, M. 2002. First report of *Polysiphonia morrowii* Harvey (Ceramiales, Rhodophyta) in the Mediterranean Sea. Botanica Marina, 45: 66–70.

Daehler, C. C., and Strong, D. R. 1997. Hybridization between introduced smooth cordgrass (*Spartina alterniflora*; Poaceae) and native California cordgrass (*S. foliosa*) in San Francisco Bay, California, USA. American Journal of Botany, 84(5): 607–611.

Daguin, C., Voisin, M., Engel, C., and Viard, F. 2005. Microsatellites isolation and polymorphism in introduced populations of the cultivated seaweed *Undaria pinnatifida* (Phaeophyceae, Laminariales). Conservation Genetics, 6(4): 647–650.

De Biasi, A. M., and Aliani, S. 2003. Shallow-water hydrothermal vents in the Mediterranean Sea: stepping stones for Lessepsian migration? Hydrobiologia, 503: 37–44.

De Boer, M. K., Koolmees, E. M., Gieskes, W. W. C., Vrieling, E. G., Breeman, A. M., and van Rijssel, M. 2002. Evidence for recent introduction of the toxic microalga *Fibrocapsa japonica* (Raphidophyceae) in the North Sea/Wadden Sea. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 66.

Devillele, X., and Verlaque, M. 1995. Changes and degradation in a *Posidonia oceanica* bed invaded by the introduced tropical alga *Caulerpa taxifolia* in the north-western Mediterranean. Botanica Marina, 38: 79–87.

den Hartog, C. 1997. Is *Sargassum muticum* a threat to eelgrass beds? Aquatic Botany, 58: 37–41.

Díez, I., Santolaria, A., and Gorostiaga, J. M. 2003. The relationship of environmental factors to the structure and distribution of subtidal seaweed vegetation of the western Basque coast (N Spain). Estuarine Coastal and Shelf Science, 56: 1041–1054.

Dijkema, R. 1992. The risk of provoking toxic dinoflagellate blooms in the Dutch coastal waters through immersion of imported bivalves, originating from red tide areas. ICES CM 1992/K:48.

Doblin, M. A., Drake, L. A., Coyne, K. J., Rublee, P. A., and Dobbs, F. C. 2002. *Pfiesteria* species identified in ballast water and residuals: a possible vector for introductions to coastal areas. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 74.

Duffy, K. C., and Baltz, D. M. 1998. Comparison of fish assemblages associated with native and exotic submerged macrophytes in the Lake Pontchartrain estuary, USA. Journal of Experimental Marine Biology and Ecology, 223: 199–221.

Duffy, J. E., and Harvilicz, A. M. 2001. Species–specific impacts of grazing, amphipods in an eelgrass-bed community. Marine Ecology Progress Series, 223: 201–211.

Elbrächter, M. 1999. Exotic flagellates of coastal North Sea waters. Helgoländer Meeresuntersuchungen, 52: 235–242.

Ellegaard, M., and Moestrup, O. 1999. Fine structure of the flagellar apparatus and morphological details of *Gymnodinium nolleri* sp. nov. (Dinophyceae), an unarmored dinoflagellate producing a microreticulate cyst. Phycologia, 38: 289–300.

Ellegaard, M., Kulis, D. M., and Anderson, D. M. 1998. Cysts of Danish *Gymnodinium nolleri* Ellegaard et Moestrup sp. ined. (Dinophyceae): studies on encystment, excystment and toxicity. Journal of Plankton Research, 20: 1743–1755.

Engel, C., Voisin, N., and Viard, F. 2003. Tracing an exotic species' migration routes: dispersal patterns of the pandemically introduced brown alga *Undaria pinnatifida*, Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and Book of abstracts, P1–9, p. 67.

Engelen, A., Santos, R., and Alves, C. 2003. Demography of the alien species *Sargassum muticum* at its southern European distribution limit. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and book of abstracts, M8–2, p. 48.

Farnham, W. F. 1997. Invasive species on the English Channel and Atlantic coasts. *In* Dynamics of Invasive Marine Species: Application to the Expansion of Caulerpa taxifolia in the Mediterranean. Actes de Colloques Septembre 1997, Académie des Sciences, pp. 15–35. Lavoiser Technique & Documentation, Paris.

Fletcher, R. L., and Farell, P. 1999. Introduced brown algae in the North East Atlantic with particular respect to *Undaria pinnatifida* (Harvey) Suringar. Helgoländer Meeresuntersuchungen, 52: 259–275.

Fletcher, R. L., and Manfredi, C. 1995. The occurrence of *Undaria pinnatifida* (Phaeophyceae, Laminariales) on the south coast of England. Botanica Marina, 38: 355–358.

Flagella, M. M., Guala, I., Esposito, A., Lorenti, M., and Buia, M. C. 2003. *Asparagopsis taxiformis* and *Caulerpa racemosa*: ecophysiological traits and interactions with native algal communities. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and book of abstracts, M3–8, p. 37.

Floc'h, J-Y., Pajot, R., and Wallentinus, I. 1991. The Japanese brown alga *Undaria pinnatifida* on the coast of France and its possible establishment in European waters. Journal du Conseil International l'Exploration de la Mer, 47: 379–390.

Floc'h, J-Y., Pajot, R., and Mouret, V. 1996. *Undaria pinnatifida* (Laminariales, Phaeophyta) 12 years after its introduction into the Atlantic. Hydrobiologia, 326/327: 217–222.

Gallagher, A. M., Loughnane, C. J., Keane, S., and Stengel, D. B. 2003. Productivity of *Sargassum muticum* (Yendo) Fensholt (Phaeophyta), recently introduced to Ireland, in relation to temperature, irradiance and habitat. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and book of abstracts, P1–7, p. 67.

Garbary, D. J., Vandermeulen, H., and Kim, K. Y. 1997. *Codium fragile* ssp. *tomentosoides* (Chlorophyta) invades the Gulf of St Lawrence, Atlantic Canada. Botanica Marina, 40: 537–540.

Gärdenfors, U. 2000. The 2000 Red List of Swedish Species. ArtDatabanken, SLU, Uppsala. 397 pp.

Gavio, B., and Fredericq, S. 2002. *Grateloupia turuturu* (Halymeniaceae, Rhodophyta) is the correct name of the non-native species in the Atlantic known as *Grateloupia doryphora*. European Journal of Phycology, 37: 349–359.

Giacobbe, M. G., and Maimone, G. 1994. First report of *Alexandrium minutum* Halim in a Mediterranean lagoon. Cryptogamie Algologie, 15(11): 47–52.

Glasgow, H. B., Burkholder, J. M., Morton, S. L., and Springer, J. 2001. A second species of ichtyotoxic *Pfiesteria* (Dinamoebales, Dinophyceae). Phycologia, 40(3): 234–245.

Goulletquer, P., Bachelet, G., Sauriau, P. G., and Noel, P. 2002. Open Atlantic coast of Europe – a century of introduced species into French waters. *In* Aquatic Invasive Species of Europe: Distribution, Impacts and Management, pp. 276–290. Ed. by E. Leppäkoski, S. Gollasch, and S. Olenin. Kluwer Academic Publishers, Dordrecht.

Gravez, V., Boudouresque, C-F., Meinesz, A., and Scabbia, G. 2001. Fourth International Workshop on Caulerpa taxifolia, Lerici, 1–2 February 1999. GIS Posidonie, Marseille.

Guiry, M. D., Rindi, F., and Guiry, G. M. 2006. AlgaeBase version 4.0. World-wide electronic publication, National University of Ireland, Galway. http://www.algaebase.org.

Hajdu, S., Edler, L., Olenina, I., and Witek, B. 2000. Spreading and establishment of the potentially toxic dinoflagellate Prorocentrum minimum in the Baltic Sea. International Review of Hydrobiology, 85: 561–575.

Hales, J. M., and Fletcher, R. L. 1989. Studies on the recently introduced brown alga *Sargassum muticum* (Yendo) Fensholt. V. Receptacle initiation and growth, and gamete release in laboratory culture. Botanica Marina, 33: 241–249.

Hallegraeff, G., Anderson, D. M., Cembella, A. D. 2003. Manual on Harmful Marine Microalgae. UNESCO Publishing, Paris.

Harlin, M. M., and Villalard-Bohnsack, M. 2001. Seasonal dynamics and recruitment strategies of the invasive seaweed *Grateloupia doryphora* (Halymeniaceae, Rhodophyta) in Narragansett Bay and Rhode Island Sound, Rhode Island, USA. Phycologia, 40: 468–474.

Hawkes, M. W., and Scagel, R. F. 1986. The marine algae of British Columbia and northern Washington: division Rhodophyta (red algae), class Rhodophyceae, order Rhodomeniales. Canadian Journal of Botany, 64: 1549–1580.

Hay, C. H., and Villouta, E. 1993. Seasonality of the adventive Asian kelp *Undaria pinnatifida* in New Zealand. Botanica Marina, 36: 461–476.

Hitchcock, A. S. 1950. Manual of the grasses of the United States. US Department of Agriculture, 200: 1–1051.

Hopkins, C. C. E. 2002. Introduced marine organisms in Norwegian waters, including Svalbard. *In* Aquatic Invasive Species of Europe: Distribution, Impacts and Management, pp 240–252. Ed. by E. Leppäkoski, S. Gollasch, and S. Olenin. Kluwer Academic Publishers, Dordrecht.

ICES. 1987. Report of the Working Group on Introductions and Transfers of Marine Organisms, Brest, France, 10–12 June 1987. ICES CM 1987/F:35.

ICES. 1990. Report of the Working Group on Introductions and Transfers of Marine Organisms, Halifax, Canada, 6–8 June 1990. ICES CM 1990/F:14.

ICES. 1992 Report of the Working Group on Introductions and Transfers of Marine Organisms, Lisbon, Portugal, 14–17 April 1992. ICES CM 1992/POLL:3.

ICES. 1993. Report of the Working Group of Introductions and Transfers of Marine Organisms, Aberdeen, Scotland, 26–28 April 1993. ICES CM 1993/ENV:7.

ICES. 1994. Report of the Working Group of Introductions and Transfers of Marine Organisms, Mystic, CT, 20–22 April 1994. ICES CM 1994/ENV:7.

ICES. 1995. Report of the Working Group of Introductions and Transfers of Marine Organisms, Kiel, Germany, 10–13 April 1995. ICES CM 1995/ENV:9.

ICES. 1996. Report of the Working Group of Introductions and Transfers of Marine Organisms, Gdynia, Poland, 22–26 April 1996. ICES CM 1996/ENV:8.

ICES. 1997a. Report of the Working Group of Introductions and Transfers of Marine Organisms, La Tremblade, France, 22–25 April 1997. ICES CM 1997/Env:6.

ICES. 1997b. Report of the Study Group on Marine Biocontrol and Invasive Species.

ICES. 1998. Report of the Working Group of Introductions and Transfers of Marine Organisms, The Hague, Netherlands, 25–27 March 1998. ICES CM 1998/ACME:4.

ICES. 1999. Report of the Working Group of Introductions and Transfers of Marine Organisms, Conwy, UK, 14–16 April 1999. ICES CM 1999/ACME:1.

ICES. 2000a. Report of the Working Group of Introductions and Transfers of Marine Organisms, Parnu, Estonia, 27–29 March 2000. ICES CM 2000/ACME:07.

ICES. 2000b. Report of the Study Group on Ballast and Other Ship Vectors, By Correspondence. ICES CM 2000/ACME:08.

ICES. 2001. Report of the Working Group of Introductions and Transfers of Marine Organisms, Barcelona, Spain, 21–23 March 2001. ICES CM 2001/ACME:08.

ICES. 2002 Report of the Working Group of Introductions and Transfers of Marine Organisms, Gothenburg, Sweden, 20–22 March 2002. ICES CM 2002/ACME:06.

ICES. 2007. Alien Species Alert: *Undaria pinnatifida* (wakame or Japanese kelp). ICES Cooperative Research Report, No. 283. 38 pp.

Jakobsen, K. S., Tengs, T., Vatne, A., Bowers, H. A., Oldach, D. W., Burkholder, J. M., Glasgow, H. B., Rublee, P. A., and Klaveness, D. 2002. Discovery of the toxic dinoflagellate *Pfiesteria* in northern European waters. Proceedings of the Royal Society of London Series B-Biological Sciences, 269(1487): 211–214.

James, K. J., Furey, A., Lehane, M., Ramstad, H., Aune, T., Hovgaard, P., Morris, S., Higman, W., Satake, M., and Yazumoto, T. 2002. First evidence of an extensive northern European distribution of azaspiracid poisoning (AZP) toxins in shellfish. Toxicon, 40: 909–915.

Jansson, K. 1994. Alien species in the marine environment. Introductions to the Baltic Sea and the Swedish west coast. Swedish Environmental Protection Agency Report, 4357: 1–68.

Jousson, O., Pawlowski, J., Zaninetti, L., Zechman, F. W., Dini, F., Di Guiseppe, G., Woodfield, R., Millar, A., and Meinesz, A. 2000. Invasive alga reaches California – The alga has been identified that threatens to smother Californian coastal ecosystems. Nature, 408(6809): 157–158.

Kaiser, J. 2000. Ecology – California algae may be feared European species. Science, 289(5477): 222–223.

Karlsson, J., and Loo, L-O. 1999. On the distribution and the continuous expansion of the Japanese seaweed – *Sargassum muticum* – in Sweden. Botanica Marina, 42: 285–294.

Karlsson, J., Kuylenstierna, M., and Åberg, P. 1992. Contributions to the seaweed flora of Sweden: New or otherwise interesting records from the west coast. Acta Phytogeographica Suecica, 78: 49–63.

Kask, M., Vaga, A. 1966. *Eesti taimede määraja*. Kirjastus "Valgus", Tallinn. 1187 pp.

Kittelson, P. M., and Boyd, M. J. 1997. Mechanisms of expansion for an introduced species of cordgrass, *Spartina densiflora*, in Humboldt Bay, California. Estuaries, 20(4): 770–778.

Klein, J., and Verlaque, M. 2005. *Laurencia caduciramulosa* Masuda et Kawaguchi (Ceramiales, Rhodophyceae), first record on the Mediterranean coast of France. Cryptogamie Algologie, 26(2): 209–216.

Køie, M., Kristiansen, A., and Weitemeyer, S. 2000. Havets dyr og planter. Gads Forlag, København. 351 pp. (in Danish).

Kooistra, W. H. C. F., de Boer, M. K., Vrieling, E. G., Connell, L. B., and Gieskes, W. W. C. 2001. Variations along ITS markers across strains of *Fibrocapsa japonica* (Rhaphidophyceae) suggests hybridisation events and recent range expansion. Journal of Sea Research, 46: 213–222.

Kornmann, P., and Sahling, P-H. 1983. Meeresalgen von Helgoland: Ergänzung. Helgoländer Meeresuntersuchungen, 36: 1–65.

Kraan, S., and Barrington, K. A. 2005. Commercial farming of *Asparagopsis armata* (Bonnemaisoniceae, Rhodophyta) in Ireland, maintenance of an introduced species? Journal of Applied Phycology, 17: 103–110.

Kylin, H. 1944. Die Rhodophyceen der schwedischen Westküste. Lunds Universitets Årsskrift N. F. Avd. 2 Bd 40(2): 1–104 + 32 plates.

Laabir, M., Génovési-Giunti, B., Barré, N., Vaquer, A., Collos, Y., Cecchi, P., Pons, V., and Bibent, B. 2002. Study on the biology of *Alexandrium catenella*, a toxic dinoflagellate species colonising Thau Lagoon (French Mediterranean coast). 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 159.

Lein, T. E. 1999. A newly immigrated red alga ("*Dasysiphonia*", Dasyaceae, Rhodophyta) to the Norwegian coast. Sarsia, 84: 85–88.

Litaker, R. W., Vandersea, M. W., Kibler, S. R., Madden, V. J., Noga, E. J., and Tester, P. A. 2002a. Life cycle of the heterotrophic dinoflagellate *Pfiesteria piscicida* (Dinophyceae). Journal of Phycology, 38: 442–463.

Litaker, R. W., Vandersea, M. W., Kibler, S. R., Noga, E. J., and Tester, P. A. 2002b. Reply to comment on the life cycle and toxicity of *Pfiesteria piscicida* revisited. Journal of Phycology, 38: 1268–1272.

Litaker, R. W., Steidinger, K. A., Mason, P. L., Landsberg, J. H., Shields, J. D., Reece, K. S., Haas, L. W., Vogelbein, W. K., Vandersea, M. W., Kibler, S. R., and Tester, P. A. 2005. The reclassification of Pfiesteria shumwayae (Dinophyceae): Pseudopfiesteria, gen. nov. Journal of Phycology, 41(3): 643–651.

Lugliè, A., Giacobbe, M., Fiocca, F., Sannio, A., and Sechi, N. 2002. The geographical distribution of *Alexandrium catenella* is extending to Italy! First evidences from the Tyrrhenian Sea. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 177.

Luther, H. 1979. *Chara connivens* in the Baltic Sea area. Annales Botanici Fennici, 16: 141–150.

MacKinnon, S. L., Cembella, A. D., Quilliam, M. A., LeBlanc, P., Lewis, N., Hardstaff, W. R., Burton, I. W., and Walter, J. A. 2002. The characterization of two new spiroldes isolated from Danish strains of the toxigenic dinoflagellate *Alexandrium ostenfeldii*. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 180.

Maggs, C. A., and Hommersand, M. H. 1993. Seaweeds of the British Isles Vol. 1 Rhodophyta, Part 3A Ceramiales. HMSO, London. 444 pp.

Maggs, C. A., and Stegenga, H. 1999. Red algal exotics on North Sea coasts. Helgoländer Meeresuntersuchungen, 52: 243–258.

Magne, F. 1992. *Goniotrichopsis* (Rhodophyceae, Porphyridiales) in Europe. Cryptogamie Algologie, 13: 109–112.

Mathieson, A. C., Dawes, C. J., Harris, L. G., and Hehre, E. J. 2003. Expansion of the Asiatic green alga Codium fragile subsp. tomentosoides in the Gulf of Maine. Rhodora, 105(921): 1–53.

McIvor, L., Maggs, C. A., Provan, J., and Stanhope, M. J. 2001. *rbc*L sequences reveal multiple cryptic introductions of the Japanese red alga *Polysiphonia harveyi*. Molecular Ecology, 10: 911–919.

Meinesz, A. 1997. The use of Ascoglossan as a biological control of *Caulerpa taxifolia* in the Mediterranean Sea. *In* Dynamics of Invasive Marine Species: Application to the Expansion of Caulerpa taxifolia in the Mediterranean. Actes de Colloques, Septembre 1997, Académie des Sciences, pp. 291–300. Lavoiser Technique & Documentation, Paris (in French).

Meinesz, A., Belsher, T., Thibaut, T., Antolic, B., Ben Mustapha, K., Boudouresque, C-F., Chiaverini, D., Cinelli, F., Cottalorda, J-M., Djellouli, A., El Abed, A., Orestano, C., Grau, A. M., Ivesa, L., Jaklin, A., Langar, H., Massuti-Pascual, E., Peirano, A., Tunesi, L., de Vaugelas, J., Zavodnik, N., and Zuljevic, A. 2001. The introduced green alga *Caulerpa taxifolia* continues to spread in the Mediterranean. Biological Invasions, 3: 201–210.

Miller, A. W., Chang, A. L., Cosentino-Manning, N., Ruiz, G. M. 2004. A new record and eradication of the Northern Atlantic alga *Ascophyllum nodosum* (Phaeophyceae) from San Francisco Bay, California, USA. Journal of Phycology, 40: 1028–1031.

Montresor, M., Zingone, A., and Sarno, D. 1998. Dinoflagellate cyst production at a coastal Mediterranean site. Journal of Plankton Research, 20(12): 2291–2312.

Montresor, M., Sarno, D., and Zingone, A. 2000. Can we peacefully live together with harmful phytoplankton? The case of the Gulf of Naples. 9th International Conference on Harmful Algal Blooms, Tasmania, Australia, 7–11 February 2000, p. 182. University of Tasmania, Hobart (abstract).

Ni Chualáin, F., Maggs, C. A., Saunders, G. W., and Guiry, M. D. 2004. The invasive genus *Asparagopsis* (Bonnemaisoniaceae, Rhodophyta): Molecular systematics, morphology, and ecophysiology of *Falkenbergia* isolates. Journal of Phycology, 40: 1112–1126.

Nielsen, R. 2002. Danish seaweeds. http://www.nathimus.ku.dk/BOT/DIV/distribution-index.pdf.

Occhipinti Ambrogi, A. 2002. Current status of aquatic introductions in Italy. *In* Aquatic Invasive Species of Europe: Distribution, Impacts and Management, pp 311–324. Ed. by E. Leppäkoski, S. Gollasch, and S. Olenin. Kluwer Academic Publishers, Dordrecht.

Panayotis, P., and Montesanto, B. 1994. *Caulerpa racemosa* (Chlorophyta) on the Greek coasts. Cryptogamie Algologie, 15: 159–161.

Parente, M. I., Neto, A. I., and Fletcher, R. L. 2003. Morphology and life history studies of *Endarachne binghamiae* (Scytosiphonaceae, Phaeophyta) from the Azores. Aquatic Botany, 76: 109–116.

Pena, V., and Bárbara, I. 2003. Seaweeds of A Coruña harbour (N. W. Spain). Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and book of abstracts, P5–15, p. 90.

Peters, A. F., Kawai, H., and Novaczek, I. 1993. Intraspecific sterility barrier confirms that introduction of *Sphaerotrichia divaricata* (Phaeophyceae, Chordariales) into the Mediterranean was from Japan. Hydrobiologia, 260/261: 31–36.

Piazzi, L., and Cinelli, F. 2003. Evaluation of benthic macroalgal invasion in a harbour area of the western Mediterranean Sea. European Journal of Phycology, 38: 223–231.

Piazzi, L., Balata, D., Ceccherelli, G., and Cinelli, F. 2001. Comparative study the growth of two co-occurring introduced green algae *Caulerpa taxifolia* and *Caulerpa racemosa*

along the Tuscan coast (Italy, western Mediterranean). Cryptogamie Algologie, 22: 459–466.

Piazzi, L., Balata, D., and Cinelli, F. 2002. Epiphytic macroalgal assemblages of *Posidonia oceanica* rhizomes in the western Mediterranean. European Journal of Phycology, 37: 69–76.

Renfrew, D. E., Gabrielson, P. W., and Scagel, R. F. 1989. The marine algae of British Columbia, northern Washington, and southeast Alaska – division Rhodophyta (red algae), class Rhodophyceae, order Gelidiales. Canadian Journal of Botany, 67: 3295–3314.

Rhodes, L. L., Burkholder, J. M., Glasgow, H. B., Rublee, P. A., Allen, C., and Adamson, J. E. 2002. *Pfiesteria shumwayae* (Pfiesteriaceae) in New Zealand. New Zealand Journal of Marine and Freshwater Research, 36: 621–630.

Ribera, M. A., Ballesteros, E., Boudouresque, C-F., Gómez, A., and Gravez, V. 1996. Second International Workshop on *Caulerpa taxifolia*, Barcelona, Spain, 15–17 December 1994. Univ. de Barcelona.

Ribera Siguan, M. A. 2002. Review of non-native marine plants in the Mediterranean Sea. *In* Aquatic Invasive Species of Europe: Distribution, Impacts and Management, pp. 291–310. Ed. by E. Leppäkoski, S. Gollasch, and S. Olenin. Kluwer Academic Publishers, Dordrecht.

Rico, J., and Fernández, C. 1997. Ecology of *Sargassum muticum* on the north coast of Spain. II. Physiological differences between *Sargassum muticum* and *Cystoseira nodicaulis*. Botanica Marina, 40: 405–410.

Rindi, F., Papi, I., and Cinelli, F. 1996. New records of Ceramiales (Rhodophyta) for the North-Western Mediterranean. Cryptogamie Algologie, 17(4): 223–238.

Rindi, F., Sartoni, G., and Cinelli, F. 2002. A floristic account of the benthic marine algae of Tuscany (Western Mediterranean Sea). Nova Hedwigia, 74: 201–250.

Rojas-Gonzáles, B., Afonso-Carillo, B. J., Ibeas, C. 1994. New records of Rhodomelaceae (Rhodophyta) from the Canary Islands. Botanica Marina, 37: 133–138.

Roland, A. E., and Smith, E. C. 1969. The Flora of Nova Scotia. The Nova Scotia Museum, Halifax. 704 pp.

Rosenvinge, L. K. 1920. Om nogle i nyere tid indvandrede havalger i de danske farvande. Botanisk Tidskrift, 37: 125–135 (in Danish with English abstract).

Rublee, P. A., Allen, C., Schaefer, E., Rhodes, L., Adamson, J., Lapworth, C., Burkholder, J., and Glasgow, H. 2002. Global distribution of toxic *Pfiesteria* complex species. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 246.

Rueness, J. 1997. A culture study of *Caulacanthus ustulatus* (Caulacanthaceae, Gigartinales, Rhodophyta) from Europe and Asia. Cryptogamie Algologie, 18: 175–185.

Rueness, J. 1998. Alger i farger – En felthåndbok om kystens makroalger. Almater Forlag AS, Oslo. 136 pp. (in Norwegian).

Rueness, J. 2005. Life history and molecular sequences of *Gracilaria vermiculophylla* (Gracilariales, Rhodophyta), a new introduction to European waters. Phycologia, 44: 120–128.

Rueness, J., and L'Hardy-Halos, M. T. 1991. *Aglaothamnion westbrookiae* sp. nov. (Rhodophyta), a species previously confused under the name *Callithamnion byssoides*. Journal of Phycology, 27: 649–652.

Rueness, J., and Rueness, E. K. 2000. *Caulacanthus ustulatus* (Gigartinales, Rhodophyta) from Brittany (France) is an introduction from the Pacific Ocean. Cryptogamie Algologie, 21: 355–363.

Rühl, A., Hummert, C., Gerdts, G., and Luckas, B. 2002. Spirolides (algal neurotoxins) found near the Scottish east coast. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 246.

Ruperez, P., and Saura-Calixto, F. 2001. Dietary fibre and physiochemical properties of edible Spanish seaweeds. European Food Research and Technology, 212: 349–354.

Sanchez, I., Fernandez, C., and Arenas, F. 2003. Survival rates of *Sargassum muticum* in rockweed communities. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and book of abstracts, P1–6, pp. 66–67.

SanLeón, D. G., Izco, J., and Sánchez, J. M. 1999. *Spartina patens* as a weed in Galician saltmarshes (NW Iberian Peninsula). Hydrobiologia, 415: 213–222.

Sansón, M., and Reyes, J. 1995. Morphological and geographical observations on four species of Ceramiaceae (Rhodophyta) new to Canary Islands. Botanica Marina, 38: 89–95.

Sansón, M., Reyes, J., Afonso-Carrillo, J., and Muñoz, E. 2002. Sublittoral and deep-water red and brown algae new from the Canary Islands. Botanica Marina, 45: 35–49.

Sartoni, G., and Boddi, S. 1993. *Apoglossum gregarium* (Delesseriaceae, Rhodophyta), a new record for Mediterranean algal flora. Botanica Marina, 36: 297–302.

Sartoni, G., and De Biasi, A. M. 1999. A survey of marine algae of Milos Island, Greece. Cryptogamie Algologie, 20: 271–283.

Schaffelke, B., Evers, D., and Walhorn, A. 1995. Selective grazing of the isopod *Idotea baltica* between *Fucus evanescens* and *F. vesiculosus* from Kiel Fjord (western Baltic). Marine Biology, 124: 215–218.

Schories, D., Albrecht, A., and Lotze, H. 1997. Historical changes and inventory of macroalgae from Königshafen Bay in the northern Wadden Sea. Helgoländer Meeresuntersuchungen, 51: 321–341.

Shumway, S. E., Lewitus, A., Coen, A., and Burkholder, J. M. 2002. Shellfish transfer and transplantation as vectors for introduction and establishment of harmful algal blooms via dinoflagellate cells and cysts: potential or imaginary risk? 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 259.

Silva, P. C., Woodfield, R. A., Cohen, A. N., Harris, L. H., and Goddard, J. H. R. 2002. First report of the Asian kelp *Undaria pinnatifida* in the northeastern Pacific Ocean. Biological Invasions, 4: 333–338.

Simon, C., Gall, E. A., and Deslandes, E. 2001. Expansion of the red alga Grateloupia doryphora along the coasts of Brittany (France). Hydrobiologia, 443: 23–29.

Soto Moreno, J., and Conde Poyales, F. 1993. Datos sobre la flora algal betonica de la isla de Albaran (Mar de Alboran, Mediterrano occidental). Cryptogamie Algologie, 14: 183–190.

South, G. R. 1968. Observations on the occurrence of a species of *Lomentaria* in southern British Columbia and northern Washington. Canadian Journal of Botany, 46: 727–732.

Springer, J. J., Shumway, S. E., Burkholder, J. M., and Glasgow, H. B. 2002. Interactions between the toxic estuarine dinoflagellate *Pfieasteria piscicida* and two species of bivalve molluscs. Marine Ecology Progress Series, 245: 1–10.

Stæhr, P. A., Pedersen, M. F., Thomsen, M. S., Wernberg, T., and Krause-Jensen, D. 2000. Invasion of *Sargassum muticum* in Limfjorden (Denmark) and its possible impact on the indigenous macroalgal community. Marine Ecology Progress Series, 207: 79–88.

Standley, L. A. 1983. *Caarex kobomugi* Owhi an adventive sedge new to New England. Rhodora, 85: 265–269.

Steidinger, K. A., Burkholder, J. M., Glasgow, H. B., Hobbs, C. W., Garrett, J. K., Truby, E. W., Noga, E. J., and Smith, S. A. 1996. *Pfiesteria piscicida* gen et sp nov (Pfiesteriaceae

fam nov), a new toxic dinoflagellate with a complex life cycle and behavior. Journal of Phycology, 32: 157–164.

Steidinger, K., Landsberg, J., Richardson, R. W., Truby, E., Blakesley, B., Scott, P., Tester, P., Tengs, T., Mason, P., Morton, S., Seaborn, D., Litaker, W., Reece, K., Oldach, D., Haas, L., and Vasta, G. 2001. Classification and identification of *Pfiesteria* and *Pfiesteria*-like species. Environmental Health Perspectives, 109(Suppl.5): 661–665.

Stiger, V., Jechoux, G., Le Berre, S., Plouguerne, E., Trepos, R., and Deslandes, E. 2003. Comparison of some biological characteristics of two introduced species in French Brittany, *Sargassum muticum* (Fucales, Phaeophyceae) and *Grateloupia doryphora* (Cryptonemiales, Rhodophyceae): preliminary results. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and book of abstracts, P1–8, p. 67.

Tittley, I., and Neto, A. I. 2005. The marine algal (seaweed) flora of the Azores: additions and amendments. Botanica Marina, 48: 248–255.

Tognetto, L., Bellato, S., Moro, I., and Andreoli, C. 1995. Occurrence of *Ostreopsis ovata* (Dinophyceae) in the Tyrrhenian Sea during summer 1994. Botanica Marina, 38: 291–295.

Tomas, C. R., Ono, C., Yoshimatsu, S., and Goebel, J. 2002. *Chattonella verriculosa* and related species from Japan, Europe (North Sea) and US coastal waters: cases of mistaken identity? 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 282.

Torn, K., and Martin, G. 2003. Changes in the distribution of charophyte species in enclosed seabays of western Estonia. Proceedings of the Estonian Academy of Sciences, Biology and Ecology, 2003: 134–140.

Torn, K., Martin, G., Kukk, H., and Trei, T. 2003. Distribution of charophyte species in Estonian coastal water (NE Baltic Sea). Scientia Marina, 67(Suppl. 3).

Trowbridge, C. D. 1998. Ecology of the green macroalga *Codium fragile* (Suringar) Hariot 1889; invasive and non-invasive subspecies. Oceanography and Marine Biology, Annual Review, 36: 1–64.

Trowbridge, C. D. 2001. Coexistence of introduced and native congeneric algae: *Codium fragile* and *C tomentosum* on Irish rocky intertidal shores. Journal of the Marine Biological Association of the United Kingdom, 81: 931–937.

Trowbridge, C. D., Farnham, W. F., and White, L. 2003. Thriving populations of the native macroalga *Codium tomentosum* on Guernsey rocky shores. Third European Phycological Congress, Queens University, Belfast, 21–26 July 2003. Programme and book of abstracts P1–4, p. 66.

Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M., and Webb, D. A. 1972. Flora Europaea, Vol. 3. Diapensiaceae to Myoporaceae. Cambridge University Press, Cambridge. 370 pp.

Tutin, T. G., Heywood, V. H., Burges, N. A., Moore, D. M., Valentine, D. H., Walters, S. M., and Webb, D. A. 1980. Flora Europaea, Vol. 5. Alismataceae to Orchidaceae *(Monocotyledones)*. Cambridge University Press, Cambridge. 452 pp.

van der Velde, G., Nagelkerken, I., Rajagopal, S., and bij de Vaate, A. 2002. Invasions by alien species in inland freshwater bodies in western Europe: the Rhine delta. *In* Aquatic Invasive Species of Europe: Distribution, Impacts and Management, pp. 360–372. Ed. by E. Leppäkoski, S. Gollasch, and S. Olenin. Kluwer Academic Publishers, Dordrecht.

Verlaque, M. 1994. Inventaire des plantes introduites en Méditerranée: origines et répercussions sur l'environment et les activités humaines. Oceanologica Acta, 17: 1–22.

Verlaque, M. 2001. Checklist of the macroalgae of Thau Lagoon (Hérault, France), a hot spot of marine species introduction in Europe. Oceanologica Acta, 24: 29–49.

Verlaque, M. 2002. Morphology and reproduction of *Dasya sessilis* (Ceramiales, Rhodophyta) – an introduced Asian species thriving in Thau Lagoon (France, Mediterranean Sea). Phycologia, 41: 612–618.

Verlaque, M., and Latala, A. 1996. Sur une espèce Japonaise de *Chondrus* (Gigartinaceae, Rhodophyta) accidentellement indroite dans l'Étang de Thau (France, Mediterranée). Cryptogamie Algologie, 17(3): 153–164.

Verlaque, M., Boudouresque, C-F., Meinesz, A., and Gravez, V. 2000. The *Caulerpa racemosa* complex (Caulerpales, Ulvophyceae) in the Mediterranean Sea. Botanica Marina, 43: 49–68.

Verlaque, M., Belsher, T., and Deslous-Paoli, J. M. 2002. Morphology and reproduction of Asiatic *Ulva pertusa* (Ulvales, Chlorophyta) in Thau Lagoon (France, Mediterranean Sea). Cryptogamie Algologie, 23: 301–310.

Verlaque, M., Durand, C., Huisman, J. M., Boudouresque, C. F., and Le Parco, Y. 2003. On the identity and origin of the Mediterranean invasive *Caulerpla racemosa* (Caulerpales, Chlorophyta). European Journal of Phycology, 38: 325–339.

Viejo, R. M. 1997. The effects of colonization by *Sargassum muticum* on tidepool macroalgal assemblages. Journal of the Marine Biological Association of the United Kingdom, 77: 325–340.

Viejo, R. M., Arrontes, J., and Andrew, N. L. 1995. An experimental evaluation of the effect of wave action on the distribution of *Sargassum muticum* in northern Spain. Botanica Marina, 38: 437–441.

Vila, M., Camp, J., Garces, E., Maso, M., and Delgado, M. 2001. High resolution spatio-temporal detection of potentially harmful dinoflagellates in confined waters of the NW Mediterranean. Journal of Plankton Research, 23: 497–514.

Villalard-Bohnsack, M., and Harlin, M. M. 1997. The appearance of *Grateloupia doryphora* (Halymeniaceae, Rhodophyta) on the northeast coast of North America. Phycologia, 36: 324–328.

Villalard-Bohnsack, M., and Harlin, M. M. 2001. *Grateloupia doryphora* (Halymeniaceae, Rhodophyta) in Rhode Island waters (USA): geographical expansion, morphological variations and associated algae. Phycologia, 40: 372–380.

Vogelbein, W. K., Lovko, V. J., Shields, J. D., Reece, K. S., Mason, P. L., Haas, L. W., and Walker, C. C. 2002. *Pfiesteria shumwayae* kills fish by micropredation not exotoxin secretion. Nature, 418(6901): 967–970.

Voisin, M., Engel, C. R., and Viard, F. 2005. Differential shuffling of native diversity across introduced regions in a brown alga: Aquaculture vs. maritime traffic effects. Proceedings of the National Academy of Sciences, 102(15): 5432–5437.

Wallentinus, I. 1992. The dispersal of *Sargassum muticum* in the ICES countries. *In* Report of the Working Group on Introduction and Transfers of Marine Organisms, 14–17 April 1992, Lisbon. ICES CM 1992/Poll:3.

Wallentinus, I. 1999a. Introductions and transfers of plants. *In* Status of Introductions of Non-indigenous Marine Species to North Atlantic Waters 1981–1991, pp. 1–43. Ed. by A. L. S. Munro, S. D. Utting, and I. Wallentinus. ICES Cooperative Research Report, No. 231. pp. 91.

Wallentinus, I. 1999b. *Undaria pinnatifida* (Harvey) Suringar, 1872. *In* Exotics Across the Ocean. Case Histories on Introduced Species, pp. 11–19. Ed. by S. Gollasch, D. Minchin, H. Rosenthal, and M. Voigt. University of Kiel.

Wallentinus, I. 1999c. *Sargassum muticum* (Yendo) Fensholt, 1955. *In* Exotics Across the Ocean. Case Histories on Introduced Species, pp. 21–30. Ed. by S. Gollasch, D. Minchin, H. Rosenthal, and M. Voigt. University of Kiel.

Wallentinus, I. 2002. Introduced marine algae and vascular plants in European aquatic environments. *In* Aquatic Invasive Species of Europe: Distribution, Impacts and Management, pp. 27–54 + 1 App. Ed. by E. Leppäkoski, S. Gollasch, and S. Olenin. Kluwer Academic Publishers, Dordrecht. http://www.ku.lt/nemo/.

Walters, L. J., Brown, K. R., Stam, W. T., and Olsen, J. L. 2006. E-commerce and *Caulerpa*: unregulated dispersal of invasive species. Frontiers in Ecology and the Environment, 4(2): 75–79.

Watson, K. L., Cheney, D. P., and Levine, I. 2000. Biomonitoring of an aquacultured introduced seaweed, *Porphyra yezoensis* (Rhodophyta, Bangiophycidae), in Cobscook Bay, Maine, USA. *In* Marine Bioinvasions. Proceedings of a Conference, 24–27 January 1999, pp. 260–264. Ed. by J. Pederson. MIT Sea Grant College Program, MIT, Cambridge, MA.

Weber, E., and D'Antonio, C. M. 1999. Germination and growth responses of hybridizing *Carpobrotus* species (Aizoaceae) from coastal California to soil salinity. American Journal of Botany, 86: 1257–1263.

Wennberg, T. 1992. Colonization and succession of macroalgae on a breakwater in Laholm Bay, a eutrophicated brackish water area (SW Sweden). Acta Phytogeographica Suecica 78: 65–77.

Wernberg, T., Thomsen, M. S., Stæhr, P. A., and Pedersen, P. M. 2001. Comparative phenology of *Sargassum muticum* and *Halidrys siliquosa* (Phaeophyceae: Fucales) in Limfjorden, Denmark. Botanica Marina, 43: 31–39.

West, A. L., Mathieson, A. C., Klein, A. S., Neefus, C. D., and Bray, T. L. 2005. Molecular ecological studies of New England species of *Porphyra* (Rhodophyta, Bangiales). Nova Hedwigia, 80: 1–24.

Wiedemann, A. M., and Pickart, A. 1996. The *Ammophila* problem on the northwest coast of North America. Landscape and Urban Planning, 34: 287–299.

Wikström, S. A., von Wachenfeldt, T., and Kautsky, L. 2002. Establishment of the exotic species *Fucus evanescens* C. Ag. (Phaeophyceae) in Öresund, southern Sweden. Botanica Marina, 45: 510–517.

Williams, S. L., and Grosholz, E. D. 2002. Preliminary reports from the *Caulerpa taxifolia* invasion in southern California. Marine Ecology Progress Series, 233: 307–310.

Wolf, W. J. 2005. Non-indigenous marine and estuarine species in the Netherlands. Zoologische Mededelningen, 79–1: 1–116.

Wootton, L. S., Halsey, S. D., Bevaart, K., McGough, A., Ondreicka, J., and Patel, P. 2005. When invasive species have benefits as well as costs: Managing *Carex kobomugi* (Asiatic sand sedge) in New Jersey's coastal dunes. Biological Invasions, 7(6): 1017–1027.

Yasumoto, T., Igarashi, T., Furey, A., James, K. J., and Koike, K. 2002. Discovery of the origin of azaspiracids. 10th International Conference on Harmful Algae, October 21–25 2002, St Pete Beach, FL. Book of abstracts, p. 309.

Zenetos, A., Lantzouni, M., and Nicolaido, A. 2002. An account of our knowledge on fouling and ballast invaders in Greek waters. In: ICES/IMO/IOC Report of the Study Group on Ballast and Other Ship Vectors, 18–19 March 2002, Gothenburg, Sweden. ICES CM 2002/ACME:05.

Zuljevic, A., Thibaut, T., Elloukal, H., and Meinesz, A. 2001. Sea slug disperses the invasive *Caulerpa taxifolia*. Journal of Marine Biological Association of the United Kingdom, 81: 343–344.

Table 2.1. Introduced macroalgae ≤2002. Areas follow the international codes, except for Ire, which includes both Ireland and Northern Ireland. () = species listed, but not established |Az| = the Azores, |Bal| = the Baleares, |Co| = Corsica , |Sa| = Sardinia, |Si| = Sicily, c = central, n = northern, e = eastern, s = southern, w = western, Atl = the Atlantic, Pac = the Pacific, IndO = the Indian Ocean, Carib = the Caribbean, Mediterr = the Mediterranean, Eur = Europe, Afr = Africa, trop = tropical, subtr = subtropical. Vectors: Aqu = aquaria trade, Bal = solid ballast, Cul = cultivated, Exp = experiments, Fi = fishing activities (with baits or nets), Les = Lessepsian immigrant, Mol = mollusc transports, Oy = oyster transports, Pack = packing material around bait or shellfish, Shi = shipping activities (hull fouling or ballast). Species in bold = invasive, bold + underlined = highly invasive.

TAXON	TOTALLY NEW FOR ALL AREAS ≥1991	NEW IN SOME AREAS ≥1991 WHILE EARLIER IN OTHERS	INTRODUCED INTO THE FOLLOWING AREAS < 1991	PROBABLE ORIGIN	PROBABLE VECTOR
RHODOPHYTA (= Red algae)					
Acanthophora nayadiformis			s&seIT, MT, e&nGR	RedS/IndO	Les
Acrochaetium balticum	NL			Baltic Sea?	Shi?
Acrochaetium cf. *codicolum*	sFR			N.Atl?	Host?
Acrochaetium densum			NL	Pac?	?
Acrothamnion preissii		ES|Bal|	sFR, nw&sIT	IndO-Pac	Shi
Agardhiella subulata		NL	GB, sFR, sIT	N.Atl?/IndO?	Shi?/Mol?
Aglaothamnion feldmanniae			sFR, nw&neIT	N.Atl	Shi
Aglaothamnion halliae			NO, DE	N Amer?	Shi?
Ahnfeltiopsis flabelliformis	sFR			Japan	Oy
Anotrichium furcellatum			NL, nFR, GB, nES	n Pac?/Mediterr?	Oy?
Antithamnion amphigeneum		wIT	seES&|Bal|	e AU?	Shi
Antithamnion decipiens			ES|Bal, Alb|, FR|Co|, w,sw&seIT, nGR	Native?	?
Antithamnion densum			Ire, nFR, nES&|CanI|,	IndO-Pac?	?
Antithamnion diminuatum			PT|Az|, ES|Can|	s AU?/S.Atl?	Shi?
Antithamnion nipponicum		neIT	sFR, PT|Az|, US	Japan	Oy
Antithamnionella elegans			wIT	Japan	Shi
Antithamnionella spirographidis		BE	NL, GB, Ire, nwFR, ?PT|Az|, n&sES, seIT	n Pac	Shi
Antithamnionella sublittoralis			sIT	wPac	Shi
Antithamnionella ternifolia		BE	(NL), nFR, GB, Ire, PT, nES	South Hemisph?	Shi
Apoglossum gregarium	nwIT			RedS	
Asparagopsis armata			(NL), GB, Ire, n-sw&sFR, PT, n&sES, IT, MT	AU	Shi
"			s&nGR, PacUS		
Asparagopsis taxiformis	nw-sIT			trop & subtr	Les?
Bonnemaisonia hamifera			IS, FO, NO, wSE, DK, wDE, (NL), GB, Ire, n-swFR	Japan	Shi
"			PT|Az|), n&sES, IT|Si|, AtlCA, AtlUS		
Botryocladia madagascariensis	seIT, MT			s IndO	?
Callithamnion byssoides			PacUS	N.Atl.?	Shi?
Caulacanthus ustulatus			nwFR	nw Pac	Oy
Ceramium strobiliforme	s&eIT			Atl	?
Chondria coerulescens	sFR			Atl?/Mediterr?	Oy

TAXON	TOTALLY NEW FOR ALL AREAS ≥1991	NEW IN SOME AREAS ≥1991 WHILE EARLIER IN OTHERS	INTRODUCED INTO THE FOLLOWING AREAS < 1991	PROBABLE ORIGIN	PROBABLE VECTOR
Chondria polyrhiza		sIT	neGR	?	?
Chondria pygmaea	AL, IT, MT			RedS/IndO	Les
Chondrus giganteus	sFR			Japan?	Oy
Chryptonemia hibernica			(Ire)	Pac?	?
Chrysymenia wrightii			sFR	nw Pac	Oy
Colaconema dasyae			NL	Mediterr/ne Atl?	Host?
Dasya baillouviana		BaltDE	NO, wSE, DK, NL	Mediterr/ne Atl	Shi/Oy?
Dasya sessilis			sFR	nw Pac	Oy
Furcellaria lumbricalis			Atl CA	Europe	Shi
Gelidium vagum			PacCA, PacUS	Japan	Oy
Goniotrichiopsis sublittoralis			nFR, ES|Bal|	nw Pac?	?
Gracilaria multipartita			(Ire)	N.Atl	?
Gracilaria vermiculophylla	nFr, NL			wPac	Oy?/Shi?
Grallatoria reptans			ES|Can|	Carib?	Native?
Grateloupia filicina var. *luxurians*		n&sFR	GB, nwES,	AU?/Japan?	Oy
Grateloupia lanceolata	sFR			Japan	Oy
Grateloupia sp.			sFR	nw Pac?	Oy
Grateloupia turuturu		NL, PT, US	sGB, n&sFR, n&sES, IT	nw Pac	Mol/Shi
Griffithsia corallinoides			sFR, IT	Japan?/Atl?	Oy
Gymnophycus hapsiphorus			ES|CanI|	e Austr	Shi
Herposiphonia parca	sFR			Pac/Japan?	Oy
Heterosiphonia japonica	NO, wSE, NL, n&sFR, nES			Japan	Oy/Shi
Hypnea cornuta	sIT			RedS/IndO	Les
Hypnea esperi			sGR	RedS/IndO	Les
Hypnea spinella			sIT, neGR	Carib?	Shi?
Hypnea valentiae		sFR	sGR	Pac?, RedS	Oy?/Les
Laurencia brogniartii			nFR	Carib?/Japan?	Oy
Laurencia caduciramulosa		sFR	sIT	se Asia	Shi?
Laurencia chondroides			sIT	?	?
Laurencia majuscula			sIT	?	?
Laurencia okamurae			sFR	e Asia	Oy
Lithophyllum yessoense	sFR			Japan?	Oy
Lomentaria clavellosa			AtlUS	Europe?	?
Lomentaria hakodatensis		nES, neIT	s&nFR, PacCA, PacUS	Japan	Oy
Lomentaria orcadensis			(AtlCA)	E Atl?	?
Lophocladia lallemandii			sES, IT, MT, sGR	Pac?	Les?
Mastocarpus stellatus			DK, wDE	N.Atl	Exp/Shi?
Neosiphonia harveyi		wSE, BE, ES|CanI|	NO, DK, wDE, NL, GB, Ire, n&sFR,	n Pac/nwAtl	Shi/Host?
"			nES, nwIT, AtlCA, AtlUS		
Pikea californica			GB	California	Shi?
Platysiphonia caribaea			ES|CanI|	S.Atl?	?
Pleonosporium caribaeum			n&sFR, PT, sES&|CanI|	Antilles?	Shi

TAXON	TOTALLY NEW FOR ALL AREAS ≥1991	NEW IN SOME AREAS ≥1991 WHILE EARLIER IN OTHERS	INTRODUCED INTO THE FOLLOWING AREAS < 1991	PROBABLE ORIGIN	PROBABLE VECTOR
Plocamium secundatum			IT|Si|	sub-Antarctic?	?
Polysiphonia cf. *breviarticulata*			AtlUS	?	?
Polysiphonia denudata			PacUS	?	?
Polysiphonia fucoides			sFR, IT, GR?	N.Atl	Fi?
Polysiphonia morrowi	sFR, neIT			nw Pac	Oy
Polysiphonia paniculata			sFR	e Pac	Oy
Polysiphonia senticulosa	NL, BE			n Pac	Oy?
Porphyra yezoensis		(AtlCA?), AtlUS	sFR, (PacUS?)	Japan	Oy
Predaea huismanii			ES|CanI|	AU	Shi
Prionitis patens	sFR			Japan	Oy
Pterosiphonia pinnulata			sGB	Med?/Jap?	Oy?
Pterosiphonia tanakae	sFR			Japan	Oy
Rhodophysema georgii			sFR	N.Atl?/N.Pac?	Oy?
Sarconema filiforme			sFR	IndO	Les
Sarconema scinaiodides			GR	IndO	Les
Solieria chordalis			GB	Atl	?
Solieria filiformis			sIT	trop & subtr Atl?	?
Symphyocladia marchantioides			PT|Az|, nwIT	AU?	Shi?
Womersleyella setacea		ES|Bal|, MT, GR	sFR, nw-sIT	trop	Shi/Fi
PHAEOPHYCEAE (= Brown algae)					
Acrothrix gracilis	sFR			Japan	Oy
Ascophyllum nodosum ecad mackayi	(PacUS)			N Atl	Pack
Asperococcus scaber	NL			Adriat	?
Botryella sp.			NL	?	?
Chorda filum			sFR, GR?	N.Atl?/nw Pac?	Oy
Cladosiphon zosterae		sFR	sIT	Japan?/Atl?	Oy
Colpomenia peregrina			NO, wSE, DK, NL, GB, Ire, n&sFR,	Pac	Oy
"			PT, n&sES, IT, AtlCA		
Corynophlaea umbellata			GB	Japan?/Mediterr?	Host?
Desmarestia viridis			sFR, sES, neIT, HR	N.At?/nw Pac?	?/Oy?
Ectocarpus siliculosus var. hiemalis	neIT			Atl?	?
Elachista sp.			NL	?	?
Endarachne binghamiae			PT|Az|	?	?
Fucus evanescens			sNO, wSE, DK, GB, BaltDE,	n N.Atl	Fi
Fucus serratus			AtlCA	Europe	Shi
Fucus spiralis			(sFR)	N.Atl?	Fi
Halothrix lumbricalis			sFR, sIT	Japan?/N Atl?	Oy
Laminaria japonica			sFR	Japan	Oy
Leathesia difformis		neIT	sFR	N.Atl?	Oy
Leathesia verruculiformis	NL			nw Pac	?

TAXON	TOTALLY NEW FOR ALL AREAS ≥1991	NEW IN SOME AREAS ≥1991 WHILE EARLIER IN OTHERS	INTRODUCED INTO THE FOLLOWING AREAS < 1991	PROBABLE ORIGIN	PROBABLE VECTOR
Myriactula sp.			NL	?	?
Padina boergesenii			IT	Red S	Les
Pilayella littoralis			sFR	N.Atl?/N.Pac?	Oy
Punctaria tenuissima	neIT			N.Atl?	Oy
Sargassum muticum		BE, Ire, PT, neIT	NO, wSE, wDE, DK, NL,	n Pac	Oy
"			s&wGB, n&sFR, nES, PacCA, PacUS		
Scytosiphon dotyi		sFR	GB, neIT	Pac	Oy/Mol
Sorocarpus sp.	neIT			Atl?	?
Sphaerotrichia divaricata			sFR	Japan	Oy
Stypopodium schimperii	ES|CanI|, sGR			Red S	Les
Undaria pinnatifida		NL, BE, sGB, s&neIT, PacUS	n&sFR, nES	Japan	Oy, Cul.& Shi
CHLOROPHYTA (= Green algae)					
***Bryopsis* sp.**			PacUS	?	?
Caulerpa brachypus	se US			IndO/Pac?	Aqu?
Caulerpa racemosa		sFR, seES, nw-sIT	GR	IndOc?	Les/Aqu?
Caulerpa scalpelliformis			IT	IndOc	Les
Caulerpa taxifolia		ES|Bal|, nw-sIT, HR, PacUS	sFR, MO	trop Aquar	Aqu, Shi & Fi
Chara connivens			eSE, EE, LV, wRU, PL, BaltDE	w Eur, n Afr	Bal
Codium fragile* ssp. *tomentosoides		BE, AtlCA	IS, NO, wSE, DK, wDE, NL,GB, Ire, n&sFR,	Japan	Shi/Oy
"			n&sES, PT|Az|, s&neIT, GR, Atl&PacUS		
Codium fragile ssp. *scandinavicum*			NO, wSE, DK	Pac	Shi?
Codium fragile ssp. *atlanticum*			NO, NL, GB, Ire, PT|Az|	Pac	Shi?
Derbesia rhizophora			sFR	Japan	Oy
Monostroma obscurum			sFR	Atl?/Pac?	Oy
Ulva pertusa		NL	sFR	IndO/Pac?	Oy

3 Invertebrates

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This section reviews marine invertebrate introductions as identified in WGITMO national reports submitted between 1992 and 2002. First records of non-indigenous species are provided in Section 3.20. WGITMO reports should be consulted in conjunction with this text. Qualitative data on deliberate introductions and transfers, as well as live imports and transfers of non-native invertebrate species, are presented in Section 3.20 (excluding species movements within one country and species introductions for research purposes).

Most deliberate introductions of live invertebrates were for aquaculture, direct human consumption, or recreational purposes such as game fishing. In aquaculture, introductions of molluscs were most common. In a limited number of countries, crustacean introductions prevail. As reported in the previous summary report (1981–1991) of the molluscs, the Pacific oyster *Crassostrea gigas* continued to be of primary interest.

Other species of primary concern are the unintentional introduction of the large Asian gastropod mollusc *Rapana venosa* native to the Sea of Japan, Yellow Sea, Bohai Sea, and the East China Sea to Taiwan, and the intentional introduction of the red king crab, *Paralithodes camtschaticus*, native to the northwestern Pacific. WGITMO prepared detailed reports on these species that were published in the *ICES Cooperative Research Report* series (ICES, 2004, 2005b).

Rapana venosa was introduced to the Black Sea with subsequent range expansion to the Adriatic and Aegean Seas, the Chesapeake Bay on the east coast of the US, and the Rio de la Plata between Uruguay and Argentina. Reproductive populations are or appear to be present in all three receptor regions. In addition, there are a limited number of reports of the species from the Brittany coastline of France, Washington state (US), and two collections from the North Sea and New Zealand. The life history of this species makes it a viable candidate for continuing range expansion, and new invasions may have been facilitated by shipping vectors. The ecological impacts of this invader have been severe. The broad dietary preference for bivalve molluscs, including the soft-sediment infaunal mollusc species, identifies *R. venosa* predation as the prime reason for the decline of bivalves in invaded habitats. Their predatory impact comes especially into focus in areas with aquaculture activities involving bivalves.

The red king crab (*Paralithodes camtschaticus*) is a native of the Seas of Okhotsk and Japan, Bering Sea, and Northern Pacific Ocean. On the Asian side of the Pacific, crabs are found from Korea, along the east coast of Siberia and the coasts of the Kamchatka peninsula. In the Northeast Pacific and Bering Sea, red king crab are distributed throughout the Aleutian Island chain, north to Norton Sound, Alaska, and southeast to Great Bay in Vancouver Island, Canada. Russian scientists intentionally introduced larvae, juveniles, and adults of this species from the western Kamchatka peninsula to the southern Russian Barents Sea during the period 1961–1969. In the late 1970s, a reproductive population of red king crab had become established in the recipient region. The spread from this location may have resulted from natural dispersal of both larva by coastal currents and by adult migration. Scallop beds along the Norwegian coast represent a potential food reservoir in spring/summer (May–July) for mature migrating red king crab that are increasing food ingestion to replace recently expended energy. The impact of the crab was assessed by a before–after analysis. A predatory impact was clearly shown.

This documentation of species introductions is clearly an underestimate inasmuch as information on certain species is only available without taxonomic identification, e.g. bait worms. Furthermore, not all ICES member countries made national reports available at all WGITMO meetings. In the review below, the reporting year is indicated for ICES member

countries that submitted only a few reports. The national reports for Australia (observer status) and Italy (guest status) are also included in this review.

Many of the newly introduced species are attributed to the introduction vector shipping, i.e. ballast water and hull fouling, and are excluded here. For further details, consult the annexes to this document (Sections 3.20 and 4.12) and reports of ICES/IOC/IMO Working Group on Ballast and Other Ship Vectors (WGBOSV).

3.1 Belgium

National reports have been received since 2001.

Belgium expressed concern about the import and export of a wide variety of marine and freshwater species for aquaculture, aquaria, human consumption, and research. Much of this transfer appears uncontrolled. Oysters (*Crassostrea gigas*), imported from a number of countries (mainly from Canada and France in 2001 and 2002), have formed dense populations in several harbours and are present offshore on buoys. Other imported invertebrates included *Perna* sp., *Cyrtodaria siliqua*, *Mercenaria mercenaria*, *Spisula polynyma*, and *Ruditapes philippinarum*.

As reported by several other European countries, records of the North American lobster (*Homarus americanus* imported from Canada in 2001 and 2002 for direct human consumption) are of concern because of the potential genetic impact on native species.

3.2 Canada

During the reporting period, most of the deliberate species introductions were *Placopecten magellanicus*, *Crassostrea virginica*, *Mercenaria mercenaria*, and *Mytilus edulis*.

Extensive research continues on the invasion of the Eurasian zebra mussel *Dreissena polymorpha* in Canada. A second species of the invasive zebra mussel *Dreissena* has been identified. This quagga mussel (*D. bugensis*) is common in Lake Erie, Lake Ontario, and the St Lawrence River. Unlike its range expansion into the US, the zebra mussel has had a limited expansion north from the Great Lakes into adjacent Canadian watersheds. The zebra mussel continued its spread during the entire reporting period.

In 1993, blue mussels (*Mytilus edulis*) were imported from Ireland for processing evaluation on Prince Edward Island. The mussels were held in quarantine until processed. A health check revealed the presence of four parasites previously unrecorded in Canadian mussels (a *Mytilicola*-like copepod; *Steinhausia mytilovum*, a microsporidian of mussel ova; *Nematopsis*-like gregarine cysts; and a *Proctoeces*-like digenean flatworm). All the mussels were processed, and waste was disposed of according to guidelines set by the Prince Edward Island Introductions and Transfers Committee.

Manila clam (*Ruditapes philippinarum*) and *Crassostrea gigas* seedstock have been imported from the Pacific coast of the US since 1994 for beach seeding purposes. Japanese scallops (*Placopecten yessoensis*) were imported from Japan in 1994. In the latter case, only the F_1 generation will be outplanted into coastal waters of British Columbia.

In 1994, a South Carolina bivalve hatchery made an official request to the provincial Department of Fisheries and Aquaculture, New Brunswick, to import hard-shell clams (*Mercenaria mercenaria*). The health of the proposed export stock was examined by a shellfish pathologist on-site and certified to be free of disease organisms of concern. A permit was issued, allowing import into quarantine facilities in New Brunswick in February 1995. The stock spawned in quarantine, and 100% of the original imported organisms were killed and examined before release of the F_1 generation was authorized.

Adult sea urchins (*Strongylocentrotus purpuratus*, *S. droebachiensis*, and *Lytechinus pictus*) were imported by the Federal Department of Environment to Nova Scotia from California. The organisms were held in quarantine. The mussel (*Mytilus californianus*) was imported from California.

The use of bay scallops (*Argopecten irradians*) increased in the Maritime Provinces after a moratorium on their culture in open waters around Prince Edward Island had been lifted when studies showed that bay scallop parasites are not transmitted to five commercially important native bivalve species. Bay scallops are currently cultured along the Atlantic and Gulf of St Lawrence coasts of Nova Scotia. In 1993, New Brunswick introduced bay scallops into its Gulf of St Lawrence waters for aquaculture. Commercial facilities in the Maritimes should satisfy all the region's requirements for bay scallop spat.

Species imported for direct human consumption included rockfish (unspecified); red abalone (*Haliotis rufescens*); mussels (mostly *Mytilus edulis*); oysters (mostly *Crassostrea gigas*); prawns and shrimps (unspecified); crab (*Scilla serrata* and other unspecified); geoduck (*Panopea abrupta*); lobster (including rock and slipper lobster); sea urchins (*Strongylocentrotus* spp.); and whelk (unspecified).

A living specimen of the Chinese mitten crab (*Eriocheir sinensis*) was collected on the Canadian side of Lake Erie in April 1994. It is not clear whether the crab was introduced by shipping or is an escape from Asian markets after illegal import.

The rusty crayfish (*Orconectes rusticus*) was introduced in central and northwestern Ontario in 1994 and continues to spread. Its spread may be supported by bait-bucket transfers. Bait (unknown species) have also been introduced from the US.

In 1999, bar clams (*Spisula solidissima*) and ocean quahog (*Polynema mactromeris*) were transferred as seed stock, broodstock, or for relay purposes.

Since 1999, a new species, *Crassostrea sikamea* (Kumamoto oyster), has been cultured in British Columbia. All imports must be from health-certified sites. Especially in the Pacific Region, a growing number of freshwater and marine species have been imported live for human consumption, in addition to the traditional species found in the live food market (e.g. *Homarus* sp., *Mytilus edulis*).

Varnish clams (*Nuttallia obscurata*), first recorded from the Gulf of Georgia in the 1990s, were found in Barkley Sound on the west coast of Vancouver Island by 1997, including areas within the Pacific Rim National Park. They have now extended their range farther north. Because of the density of clams in some areas, a commercial and recreational fishery was considered.

Seafood outlets in the Pacific Region import a large variety of live invertebrates. There are annual reports in the news media of exotic species being found in waters near Vancouver, BC (e.g. Atlantic lobsters). One of the potential avenues of release of such species is through religious ceremonies for which live seafood is purchased for release. Accidental releases may also have occurred.

3.3 Denmark

The only national report received was submitted in 1993 (ICES, 1993) and did not include details of invertebrate importations. According to Swedish national reports, an unknown quantity of *Perna* sp. was imported to Denmark from Sweden in 2000.

3.4 Finland

Being exposed to brackish and freshwater conditions, marine introductions in Finland are rare. However, hobby aquarists and restaurants import live marine invertebrates, including oysters, lobsters, and crabs. These imports are permitted without government authorization inasmuch as it is unlikely that the species will survive when accidentally released. Nevertheless, authorization is required for live freshwater species imports when planning to release them in natural waters.

In the early 1990s, eggs of the signal crayfish (*Pacifastacus leniusculus*) were imported from Sweden. Other crayfish are mainly imported from Russia and the US, and they must be cooked before sale for consumption (soon after arriving in the country).

Since 1995, *Dreissena polymorpha* has been recorded in the eastern parts of the Gulf of Finland. The abundance of the species seems to be very low.

The mitten crab (*Eriocheir sinensis*), was first reported from the southeastern lake district in 1998.

3.5 France

An official request to study the introduction of the American bay scallop (*Argopecten irradians*) was submitted to ICES in time for the 1993 WGITMO meeting. The reasoning behind the proposed introduction was that the native scallop (*Pecten maximus*) fishery is insufficient to support market demand, and 40 000 tonnes of scallop meat are imported into France each year. Also, the recently introduced Japanese scallop *Patinopecten yessoensis* appears unsuitable for commercial culture. To satisfy the demand for scallop meat and to diversify from the monoculture of oysters in France, *Argopecten* will be assessed for its potential for commercial cultivation. Broodstock scallops will be imported from Canada or the US into quarantine at La Tremblade, and seed will be reared at the Argenton hatchery, following the ICES Code of Practice. Once the F_1 generation has been diagnosed free of diseases, etc., seed will be planted out at experimental sites. *Argopecten irradians* was imported and held in quarantine. Owing to a change of focus, this project was not developed further. However, individuals of *Argopecten irradians* are still in use (in containment) for scientific purposes.

France reported in 1994 that, as in previous years, oysters (*Crassostrea gigas*) were imported for consumption mainly from Ireland, Portugal, the UK, and the Netherlands, and imports continued during most of the reporting period. Mussels were also imported from several European countries (Spain, the Netherlands, UK, Ireland, and Denmark). In 1997, flat oysters (*O. edulis*) were also imported from the former Yugoslavia, Croatia, and the Netherlands.

An F_2 generation of *Patinopecten yessoensis* was produced from the F_1 generation resulting from the broodstock introduced into France in 1988. Bad results brought the planned programme to an end, but to maintain a strain of *P. yessoensis*, an F_2 generation composed of some thousands of individuals was immersed in bags during the juvenile stages in the estuary of the "Rade de Brest" (St Anne). Following this initiative, a new experiment was started in Ile de Houat to test the growth performance using the longline technique. From November 1993 to November 1994, the average size increased from 50 mm to 88 mm, with a survival rate of 75%.

The Manila clam (*Ruditapes philippinarum*) was introduced for aquaculture purposes during the 1980s. This species spread naturally to the extent that a public fishery is now operating year-round. Landings reached 4000–5000 metric tonnes in 1996. A fishery management plan was developed. *T. philippinarum* is now widely distributed. Both the Manila clam and the native European species *T. decussatus* occur concomitantly on the same beds, with an overlap of the populations. However, no hybrids have been yet observed. Juvenile clams of *T. philippinarum* were imported in 1998 for aquaculture purposes from Italy.

In 1998, juveniles (post-larval stages from hatcheries) of the shrimp *Penaeus japonicus* were imported from Spain for aquaculture purposes in ponds on the Atlantic coastline.

Three living adult gastropods of *Rapana venosa* were collected in a subtidal area of the Bay of Quiberon (Southern Brittany; biometric characteristics: height 140 and 136 mm; width 101–102 mm). Originating in the tropical Indo-Pacific region, this species was introduced into the Black and Marmara Seas during the 1940s and has since spread to the Aegean and Adriatic Seas. The first animal was sighted in June 1998. A local enquiry tracked and verified another sighting back to summer 1997. In the quarantine station at the research laboratory before destruction, these individuals could efficiently prey on the locally reared oyster *C. gigas*, and so pose a potential threat in case of further development. No juvenile has been found, and as yet, there is no evidence that a local population is established. A fourth specimen was caught on 21 March 2000. Additional *Rapana* findings were reported and, since its first sighting in 1997, 11 *Rapana* individuals have been observed at the same location until 2000. In 2001, two more individuals were captured by fishers. Although unsuccessful, new trials using nets and dredge were carried out to catch additional specimens. Leaflets and information campaigns to the public and fishers are currently used to disseminate information and to reward any catch. The introduction of this predatory snail is of great concern (see also ICES, 2007). The species may have been introduced with shipping or accidentally with species imports for aquaculture purposes. In 2002, France reported that the (likely) introduction vector for this species has been explained: transfers of *Ruditapes philippinarum* from the Adriatic Sea (Italy) towards Southern Brittany. *Rapana* individuals were used to ballast clam bags.

A new species of drilling gastropod *Ocinebrellus inornatus* (= *Ocenebra japonica*) was observed along the French Atlantic coastline, in the Marennes Oleron and Arcachon Bays. The first sighting was in April 1997, but it seems to be more common since 1998, a year showing a large recruitment of gastropod species. The species spread was likely increased by shellfish trade and may have a negative impact on aquaculture activities. With a native northwestern Pacific range and distributed in the northeastern Pacific as well, the introduction vector is unknown and might be related to either ballast water or shellfish trade.

France reported in 1999 that the slipper limpet (*Crepidula fornicata*) was well distributed along the French Atlantic coastline and had reached a very high density in specific locations (e.g. 250 000 metric tonnes in the Bay of St Brieuc), interacting significantly with other species, including commercial species and fisheries (e.g. scallop *Pecten maximus*). A comprehensive research programme was carried out by four research institutes and funded by the French Ministry of the Environment. The objectives included to: (i) assess interactions between environmental factors and species proliferation; (ii) assess the effects on biodiversity; (iii) assess interactions with species of commercial interest; (iv) improve knowledge of proliferation mechanisms for this species to develop a spatialized model to simulate population removal; and (v) assess the efficiency of management practices to limit invasion. Four sites along the Atlantic coastline were the focus of this research programme. The species was suspected to have been introduced accidentally by oyster shipments.

In 2000, France reported that the shellfish trade between Ireland, France, and Portugal included the abalone *Haliotis tuberculata*. Abalone juveniles were provided by an Irish hatchery and then imported to France and Portugal for growing. Moreover, imports of a second abalone species, *Haliotis discus hannai* in culture in Ireland, were confirmed. Recent mortalities affected *Haliotis tuberculata* in Brittany resulting from a *Vibrio courtier*, already described in Japan and known for inducing *H. discus hannai* mortality rates. Ongoing investigations aim to assess whether a transfer of *H. discus hannai* could be considered a healthy carrier for a bacterial transfer, which would then become active in warmer seawaters.

The aquarium trade imported several invertebrate species in 2000 and, specifically from Canada, the following species: pink anemones (*Anthopleura elegatissima*), giant anemones (*A.*

xanthogrammica), white spotted anemones (*Urticina lofotensis*), sunflower stars (*Picnopodia helianthoides*), California cucumber (*Parastichopus californianus*), giant barnacle clusters (*Balanus nobilus*), and the Pacific giant octopus (*Octopus dofleini*). No release into the environment is expected owing to aquarium seawater management.

In 2001, an emerging trend was reported concerning the increasing non-commercial fishing activities using live baits.

3.6 Germany

An oyster farm has been operated on the Island of Sylt in the Wadden Sea since the 1980s. In the early years of this aquaculture business, several tens of thousands of juvenile specimens were imported annually from Ireland and the UK. Although the seed oysters usually originate in certified hatcheries, it was necessary to postpone direct importation from the hatchery several times because of unforseen events in Germany, which prevented immediate use of the imported individuals. Space problems in keeping seed oysters longer than anticipated made it necessary to "park" juvenile oysters outside the hatchery in Ireland for a few days, or two weeks at the most. This led to some fouling, and non-indigenous species were transmitted gradually through this (but also through other pathways). Therefore, through these oyster imports, the culture site served as a gateway for other species into this part of the Wadden Sea. These include an alga and the ascidian *Styela clava*, which originate in the Northwest Pacific, and the seaweed *Ascophyllum nodosum* and the ascidian *Aplidium nordmanni* from the North Atlantic. All species had been found previously, but were reintroduced accidentally through activities of this aquaculture farm.

The Pacific oyster culture also caused the establishment of *Crassostrea gigas* in the Wadden Sea outside the oyster farm. *C. gigas* has reproduced successfully, and strong spatfalls occurred already in 1991 and 1994 on natural mussel beds. The wild oyster population comprised about one million during the summer of 1995. Resampling by scientists from the Biologische Anstalt Helgoland in 1996 revealed a survival of 66% despite a previous severe winter. Oysters growing on mussel beds attained a length of 20 to 50 mm in their first year and 50 to 80 mm in their second year. Some of the oysters were larger and presumably much older, indicating that some specimens had survived since the 1991 reproduction. Abundance was highest (up to eight oysters per m^2) on exposed mussel beds at low tide level. These mussels were not covered by any of the common macroalgae. It is expected that *C. gigas* will become a permanent member of the biotic community in the Wadden Sea. Since the late 1990s, the oysters have shown good growth and seem to have reached maturity, and spawning may have taken place. Field studies document the spread of the Pacific oyster, and it was reported that *C. gigas* was frequently found on blue mussel beds.

Germany reports annually that live crustaceans (*Nephrops norvegicus*, *Homarus gammarus*, *H. americanus*, *Callinectes sapidus*, and *Cancer pagurus*) have been imported for human consumption from various European countries and North America in unknown quantities, a practice believed to have been going on for a long time. Live blue mussels (*Mytilus edulis*) have been imported from Denmark for human consumption in an unknown quantity.

At the beginning of the 1990s, about 60 years after the known extreme mass occurrence in German rivers, the Chinese mitten crab was becoming very abundant again. In spring 1998, 850 kg juvenile crabs were caught by hand in the Elbe River in only two hours. It is supposed that the daily catch could exceed 3000 kg juvenile crabs. This figure is comparable with or even higher than the data of the 1930s (a maximum of 2500 kg crabs were caught in one day), the peak of the former mass occurrence in German waters. The same trend was observed in 1999. During mass occurrences of the crab, a loss of the harvest of the estuarine and inland fishing industry is known, caused by its feeding activity on the fish and the fish food. The crabs damage dams, retaining walls, and irrigation channels by perforating them with burrows.

Openings of the burrows reach 12 cm and a length of 50 cm. In the mid-1930s, up to 30 holes per square meter were found in river banks of the mouth of the Elbe River. In the late 1990s, the crab was found in the Kiel fjord. It had not been found in the regions since 1910, and this record might be taken as an indication of an increasing tendency in the population size.

As in many other countries, the zebra mussel *Dreissena polymorpha* is spreading, and this seems to take place mainly at the fringes of previous distribution patterns in Europe. One reason for this behaviour may be the improvement in water quality of some German rivers (Elbe and Weser Rivers) in the past few years, through additional urban waste water treatment plants installed in the former East Germany. In 1999, the Institute for Marine Research undertook a monitoring programme on the settling pattern of zebra mussels in the port of Hamburg, which serves several industries. Distribution and growth at various sites, including the water cooling systems, were investigated over a period of nine months (March–December 1999). There may also be a reintroduction of zebra mussels to Europe from areas to which the mussel was transmitted several decades ago (e.g. Great Lakes and Mississippi River basin) with shipping.

The opening of several oceanaria/public aquaria along the German coast has led to the transfer and introduction of many ornamental species. Coastal aquarium systems operate with pretreated water taken from the sea. Inland aquaria depend on artificial seawater.

3.7 Iceland

No information available.

3.8 Ireland

Earlier imported species were continuously cultured in 1992, including *Haliotis discus hannai*, *H. tuberculata*, and *Ruditapes semidecussata*. The Manila clam (*Ruditapes semidecussata*) (= *Ruditapes philippinarum*) was cultivated on all Irish coasts. Seed was produced in Irish hatcheries and supplemented with imports from Guernsey, the UK, and Norway.

During the entire reporting period, cultivation of *Crassostrea gigas* took place on all Irish coasts. Production exceeded that of the native oyster, and oyster imports are recorded annually from the UK and France. Most seed imports are from Guernsey and the UK. Cultivation takes place on all Irish coasts, with the main production from Carlingford Lough (east coast) and Dungarvan Bay (south coast). In 1993, a number of non-native species, including the oyster parasitic copepods *Mytilicola orientalis* and *Myicola ostreae*, were introduced to Irish waters from France with shipments of half-grown Pacific oysters. These were permitted entry after a European decision to permit a more open trade of Pacific oysters following a previous embargo on all shellfish entries to Ireland since the 1960s. Pacific oysters examined in 1999 from Dungarvan Bay still had the gut parasite *Mytilicola orientalis* present. The species *Myicola ostreae* was found in Pacific oysters imported from the same region in 1999. In 2000, a gill condition was found in Pacific oysters from Cork Harbour, and almost certainly this was the result of a different copepod species that damaged the gill margin to cause loss of gill tissue. The gill condition, found previously in the native oyster (*Ostrea edulis*) from Cork Harbour, was noted again in Pacific oysters in 2002 from both Cork and Waterford Harbours on the Irish south coast. It is possible that this damage to the gills may affect growth. Irish oyster growers continue to be advised against bringing in half-grown oysters because of the high risk of importing unwanted biota. Imports of imported seed continue to be examined. Summer mortalities resulted in some losses in late summer and were recorded from the Irish south coast in 2001.

The Japanese scallop *Patinopecten yessoensis* was introduced to Ireland following requests by an Irish fish and shellfish processor to cultivate the species on the southeast coast of Ireland. The earliest discussions took place in late 1988, at which time it was agreed to follow the

procedure set forth in the revised ICES Code of Practice of 1988 (ICES, 1988). The use of the Code was rigorously tested and subsequently modified, based on the experience of this introduction. Two WGITMO meetings in 1989 and 1990 were required before the modified project was approved. Progress reports were submitted at subsequent annual meetings of the WGITMO and continued until 1994. Seventy-one specimens of *Patinopecten yessoensis* were imported from Japan. They were held in quarantine and, following spawning, were destroyed. *Patinopecten yessoensis* were held in lantern nets off the southeast coast of Ireland. In 1994, the project was terminated after the longline holding the F_1 broodstock was torn from its moorings in a storm. The longline was recovered, but all the scallops were dead.

In 1993, a small number of male slipper limpet (*Crepidula fornicata*) and the polychaete worm *Terebella lapidaria* were found associated with half-grown Pacific oysters from France; in addition, an anthozoan *Haliplanella lineate* and a serpulid polychaete worm were also found.

The zebra mussel *Dreissena polymorpha* arrived in Ireland in 1994 (or perhaps in 1993) and spread rapidly through the navigable waterways as fouling on the hulls of boats. Annual monitoring surveys of the zebra mussel revealed increases of abundance throughout the Shannon navigation. The zebra mussel expanded its range into northern Lough Erne by 1996. It occurs throughout the Rivers Shannon and Boyle Rivers. Small numbers were found in the winter of 1998/1999 in the western region of the Grand Canal, which links the Shannon navigation to Dublin. There have been increases in water clarity in Loughs Derg and Ree, and the freshwater mussel *Anodonta anatina* is no longer known in lakes where the zebra mussel occurs. Freshwater mussels often had more than a thousand attached zebra mussels. Fouling of power plant and municipal water work water intake screens has been noted. The public awareness campaign advising anglers on the risks of transporting zebra mussels to lakes by overland transport appears to have aided in the reduced spread of the species, although the species continues to expand its range.

An unapproved introduction of American oysters to Ireland from Long Island Sound was intercepted in air freight in 1997 and later destroyed. The sample of 10 kg contained the commensal pea crab *Pinnotheres ostreum* (5% prevalence); the slipper snails *Crepidula plana* and *Crepidula fornicata* were common (despite oysters being brushed and cleaned); and egg cases of the predatory oyster drill *Urosalpinx cinerea* were found. The intended recipient was anxious to develop a trade in Europe for American oysters. There was a risk that American oysters, although intended for human consumption, would be relaid somewhere in Europe and act as a vector for pests and diseases.

Also in 1997, a consignment of 11 tonnes of rope-grown, market sized mussels from the Venice Lagoon (Chioggio) were transported to Ireland for processing, but these were refused on arrival because they had spawned. The haulier disposed of the mussels on the shore within 0.5 km of an oyster farm. The sample obtained from the shore a week later consisted mainly of dead mussels, although some were alive. The shells of these mussels had little fouling on their shells.

A single consignment of 250 000 scallops, *Pecten maximus*, was introduced in 1997 from the west coast of Scotland.

The Chinese hat limpet (*Calyptraea chinensis*), which lacks a planktonic stage, was probably spread to Ireland in the middle of the 20th century with native oyster imports used for restocking the Clew and Ballinakill Bays (west coast of Ireland). The species has recently appeared in eastern Galway Bay and was first noted in 1999, probably as a result of oyster movements from the bays where it was previously established. A separate introduction to Cork Harbour was noted in 2000. It has probably been established there for at least three years and may have come from Loch Ryan in Scotland.

3.9 The Netherlands

The blue crab (*Callinectes sapidus*) is reported annually from the ports at Amsterdam, Hoek van Holland, and Rotterdam. Four American blue crabs were caught in 1999. One female crab was carrying eggs and this is, as far as we know, the second observation of an egg-carrying female in the Netherlands. However, it remains unclear whether the species was introduced on purpose or was accidentally released from a holding tank. Ballast water release was also suspected inasmuch as the most likely introduction vector because the crabs were predominantly found in port regions, where ballast water discharges occur frequently.

The Pacific oyster *Crassostrea gigas* is well established and has expanded in the Dutch Wadden Sea. *C. gigas* have spawned and recruited successfully in the Wadden Sea since at least 1996. Between 1995 and 1999, the *C. gigas* was found in at least eight locations in the Dutch Wadden Sea. In southwestern Netherlands, *C. gigas* was imported by fishers during the 1960s. Wild-grown *C. gigas*, however, became very abundant in Lake Grevelingen, in the Oosterschelde, and in the Westerschelde. Recently, fishers have become concerned about the explosive growth rate. In Lake Grevelingen, *C. gigas* may become a competitor for food for the native flat oyster *Ostrea edulis* and the blue mussel *Mytilus edulis*, both commercially cultured in this region. Low spatfalls of the native mussel *Mytilus edulis* in recent years are causing concern and may have triggered the success of *C. gigas*.

In 2000, *Perna* sp. was imported from Sweden, and in 2002 *Strongylocentratus purpuratus* and *S. franciscanus* arrived from Canada.

Large numbers of live American lobsters (*Homarus americanus*) are imported for direct human consumption from the North American east coast. As other North Sea and Baltic countries, the Netherlands is concerned about the escape and possible interaction of *H. americanus* with the native lobster *H. gammarus*.

The trade in marine pet fish and other aquarium species introduces a very large variety of animals from worldwide sources. A comprehensive overview is currently lacking. Only Canada reported on a number of marine species exported to the Netherlands and sold live there. Several live freshwater aquarium species were caught in Dutch inland waters.

3.10 Norway

Regulations of marine enhancement and sea ranching were proposed and evaluated. The Ministry of Fishery developed a schedule for review in the Parliament. An expert group considered the potential problems associated with the commercial import of ornamental fish, and a report, including a number of recommendations, was drafted in September 1997. The report was evaluated by the Norwegian Ministry of Agriculture. On 1 January 1999, Norway joined the European Economic Area Agreement and serves as a controlling body for imports from non-EU countries. Regulations of imports and exports have generally been harmonized with the EU, with some exceptions. Export/import for aquaculture or sea ranching for the specified life-stages of a certain number of species is allowed. In 2001, Norway reported that importing viable marine fish, shellfish, etc., for aquaculture or restocking purposes is not allowed without permission from the department.

The Kamchatka king crab (*Paralithodes camtschatica*) was originally introduced to Russian waters in the southern Russian Barents Sea during the period 1961–1969 and became established. The subsequent spread resulted in an established population in Norway (see also ICES, 2005b). In 1992, more than 200 specimens were reported in gillnet catches in the Varangerfjord in Finnmark County. One specimen weighed 5 kg. Some of the specimens were egg-bearing females. The increases in population and distribution were also observed in the longline and net fisheries where crabs were taken as bycatch. This represents a number of practical problems for the fishers, and a systematic collection of information from the fishery

suggests that a significant fraction of the crab population is taken in this fishery. Investigations of the king crab in 1998 were confined to within the Varangerfjord and adjacent fjords, so little reliable information on a westward migration is available. In 2000, the core area was still east of North Cape, but some westward migration has been reported. In addition, 2002 was the first year with a regular commercial catch of the red king crab in Norway. The red king crab will be managed as a resource species rather than a feral species. *Paralithodes camtschatica* continued to spread during the entire report period. No decision has yet been reached on how to prevent the species from migrating south- and westwards.

Crassostrea gigas was introduced from France in 1970 in unknown quantities and has since been cultivated at only one location (western Norway). There have been no observations outside the cultivation facility.

Manila clams (*Ruditapes philippinarum*) were imported for aquaculture in 1986 to two locations. Although cultivation was terminated, large mature individuals have been found in open waters at one location. The species seems to reproduce in the wild.

The slipper limpet (*Crepidula fornicata*; unintentionally introduced from North America through oyster imports) was first detected in the wild in Denmark and Germany in 1872. The first specimen was found in 1962 in Norwegian waters at the Skagerrak coast. Since then, several observations of this species have been reported, mainly in the Skagerrak region. In summer 1996, a new live individual was found at Kvitsoy, in western Norway. This indicates a westerly and northerly increase in the distribution area.

The American lobster (*H. americanus*) was discovered in 1999 in southern Norway. During 2000, a network of collecting stations was established in southern Norway. Twenty-four lobsters were collected in December, and five of these were confirmed to be *H. americanus* when genetically tested. In addition to the five confirmed *H. americanus*, three specimens had morphological features resembling the American lobster. Another confirmed specimen of the American lobster was found in 2001 in the Oslofjord, bringing the number of confirmed cases to 11. The introduction vector remains unclear, but escapes from live storage tanks seem likely. The potential interactions with the native lobster are of concern.

3.11 Poland

No data on deliberate or accidental invertebrate introductions are known. However, the Chinese mitten crab occurs in Polish waters, and records show an increasing trend since the end of the 1990s.

Imports of crustaceans and other marine organisms for aquaria continued, but no detailed data are currently available.

3.12 Portugal

The only national report received was submitted in 1992 (ICES, 1992). The following invertebrate species were deliberately introduced from various sources: *Ruditapes philippinarum*, *Crassostrea gigas*, *Pecten maximus*, and *Ostrea edulis*. For direct human consumption, *Cancer pagurus*, *Maja squinado*, *Panulirus guttatus*, *Jasus lalandi*, *Penaeus japonicus*, and *Homarus americanus* were imported from France, the UK, and the US. According to the 1995 Irish national report, *Crassostrea gigas* and *Ruditapes philippinarum* were imported to Portugal from Ireland, and in 1998, the Pacific oyster and *Tapes decussatus* were imported from France.

It was also reported that freshwater crayfish were accidentally introduced and may have reached the Guadiana River by secondary spread from Spain.

Portugal reports that the clam *Ruditapes decussatus* and the sea urchin *Paracentrotus lividus* were exported to France in unknown quantities.

3.13 Spain

Spain submitted three national reports in 1992, 1993, and 2001 (ICES, 1992, 1993, 2001). The introduction of macroalgae is of primary concern in Spain (see relevant section in this report).

For aquaculture purposes, *Crassostrea gigas* was imported from the UK in 1992 and 1993, *Penaeus japonicus* in 1998 from France, and *Perna* sp. in 2000 from Sweden.

3.14 Sweden

Since the early 1990s, American lobsters have been introduced in unknown quantities from the US and Canada. In 2001, a lobster resembling the American lobster was caught.

Oyster imports from France have been reported since 1995.

The Chinese mitten crab (*Eriocheir sinensis*) was reported several times during summer and early autumn 1998 from Swedish coastal and inland waters (Kungsbackafjorden, south of Göteborg, in the Hanö Bight in the southern Baltic proper, the island of Lisö in the archipelago south of Stockholm, the northern Baltic proper, and in Vänersborg at Lake Vänern). On the Swedish coast of the Bothnian Sea, it appears very rarely. Lately it seems to be found more frequently across the Gulf of Bothnia, around the Finnish town of Jakobsstad, probably the result of increased the ferry traffic with Bremerhaven, Germany, with one ship arriving every ten days. The mitten crab turned up in 1994 and is now encountered quite often and kept in aquaria by schools.

3.15 United Kingdom

Seed of *Crassostrea gigas* and *Ruditapes philippinarum* (= *Ruditapes semidecussata*) were planted out for commercial cultivation in the early 1990s. Although these species are not released for the purpose of establishing self-sustaining populations, there is evidence that, in recent warm summers, natural settlement of *C. gigas* has occurred in the River Teign and in the Menai Strait area of North Wales. Numbers of naturally settled seed are low, but there has been natural recruitment of the Pacific oyster *Crassostrea gigas*.

In 1992, an article appeared in the *London Times* (26 August) about giant Japanese whelks (*Rapana venosa*) that were said to have been brought up in a lobster pot from the bed of the North Sea, south of Dogger Bank and about 20 miles out. It was speculated that the whelks could have been carried as eggs from the Black Sea on the hull of a ship. The most recent information is that, in fact, the find was a hoax. However, living *Rapana* were found later in the region (ICES, 2007).

As reported in 1993, several species are in current commercial practice, including lobsters (*H. americanus*) mainly from Canada and the US; oysters from Ireland, Denmark, France, the Netherlands, Chile, Japan, China, and Hong Kong; scallops (*Pecten*, *Chlamys*, *Placopecten*) from France, China, and the US, and in smaller quantities from the Netherlands, Spain, and Ireland; mussels (*Mytilus*) from Ireland and the Netherlands. Live American lobsters were imported each year for direct human consumption during the reporting period.

Some *Crassostrea gigas* and *Ruditapes philippinarum* seed were imported from Guernsey for cultivation, but the industry relied mainly on seed produced in England. The beds of wild Manila clams in Poole Harbour, which have become established after the successful recruitment of seed from intentional introductions for aquaculture purposes, were fished on a limited commercial basis. Approximately 40 tonnes of clams were fished. As a result of a local management plan, there is some control of this new fishery.

Squid (*Loligo* spp., *Ommastrephes sagittatus*) were imported from France. Other imports included saltwater ornamentals and sea urchins.

The Chinese mitten crab (*Eriocheir sinensis*) has been reported in the River Thames since 1935. Since then, their numbers in the Thames have increased significantly. From surveys carried out by the Environment Agency since early 1998, it has been demonstrated that burrows are present at every suitable site from Grays in Essex to the Richmond half-tide weir, which is a distance of 63 km. The crabs dig and use burrows, even when there is no tidal cycle, and burrows are permanently submerged. Up to 28 burrows per square metre have been found, and it was believed that burrows were less than one year old. This is the first evidence of burrowing behaviour from the British Isles. The burrows are reported to have caused considerable damage by weakening the bank structure and causing areas of bank to collapse. Chinese mitten crabs have also been found in other estuaries along the English east coast, from the River Tyne in the north to the River Rother on the southern Kent coast.

During the mid-1990s, the UK imported four tonnes of wild-caught marine ornamentals (equivalent to 350 000 individuals) annually. Trade involves around 1000 species.

3.16 United States of America

As noted in the national reports from the US and Canada over the past several years, the European zebra mussel *Dreissena polymorpha* was discovered by biologists in the Great Lakes in June 1988 in Lake St Clair. It is now known that it was observed earlier by a fisher in December 1987 in Lake Erie. It is believed to have been introduced about 1985/1986. The zebra mussel is now in the major river drainages leading out of the Great Lakes, including the Mississippi, Illinois, Ohio, Tennessee, Arkansas, Hudson, and Susquehanna River systems. In the "first 1000 days" since its escape from the Great Lakes, it has entered 18 American states. In January 1993, it was first detected in eastern Oklahoma. No significant new jumps of the zebra mussel's range have been reported since spring 1994. The zebra mussel, now recognized as consisting of two different species in North America, *Dreissena polymorpha* and *Dreissena bugensis*, continues to fill in many rivers and lakes within its reported range, which now extends into Oklahoma, to the Gulf of Mexico coast in Louisiana, into Lake Champlain on the Vermont–New Hampshire border, and down the Hudson River. The spread of the zebra mussel continued during the entire reporting period.

In 1993, it was reported that the Pacific white shrimp (*Penaeus vannamei*) had been taken in great numbers during commercial shrimp hauls off South Carolina. All caught individuals are believed to be aquaculture facility escapees, and the establishment of reproducing populations has not yet been demonstrated, although a sexually mature male was collected.

The newest and most startling discovery of an introduced aquatic organism in the US occurred in November 1994 when specimens (male and ovigerous females) of the Chinese mitten crab (*E. sinensis*) were brought to the California Academy of Sciences in San Francisco, having been captured in trawlnets in the southern end of San Francisco Bay. It was later determined that shrimp fishers had seen the crab as early as 1992. Numerous specimens collected in autumn 1994 and winter/spring 1995 represent at least two distinct year classes; ovigerous females are common and readily produce swimming larvae in laboratory aquaria. On this basis, it appears that, at long last, *Eriocheir* has become established in North America. The Chinese mitten crab was collected irregularly between the 1970s and spring 1994 in the Great Lakes (largely Lake Erie), always as individual, relatively large crabs. They are believed to be the result of larvae or juvenile crabs having been released in the Great Lakes some years earlier in ballast water. Being a catadromous species, *Eriocheir* cannot establish in the Great Lakes. However, the large stream and river systems of San Francisco Bay provide the habitat necessary for a catadromous life style.

Eriocheir is recognized as a burrower in river banks, and so there is some concern about the 1000 and more kilometres of dikes that pepper the vast agricultural lands of the San Francisco Bay Delta system (the Sacramento and San Joaquin River systems). In addition, *Eriocheir* is the second intermediate host of the Oriental lung fluke; primary hosts, aquatic snails, were already present in California, introduced earlier from Asia. *Eriocheir* thus completes the lung fluke's cycle in America. The potential trophic effects of the Chinese mitten crab on the Bay are unknown. This question is particularly complex given the wave upon wave of invasions that sequentially destabilize and restructure the Bay's foodwebs, including the previous invasions of the Chinese clam *Potamocorbula amurensis*, discovered in 1986, and the European shore (green) crab *Carcinus maenas*, discovered in 1990/1991.

How *Eriocheir* arrived in the Bay is not clear. The two potential primary mechanisms are (i) ballast water release and the concomitant release of larvae or juveniles directly from China or Korea; and (ii) the release of adult crabs from the "live food industry". Although the import of live Chinese mitten crabs is prohibited under both US federal law and California state law, customs inspectors at large west coast airports (such as Los Angeles, San Francisco, and Seattle) regularly intercept and impound live crabs that are being brought in either for private consumption or to be sold at Asian markets. The crab is sufficiently popular in Asia as a food item that its release in San Francisco Bay was to be expected. The Chinese mitten crab is now well established and continues to expand its range within San Francisco Bay. A single specimen was reported to have been captured in the Columbia River in 1997.

The commercial shellfish industry continues to culture and release multiple non-native invertebrate species. Along the Pacific coast, these species include the oyster *Crassostrea gigas*, mussel *Mytilus galloprovincialis*, and clam *Venerupis philippinarum*. Non-native species cultured and released along the Atlantic coast include *Ostrea edulis*. Fisheries use these species on a regular basis.

In 1997, it was reported that *Ostrea edulis* continued to expand its range on the American Atlantic coast and continued to spread. Intentional plantings in the 1940s resulted in small permanent populations in Maine. However, since the late 1980s, established populations have been reported in Rhode Island and, more extensively, along the Maine coast. About 1996, *O. edulis* was reported from the Great Bay Estuary, New Hampshire.

In June 1998, the first specimens of the large, clam-eating Asian whelk *Rapana venosa* were found in lower Chesapeake Bay. This species was earlier introduced to the Black Sea and the Mediterranean Sea, from where it may have arrived in America. *Rapana* is considered to be established in the Chesapeake Bay with a potential to spread farther (see ICES, 2004).

In 2000, a Virginia oyster industry group requested the Virginia Marine Resources Commission to undertake an experimental study with the Japanese oyster *Crassostrea ariakensis*. These were individually certified triploids from F_1-generation ICES-protocol parents, which were quarantined in the Virginia Institute of Marine Sciences hatchery at Gloucester Point, Virginia. A time-limited trial was arranged, with a long list of prerequisites and protocols to be followed. In addition, limited experiments were conducted to test the performance of *C. ariakensis* in Chesapeake Bay waters. The proposed tests used triploid oysters, and each individual was tested for triploidy prior to the tests. Eventually, limited field trials were used to test the performance of non-native oysters in Chesapeake Bay waters as reported in 2002. Proponents of developing this fishery submitted a multiyear proposal for further evaluation and development of a *C. ariakensis* fishery. In 2002, the proposal was evaluated by an *ad hoc* review committee of the EPA Chesapeake Bay Program. The review committee recommendations are advisory in nature, and Virginia will make final decisions on the scope and tempo of this effort. It was requested that a similar proposal be submitted simultaneously to ICES by the proponents, serving as the prospectus called for by the ICES Code of Practice (ICES, 2005a).

3.17 Australia

Australia has observer status and submitted national reports in 1998 and 2002. The national report provided in 1998 deals exclusively with ballast-water-mediated species introductions. In 2002, Australia reported that mariculture operations continue to result in spawning release of oyster (*Crassostrea gigas*) spat in Tasmania, New South Wales, and South Australia, and blue mussel (*Mytilus galloprovincialis*) spat in Western Australia, South Australia, Victoria, Tasmania, and New South Wales. No new deliberate releases of marine species were reported in 2001/2002. Information on live imports and exports to ICES member countries as well as on planned introductions of non-indigenous species was unavailable.

3.18 Italy

Italy has guest status and provided detailed national reports in 1998 and 2000–2002. The main invertebrate species introduced in the open environment for fishery are the bivalves *Crassostrea gigas* and *Ruditapes philippinarum*. *Crassostrea gigas* was introduced in 1960 in the northern Adriatic from Atlantic cultures. It is now widespread, colonizing all the northern Adriatic lagoons, having supplanted the native *Ostrea adriatica* (= *edulis*?) whose populations were already rather scanty.

In some cases, *Ruditapes philippinarum* is cultivated in ponds, without control of possible release to the open environment, but in most cases, it has been seeded deliberately in open waters. It was first introduced in 1983 as an experiment on one island outside Venice and was subsequently seeded over large areas of the main northern Adriatic lagoons. Since then, the catch of the Japanese clams has increased, supplanting the catch of the native clams such as *Tapes decussatus* and *Venerupis aurea*, whose populations had been declining already before the introduction. The clam *Ruditapes philippinarum* (Adams and Reeve) has substituted the indigenous species *Tapes decussatus* (L.) in most areas of the central and northern Adriatic Sea; the same occurred with the oyster *Crassostrea gigas* against *Ostrea edulis*, and in some locations the native oyster is now absent.

The whelk *Rapana venosa* (Mollusca Gastropoda) has been known in the northern Adriatic since 1973. It is widespread along the northern Adriatic coast (including the lagoon of Venice), both on the Italian side and on the Slovenian coast (1997). One specimen has also been found near Elba Island in the Tyrrhenian Sea. The large population in the northern Adriatic Sea is generally considered to have had no major detrimental effect. The gradual but sustained nature of this range expansion suggests that *Rapana* has yet to exploit all susceptible locations within the Mediterranean. It is believed that *Rapana* was introduced with oyster imports. No damage to the mussel cultures or exploited clam beds has been reported (see also ICES, 2004).

The lobster *Homarus americanus* is imported live for consumption and held in aquaria until consumption. Requests to use this species for restocking the natural populations of *Palinurus vulgaris* have been repeatedly put forward by fisher or divers' associations.

In 2001, Italy reported that the crayfish *Penaeus japonicus*, as well as *Penaeus monodon* and *Penaeus vannamei*, are reared in ponds using semi-intensive systems, but they have been recorded in an open habitat only once. A *P. monodon* introduction was planned under controlled and restrictive conditions for semi-intensive rearing in a pond. The introduction of this species has underlined the risk of introducing pathogenic agents such as the *Baculovirus*, a pathogen to be reported to the OIE when using larvae and post-larvae. Fertilized eggs are preferred for import to reduce the risk of disease.

In 2002, Italy reported that *Ruditapes philippinarum* had been released in the brackish coastal Lake Fusaro (near Naples).

3.19 References

ICES. 1988. ICES Code of Practice on the Introductions and Transfers of Marine Organisms, 1988. 30 pp.

ICES. 1992 Report of the Working Group on Introductions and Transfers of Marine Organisms, Lisbon, Portugal, 14–17 April 1992. ICES CM 1992/POLL:3.

ICES. 1993. Report of the Working Group of Introductions and Transfers of Marine Organisms, Aberdeen, Scotland, 26–28 April 1993. ICES CM 1993/ENV:7.

ICES. 2001. Report of the Working Group of Introductions and Transfers of Marine Organisms, Barcelona, Spain, 21–23 March 2001. ICES CM 2001/ACME:08.

ICES. 2004. Alien Species Alert: *Rapana venosa* (veined whelk). Edited by Roger Mann, Anna Occhipinti, and Juliana M. Harding. ICES Cooperative Research Report, No. 264. 14 pp.

ICES. 2005a. ICES Code of Practice on the Introductions and Transfers of Marine Organisms, 2005. 30 pp.

ICES. 2005b. 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. 2007. Alien Species Alert: *Undaria pinnatifida* (wakame or Japanese kelp). ICES Cooperative Research Report, No. 283. 36 pp.

3.20 Deliberate introductions and transfers, and live imports and transfers of non-native invertebrates

Qualitative data on deliberate introductions and transfers, and on live imports and transfers of non-native invertebrate species (excluding species movements within one country) extracted from national reports considered at WGITMO meetings 1992–2002. ← = imported from (source region indicated when available), WC = west coast, EC = east coast, Be = Belgium, Ca = Canada, De = Denmark, E&W = England and Wales, Fi = Finland, Fr = France, Ge = Germany, Ir = Ireland, It = Italy, Ne = the Netherlands, No = Norway, Po = Portugal, Sc = Scotland, Sp = Spain, Sw = Sweden, USA = United States of America. Information gaps refer to unavailable national reports.

Atlantic seaboard of North America

Recipient country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Canada	*Limolus polyphemus* ←USA (EC)	*Lytechinus pictus* ←USA (WC) *Mytilus edulis* ←Ir *Strongylocentrus droebachiensis* ←USA (WC) *Strongylocentrus purpuratus* ←USA (WC)	*Placopecten magellanicus*	*Mercenaria mercenaria* ←USA (EC) *Mytilus californianus* ←USA (WC) *Placopecten magellanicus* *Rhepoxynius abronius* ←USA (WC) *Strongylocentrus purpuratus* ←USA (WC)	*Crassostrea virginica*, *Lytechinus pictus* ←USA (WC) *Macoma nasuta* ←USA (WC) *Mercenaria mercenaria*, *Mytilus edulis*, *Placopecten magellanicus*, *Rhepoxynius abronius* ←USA (WC) *Strongylocentrus purpuratus* ←USA (WC)	*Crassostrea virginica*, *Lytechinus pictus* ←USA (WC) *Mercenaria mercenaria*, *Mytilus edulis*, *Ostrea edulis*	*Argopecten irradians* ←USA (WC) *Crassostrea virginica*, *Mercenaria mercenaria*, *Mytilus edulis*, *Ostrea edulis*, *Placopecten magellanicus*	*Argopecten irradians* ←USA (WC) *Crassostrea virginica*, *Mercenaria mercenaria*, *Ostrea edulis*, *Placopecten magellanicus*	*Argopecten irradians* ←USA (WC) *Crassostrea virginica*, *Mercenaria mercenaria*, *Ostrea edulis*, *Placopecten magellanicus*	*Argopecten irradians* ←USA (WC) *Crassostrea virginica*, *Mercenaria mercenaria*, *Ostrea edulis*, *Placopecten magellanicus*	*Crassostrea virginica*, *Haliotis rufescens* ←Iceland *Ostrea edulis*
USA			*Crassostrea gigas*							*Crassostrea ariakensis*, *Ostrea edulis*	*Crassostrea ariakensis*, *Ostrea edulis*

Atlantic seaboard of southwestern Europe

Recipient country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Portugal	*Crassostrea gigas* ←Sp *Homarus americanus* ←UK/Fr *Penaeus japonicus*, *Ruditapes philippinarum* ←Sp			*Crassostrea gigas* ←Ir *Ruditapes philippinarum* ←Ir			*Crassostrea gigas* ←Fr *Tapes decussatus* ←Fr				
Spain	*Crassostrea gigas* ←E&W	*Crassostrea gigas* ←E&W					*Penaeus japonicus* ←Fr		*Perna* sp. ←Sw		
France	*Crassostrea virginica* ←E&W	*Crassostrea gigas* ←Ir *Crassostrea virginica* ←E&W		*Crassostrea gigas* ←E&W, Ir, Ne *Patinopecten yessoensis*		*Crassostrea gigas* ←E&W, Ir, Po	*Crassostrea angulata* ←Guyana *Crassostrea gigas* ←E&W, Ir, Ne, Po *Crassostrea rhizophorae* ←Guyana *Penaeus japonicus* ←Sp *Ruditapes philippinarum* ←It *Tiostrea chilensis* ←Guyana	*Crassostrea gigas* ←E&W, Ir, Ne, Po	*Crassostrea gigas* ←E&W, Ir, Ne, Po *Haliotis discus hannai* ← Ir	*Crassostrea gigas* ←E&W, Ir, Ne, Po	clams ←It, Ne *Crassostrea gigas* ←E&W, Ir, Ne, Po mussels ←Sp

Northwestern Europe

RECIPIENT COUNTRY	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ireland	*Crassostrea gigas* ←E&W, No *Patinopecten yessoensis* ←Japan *Ruditapes philippinarum* ←E&W	*Crassostrea gigas* ←E&W *Ruditapes philippinarum* ←E&W, No	*Crassostrea gigas* ←E&W, Fr *Ruditapes philippinarum* ←E&W	*Crassostrea gigas* ←E&W, Fr *Ruditapes philippinarum*←E&W	*Crassostrea gigas* ←E&W, Fr *Ruditapes philippinarum* ←E&W	*Crassostrea gigas* ←E&W, Fr *Ruditapes philippinarum* ←E&W	*Crassostrea gigas* ←E&W, Fr *Ruditapes philippinarum*	*Crassostrea gigas* ←E&W,Fr	*Crassostrea gigas* ←E&W, Fr	*Crassostrea gigas* ←E&W, Fr	*Crassostrea gigas* ←E&W, Fr
Scotland	*Crassostrea gigas* ←E&W	*Crassostrea gigas* ←E&W	*Crassostrea gigas* ←E&W lobsters ←Ca	*Crassostrea gigas* ←E&W							
England & Wales	*Homarus* sp. ←Ca *Nucella lapillus* ←USA	lobsters ←Ca, USA	lobsters, *Perna* sp.		*Crassostrea gigas* ←Ir			*Homarus americanus* ←Ca	*Homarus americanus* ←Ca	*Haliotis tuberculata* ←Ir *Homarus americanus* ←Ca, USA	*Crassostrea gigas* ←Ir *Haliotis tuberculata* ←Ir *Homarus americanus* ←Ca, USA
Belgium									*Perna* sp. ←Sw	*Crassostrea gigas* ←Ca, Fr *Cyrtodaria siliqua* ←Ca *Homarus americanus* ←Ca *Mercenaria mercenaria* ←Fr? *Spisula polynyma* ←Ca *Ruditapes philippinarum* ←Fr?	*Crassostrea gigas* ←Ca, Fr *Homarus americanus* ← *Mercenaria mercenaria* ← *Ruditapes philippinarum* ←
Netherlands									*Perna* sp. ←Sw	*Homarus americanus* ←Ca (EC), USA (EC)	*Strongylocentratus purpuratus* ←Ca *Strongylocentratus franciscanus* ←Ca

Recipient country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Germany			*Crassostrea gigas* ←Ir			*Crassostrea gigas* ←Ir	*Crassostrea gigas* ←Fr, Ir *Homarus americanus*	*Callinectes sapidus* ← *Crassostrea gigas* ←Ir *Homarus americanus*	*Homarus americanus* ←Ca	*Callinectes sapidus* ← *Homarus americanus* ←Ca	*Callinectes sapidus* ← *Crassostrea gigas* ←Ir *Homarus americanus*
Denmark									*Perna* sp. ←Sw		
Norway		*Crassostrea gigas* ←Fr							*Perna* sp. ←Sw	*Homarus americanus*	

Baltic Sea

Recipient country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Finland	freshwater crayfish ←Russia, USA *Pacifastacus leniusculus* ←Sw	freshwater crayfish ←Russia, USA *Pacifastacus leniusculus* ←Sw	freshwater crayfish ←Russia, USA *Pacifastacus leniusculus* ←Sw					*Pacifastacus leniusculus* ←Sw	*Perna* sp. ←Sw		
Sweden	*Crassostrea gigas* ←Fr *Homarus americanus* ←Ca, USA	*Homarus americanus* ←Ca, USA	*Homarus americanus* ←Ca, USA	*Crassostrea gigas* ←Fr *Homarus americanus* ←Ca, USA	*Crassostrea gigas* ←Fr *Homarus americanus* ←Ca, USA	*Crassostrea gigas* ←Fr *Homarus americanus* ←Ca, USA	*Crassostrea gigas* ←Fr *Homarus americanus* ←Ca, USA	*Crassostrea gigas* ←De, Fr, Ir, Ne, No *Homarus americanus* ←Ca, USA *Perna* sp. ←De, Ne, No, New Zealand	*Homarus americanus* ←Ca, USA *Perna* sp. ←De, Ne, No	*Homarus americanus* ←Ca, USA	*Homarus americanus* ←Ca, USA

Mediterranean Sea

Recipient country	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Spain	no data available for the Mediterranean coast										
France	no data available for the Mediterranean coast										
Italy									*Cancer pagurus*, *Glycera dibranchiata*, *Homarus americanus*, *Jasus ialandi*, *Panulirus* sp., *Perinereis vancaurica*	*Penaeus japonicus*, *Penaeus monodon*, *Penaeus vannamei*	*Ruditapes philippinarum*

4 Fish

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4.1 Introduction

This review lists the activities reported to the Working Group on Introductions and Transfers of Marine Organisms, which has met annually over the period of this report, 1992 to 2002 (ICES, 1992–2002), and follows the previous ICES summary (1999). The condensed account is arranged according to geographical area, and it should be noted that not all activities have been included owing to the limited representation by fish biologists at each meeting. Records of imports and movements, using a common or local name that could relate to more than one species or lead to inaccurate recording, have been deleted to avoid confusion. Most recorded fish movements were of salmonids. Egg movements flown to various world regions were composed mainly of Atlantic salmon and rainbow trout. These movements have permitted aquacultural development in places such as Chile. In Europe, recent developments in sturgeon culture have led to records of vagrant specimens over a wide area. For other species – and of note – are the conditions laid down for the culture of hybrid striped bass in an enclosed system.

Precautionary measures in the management of fish in transit should be considered as recommended under the recent revision of the ICES Code of Practice (ICES, 2005). Scientific and common names of fish used in this account are recorded in the tables at the end of this section.

Summary tables for fish moved for aquaculture and stocking (Table 4.11.1), for research purposes, including fish transported alive for human consumption (Table 4.11.2), and unintentionally and unauthorized releases (Table 4.11.3) are shown at the end of this section.

4.2 Introduced species in the different regions

4.2.1 Salmonid movements

The principal pathways of transmission take place within either North America or Europe and relate to stocking or aquaculture. Salmon and rainbow trout are moved between all continents except Antarctica (Table 4.2.1). Movements normally consist of developing eggs transported by plane to hatcheries where they are reared until big enough to support either aquaculture or stocking programmes. Eggs come from approved hatcheries and are disinfected prior to departure. Several million eggs are moved each year. Local transmissions tend to be of young fish. All transmissions from within North America or Europe require health certification, and this greatly reduces the consequences of introducing unwanted diseases. There has been increased awareness that non-native salmonids are likely to compete with native species, and these impacts are of concern. There have been many salmonid releases for the purpose of stocking, such as those in the Baltic Sea for salmon, trout, and lake whitefish.

Table 4.2.1. Movements of salmonids during the period 1992–2002.

SPECIES	ORIGIN	DESTINATION
Oncorhynchus mykiss	Canada, Denmark, Isle of Man, Northern Ireland, South Africa	USA
	Czech Republic, Denmark, the Netherlands, Poland	Germany
	Denmark, Isle of Man, Northern Ireland, South Africa, Tasmania	Ireland, UK
	Denmark, Isle of Man, Northern Ireland, Scotland, South Africa	Ireland
	England	Denmark, Isle of Man, Northern Ireland, South Africa, Tasmania
	Finland	Chile, Estonia, Portugal, Russia
	Germany	Austria
	Poland	Russia
	Sweden	Austria, Bulgaria, Chile, Croatia, Czech Republic, Estonia, Finland, Greece, Israel, Spain, Norway, Montenegro, Portugal, USA
O. tshawytscha	Canada	Japan
	Sweden	Greece, Norway, Taiwan, Turkey
Salmo salar	Canada	Chile, USA
	Denmark, Iceland, Norway, Sweden, Tasmania	Ireland
	England	Sweden
Rainbows?	Estonia	Cyprus, Luxemborg, Marshall Islands, St Vincent and the Grenadines
	Finland	Norway, Shetlands
	Ireland	Belgium, Chile, Denmark, England, France, Germany, Northern Ireland, Scotland, Spain, Wales
	Latvia	Poland
	the Netherlands	Chile
	Norway	Chile, China
	Scotland	Ireland, Tasmania
	Sweden	Denmark, Germany, Finland, Taiwan
	UK	Brazil, Chile, Denmark, Ireland, Morocco, Northern Ireland
Salmo trutta	Ireland	Luxemborg
	UK	Jersey, Turkey, Mexico, South America
Salvelinus alpinus	Canada	China, France, Germany, Ireland, Scotland, USA
	Canada	UK
	Iceland, Sweden	Ireland
	Ireland	England
	Sweden	Canada, Estonia, Finland, Germany
S. alpinus x *S. fontinalis*	Canada	Germany, France, USA
Salvalinus fontinalis	Canada	France, Italy, USA
Salvelinus naymacush	Canada	USA

4.2.2 Increased interest in the sturgeon

Several species of sturgeon are reared in culture in areas beyond their native range. These fish generally have a long lifespan. However, because of their late maturation, deterioration of spawning habitats, and overfishing, their populations have greatly declined. This has resulted in attempts to supplement the lack of natural recruitment with hatchery-produced stocking, with highly variable results. Their use in aquaculture has also developed significantly over the past two decades. Farms have produced sturgeon for food and attempted to produce caviar and ornamental fish for ponds. Some species have been imported as aquarium species to Europe. Escapes from aquaculture pond operations, together with deliberate releases from small private ponds after fish become too large, account for occasional captures from the wild. Experimental studies on hybridization such as the bester (*Huso huso* x *Acipenser ruthenus*) hybridize easily under culture conditions. Despite different species co-occurring in the wild, they do not appear to freely hybridize in the wild. Yet natural hybridization has occurred, and the potential for natural cross-breeding exists from releases and may be damaging to those populations that are reduced and endangered.

In December 1999, a storm flooded a sturgeon culture facility on the banks of the Gironde River, France, resulting in the loss of over 20% of the stock of *Acipenser baerii*. Local fishers were employed to recapture escapees because of concerns about possible habitat competition and interbreeding with the highly endangered native population of *Acipenser sturio*.

In a further case, several specimens of the Russian shovelnose sturgeon *Scaphirhynchus platorynchus* were found at one location in North America and removed from the wild because of similar concerns that these could provide competition for native species.

There has been a marked increase in the number of released or escaped specimens reported in German waters during the period 1991–2000: (315 fish) compared with 1981–1990 (23 fish), with most of these captures taken in estuarine and coastal waters and in large rivers (90%). They are made up of *A. baerii* (44%) and *A. ruthenus* (4%), with the remaining fish not identified to species level.

The restoration of *A. sturio* in Europe depends on habitat restoration and requires their survival over several decades for the population, based on hatchery releases, to become re-established.

The management, development, and restoration of world sturgeon populations are supported by the recently established World Sturgeon Conservation Society, based in Germany (http://www.wscs.info).

4.2.3 Aquarium and pond fish

The interest in ornamental fish for ponds, such as koi carp, has increased in the past decade, and many garden centres sell koi and other temperate species directly to the public. This now includes sturgeon.

Aquarium fish imports rely on captures of wild fish of which ca. 1000 species are imported to Europe. These imports are channelled through centres such as the one near London's Heathrow Airport. The centre also has a breeding programme, involving about 12 species, including the anemone fish *Amphiprion* spp. In 1992, this involved imports from 23 countries including France, the Netherlands, Denmark, the US, Costa Rica, Brazil, Barbados, Egypt, Saudi Arabia, Dubai, Kenya, Australia, Singapore, Thailand, the Maldives, Sri Lanka, the Philippines, Indonesia, Fiji, and the Cook Islands. The centre uses water from a borehole and sea salt preparations. Examples of some of the fish imports appear in Table 4.2.3.

Similar centres, e.g. in Germany, import both fresh and saltwater fish, and it is likely that millions of fish are imported each year, principally from South America and Southeast Asia.

In 1980, the estimated biomass of imports was 60 mt, whereas in 2000 imports had risen to 105 mt of freshwater fish and 45 mt of marine fish.

Table 4.2.3. Some of the aquarium and pond cultivated species in transmission. Note that there are probably >1000 species in transmission.

SPECIES	COMMON NAME	SOURCE	DESTINATION	PURPOSE
Anarhichas ocellatus	spotted wolffish	Canada	Portugal	marine aquaria
Anarhichas ocellatus	spotted wolffish	Canada	the Netherlands	
Balantiocheilos melanopterus	silver 'shark'	Singapore	Ireland	freshwater aquaria
Betta splendens	Siamese fighting fish	Singapore	Ireland	freshwater aquaria
Botia morleti	horae botia	Singapore	Ireland	freshwater aquaria
Brachydanio albolineatus	pearl danio	Singapore	Ireland	freshwater aquaria
Carassius carassius	goldfish	Malaysia	Ireland	freshwater aquaria
Cichlasoma everum	severum cichlid albino	Singapore	Ireland	freshwater aquaria
Colisa lalia	golden gourami	Malaysia	Ireland	freshwater aquaria
Corydoras aenus	aenus cory	Malaysia	Ireland	freshwater aquaria
Ctenopharyngodon idella	grass carp	unknown	Finland	pond
Cyprinus carpio	koi carp	Malaysia	Ireland	freshwater aquaria
Gymnocorymbus ternetzi	black tetra	Singapore	Ireland	freshwater aquaria
Haplochromis spp.	cichlids	Singapore	Ireland	freshwater aquaria
Hemigrammus erythrozonus	glowlight tetra	Malaysia/Singapore	Ireland	freshwater aquaria
Hemigrammus ocellifer	head and tail light	Singapore	Ireland	freshwater aquaria
Hemilepidotus hemilepidotus	red Irish lord	Canada	France	marine aquaria
Hexagrammus decagrammus	kelp greenling	Canada	France	marine aquaria
Hydrolagus colliei	spotted ratfish	Canada	France	marine aquaria
Hyphessobrycon erythrostigma	bleeding-heart tetra	Singapore	Ireland	freshwater aquaria
Hyphessobrycon flammeus	red-tail tetra	Singapore	Ireland	freshwater aquaria
Hyphessobrycon herbertaxelrodi	black neon-tetra	Singapore	Ireland	freshwater aquaria
Hyphessobrycon herberxa	black neon-tetra	Malaysia	Ireland	freshwater aquaria
Labeo bicolor	red-tail black 'shark'	Singapore	Ireland	freshwater aquaria
Lepomis gibbosus	pumpkinseed	Czech Republic	Ireland	ponds?
Macropodius opercularis	paradise fish	Singapore	Ireland	freshwater aquaria
Osphronemus goramy	pearl gourami	Singapore	Ireland	freshwater aquaria
Paracheirodon axelrodi	cardinal tetra	Malaysia	Ireland	freshwater aquaria

SPECIES	COMMON NAME	SOURCE	DESTINATION	PURPOSE
Paracheirodon innesi	neon tetra	Malaysia/Singapore	Ireland	freshwater aquaria
Poecilia latipinna	golden molly	Singapore	Ireland	freshwater aquaria
Poecilia reticulata	fantail guppy	Singapore	Ireland	freshwater aquaria
Poecilia sphenops	black molly	Singapore	Ireland	freshwater aquaria
Pontius conchonius	rosy barb	Singapore	Ireland	freshwater aquaria
Pseudotrophaeus spp.	cichlids	Singapore	Ireland	freshwater aquaria
Pseudotrophaeus zebra	golden zebra cichlid	Singapore	Ireland	freshwater aquaria
Pterophyllum scalare	golden angel	Malaysia	Ireland	freshwater aquaria
Pterophyllum scalare scalare	angel fish	Singapore	Ireland	freshwater aquaria
Puntius sachsi	neon golden barb	Malaysia/Singapore	Ireland	freshwater aquaria
Rasbora heteromorpha	harlequin rasbora	Malaysia/Singapore	Ireland	freshwater aquaria
Rhodeus sericeus	bitterling	Czech Republic	Ireland	freshwater aquaria
Rocca saxatilis	striped bass	Canada	USA	marine aquaria
Sphaericthys osphromeniodes	chocolate gourami	Singapore	Ireland	freshwater aquaria
Thayeria boehlkei	penguin	Singapore	Ireland	freshwater aquaria
Trichogaster tricopterus	golden gourami	Malaysia	Ireland	freshwater aquaria
Trichogatser leeri	pearl gourami	Singapore	Ireland	freshwater aquaria
Xiphister mucosus	monkey-face eel	Canada	Portugal	marine aquaria
Xiphophorus helleri	red platy	Singapore	Ireland	freshwater aquaria
Xiphophorus maculatus	red wagtail platy	Malaysia/Singapore	Ireland	freshwater aquaria

In Germany, at warm-water discharges, there have been trial studies in the production of ornamentals such as koi carp, goldfish, and sterlet (*Acipenser ruthenus*).

In the expanding trading block of the European Union, procuring records is difficult because imports at one specific entry point within the EU require documentation. As a result, the subsequent trade to other European destinations cannot be readily traced. The market in any EU country often includes movements from other European countries.

4.2.4 Management of exotic species cultivation in closed recirculating systems

It is acknowledged that cultivation of an exotic species can lead to releases into the wild and that these releases may have impacts on native populations. Management of quality fish products in closed recirculating systems is an industry that can supply a specialist market and is likely to evolve further. In one case in 1993, WGITMO (ICES, 1994) considered the planned introduction of striped bass *Rocca saxatilis* and white bass *Rocca chrysops* and their hybrids to a European culture facility from North America. This exercise provided a useful template for the introduction of an exotic fish species to closed recirculating systems and should be considered together with improved knowledge gained in the meantime by

WGITMO. In the bass proposal, WGITMO did not oppose the introduction subject to the following conditions:

- An assessment will be carried out that addresses the operational and environmental aspects of the disposal of waste products, including dead fish, waste water, and liquid manure (the disposal of these products must meet the requirements of the relevant authorities).
- The facility will be constructed so that, in the event of complete tank(s) failure, all fish and water will be physically contained within the facility.
- A contingency plan will be prepared that addresses all identifiable potential accidental events that could lead to fish escape (such as the loss of fingerlings during transfer from the port of entry to the culture facility).
- Breeding stocks will be established within the culture facility as soon as possible by importing surface-disinfected eggs from parents that have been lethally sampled for bacteria, viruses, and other potentially vertically transmitted organisms. These breeding stocks should be maintained within the site in isolation from fingerlings in culture.
- No live fish or viable gametes will leave the security of the site.

4.3 Atlantic seaboard of North America

4.3.1 Salmonids

There are frequent annual movements of eggs, fry, and smolts of salmonids in the Eastern Provinces of Canada and exports to the US and elsewhere in the world (Table 4.11.1). These movements are for stock enhancement, aquaculture, and research. The great majority of movements arise from stocks that already exist east of the Rocky Mountains. Atlantic salmon and rainbow trout are especially important in aquaculture. Triploid rainbow trout eggs have been moved between Eastern Canadian Provinces and released into drainages, where there may be a risk to local stocks from competition, should they become otherwise established. Other developments will have included the movement of milt of salmon from transgenic fish to New Brunswick from Nova Scotia.

Research into developing faster growing and cold-tolerant Atlantic salmon using Chinook salmon growth hormone and eelpout (*Zoarces* sp.) "anti-freeze" promoter took place in Canada in 1996.

4.3.2 Attempts to develop a recreational fishery based on Pacific salmon on the eastern Atlantic seaboard

Early studies commenced in 1971 (ICES, 1999a) in New Hampshire and Massachusetts to develop an autumn/winter sport fishery using releases of the Pacific coho salmon *Oncorhynchus kisutch*, and in 1985 records of 100 000 pen-reared F_3 and F_4 generations were released in Massachusetts and 118 000 smolts in New Hampshire. In 1986, this ceased, but a further programme of smolt releases to the Lamprey River was embarked upon over a five-year period, 1989–1993, with annual releases of 400 000–550 000 smolts in September/October. The fish were supplied by a hatchery in New York State. A study had indicated that any significant environmental impact from this project was unlikely. However, because the returns were very poor, the project was discontinued. In the earlier studies, small numbers of Chinook salmon, *Oncorhynchus tshawytscha*, were also released. To 1994, only four returns were recorded from the Lamprey River. New Jersey considered releases of Chinook salmon to support a sport fishery, but the results from the coho study and lack of returns from the earlier investigations led to a decision not to make these releases.

4.3.3 Development of species for aquaculture

Several marine species are under consideration for aquaculture. Already some experimental cultivation of Atlantic halibut in Canada has taken place with imports of young specimens from Iceland. Research into the development of several other species is outlined in Table 4.11.2.

4.3.4 Other species

Live fish for human consumption are exported to Canada in relatively small quantities, including carp, brown bullhead, pacu, tambaqui, and tilapia; some of these were imported to Nova Scotia for research purposes. For most of these species, the true volumes imported remain unknown, but also included smaller numbers of black bullhead, lake trout, yellow perch, and lake sturgeon. Some species were either imported alive for the table or for research, including the Arroyo chub *Gila orcotti*, inconnu *Stenodus leucichthys*, and shovelnose sturgeon *Scaphirhynchus platorhynchus*. In 1996, muskellunge were imported to Manitoba from Minnesota in an attempt to develop a self-sustaining population where previous attempts had failed.

The northern pike *Esox lucius* and the pikeperch/walleye *Stizostedion vitreum* have been used to stock lakes in Manitoba, to create self-sustaining populations, or to replace populations that expire during cold winters. *Micropterus dolomieui* and *Ictalurus nebulosus* were imported to Canadian waters supporting aquaculture projects.

4.3.5 Species unintentionally introduced to the Atlantic region of North America

***Esox masquinongy* – the muskellunge (Esocidae)**

This North American fish was north of its range in the St John River in Quebec in 2001; it is thought to have been introduced there in 2000.

***Esox niger* – the pickerel (Esocidae)**

This predatory fish was found in a lake on the Miramichie River basin. The lake was treated with rotenone to eliminate the species on account of its threat to wild fish in the system.

***Oreochromis niloctica* – Nile tilapia (Cichlidae)**

This euryhaline species was found in the estuary of the Pascagoula River in the Mississippi basin. It is probably an escape from an aquaculture facility. As it had survived two winters at the time of the report, the species is most probably established.

***Pterois volitans* – lionfish (Scorpaenidae)**

This Indo-Pacific species was first recorded in Biscayne Bay in 1992, and since then, it has been seen at wreck sites by divers as far north as Long Island. As juveniles have been found off the North Carolina coast, indicating successful recruitment, the species may be established. It may have been an aquarium or ballast water release.

4.4 Great Lakes region

4.4.1 Species unintentionally introduced to the Great Lakes region

Over the past two decades, there has been a noticeable increase in the number of exotic species becoming established within the Great Lakes region, including fish. Some of these are aggressive competitors with consequences for some native populations. It should be noted that there have been noticeable changes to the environment following the invasion by the zebra mussel in the mid-1980s. They are efficient filter-feeders and have removed much of the particulate matter from the water column that provides an energy-rich benthic environment.

The reduced plankton biomass has almost certainly affected the recruitment of some fish species.

***Neogobius melanostomus* – round goby (Gobiidae)**

This Pontocaspian species, often reaching 15 cm in length, was first noticed in a small river between Lakes Huron and Erie in 1990. It is thought to have been introduced with ballast water from ships. By 1994, the species had become common in the southern part of Lake Erie, and specimens were found in the Welland Canal in 1996.

***Proterorhinus marmoratus* – tube-nosed goby (Gobiidae)**

Found on the American side of the St Clair River in 1990, this Pontocaspian species became common on the south side of Lake St Clair in 1994 and spread to the lower Detroit River in 1995. The species had become rare by 1996, possibly as a result of competition from the round goby.

***Scardinius erythropthalmus* – rudd (Cyprinidae)**

This European fish was found in the St Lawrence River and is thought to have been introduced through releases of baitfish by anglers, and by 1996, it was found in western Lake Ontario and eastern Lake Erie.

***Platichthys flesus* – European flounder (Pleuronectidae)**

This estuarine species is known to ascend rivers in Europe and is tolerant of freshwater. Its occurrence is thought to have been caused by ballast water discharges, with records from Thunder Bay. Previously, there had been occasional records of this species.

***Noturus insignis* – madtom (Ictaluridae)**

This fish was established by 1994 in Lakes Muskoka and Rousseau, Ontario, and may have arrived as a result of bait bucket releases.

***Gymnocephalus cernuus* – Ruffe (Percidae)**

This European fish was first noted in Duluth Harbour in 1986. By 1993, it was found 156 miles away, with an average expansion of 29 miles per year, spreading its range along the south coast of Lake Superior. By 1995, the species had spread to rivers in Wisconsin and Michigan and in Thunder Bay, western Lake Superior, and was found for the first time in Canadian waters in 1994 in the Kaministiquia River. A Ruffe control programme was set up to manage the expansion of this invasive fish in 1994 through chemical piscicides, population investigations, biogeographical recording and biological interaction assessments, and a public information campaign. Despite this, the species continued to spread and was found for the first time in Lake Huron in 1995.

***Apeltes quadracus* – four-spined stickleback (Gasterosteridae)**

This species has a natural range in Atlantic North America and was found in Thunder Bay, Lake Superior.

***Ctenophyrangodon idella* – grass carp (Cyprinidae)**

Grass carp were introduced to Alberta to examine its potential for controlling aquatic vegetation in irrigation canals and farm dugout ponds. The stock was imported from the US.

4.5 Northwestern Europe

4.5.1 Salmonids

Salmonids almost certainly make up the greatest number of fish in transit. These are principally rainbow trout and salmon. Some of the movements are clearly experimental, whereas the bulk of consignments are part of an established trade. Large volumes of surface-

disinfected eggs continue to be exchanged within Europe, as well as exported to Chile to support aquaculture ventures. Some of these movements are extensive. For example, imports of one million salmon eggs to England and Wales were planned, based on broodstock grown in New South Wales, Australia, previously introduced from British Columbia. Rainbow trout eggs were imported for culture; coming from Tasmania and South Africa, they allow a more continuous production. Eggs from South Africa arrive in July and August. Imports to England and Wales ranged from 20 to 60 million eggs each year. Such movements appear to be consistent annually and are part of an established trading practice.

In a conservation plan to re-establish the Atlantic salmon in the Meuse River in northern Europe, salmon have been imported from Ireland for stocking.

Recently, there has been interest in the use of Arctic char for cultivation in Europe with a flow of >100 000 eggs from Sweden to Ireland in 1992. Imports in 1994 included eggs from Canada and Iceland, and by 1998, 1.2 million eggs were imported.

4.5.2 Other species

Most specific species movements follow developed practices in aquaculture. Until 1996, when local hatchery production in Spain became sufficient, turbot cultivation in Galicia, Spain, was partly supported with annual imports of 250 000 to 500 000 fry from the Isle of Man. Research into turbot in Ireland has also resulted in imports from the same source. Cultured turbot are marketed within Europe. Imports of turbot to Ireland from the Isle of Man were 8000 and had increased to 45 000 by 1994.

Striped bass cultivation in England involves the import of 250 000 fry annually. These are cultivated at one site in water heated from thermal discharges from a power plant.

Eels, *Anguilla anguilla*, are moved within Europe for human consumption, and this has involved imports of eels, *Anguilla* sp., from Canada, the US, and New Zealand.

Live elvers of *A. anguilla* have been collected for redistribution in Europe, either for human consumption, culture activities, or restocking. In Ireland, these are captured in the estuaries and brought inland for restocking, a practice that promotes their survival. Similar programmes occur with elver imports to the Baltic region and Germany. Elvers have also been exported from Europe to Asia for culture. Some Atlantic halibut cultivation research programmes involved the movement of juveniles from the Orkneys and from the Isle of Man to Ireland, and from Iceland to Canada.

4.5.3 Species unintentionally introduced to northwestern Europe

***Acipenser baerii* – Siberian sturgeon (Acipenseridae)**

The Siberian sturgeon was recorded in Germany and may have been released from private aquaria or escaped from aquaculture ponds. There are further accounts recalled by German fishers, but these have not been verified.

***Tetraodon fluviatilis* – green puffer (Tetraodontidae)**

There is a single record of this Asian fish captured off the coast of Belgium. It may have been originally in an aquarium and was subsequently released.

***Micropogonias undulatus* – Atlantic croaker (Sciaenidae)**

This species is native to the east coast of North America and the Gulf of Mexico, and a single specimen was found in the Scheldt Estuary in 2001. It may have been a ballast water release.

***Vimba vimba* – Baltic vimba (Cyprinidae)**

Two juveniles were found in the Scheldt estuary. The species is native to the rivers draining into the Baltic Sea. It is not known how they arrived.

4.6 Baltic Sea

4.6.1 Whitefish reintroduction to the Baltic Sea

The whitefish *Coregonus lavaretus* programme to reintroduce this species was undertaken by Sweden, Finland, Estonia, and Poland. This commenced in 1991 with juvenile releases into Puck Bay and the Szczecin Lagoon, Poland. Fish reared in Finland were exported to Sweden. In Finland in 1999, 28 million newly hatched and 10 million juveniles were released into the Baltic Sea. Estonia released 117 000 in 2000.

4.6.2 Restocking northern pike

Pike *Esox lucius* juveniles have been released into two coastal lagoons on the Polish coast, Szczecin and Vistula lagoons, with releases of 381 000 and 436 000 fish, respectively.

4.6.3 Species unintentionally introduced to the Baltic Sea

***Neogobius melanostomus* – round goby (Gobiidae)**

The species may have been introduced to the Gulf of Gdańsk before 1987, and by 1990, it was found from Gdańsk westwards to all of the shallows of Puck Bay. The species may have arrived with ballast water coming from the Caspian and Black Seas region. A further possible means of arrival is via the canal and river system entering the Gulf of Finland. Some specimens were found in the rivers along this route. However, if this is the case, it is difficult to explain why the species has not been observed in the Gulf of Finland or coastal bays and lagoons north of the Gulf of Gdańsk. By 1999, the species had reached the eastern border of Germany and appeared for the first time in the Vistula Lagoon, Poland. In 2004, the species was found at one isolated location, Rügen Island, on the Baltic Sea coast of Germany. This fish is avidly eaten by cod and cormorants.

***Polyodon spathula* – Mississippi paddlefish (Polyodontidae)**

A single *Polyodon spathula* was found in 1999 in the southern part of the Szczecin Lagoon, Poland.

***Acipenser güldenstädti* – Russian sturgeon (Acipenseridae)**

Two Russian sturgeon were captured on the southwest coast of Finland and in the eastern Gulf during 2000.

***Acipenser stellatus* – starry sturgeon (Acipenseridae)**

A single specimen was captured in 1999, and three further specimens were captured in 2000, all in Finnish waters. A single specimen was captured in Swedish waters in 2000.

4.7 Atlantic seaboard of southwestern Europe

4.7.1 Species unintentionally introduced to the Atlantic Iberian region

***Fundulus heteroclitus* – mummichog (Fundulidae)**

The mummichog from the North American Atlantic coast was introduced to Spain during the period 1973–1976 from eastern Canada and has now expanded its range towards Portugal.

4.8 The Mediterranean Sea

4.8.1 Species in cultivation

The fish used in aquaculture in Italy include the bastard flounder *Paralichthys olivaceus*, the drum *Sciaenops ocellatus*, and the sparid *Pagrus major*. *P. major* is reared in commercial hatcheries that include land-based culture facilities. Broodstock of *P. olivaceus* and *S.*

ocellatus were introduced in 1994, and their subsequent generations have been cultured under semi-intensive and intensive conditions. By 2000, these species produced 100 tonnes.

4.8.2 Species unintentionally introduced to the Mediterranean Sea

***Stephanolepis diaspros* – filefish (Monocanthidae)**

The small monocanthid filefish is a Lessepsian migrant first known from the Mediterranean in 1927 and well established in the eastern Mediterranean; it had expanded its range to Italian waters by 2000.

***Abudefduf vaigiensis* – damselfish (Pomacentridae)**

This is a Lessepsian species, first recorded in Italy before 1959. Very few records of this species exist, and its appearance as a natural range expansion from the Suez region is difficult to explain, unless the species was introduced by some other means.

***Epinephelus coioides* – spotted grouper (Serranidae)**

This is a Lessepsian migrant that can be mistaken for *E. malabaricus*, which also emerged in the Mediterranean from the Red Sea. A single juvenile was found in the Gulf of Trieste, Italy.

4.9 Summary

There is an apparent increase in the number of fish being tried as "new" aquaculture species because of an interest, for various reasons, in research on non-native species. Some of the non-native species recoveries from the wild most probably relate to releases or escapes from research establishments and the pet trade. With competition for space in sheltered inlets and the expense of using offshore facilities, it is likely that more land-based intensive culture operations will take place. If the security of these operations is effective, escapes from such operations are not expected. Of concern, however, is the large number of reports of established non-native fish, whose occurrence has been presumed to be a result of ballast water releases by shipping or bait releases by fishers. In the case of the expanding European Union and reduced controls on trade, further Pontocaspian species and exotic species, already established in regions of the EU, may be expected to spread to central and western Europe. The gradual impact of a changing climate may result in some severe meteorological events such as the flooding of the Rhine, Danube, and Gironde Rivers, and are likely to result in further purges from ponds. Escapes from storm-damaged cage culture units of non-native fish in the sea, such as rainbow trout, will allow further access to the wild. It is likely that there will be major advances in the culture and management of fish in the next decade.

4.10 References

ICES. 1992. Report of the Working Group on Introductions and Transfers of Marine Organisms, Lisbon, Portugal, 14–17 April 1992. ICES CM 1992/POLL:3.

ICES. 1993. Report of the Working Group on Introductions and Transfers of Marine Organisms, Aberdeen, Scotland, 26–28 April 1993. ICES CM 1993/ENV:7.

ICES. 1994. Report of the Working Group on Introductions and Transfers of Marine Organisms, Mystic, CT, 20–22 April 1994. ICES CM 1994/ENV:7.

ICES. 1995. Report of the Working Group on Introductions and Transfers of Marine Organisms, Kiel, Germany, 10–13 April 1995. ICES CM 1995/ENV:9.

ICES. 1996. Report of the Working Group on Introductions and Transfers of Marine Organisms, Gdynia, Poland, 22–26 April 1996. ICES CM 1996/ENV:8.

ICES. 1997. Report of the Working Group on Introductions and Transfers of Marine Organisms, La Tremblade, France, 22–25 April 1997. ICES CM 1997/ENV:6.

ICES. 1998. Report of the Working Group on Introductions and Transfers of Marine Organisms, The Hague, the Netherlands, 25–27 March 1998. ICES CM 1998/ACME:4.

ICES. 1999. Report of the Working Group on Introductions and Transfers of Marine Organisms, Conwy, UK, 14–16 April 1999. ICES CM 1999/ACME:1.

ICES. 1999a. Status of introductions of non-indigenous marine species to North Atlantic waters. ICES Cooperative Research Report, No. 231. 95 pp.

ICES. 2000. Report of the Working Group on Introductions and Transfers of Marine Organisms, Parnu, Estonia, 27–29 March 2000. ICES CM 2000/ACME:07.

ICES. 2001. Report of the Working Group on Introductions and Transfers of Marine Organisms, Barcelona, Spain, 21–23 March 2001. ICES CM 2001/ACME:08.

ICES. 2002. Report of the Working Group on Introductions and Transfers of Marine Organisms, Gothenburg, Sweden, 20–22 March 2002. ICES CM 2002/ACME:06.

ICES. 2005. ICES Code of Practice on the Introductions and Transfers of Marine Organisms, 2005. 30 pp.

4.11 Tables

Table 4.11.1. List of fish transferred for aquaculture and stocking purposes, 1991–2002. Fish stages: E = eggs, F = fry, Y = juveniles, A = adults. Countries in bold have significant transfers within them.

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
A. ruthenus x *A. baeri*	sturgeon hybrid	91			Russia	Portugal	aquaculture
Acipenser baerii	Siberian sturgeon	97, 98, 99, 00, 01		Y, E	Russia	Germany, Poland	aquaculture
Acipenser ruthenus	sterlet	00				Germany	aquaculture
Acipenser sturio	sturgeon	97		Y	Russia	Germany	stocking
Amphiprion sp.	clownfish	96				Britain	aquaculture/aquaria
Anguilla anguilla	freshwater eel	92		Y	France, UK	Denmark	aquaculture
Anguilla anguilla	freshwater eel	96		Y	France	Japan, South Korea, China	aquaculture
Anguilla anguilla	freshwater eel	94, 01		Y	Sweden	Finland	stocking
Anguilla anguilla	freshwater eel	91, 95, 96, 00, 01	5 mt	Y	England	Sweden	stocking
Anguilla anguilla	freshwater eel	98			Britain	Estonia	stocking
Coregonus artedii	cisco	96		E	Canada	China	aquaculture
Coregonus lavaretus	whitefish	91–01	200 000	Y	Poland, Finland	Poland, Finland	stocking
Coregonus lavaretus	whitefish	95, 97, 98, 99	ca. 30 000+	Y		Estonia, Poland	stocking
Ctenopharyngdon idella	grass carp	95			USA	Canada	weed control
Cyprinus carpio	common carp	01	~5000 mt		Poland, Hungary, Czech Rep.	Germany	aquaculture
Cyprinus carpio	common carp	96, 97, 98, 99		Y		Estonia	stocking
Dicentrarchus labrax	bass	99, 00	120 000	Y	France, Malta	Norway	aquaculture
Dicentrarchus labrax	bass	92/96, 97		E	France	Denmark, Greece, Italy	aquaculture
Dicentrarchus labrax	bass	97		Y	France	Malta,Turkey, Tunisia, Spain	aquaculture
Esox lucius	northern pike	95, 96			USA	Canada	stocking
Esox lucius	northern pike	95, 96, 98, 99, 01		Y		Estonia	stocking
Esox masquinongy	muskellunge	97	250 000		Canada	USA	stocking
Gadus morhua	cod	01				Canada	aquaculture

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
Hippoglossus hippoglossus	Atlantic halibut	98	>50 000	Y	Iceland	USA	aquaculture
Hippoglossus hippoglossus	Atlantic halibut	99, 00, 01	>100 000 (2 000 000)	F (E)	Iceland	Norway	aquaculture
Ictalurus nebulosus	brown bullhead	95				Canada	aquaculture/stocking
Micropterus dolomieui	smallmouth bass	96	25 000		USA	Canada	stock
Morone chrysops	wild white bass	95	<500		Canada	**USA**	research
Oncorhynchus kisutch	coho salmon	96			W. Canada	Canada	research
Oncorhynchus mykiss	Rainbow trout	91–02	>1 000 000	E, F	**Canada**	various	aquaculture/stocking
Oncorhynchus mykiss	Rainbow trout	92, 95	>100 000	E	**Canada**		aquaculture/stocking
Oncorhynchus mykiss triploids	chinook	92	500 000	Y		USA	stocking
Oncorhynchus tshawytscha	nile tilapia	01			USA	Canada	aquaculture
Oreochromis nilocticus	yellow perch	96				Canada	stocking/aquaculture
Perca flavescens	plaice	92		Y	**Denmark**		stocking
Pleuronectes platessa	turbot	01	100 000		Ireland	China	aquaculture
Psetta maxima	turbot	00	5 000 000	L	Norway	Spain	aquaculture
Psetta maxima	turbot	01			France, Spain, Denmark	Norway	aquaculture
Psetta maxima	turbot	92, 01	3 000 000	L	Norway	Denmark	aquaculture
Psetta maxima	turbot	92–01	<25 000	Y	Isle of Man	Ireland	aquaculture
Psetta maxima	turbot	97		Y	France	Malta, Turkey, Tunisia, Spain	aquaculture
Psetta maxima	turbot	96		Y	**France**	Spain, Italy	aquaculture
Psetta maxima	turbot	00, 01	2000	Y	France	Belgium	stocking
Psetta maxima	turbot	92		Y	**Denmark**		stocking
Psetta maxima	turbot	92		E	France	Denmark	stocking
Rocca saxatilus	striped bass	91–02	250 000	F @ 1g	USA	UK	aquaculture
Rocca saxatilus	striped bass	96	/1500		**Canada**	USA	aquaculture/stocking
S. alpinus x *S. fontinalis*	hybrid trout	96				Canada	stocking
S. fontinalis x *S. namaycush*	splake	95, 96				Canada	stocking
Salmo clarkii	cutthroat trout	97				Canada	unclear
Salmo salar	Atlantic salmon	93, 02	>1 000 000	E, F	see Table 4.11.2	various	aquaculture & stocking
Salmo trutta	brown trout	96			see Table 4.11.2	various	stocking
Salvelinus alpinus	Arctic charr	93		E	see Table 4.11.2	various	stocking
Salvelinus fontinalis	brook trout	91–02	>1 000 000	E, F	see Table 4.11.2	various	stocking
Salvelinus	lake trout	92, 94	>10 000	E, F	see Table	various	stocking

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
namaycush					4.11.2		
Solea solea	sole	00		E	USA	Spain	aquaculture
Sparus aurata	gilthead bream	94		Y	Greece	Germany	research
Stizostedion lucioperca	pikeperch	95, 96, 97, 98, 99, 01	40 000+	Y		Estonia	stocking
Stizostedion vitreum	zander, walleye	95	4 000 000	E	**Canada**	China	stocking
Thymallus thymallus	grayling	92, 96		E	Sweden	Germany, France	stocking?
Thymallus thymallus	grayling	91, 92, 01		E	Finland	France/Austria	stocking?
Zander lucioperca	pikeperch			Y	Sweden	Sweden	stocking

Table 4.11.2. List of fish transferred for research purposes or transported alive for human consumption. Countries in bold have significant transfers within them. See Table 4.11.1 for abbreviations used.

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
A. baeri x *A. medirostis*	sturgeon hybrid	01				Poland	research
Acipencer brevirostrum	shortnose sturgeon	97				Canada	research
Acipenser baeri	Siberian sturgeon	99				Poland	research
Acipenser baeri x *A. ruthenus*	hybrid sturgeon	91	triploids		Russia	Portugal	research?
Acipenser fulvescens	lake sturgeon	93				Canada	food
Acipenser medirostris	green sturgeon	99				Poland	research
Acipenser sturio	European sturgeon	97, 99				Germany, Poland	conservation
Acipenser transmontanus	white sturgeon	01			USA	Canada	research
Acipenser transmontanus	white sturgeon	93, 94	several		USA, Italy	Germany	research
Aciperser baeri x *A. medirostris*	hybrid sturgeon	99			Russia	Poland	research
Ameiurus nebulosus	brown bullhead	97				Canada	unclear
Anarhichas lupus	wolffish	97		A		Canada	research
Anguilla anguilla	freshwater eel	00		A	Sweden	Germany, Denmark, Belgium	food
Anguilla anguilla	freshwater eel	94, 95		A	Sweden	Poland, Hong Kong, Japan	food
Anguilla anguilla	freshwater eel	99		A	Lithuania, Norway	Sweden	food
Anguilla anguilla	freshwater eel	97		A	Sweden	Israel, Italy, Spain, Poland	food

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
Anguilla anguilla	freshwater eel	91		A	England	Europe, Israel, Hong Kong	food
Anguilla anguilla	freshwater eel			A	Ireland	UK	food
Anguilla rostrata	freshwater eel	00		A	Canada	the Netherlands	food
Anguilla rostrata	freshwater eel			A	Canada, USA	UK	food
Anguilla sp.	freshwater eel	91, 92		A	New Zealand	UK	food
Centrarchus macrochirus	bluegill sunfish	92	2000		USA	Scotland	research
Channa sp.	snakehead	99			Pacific	Canada	food
Colossoma macropomum	tambaqui	96			Brazil	Canada	food
Ctenopharyngdon idella	grass carp (triploids)	95		A	USA	Canada	plant control research
Cyclopterus lumpus	lumpfish	97				Canada	research
Cyprinus carpio	common carp	00	3000 mt	A	Denmark, Poland	Germany	food
Cyprinus carpio	common carp	00		A	Poland, the Netherlands	Sweden	food
Cyprinus carpio	common carp	91, 93, 95, 99			W-USA, USA	Canada	research
Cyprinus carpio	common carp	95			Canada	USA	research
Dicentrarchus labrax	bass	99		Y	Malta, France	the Netherlands	research
Fundulus sp.	killifish	91		Y	Canada	Norway	research
Gadus morhua	cod	97, 99, 01		E		Canada	research
Gadus ogac	Greenland cod	97				Canada	research
Gila orcotti	arroyo chub	94			USA	Canada	food/research
Glyptocephalus glyptocephalus	witch flounder	00				Canada	research
Hippoglossoides platessoides	American plaice	97				Canada	research
Hippoglossus hippoglossus	Atlantic halibut	97, 98, 99, 00, 01		E		Canada	Research
Hippoglossus hippoglossus	Atlantic halibut	01	>1000	Y	Isle of Man	Ireland	research
Hippoglossus hippoglossus	Atlantic halibut	94			Norway	Ireland	research
Hippoglossus hippoglossus	Atlantic halibut	95	5000	A	Orkneys	Ireland	research
Hippoglossus hippoglossus	Atlantic halibut	01	1000	F	Norway	Britain	research
Hypophthalmichthys nobilis	bighead carp	91			USA	Canada	unclear
Ictalurus nebulosus	brown bullhead	92	3 mt		USA	Canada	food
Ictalurus punctatus	channel catfish	91			USA	Canada	unclear
Ictiobus sp.	buffalo fish	91			USA	Canada	unclear
Limanda ferruginea	yellowtail flounder	97, 98, 99, 00				Canada	research

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
Melanogrammus aeglefinus	haddock	99, 00, 01				Canada	research
Microgadus tomcod	tomcod	96	gametes		USA	Canada	research
Morone chrysops	white bass	96			Canada	USA	food
Morone saxatilus	striped bass	96, 99, 00			USA	Canada	research
Muranaesox talabonoides	Indian pike conger	99			Pacific	Canada	food
Noturius insignis	mad tom	96		E, milt	USA	Canada	research
Oncorhynchus apache	apache trout	01			Finland, Denmark	Estonia	research
Oncorhynchus chrysogaster	Mexican golden trout	01			Finland, Denmark	Estonia	research
Oncorhynchus gilae	gila trout	99			Finland, Russia	Estonia	food?
Oncorhynchus kisutch	coho salmon	95			W Canada	Canada	research
Oncorhynchus mykiss	rainbow trout	92	>10 000		**Canada**		food
Oncorhynchus tshawytscha	chinook salmon	89–93	>100 000	Y	**USA**		research/stocking
Oreochromis nilocticus	Nile tilapia	99			Pacific	Canada	food
Paralichthys dentatus	summer flounder	99, 00				Canada	research
Paralichthys dentatus	summer flounder	93				Canada	food
Phoxinus sp.	dace	96	50 gallons	A	Canada	USA	baitfish
Piaractus brachypomus	characin	96			Brazil	Canada	research
Pinguipes brasilianus	sandperch	97				Italy	ballast water?
Psetta maxima	turbot	99			Iceland, France	the Netherlands	research
Psetta maxima	turbot	01	~1000	F	Norway	UK	research
Pseudopleuronectes americanus	winter flounder	97, 98, 99, 00				Canada	research
Rutilus rutilus	roach	00	15 kg	A	Ireland	England	research
Salmo salar	Atlantic salmon	96			W-Canada	Canada	research
Salmo salar transgenics	Atlantic salmon	96	8 vials	milt	**Canada**		research
Salvelinus alpinus	char	92–02	>100		**Canada**		food
Salvelinus namaycush	lake whitefish	92				Canada	food
Scaphirhynchus platorynchus	shovelnose sturgeon	95				Canada	research
Sparus aurata	gilthead bream	94	250 @ 1–2 g	F	Greece	Germany, UK	research
Sparus aurata	gilthead bream	94		Y	France	Germany, UK	research
Stenodus leucicthys	inconnu	95				Canada	research
Thymallus thymallus	grayling	96		E	Sweden	France	research
Tilapia sp.	tilapia	92			USA	Canada	food
Tilapia sp.	tilapia	96	<1 mt			Canada	food

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
Tilapia sp.	tilapia	92	1000		Scotland	Norway	research
Tilapia sp.	tilapia	99	>1000		Thailand	Canada	research
Tliapia aura	gold tilapia	94			Mexico	Canada	research/ food
Torpedo marmorata	marbled electric ray	97	9		France	England	research

Table 4.11.3. Fish unintentionally released into the wild, including unauthorized releases. See Table 4.11.1 for abbreviations used.

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
Abudefduf vaigiensis	damselfish	00	record			Italy	unknown
Abudefduf vaigiensis	damselfish	97		A	Red Sea	Italy	Lessepsian immigrant
Acipenser baerii	Siberian sturgeon	00	records	A		Germany	escapes
Acipenser gueldenstaedti	Russian sturgeon	00	records	A		Germany	escapes
Acipenser gueldenstaedti	Russian sturgeon	00	record	A		Sweden, the Netherlands	escape
Acipenser gueldenstaedti	Russian sturgeon	00	records	A		Italy	escape?
Acipenser transmontanus	white sturgeon	00	records	A		Germany	escapes
Apeltes quadracus	four-spine stickleback	97	record			Canada	unknown
Aspius aspius	asp	97	record			Canada	range expansion?
Coregonus oxyrhinchus	houting	97, 02	records	A		the Netherlands	re-establishment?
Epinephalus coioides	grouper	01	record			Italy	Lessepsian migrant
Esox masquinongy	muskellunge	01	records	A		Canada	from stocking?
Esox niger	pickerel	01	eradicated?	A		Canada	unknown
Fundulus heteroclitus	mummichog	00	established		Canada	Spain	unknown
Gymnocephalus cernuus	ruffe	92	established			Canada	ballast water?
Hypophthalmichthys molitrix	silver carp	97	record			Canada, USA	unknown
Hypophthalmichthys nobilis	bighead carp	97	record			Canada	unknown
Hypostomus plecostomus	sucker-mouth catfish	01	record		USA?	Spain	aquarium release?
Hypostomus plecostomus	sucker-mouth catfish	01	record	A	USA		aquarium release?
Lepomis gibbosus	pumpkinseed	98	record			Poland	aquarium release?
Micropogonias undulatus	Atlantic croaker	01	records	Y		the Netherlands	ballast water?
Mugil labrosus	grey mullet	98	record	A		Poland	unknown
Neogobius melanostomus	round goby	92	established			Canada, USA	ballast water?

Species	Common name	Years	Relative volume	Stage	Source	Destination	Purpose
Neogobius melanostomus	round goby	92	established			Poland	range expansion?
Noturis insignis	mad tom	93	established		USA	Canada	baitfish release?
Oreochromis nilocticus	nile tilapia	00	established			USA	aquaculture escape?
Platichthys flesus	European flounder	94, 97	records			Canada, USA	ballast water?
Polyodon spathula	Mississipi paddlefish	02	record			Poland	unknown
Pomadasys stridens	grunt	02	record	A	Red Sea	Italy	Lessepsian migrant
Pseudorasbora parva	stone moroka	97	record			the Netherlands	range extension?
Pterois volitans	lionfish	00	established	Y, A		USA	aquarium release?
Rocca saxatilus	striped bass	02	records			the Netherlands	unknown
Scaphirhynchus platorynchus	shovelnose sturgeon	95, 96	<10			Canada	research escape
Scardinius erythrophthalmus	rudd	00	established?			Canada	baitfish release?
Serrasalmas nattereri	red-bellied piranha	91	record			Canada	aquarium release?
Stephanolepis dispros	filefish	00	record			Italy	Lessepsian species
Synagrops japonicus	Japanese splitfin	00	record			Italy	Lessepsian immigrant?
Tetraodon fluviatilis	green puffer	01	record			Belgium	aquarium release?
Tinca tinca	tench	99	records			Canada	escapes from pond?
Trinectes maculatus	hogchoker	97	record	A		the Netherlands	unknown
Vimba vimba	Baltic vimba	00	records			Belgium	expansion? bait?

4.12 Records of non-indigenous species

First records of non-indigenous species (all taxa) 1992–2002 worldwide, including uncertain introductions and excluding species in containment. Entries are sorted by the name of the taxa (after national reports and abstracts in recent WGITMO and ICES/IOC/IMO WGBOSV meeting reports). N = North, E = East, S = South, and W = West. Additional data from http://www.ciesm.org/atlas/. The account includes some vagrant species.

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Abudefduf vaigiensis Fish	1990s? (since 1959 in Italy)	Israel	rare	unknown	Suez Canal, range expansion	Indo-Pacific, Red Sea, S Africa to Oceania
Acanthaster planci Echinodermata	2000	France, Port of Cros, Mediterranean Sea	unknown	unknown	unknown	
Acanthomysis aspersa Mysid	1992	USA, San Francisco Bay	unknown	unknown	ballast water	Japan
Acanthomysis sp. Mysid	1992	USA, San Francisco Bay	unknown	unknown	ballast water	Pacific?
Acanthurus monroviae Fish	1990s? (since 1987 in S. Spain)	Israel	single specimens	unknown	range expansion (via Gibraltar)	tropical W Africa from Morocco to Angola
Acartia grani Copepoda	1997	Italy, Ligurian Sea	unknown	unknown	ballast water, range expansion	NW Europe
Acartiella sinensis Copepoda	1993	USA, San Francisco Bay	unknown	unknown	ballast water	China
Acentrogobius (cf) pflaumi Fish	2002	New Zealand	unknown	unknown	unknown	Japan & Korea
Achirus fasciatus Fish	1998	the Netherlands, off shore	single specimen	unknown	unknown	America
Acipenser baeri Fish, Siberian sturgeon	1998	Germany	occasional records	unknown	stocking	NE Asia, Siberia
Acipenser baeri Fish, Siberian sturgeon	1999	France, Port of Cros	single specimen	unknown	escaped from farm	NE Asia, Siberia
Acipenser cf. gueldenstaedti Fish	2000	Sweden, near Kalmar	unknown	unknown	stocking	Ponto-Caspian
Acipenser gueldenstaedti Fish	2000 & 2001	Finland, southwest coast	single specimen	unknown	stocking	Ponto-Caspian
Acipenser spp. Fish	1998	the Netherlands	unknown	unknown	aquarium release	cannot be determined at species level
Acipenser stellatus Fish	1999	Finland, coastal water	unknown	unknown	stocking	Ponto-Caspian
Acipenser stellatus Fish	1999	USA, Great Lakes	unknown	unknown	stocking	Ponto-Caspian

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Acrochaetium balticum Red alga	1990s	Norway, W coast	unknown specimens	unknown	unknown	Baltic
Acrochaetium balticum Red alga	1998	Netherlands, Lake Veere	occasional records	minimal	unknown	Baltic
Acrothamnion preissii Alga	1994	Spain, Balearic Islands (Mallorca, Menorca)	unknown	fouling, competition	unknown	South Pacific?
Acteocina mucronata Gastropoda	1990s? (since 1986 in Israel)	Greece, Naxos Island	unknown	unknown	Suez Canal, range expansion	Red Sea
Adelactaeon amoenus Gastropoda	1990s? (Since 1978 in Israel)	Cyprus	unknown	unknown	Suez Canal, range expansion	Indo-Pacific
Agardhiella subulata Red alga	1998	the Netherlands, Oosterschelde	occasional records	unknown	unknown	N America
Alcyonidium sp. Tentaculata	2002	USA	unknown	fouling?	unknown	Europe?
Alexandrium angustitabulatum Phytoplankton, Dinoflagellate	1997	Sweden, Skagerrak	unknown	potentially toxic	ballast water?	New Zealand?
Alexandrium angustitabulatum Phytoplankton, Dinoflagellate	1997	Sweden, west coast	established	unknown	ballast water?	New Zealand
Alexandrium catenella Phytoplankton, Dinoflagellate	1998	Spain, Catalonia	established	potentially causing harmful algal blooms	ballast water	
Alexandrium leeii Phytoplankon, Dinoflagellate	1995	North Sea	localized	unknown	unknown	N Pacific
Alexandrium minutum Phytoplankton	1996	Sweden, eastern Skagerrak	unknown	PST production	ballast water, range expansion?	
Alexandrium ostenfeldi Phytoplankon, Dinoflagellate	1997	Baltic proper, near Öland Island	unknown	potentially causing algal blooms	ballast water?	
Alexandrium taylori Phytoplankon, Dinoflagellate	1994	France, Atlantic coast near Arcachon	unknown	unknown	unknown	
Alexandrium taylori Phytoplankon, Dinoflagellate	1995	Italy, near Sicily	unknown	unknown	unknown	
Alexandrium taylori Phytoplankon, Dinoflagellate	1998	Spain, Catalanian coast	unknown	unknown	unknown	
Alpheus audouini Prawn	2002 (earlier record 1924 in Egypt)	Turkey, Fethiye	occasional records	unknown	Suez Canal, range expansion	Indo-W Pacific, Red Sea to New Zealand, Hawaii
Alpheus migrans Prawn	1994 (earlier record 1978 in Egypt)	Turkey, S coast	occasional records	unknown	Suez Canal, range expansion	Red Sea

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Ampharetidae Polychaete	2001	Italy, Gulf of Noto, Sicily	unknown	unknown	Suez Canal or transferred via ballast water	Indian Ocean
Anachis savignyi Gastropoda	1990s? (since 1954 in Israel)	Turkey	established	unknown	Suez Canal	Red Sea
Anachis selasphora Gastropoda	1990s? (since 1980 in Israel)	Turkey	established	unknown	Suez Canal	Indian Ocean, Red Sea
Anadara demiri Bivalve	1990s (since 1972 in Turkey)	Greece, N Aegean Sea	unknown	unknown	hull fouling? range expansion	Indian Ocean
Anadara demiri Bivalve	2000 (since 1972 in Turkey)	Italy, Central Adriatic Sea & Venice Lagoon	unknown	unknown	hull fouling?, range expansion	Indian Ocean
Anguillicola crassus Nematode	1997	Ireland, Shannon River	spreading, common locally	eel parasite	living imports	Japan, NW Pacific
Anguillicola crassus Nematode	2002	Finland	rare	eel parasite	living imports, secondary introduction	Japan, NW Pacific
Antigona lamellaris Bivalve	1992	Turkey, Iskenderum	single specimen (one valve found)	unknown	Suez Canal questionable as not known from Israel. Shipping?	Indo-Pacific, Red Sea
Antithamnion amphigeneum Alga	1992	Spain, Balearic Islands, Mallorca	established?, Catalonian coast in 1997, Valencio in 1999	unknown	unknown	South Pacific
Antithamnionella spirographidis Red alga	1992	Belgium, Oostende	Established in Zeebrügge before 1983	unknown		North Pacific?
Apeltes quadracus Fish	1996	Canada, Lake Superior	occasional records	unknown	shipping?, range expansion	W Atlantic, Gulf of St Lawrence North Carolina
Aplidium nordmanni Ascidian	1998	Germany, near Sylt Island, North Sea	spreading	unknown	escapes from oyster farm	SW England, Brittany to Mediterranean
Aplysia dactylomela Gastropod	2002	Italy, near Sicily	unknown	unknown	unknown	circum-tropical
Asperococcus scaber Brown alga	1998	the Netherlands, Lake Grevelingen	occasional records	minimal	unknown	Mediterranean
Aspius aspius Fish	1998	the Netherlands	unknown	unknown	range expansion?	Europe
Atyaephyra desmaresti Crustacea	2000	Poland, Odra River	unknown	unknown	unknown	Mediterranean
Aulacomya ater Bivalve	1994 & 1997	United Kingdom, Moray Firth	occasional records	unknown	ballast water, hull fouling?	S America
Aurelia aurita Jelly fish	1998	Caspian Sea	unknown	zooplankton predator	ballast water?	cosmopolitan
Balanus perforatus Barnacle	1996 (earlier records known)	Belgium (on buoys). Recorded from Dutch buoys in 1978.	occasional records	fouling	hull fouling, range expansion from Iberian peninsula?	E Atlantic, warm-water species

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Balanus reticulatus Barnacle	1997	Belgium (on buoys)	occasional records	fouling	hull fouling	circum-tropical
Balanus trigonus Barnacle	1997	Belgium (on buoys)	one empty shell settled on a buoy	fouling	hull fouling, range expansion from Iberian peninsula?	tropical & warm-temperate seas
Balanus variegatus Barnacle	1997	Belgium (on buoys)	occasional records	fouling	hull fouling	Indo-Pacific
Batophora sp. Green alga	2002	Italy, Ionian Sea	unknown	unknown	unknown	cannot be determined on genus level
Beroe cucumis Ctenophore	1998	Black Sea	common	zooplankton predator	ballast water	N Atlantic
Beroe ovata Ctenophore	1999	Black Sea	unknown	zooplankton predator	ballast water	USA, Atlantic coast
Beroe ovata Ctenophore	2001	Caspian Sea	unknown	zooplankton predator	ballast water	USA, Atlantic coast
Beryx splendens Fish	1995	Italy, Ligurian Sea	single specimen	unknown	range expansion via Gibraltar	Atlantic, Indian Ocean, Pacific (Australia, Japan, Hawaii & New Zealand)
Bonamia ostreae Haplosporida	1994	Spain, Catalan coast	unknown	disease agent of mussels	mussel movements?	North Pacific
Botryllus schlosseri Tunicate	2002	Canada, E coast, Prince Edward Island	unknown	fouling?	shipping?	Asia
Botryllus violaceus Tunicate	2000	USA, Alaska at Sitka and Tatilek	unknown	fouling?	shipping?	North Pacific
Bractechlamys vexillum Bivalve	2000	France, Port of Cros, Mediterranean Sea	unknown	unknown	unknown	N Australia
Bugula neritina Bryozoan	1999	Belgium, Oostende	occasional records	fouling	hull fouling	
Bugula simplex Bryozoan	2000	Belgium, Oostende	established? range extension	fouling	hull fouling	
Bulla ampulla Gastropoda	1990s? (since 1978 in Israel)	Greece, Saronikos	established, but rare	unknown	Suez Canal, range expansion	tropical Indo-Pacific
Bythotrephes (cederstroemi) longimanus Cladoceran	1995 (earlier records known)	Canada, Great Lakes region	continues spreading during entire period of this report	unknown	unknown	Asia & Europe
Cabomba caroliana Macrophyte	2000	Canada, Lake Kasshabog, Ontario	extremely dense, established?	driving native species to extinction	aquarium release	South America
Calappa pelii Decapod	1996 (earlier record off Marocco in 1991)	Italy, Gulf of Taranto	occasional records	unknown	Suez Canal, range expansion	E Atlantic

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Callinectes bocourti Decapod	1990 (first record in 1971)	USA, Alabama, Mississippi, Gulf of Mexico.	occasional records in 1997, 1998, one juvenile in 2001 in Alabama	unknown	ballast water, range expansion	Caribbean to S Florida, West Indies, Colombia, Brazil
Callinectes sapidus Decapod	1995–2002	France, Atlantic coast	occasional records	predation	shipping	NW Atlantic, Nova Scotia to Uruguay
Callinectes sapidus Decapod	1995–2002 (earlier records in Europe since 1900)	Belgium	occasional records	predation	shipping	NW Atlantic, Nova Scotia to Uruguay
Callinectes sapidus Decapod	1999	the Netherlands, Ports of Amsterdam & Rotterdam	occasional records also in 2000 from Westerschelde, including egg- carrying females	predation	shipping	NW Atlantic, Nova Scotia to Uruguay
Callionymus filamentosus Fish	1994 (since 1953 in Israel)	Turkey	common	unknown	Suez Canal, range expansion	Indo-Pacific, Red Sea, E Africa, Madagascar & Mauritius to New Guinea & China
Calyptraea chinensis Gastropod	1999 (first record in 1950s)	Ireland, E Galway Bay, Cork Harbour in 2000	established	unknown	mussel movements	Continental Europe
Caprella mutica Amphipod	1998	Belgium, buoys of Zeebrügge harbour	established	unknown, clogging of gear?	ballast water, hull fouling?	E Asia, Siberia
Caprella mutica Amphipod	1998	the Netherlands	unknown	unknown, clogging of gear?	ballast water, hull fouling?	E Asia, Siberia
Caprella mutica Amphipod	2000	Norway, near Stavanger	unknown	unknown, clogging of gear?	ballast water, hull fouling?	E Asia, Siberia
Caprella mutica Amphipod	2000	USA, Massachusetts & Rhode Island	rapid range expansion	unknown, clogging of gear?	ballast water, hull fouling?	E Asia, Siberia
Carcharhinus altimus Shark	1996 (since 1983 in Algeria)	Israel, Levatine Basin	single specimen	unknown	range expansion via Gibraltar	temperate and tropical waters of Atlantic, Pacific and W Indian Oceans
Carcinus maenas Decapod	1993 (first record 1990/91)	USA, San Francisco Bay	established, spreads northwards during entire period of this report. Hundreds of crabs have been found in Washington	predator	ballast water	Atlantic Europe
Carcinus maenas Decapod	1998 (first record 1950s)	Canada, Prince Edward Island, S Gulf of St Lawrence & Cape Breton in 1999	established, further spread in 2000	ecosystem engineer, predation, eel fishing and oyster production threatened	secondary introduction from Fundy Bay or range expansion	Atlantic Europe

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Carcinus maenas Decapod	1999	Canada, W coast, Barkley Sound, Vancouver Island	rare specimens, additional findings in northern British Columbia over the entire duration of this report	ecosystem engineer, predation	secondary introduction from US Pacific Coast or range expansion	Atlantic Europe
Carupa tenuipes Decapoda	1996	SW Turkey	occasional records	unknown	Suez Canal	Indo-Pacific, Red Sea to Japan, Australia, Polynesia, Hawaii
Carupa tenuipes Decapoda	2002	Israel, Tel Aviv	several specimens	unknown	Suez Canal, range expansion	Indo-Pacific, Red Sea to Japan, Australia, Polynesia, Hawaii
Caulerpa racemosa Green alga	1993	Italy, Lampedusa Island	spreading	unknown	Suez Canal	
Caulerpa racemosa Green alga	1998	France, Marseille	unknown	unknown	Suez Canal	
Caulerpa racemosa Green alga	1998	Spain, Balearic Islands (Mallorca, Ibiza)	spreading	unknown	Suez Canal	
Caulerpa taxifolia Green alga	1992 (first record 1980s)	France	spreading during the entire period of this report	competition, habitat modification	likely an accidental aquarium release	aquarium strain from Germany
Caulerpa taxifolia Green alga	1992	Italy, Ligurian Sea, Messina Strait in 1999	established, spreading during entire period of this report	competition, habitat modification	range expansion	aquarium strain from Germany
Caulerpa taxifolia Green alga	1993	Spain, Balearic Islands	not spreading	competition, habitat modification	range expansion	aquarium strain from Germany
Caulerpa taxifolia Green alga	1998	Croatia	established, spreading during entire period of this report	competition, habitat modification	range expansion	aquarium strain from Germany
Caulerpa taxifolia Green alga	1998	Tunisia	established, spreading during entire period of this report	competition, habitat modification	range expansion	aquarium strain from Germany
Caulerpa taxifolia Green alga	2000	Australia, near Sidney	unknown	competition, habitat modification	range expansion	native strain
Caulerpa taxifolia Green alga	2000	USA, San Diego, Aqua Hedionda Lagoon, Carlsbad, California, & Huntington Harbour, California	eradication effort carried out/underway	competition, habitat modification	aquarium trade?	Mediterranean Sea strain
Cellana rota Gastropoda	1990s? (since 1961 in Israel)	Greece, Saronikos Gulf	unknown	range expansion	Suez Canal, range expansion	Red Sea & Indian Ocean
Ceramium bisporum Red alga	2002	Italy, Tuscany	unknown	minimal	unknown	

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Cercopagis pengoi Cladoceran	1992	Estonia, Gulf of Riga (first record in Baltic)	established, spreading over the entire period of this report	competition, predation on zooplankton, clogging of fishing gear	ballast water	Ponto-Caspian
Cercopagis pengoi Cladoceran	1995	Finland	established, spreading	competition, predation on zooplankton, clogging of fishing gear	range expansion from earlier introduction in 1992	Ponto-Caspian
Cercopagis pengoi Cladoceran	1995	Sweden and central & southern parts of Baltic	established, spreading. Mass development in 2001	competition, predation on zooplankton, clogging of fishing gear	range expansion from earlier introduction in 1992	Ponto-Caspian
Cercopagis pengoi Cladoceran	1998	Canada, Great Lakes	established, spreading	competition, predation on zooplankton, clogging of fishing gear	ballast water	Ponto-Caspian
Cercopagis pengoi Cladoceran	1998	USA, Great Lakes	established, spreading	competition, predation on zooplankton, clogging of fishing gear	ballast water	Ponto-Caspian
Cercopagis pengoi Cladoceran	1999	Poland, Vistula Lagoon	established, spreading, mass development	competition, predation on zooplankton, clogging of fishing gear	range expansion	Ponto-Caspian
Cerithium nesioticum Gastropoda	1990s? (since 1970 in Israel)	Cyprus	unknown	unknown	Suez Canal, range expansion	Red Sea, Indian Ocean, tropical W Pacific
Cerithium scabridum Gastropoda	1990s?	Cyprus	unknown	unknown	Suez Canal, range expansion	Red Sea, Persian Gulf, W & S India
Cerithium scabridum Gastropoda	1990s?	Turkey, S coast	unknown	unknown	Suez Canal, range expansion	Red Sea, Persian Gulf, W & S India
Charybdis helleri Decapod	1990s (first records in Medit. 1924 in Israel)	Syria	occasional records	unknown	ballast water, hull fouling, range expansion	Indo-W Pacific, Red Sea to New Caledonia
Charybdis helleri Decapod	1999 (first records in Medit. 1924 in Israel)	Cyprus	occasional records	unknown	ballast water, hull fouling, range expansion	Indo-W Pacific, Red Sea to New Caledonia
Charybdis helleri Decapod	2000	USA, Florida to North Carolina	spreading	unknown	unknown	Indo-W Pacific, Red Sea to New Caledonia
Charybdis japonica Decapod	2000	Australia, near Adelaide	single specimen	nuisance to fishers, gets into nets, very aggressive to remove	unknown	Japan, Korea, Malaysia

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Charybdis japonica Decapod	2000	New Zealand, Auckland region	established	nuisance to fishers, gets into nets, very aggressive to remove	unknown	Japan, Korea, Malaysia
Charybdis longicollis Decapoda	2002? (first record in Medit. 1959 in Turkey)	Greece, Rhodes Island	established	unknown	Suez Canal	Red Sea, East Africa, Persian Gulf
Chattonella cf. verruculosa Phytoplankton, Rhaphidophycean	1998	Denmark, North Kattegat, Skagerrak	established, blooming	causing harmful algal blooms	ballast water?	Japan
Chattonella cf. verruculosa Phytoplankton, Rhaphidophycean	1998	Norway	established, blooming	causing harmful algal blooms, severe fish kill in 2001	ballast water?	Japan
Chattonella cf. verruculosa Phytoplankton, Rhaphidophycean	1998 (earlier records in 1990s)	Sweden, North Kattegat, Skagerrak	established, blooming	causing harmful algal blooms	ballast water?	Japan
Chaunax suttkusi Fish	1997	Italy, Sicily Strait	rare	unknown	range expansion via Gibraltar	WE Atlantic
Chaunax suttkusi Fish	2000	Italy	unknown	unknown	unknown	E Atlantic, Azores to Angola. W Atlantic South Carolina to Rio Grande
Chilomycterus spilostylus Fish	1993	Israel	single specimen	unknown	Suez Canal	Indo-Pacific
Chionoecetes opilio Decapod	1996	Barents Sea, SE part	occasional records, no findings in 2001	unknown	ballast water?	NW Atlantic
Chrisallida fisheri Gastropod	2002	Italy, Adriatic Sea	unknown	unknown	range expansion?	Red Sea, E Mediterranean
Chrysallida maiae Gastropoda	1990s? (since 1935 in Israel)	Cyprus	occasional records	unknown	Suez Canal, range expansion	Red Sea
Chrysallida maiae Gastropoda	1990s? (since 1935 in Israel)	Turkey, near Tasuçu	occasional records	unknown	Suez Canal, range expansion	Red Sea
Ciona savignyi Tunicata	1993	USA, San Francisco Bay	unknown	unknown	ballast water, hull fouling	Japan?
Cipangopaludina chinensis malleata Gastropod	1996	Canada, Ontario's inland lakes	established, first record in Great lakes in 1930s	unknown	unknown	Asia
Clathrofenella ferruginea Gastropoda	1990s? (since 1970 in Israel)	SE coast of Turkey, Mersina to Tasuçu	established	unknown	Suez Canal, range expansion	Indo-Pacific, Red Sea and Persian Gulf, E Japan
Cochlodinium polykrikoides Phytoplankton, Dinoflagellate	1998	Canada, W coast	increasing	fish kills (salmon farming)	ballast water?	Korea?

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Codium fragile ssp. *tomentosoides* Green alga	1992	Canada, Nova Scotia	established, spreading during the entire period of this report, eradication trial underway	algal mats cover oysters making harvests difficult	boat traffic from USA or tidal flow	North Pacific?
Codium fragile ssp. *tomentosoides* Green alga	1998	Belgium, Oostende	secondary introduction, not persisting. No records since 2001	habitat modification, fouling on shellfish and gear	oyster imports?, range expansion	Japan
Coenobita rugosus Fish	2000	France	unknown	unknown	release with bait	Asia?
Convoluta convoluta Flatworm	1995	Canada, Nova Scotia	spreading	unknown	ballast water	Europe
Convoluta convoluta Flatworm	1999	USA, from Canada to Massachusetts	spreading	unknown	ballast water	Europe
Corbula gibba Bivalve	1995	the Netherlands	spreading	E Atlantic	ballast water, hull fouling?	Europe
Corbula gibba Bivalve	1996	France, Dunkerque	unknown	unknown	ballast water, hull fouling?	Europe
Corbula gibba Bivalve	1998	Belgium	unknown	unknown	ballast water, hull fouling?	Europe
Coregonus lavaretus Fish	1999	the Netherlands, large rivers	unknown	unknown	restocking, range expansion	Europe
Coregonus oxyrhynchus Fish	1996	the Netherlands, Yssel Lake	unknown	unknown	restocking (fish was extinct)	Europe
Corella eumyota Sea squirt	2002	France, Brittany	unknown	unknown	unknown	southern hemisphere
Chelicorophium (Corophium) curvispinum Amphipod	1995	the Netherlands	spreading	unknown	ballast water, hull fouling?	Ponto-Caspian
Corophium sextonae Amphipod	1997	North Sea, S & E coasts	established	unknown	ballast water, hull fouling	S Pacific
Crangonyx pseudogracilis Amphipod	1992	Germany	rare	unknown	release	N America
Crassostrea gigas Bivalve	1994	Germany, North Sea	occasional records. Since end of 1990s established, spreading	unknown	accidental release, recruitment outside farm	Japan
Crassostrea gigas Bivalve	1995 (imported in 1960s)	Belgium, the Netherlands	established, very common, spreading	unknown	accidental release, recruitment outside farm	Japan
Crassostrea gigas Bivalve	1995	United Kingdom, Conwy Estuary, N Wales	small population of patchy distribution	unknown	accidental release, recruitment outside farm	Japan

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Crassostrea gigas Bivalve	1999	United Kingdom, Carrew River, SW Wales	small population	unknown	accidental release, recruitment outside farm	Japan
Crepidula fornicata Gastropod	1996 (first record in 1962)	Norway, Kvitsoy, near Stavanger	spreading until 2000. Not reported in 2000	competition	oyster imports, range expansion?	East coast of N America
Crepidula fornicata Gastropod	1996	Spain, Galicia	unknown	unknown	oyster imports from France & Ireland	East coast of N America
Crepidula fornicata Gastropod	1999 (first record in 1957)	France, Atlantic coast	established, mass development	competition	oyster imports, range expansion?	E coast of N America, from Canada to Florida and Texas
Crepidula fornicata Gastropod	2000 (first record in 1940s)	Belgium	established, mass development	competition	oyster imports, range expansion?	East coast of N America
Cyclope neritea Gastropoda	1992	Spain, Galicia	unknown	unknown	range expansion	Mediterranean
Cylichna girardi Gastropoda	1990s? (since 1976 in Egypt)	Cyprus	unknown	unknown	Suez Canal, range expansion	Indo-Pacific
Cylichna girardi Gastropoda	1990s? (since 1976 in Egypt)	Greece, Crete	unknown	unknown	Suez Canal, range expansion	Indo-Pacific
Daphnia lumholtzi Cladoceran	1999	USA, Great Lakes	established	unknown	ballast water	Africa, India, Australia
Dasya baillouviana Red alga	1999 (first record in 1950s)	Sweden, near Ringhals, E Kattegat, being the southernmost record in Sweden	unknown	unknown	secondary spread, range expansion	S Europe (incl. Mediterranean Sea), W Atlantic
Dasya baillouviana Red alga	2002	Germany	unknown	unknown	secondary spread, range expansion	S Europe (incl. Mediterranean Sea), W Atlantic
Dasysiphonia sp. Red alga	1994	the Netherlands	localized	unknown	ballast water, hull fouling	N Pacific
Dasysiphonia sp. Red alga	1996	Norway, near Bergen, reached Sognefjord in 2001	established, spreading rapidly north- & southwards	overgrows other algae	ballast water, hull fouling	N Pacific
Dendrocoelum romanodanubiale Triclad	1992	Germany, inland waters	rare	unknown	ballast water?	Ponto-Caspian
Desmarestia viridis Brown alga	1998	Italy	unknown	overgrows other algae	introduction with oysters?	Asia
Didemnum sp. Ascidian	2000	USA, Cape Cod, Massachusetts & Rhode Island	unknown	fouling	unknown	unknown
Dinophysis acuta Dinoflagellate, Phytoplankton	1992	Norway	first observation, bloom	unknown	ballast water	United Kingdom

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Diodora ruppellii Gastropoda	1990s? (since 1940s in Israel)	Turkey	unknown	unknown	range expansion from Israel	Indo-Pacific, Red Sea, Aden, Persian Gulf, Somalia, Madagascar, Natal, Seychelles, Mauritius, Hawaii
Discroerisma psilonereiella Dinoflagellate, Phytoplankton	1997	Sweden, Skagerrak	unknown	unknown	ballast water?	Kamchatka, Canada (BC)
Discroerisma psilonereiella Dinoflagellate, Phytoplankton	1997	Sweden, W coast	unknown	unknown	ballast water	Kamchatka, Canada
Dispio uncinata Polychaete	2001	Italy, Gulf of Noto, Sicily	unknown	unknown	unknown	Atlantic, Pacific, Red Sea
Dreissena bugensis Bivalve	1993	Canada, Great Lakes	unknown	unknown	unknown	Ukraine
Dreissena bugensis Bivalve	1993	USA, Great Lakes	unknown	unknown	unknown	Ukraine
Dreissena polymorpha Bivalve	1992 (first record 1986)	Canada, Great Lakes region	continues spreading during entire period of this report	severe fouling	ballast water (or hull fouling)	Ponto-Caspian
Dreissena polymorpha Bivalve	1992 (first record 1986)	USA, Great Lakes region, reached Mississippi River	continues spreading during entire period of this report	severe fouling	ballast water (or hull fouling)	Ponto-Caspian
Dreissena polymorpha Bivalve	1994	Ireland, Shannon River	established, spreading during the entire period of this report	severe fouling, drives native mussels to extinction	hull fouling, ballast water?	Ponto-Caspian
Dreissena polymorpha Bivalve	1995	Finland, E Gulf of Finland	spreading	severe fouling	ballast water or hull fouling	Ponto-Caspian
Dreissena polymorpha Bivalve	1996	Germany, S inland lakes	spreading	severe fouling	ballast water or hull fouling	Ponto-Caspian
Dreissena polymorpha Bivalve	2000	Canada, W coast	not found in the environment, but on boat hull trailered from Michigan	severe fouling	hull fouling	Ponto-Caspian
Dreissena polymorpha Bivalve	2000	Estonia	spreading	severe fouling, phytoplankton biomass decline?	hull fouling, ballast water?	Ponto-Caspian
Dreissena polymorpha Bivalve	2001	Spain, Ebro River	unknown	severe fouling	hull fouling, ballast water?	Ponto-Caspian
Drymonema dalmatinum Cnidaria	2000	USA, Florida to Mississippi, Gulf of Mexico	unknown	unknown	range expansion, ballast water, hull fouling	Atlantic and Pacific oceans
Dyspanopeus sayi Decapod	1992	Italy, Venice Lagoon	spreading	unknown	ballast water, hull fouling, mussel movements?	NW Atlantic

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Dyspanopeus sayi Decapod	1999	Italy, Romagna coast	spreading	unknown	ballast water, hull fouling, mussel movements?	NW Atlantic
Echinogammarus ischnus Amphipod	1996	Canada, Great Lakes region	established, continues spreading during the entire period of this report	unknown	ballast water	Ponto-Caspian
Echinogammarus ischnus Amphipod	1998	USA, Great Lakes	established, continues spreading during the entire period of this report	unknown	ballast water	Ponto-Caspian
Echinogammarus trichiatus Amphipod	1996	Germany	rare	unknown	ballast water?	Ponto-Caspian
Ectocarpus siliculosus Brown alga	1998	Italy, Venice	unknown	competition	fishing	unclear
Ensis directus Bivalve	1990s	United Kingdom, SE coast	established, spreading	unknown	ballast water, range expansion	N America
Ensis directus Bivalve	1992	France, Channel coast	established, spreading	unknown	ballast water, range expansion	N America
Epinebalia sp. Crustacea	1992	USA, San Francisco Bay	unknown	unknown	ballast water	cannot be determined at species level level
Epinephelus coiodes Fish	1998 (since 1969 in Israel)	Italy	occasional records	unknown	Suez Canal, ballast water	Red Sea
Ergalatax obscura Gastropoda	1990s?	Turkey, Mersina to Tasuçu, S coast	unknown	unknown	Lessepsian migrant	Red Sea, Gulf of Aden
Eriocheir sinensis Decapod	1990s (first record 1935)	United Kingdom, Thames River. River Tyne in 2000	established, spreading along northeast coast	predation, clogging of water intakes, increase of erosion	ballast water	China
Eriocheir sinensis Decapod	1992	USA, San Francisco Bay, Columbia River in 1997	established, spreading in California during the entire period of this report	unknown	ballast water, release	China or Europe
Eriocheir sinensis Decapod	1994	Canada, Lake Erie	single specimen	unknown	ballast water	China or Europe
Eriocheir sinensis Decapod	1996–2000 (first record 1912)	Germany, Elbe River	established, mass development, further spread	predation, pond fisheries, clogging of water intakes and fishing nets, increase of erosion	ballast water	China
Eriocheir sinensis Decapod	1998	Finland	occasional records	predation, competition, habitat modification	ballast water, hull fouling, migration from Germany	China

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Eriocheir sinensis Decapod	1998	Sweden	occasional records	predation, competition, habitat modification	ballast water, hull fouling, migration from Germany	China
Eriocheir sinensis Decapod	1998	Ukraine, Black Sea	occasional records	predation, competition, habitat modification	ballast water, hull fouling	China
Eriocheir sinensis Decapod	2001	Spain, Guadalquivir Estuary	established	predation, competition, habitat modification	ballast water, hull fouling	China
Erugosquilla massavensis Shrimp	1994 (first record in Medit. 1933 in Egypt)	Greece, Crete	established	unknown	Suez Canal	Red Sea, Persian Gulf
Erugosquilla massavensis Shrimp	2002 (first record in Medit. 1933 in Egypt)	Greece, Rhodes Island	established	unknown	Suez Canal	Red Sea, Persian Gulf
Esox masquinongy Fish	2000	Canada, St John River System	unknown	unknown	import from Quebec	N America, St Lawrence River–Great Lakes, Hudson Bay, Mississippi
Esox niger Fish	2000	Canada, lake in the Miramichie drainage	Eradication effort underway	unknown	unknown	Africa
Etrumeus teres Fish	2000 (since 1963 in Israel)	Cyprus	common	unknown	Suez Canal, range expansion	Red Sea, E Africa, Japan, S Australia, E Pacific, W Atlantic
Etrumeus teres Fish	1997 (since 1963 in Israel	Turkey	unknown	unknown	Suez Canal, range expansion	Red Sea, E Africa, Japan, S Australia, E Pacific, W Atlantic
Eucrate crenata Decapod	1997 (first record in Medit. in 1924)	Israel	locally common	unknown	Lessepsian migrant	Indo-Pacific, Red Sea to Hawaii
Eunapius carteri Porifera	1993	Germany, inland waters	rare	unknown	release	Africa, Asia
European Sheatfish Virus (ESV) Disease agent	2002	Finland	unknown	fish disease	unknown	Europe
Favonogobius exquisites Fish	2001	New Zealand	unknown	unknown	unknown	Australia
Ficopomatus enigmaticus Polychaete	1997 (first record 1921)	France, Normandy, Mediterranean lagoons in 1999	established, mass development in 1997	fouling impact	hull fouling, ballast water	Indo-Pacific
Ficopomatus enigmaticus Polychaete	1998 (first record 1972)	Ireland, Shannon Estuary	established	small fouling impact	hull fouling, ballast water	Indo-Pacific
Ficopomatus enigmaticus Polychaete	2000	USA, Chesapeake Bay	established	fouling	hull fouling, ballast water	Indo-Pacific

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Fistularia commersonii Fish	2000	Israel	common	species is of commercial importance	Suez Canal	Indian Ocean, Pacific Ocean, Central and S America.
Fistularia petimba Fish	1997	Spain, Alboran Sea	single specimen	unknown	range expansion via Gibraltar	E Atlantic, Angola to Senegal and Cape Verde Islands, Indo-west Pacific to Hawaii
Fundulus heteroclitus Fish	1996 (first record 1973)	Spain	spreading westwards	unknown	unknown	Atlantic coast of N America
Galeocerdo cuvier Shark	1990s? (since 1987 Spain, Malaga)	Italy, Messina	unknown	unknown	range expansion via Gibraltar	circumglobal, tropical and temperate waters
Gammarus tigrinus Amphipod	1995 (first record 1988)	Poland, Szczecin Lagoon, Vistula Lagoon in 1999	established, spreading eastwards	unknown	range expansion	North America
Gibbula adansoni Gastropod	1992	Spain, Galicia	unknown	unknown	range expansion	Mediterranean
Grateloupia doryphora Red alga	1993	North Sea	established	unknown	shipping?	Pacific
Grateloupia doryphora Red alga	1996	USA, Rhode Island, S of Cape Cod in 1998	established, spreading	unknown	shipping?	Pacific
Gymnocephalus cernuus Fish	1992 (first record in 1986)	Canada, Great Lakes, first record outside Lake Superior in Lake Huron	continued spreading during the entire period of this report	unknown	unknown	Europe
Gymnocephalus cernuus Fish	1995 (first record in 1986)	USA, Great Lakes, first records outside Lake Superior in Lake Huron	continues spreading	unknown	unknown	Europe
Gymnodinium catenatum Phytoplankton, Dinoflagellate	2000	Black Sea	unknown	harmful algal bloom, PSP	ballast water	
Gymnodinium catenatum Phytoplankton, Dinoflagellate	2000	New Zealand	recorded during bloom	harmful algal bloom, PSP	ballast water?	
Gyrodactylus salaris Trematode	1992	Norway, 35 Salmon rivers	unknown	unknown	unknown	Europe
Gyrodinium corallinum Phytoplankton, Dinoflagellate	1997	Sweden, W coast	unknown	unknown	ballast water	USA, California
Gyrodinium corallium Phytoplankton, Dinoflagellate	1997	Sweden, Skagerrak	unknown	unknown	ballast water?	USA, California?
Halimede tyche Decapod	1998	Israel	single specimen	unknown	Lessepsian migrant	Indo-W Pacific, Persian Gulf to Australia
Haliplanella lineata Anthozoan	1998	Belgium	established, range extension	fouling?	oyster imports?	Pacific

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Haminoea callidegenita Gastropod	1992	Italy, Venice Lagoon	established	unknown	mussel movements	USA, Washington State, NE Pacific and E Atlantic in Arosa and Eo estuaries, NW Spain
Haminoea cyanomarginata Gastropod	2001	Mediterranean	unknown	unknown	shipping, Suez Canal?	Red Sea
Haplosporidium costale Disease agent causing SSO disease	2002	Canada, Nova Scotia, Prince Edward Island, New Brunswick	First observation	Disease of oysters	unknown	Atlantic coast of USA
Haplosporidium nelsoni Disease agent causing MSX disease	2002	Canada, Nova Scotia	First observation	Disease of oysters	shipping?	Pacific?
Hemigrapsus penicillatus Decapod	1994	France, near La Rochelle	spreading north- and southwards, Le Havre, English Channel in 1998	competition	hull fouling, ballast water?	NW Pacific
Hemigrapsus penicillatus Decapod	1997	Spain, Laredo	spreading	competition	hull fouling, ballast water?	NW Pacific
Hemigrapsus penicillatus Decapod	2000	Netherlands, Oosterschelde	at one location, females carrying eggs about to hatch	competition	hull fouling, ballast water?	NW Pacific
Hemigrapsus sanguineus/takanoi Decapod	1993 (first record in New Jersey 1988)	USA, Cape Cod, occurs from Massachusetts to North Carolina in 1997, reached Maine in 2000	continues spreading northwards and southwards during entire period of this report	unknown	unknown	Japan
Hemigrapsus sanguineus/takanoi Decapod	1999	the Netherlands, Oosterschelde	occasional finding, not observed in 2000	competition	hull fouling, ballast water?	W Pacific
Hemigrapsus sanguineus/takanoi Decapod	2001	Croatia, western Istra, northern Adriatic	single specimen	competition	hull fouling, ballast water?	W Pacific
Heimysis anomala Mysid	1992	Finland	range extension, spreading	unknown	ballast water	Ponto-Caspian
Heimysis anomala Mysid	1995	Sweden, near Stockholm	range extension, spreading	unknown	ballast water	Ponto-Caspian
Heimysis anomala Mysid	1999	Belgium	established? range extension	unknown	unknown	Ponto-Caspian
Herbstia nitida Decapoda	2002	Italy, Otranto Channel	few specimens	unknown	ballast water, hull fouling?	E Atlantic, Gulf of Guinea
Himantura uarnak Ray	1998 (since 1955 in Israel)	Turkey	established	unknown	range expansion	Indo-Pacific from Red Sea, E Africa to N Australia & the Philippines

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Himantura uarnak Ray	1994 (since 1955 in Israel)	Egypt	established	unknown	range expansion	Indo-Pacific from Red Sea, E Africa to N Australia & the Philippines
Hippolyte longirostris Crustacea	1999 (earlier records known)	United Kingdom, Cornwall	few specimens	unknown	unknown	
Homarus americanus Decapod	1999	Norway, Oslofjord	occasional findings annually	hybridization, disease transfer	accidental release?	N America, Atlantic
Homarus americanus Decapod	2002	Canada, British Columbia, Vancouver harbour	unknown	hybridization, disease transfer	accidental release?	N America, Atlantic
Homarus americanus Decapod	2002	France	unknown	hybridization, disease transfer	accidental release?	N America, Atlantic
Homarus cf. americanus Decapod	2000 & 2001	Sweden	single specimen annually	hybridization, disease transfer	accidental release?	N America, Atlantic
Hydrocharis morsus-ranae Macrophyte	1996	Canada, Ontario's inland lakes	established, first record in 1932, spreading	unknown	unknown	Asia
Hydroides sanctaecrucis Polychaete	2001	Australia, Cairns	not spreading	unknown	hull fouling	Caribbean
Hypnea cornuta Red alga	2002	Italy, Ionian Sea	unknown	unknown	unknown	Atlantic
Hypophthalmichthys molitrix Fish	1998	the Netherlands	unknown	unknown	secondary spread	Asia, China, E Siberia
Hypophthalmichthys nobilis Fish	1998	the Netherlands	unknown	unknown	secondary spread	China
Hypophthalmichthys nobilis Fish	2002	Estonia, Gulf of Riga	unknown	unknown	secondary spread	China
Hypostomus plecostomus Fish	1992	Canada, Lake Erie	occasional records	unknown	accidental aquarium release	South USA
Ianiropsis sp. Isopoda	2000	USA, Massachusetts & Rhode Island	unknown	unknown	unknown	cannot be determined determined to species level
Illex illecebrosus Squid	1998	USA, washed ashore Lake Huron	few specimens. Will not survive freshwater conditions	no impact in Great Lakes	taken on-board during ballast water exchange	N Atlantic
Infectious Salmon Anemia (ISA) Disease agent	1999	Scotland	unknown	impact on farmed salmon	fish movements or imports	
Infectious Salmon Anemia (ISA) Disease agent	2001	USA, Maine	unknown, eradication effort and control plan	impact on farmed salmon	fish movements or imports	
Iolaea neofelixoides Gastropod	1994	Turkey, Yumurtalik Harbour	unknown	unknown		Japan

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Isolda pulcella Polychaete	2001	Italy, Gulf of Noto, Sicily	unknown	unknown	unknown	Atlantic & Indian Ocean
Ixa monody Decapod	2002 (earlier record in Turkey in 1955)	Greece, Rhodes Island	occasional records	unknown	Suez Canal, range expansion	Red Sea?
Leathesia verruculiformis Brown alga	1994	the Netherlands, Lake Grevelingen & Oosterschelde	unknown, annual findings	unknown	unknown	NW Pacific
Lepomis gibbosus Fish	1999	Poland, Odra River, Szczecin Lagoon	rare	unknown	unknown	N America, New Brunswick, South Carolina
Libinia dubia Decapod	1996	Tunisia, S coast	common	unknown	ballast water, hull fouling?	W Atlantic, from Massachusetts to Cuba
Limnoithona tetraspina Copepod	1993	USA, San Francisco Bay	unknown	unknown	ballast water	China
Limnomysis benedeni Mysid	1994	Germany	rare	unknown	ballast water?	Ponto-Caspian
Littorina saxatilis Gastropod	1993	USA, San Francisco Bay	unknown	unknown	seaweed packing from New England	N Atlantic
Lomentaria hakodatensis Alga	1992	Spain	unknown	unknown	oyster culture	Japan, Korea
Lomentaria hakodatensis Alga	1993	Spain, Galicia	spreading	unknown	oyster culture	Japan, Korea
Lophocladia lallemandii Alga	1999 (first records on mainland in 1988)	Spain, Balearic Islands, Ibiza	established, locally very abundant	outcompetes natives species	unknown	unclear
Macrophthalmus graeffei Decapoda	1994	S Turkey	unknown	unknown	Suez Canal	Indo-W Pacific
Macrophthalmus graeffei Decapoda	2003	Israel, Haifa Bay	rare	unknown	Suez Canal	Indo-W Pacific
Maeotias inexpectata Cnidarian	1992	USA, San Francisco Bay	unknown	unknown	ballast water, hull fouling	Black
Maeotias inexpectata Cnidarian	1999	Estonia	occasional records	possibly predation on zooplankton	ballast water	Ponto-Caspian
Marenzelleria cf. wireni Polychaete	1995 (first record in 1989)	Netherlands, W Scheldt, Rotterdam in 1997	spreading	unknown	ballast water?	N America, Atlantic
Marenzelleria viridis Polychaete	1990s	Poland, Szczecin Lagoon	established, spreading	unknown	range expansion	N America, Atlantic

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Marenzelleria viridis Polychaete	1991	Estonia	established, spreading over the entire period of this report	unknown	range expansion	N America, Atlantic
Marenzelleria viridis Polychaete	1992 (first record in 1990)	Sweden, E coast, reached Bothnian Bay in 2001	spreading during entire period of this report	unknown	ballast water	N America, Atlantic
Marenzelleria viridis Polychaete	1993	Finland	established, spreading	unknown	range expansion	N America, Atlantic
Marsupenaeus japonicus Prawn	1996	Greece. First record in Mediterranean in 1927	established	unknown	Suez Canal, aquaculture release	Indo-Pacific
Marsupenaeus japonicus Prawn	2001	Turkey, Marmara Sea. First record in Mediterranean in 1927	occasional records	unknown	Suez Canal, aquaculture release	Indo-Pacific
Mediomastus capensis Polychaete	1990	Italy, in 2001 in Salerno	spreading	unknown	Suez Canal	
Megabalanus coccopoma Barnacle	1998	Belgium (on buoys)	occasional records	fouling	hull fouling	E Pacific
Megabalanus sp. Barnacle	2000	France, Port of Cros, Mediterranean	unknown	unknown	unknown	W Pacific
Megabalanus tintinnabulum Barnacle	1998 (earlier records known)	Belgium (on buoys)	occasional records annually until 2002	fouling	hull fouling, range expansion	cosmopolitan
Melicertus hathor Prawn	1997	Israel, Haifa Bay, Ashdod & Palmahim	locally common	unknown	Suez Canal	Indian Ocean, Red Sea
Melicertus hathor Prawn	2002	Turkey, SE coast, Yumurtalik bight	occasional records	unknown	Suez Canal	Indian Ocean, Red Sea
Melita sp. Isopod	1993	USA, San Francisco Bay	unknown	unknown	ballast water, hull fouling	cannot be determined on genus level
Merceneria merceneria Bivalve	1995 (imported < 1900)	Netherlands	unknown	unknown	remains of imported and released populations	North west Atlantic
Metapenaeopsis aegyptia Prawn	1998 (first records in Med. in 1987 in Israel)	Greece, Rhodes Island	occasional records	unknown	Suez Canal, range expansion	
Metapenaeopsis mogiensis consobrina Prawn	1996	Israel	common	unknown	Suez Canal?	Indo-W Pacific, Red Sea to Indonesia
Metapenaeopsis mogiensis consobrina Prawn	1998	Greece, Rhodes Island	occasional records	unknown	Suez Canal?	Indo-W Pacific, Red Sea to Indonesia
Metaxia bacillum Gastropod	1990s? (since 1978 in Israel)	Southern Turkey, from Gulf of Iskenderun to Tasuçu	established	unknown	Suez Canal, range expansion	Red Sea, Indo-Pacific
Micippa thalia Decapod	1994	Turkey	rare	unknown	Suez Canal	Indo-W Pacific

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Micippa thalia Decapod	1999	Lebanon	unknown	unknown	Suez Canal	Indo-W Pacific
Micropogonias undulatus Fish	1998	Belgium	unknown	competition	unknown	NW Atlantic, USA–Mexico
Mnemiopsis leidyi Comb jelly	2001	Caspian Sea	established?	predation	ballast water?	W Atlantic
Morone saxatilis Fish	1998	the Netherlands, Yssel Lake	single specimen	unknown	unknown	N America
Mugil labrosus Fish	1998	Poland, Puck Bay	single specimen	unknown	release?	E Atlantic, Scandinavia, Iceland S to Senegal and Cape Verde, Mediterranean, SW Black Sea
Mugil soiuy Fish	1998	Greece, NE Thracian Sea & N Aegean Sea	single specimen	unknown	Introduced by humans for aquaculture in the Sea of Azov, Black Sea before entering the Mediterranean (the northern Aegean Sea) via the Sea of Marmara	Far-Eastern Asia, from Russia to China
Mugiligobius sp. Fish	1993	USA, Hawaii	unknown	unknown	ballast water	Philippines
Murchisonella columna Gastropod	1990s?	Turkey, near Tasuçu	occasional records	unknown	Suez Canal? No records from Israel, i.e. ballast water introduction?	Indo-Pacific
Musculista senhousia Bivalve	1997	Canada, British Columbia, Barkley Sound, Vancouver Island	Uncommon scattered. Spreading. Species occurred in Puget Sound USA since 1940s, but not in BC	unknown	unknown	NW Pacific
Myicola ostraea Copepod	1993	Ireland	unknown	undulating oyster gill condition	live oyster imports from France	NW Pacific
Mytilicola orientalis Copepod	1992	North Sea	few localities	unknown	live oyster imports	N Pacific
Mytilicola orientalis Copepod	1993	Ireland	established	unknown	live oyster imports from France	NW Pacific
Mytilicola ostreae Copepod	1992	North Sea	few localities	unknown	live oyster imports	N Pacific
Mytilopsis leucophaeta Bivalve	1994	Belgium, Antwerp	established	fouling problems, clogging of water intakes	hull fouling, ballast water	America
Mytilopsis leucophaeta Bivalve	1996	United Kingdom, Cardiff docks	established	fouling problems	hull fouling, ballast water	America

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Mytilopsis sallei Bivalve	1998	Australia, Darwin	established population was eradicated by chemical treatment	fouling problems	hull fouling, pleasure boats	Central west Atlantic and Caribbean
Nemopsis bachei Cnidaria	1994	Netherlands	unknown	fouling?	oyster imports?	Pacific
Nemopsis bachei Cnidaria	1996	Belgium, Zeebrügge	established, range extension	fouling?	oyster imports?	Pacific
Neogobius melanostomus Fish	1992 (first record in 1990)	Canada, Great Lakes, outside St Claire river	spreading during the entire period of this report	competition	range expansion	Ponto-Caspian
Neogobius melanostomus Fish	1992 (first record in 1990)	USA, Great lakes, outside St Claire river in Michigan & Erie Lakes until 1993, Lake Superior in 1995	spreading during the entire period of this report	competition	range expansion	Ponto-Caspian
Neogobius melanostomus Fish	1999	Germany, Rügen Island, Baltic	occasional records	competition	secondary introduction?	Ponto-Caspian
Neogobius melanostomus Fish	1999 (first record in 1985)	Poland, Vistula Lagoon	established	competition	secondary introduction?	Ponto-Caspian
Neogobius melanostomus Fish	2002 (first record in 1990)	Gulf of Riga	unknown	competition	secondary introduction?	Ponto-Caspian
Neogobius melanostomus Fish	2002 (first record in 1990)	Lithuania, Curonian Lagoon	unknown	competition	secondary introduction?	Ponto-Caspian
Nuttalia obsurata Bivalve	1997	Canada, British Columbia, Barkley Sound, Vancouver Island	established, spreading northwards	fishing on species considered	unknown	NW Pacific
Nuttalia obsurata Bivalve	2000	USA, Washington, Oregon until Coos Bay	established	fishing on species considered	unknown	NW Pacific
Obesogammarus obesus Amphipod	1995	Germany	rare	unknown	ballast water?	Ponto-Caspian
Ocinobrellus inornatus Gastropod	1997	France, Atlantic coast	established, spreading	oyster drill	shellfish trade or ballast water	NW Pacific
Olisthodiscus luteus Phytoplankton, Rhaphidophycean alga	1999	Norway	unknown	harmful to fish?	unknown	
Oncorhynchus mykiss Fish	2001	Finland	unknown	unknown	escapes from farm	E Pacific: Kamchatka
Ophryotrocha japonica Polychaete	1999	Italy, Ravenna harbour	established, spreading	unknown	unknown	Pacific Ocean
Orchestia cavimana Amphipod	1999	Estonia	established	unknown	secondary introduction	N Africa
Orconectes rusticus Decapod	1995 (earlier records known)	Canada, Great Lakes	continues spreading	unknown	unknown	North America

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Oreochromis niloticus Fish	2000	USA, Mississippi region	unknown	unknown	Aquaculture escape	Africa
Ostrea edulis Bivalve	1992	USA, Rhode Island, in 1996 in New Hampshire	established, continues spreading	unknown	range expansion, accidental release of larvae, ballast water	Europe
Oxyurichthys petersi Fish	1992 (since 1983 in Israel)	Turkey	common	unknown	Suez Canal, range expansion	Red Sea
Oxyurichthys petersi Fish	1995 (since 1983 in Israel)	Syria	common	unknown	Suez Canal, range expansion	Red Sea
Palaemonella rotumana Prawn	1999 (first record in Medit. 1948 in Israel	Turkey, Fethiye	occasional records	unknown	Suez Canal, range expansion	Indo-W Pacific, Red Sea to Hawaii
Palmadusta lentiginosa lentiginosa Gastropod	1990	Israel, Tel Aviv, Habonim & Palmahim	occasional records	unknown	Suez Canal?	Indian Ocean & Persian Gulf
Paracorophium brisbanensis Amphipod	2002	New Zealand, Tauranga Harbour	unknown	unknown	shipping?	Australia
Paradexamine sp. Isopod	1993	USA, San Francisco Bay	unknown	unknown	ballast water, hull fouling	W Pacific?
Paralithoides camtschaticus Decapod	1993	N Norway	established, continues spreading during the entire period of this report	predator, fishing of species initiated with regular commercial catch in 2002	range expansion from Russia. Deliberate release in Russia	Kamtschatka
Paranthura sp. Isopod	1993	USA, San Francisco Bay	unknown	unknown	ballast water, hull fouling	W Pacific?
Perccotus glehni Fish	1999	Poland, Vistula Lagoon & River	unknown	unknown	shipping	Asia
Penaeus vannamei Shrimp	1993	USA, South Carolina	unknown	unknown	accidental release	Pacific
Percnon gibbesi Decapod	1999	Italy, Sicily	established, locally common, spreading. In 2002 S coast of Sardinia, in 2003 Ionian coast of Calabria	competition	fishing, shipping	California to Chile, Florida to Brazil
Percnon gibbesi Decapod	1999	Spain, Balearic Islands	established	competition	fishing, shipping	California to Chile, Florida to Brazil
Percnon gibbesi Decapod	2002	Malta	established	competition	fishing, shipping	California to Chile, Florida to Brazil
Perkinsus atlanticus Haplospordian	1993	Spain, mar Menor (first record in Mediterranean)	unknown	disease agent of oysters	mussel movements?	

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Perna perna (viridis) Bivalve	1993	USA, Texas reached Tampa Bay in 1999	spreads eastwards	fouling	ballast water, hull fouling	Venezuela
Perna perna (viridis) Bivalve	1998	Australia	eradication successful in 1998. New finding in 2000 near Cairns	fouling	hull fouling	Venezuela
Perophora japonica Ascidian	2000	United Kingdom, Plymouth	established, spreading	fouling?	unknown	Japan
Petromyzon marinus Fish	2002	Poland, Puck Bay	single specimen	unknown	range expansion	NE Atlantic, Mediterranean, Baltic & North Sea
Petroscirtes ancylodon Fish	2000 (since 1989 in Israel)	Turkey, Iskenderan Bay	single specimen	unknown	Suez Canal, range expansion	Red Sea to Arabian Gulf
Pfiesteria piscicida Phytoplankton, Dinoflagellate	2000	New Zealand	unknown	potential for fish kill	unknown	possibly native
Pfiesteria piscicida Phytoplankton, Dinoflagellate	2002	Norway, Oslo fjord	unknown	potential for fish kill	unknown	possibly native
Pfiesteria shumwayae Phytoplankton, Dinoflagellate	2002	Norway, Oslo fjord	unknown	potential for fish kill	unknown	possibly native
Philine auriformis Gastropod	1992	USA, San Francisco Bay	unknown	unknown	ballast water	New Zealand
Photobacterium damsela Bacterium	1992	Italy, N Adriatic Sea	spreading	causing Pasteurellosis & Nodavirus of fish	imported with fish fry for aquaculture	
Phyllorhiza punctata Cnidarian	2000	USA, Gulf of Mexico, Atlantic coast of Florida. Indian River Lagoon (Cape Canaveral, Florida) in 2001	established. Rare & sporadic in 2001–2002	unknown	ballast water, hull fouling	tropical Pacific
Pinguipes brasilianus Fish	1990	Itaky, Loano, Ligurian Sea, Messina	occasional records	unknown	unknown	Argentina, Uruguay, Brazil
Pisodonophis semicinctus Eel	1990s? (since 1958 in Algeria)	Italy, Strait of Sicily & Tyrrhenian Sea	unknown	unknown	range expansion	E Atlantic, Gibraltar to Angola
Pisodonophis semicinctus Eel	1990s? (since 1958 in Algeria)	Malta	unknown	unknown	range expansion	E Atlantic, Gibraltar to Angola
Pisodonophis semicinctus Fish	1999	Italy	unknown	unknown	unknown	Atlantic
Planaxis savignyi Gastropoda	1990s? (<1905 in Egypt, Medit.)	Israel, Haifa	established	unknown	Suez Canal, range expansion	Red Sea
Platichthys flesus Fish, European Flounder	1994 (earlier records known)	Canada, Ontario	occasional records	unknown	ballast water?	Europe
Pleurosira laevis f. polyphorma Diatom, Phytoplankton	1995	Sweden in cooling water of power plants	unknown	unknown	eel stocking?	subtropical regions

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Polycerella emertoni Gastropod	2000	Greece	unknown	unknown	shipping	Atlantic
Polydora redeki Polychaete	1998	Sweden, Oesthammer	unknown	unknown	range expansion (known from Finland since 1950s), shipping	Europe
Polyodon spathula Fish	1999	Poland, Szczecin Lagoon	single specimen	unknown	unknown	N America: Mississippi River system
Polysiphonia harveyi Red alga	1997	USA, Massachusetts, Rhode Island	unknown	unknown	unknown	Atlantic North America
Polysiphonia morrowii Red alga	1999	Italy	spreading	unknown	unknown	Japan, China & Korea
Polysiphonia senticulosa Red alga	1993	Netherlands, Oosterschelde	spreading	unknown	aquaculture	NE Pacific
Polysiphonia senticulosa Red alga	2001	Belgium, Oostende	spreading	unknown	aquaculture	NE Pacific
Pontogammarus robustoides Amphipod	1994	Germany	rare	unknown	ballast water?	Ponto-Caspian
Pontogammarus robustoides Amphipod	1998 (first record in 1988)	Poland, Szczecin Lagoon, Vistula River in 1999	spreading eastwards	unknown	ballast water, canal migrant?	Ponto-Caspian
Porphyra yezoensis Alga	1996–1998	USA, Maine	rare	unknown	imported for aquaculture, now outside culture facility. No indication to affect native *Porphyra*	Japan
Portumnus latipes Decapod	2001	Germany	occasional records	competition	range expansion	S North Sea to N Africa, Black Sea and Mediterranean
Portunus hastatus Decapod	1998	France, Port Cros, Mediterranean	single specimen	predation	range expansion?	E Mediterranean
Potamopyrgus antipodarum Gastropod	1993	Canada, Great Lakes	established	unknown	ballast water	New Zealand
Procambrus clarckii Decapoda	1992	Portugal	wide-spread	unknown	range expansion	N America
Proterorhinus marmoratus Fish	1992 (first record 1990)	Canada, Great Lakes	spreading during the entire period of this report	unknown	shipping?	E Europe, Black Sea, Sea of Azov and Caspian Sea
Proterorhinus marmoratus Fish	2002	Netherlands, Waal River	unknown	unknown	unknown	Ponto-Caspian
Protodorvillea egena Polychaete	2001	Italy, Gulf of Noto, Sicily	unknown	unknown	unknown	S Africa

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Psammotreta praerupta Bivalve	1992	Turkey, off Adana	single specimen (four valves found)	unknown	Suez Canal questionable as not known from Israel. Shipping?	Indo-Pacific including Red Sea
Psenes pellucidus Fish	1990s? (since 1995 in Algeria)	France, Gulf of Lions & Provence	rare	unknown	range expansion from Spain	temperate and warm water of Atlantic, Indian and W Pacific Oceans
Psenes pellucidus Fish	1995 (since 1995 in Algeria)	Spain, Balearic Islands	rare	unknown	range expansion via Gibraltar	temperate and warm water of Atlantic, Indian and W Pacific oceans
Pseudobacciger harengulae Digene parasite	1994	Sweden, W coast	unknown, in ca. 20% of herring catch	parasite	ballast water or with introduction of intermediate host (*Ensis directus*)	tropical to warm-temperate waters of Atlantic, Indic, Pacific and Black Sea
Pseudodactylogyrus anguillae Trematode	1992	Canada, Gulf of Maine, Nova Scotia	unknown	unknown	import of live eel	Asia, NW Pacific
Pseudodactylogyrus anguillae Trematode	1995	USA, Chesapeake Bay, Maryland, Cooper & Edisto Rivers, South Carolina	unknown	unknown	import of live eel, ballast water	Asia, NW Pacific
Pseudodactylogyrus bini Trematode	1999	USA, Cooper & Edisto Rivers, South Carolina	unknown	unknown	import of live eel, ballast water	Asia, NW Pacific
Pseudodiaptomus inopinus Copepod	1992	USA, Oregon, Washington	abundant	unknown	ballast water	Asia
Pseudofabriciola filamentosa Polychaete	1986	Italy, Porto Cesareo Lagoon, Ionian Sea, in 2001 in Salerno	spreading	unknown	Suez Canal	
Pseudominolia nedyma Gastropod	1990s? (since 1966 in Israel)	Turkey, from Mersina to Tasuçu	established	unknown	Suez Canal, range expansion	Red Sea, Persian Gulf, Ceylon
Pseudonitzschia sp. Phytoplankton, Diatom causing Amnesic Shellfish Poisoning (ASP)	1999	Ireland, W coast	unknown	affecting *Pecten maximus*	live mussel trade?	cannot be determined on genus level
Pseudorambara parva Fish	1998	the Netherlands	unknown	unknown	release of aquarium spp. and canal migrant from Romania	Asia?
Pteragogus pelycus Fish	1999	Greece, Rhodes Island	established	unknown	Suez Canal, range expansion	Red Sea to E Africa, Madagascar & Mauritius
Pteragogus pelycus Fish	2000	Cyprus, N coast	unknown	unknown	Suez Canal, range expansion	Red Sea to E Africa, Madagascar & Mauritius
Pteragogus pelycus Fish	1992	Israel, Haifa Bay	rare	unknown	Suez Canal	Red Sea to E Africa, Madagascar & Mauritius
Pterois miles Fish	1992	Israel	single specimen	unknown	Suez Canal, aquarium release	Red Sea & E Indian Ocean

SPECIES (INCLUDING HIGHER TAXON)	YEAR OF FIRST RECORD	REGION OF FIRST RECORD	POPULATION STATUS	IMPACT OR POTENTIAL IMPACT	LIKELY INTRODUCING VECTOR	NATIVE RANGE
Pterois volitans Fish	1992	USA, Biscayne Bay, Florida	occasional records since 1992. In 2001 juveniles collected from Long Island, persistent population off North Carolina.	unknown	aquarium release, ballast water	Indo-Pacific
Punctaria tenuissima Brown Alga	1998	Italy, Venice	established	competition	fishing	Atlantic
Pyrunculus fourierii Gastropod	1990s? (<1987 in Lebanon)	Cyprus	unknown	unknown	Suez Canal, range expansion	Indo-W Pacific, Red Sea
Questa caudicirra Polychaete	1993	Italy, Ponza Island, Tyrrhenian Sea, in 2001 in Gulf of Noto, Sicily	spreading	unknown	range expansion, ballast water?	Atlantic & Pacific coasts of America
Rapana venosa Gastropod	1992	North Sea, near Dogger Bank	single specimen	predation, mussel culture at risk	disposal from ship`s galley?	SE Asia
Rapana venosa Gastropod	1997 (first records in 1973)	Adriatic Sea, N coast	spreading	predation, mussel culture at risk	hull fouling, ballast water, live oyster imports? Range expansion from Black Sea (first records 1947)?	SE Asia
Rapana venosa Gastropod	1997	France, Atlantic coast	occasional records during entire period of this report, eradication trial in 2000. New findings in 2001, including egg cases.	predation, mussel culture at risk	hull fouling, ballast water, live oyster imports? Range expansion from Adriatic Sea (first records 1973)? *Rapana* was used to ballast culture bags of *Ruditapes philippinarum* transferred from the Adriatic Sea.	SE Asia
Rapana venosa Gastropod	1998	USA, Chesapeake Bay	spreading during entire period of this report within the bay. Single specimens from Washington State in 1950s	predation, mussel culture at risk	hull fouling, ballast water, live oyster imports?	SE Asia
Rapana venosa Gastropod	1999	Argentina, Rio de la Plata	not established	predation, mussel culture at risk	hull fouling, ballast water, live oyster imports?	SE Asia
Rapana venosa Gastropod	1999	Uruguay, Rio de la Plata	established	predation, mussel culture at risk	hull fouling, ballast water, live oyster imports?	SE Asia
Rhabdosargus haffara Fish	1992	Israel	rare	unknown	Suez Canal	Red Sea, Arabian Gulf
Rhinoclavis kochi Gastropod	1990s? (since 1963 in Israel)	Turkey, from Gulf of Iskenderun to Alanya	unknown	unknown	Suez Canal, range expansion	Red Sea, Indian Ocean Natal to NW Australia, W Pacific N Australia and New Caledonia

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Rhithropanopeus harrisii Decapod	1994	Italy, Po River Delta, Adriatic Sea	established, spreading. Reached in 2000 Italy, Emilia Romagna coast	unknown	ballast water, hull fouling	NW Atlantic
Rhithropanopeus harrisii Decapod	1996	United Kingdom, Cardiff	unknown	unknown	ballast water, hull fouling	NW Atlantic
Rhithropanopeus harrisii Decapod	1999	France, near Marseille	established, spreading	unknown	ballast water, hull fouling	NW Atlantic
Rhynchoconger trewavasae Fish	1993	Israel	occasional records	unknown	Suez Canal	Red Sea
Rissoina bertholleti Gastropod	1990s? (since 1965 in Israel)	Southeast coast of Turkey, from Gulf of Iskenderun to Tasuçu	established	unknown	Suez Canal, range expansion	Red Sea and Indian Ocean
Rissoina spirata Gastropod	1990s?	Israel, Haifa	unknown	unknown	Suez Canal	Indo-Pacific
Sabia conica Gastropod	1990s (single shell in Israel 1980)	Italy, Sicily	single specimen	unknown	Suez Canal, range expansion	Red Sea, Indian Ocean, tropical Pacific
Sagartia elegans ssp. *roseacae* Anthozoan	2000	USA, Massachusetts	not spreading	unknown	hull fouling	Europe
Salmo salar Fish	1996	Canada, British Columbia, Vancouver Island	occasional records until 2001	hybridization	aquaculture escapes?	Atlantic
Sargassum muticum Brown alga	1991	Portugal, near Oporto	spreading, southwards	fouling	unknown	NW Pacific
Sargassum muticum Brown alga	1991	United Kingdom, Cornwall, SW coast of Wales in 1995	established, spreading during the entire period of this report	unknown	oyster imports	NW Pacific
Sargassum muticum Brown alga	1992	Italy, Adriatic Sea near Venice	spreading	fouling	oyster imports, range expansion	NW Pacific
Sargassum muticum Brown alga	1992	Norway, Skagerrak coast	spreading northwards, reached Bergen in 1993, Rogaland in 1997, Sognefjord 1998. Since 1998 no record of further spreading	fouling	range expansion?	NW Pacific
Sargassum muticum Brown alga	1992 drifting, 1995 attached	Sweden, W coast, southernmost record of attached plants in middle part of the Halland province	spreading until 1999. Since 1999 no major changes	fouling	unknown	NW Pacific
Sargassum muticum Brown alga	1993	Denmark, Kattegat	spreading	fouling	range expansion?	NW Pacific
Sargassum muticum Brown alga	1995	United Kingdom, Northern Ireland	eradication trial since 1996 failed. Spreading	fouling	oyster imports	

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Sargassum muticum Brown alga	1998	Germany, near Sylt Island, North Sea	spreading	unknown	escapes from oyster farm	NW Pacific
Sargassum muticum Brown alga	1999	Belgium, Zeebrügge, Oostende	first record of attached specimens. Floating algae recorded since 1977. Not persisting. No records after 1999	competition, habitat modification	oyster imports, secondary introduction	NW Pacific
Sargassum muticum Brown alga	2001	Ireland, SE coast, SW coast & W coast	spreading	fouling	oyster imports, range expansion	NW Pacific
Scardinius erythrophthalmus Fish	1992 (first records 1990)	Canada, Great Lakes	occasional records	unknown	shipping?	Europe, Asia, North, Baltic Black, Caspian & Aral Seas
Seriola carpenteri Fish	1990s	Italy	established	unknown	unknown	E Atlantic, Angola to Bay of Biscay
Seriola fasciata Fish	1990s	Italy, southern Tyrrhenian Sea, off Sicily & Lampedusa in the Sicilian channel	rare	unknown	range expansion	Madeira & Canary Islands, Gulf of Mexico, Cuba, Puerto Rico & Bermuda
Seriola fasciata Fish		Spain, Balearic Islands	unknown	unknown	range expansion via Gibraltar	Madeira & Canary Islands, Gulf of Mexico, Cuba, Puerto Rico & Bermuda
Seriola rivoliana Fish	2002	Italy	unknown	unknown	unknown	Atlantic
Serrasalmas nattereri Fish	1992	Canada, Lake Ontario	single specimen	unknown	accidental aquarium release	tropical S America
Serrasalmas nattereri Fish	1993	Germany, Elbe River	single specimen	unknown	accidental aquarium release	tropical S America
Silhouetta aegyptia Fish	1999 (since 1970s in Medit., Egypt)	Israel, Mediterranean, Ashdod	common	unknown	Suez Canal, range expansion	N Red Sea
Sillago sihama Fish	1994 (since 1977 in Lebanon)	Turkey	Very common in the Eastern Levant	unknown	Suez Canal	Indo-Pacific, Red Sea E Africa to Korea, N Australia, to Solomon Islands
Sillago sihama Fish	1994 (since 1977 in Lebanon)	Egypt	Very common in the Eastern Levant	unknown	Suez Canal	Indo-Pacific, Red Sea E Africa to Korea, N Australia, to Solomon Islands
Smaragdia souverbiana Gastropod	1990s?	SE Turkey	established	unknown	Suez Canal	Indo-Pacific, Japan, to Fiji, Tonga & Samoa in W Pacific, Indian Ocean, Red Sea

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Solanema corona Cnidarian	1997	Shetland Islands	unknown	unknown	unknown	
Sphoeroides pachygaster Fish	1992 (since 1981 in Spain, Mallorca)	Greece	common	unknown	range expansion via Gibraltar or Suez Canal	Atlantic, Irish waters to S Africa & New Jersey to Argentina. Indian Ocean
Sphoeroides pachygaster Fish	1996 (since 1981 in Spain, Mallorca)	Israel, Ashdod, Mediterranean coast	common	unknown	range expansion via Gibraltar or Suez Canal	Atlantic, Irish waters to S Africa & New Jersey to Argentina. Indian Ocean
Sphoeroides pachygaster Fish	1990 (since 1981 in Spain, Mallorca)	Italy, S Adriatic, Ionian Sea	common	unknown	range expansion via Gibraltar or Suez Canal	Atlantic, Irish waters to S Africa & New Jersey to Argentina. Indian Ocean
Sphoeroides pachygaster Fish	1993 (since 1981 in Spain, Mallorca)	Tunesia	common	unknown	range expansion via Gibraltar or Suez Canal	Atlantic, Irish waters to S Africa & New Jersey to Argentina. Indian Ocean
Sphyraena chrysotaenia Fish	1990s? (since 1931 in Israel)	Malta	established	unknown	Suez Canal	Indo-Pacific, Red Sea, E Africa, Madagascar & Seychelles to China & N Australia
Sphyraena flavicauda Fish	1992	Israel	occasional records	unknown	Suez Canal	Indo-Pacific, Red Sea, eastern Africa to Durban
Spondylus groschi Bivalve	1990s?	Israel	established?	unknown	Suez Canal	E Africa, Red Sea & Persian Gulf
Spondylus spinosus Bivalve	1990s? (since 1988 in Israel)	Turkey: Iskenderum	established	unknown	Suez Canal, range expansion	Indo-Pacific, Red Sea
Spring Viraemia of Carp Virus	2002	United Kingdom	unknown	fish disease	movement of live fish?	?
Stephanolepis cf. dispros Fish	1999	Italy	unknown	unknown	Suez Canal?	Red Sea, Indo-W-Pacific
Stephanolepis diaspros Fish	1993 (since 1927 in Israel)	Italy, Gulf of Palermo, Sicily	spreading	unknown	Suez Canal, range expansion	Red Sea to Arabian Gulf
Sticteulima cf. lentiginosa Gastropod	1990s?	Turkey, Aydincik & Tasuçu	occasional records	unknown	Suez Canal?	Indo-Pacific
Styela clava Ascidian	1997	Germany, Sylt island, North Sea	spreading	fouling	escaped from oyster farm	N Pacific
Styela clava Ascidian	1998	Canada, Prince Edward Island	established, mass development in 1999 + 2000	fouling, competition with mussels for food	mussel or boat movements	Asia
Styloptygma beatrix Gastropod	1990s? (since 1988 in Turkey)	Israel	established, but rare	unknown	ballast water?	Persian Gulf
Syrnola cinctella Gastropod	1994	Turkey, Yumurtalik Harbour	single specimens (two empty shells)	unknown	unknown	Indo-Pacific, Korea & Japan to the Persian Gulf & Red Sea

SPECIES (INCLUDING HIGHER TAXON)	YEAR OF FIRST RECORD	REGION OF FIRST RECORD	POPULATION STATUS	IMPACT OR POTENTIAL IMPACT	LIKELY INTRODUCING VECTOR	NATIVE RANGE
Syrnola fasciata Gastropod	1990s? (since 1958 in Israel)	Cyprus	established	unknown	Suez Canal, range expansion from population in Turkey or Israel	Indo-Pacific
Teredo navalis Bivalve	1994	Germany, Baltic	first record of free living larvae	unknown	unknown	tropical coasts of Asia?
Tetraodon fluviatilis Fish	2001	Belgium, off shore	unknown	unknown	aquarium release	Asia
Thais lacerus Gastropod	1990s? (since <1939 in Egypt)		unknown	unknown	Suez Canal questionable as no occurrence in Red Sea. Ballast water?	Indian Ocean & Persian Gulf
Thalamita poissonii Decapod	1994 (first record in Medit. in Israel 1952)	Greece, Crete	locally common	unknown	Suez Canal, range expansion	Indo-W Pacific, Red Sea to Taiwan
Tinca tinca Fish	2000	Canada, near St Lawrence River	few specimens	unknown	escaped from aquaculture pond	Europe, Arctic Ocean drainage, Lake Baikal
Tortanus sp. Copepod	1993	USA, San Francisco Bay	unknown	unknown	ballast water	cannot be determined on genus level
Trachysalambria palaestinensis Prawn	1998 (earlier records 1924 Israel, 1960s Turkey, 1970s Egypt, 1990s Tunesia	Greece, Rhodes Island	established	species is of commercial interest, competes with other Red Sea prawns	Suez Canal, range expansion	Red Sea
Trachyscorpia cristulata chinata Fish	1990s? (since 1962 in Marocco)	Spain, Balearic Islands	rare	unknown	range expansion via Gibraltar	E Atlantic, Ireland to Angola & Namibia
Tricellaria inopinata Bryozoan	1998	Southern England	established, abundant	fouling, competition	hull fouling	Indo-Pacific
Tricellaria inopinata Bryozoan	2000	Belgium (various ports)	occasional records, range extension	fouling, competition	fouling on pleasure crafts, range expansion	Indo-Pacific
Tricellaria inopinata Bryozoan	2000	France, the Netherlands	established	fouling, competition	hull fouling, range expansion	Indo-Pacific
Trochus erythreus Gastropod	1990s? (since 1968 in Israel)	Greece, Crete	established, spreading	unknown	Suez Canal, range expansion	Red Sea, Gulf of Aden & Persian Gulf
Trochus erythreus Gastropod	1990s? (since 1968 in Israel)	Turkey Gulf of Iskenderun	established, spreading	unknown	Suez Canal, range expansion	Red Sea, Gulf of Aden & Persian Gulf
Turbonilla edgarii Gastropod	1990s? (since 1980 in Israel)	Cyprus	established	unknown	Suez Canal, range expansion from population in Turkey or Israel	Indo-Pacific

SPECIES (INCLUDING HIGHER TAXON)	YEAR OF FIRST RECORD	REGION OF FIRST RECORD	POPULATION STATUS	IMPACT OR POTENTIAL IMPACT	LIKELY INTRODUCING VECTOR	NATIVE RANGE
Undaria pinnatifida Brown alga	1992	Italy, Adriatic Sea, near Venice, records near Bari in 1999	established, spreading	competition with other algae, problems with harvesting/ dredging of oysters, habitat modification	mussel movements, hull fouling?	Japan
Undaria pinnatifida Brown alga	1992 (first record in 1981)	Spain, Ria de Arosa	established	unknown	range expansion	Japan
Undaria pinnatifida Brown alga	1994	United Kingdom, Hamble estuary, Isle of Wight by 1997	established, continued spreading during the entire period of this report	unknown	oyster movements, range expansion?	Japan
Undaria pinnatifida Brown alga	1996	Australia, near Melbourne (former record in Tasmania in 1988)	unknown	unknown	hull fouling. Unlikely introduced from Tasmania, but rather from New Zealand or Asia	Japan
Undaria pinnatifida Brown alga	1998	Belgium, Zeebrügge	occasional records, not spreading	unknown	fouling on pleasure crafts, range expansion	Japan
Undaria pinnatifida Brown alga	1999	the Netherlands, Oosterschelde	spreading fast since 2000	unknown	unknown	Japan
Undaria pinnatifida Brown alga	1999	USA, Santa Barbara Harbor; Cabrillo Beach (San Pedro); Channel Islands Harbor (Oxnard), southern California	established	unknown	ballast water, hull fouling	Japan
Veneruperis philippinarum Bivalve	1994	United Kingdom, south coast	established	unknown	range expansion from aquaculture areas	Philippines
Veneruperis philippinarum Bivalve	1998	Norway	occasional records	unknown	records at aquaculture site, operation terminated in 1991	Philippines
Vibrio heamolyticus Disease agent	1994	the Netherlands, near Amsterdam	unknown	disease agent affecting humans	life eel imports	?
Vimba vimba Fish	2001	Belgium	occasional records	competition	bait imports, range expansion	Black, Caspian & Azov Seas
Viral Haemorrhagic Septicaemia (VHS) Disease agent	2000	Finland & Baltic	first observation	disease of rainbow trout in fish farms	unknown. Herring stocks suspected	?
Viral Haemorrhagic Septicaemia (VHS) Disease agent	1995	Scotland	disease of turbot (*Scophthalmus maximus*)	unknown	unknown	?
Womersleyella setacea Alga	1993	Spain, Balearic coasts of Cabrera Island	spreading, Alboran Island in 1995, Menorca in 1997	competition and fisheries	unknown	
Xenostrobus secures Bivalve	1992	Italy, Ravenna Lagoon, Venice Lagoon	established	unknown	shipping	Australia, New Zealand

Annex 1: Participants of WGITMO Meetings 1992–2002 per country

COUNTRY	NAME	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Australia	Colgan								X			
	Goggin						X					
	Hewitt							X				
	Lockwood							X				
	Oemcke							X				
	Rigby							X				
	Thresher						X					
Belgium	Kerckhof										X	X
Bermuda	Knap							X				
Canada	Arthur					X						
	Campbell		X	X		X	X	X	X			
	Carey	X	X	X								
	Cook			X								
	Dermott	X										
	Gilbert						X	X	X		X	
	Kieser			X	X	X		X	X	X	X	X
	Randall		X				X					
Estonia	Eero									X		
	Ojaveer					X			X	X	X	
	Pollumäe									X		
Finland	Leppäkoski					X				X		
	Rahkonen	X		X								
	Tuunainen								X			
	Urho										X	
France	Goulletquer						X	X		X		
	Grizel	X	X		X		X				X	
	Heral						X					
	Masson								X			
	Meinesz						X					
	Noel						X					
	Thibaut						X					
Georgia	Gogothishvili								X			
	Shotadze							X	X		X	
	Tengiz										X	
Germany	Dammer		X		X							
	Gollasch		X	X	X	X	X	X	X	X	X	X
	Huelsmann				X		X	X	X			
	Rosenthal				X							X
	Schulz					X						
Ireland	Clarke									X		
	Minchin	X	X	X	X	X	X	X	X	X	X	X
Israel	Abelson							X	X			
	Galil							X				
Italy	Occhipinti								X	X	X	X
	Relini							X				
Lithuania	Olenin				X	X		X				

COUNTRY	NAME	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
the Netherlands	de Groot							X	X			
	Weststeyn									X	X	
New Zealand	Hall							X				
	Hay							X				
Norway	Botnen							X				
	Jelmert						X	X	X	X	X	
	Jörgensen											X
	Jorstad					X	X	X				
	Loennechen								X			
	Tilseth		X	X								
Poland	Gruszka					X						
	Janta					X						
	Pelczarski					X				X		
	Sapota					X						
	Skora					X						
	Sobol					X						
	Wolowicz					X						
Portugal	Brogueira	X										
	Cabecadat	X										
	Figueiredo	X										
	Ruano	X										
Russia	Karasiova					X						
Spain	Pages										X	
	Ribera						X				X	
Sweden	Carlberg											X
	Dybern	X	X		X	X						
	Holmberg	X	X			X	X					
	Jansson				X	X	X	X				
	Nordwall											X
	Sparrevik									X	X	
	v. Wachenfeld					X						
	Wallentinus	X	X	X	X	X	X	X	X	X	X	X
United Kingdom	Dyrynda								X	X		
	Eno				X	X	X	X	X			
	Frazer		X									
	Hamer						X					
	Hayes			X	X							
	Laing								X			
	Lucas							X	X			
	Macdonald							X				
	McCollin						X	X	X			
	McGillivary		X									
	McVicar		X									
	Mueller				X							
	Munro	X	X									
	Side		X									
	Utting	X	X	X	X		X	X	X	X		
USA	Allen			X								
	Cangelosi							X				
	Carlton	X	X	X	X	X	X	X	X	X		
	Crawford			X								

COUNTRY	NAME	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
	Dehalt								X			
	Goldman			X								
	Gollamudi						X					
	Harbison			X								
	Holohan							X				
	Joseph			X								
	Kern			X								
	Kopp							X	X			
	Levine		X		X	X	X		X			
	Lindell			X								
	Mann								X			X
	Miller							X				
	Pederson							X				X
	Ruiz										X	X
	Smith			X								
	Tinsman			X								
International Maritime Organization	Nauke					X	X	X	X			
Total		15	19	21	17	27	28	37	30	18	18	13

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