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

By Correspondence

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer
H.C. Andersens Boulevard 44-46
DK-1553 Copenhagen V
Denmark
Telephone (+45) 33 38 67 00
Telefax (+45) 33 93 42 15
www.ices.dk
info@ices.dk

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Contents

1 Opening of the Meeting and Introduction

In 2004/2005 the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) met by correspondence and with Stephan Gollasch (Germany) as Chair. The fruitful discussions were predominantly carried out between October 2004 and April 2005. Representatives from Australia, Belgium, Canada, Estonia, Finland, France, Germany, Ireland, Italy, New Zealand, Norway, Sweden, United Kingdom, and the United States of America contributed to the discussions (Annex 1). National Reports were received from 10 countries (Annexes 3 and 4).

The Chair forwarded the feedback from ICES on the progress made at last year's meeting to the Group. The group notes with appreciation that the ICES Code of Practice for the Introduction and Transfer of Marine Organisms was translated into French and will shortly be printed. Also the Alien Species Alert report on the Red King Crab, *Paralithodes camtschaticus* will be printed in the ICES Cooperative Research Report series soon. The group noted also with appreciation that the WGITMO handbook on invasion vectors, entitled "Vector Pathways and the Spread of Exotic Species in the Sea" was published as ICES Cooperative Research Report 271 in March 2005.

2 Terms of Reference, Adoption of Agenda, Selection of Rapporteur

2.1 Terms of Reference

The terms of reference (ToR) (Annex 2) were addressed by correspondence. This required preparation of statements and reports by discussion group members, and these are contained in the Annexes of this report. The Chair expressed his thanks to the WGITMO members for preparing these contributions.

2.2 Status of the terms of references

The status of the Terms of Reference are as follows:

ToR a) Synthesise and evaluate National Reports particularly focussing on Risk assessment approaches and treatment and management approaches.

Status: Completed for 2004.

ToR b) Advance the discussion with the aim to prepare a draft report for rapid response and control options (such as decision trees and regulations) by 2006.

Status: To be continued intersessionally. It is planned to prepare a first draft in 2005 intersessionally and work towards the final draft at the 2006 meeting of WGITMO. The product will be finalized intersesssionally during 2006.

ToR c) Prepare data (in Excel spreadsheet format) which quantifies the distribution and densities of species introductions. Where possible, this should be based on ICES rectangles and for the period 1984–2004 and include any seasonal observations if available. The data should be submitted to the REGNS secure website in preparation for the REGNS integrated assessment workshop in 2005.

Status: WGITMO suggests ICES to consider this item to be dealt with at next years WGITMO meeting. Intersessional activities will result in draft material to be considered at next years meeting. It is planned to hold additional drafting sessions on this ToR at next years meeting.

ToR d) Plan Alien Species Alert reports including evaluation of impacts and increasing public awareness.

Status: completed for 2004

ToR e) Develop risk assessment guidelines for:

i) accidental and intentional introductions,
ii) control options,
iii) rapid response plans,
iv) current Code of Practice (review in light of new initiatives on risk assessment, impact assessment protocols and developmental practices.

Status: Existing rapid response strategies and recommendations were reviewed (see also The Mitten Crab warning as Appendix to the Canadian National Report, Annex 3). WGITMO suggests ICES to consider this item to be dealt with at next years WGITMO meeting.

2.3 Selection of Rapporteur

The group worked intersessionally with a final report completed by S. Gollasch with help from participants and the rapporteur from previous meetings (D. Kieser, Canada).

3 Dissemination of Relevant Material for Public Information

WGITMO recognized that public awareness is of vital importance to avoid species introductions and to slow down the spread of previously established non-indigenous species. The group very much appreciates that relevant public awareness material was published on the ICES homepage (*i.e.* "Aliens invade the sea" and "Veined whelks: Wanted dead or alive"). Of special interest is the publication of the electronic version of the Species Alert Report on *Rapana* which may be downloaded from http://www.ices.dk/pubs/crr/crr264/crr264.pdf and the availability of the handbook "Vector pathways and the spread of exotic species in the sea" printed as ICES Cooperative Research Report 271.

3.1 Conclusions

To further ease the finding of relevant reports and public awareness material and as suggested at last years meeting WGITMO asks ICES to consider using the Internet download section of WGITMO´s meeting reports at www.ices.dk to:

- provide background information on WGITMO´s history by making the Summary of National Reports 1991–2001 (to be prepared) available in electronic format,
- include a download link to the Code of Practice and its Appendices available here,
- include a link here to the Advisory Report on *Rapana venosa* and future reports as developed (*e.g.* the Alien Species Alert Report on Red Kind Crab *Paralithodes camtschaticus*),
- include a link to the electronical version of the directory of dispersal vectors entitled: "Vector pathways and the spread of exotic species in the sea".

3.2 Recommendations

- ICES is asked to consider linking the above mentioned material to the download section of WGITMO at www.ices.dk.

4 Interaction with PICES

The PICES representative expressed the interest in PICES to deal with planned species introductions in the future. Of particular interest is ICES Code of Practice on Introductions and

Transfers of Marine Organisms. Further, interest to interact with WGBOSV was also expressed (see also WGBOSV Meeting Report 2005).

PICES noted also that the global demand for seafood is increasing. As a result aquaculture efforts will likely increase the supply of seafood for human consumption.

At the PICES Annual Meeting XIII in October 2004 in Honolulu, Hawaii a session entitled '*Natural and Anthropogenic Introduction of Marine Species*' was held. This session was jointly co-convened by Stephan Gollasch (ICES), Yasuwo Fukuyo (PICES) and William Cochlan (PICES). A summary of the PICES session is attached as Annex 8. To continue the effective ICES-PICES cooperation relevant to biological invasions a session will be held at the PICES Annual Meeting XIV to be held in Vladivostock in October 2005. As Chair Stephan Gollasch expressed his interest to attend PICES XIV representing both WGBOSV and WGITMO. He was invited to co-convene a session at the meeting and ICES kindly agreed to fund his participation. It is anticipated that a PICES working group on biological invasions will be launched at the PICES Annual Meeting XIV.

4.1 Conclusions

- The interaction with PICES is seen as essential noting that several invaders already present in ICES-member countries originate from PICES-member countries.
- Mutual benefits will arise due to cooperational activities between ICES and PICES.
- Cooperating with PICES-member countries may result in spreading the knowledge on the Code of Practice further.
- PICES considers to launch a working group on biological invasions at this years PICES Annual Science Conference.

4.2 Recommendations

- WGITMO recommends to continue the ICES-PICES cooperation for mutual benefit and to distribute relevant ICES publications produced by WGITMO as well as the ICES Code of Practice on Introductions and Transfers of Marine Organisms.
- It is recommended that this item should remain on the agenda of WGITMO.

5 ICES Alien Species Alert Reports (ToR D)

At last year's meeting the following species were suggested for Aliens Species Alert reports: *Undaria pinnatifida*, *Hemigrapsus penicillatus* and *H. sanguineus*, and *Crepidula fornicata*. In addition we suggest that in the future the Chinese mitten crab, (*Eriocheir sinensis*) be the topic of an Alien Species Alert report because it is one of the invasive species of considerable concern both from a habitat destruction perspective and potentially from a human health perspective (note that Canada has Chinese mitten crab listed as prohibited from importation because of the potential infection of mitten crab with a lung fluke, *Paragonimus westermani* that can affect human health). During the 1920s and 1930s the mitten crab spread rapidly throughout northern Europe. Its present estimated distribution ranges from Finland, through Sweden, Russia, Poland, Germany, the Czech Republic, Netherlands, Belgium and England to France. The southernmost Atlantic coast record is in Portugal, and the crab has extended its range into southern France. The crab has also been reported from North America, with reports from the Detroit River and Great Lakes (without establishment in the 1990s). Recent evidence suggests that the population that now occurs in the San Francisco Bay area is steadily on the increase. During 2004 a crab was found in the St. Lawrence estuary which causes concern for establishment in the area, including further transfers into local river systems and possibly the Great Lakes area.

At last year's meeting the final draft Alien Species Alert Report on Red Kind Crab *Paralithodes camtschaticus* was reviewed by WGITMO and subsequently submitted to ICES. The group very much appreciates that the Red King Crab report was accepted for publication in the ICES Cooperative Research Report series.

As requested by ICES the group continues planning additional Alien Species Alert Reports. By correspondence the WGITMO member Inger Wallentinus (Sweden) prepared a draft Alien Species Alert Report on *Undaria pinnatifida*. The comprehensive draft is attached as Annex 5.

5.1 Conclusions

- A comprehensive draft Alien Species Alert Report on *Undaria pinnatifida* (attached as Annex 5) was prepared by correspondence. WGITMO suggest that experts from a number of countries be invited to the 2006 meeting to finalize the draft Alien Species Alert Report on *Undaria pinnatifida* at the meeting. The group also suggests to invite experts on the species next chosen for an Alien Species Alert Report (*Hemigrapsus* spp.)
- ICES is asked to consider to make earlier Alien Species Alert Reports available via the Internet with a link at the download section of WGITMO´s meeting reports.
- It is hoped that awareness resulting from Alien Species Alert Reports will reduce the risk of further spread of these species.

5.2 Recommendations

- WGITMO appreciates the positive feedback of ICES regarding the preparation of Alien Species Alert Reports. These accounts are seen as essential tools for *e.g.* public awareness campaigns. Therefore, WGITMO plans in the future to have one Alien Species Alert Report finalized at each meeting with an additional Alien Species Alert Report being ready as first draft as an outcome of the meeting. Inline, WGITMO recommends to finalize the *Undaria* report (draft attached as Annex 5) at next years meeting and to prepare a first draft of *Hemigrapsus* spp. at the meeting.
- WGITMO also suggests to prepare similar species reports on intentionally introduced species, by outlining the dimension of species movements within ICES Member Countries and their impact on native species. Candidate species here may include the Pacific oyster *Crassostrea gigas* and various salmonids.
- The information provided in relevance of this ToR may also be of relevance to REGNS.

6 Report for Rapid Response and Control Options (ToR B)

One primary function of WGITMO is, through regular updates of the ICES Code of Practice, to evaluate the potential of deliberately introduced species for becoming a nuisance species in the area of introduction and/or having negative impacts on local stocks through introductions of disease agents, of non-target species and fellow travellers accompanying the introductions and transfers, through changes in genetic characteristics of indigenous stocks or through habitat impacts (see also The Mitten Crab warning as Appendix to the Canadian National Report). As such contingency plans for rapid response and control options are necessary should there be problems following an intentional introduction. Members attending the WGBOSV have been contacted to assist and review drafted material.

By correspondence, Judy Pederson (USA) provided the following material with the aim to give guidance how to address this ToR best:

The purpose of early detection is to identify populations that pose an economic or ecological risk, but have not yet spread beyond a delimited region. A restricted distribution may permit eradication or other management actions that reduce or contain populations to a restricted area. A rapid response may be taken to eradicate or attempt to eradicate the population. Implicit in this action is a rapid assessment of the potential economic and ecological costs, a willingness to take action, the likelihood of success, an acceptance of consequences of actions, and anticipated outcomes if no action is taken. The assessment and response requires a coordinated effort on the part of government, the public and often the private sector.

Early detection involves being able to identify new introductions that are in early stages of establishment, preferably before dispersal. This in turn requires monitoring to identify new populations, verified taxonomic identifications, vouchers for continued verification, and awareness of potential vectors and species that may arrive. Monitoring for early detection is challenging. Species may be localized, small, and inconspicuous for several years and frequently they are misidentified. Active monitoring programs are those that are dedicated to identifying non-indigenous species whereas passive monitoring programs may be conducted for other purposes (*e.g.* water quality or biodiversity). Few agencies commit to active marine invasion monitoring programs that are suitable to provide early detection.

A decision to implement a rapid response implies that a risk assessment has been undertaken in a timely fashion. The rapid risk assessment has several built in conditions: *e.g.* a definition and acceptance of the goals, information on the life history of the species in question, information on treatment alternatives, a "command" group that has authority and can coordinate activities, and the likelihood of success. Implied in a risk assessment is that information is readily available for species of concern and lessons learned from other attempts to eradicate.

A rapid response generally implies eradication is attempted. Potential treatments include chemical, physical, and biological options that are targeted for specific taxa or species. A list of available treatments and the organisms or taxonomic group that they target is available from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) [http://www.marine.csiro.au/crimp/reports/Toolbox.pdf]. In addition, case studies indicate how decisions were made, problems encountered during implementation, and level of success. The application of any treatment will usually cause harm to the community and thus, could involve significant discussion by interested parties. One recommendation to allow the rapid actions often needed to eradicate or delimit the undesired species is to have pre-approved treatments by permitting or licensing agencies. Another suggestion is to have training of those likely to participate comparable to oil spill response teams and forest fire fighters. All actions should include sessions on lessons learned to inform those responsible for future actions.

Developing and implementing Early Detection/Rapid Response programs for ICES countries would necessitate meeting many of the elements described above. Cooperation between neighbouring countries would add an additional layer of complexity and commitment. Geographic Information Systems mapping should be explored as a tool for assisting with introduced species detection or potential spread.

Together with Vadim Panov (Russia), Germany coordinates an initiative to link European working groups in the field of biological invasions (European Research Network on Aquatic Invasive Species (ERNAIS)). At present the network includes more than 100 experts from 28 countries (http://www.zin.ru/rbic/projects/ernais/). ERNAIS currently develops an electronical journal which may be used as tool to announce new findings of biological invaders as an early warning instrument.

6.1 Conclusions

- WGITMO will intersessionally draft a document relevant to this ToR.

6.2 Recommendations

- WGITMO recommends to keep this ToR on the Agenda for next years meeting with the aim to finalize a report on early detection methods and rapid response options and a risk assessment of the options (see ToR E) at the meeting.

7 Develop Risk Assessment Guidelines (ToR E)

Risk assessment approaches have been a topic of discussion at previous meetings (*e.g.* Vancouver meeting in 2003) and tables have been worked out for suggested National use within and beyond ICES Member Countries. The 2003 meeting report (http://www.ices.dk/reports/ACME/2003/WGITMO03.pdf) and subsequently, the 2003 ICES Code on Introductions and Transfers provide details. In addition the 2005 report of WGBOSV may be consulted for risk assessment approaches on accidental species invasions with ships.

7.1 Accidental and intentional introductions

The ICES Code of Practice follows the precautionary approach according to the FAO principles with the key objective of to reduce the spread of exotic species. The code addresses the risks associated with species movement (*e.g.* current commercial practices, ornamental trade and bait organisms and research). The Code consists of seven sections of recommendations outlining the evaluation process for a proposed new introduction, including an evaluation of risks.

The risk assessment part provides a detailed approach for evaluating the risk in the receiving environment, as well as the potential for introducing non-target species. An assessment of each potential hazard as to the probability of the establishment and consequences of the establishment in the receiving environment needs to be carried out. Mitigation factors and management issues also have to be addressed.

The overall assessment is based upon the risk estimate (high, medium and low probability) and an uncertainty estimate (very certain, reasonably certain, reasonably uncertain, very uncertain).

7.2 Rapid response plans and control options

Rapid control options, while often difficult to administer especially in an aquatic environment, can and should be considered after a risk assessment taking into account biological information on the species, its distribution in the new environment and the potential harm to the environment and local species should certain actions be taken.. Such discussions are starting to take place in a number of jurisdictions and we suggest that at the 2006 experts on these topics (*e.g.* from Australia) be invited to facilitate development of such guidelines (see also ToR B above).

7.3 Review the current Code of Practice in light of new initiatives on risk assessment, impact assessment protocols and developmental practices

The current ICES Code on Introductions and Transfers provides a framework to assess the risks associated with intentional introductions, while accidental introductions, especially those associated with shipping vectors have been the purview of the WGBOSV which has looked at possibilities of control options.

In addition we suggest that the current code of Practice be reviewed. The current code pays detailed attention to the prevention of disease agents and pests and fellow travellers accompanying a shipment, however the genetic impacts and habitat alterations need more detailed risk assessment guidelines. Because expertise on such topics is not available within the WG and because other ICES WGs such as the WG on Application of Genetics in Fisheries and Mariculture will have the necessary expertise and may have put thought into the genetics aspects of introductions and transfers and invasive species issues we suggest a closer linkage and possible invitation of a geneticist to next year's meeting.

7.4 Conclusions

- WGITMO will intersessionally draft a document relevant to this ToR. WGITMO members will intersessionally collect relevant information for consideration at next years meeting.
- WGITMO suggest ICES to consider initiating the contact to the other relevant WGs by putting the topic into their terms of reference to interact with WGITMO to strengthen the Code.

7.5 Recommendations

- WGITMO recommends to deal with this ToR at next years meeting. WGITMO proposes to update the existing risk assessment approach in the Code of Practice at next year's meeting and to facilitate the discussions by intersessionally work.

8 Summary of National Reports 1984–2004 (ToR C)

The group discussed this ToR in great detail and believes that it cannot deliver maps with organism densities as the information provided in National Reports is too scattered. However, WGITMO suggests to deal with certain species frequently having been moved between ICES Member Countries in greater depth likely resulting in reports similar to the Species Alert Reports as delivered on the Rapana Whelk and Red King Crab.

At last years meeting, WGITMO was given the ToR to summarize the National Reports received for the period 1992–2002 in a similar fashion as the National Report summary 1981–1991. WGITMO took the earlier summary of National Reports as a guiding document, but agreed to restructure its approach for the 1992–2002 summary (see last years meeting report). Summary material was prepared intersessionally and circulated for consideration at this years meeting. Certain group members have started to compile the information. Inger Wallentinus (Sweden) focuses on algae, Dan Minchin (Ireland) on fish and Chad Hewitt (New Zealand) and Stephan Gollasch (Germany) dealt with invertebrates. WGITMO discussed including a viruses and pathogens section which Dorothee Kieser (Canada) had volunteered to cover. However, given that other ICES WG are covering the diseases and disease agent distribution and related topics, it was decided to limit WGITMO's topics to fish, invertebrates and algae.

Having received the group's comments the volunteers will prepare intersessionally a final draft document until next years meeting. Therefore the group felt that this ToR should be kept on the Agenda of WGITMO.

To support the REGNS integrated assessment WGITMO prepared a summary of non-native species known to occur in the North Sea. The list contains intentionally introduced species and accidental introductions (Annex 6). A number of species were selected to be covered in a more detailed format during an earlier EU-funded study. These case histories of impacting invaders have been included as Annex for the consideration of REGNS (Annex 7).

8.1 Conclusions

- It was agreed by WGITMO that intersessional activities are essential to finalize this ToR at next years meeting.

8.2 Recommendations

- WGITMO recommends to keep the related ToR to prepare a 10 year summary of National Reports (1992–2002) on the Agenda for finalization at next years meeting.

9 Regional Ecosystem Study Group for the North Sea (REGNS) (ToR C)

The preparation of a report summarising introductions and transfers of marine organisms into the North Sea and their consequences are to be considered at the 2006 meeting of REGNS and the 2006 Theme Session on Integrated Assessments. The guidance letter received was circulated. To support the REGNS integrated assessment WGITMO prepared a summary of non-native species known to occur in the North Sea and made the list available prior the 2005 REGNS meeting in May. The list contains intentionally introduced species and accidental introductions which form self-sustaining populations or are only known to occur occasionally (see also summary of National Reports).

Key vectors for species invasion into the North Sea and adjacent waters are ballast water, hull fouling and aquaculture. However, it should be noted that for some species the introducing vector cannot clearly be identified as larval transport in ballast water or transport of adult organisms in the hull fouling of ships may have caused in the invasion.

In aquaculture non-target species, such as fouling organisms of oysters and disease agents, as well as unintentional or accidental releases of aquaculture organisms are included. It is also interesting to note that certain exotic species were introduced during scientific experiments. Parts of these experiments had the objective to prove whether or not the species can survive in the region. Other species may have reached the North Sea waters as result of a range expansion, either with natural means (*e.g.* currents) or with anthropogenic support (*e.g.* shipping). Most of the range expansion taxa are known to occur in warmer climates and the fact that these were introduced to north-temperate waters may be an indication for global warming.

An overall impact assessment for invaders cannot be carried out due to the lack of relevant information. Data are not available in a consistent and comprehensive format. In addition the limited information available is geographically scattered. The three most impacting species are the ship-worm *Teredo navalis*, the Zebra mussel *Dreissena polymorpha* and the Chinese mitten crab *Eriocheir sinensis*.

Ecological impact

Reise *et al.,* (1999)[1] conclude that the North Sea is not severely impacted by invaders and that invaders here are more additive without major consequences. However, as several examples have shown world-wide, each invader poses a potential risk to the environment and economy of a region. Today, the Pacific Oyster *Crassostrea gigas* is spreading in the North Sea and may cause unwanted impacts in the future as competitor to the native blue mussel *Mytilus edulis*.

Economic impact

An overall impact calculation including all known introduced aquatic species remains a challenge, especially due to the lack of relevant information. However, during an unpublished German impact assessment, carried out in 2004, the monetary impact was assessed for two

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1 Reise, K., Gollasch, S., and Wolff, W.J. 1999. Introduced marine species of the North Sea Coasts. Helgoländer Meeresuntersuchungen, 52: 219-234.

species, the Chinese Mitten Crab *Eriocheir sinensis* and the ship worm *Teredo navalis*. It was calculated that these two invaders, since their first records 1912 and 1731 respectively, caused a negative impact of 98.5 to 134.8 Million € in German waters (including the Baltic Sea coast).

With today's knowledge no further monetary impact calculation can be made.

9.1 Conclusions

- The list of introduced species in the North Sea gives a very first indication on the dimension of the risk associated with species invasions (Annex 6).
- To document the impact of selected introduced species case histories of impacting invaders in the North Sea region have been attached (Annex 7). These accounts are a result of the EU Concerted Action "Introductions with Ships" and were published as: Gollasch, S., Minchin, D., Rosenthal H. and Voigt, M. (eds.) (1999): Exotics Across the Ocean. Case histories on introduced species: their general biology, distribution, range expansion and impact. Logos Verlag, Berlin. 78 pp. ISBN 3-89722-248-5.
- Both, the species list and the detailed case histories of North Sea invaders, were made available for consideration of REGNS. Andrew Kenny (United Kingdom) noted that the WGITMO input "…is greatly valued and will form an important component of our Integrated Assessment…".
- WGITMO also suggests that the Alien Species Alert reports, prepared by WGITMO, may be brought to REGNS attention including the draft Alien Species Alert Report on *Undaria pinnatifida* (Annex 5),

9.2 Recommendations

- It is recommended that this ToR remain on the agenda of WGITMO. Having been instructed by REGNS WGITMO will work out a more detailed contribution for consideration at the 2006 meeting of REGNS.

10 Information from National Reports (ToR a)

The 2005 work of the WGITMO was by correspondence as instructed by ACME. National Reports were submitted by the following countries: Belgium, Canada, Estonia, France, Finland, Germany, Italy, Sweden, United Kingdom, and USA (Annexes 3 and 4). The current format for the preparation of National Reports was developed during the 2001 meeting of the working group in Barcelona and was agreed to by ACME subsequent to the meeting. This format does not lend itself easily to the capture of treatment and management approaches, topics that have been on the agenda for the WGBOSV. WGITMO suggests that the overlap and differences and primary topics of interest for the two working groups should be reviewed at the 2006 meetings where the two working groups may meet back to back and could schedule a joint session. WGITMO also looks forward to guidance from ACME as to the structure of call information for future National Reports.

Until an updated format for National Reports is in place, the information from the submitted National reports has provided the following information.

10.1 Summary and highlights of 2004 National Reports (ICES member countries, countries with observer and guest status)

Highlights from National Reports:

Belgium

- The major event during 2004 was the first discovery in the southern bay of the North Sea of the Asian shrimp *Palaemon macrodactylus* Rathbun, 1902 yet another introduction originating form the temperate North-West Pacific. The species proved to be already established in several suitable habitats.

Canada

- A single adult female mitten crab, *Eriocheir sinensis*, was found in the lower St Lawrence River. If this species were to become established, there would be a risk of invasion into the Great Lakes and tributaries in the area.
- Several invasive species, such as *Stylea clava, Ciona intestinalis, Botrylloides violaceus* and *Botryllus schlo*sseri are causing problems to shellfish growers, primarily in Prince Edward Island. On the Pacific Coast, work on a removal program for *Spartina anglica* is ongoing.

Estonia

- A new "Nature Conservation Act" came into force in Estonia which includes regulations on the importation and rearing of certain species.
- There has been a population explosion of the gibel carp, *Carassius gibelo*, in Estonian coastal waters. While this species was introduced decades ago into fresh water, it now dominates biomass in commercial catches in some coastal waters.

Finland

- Routine exports and imports were submitted in the National report.

France

- A new campaign against the slipper limpet, *Crepidula fornicata,* was started in 2004. The high recruitment during 2003 lead to an expansion of the species.
- The European Project on Disease Interaction and Pathogen Exchange network (Dipnet) was started with the aim to integrate current knowledge on the transfer of pathogens between wild and cultured aquatic animal populations.

Germany

- The cladoceran *Cercopagis pengoi* was recently recorded from German waters (Gruzka, pers. com.). Germany reported also on the spread of the previously introduced non-indigenous oyster *Crassostrea gigas.* Activities on aquaculture and restocking focused in 2004 on eels, sturgeon and salmon. Ornamental trade is continuing to be popular. For direct human consumption, various crustaceans, blue mussels, common carp, and *Tilapia* species are imported. Live exports to ICES Member Countries focus on *Mytilus edulis* predominantly for the Belgium and Dutch market.
- Together with Vadim Panov (Russia), Germany coordinates an initiative to link European working groups in the field of biological invasions (European Research Network on Aquatic Invasive Species (ERNAIS)). At present the network includes more than 100 experts from 28 countries (http://www.zin.ru/rbic/projects/ernais/). ERNAIS currently develops an electronical journal which may be used as tool to announce new findings of biological invaders as an early warning instrument.
- Aquaculture and ballast water issues become more and more important. It is discussed to take advantage of planned offshore wind park installations to allow colonization with native hard bottom species and establish new maritime users, as *e.g.* aquaculture sites for oyster and macroalgae cultures (native and non-indigenous species such as the Pacific oyster may be included in the trials). Longline mussel culture is also discussed.

Italy

- New findings and updates of non-indigenous species in Italian marine waters are reported. A revision of the list of NIS found in Italian waters in he last decades, together with an annotated catalogue of algae has been produced. Some information is available for species that are enlarging their distribution in Italian waters. Some specific research projects have been concluded and the results allow a better understanding of the situation of Italy in the context of the Mediterranean Sea.

Sweden

- The new Asiatic red alga, *Gracilaria vermiculophylla*, in 2004 occurred at all stations in The new Asiatic red alga, *Gracilaria vermiculophylla*, in 2004 occurred at all stations in the Göteborg archipelago, where it was found in 2003, and at another eight sites not visited in 2003, but not at the around 30 other sites visited 2003–2004. Salinity tolerance experiments showed that it survived and grew in salinities as low as 2 psu (*i.e.* the innermost parts of the Bothnian Bay). Further, it could survive when kept out of water (but moist) in darkness for at least 175 days.
- During 2004 the Japanese red alga *Heterosiphonia japonica* was very common on both sides of the Kosterfjord, being especially frequent on mussels and it was also recorded from a very exposed offshore "shallow" area in the Skagerrak.
- Surveys in the Gulf of Bothnia in 2004 showed that the cladoceran, predatory water flea, *Cercopagis pengoi*, now occurs in the Baltic proper and in the Bothnian Sea along the Swedish east coast, but in varying and often low abundances. There are still no reports of its occurrence in freshwater ecosystems anywhere in Scandinavia
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United Kingdom

- Deliberate releases of ornamental species into public ponds have been studied, showing that the varieties of ornamentals can be predicted from the distance of a ponds to the nearest road.
- Species sold for ornamental purposes (*Acipenser spp., Siluris glanis, Leuciscus idus*) also continue to be captured in river systems.
- *Caprella mutica* has been shown to be widespread on the Scottish coast and *Palaemon macrodactylus*, discovered for the first time in 2001 in the UK has now been located in Suffolk. *Marenzellaria viridis* has been recorded in the Thames. Signal crayfish, *Pacifastacus leniusculus*, continue to spread.
- *Sargassum muticum* is continuing to spread along the Welsh coast and had its first confirmation in Scotland. *Heterosiphonia japonica* was detected for the first time in Scotland.

USA

- U.S. Congress has not passed new legislation on aquatic invasions since the reauthorization of the Nonindigenous Species Act (NISA) of 1996 which expired in 2002. However, several new bills are before Congress, a few of which are receiving attention. One relates directly to ballast water (Senate Bill 363) and two complementary proposed bills have been introduced by the Senate (S. 770, number not yet assigned but entered on April 15, 2005) and the House of Representatives (H.R. 1592) also address aquatic (and marine) non-indigenous species issues.

- The U.S. Coast Guard is preparing an Environmental Impact Statement (EIS) that will propose standards and a process for evaluating standards and environmental effects of proposed alterative technologies. The EIS is required as part of the National Environmental Protection Act.
- *Crassostrea* ariakensis *in eastern North America*
- The introduction of *Crassostrea ariakensis* into tidal waters of the Chesapeake Bay was approved and implemented in 2004 when 800 000 oysters were deployed. These were removed in February 2005 from the test sites. Of 7600 oysters tested, four had the ability to reproduce, but the odds are purported to be low (no number given) that fertile oysters were close enough to reproduce.
- *Crassostrea ariakensis*, the Suminoe oyster, was used in a research project in Roanoke and Pamilico Sounds, North Carolina where it was accidentally released in 2004.
- *Charybdis hellerii*. The first report in Florida's Gulf Coast of this Indo-Pacific crab was from Bradenton in 2004. It was previously only reported on Florida's Atlantic Coast.
- *Mytella charruana.* The Charru mussel was first collected near a power plant in Jacksonville, Florida in 1986, but appeared to disappear. It was collected in 2004 in Mosquito Lagoon near Titusville, Florida. The mussel is a native of the east coast of South America.
- *Platax orbicularis.* In June 2004, three orbiculate species of batfish were reported off Molasses Reef in the Florida Keys. Two of the three species were captured and taken to the Florida aquarium, but *P. orbicularis* has been sighted in the area.
- *Salmo salar*. In 2003 and 2004, Atlantic salmon were captured in Ketchikan, Alaska. They are believed to be escapees from fish farms and are a concern that they may outcompete native species.
- *Pterois volitans.* The lionfish has been observed off the coast of North Carolina since 2000 and were sighted again in 2004. Anecdotal information suggests that young fish were also observed suggesting the lionfish may be breeding.
- *Cephalopholis argus.* In December 2004, a peacock hind was reported off Boca Raton, Florida.

National Reports contain details of new laws and regulations, deliberate releases, accidental introductions and transfers, live imports, live exports, planned introductions, and meetings.

10.2 New laws and regulations

Some countries have made changes or are planning to change their laws and regulations as outlined in the National Reports submitted. A brief overview is presented in the Table 1 below. Additional details can be found in the individual National Reports. It should be noted that this table is not fully comprehensive as not all ICES-member countries provided National Reports to WGITMO (Annexes 3 and 4).

Table 1 New laws and regulations relevant to species movements and biological invasions (based on information provided in the National Reports)

COUNTRY	NEW LAWS AND REGULATIONS
Belgium	No changes in 2004
Canada	Proposed development of a National Aquatic Invasive Species Revision of Canadian Shipping Act for the placement of alternative ballast water exchange zones
Estonia	New nature Conservation Act to include Alien species and their placement in the wild
Finland	No changes in 2004
France	EU Directives for the importation of molluscs (2003/804/EC) and finfish (2003/858/EC), their eggs and gametes for further growth, fattening, relaying or human consumption
Germany	Nothing new reported
Italy	Italy, Croatia, and Slovenia have established a Trlateral Ballast Water Management Sub-commission for the Adriatic Sea signed by IMO
Sweden	Commission Decision 2004/453/EG. The decision concerns all species intended for aquaculture, implying that the fish only can be brought from facilities having the same health status.
United Kingdom	New EU legislation on imports of live fish (2003/858/EC as amended by 2004/454/EC and 2004/914/EC) and shellfish (2003/804/EC as amended by 2004/319/EC, 2004/609/EC and 2004/623/EC) from third countries came into force in May 2004. This legislation will provide stricter controls on these imports. The UK Biodiversity Research Action Group (BRAG) has a Non-Natives Species Sub-Group that is specifically looking at gaps in research needed to inform UK policy and practice. The main recommendations from this group will contribute to the European Platform-BRAG. Defra has been developing a Code of Practice with the horticultural sector – this includes consideration of the disposal of pondweeds, which can disrupt riparian ecosystems. It is hoped that the Code will be launched this spring (2005). The Water Framework Directive TAG is further progressing their Risk Assessment system in 2003 (water bodies at risk of not meeting the required ecological status due to non-native species). Through the Global Invasive Species Programme (GISP), CABI is also involved in developing new toolkits for (1) best practice on islands, and (2) pathways.
USA	U.S. Congress has not passed new legislation on aquatic invasions since the reauthorization of the Nonindigenous Species Act (NISA) of 1996 which expired in 2002. However, several new bills are before Congress, a few of which are receiving attention. One relates directly to ballast water (Senate Bill 363) and two complementary proposed bills have been introduced by the Senate (S. 770, number not yet assigned but entered on April 15, 2005) and the House of Representatives (H.R. 1592) also address aquatic (and marine) nonindigenous species issues.

10.3 Live imports, live exports, planned introductions and deliberate releases

It has to be noted that the following tables do not claim to be fully comprehensive as not all ICES member states submitted National Reports to the meeting. Further, the origin of several importations remains unclear as some countries exhibit a lack of import and/or export documentation. As in last years meeting report, it is interesting to note that on several occasions a country states that a species was imported from another country whereby the exporting country has no mention of this movement in its National Report. This further indicates the patchiness of information available. In general, information on exports appears more difficult to collect than information on imports (Tables 2 and 3).

Table 2 Species exported by ICES-member countries according to the National Reports submitted prior March 2005

EXPORTING COUNTRY	SPECIES
Belgium	Uncontrolled imports
Canada	Finfish Aquaculture: Brook trout, Arctic charr, Atlantic sturgeon Aquarium trade *Sebastes caurinus, Embiotoca lateralis, Hexagrammus decagrammus, Anarrhichties ocellatus*. Invertebrates Aquaculture: Giant scallop seed is transferred from the Magdalen Islands to St. Pierre et Miquelon (France) Aquarium trade: *Crossaster papposus, Evasterias troschelli, Enteroctopus dofleini, Medaster aequalis, Metridium giganteum, Ptilosarcus guernii,Parastichopus californicus, Orthasterias koehleri, Cryptochiton stelleri, Hemileptodotas hemileptodotas*
Estonia	Data not available
Finland	Rainbow trout, Arctic Charr, grayling (*Thymallus thymallus*)
France	Nothing reported
Germany	Blue mussel (*Mytilus edulis*)
Italy	Nothing reported
Sweden	Eel, salmon, trout, carp, ornamental fish, blue mussel, scallops, oysters, crabs, various invertebrates
United Kingdom	Atlantic salmon, Pacific oyster, blue mussel

Table 3 Species imported by ICES-member countries according to the National Reports submitted prior March 2005.

IMPORTING COUNTRY	SPECIES
Belgium	Uncontrolled imports (no species listed)
Canada	Atlantic salmon, wolf eel (*Anarhinchas minor*), oysters (*C. gigas, C. virginica and C. sikamea*) Manila clams, mussels (*M. edulis* and *M. galloprovincialis*), red abalone, cod
Estonia	No data available
Finland	Sturgeon, rainbow trout, freshwater crayfish
France	No information listed
Germany	Koi, goldfish, sterlett, Asian carp, *Tilapia*, glass eel, sturgeon (*Acipenser baeri* and *A. oxyrhinchus*), salmonid species including Atlantic salmon, common carp, marine, brackish and freshwater ornamentals, blue mussels, *Nephrops norvegicus, Homarus gammarus, H. americanus, Callinectes spidus, Laminaria saccharina, Palmaria palmata*
Italy	No information listed
Sweden	Eels, salmon, rainbow and other trout, carp, Ornamental species, *Mylilus*, scallops, oysters, various invertebrates, lobsters, crab
United Kingdom	Rainbow trout, eel, Atlantic salmon, oysters (native and Pacific), other bivalves and crustaceans,
USA	*Crassostrea ariakensis, Crassostrea gigas*, *Mytilus galloprovincialis*, and *Tapes philippinarum*

The following table (Table 4) summarizes live imports and exports of aquatic species according to higher taxa and area of origin based on National Reports considered.

Table 4. Summary of live imports and exports of aquatic species (including ornamental trade and imports for containment) according to National Reports submitted prior March 2005. (cr = crustacean, fi = fish, mo = molluscs, pl = plants, Bel = Belgium, Bra = Brazil, Can = Canada, Col = Columbia, Cze. R = Czech Republic, Den = Denmark, Est = Estonia, Fin = Finland, Fra = France, Ger = Germany, Hon = HongKong, Hun = Hungaria, Ice = Iceland, Ind = Indonesia, Ire = Ireland, Isr = Israel, Ita = Italia, Mala =Malaysia, Net = the Netherlands, Nig = Nigeria, Nor = Norway, Pol = Poland, Rus = Russia, S. Afr = South Africa, Sin = Singapore, Spa = Spain, Sri = Sri Lanka, Swe = Sweden, Tai = Taiwan, Tha = Thailand, UK = United Kingdom, USA = the United States of America, Vie = Vietnam).

	IMPORT (LIMITED TO ICES MEMBER COUNTRIES)														
Exporting country	**Bel**	**Can**	**Den**	**Est**	**Fin**	**Fra**	**Ger**	**Ire**	**Net**	**Nor**	**Pol**	**Rus**	**Spa**	**Swe**	**UK**	**USA**
Austral															fi	
Bel														fi mo cr		
Bra														fi		
Can						fi	fi	fi			fi			cr	cr	
Chile														mo		
Col														fi		
Cze. R							fi							fi		
Den					fi		fi mo							fi mo cr	fi	
Fin				fi			fi					fi				
Fra							fi							fi	fi	
Ger	mo				fi				mo					fi		
Hon														fi		
Hun							fi									
Ice		fi, mo													fi	
Ind							fi							fi		
India														fi		
Ire							fi							mo, cr	mo	
Isr														fi		
Ita														mo		
Mala														fi		
Net							fi							fi mo	fi	
Nig														fi		
Nor		fi												fi mo cr	fi	
Peru														fi		
Phil							fi									
Pol							fi									
Rus							fi									
Spa															fi	
S. Afr.															fi	
Sin							fi							fi		
Sri														fi		
Swe	fi mo		fi		fi mo	mo	fi mo	mo	fi mo	fi mo	fi mo		mo			
Tha							fi							fi		
UK								mo						fi mo		
USA		mo fi					fi							fi mo cr	fi cr	mo
Vie														fi		

The country with the highest number of source regions in commercial species imports in 2004 was Sweden with 26 source regions (25 in 2003) to be followed by Germany with 16 (12 in 2003). Most other importing countries import species from less than 6 source regions (Table 4). However, it should be noted that the detail level when documenting species varies enormously between certain countries. Several countries refer to source regions as "from various countries" thereby documenting that more detailed information is not available.

As in previous years, the most commonly moved species in 2004 were Atlantic salmon *Salmo salar* and the Pacific oyster *Crassotrea gigas*.

10.4 Accidental introductions

Several new records of accidentally introduced species were reported in 2004 (Table 5). Table 5 also provides details on the spread of previously introduced species (see also National Reports in Annexes 3 and 4).

Table 5 New records of accidental species introductions and notes on the spread of previously reported accidental introductions in ICES-member countries according to the National Reports submitted prior March 2005. For references see National Reports in Annexes 3 and 4.

COUNTRY	SPECIES
Belgium	*Palaemon macrodactylus*: This Asian shrimp was first identified from Zeebrugge, were it was fished on 12 June 2004 between the epiflora and epifauna of the pontoons of the marina. *Telmatogeton japonicus*: This giant chironomid has recently been identified from buoys off the Belgian coast. *Hemigrapsus penicillatus*: This species was recorded for the first time from the coasts of Belgium and Northern France in 2003. The pencil-crab is now very abundant especially in estuaries and harbour areas for instance amongst reefs of pacific oysters *Crassostrea gigas.* During 2004 the species has also been discovered, although in lower numbers, on groins in the vicinity of Oostende thus in an open shore habitat.
Canada	New Brunswick There was an accidental release of 55 000 Atlantic salmon smolts from a farm on Grand Manan Island. Quebec The green crab *Carcinus maenas* was reported for the first time in August–September in 2004 in the lagoon of the Grand Entrée of Magdalene Islands. Atlantic Coast The clubbed tunicate *Styela clava* has now been in Prince Edward Island (PEI) waters for approximately 7-8 years and is still causing problems to the mussel industry. *S. clava* abundance have not yet declined and are increasing in the most recently infested areas. Three more species of invasive tunicates were found in aquaculture sites in PEI: *Ciona intestinalis*; *Botrylloides violaceus*; and *Botryllus schlosseri*. During 2004 the Chinese mitten crab *Eriocheir sinensis* was found in the St. Lawrence estuary which causes concern for establishment in the area, including further transfers into local river systems and possibly the Great Lakes area. Pacific Region The Varnish clam (*Nuttalia obscurata)* appears to be spreading northward.
Estonia	The gibel carp *Carassius gibelio* (Bloch) was first introduced into fish ponds and small lakes of Estonia in 1948. The fish was first found in marine waters in 1985 in the Gulf of Riga. During the most recent years the species has been caught almost everywhere in Estonian coastal sea.
Finland	The round goby *Neogobius melanostomus* was first recorded from the Turku archipelago in February 2004 – being the first finding in Skandinavia.
France	Four individuals of *Rapana venosa* were captured in 2004 in south Brittany (west coast of France) documenting its spread.
Germany	The cladoceran *Cercopagis pengoi* was first recorded from German waters (Baltic Sea). The Ponto-Caspian fish *Neogobius melanostomus*, known from the German Baltic coasts, was recently recorded in the Netherlands – the first record from the North Sea. It is assumed that the species may also be recorded from the German North Sea coast in the near future. *Crassostrea gigas* continues to spread southwards in the Wadden Sea and competes with native *Mytilus edulis* for habitat and food. It was documented at certain sites that the oysters have overgrown mussel beds with an increasing tendency.
Italy	*Siganus luridus* has been recorded for the first time in Italy from the Linosa and Lampedusa islands near Sicily.

COUNTRY	SPECIES
	One juvenile specimen of the sandbar shark *Carcharhinus plumbeus* was recorded for the first time from the southern Tyrrhenian Sea. *Aplysia dactylomela* has been recorded for the first time from Italian waters, from a marine reserve area in Sicily. Further records of *Melibe viridis* (syn. *Melibe fimbriata*) have been reported from Sicily in 2003 and in the North-Western Ionian Sea in 2004. The arcid bivalve *Anadara demiri* appears to have gained full status as a component of the Adriatic Sea coastal benthic community despite its very recent first entry, three years ago. Numerous clams of *Mercenaria mercenaria* have been collected in the brackish embayment of Goro, in the Po River Delta region. The eastern Pacific isopod *Paracerceis sculpta* has been recorded in the Gulf of Olbia, Sardinia. The American mud crab *Dyspanopeus sayi* has established a population in the North Adriatic brackish environment of the Valli di Comacchio. The subtropical crab *Percnon gibbesi*, already known from Sicily, is rapidly expanding northwards being recorded along the islands of Ischia and Procida and along the coast of Campania at Gaeta. The stolidobranch ascidian *Polyandrocarpa zorritensis* was detected, for the third time in the Mediterranean, in the harbour of Taranto. In a ballast water sample coming from Port Said (Egypt), the macroalga *Ulva ohnoi* (Ulvales, Chlorophyta) was identified. This species was originally described for the first time in Japan and was not yet reported in the Mediterranean. For that reason, even if the species was not found in the field, it represents a new record for the Mediterranean Sea. The colonization of the green alga *Caulerpa racemosa*, ten years after it began to spread in the Mediterranean Sea, has been reassessed. The alga has been documented along the coasts of 11 states, developing on all kind of substrata, both in polluted and in unpolluted areas, between 0 and 70 m. The colonisation of *C. racemosa* invasive variety in the northern coasts of the Mediterranean Sea, from French to Croatia, concerns approximately 600 km of coastline.
Sweden	Surveys in the Gulf of Bothnia in 2004 showed that the cladoceran, predatory water flea *Cercopagis pengoi* now occurs along the Swedish east coast in the Baltic proper and in the Bothnian Sea. The rhabdovirus Eel Virus Europe X (EVEX) was found in samples of small adult eels caught at Hälleviksstrand on the island Orust, in the middle part of Bohuslän, and at Resö on the northern part of the Swedish west coast. Every year single specimens of the Chinese mitten crab, *Eriocheir sinensis* are reported to have been caught by fishermen (***e.g.*** in the S Bothnian Sea in autumn 2004). There are no reports of mass occurrences. However, a fisherman from a village ca. 30 km south of Göteborg claimed to have seen fertile females and that the numbers of caught specimens seems to be increasing (salinity in the area around 20–25 psu). As reported in 2004 (WGITMO 2004) the Asiatic red alga *Gracilaria vermiculophylla* was first recorded during August–September 2003 in the Göteborg archipelago. In 2004 it still occurred at all stations – with tendency to spread. The occurrence of the Japanese red alga *Heterosiphonia japonica* (***i.e.*** "*Dasysiphonia* sp." in WGITMO reports until 2003) in the Koster archipelago since 2002 was reported last year (WGITMO 2004). During 2004 this alga was very common on both sides of the Kosterfjord. The red alga *Dasya baillouviana*, introduced in Sweden in the early 1950s, was in the summer of 2004 in some areas seen in higher abundances than previously. Also the introduced green alga *Codium fragile* was more common during 2004 than in previous years and was found also in offshore areas in the middle of Kattegat. The Japanese brown alga *Sargassum muticum* has started to occur within the fucoid belts also around Göteborg where previously mostly barren shores have been colonized.
United Kingdom	The skeleton shrimp (*Caprella mutica*), an alien crustacean species discovered colonising the sea lochs of the west Scottish coast (see previous UK report) has been noted on fish farm nets in Shetland. The polychaete *Marenzellaria viridis* recently identified at Woolwich in the Thames. As far as is known this is the first record of this species for the Thames. An alien freshwater crayfish species is reported from the River Waveney, Suffolk. Identification is yet to be confirmed, but it is not signal crayfish. The signal crayfish (*Pacifastacus leniusculus*) continues to spread. *Sargassum muticum* is continuing to spread northwards up the west coast of the UK. It has

COUNTRY	SPECIES
	been found in Loch Ryan (Dumfries and Galloway) and this is the first record for this species in Scotland. During 2004, the presence of *Heterosiphonia japonica* at Alturlie Point near Inverness in the inner Moray Firth was confirmed. This is the first occurrence of this species in Scotland. Imported sturgeon species, *Acipenser* spp., European catfish *Siluris glanis* and golden orfe *Leuciscus idus*, all normally sold exclusively for ornamental purposes or for angling amenity in enclosed still waters, continue to be captured in river systems. The Asian cyprinid topmouth gudgeon *Pseudorasbora parva* continues to spread, as does sunbleak *Leucaspius delineatus*, with an increasing number of both confirmed and unconfirmed reports.
USA	*Crassostrea ariakensis*, the Suminoe oyster, was used in a research project in Roanoke and Pamilico Sounds, North Carolina where it was accidentally released in 2004. *Platax orbicularis.* In June 2004, three orbiculate species of batfish were reported off Molasses Reef in the Florida Keys. Two of the three species were captured and taken to the Florida aquarium, but *P. orbicularis* has been sighted in the area. *Cephalopholis argus.* In December 2004, a peacock hind was reported off Boca Raton, Florida. In 2000, a survey in Massachusetts reported that a species of *Didemnum* was first identified in New England waters. Upon examination of archived samples, *Didemnum* sp. was present in Boothbay Harbor, Maine in 1993 and the Damariscotta River, Maine in 1988. The species is very abundant in biomass and is growing aggressively along both the Pacific and Atlantic coasts, occurring abundantly in both shallow and deep water in the northeastern U.S. The current range is much greater than reported last year. *Perna viridis.* The range for this species has increased and can be found from Titusville north to Jacksonville (about 210 km). This is an expansion of its range from the first report of its introduction in Tampa Bay, Florida (Gulf of Mexico coast). Charybdis hellerii. The first report in Florida's Gulf Coast of this Indo-Pacific crab was from Bradenton in 2004. It was previously only reported on Florida's Atlantic Coast. *Mytella charruana.* The Charru mussel was first collected near a power plant in Jacksonville, Florida in 1986, but appeared to disappear. It was collected in 2004 in Mosquito Lagoon near Titusville, Florida. *Salmo salar*. In 2003 and 2004, Atlantic salmon were captured in Ketchikan, Alaska. They are believed to be escapees from fish farms and are a concern that they may outcompete native species. *Pterois volitans.* The lionfish has been observed off the coast of North Carolina since 2000 and were sighted again in 2004. Anecdotal information suggests that young fish were also observed suggesting the lionfish may be breeding. Recent evidence suggests that the Chinese mitten crab population that now occurs in the San Francisco Bay area is steadily on the increase.

10.5 Conclusions

- As in previous years, ICES is asked to urge member countries and other jurisdictions wherever possible and appropriate to inform WGITMO of any new record of introduced species or suspected introductions and changes in the distribution and abundance of previously introduced species in their jurisdiction in the form of National Reports.
- WGITMO plans to re-formate the National Report structure at the next meeting with the aim to collate information in a table format and to ease the annual reporting, documentation and synthesis of the spread and impact of introduced species. A spreadsheet format is likely to allow a continuous overview of information from National Reports and the annual preparation of a concise summary report on the ecological significance of any new proposed introductions. It is further suggested to use a "rolling format" covering ten years and by doing so to simplify future ten year summaries of National Reports.

10.6 Recommendations

- WGITMO recommends that future annual meetings include an opportunity for the participation from non-ICES countries (*e.g.*, Australia, New Zealand, Mediterranean countries, PICES and other international organizations, such as CIESM) on the basis of their expertise relevant to the Alien Species Alert Report in preparation by WGITMO.
- It is recommended that this ToR should remain on the agenda of WGITMO.

11 Recommendations to ICES Council

The recommendations from this year's discussions by correspondence are provided in Annex 13 of this report.

12 Planning of Next Year's Meeting

The invitation of Belgium to host next years meeting of WGITMO was much appreciated by the group. The group suggested meeting in Oostende, Belgium for at least 2 days during the week beginning March 13, 2006 in conjunction with WGBOSV.

13 Final Discussion and Adjournment

The correspondence discussion of WGITMO was closed on Thursday, March 24 2005. Stephan Gollasch, as Chair, thanked all that worked very hard during the correspondence/discussion period, and especially the rapporteur Dorothee Kieser (Canada).

Annex 1: List of Participants in Discussions by Correspondence

Name	Address	Telephone	E-mail
Copp, Gordon	CEFAS Salmon & Freshwater Team Pakefield Road Lowestoft, Suffolk United Kingdom	T +44 1502 527751 F +44 1502 513865	g.h.copp@cefas.co.uk
Edwards, Tracy	Joint Nature Conservation Committee Dunnet House 7 Thistle Place Aberdeen AB10 1UZ United Kingdom	T +44 1224 655 707 F +44 1224 621 488	tracy.Edwards@jncc.gov.uk
Gollasch, Stephan	Bahrenfelder Straße 73 a 22765 Hamburg Germany	T +49 40 390 54 60 F +49 40 360 309 4767	sgollasch@aol.com
Hayes, Keith	CSIRO Marine Laboratory GPO Box 1538 Hobart, Tasmania 7001 Australia	F +613 6232 5485	Keith.Hayes@csiro.au
Hewitt, Chad	Ministry of Fisheries PO Box 1020 Wellington New Zealand	T +64 4 494 8201 F +64 4 494 8208	**chad.hewitt@fish.govt.nz**
Jelmert, Anders	Institute of Marine Research Floedevigen Research Station 4817 HIS Norway	T +47-3705-9052 F +47-3705-9001	anders.jelmert@imr.no
Kerckhof, Francis	Management Unit of the North Sea Mathematical Models 3 e en 23 e Linieregimentsplein 8400 Oostende Belgium	T +32 59 24 2056 F +32 59 70 4935	f.kerckhof@mumm.ac.be
Kieser, Dorothee	Department of Fisheries & Oceans Pacific Biological Station 3190 Hammond Bay Road Nanaimo, B.C. V9T 6N7 Canada	T +1 250 756 7069 F +1 250 756 7053	kieserd@pac.dfo-mpo.gc.ca
Leppäkoski, Erkki	Abo Akademi University Dept. of Biology FIN-20500 Turku / Abo Finland	T +358 2 215 4355 F +358 2 215 4748	eleppako@abo.fi
Minchin, Dan	Marine Organism Investigations 3 Marina Village Ballina, Killaloe, Co Clare Ireland	T +353 86 60 80 888	minchin@indigo.ie
Miossec, Laurence	IFREMER Laboratoire Génétique et Pathologie, DRV/RA B.P. 133 17390 La Tremblade France	T +33 05 46 36 98 36 F +33 05 46 36 37 51	Laurence.Miossec@ifremer.fr
Nordwall, Fredrik	National Board of Fisheries; P.O. Box 423 SE 401 22 Göteborg SWEDEN		Fredrik.Nordwall@fiskeriverket.se

Occhipinti, Anna	Dipartimento di Genetica e Microbiologia University degli Studi di Pavia, Sezione Ecologia Via Sant Epifanio 14 27100 Pavia Italy	T +39 0382 504 876 F +39 0382 304 610	occhipin@unipv.it
Pederson, Judith	Massachusetts Institute of Technology, Sea Grant College Program 292 Main Street E38-300 Cambrigde, MA 02139 USA	T +1 617 252 1741 F +1 617 252 1615	jpederso@mit.edu
Ruiz, Greg	Smithsonian Environmental Research Center P.O.Box 28 Edgewater, MD 21037-0028 USA	T +1 443 482 2227 F +1 443 482 2380	ruizg@si.edu
Wallentinus, Inger	Department of Marine Ecology, Marine Botany University of Göteborg P.O. Box 461 405 30 Göteborg Sweden	T +46 31 773 2702 F +46 31 773 2727	inger.wallentinus@marbot.gu.se
Laing, Ian	CEFAS, Weymouth Laboratory Barrak Road, The Nothe, Weymouth Dorset DT4 8UB United Kingdom, Wales	T +44 1305 206711 F +44 1305 206601	i.laing@cefas.co.uk
Ojaveer, Henn	Estonian Marine Institute Viljandi Rd. 18b 11216 Tallinn Estonia	T +372 6 281 584 F +372 6 281 563	henn@pc.parnu.ee
Rosenthal, Harald	Schifferstraße 48 21629 Neu Wulmstor Germany	T +49 40 700 65 14 F +49 40 701 02 676	haro.train@t-online.de
Urho, Lauri	Finnish Game and Fisheries Institute P.O. Box 6 00721 Helsinki Finland	T +358-205-751-258 F +358-205-751-201	lauri.urho@rktl.fi

Annex 2: Terms of Reference

The Working Group on Introductions and Transfers of Marine Organisms [WGITMO] (Chair: S. Gollasch, Germany) will work by correspondence in 2005 to:

a) Synthesise and evaluate National Reports particularly focussing on Risk assessment approaches and Treatment and management approaches;

b) Advance the discussion with the aim to prepare a draft report for rapid response and control options (such as decision trees and regulations) by 2006;

c) Prepare data (in excel spreadsheet format) which quantifies the distribution and densities of species introductions. This should where possible be based on ICES rectangles and for the period 1984–2004 where possible and include any seasonal observations if available. The data should be submitted to the REGNS secure website in preparation for the REGNS integrated assessment workshop in 2005 (deadline date missing);

d) Plan Aliens Species Alert report including evaluation of impacts and increasing public awareness;

e) Develop risk assessment guidelines for:

- accidental and intentional introductions,
- control options,
- rapid response plans,
- current Code of Practice (review in light of new initiatives on risk assessment, impact assessment protocols and developmental practices.

WGITMO will report by 30 April 2005 for the attention of the Marine Habitat Committee and ACME.

Annex 3: National Reports (ICES Member Countries)

NATIONAL REPORT

Belgium

2004

Prepared by Francis Kerckhof

Highlights

The major event during 2004 was the first discovery in the southern bay of the North Sea of the Asian shrimp *Palaemon macrodactylus* Rathbun, 1902 yet another introduction originating form the temperate North-West Pacific. The species proved to be already established in several suitable habitats.

1.0 Laws and regulations

There is no new legislation to report.

2.0 Deliberate releases

2.1 Fish

The Sea Fisheries Department (CLO-SFD, Oostende, Belgium) has stopped the restocking project of sole *Solea solea* and turbot *Scophtalmus rhombus*.

A private company, the N.V. Joosen-Luyckx Aqua Bio in Turnhout, is still elevating 6 species of sturgeons, including *Acipenser baeri, A. gueldenstaedti* (Osietra) and *A. ruthenus* (sterlet). The firm uses *A. baeri* for the production of caviar (Royal Belgian Caviar). Research I ongoing on the production of caviar from other species and some species are cultivated for ornamental use.

3.0 Accidental Introductions and transfers

Several non-indigenous species such as *Crassostrea gigas*, *Ensis directus*, *Crepidula fornicata*, *Elminius modestus, Hemigrapsus penicellatus* constitute now an important, and in some cases even a dominant, part of the Belgian marine fauna. And the number is still augmenting. Their success is for a great deal due to the alterations made by man to the environment, chiefly beamtrawling and the construction of artificial hard substrates. In man-made environments such as harbours, the overall presence of non-indigenous species is even more obvious (Kerckhof and Houziaux, 2003).

3.2 Invertebrates

Mytilopsis leucophaeata (=*Congeria cochleata*): This species is present in the harbour of Antwerpen, causing nuisance by the obstruction of water intake pipes of some chemical plants. A Ph.D. study is ongoing at the University of Gent, with the aim to find a possible biological control of the problems caused by this species.

Caprella mutica: This species has been first recorded in 1998 when it was present on several buoys marking the entrance to the harbour of Zeebrugge. Also recorded from the marina of Zeebrugge and from buoys off Blankenberge and Oostende. In the Zeebrugge area, the species is still present.

Ficopomatus enigmaticus: As in 2002 and 2003 this species was also in 2004 very abundant in the harbour of Oostende, forming reef like structures on several submerged substrates on vessels.

Megabalanus coccopoma: This species proved to be already present on buoys off the Dutch coast (off Terschelling) in 1976 and 1977 but was apparently not properly recognised. Recent investigations confirmed that the species is still present on the buoys in the same area off Terschelling. From 1997 on this species has been found each year in the southern bight of the North Sea, mainly on buoys but also on floating objects and even in the littoral zone. The continuous findings along the Belgian and Dutch coast prove that it is well established in this region of the North Sea.

Hemigrapsus penicillatus: This species was recorded for the first time from the coasts of Belgium and Northern France in 2003. The pencil-crab is now very abundant especially in estuaries and harbour areas for instance amongst reefs of pacific oysters *Crassostrea gigas.* During 2004 the species has also been discovered, although in lower numbers, on groins in the vicinity of Oostende thus in an open shore habitat.

Hemigrapsus sanguineus: *H. sanguineus* has not been found yet in Belgium.

Palaemon macrodactylus: This Asian shrimp was first identified from Zeebrugge, were it was fished on 12 June 2004 between the epiflora and epifauna of the pontoons of the marina (d'Udecem d'Acoz *et al.,,* 2005).

After this initial discovery, searches have been made in sheltered biotopes, estuaries and lagoon-like habitats (tidal and non-tidal) from June until early October in the southern Bay of the North Sea (Northern France, Belgium and the Netherlands). No attention has been paid to open coasts since the occurrence of *P. macrodactylus* is less probable in such habitats. Additionally, a single sample collected in November 1999 from Walsoorden (Westerschelde estuary) was also considered since it included some aberrant Palaemon specimens that indeed proved to be *P. macrodactylus*. These investigations showed that the species was present in several localities along the Dutch and Belgian coast including the Westerschelde estuary, but is has not been found yet in the northern French ports of Calais and Dunkerque.

The specimens were found in sheltered, polluted marine habitats (marina of Zeebrugge, sluice dock at Oostende), in the mesohaline part of the Westerschelde estuary (several marinas and harbours) and in brackish canals (IJmuiden, Rotterdam). All specimens were collected between fouling of pontoon floats, along harbour walls or between litter and reeds (*Phragmites australis*) in canals.

The invasion of *P. macrodactylus* is probably of recent date. Taking into account the sample from November 1999 *P. macrodactylus* must have been introduced in the Westerschelde estuary most likely prior to that year. Worth mentioning is also that, although the Asian shrimp is now present in the sluice dock of Oostende, a pond known to harbour many introduced species, it was not found there in 1996, 1998 and 1999.

P. macrodactylus has probably been introduced to Belgium and The Netherlands via ballast water of ships and not by shellfish importations. All water bodies where this species was caught are characterised by intensive intercontinental and regional ships' traffic.

It is clear that *P. macrodactylus* is a very successful invader and it is likely that it will colonise an extensive range of localities.

Telmatogeton japonicus: This giant chironomid has recently been identified from buoys off the Belgian coast. *T. japonicus* is common on all of the offshore buoys even the remote ones. Specimens live in the splash zone, *i.e.* the vertical zone of the buoy, above the algae zone, were they from a characteristic zone. The species is present during most of the year and apparently the only Chironomid living on the buoys.

T. japonicus can live on ships' hulls and is probably transported around the world by shipping. Other European records are from Denmark (2002 on the towers of windmills of the offshore windmill park Horns Rev), the Netherlands (several localities), Iceland, Ireland, Norway, Poland and Germany. It has been first discovered along the Kieler Förde in 1962 and then described as *T. remanei* (now considered a junior synonym of *T. japonicus*).

3.3 Algae and higher plants

Undaria pinnatifida: After the first record in 2000, this species is still present in de marina of Zeebrugge, but apparently not spreading due to predating of Coots *Fulica atra*.

4.0 Live Imports

In Belgium there is a lot of (uncontrolled) import and export of a wide variety of marine and fresh water species, for research, human consumption, aquaculture and aquariums. It is almost impossible to obtain figures on quantities or on origin.

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NATIONAL REPORT

Canada

2004

Prepared by Dorothee Kieser

1.0 LAWS AND REGULATIONS

National:

National Aquatic Invasive Species Plan

A Task Group, operating under the auspices of the Canadian Council of Fisheries and Aquaculture Ministers, and including representation from all provinces and territories, and the Department of Fisheries and Oceans (DFO) has been assigned responsibility for developing the National Aquatic Invasive Species Plan.

Details can be found at http://www.cbin.ec.gc.ca/primers/ias_documents.cfm?lang=e

Ballast Water Initiatives

DFO provided scientific advice to Transport Canada as to the placement of alternative ballast exchange zones for the revision of the Canada Shipping Act Regulations and Guidelines respecting Ballast Water Management for Ships in waters under Canadian Jurisdiction. Central and Arctic Region and the Great Lakes Region provided input into the papers with respect to the Lawrentian Channel and its use for transoceanic vessels heading to the freshwaters of the Great Lakes. Input into alternative zones for vessels heading into Eastern Arctic waters remained the same under the proposed regulations. These regulations are expected to be in place by spring 2005.

In preparation for the ratification of the International Convention of the Control and Management of Ships' Ballast Water & Sediments adopted in February of 2004 at the International Maritime Organization, a risk assessment consistent with the model utilized by GLOBALLAST /IMO is being carried jointly between DFO and Transport Canada with respect to foreign shipping entering the Great Lakes. Ratification of the Convention is on the regulatory plan for 2006.

2.0 DELIBERATE RELEASES AND PLANNED INTRODUCTIONS

Deliberate Releases

2.1 Finfish

Pacific Region

Under the Canada-US Transboundary agreement, approximately 8 million sockeye (*Oncorhynchus nerka*) fry were returned to the Taku and Stikine River systems in Canada after initial incubation in an isolation unit at an Alaskan Hatchery.

Quebec

Spotted wolf eel (*Anarhinchas minor*) and Atlantic wolf eels (*A. lupus*) were released into the St. Lawrence estuary.

Atlantic Provinces

No releases reported

3.0 ACCIDENTAL INTRODUCTIONS AND TRANSFERS

3.1 Fish

Pacific Region

No new reports

Great Lakes area (Central and Arctic Region)

No new reports

New Brunswick:

There was an accidental release of 55 000 Atlantic salmon smolts from a farm on Grand Manan Island.

3.2 Invertebrates

Pacific Region

No green crabs (*Carcinus maenas*) were found in 2004. No additional information is available on the mussel, *Musculista senhousia*. The Varnish clam (*Nuttalia obscurata)* appears to be spreading northward.

Quebec

The green crab was reported for the first time in August-September in 2004 the lagoon of the Grand Entrée of Magdalene Islands. The vector is unknown.

A single 40-gram female adult mitten crab (*Eriocheir sinensis*) was found in the St. Lawrence estuary (see Appendix 1 for newspaper report). While this species was first reported in the Laurentian Great Lakes in 1965 and has had occasional sitings in that freshwater area since then, this is the first identification in the Lower St. Lawrence River where the species might have access to salt water and hence potential for establishment. The vector for this apparently healthy specimen is thought to be trans-oceanic shipping traffic in the area. Should the species become established in the Lower St. Lawrence, and the potential exists, other tributaries in the region would be at risk of invasion. The environmental and economic impact of such a scenario is unknown. (De LaFontaine, pers. com.)

Atlantic Coast

The clubbed tunicate *Styela clava* has now been in Prince Edward Island (PEI) waters for approximately 7–8 years and is still causing problems to the mussel industry. *S. clava* abundance have not yet declined and are increasing in the most recently infested areas. Areas that are now infested with this tunicate are Murray River; Brudnell River; Montague River; St. Mary's Bay; Orwell River; and the most recent areas are Cardigan River and Malpeque Bay. Spread of *S. clava* seem to have slowed down with restrictions placed on movement of product from infested areas. However, once high abundance are established in an area it is very difficult to reduce their numbers because the species is highly reproductive.

This past year 3 more species of invasive tunicates were found in aquaculture sites in PEI. The 3 species are: *Ciona intestinalis*; *Botrylloides violaceus*; and *Botryllus schlosseri*. *C. intestinalis* is the same tunicate that has caused problems to mussel growers in Nova Scotia, resulting in loss of crop or even cessation of operations. Underwater surveys conducted by government agencies suggest that the present distribution is limited to a small area of Montague River. Infestation levels for the time being pale in comparison to *S. clava* abundances in the same area.

The 2 other species, *B. violaceus* and *B. schlosseri*, were identified in December 2004. The extent of infestation has not yet been assessed, but appears to be limited to one mussel culture area, Savage Harbour. These 2 species differ from the other species mentioned above because they are colonial. They reproduce both sexually and asexually. The colonies form large mats covering mussel growing gear as well as the mussels, possibly smothering them. The impact of these tunicates on mussel culture in PEI is unknown at this time. However, there is rising apprehension within the aquaculture sector regarding the increased presence of tunicates and predators that directly impact their bottom lines. Alleged vectors are related to boating traffic, both commercial and industrial, but the management agency is trying to mitigate transfer concerns related to typical husbandry activity within the industry.

Also, with the hope of reducing the green crab population, PEI has allowed the bycatch of the crab by trap net fishers.

3.3 Algae and higher plants

Pacific Region

The aquatic nuisance species, *Spartina anglica*, was discovered in July, 2003 during a survey for Vancouver Port expansion. Work on removal is ongoing and a report of how the project was planned and carried out in 2004 and suggestion for next steps for control of this aquatic nuisance species which is a serious threat to fish and wildlife habitat are attached. For portions of the report see Appendix 2.

Quebec

No new reports

3.4 Pathogens and Parasites

No new reports

4.0 Live imports and transfers

Importations of Finfish and Shellfish

Note: Country of origin is given in brackets.

Pacific

Imports

The pattern of importation matches that of previous years including the importation of Atlantic salmon eggs (Iceland), oysters (*C. gigas* and *C. sikamea*) (USA), Manila clams (USA), mussels (*Mytilus edulis, M. galloprovincialis*) (USA). The molluscs are primarily used for beach seeding and grow-out on open water structures.

Within Region transfers

Finfish: All *Oncorhynchus* species (chinook, coho, steelhead, rainbow, chum, pink, sockeye, kokanee), wolf eel, white sturgeon (*Acipenser transmontanus*), sablefish (*Anoplopoma fimbria*), halibut, eulachon, koi carp, burbot.

Shellfish: Japanese scallop, sea urchin, abalone, cockles, Manila clam, horse clam, Pacific oysters and Kumamoto oysters, blue and gallo mussels, geoduck.

Atlantic (including Quebec)

Imports

Quebec imported spotted wolf eel (*Anarhinchas minor*) eggs (Norway).

The Maritime provinces (New Brunswick, Nova Scotia and Prince Edward Island) imported following species for aquaculture: red abalone (*Haliotis rufescence*) (Iceland), Atlantic salmon (USA), cod (USA), Eastern oyster (*C. virginica*) (USA), Pacific oyster (*C. gigas*) (USA).

Within Region transfers

Atlantic salmon, trout (speckled, brook, rainbow, splake), arctic charr, halibut, haddock, cod, Atlantic sturgeon (*Acipenser oxyrhynchus*) and shortnose sturgeon (*A. brevirostrum*) and sea scallop (*Placopecten magellanicus*).

5.0 Live exports to other countries

Finfish

Aquaculture:

SPECIES	SOURCE	DESTINATION
Brook trout eggs	Quebec	China
Arctic charr	Yukon, Quebec	N. Ireland, Austria, Poland, France, Chile, Slovenia, Macedonia
♂ Brook trout. X ♀ Arctic charr eggs	Quebec	Germany
♀ Brook trout X ♂ Arctic charr eggs	Quebec	France
Atlantic Sturgeon fry and juveniles	New Brunswick	Germany, Poland

Aquarium trade

The following were exported to Spain: *Sebastes caurinus, Embiotoca lateralis, Hexagrammus decagrammus.*

Portugal received *Anarrhichties ocellatus.*

Invertebrates

Aquaculture: Giant scallop seed is transferred from the Magdalen Islands to St. Pierre et Miquelon (France)

Aquarium trade: The following were exported to Spain: *Crossaster papposus, Evasterias troschelli, Enteroctopus dofleini, Medaster aequalis, Metridium giganteum, Ptilosarcus guernii, Parastichopus californicus, Orthasterias koehleri, Cryptochiton stelleri, Hemilepto-dotas hemileptodotas*

Portugal received *Enteroctopus dofleini*

Prepared March 2005 by:
Dorothee Kieser (with much appreciated help from numerous colleagues)
Department of Fisheries and Oceans
Pacific Biological Station, Nanaimo, BC
Canada, V9T 6N7 Email: kieserd@pac.dfo-mpo.gc.ca

Appendix 1 to Canadian National Report:

PUBLICATION:	Le Devoir
DATE:	2004.12.03
SECTION:	WEEK-END NATURE
PAGE:	b5
BYLINE:	Francoeur, Louis-Gilles
ILLUSTRATION:	Le nouveau venu dans le fleuve Saint-Laurent. Source:Environnement Canada

Warning! – Chinese mitten crab spotted in the St. Lawrence

Last September, Bernard Côté, one of the last eel fishers in the St. Lawrence River, discovered a specimen of an unknown species of crab off Saint-Romuald. Since then, Canadian waters have been faced with a new, unnerving threat.

The impressive creature is large enough to cover an 8.5-x-11-inch sheet of paper. The yellowish green crab was submitted to Yves de Lafontaine, a researcher at the St. Lawrence Centre. Mr. de Lafontaine checked his books and consulted his colleagues right away, and concluded that the specimen was a Chinese mitten crab (Eriocheir sinensis), one of the one hundred most invasive and undesirable species on the planet. Weighing 40 grams, the specimen captured was a one-and-a-half-year-old adult female with the eight long legs characteristic of the species and a shell measuring 4.6 cm in width.

According to Mr. de Lafontaine, the presence of the Chinese mitten crab represents a significant environmental threat to the St. Lawrence, its major tributaries and their branches because the river offers this catadromous species a favourable environment for reproduction. Unlike anadromous species, such as the salmon, which reproduce in fresh water and mature in saltwater environments, the Chinese mitten crab must reproduce in salt water. It then makes its way into fresh water, where it lives from 10–15 years before returning to the sea to reproduce, which it does only once. When the juvenile crabs are heavy enough to reach the bottom, they swim upstream toward fresh water. In China and Korea, they can migrate from 500–600 kilometres in fresh water before establishing themselves.

The Chinese mitten crab has invaded many major rivers in Europe, and recently in England. This voracious scavenger was discovered for the first time in Germany in 1912. Locally, ecosystems could be seriously affected by its ability to burrow into sediments in search of the insects, larvae and waste that provide a livelihood for other scavenger species, including catfish and carp. The Chinese mitten crab is also adept at boring tunnels in river banks, causing them to subside and erode. Fragile buffer strips are particularly vulnerable where vegetation cover is sparse, a situation that is common in Quebec farmlands, despite the standards in effect. The Chinese crab has a reputation for making its home in irrigation and drainage systems and causing them to clog up.

The species was first noted in Canada in 1965 in the Detroit River, near Windsor, and then in 1973 in Lake Erie. Its presence there does not raise much concern among biologists because the Great Lakes do not offer the saltwater environment that the species requires for reproduction. Conversely, off the California coast, in San Francisco Bay, where conditions are similar to those of the St. Lawrence estuary, the species has installed itself permanently, causing irreversible biological pollution.

According to Yves de Lafontaine, the estuary and its main tributaries, such as the Saguenay, Saint-Maurice and Ottawa rivers and their effluents, as well as the small rivers in the estuary (including the salmon rivers) are all vulnerable to contamination by this undesirable species, which reproduces at a phenomenal rate. Mr. de Lafontaine says that one or two specimens will be captured every year for a few years, and then, as in a Hollywood horror story, the population will explode.

The St. Lawrence Centre researcher estimates that the probability of the individual caught being the only specimen in the river is less than the odds of winning a lottery. He considers that we are definitely dealing with a small population that could soon become rapidly larger.

In the saltwater estuary, the species will find a suitable environment in which to reproduce; in farming areas, it will also find hundreds of streams to invade, where it will hasten the erosion of exposed banks. The specimen captured at Saint-Romuald has just come out of obligatory quarantine and, in the next few days, the public will be able to get a close look at this environmental trouble-maker at the Quebec Aquarium.

Where this Chinese mitten crab came from is not clear. It may have migrated to the St. Lawrence from the Great Lakes, but it would have had to make its way past dam turbines in Ontario, New York and Quebec. Alternatively, a passing ship originating in Europe or Asia could have released it into the St. Lawrence, a disastrous practice that has brought several undesirable species to the mega-watershed formed by the St. Lawrence River and the Great Lakes. These species include the zebra and quagga mussels, the round gobie and the lamprey. The gobie, a carnivorous fish that loves the eggs of yellow perch, has invaded the St. Lawrence, and unfortunately, recent analyses of stomach contents suggest that our indigenous predators have not found a way of eating them.

For the time being, the tench, which was deliberately released in the Richelieu River by an amateur fish farmer a few years ago, is confining itself to that river. Rather than heading to the St. Lawrence, it has apparently tried to travel to Lake Champlain, a move that the U.S. is very interested in blocking. The rusty crayfish is another undesirable species that is moving into the Ottawa River from southern Ontario and the U.S.

Like a vampire, the lamprey sucks the blood from its victims over several days. It got into the Great Lakes by taking the Welland Canal around Niagara Falls. Its expansion is being limited by the U.S. government's liberal use of a "lampricide" in waters where it is reproducing. This pest has even become a bone of contention between Quebec and its U.S. neighbours, who are using the lampricide in Lake Champlain. Because the province refuses to use the product in Missisquoi Bay, we are drawing criticism from Americans for providing this undesirable species with an excellent reproductive environment and enabling it to contaminate the rest of the lake. It will take some time to effectively check the expansion of this freshwater vampire, as was done on the Quebec side when water chestnuts from Lake Champlain moved into the Rivière du Sud, a tributary of the Richelieu.

Appendix 2 to Canadian National Report

Report to Western Regional Panel

***Spartina anglica* in Boundary Bay, British Columbia**

Pat Lim
Fisheries & Oceans Canada
401 Burrard Street
Vancouver BC

August 2004

Introduction

In 2003, Western Regional Panel provided some funds ($2500 US) for eradication of the invasive intertidal plant, *Spartina anglica*, in Boundary Bay, British Columbia. This is an area bordering on the state of Washington and was a cross-boundary project involving agencies and volunteers from both British Columbia and Washington State. This report summarizes how the project was planned and carried out in 2004 and provides suggestion for next steps for control of this aquatic nuisance species which is a serious threat to fish and wildlife habitat.

Background

The aquatic nuisance species, *Spartina anglica,* was discovered in July, 2003 in Roberts Bank (near Tsawwassen, British Columbia) during a survey for Vancouver Port expansion (Figure 1). This is a marine mudflat which is part of the outer Fraser River estuary. Four clones of *Spartina anglica* were discovered. Each clone was approximately three metres wide and contained about 800 stalks per metre. There were also small individual seedlings (tussocks) in the surrounding area. About 50 were found. In September 2003, an attempt was made to clip all the seed heads. These were put into garbage bags and incinerated. Further attempts at eradication were made in October with about 20 volunteers who dug out the rhizomes. A survey of the nearby mudflats was planned for later in the year and a larger stand was subsequently found in Boundary Bay.

Figure 1 Spartina anglica.

As neighbouring Washington State has serious *Spartina* infestations and a well-established *Spartina* control program, advice was sought from Washington State Department of Agriculture and Washington Department of Fish and Wildlife. Control of this nuisance species is critical at this point while the stands are at 'manageable' levels. In Washington State, *Spartina* control programs have been ongoing for several years and budgets are in the millions of dollars. Their aggressive annual control programs involve mechanical, manual, biological and chemical control methods. Even with this effort, *Spartina* continues to be a problem infesting more than 8500 acres of shoreline habitat in Washington State (Murphy, 2003).

An action plan for 2004 for the British Columbia stands of *Spartina anglica* was developed by a committee formed in December 2003 comprised of representatives from various agencies (Appendix I). This report provides details of the plan and results of a three day volunteer effort which focussed on manual removal of the plants in Boundary Bay.

Figure 2 Study Area (from Canadian Nature Federation, 2000).

Study Area

Boundary BC, an internationally recognized Important Bird Area, is a critical rest stop for thousands of birds using the Pacific Flyway migration route (Figure 2 and 3). It is located at the southern end of the Fraser River delta and is one of the largest estuaries on Canada's Pacific Coast. Fish productivity is high and eelgrass beds are part of this highly valued ecosystem. The area between the foot of 96th Street and 112th Street in Delta, BC was focussed on for this project. There is a dyke bordering the mudflat which is maintained by the Greater Vancouver Regional District and is a recreational bicycle route. The area is a designated British Columbia Ministry of Water Lands and Air Protection Wildlife Management Area.

Methods

Planning

In December 2003, a meeting of representatives from British Columbia and Washington was convened in Vancouver to seek the advice of Washington State *Spartina* experts. It was unanimously decided that immediate action in the 2004 growing season was required to prevent *Spartina anglica* from spreading rapidly beyond Boundary Bay. A plan was developed to recruit volunteers to manually dig out the plants during the low tides of June 2004. Organization was through the cooperative efforts of several agencies in both British Columbia and Washington State. A budget was discussed to cover costs such as materials, hiring a volunteer coordinator, production of promotional/educational materials, volunteer needs on the days of removal, and miscellaneous field expenses. Once the rough amounts were decided upon, matching funds were negotiated from different organizations and funds were pooled for the removal. In many cases, contribution was 'in-kind' efforts of agency staff.

Mapping

Fisheries & Oceans Canada mapped the mudflat area between the foot of 104th Street and 112th Street, Delta on May 31, 2004 and June 4, 2004. Handheld GPS units (Garmin eTrex Vista and GPS 76 marine navigator) were used to map the *Spartina anglica* assemblages. The map produced was a result of overlaying the data onto recent orthophotographs of the area (Figure 2). Metadata for this mapping is found in Appendix I. The purpose of the mapping was to provide volunteers and those organizing the *Spartina* removal with some orientation of where to concentrate their efforts. The map also served to give an idea of the amount of plant material present. The map had a spatial accuracy of +/- 5m.

Outreach

On June 5, 2004 a World Oceans Day event was organized at Blackie Spit Park which is near Boundary Bay. This was an opportunity for outreach to the public and for recruitment for the *Spartina anglica* removal days of June 17–19, 2004. Information on invasive species in general and specifically on the *Spartina anglica* problem was available at three different booths. The event was well attended and the result was that some interest was generated in the volunteer dig for later in the month. A fact sheet was distributed which further introduced the plant and the potential problems with its spread in BC waters (Figure 4).

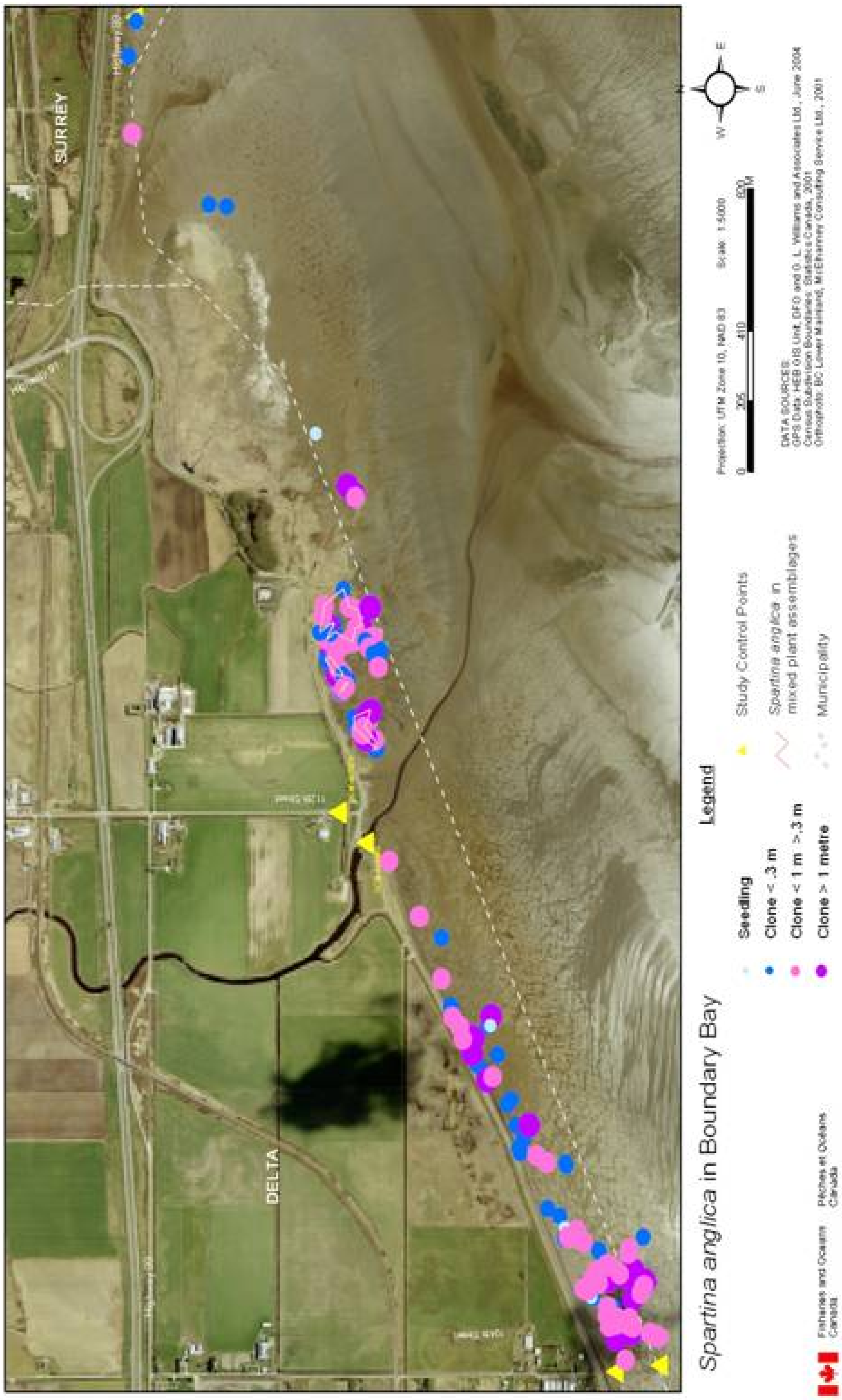

Figure 3 Map of *Spartina anglica* in Boundary Bay.

Spartina anglica

Invasive aquatic plant found in B.C.

What is it?

Spartina anglica is a grass that is not native to the West Coast. It can grow rapidly in intertidal zones – such as mudflats and beaches – and disrupt saltwater ecosystems, threaten fish and bird habitat and increase the threat of floods. *Spartina anglica* was discovered in the summer of 2003 in Boundary Bay and Roberts Bank, near the Fraser River estuary.

What's the problem?

Four species of *Spartina*, commonly know as cordgrasses, have invaded coastal estuaries of the U.S. Pacific coast. As these species proliferate, they trap sediment with their large root masses, raise the elevation of the intertidal areas and replace natural mud and sand flats, native eelgrass and algae beds, and river channels. The plants can be brought to B.C. by birds, animals, humans, water currents, recreational boats and ships' ballast water. The results can be serious:

- A loss of critical rearing habitat for fish such as juvenile salmon, clams, oysters and crab.
- A loss of valuable habitat for migrating shorebirds and waterfowl. Boundary Bay is a major resting and feeding area for more than 320 bird species.
- An increase in the risk of flooding.
- A loss of water access from shoreline areas and beaches and for boats.

What does it look like?

Spartina anglica is a grass, with round, hollow stems that grow in roundish clumps up to 2 m in height. The leaf blades, up to 12 mm wide, are flat, rough and green-gray in colour, and branch out from the stem at almost perpendicular angles. It sprouts in the spring, and blooms from July through November. The seeds resemble wheat and are found on one side of the stem.

What is being done?

The best way to control *Spartina anglica* is to catch it early, before infestations become established. Fisheries and Oceans Canada is working with the Vancouver Port Authority, Ducks Unlimited, Canadian Wildlife Service, Corporation of Delta and B.C. Ministry of Water, Land and Air Protection to control the plant's spread. The partners are consulting with Washington State, which has been aggressively battling the noxious weed since 1999. For the summer of 2004, comprehensive surveys of Boundary Bay and Roberts Bank are planned. Work crews will be digging up the identified *Spartina anglica* plants and disposing of them.

What can you do?

Volunteers are needed to raise awareness of *Spartina anglica*, to watch shoreline areas for its spread and to participate in removal efforts.

For further information, please contact:

Pat Lim
Fisheries and Oceans Canada
604-666-6529
limp@pac.dfo-mpo.gc.ca

Fisheries and Oceans Canada | Pêches et Océans Canada

Canada

Figure 4 ***Spartina anglica*** **Fact Sheet.**

Volunteer Organization

Volunteers were contacted by e-mail with information on where to meet, supplied with maps and a list of what to bring. As the mudflat provides no shelter, everyone was asked to bring hats, sunscreen, snacks and a lunch. Everyone met around 8:30 am at the foot of 104th Street and gathered in a meeting room to sign-in and gather shovels, garbage bags, and instructions. Volunteers usually went in groups of at least two and sometimes four. All volunteers signed a waiver (Figure 4). A live *Spartina anglica* was available for volunteers to look at. Laminated identification cards were also given out. These had recent pictures of the plant on one side and emergency contact numbers on the other.

Removal

Volunteer Manual Efforts

On the first day, June 17, 2004, a total of fifty-two volunteers dug *Spartina anglica* on the mudflat. Eighteen volunteers were available on each of the following two days. Digging was done with long-handled garden shovels and large garbage bags were used to contain the dug up plants (Figure 5). Bags were only partially filled because they were heavy and difficult to move. Attempts were made to remove as much of the plant material, especially the roots, as possible. Several times a day, a small all-terrain vehicle was used to gather up the bags and stockpile them at convenient places on the dyke. After all the digging was done, a backhoe loaded the bags onto a truck and they were taken to the Greater Vancouver Regional District Waste-to-Energy incinerator. Before they were incinerated, the plant material was weighed.

Figure 5 Volunteers dig *Spartina anglica* in Boundary Bay (photo by Pat Lim).

Mechanical Excavation

Concord Excavating and Contracting Ltd. was contracted to supply an amphibious excavator which provided a mechanical means of plant removal (Figure 6). This particular machine was chosen because it was designed to float and left a very light footprint. It had less than 1 psi (pounds per square inch) on dry land. The machine was accurate enough to remove clones larger than 1 metre in diameter. Only one person was required to operate it.

Figure 6 Swamp Excavator (photo by Pat Lim).

It was decided to experiment with the burying of plants to depths of greater than three metres (Figure 7). Large holes were dug in the mudflat and plants put into the holes which were re-filled with the sediment that had been removed. The sediment was compacted and the burial location left at the same level as the surrounding mudflat (Figure 8). Some of the locations were recorded with GPS equipment so evaluation can be made of the effectiveness of this idea in following years.

Figure 7 Excavator burying *Spartina anglica* (photo by Pat Lim).

Figure 8 Excavator refilling the holes (photo by Pat Lim).

Results

The substrates in the Boundary Bay area ranged from sandy to heavy mud. *Spartina anglica* was found growing successfully in all substrates. The restriction in range was difficult to detect as the plant grew high in the intertidal, close to the high tideline as well as far out in the lower intertidal. The plants assemblages were varied. Some plants grew in distinct clones or individually. These were relatively easy to dig regardless of the substrate. Beyond Boundary Bay, near Centennial Beach, a large clone was found growing close to shore in gravel.

There were large areas where the *Spartina anglica* was growing in mixed populations with other marsh plants (*Triglochin maritimum, Salicornia virginica, Distichlis spicata*). These areas tended to be muddier and the substrate more compact. In such situations, digging was slow and tedious. It was also difficult to avoid damaging native species during the removal. In these situations, volunteers quickly became frustrated and eventually, the excavator was used to remove the plants.

The results of the three day digging effort at Boundary Bay can be measured in several ways. It is easy to visually see that a large amount of plant material was removed from the mudflats. A rough measure of the amount removed is the weight that was incinerated. Approximately

7150 kg (15 765 pounds) was removed in garbage bags and incinerated. It is estimated that at least five times that amount was buried by the excavator.

An important result of this project was the raised awareness of the public, communities and agencies within the province of the potential loss of habitat that establishment of *Spartina anglica* would result in. Surrey, the neighbouring community to Delta in Boundary has taken immediate action to manually remove the *Spartina anglica* plants that were discovered during the dig in June. Recognition of the plant has also become

The excavator, though big, was found to be effective in removing plant material. It had the advantage of being very manoeuvrable. In muddier substrates, it was critical to have this larger machine instead of a smaller one because of the danger of getting stuck in the mud.

Discussion

The volunteer effort to dig out *Spartina anglica* in Boundary Bay was a successful project. It was particularly productive to have a mixture of volunteers with paid staff and to have the support of enthusiastic wetland ecologists. The plant was easy to recognize and so volunteers did not need to spend a lot of time looking for places to dig.

Mapping was an invaluable resource to determine where to concentrate volunteer and mechanical efforts. It was planning tool and a measure of what had been accomplished. Under more controlled circumstances, accurate measurements could be made of plant biomass removed through mapping of before and after situations.

The removal of *Spartina anglica* in June 2004 in Boundary Bay needs to be monitored into the next growing season to fully evaluate the value of the effort. It is particularly important to observe the areas where the plants were buried. There is confidence that there won't be regrowth from these areas. Recolonization from seeds or rhizomes left in nearby areas may occur.

Monitoring the surrounding areas of Boundary Bay and other intertidal areas in the Strait of Georgia is an important part of controlling further spread of *Spartina anglica.* An inventory of where this invasive plant is growing in British Columbia is critical to protecting the intertidal habitat it threatens. Mapping the inventory data is the recommended method of representing this to habitat managers. Using this information effective planning can be made for invasive plant containment.

Manual removal was successful to a point but without the mechanical assistance of the excavator, only a small amount of the plant material in Boundary Bay would have been removed. If more *Spartina* stands are found in the waters of British Columbia, other control and removal methods may be necessary. Consultation with Washington State Department of Agriculture *Spartina* eradication program should continue.

(Note: Remainder of report not attached)

NATIONAL REPORT
Estonia
2004
Prepared by Henn Ojaveer

1.0 Laws and regulations

New '*Nature conservation act'* has was submitted by the Parliament on the 21st of April 2004 and came into force on the 1st of May 2004. In this act, alien species are considered in paragraphs 57 and 58 followingly (unofficial translation):

§ 57 Alien species

1) Release of living specimen of alien species, planting and sowing of alien plant species into nature is prohibited.
2) The Minister of the Environment shall establish the list of alien species that endanger natural balance, the import of living specimen of which for growing in artificial conditions is prohibited.
3) Regulation of the number of an alien species that have escaped into the wild shall be organised by the County Environmental Service of the Ministry of the Environment
4) Captive-bred specimen of an alien species can be re-inhabited into a new captive-bred conditions with the permission of the environmental authority where animals are taken for re-inhabiting and that of the destination place.
5) Captive-breeding of specimen of alien species that endanger the natural balance is prohibited, except scientifically justified cases with the permission of the Minister of the Environment.

§ 58 Re-inhabiting and Taking from the Wild

1) Re-inhabiting of the wild with imported living specimen of native species is prohibited, except scientifically justified re-inhabiting with the permission of the Minister of the Environment.
2) Animals of a native species can be re-inhabited into a new place with the permission of the environmental authority where animals are taken for re-inhabiting and that of the destination place.
3) Release into the wild of captive-bred specimen of a native animal species, except for release of animals that have been kept in captivity with the purpose of curing their injuries or restoring their vitality, shall be carried out only on the basis of the Action Plan specified in the section 49.

Minister of Environment signed on the 7th of October 2004 the regulation nr 126 " The list of alien species threatening nature balance". The list consists of 21 species, including also 3 aquatic species (*Astacus leptodactylus, Orconectes limosus, Pacifascatus leniusculus).* According to this regulation, the import of named species are strictly prohibited and they can not be imported even for keeping in captivity. The import can though be carried through by the licence of the Minister of Environment for scientific purposes.

2.0 Deliberate releases

Official data on fish releases into the sea (pikeperch, whitefish and salmonids also to rivers discharging into the sea) of Estonia for 2003 (in thousands).

Salmon (Salmo salar)	in total 417.22, incl.
	0-group 209.9
	1-year old 172.21
	2-year old 35.11

Whitefish (*Coregonus lavaretus*)	0-group individuals 34.9
Sea trout (Salmo trutta trutta)	in total 90.34 ind., incl.
	0-group 38.16
	1-year old 15.40
	2-year old 36.78
Pike (Esox lucius)	larval stage – 400
Pikeperch (*Stizostedion lucioperca*)	0-group individuals 2.9
Eel (*Anguilla anguilla*)	0-group individuals 10.1

Data for 2004 were not available by the time of compilation of the report.

3.0 Accidental introductions and transfers

3.1. Fish

The gibel carp *Carassius gibelio* (Bloch) was first introduced into fish ponds and small lakes of Estonia in 1948. The fish was first found in marine waters in 1985 in the Gulf of Riga. During the most recent years the species has been caught almost everywhere in Estonian coastal sea. While in some shallow sheltered areas the species can reproduce and thrives well, in more open coastal areas only large adult specimens are caught. In some coastal areas gibel carp is dominating in commercial catches by the biomass. The experiments with developing embryos revealed that viable hatch took place at salinities 1–6 ppt and survival until hatching was the highest at 3.0 ppt. At 3.0 ppt larvae were also longer than at other salinities. Therefore it is unlikely that the salinity has been serious migration barrier for gibel carps. The recent explosion of this species in the coastal sea could be explained by unusually warm summers during the 1990s and by low abundance of predatory fish.

3.2. Invertebrates

The exploited feeding area of the native clam *Macoma balthica* and the introduced polychaete *Marenzelleria viridis* were experimentally quantified in laboratory conditions. Our feeding trials showed that *M. balthica* was able to feed at a much wider surface area than *M. viridis*. Moreover, in presence of *M. viridis* the feeding area of *M. balthica* and its cumulative increase in time were significantly higher than without the polychaete.

These results suggest that *M. balthica* is superior to *M. viridis* in terms of feeding. The experiment supports the earlier findings that the presence of *M. balthica* appears to be a key factor limiting the further expansion of *M. viridis* in the northern Baltic Sea.

An *in situ* experiment was performed to study the role of the mesoherbivores *Idotea baltica*, *Gammarus oceanicus* and *Palaemon adspersus* in the decline of charophytes in the northeastern Baltic Sea. Invertebrate grazing showed a clear seasonality. Grazing pressure was low in April, moderate in July, and high in October. Low photosynthetic activity (high decomposition rate) of the charophytes favoured grazing. The studied invertebrates preferred *Chara tomentosa* to *C. connivens*. Low consumption of *C. connivens* may reflect its non-native origin.

It was confirmed by laboratory experiments (hatch of resting eggs and studies on newly-born youngs that there is only one *Cercopagis* species in the Gulf of Riga: *Cercopagis pengoi*. Notable seasonal dynamics was observed for the gamogenetic mode of reproduction, being strongly associated with the total population density. One resting egg was, an average, found in 45.4%, two in 53.4% and three in 1.2% of females. Parthenogenetic fecundity was significantly higher in spring and early summer compared to other time. Brood pouch of parthenogenetic females was found to contain 11.6±1.0 and 10.2±0.3 embryos in the spring and summer form individuals, respectively. Variation in the two modes of reproduction and fecundity is probably solely not controlled by temperature, but also by food availability and population density.

Since the invasion of the predatory cladoceran *Cercopagis pengoi* in Pärnu Bay in 1991 the zooplankton community is likely to be regulated by the introduced species rather than phytoplankton dynamics. Negative relationship between the density of zooplankton and herring larvae in the 1990s suggests that the major shift in zooplankton community due to *C. pengoi* resulted in the food limitation of herring larvae.

4.0 Live imports

Data for 2004 were not available by the time of compilation of the report.

5.0 Live exports to ices member countries

Data for 2004 were not available by the time of compilation of the report.

6.0 Meetings, conferences, symposia or workshops on introductions and transfers

Organizing of Symposia

Organizing and co-chairing (Henn Ojaveer, together with Gordon Copp, CEFAS, UK) Alien Fish Species Symposium of the 11th European Congress of Ichthyology, 6–10 September, 2004. Tallinn, Estonia.

Presentations at International Conferences

Ikauniece, A., Ojaveer, H., Kotta, J., Olenin, S., Leppakoski, E. 2004. Research aspects of invasive species in the Baltic Sea. Helsinki Convention-30. International Co-operation for the Baltic Sea Environment: Past, Present and Future. March 22–24, 2004, Riga, Latvia. Abstracts, 64–68.

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National Report

Finland

2004

Prepared by Erkki Leppäkoski and Lauri Urho

1 LAWS AND REGULATIONS: No changes in 2004

2.0 DELIBERATE RELEASES:

2.1 Fish

Deliberate releases into the Baltic Sea were (including rivers draining into the Baltic) for fisheries and fish stock enhancement purposes in 2003 (2004 data not yet available) as follows:

- 0.13 million newly hatched and 2.3 million older salmon (*Salmo salar*),
- 0.03 million newly hatched and 1.2 million older sea trout (*Salmo trutta* m. *trutta*),
- 42.2 million newly hatched and 9.3 million older whitefish (*Coregonus lavaretus*).

2.2 Invertebrates None

2.3 Algae and Higher Plants None

3.0 ACCIDENTAL INTRODUCTIONS AND TRANSFERS

Not known for 2004

4.0 LIVE IMPORTS

4.1 Fish

Sturgeon were imported from Germany to inland area and live rainbow trout from Denmark to Åland Islands as well as from Sweden to Archipelago and inland area.

4.2 Invertebrates

Freshwater crayfish were imported to inland area for cooking and ongrowing.

4.3 Algae and Higher Plants None

5.0 LIVE EXPORTS to ICES Member Countries

5.1 Fish

As in previous years, rainbow trout (*Oncorhynchus mykiss*) juveniles and eggs were exported to Russia and Estonia. In addition, fertilized eggs of charr (*Salvelinus alpinus*) and grayling (*Thymallus thymallus*) were exported to inland farms in Austria and Germany.

5.2 Invertebrates None?

5.3 Algae and Higher Plants None

6.0 PLANNED INTRODUCTIONS OF NEW SPECIES

6.1 Fish None

6.2 Invertebrates None

6.3 Algae and Higher Plants None

7.0 MEETINGS, Conferences, Symposia or Workshops on Introductions and Transfers

None

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NATIONAL REPORT
France
2004

Prepared by Laurence Miossec

Summary:

Few new information regarding Introductions and transfers of Marine Organisms were collected in 2004. Nevertheless some national programs were finalized in 2004 on invasive molluscs in shellfish beds along the Channel and Atlantic coast; results were published accordingly (see bibliography).

1.0 Laws and regulations

Two EU decisions have been amended regarding the animal health conditions and certifications requirements for imports of molluscs and fish, their eggs and gametes for further growth, fattening, relaying or human consumption the first one is on molluscs (2003/804/EC), the second on fish (2003/858/EC).

A project of a new directive is now in discussion in Brussels. It concerns the animal health conditions governing the placing on the market of aquaculture animals and products and the minimum communauty measures for the control of certain diseases affecting aquaculture animals. For molluscs this new directive will take at the end the place of the directive 91/67/EEC and the directive 95/70/CEE. Moreover, this project includes the aquatic ornamental animals; specific measures will be developed latter on regarding this marchandise.

2.0 Deliberate releases

No deliberate release in France

3.0 Accidental introductions and transfers

3.1 Mollusca

Crepidula fornicata

A new campaign of slipper limpet dredging was realised during May 2004 with industrial suction barges to eradicate this invasive species (AREVAL project). The biomass of *Crepidula fornicata* was evaluated in the Bay of Cancale (North Brittany near the bay of Mont St Michel). The first results emphasised that following the high recruitment observed in 2003, this species has expanded in this area. This situation could jeopardize the good development of the shellfish industry in this area.

Rapana venosa

Four Rapanas were captured in 2004 in south Brittany (west of France).

DATE	SITE	WEIGHT	LENGTH	WIDTH
04/02/2004	Golfe of Morbihan	572	137	105
12/04/2004	Bay of Quiberon	803	160	118
04/05/2004	Bay of Quiberon	723	166	125
31/08/2004	Bay of Quiberon	169	105	80

4.0 Live imports

5.0 Live exports to ICES Member countries

6.0 Planned introductions and transfers

7.0 Meetings, conferences, symposia or workshops on introductions and transfers

Conference

Biodiversity: Science and Governance, 24–28 January 2005 Paris

http://www.recherche.gouv.fr/biodiv2005paris/en/index.htm

Project

DIPNET (Disease Interaction and Pathogen exchange NETwork)

DIPNET is a new European project started on October 2004. It aims to integrate current knowledge on the transfer of pathogens between wild and cultured aquatic animal populations. The project will provide health specialists and other stakeholders with a forum for debate, reinforcing efficient communication and developing science based consensus. It addresses key issues needed to ensure sustainability and responsible exploitation of aquatic environments.

A consortium of 5 participants, including IFREMER (Institut Français de la Recherche pour l'Exploitation de la Mer) as a co-coordinator of the project, VESO (Centre for Veterinary Contract and Commercial Services), FRS (Fisheries Research Services), CEFAS (Centre for Environment, Fisheries and Aquaculture Science) and University of Zaragoza, will form the co-coordinating team to facilitate the establishment and operation of the project, decide on the organisation of scientific workshops and efficient management of the project funds. A project web site has been established early in the work program to disseminate information about the project, its objectives, progress and outputs (http://www.dipnet.info/). Already 12 institutions are engaged in this proposal and additional participants will be encouraged.

The lead participant for work packages 1 to 3 has invited a target group of experts to take part in electronic discussion forums and scientific workshops (funded by the project; the first one was organised in Nantes France on the 1st and 2nd of February 2005) on relevant issues in support of EU policies identified in the task 4 description of the call for proposals. The project's specific tasks focus on (i) a review of disease interactions and pathogen exchanges, (ii) risk assessment and modelling of pathogen exchanges, (iii) epidemiology and surveillance of infectious diseases in wild fish and shellfish, and (iv) network building and knowledge dissemination.

Findings and recommendations will be disseminated to all stakeholders via the project web site and will also be collated into reports to the European Commission. In addition to enhancing exchange of knowledge and scientific opinion in the area of aquatic animal health, the project will provide the European Commission and governments with recommendations for future research priorities, and for fish health management and regulation based on sound scientific advice.

Contact: Laurence Miossec (Laurence.Miossec@ifremer.fr)

REBENT (RESeau BENThique)

REBENT is a new IFREMER monitoring network devoted to establish a based line on coastal benthic ecosystem along the French coast, then according to this reference to record potential chronic or accidental changes. The coastal zone of Brittany has been studied as an experimental site for 2 years. Sustainable conditions to extend this monitoring network along the French coast are still in discussion.

http://www.ifremer.fr/rebent/

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Report prepared by Laurence Miossec Ifremer, La Tremblade, with support of
Jean-François Bouget, Ifremer La Trinité sur mer
Philie Goulletquer, D. Masson, S. Robert, C. François Ifremer La Tremblade,
D. Hamon, Ifremer Brest

National Report

Germany

2004

Prepared by S. Gollasch and H. Rosenthal

Highlights of National Report

The cladoceran *Cercopagis pengoi* was recently recorded from German waters (Gruzka, pers. com.). Germany reported also on the spread of the previously introduced non-indigenous oyster *Crassostrea gigas*. Activities on aquaculture and restocking focused in 2004 on eels, sturgeon and salmon. Ornamental trade is continuing to be popular. For direct human consumption, various crustaceans, blue mussels, common carp, and *Tilapia* species are imported. Live exports to ICES Member Countries focus on *Mytilus edulis* predominantly for the Belgium and Dutch market.

Together with Vadim Panov (Russia), Germany coordinates an initiative to link European working groups in the field of biological invasions (European Research Network on Aquatic Invasive Species (ERNAIS)). At present the network includes more than 100 experts from 28 countries (http://www.zin.ru/rbic/projects/ernais/). ERNAIS currently develops an electronical journal which may be used as tool to announce new findings of biological invaders as an early warning instrument.

Aquaculture and ballast water issues become more and more important. It is discussed to take advantage of planned offshore wind park installations to allow colonization with native hard bottom species and establish new maritime users, as *e.g.* aquaculture sites for oyster and macroalgae cultures (native and non-indigenous species such as the Pacific oyster may be included in the trials). Long-line mussel culture is also discussed.

3 Accidental Introductions and Transfers

The cladoceran ***Cercopagis pengoi*** was recently recorded from German waters in the Pomeranian Bay region – being the first record from German coastal waters (Gruzka pers. com.).

As already pointed out in last year's report, it is assumed that the Asian shore crab ***Hemigrapsus penicillatus*** will invade German waters in the very near future as records are known from Belgium and the Netherlands indicating its eastwards directed spread into the German Bight. The Ponto-Caspian fish ***Neogobius melanostomus***, known from the German Baltic coasts, was recently recorded in the Netherlands – the first record from the North Sea. It is assumed that the species may also be recorded from the German North Sea coast in the near future.

Status report of earlier introduced species:

Crassostrea gigas

The oyster farm located on the island of Sylt in the North Sea is continuing its operation using rack culture and marketing about 1 million oysters in Germany annually. Culturing the Pacific Oysters resulted also in oyster settlement outside the farm. As there is not much hard substrate in the German Wadden Sea to settle mussel beds of *Mytilus edulis* in the adjacent Wadden Sea areas became the first foothold for oyster spat. *Crassostrea gigas* continues to spread southwards and competes with native *Mytilus edulis* for habitat and food. It was documented at certain sites that the oysters have overgrown mussel beds with an increasing tendency.

Eriocheir sinensis

The Chinese Mitten Crab population declines further in density after its mass occurrence in the 1990s.

4 Live Imports

4.1 Fish

Aquaculture and powerplants (no major changes to last years National Report)

Several culture facilities are in operation – some of them use warm water effluents of power-plants. Species are cultured for the aquarium industry (**koi carp**, **gold fish** and **sterlett**), human consumption (**Asian carp,** ***Tilapia*** species) and restocking (**glass eels**).

Glass eels are imported from various countries (*e.g.* France, Italy, Ireland, Netherlands, and Sweden) according to the ICES Code of Practice.

Several **Sturgeon** species are still imported from Russia by local farmers for small-scale culture, among them is the Siberian sturgeon ***Acipenser baeri***. Rarely records of escapees are reported.

The project "Transfer of Atlantic sturgeon (*Acipenser oxyrhinchus*) from North America for remediation efforts into Baltic Sea tributaries" is underway. However, due to funding constraints the project was put on hold for some months. It is planned to follow the ICES Code of Practice on the Introductions and Transfers of Marine Organisms (2003 version) when importing specimens from North America, likely being the first alication of the code in Germany. As the life span of sturgeons is relatively long the code cannot be followed completely (see last years National Report).

Imports of **salmonid species** continued in the year 2004 at a comparable level to previous years. It is extremely difficult to trace the routings and quantities of life fish trade in several regions as there is no mechanism to collect these data. As in previous years, rainbow trouts were imported mainly from Denmark, the Netherlands, Poland, and the Czech Republic. The tonnage of trouts imported overall varied, but is usually above 10 000 t annually. Live **Atlantic Salmon** were imported from Sweden for human consumption in an unknown quantity.

Common carp is regularly imported alive since decades. Imports source countries are Poland, Hungary, Czech Republic. The present amount being imported is approx. 5000 t.

Ornamental trade

Large quantities of marine, brackish water and freshwater organisms were imported from South America, South-East Asia and other regions (inner-European trade) to serve the aquarium and hobby industry. Several million fish are imported annually predominantly from the Philippines, Indonesia, Thailand, Singapore and Hawaii.

4.2 Invertebrates

Live **Blue Mussels** (*Mytilus edulis*) were imported from Denmark for human consumption in an unknown quantity.

Live crustaceans (***Nephrops norvegicus***, ***Homarus gammarus***, ***H. americanus***, ***Callinectes sapidus*** and ***Cancer pagurus***) have been imported for human consumption from various countries in an unknown dimension.

Offshore wind parks

Plans for large-scale offshore wind parks continue and first construction permits have been issued. A research programme to test the applicability of modern aquaculture techniques in conjunction with wind-mill foundations has been launched. Long-line mussel culture between wind park installations and mussel cage culture is also discussed.

4.3 Plants

Macro-algae for human consumption become an increasing business. Currently test cultures are underway growing the brown-alga *Laminaria saccharina* and red-alga *Palmaria palmata*.

5 Live exports to ICES Member Countries

The live **Blue Mussel** (*Mytilus edulis*) production is predominantly exported to the Belgium and Dutch markets.

7 Meetings, Conferences, Symposia or Workshops on Introductions and Transfers

7.1 Meetings

NEOBIOTA group. This German group on biological invasions (established in 1999) is an effort to co-ordinate responses to the ever increasing problems caused by the invasion of non-native organisms (see last years National Report). The group considers all species introductions, including invasions in terrestrial habitats.

Marine Environment Protection Committee (MEPC), International Maritime Organization (IMO), Ballast Water Working Group (BWWG)

Intersessional discussion groups were busy prior the next meeting of MEPC, which will be held from July 18th–22nd 2005. Current focus of MEPC work includes the preparation of various guidelines supporting the IMO Ballast Water Management Convention.

DIN Working Group on Ballast Water Treatment

The Standardization Authority for Ships and Marine Technology (Normenstelle Schiffs- und Meerestechnik, NSMT) as a member of the German Standardization Organisation (Deutsche Industrienorm, DIN) launched a Working Group on Ballast Water Treatment Oct. 22nd 2002 within its Marine Environment Protection Committee (Working Group 2.11.4). The group continued its work in 2004 and communicated its findings to the German Delegation at IMO.

Workshops in Germany addressing biological invaders in coastal waters

- The Maritime Environment: Ballast Water, Waste Water and Sewage Treatment on Ships and in Ports. Eule & Partners Workshop, September 8th to 10th 2004, Bremen
- MARBEF-Workshop on Aquatic invasive species and the functioning of European coastal ecosystems, Alfred Wegener Institute for Polar and Marine Research, Wadden Sea Station Sylt, Germany (January 27th to 29th 2005).

7.2 European Research Network on Aquatic Invasive Species (ERNAIS)

Vadim Panov, Russia and Stephan Gollasch, Germany continue to co-coordinate ERNAIS. For ERNAIS objectives see http://www.zin.ru/rbic/projects/ernais/ and earlier National Reports. At present the network includes more than 100 experts from 28 countries. ERNAIS currently develops an electronical journal which may be used as tool to announce new findings of biological invaders as an early warning instrument.

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National Report

Sweden

2004

Prepared by Inger Wallentinus and Fredrik Nordwall

1 LAWS AND REGULATIONS

Imported fish must be proven free of contagious diseases and taken from a fish farm complying with the Swedish approval on fish farms for stocking purposes. (FIFS 2004:47).

Sweden was given additional guarantees for three fish diseases: SVC (spring viremia of carp), IPN-V (infectious pancreatic necrosis) on coast and inland and BKD (bacterial kidney disease) on inland (Commission Decision 2004/453/EG). The decision concerns all species intended for aquaculture, implying that the fish only can be brought from facilities having the same health status.

During spring 2004 the Swedish EPA (Anon., 2004 a), the Swedish Biodiversity Centre (CBM) (Anon., 2004 b) and the National Board of Fisheries (Anon., 2004 c) delivered information about the ecological effects of stocking with introduced species as well as on legislation regarding these species as requested by the government. These background reports are to be used in the work with developing a new 16th Environmental Quality Objective on Biodiversity with a 5th partial goal on introduced species. This environmental quality goal is being developed in response to how Sweden will implement the Convention on Biological Diversity's decisions on Guiding Principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species. The report by CBM was especially informative, containing also national and international legislation and guidelines and how Swedish legislation could be improved to encompass all groups of organisms, similar to the legislation on GMOs. It also contained several examples of types of risk analyses. A Government Bill is expected to come later this spring, although probably much reduced in comparison to the suggestions made.

2 DELIBERATE RELEASES

2.1 Finfish

Around 5 t of small adult eels from the Swedish west coast was restocked in the Baltic Sea and 0.3 million glass eels were stocked mainly into the Baltic. For compensatory purposes 2.0 million fry of salmon and 0.7 million fry of sea trout are stocked mainly in rivers running into the Baltic.

3 ACCIDENTAL INTRODUCTIONS AND TRANSFERS

3.1 Finfish

There are still NO reports of the round goby *Neogobius melanostomus* from Swedish coastal waters, despite its common occurrence in Gdansk Bay, Poland, at some sites in northern Germany, Estonia, Lithuania and a record from the Turku archipelago, Finland, in February 2004.

In co-operation with Polish scientists a Swedish Ph. D student in the research programme AquAliens has studied the behaviour and life history traits of the invasive N. melanostomus, in Gdansk Bay in relation to habitat variations. Field studies were carried out during two periods (using several types of sampling gears) in three areas differing in depth, degree of exposure, vegetation, substrate and structure of the indigenous fish community. N. melanostomus was abundant at all sites and even comprised the dominant fish biomass in some. It spawns several times during the growth season, but growth varied among individuals and sexes. There were differences between the areas in its abundance, size structure as well as in size and age at sexual maturity.

To assess to what extent food selection by a potential predator (cod) has changed in areas where the non-native prey N. melanostomus has become established, analyses of stomachs from cod (collected in 2003–2004) are currently being run. Other important predators on N. melanostomus are perch, pike perch and cormorant.

Also there has been a study of potential food and habitat competition between the non-indigenous *N. melanostomus* and the indigenous Baltic flounder, *Platichthys flesus*, in a homogenic sandy bottom area, starting in late spring 2004 in southern Puck Bay, Poland, since both species overlap in food preferences and feed on the mussels *Mytilus*, *Macoma* and *Cerastoderma*. Round goby abundance seems to control the habitat availability and thereby also food resources for flounders. When round goby abundance is high, competitively driven resource partitioning between the species probably exist, with flounder (especially smaller ones) as the weaker competitor. Hence, high round goby abundance may effect flounder recruitment by restricting habitat utilization and food availability (Gustaf Almqvist, Stockholm univ., pers. comm.).

3.2 Invertebrates

Surveys in the Gulf of Bothnia in 2004 showed that the cladoceran, predatory water flea *Cercopagis pengoi* now occurs along the Swedish east coast in the Baltic proper and in the Bothnian Sea (Andersen and Gorokhova, 2004) but in varying and often low abundances. There are still no reports of its occurrence in freshwater ecosystems anywhere in Scandinavia.

The Swedish studies on this species in the northern Baltic proper contribute to a growing body of evidence, that it can modify food webs and trophic interactions in invaded ecosystems. For example, comparative analyses of the herring trophic position in the Himmerfjärden Bay before and after the invasion of *C. pengoi* showed a trophic level shift from 2.6–3.4, indicating substantial alterations in the food-web structure (Gorokhova *et al.,* 2005).

C. pengoi is zooplanktivorous and a potential competitor with pelagic fish (YOY herring), but fish also exert a significant predation pressure on C. pengoi, thus indicating that this species may become a valuable new food resource for both herring and sprat in the northern Baltic proper (Gorokhova *et al.,* 2004, 2005). In particular, C. pengoi consumes substantial quantities of microzooplankton, which is not readily available as prey for fish, and thus transfers microzooplankton biomass to fish production (Gorokhova *et al.,* 2005). Moreover, in coastal areas of the Baltic proper, other zooplankton groups (*i.e.*, large copepods) decline rapidly in August (Johansson *et al.,* 2004), a period when C. pengoi is most abundant. This implies that C. pengoi is a particularly important food source for zooplanktivorous fishes during late summer and autumn (Gorokhova *et al.,* 2004), when the consumption by fish peaks (Arrhenius and Hansson, 1993). In addition, it was found that predation on C. pengoi depends on its abundance and on fish size with herring showing a tendency to become more selective for C. pengoi with increasing size. Another interesting finding was that majority of diapause eggs found in sprat (69%) were immature and appeared digested, while this was the case only for 2% of eggs found in herring (Gorokhova *et al.,* 2004). This indicates that the two fish species may cause differential effects on C. pengoi population with sprat reducing egg bank and thus recruitment of the next generation, while herring is most capable of reducing population stock during the parthenogenetic phase of the life cycle. Nevertheless, as both the dominant pelagic fishes in the Baltic and C. pengoi depend largely on the same food source (i.e. mesozooplankton), a drastic increase in the C.pengoi population may result in a decreased fish production. However, the net trophic outcome of this introduced species, seen from the perspective of higher trophic levels, is complex and presently difficult to evaluate.

In our further studies, distribution, diet, and consumption estimates (*i.e.*, consumption of zooplankton by C. pengoi and consumption of C. pengoi by fish and other zooplanktivores) will be combined with population abundance data to derive and to quantify trophic interactions between these components of the pelagic ecosystem. A bioeconomic model will be developed to evaluate ecological and economic consequences of the invasion of C. pengoi in the Baltic Sea. As the expected economic costs of ecosystem damage to fisheries depend on the nature of invader's interspecific interactions with native plankton species and fish, these empirical data will be used to estimate the net costs associated with this invasion.

In the Gulf of Bothnia *Marenzelleria* cf. *viridis*, as reported in the WGITMO Reports of 2003 and 2004 (ICES, 2003, 2004), has been found from the very innermost part of the Bothnian Bay at Råne-fjärden (about 30 km north of the town Luleå) to the town of Öregrund in the S Bothnian Sea.

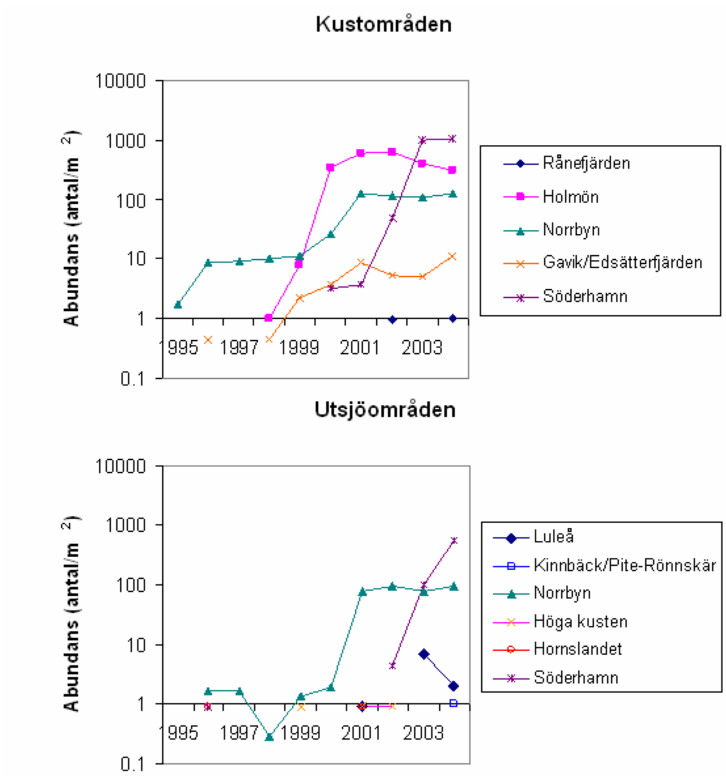

Figure 1. Abundance (ind m^{-2}; note the logarithmic scale) of *Marenzelleria* cf. *viridis* in the Bothnian Bay and the Bothnian Sea (for a map of sites see WGITMO Report 2004 (ICES, 2004)) in coastal areas (top; data based on 20 stations per area with one sample from each) and offshore (below; data based on 10 stations per area with one sample from each). Data by courtesy of Kjell Leonardsson, Umeå univ.

The increase in abundance does not seem to have continued in the north, but outside the town of Söderhamn (the Bothnian Sea) higher densities than anywhere else along the Swedish coast of Gulf of Bothnia have been recorded (Figure 1). There has been a contemporary decrease in abundance of the amphipod *Monoporeia* during the time when *Marenzelleria* increased, although it may not have been caused by the polychaee. However, the amphipods have still not recovered (Kjell Leonardsson, Umeå Univ., pers. comm.).

It has not been possible to verify if the broken parts of a juvenile polychaete, which was found in shallow waters at Kristineberg on the Swedish west coast, and looked very similar to the introduced species *Marenzelleria* cf. *viridis* (ICES, 2004), really belonged to that species since no more individuals have been found (Alf Norkko, Finnish Institute of Marin Research, pers. comm.). Thus the northernmost confirmed record on the Swedish west coast is outside Helsingborg, in the northern part of Öresund, from 2003 (Peter Göransson, Miljökontoret, Helsingborg, pers. comm.) and in Skälderviken (Charlotte Carlsson, County Administration Skåne, pers. comm.).

A new revision of the genus *Marenzelleria* (Sikorski and Bick, 2004) stated that two American species have reached the European Atlantic coasts and the Baltic Sea. The true *M. viridis* has, according to them, only been found on the Atlantic coast and it prefers salinities above 16 psu. The species recorded from the Baltic Sea was described by them, based on morphological characters, as a new species, *M. neglecta* sp. nov., which prefers salinities of 0.5–10 psu (material from the Darss-Zingst-Boddenchain, but also occurring in the US and on the North Sea coast).

Every year single specimens of the Chinese mitten crab, *Eriocheir sinensis* are reported to have been caught by fishermen (*e.g.* in the S Bothnian Sea in autumn 2004). There are no reports of mass occurrences. However, a fisherman from a village ca 30 km south of Göteborg claimed to have seen fertile females and that the numbers of caught specimens seems to be increasing (salinity in the area around 20–25 psu).

3.3 Algae and Higher Plants

Macroalgae

As reported in 2004 (ICES, 2004) the Asiatic red alga *Gracilaria vermiculophylla* was first recorded during August-September 2003 in the Göteborg archipelago. In 2004 it still occurred at all stations, where it was found the previous year, and it was also found at additionally eight sites not visited in 2003, but did not occur at the around 30 other sites visited (Figure 2a – some sites not possible to mark on the map). The maximum size measured in 2004 was 105 cm (Figure 2b). Several of the new sites were close to marinas or harbours, which points to that secondary spreading by pleasure boats or fishing vessels may occur. The record from two sites in Brofjorden could either be due to secondary spreading along the coast with boats or to a new introduction, since one site there is close to where oil tankers arrive to a refinery. It was not observed in a large-scale survey of eelgrass beds in the northern and middle part of Bohuslän in the summer of 2004, although looked for.

The only site in the northern archipelago of Göteborg, where it was observed, was in a lagoon outside a marina at the southern end of the island Öckerö. This marina had during 2004 applied for permission to dredge in the lagoon for enlarging its capacities. The alication was sent to the County Administration of Västra Götaland, who stated that since *G. vermiculophylla* had been found at that locality, as a first step the marina had to document its dispersal in the area to be dredged. Its degree of cover in the lagoon was recorded by a consultant in the beginning of autumn 2004. Secondly, since the alga did occur in the area to be dredged, the County Administration stated that the upper layer of mud with the alga should be removed before the dredging started. The alication has now gone back to the regional Environmental Court ("Miljödomstol") under the Swedish Environmental Code where the issue will be on trial in March 2005.

In an interview with a fisherman from Vallda Sandö, ca 30 km S of Göteborg, he claimed that the alga (it was seen in barrels on his boat, so he knew what it looked like) had been there for some years (he could not specify) and that it occurred all along from Vallda Sandö to Särö (Figure 2a) where he was fishing. He also said that eelgrass had disappeared in some areas (there are no available data on previous eelgrass distribution in this area). Also at Rivö, close to the harbour of Göteborg, *G. vermiculophylla* formed very dense mats surronding eelgrass plants (IW pers. obs., Lars-Harry Jenneborg, HydroGIS AB, pers. comm.). An enquiry was sent out to around 300 fishermen on the Swedish west coast in autumn 2004, 9 of the 56 who answered claimed to have seen *G. vermiculophylla* the last couple of years. Since they did not need to fill in their names and addresses, unfortunately, we cannot match the answers with our map of distribution.

Salinity tolerance experiments showed that this species survived and grew for at least 22 days in salinities as low as 2 psu. This indicates that, if only salinity is taken into consideration, the species could grow along all the coasts of Sweden, all the way to the innermost parts of the Bothnian Bay, as well as in most of the countries along the Baltic Sea (Nyberg and Wallentinus, in manuscript). Quantification of the traits of importance for the invasiveness of *G. vermiculophylla* (for the three main categories dispersal, establishment and ecological impact, further subdivided into 13 more specific categories; for details see Nyberg and Wallentinus, in press) showed that this species is one of the four most invasive macroalgae introduced into Europe. Thus an event tree was used to evaluate the plausible impact of a potential establishment in the brackish Baltic Sea.

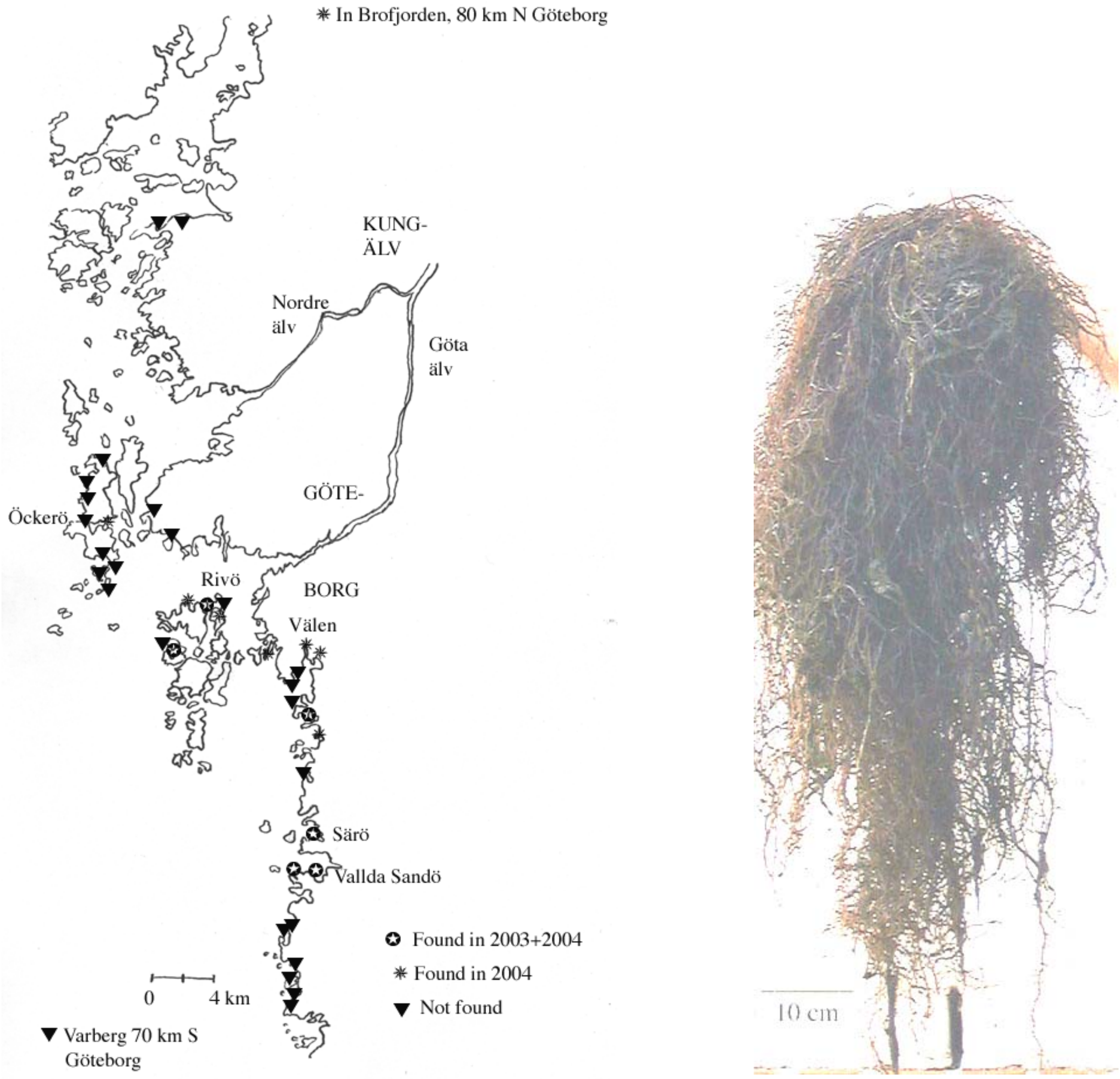

Figure 2a) The known distribution of *Gracilaria vermiculophylla* on the Swedish west coast in October 2004. b) A sample of *G. vermiculophylla* from Välen (Fig. 2a) collected by Cecilia Nyberg in July 2004. Photo Inger Wallentinus.

The species could survive and grow when kept out of water (but moist) in darkness and cold after a period as long as 175 days, when transferred to benign conditions. Furthermore, fragments of less than half a cm can grow to new plants, thus vegetative reproduction is a shortcut to create new populations, and it easily breaks into new fragments (Nyberg and Wallentinus, submitted).

G. vermiculophylla now also occurs in Denmark on the east coast of Jutland, in Horsens Fjord, where it was first observed in 2003 (Ruth Nielsen, Univ. of Copenhagen, pers. comm.) as well as in Germany on the Island of Sylt (Jan Rueness, Univ. of Oslo, pers. comm.).

The occurrence of the Japanese red alga *Heterosiphonia japonica* (*i.e.* "*Dasysiphonia* sp." in WGITMO reports until 2003) in the Koster archipelago since 2002 was reported last year (ICES, 2004). During 2004 this alga was very common on both sides of the Kosterfjord. *H. japonica* was especially frequent on mussels (*Ostrea edulis* and *Modiolus modiolus*) and it was also recorded from a very exposed offshore "shallow" area, Persgrunden, about 20–25 km south of Koster (Axelius and Karlsson, 2004). Although very frequent it is still not considered a real nuisance, but may have replaced some other red algae as an epibiont on mussels (Jan Karlsson, Göteborg univ., pers. comm.).

The red alga *Dasya baillouviana*, introduced in Sweden in the early 1950s, was in the summer of 2004 in some areas seen in higher abundances than previously. In *e.g.* Tjuvkilen (ca 60 km N of Göteborg), it occurred as dense, loose-lying patches of more than half-metre long plants, down to some metres depth (IW pers. obs.). It was also very common in the harbour area in Göteborg (IW pers. obs., Lars-Harry Jenneborg, HydroGIS AB, pers. comm.). The species seems to have increased also in Danish (Ruth Nielsen, Univ. of Copenhagen, pers. comm.) and Norwegian waters (Jan Rueness, Univ. of Oslo, pers. comm.). Also the introduced green alga *Codium fragile* was more common during 2004 than in previous years and was found also in offshore areas in the middle of Kattegat (Jan Karlsson, Göteborg univ., pers. comm.).

The Japanese brown alga *Sargassum muticum* has started to occur within the fucoid belts also around Göteborg (IW pers. comm.), where previously mostly barren shores have been colonized.

The epiphytic community of the introduced Arctic brown alga *Fucus evanescens* was compared with that of the native *F. vesiculosus* to examine to what extent an invading seaweed can modify local biodiversity (Wikström and Kautsky, 2004). *F. evanescens* was much less fouled than *F. vesiculosus*, supporting both less biomass and fewer species of epiphytes. The study showed that the invasion of *F evanescens* affects the environmental conditions for many species associated with the *Fucus* community but that the direct effect on biodiversity probably is low.

There have been NO major changes reported for the distribution or abundance of any of the other introduced macroalgae (*Aglaothamnion halliae* - for its occurrence see the report of WGITMO 2004 (ICES, 2004) - *Bonnemaissonia hamifera, Neosiphonia harveyi, Colpomenia peregrina Fucus evanescens,* on the Swedish west coast and *Chara connivens* in the province of Uppland on the Swedish east coast).

Phytoplankton

For several years we have reported of the raphidophyte *Chattonella* aff. *verruculos*a as a potentially introduced species in Scandinavian waters. Recent research, using molecular techniques as well as ultrastructure and pigment data, has shown that this species does not belong to the class Rhaphidophyceae, but to Dictyochophyceae, and it has been transferred to the new genus *Verruca* (Edvardsen *et al.,* 2004). They also found that the original Japanese species *Chattonella verruculosa* appeared in the same clade and thus the populations in Scandinavia may still have been introduced. In 2004 this alga was found in March at all but one stations along the coast of Bohuslän, with a maximum of ca. 25 000 cells per litre (Skjevik, 2004).

3.4 Parasites, pathogens and other disease agents

The rhabdovirus Eel Virus Europe X (EVEX) was found in samples of small adult eels caught at Hälleviksstrand on the island Orust, in the middle part of Bohuslän, and at Resö on the northern part of the Swedish west coast.

4.0 LIVE IMPORTS during 2004 (for EU countries amounts may be underestimated)

4.1 Fish

For consumption/processing (Metric tonnes)

	Eel from:	Salmon from:	Rainbow trout and trout from:	Carp from:
Denmark	73	4	1	2
Norway	49	22		
The Netherlands	15			
Germany	10			4
Belgium	1			
U.K.	1			
USA		7		
France		3		

Ornamental fish (not specified, marine and freshwaters.) (Metric tonnes)

The Czech Republic	17	Colombia	2
Singapore	11	Vietnam	2
Brasil	5	India	1
Indonesia	5	Malaysia	1
Sri Lanka	5	The Netherlands	1
Denmark	4	Nigeria	1
Israel	4	Peru	1
Thailand	4	Germany	1
Hong Kong	3	USA	1

5.0 Live invertebrates for consumption/processing (Metric tonnes)

	Mytilus from:	Scallops from:	Oysters from:	Various invert.
Norway	1320	354		9
The Netherlands	14	4	29	
Denmark	9	9	6	3
U.K.		13		
USA		7	1	
Belgium		1		
Ireland			10	
Chile			7	
Italy				1

	Lobsters from:	"Crabs" from:
Canada	166	
USA	12	
Norway	11	121
Belgium	8	
Denmark	8	20
Ireland	2	271

6.0 LIVE EXPORTS during 2004 (for EU countries amounts may be underestimated)

7.0 Fish

For consumption/processing (Metric tonnes)

	Eel to	Salmon to:	Rainbow trout and trout to:	Carp to:
Denmark	228			1
Germany	146			
The Netherlands	99			
Belgium	26			
Italy	6			
Poland	1			
Hungary	1			
Norway		1	3	
Finland			7	

Ornamental fish (not specified, marine & freshwater spp.) (Metric tonnes)

Norway	65
Finland	1
Denmark	1

7.2 Live invertebrates for consumption/processing (Metric tonnes)

	Mytilus to:	Scallops to:	Oysters to:	Crabs to:	Various invert.
France	900	20			
Germany	270	19			
Ireland	112				
Belgium	36	55			
The Netherlands	36	38			1
Finland	33	1	1	1	
Denmark	31	47	1		
Norway	23	1			
Poland	10				
Lithuania	1	1			
Spain	1	93			6
Italy		74			
Luxemburg		1			

8. OTHERS ON INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

Research project (others than on ballast water)

In early summer 2004 there was a mid-term evaluation of the research programme "AquAliens - Aquatic alien species - where and why will they pose a threat to the ecosystem and economy?" (financed by the Swedish EPA; http://www.aqualiens.tmbl.gu.se, co-ordinator Prof. Inger Wallentinus, Göteborg univ., see also the WGITMO report 2003 and 2004 (ICES 2003, 2004)). After a reapplication in late autumn 2004 money was guaranteed until May 2007, but some projects starting later will continue even after that. Studies on risks of establishment, dispersal and impact on different aquatic organism groups are being carried out, using both default-tree analyses and various population models.

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NATIONAL REPORT
United Kingdom
2004

Compiled by Ian Laing, Gordon Copp & Tracy Edwards

1.0 LAWS AND REGULATIONS

New EU legislation on imports of live fish (2003/858/EC as amended by 2004/454/EC and 2004/914/EC) and shellfish (2003/804/EC as amended by 2004/319/EC, 2004/609/EC and 2004/623/EC) from third countries came into force in May 2004. This legislation will provide stricter controls on these imports.

2.0 DELIBERATE INTRODUCTIONS AND TRANSFERS

2.1 Fish

A recent study (Copp *et al.,* 2005b) has demonstrated that deliberate releases of fish to public ponds of Epping Forest (NE London) are sufficiently common that the number of varieties of ornamental fish in a pond can be predicted from its distance from the nearest road, with nearest footpath and nearest house also being contributing factors. These relationships are also valid for goldfish (*Carassius auratus*) varieties only. The rate of introduction (number of varieties per year) can also be predicted from the distance to nearest road. A comparison of data from Wheeler (1998) revealed that the proportion of non-native varieties of fish species in ponds of Epping Forest increased dramatically in the 1990s (Copp *et al.,* 2005b), and a similar pattern appears to have occurred in UK rivers (Copp, Stakėnas and Carter, unpublished).

2.2 Invertebrates

Deliberate releases of pacific oysters for cultivation continue at a similar level to that in previous years. The managed manila clam fishery in Poole Harbour continues to flourish; 500 tonnes were harvested in 2003. There are no reports of recruitment of this species elsewhere. There are just two other farm sites for this species in the UK, both in England, and these produced about 18 t in 2003.

3 ACCIDENTAL INTRODUCTIONS AND TRANSFERS

3.1 Fish

Imported sturgeon species, *Acipenser* spp., European catfish *Siluris glanis* and golden orfe *Leuciscus idus*, all normally sold exclusively for ornamental purposes or for angling amenity in enclosed still waters, continue to be captured in river systems. The Asian cyprinid topmouth gudgeon *Pseudorasbora parva* continues to spread, as does sunbleak *Leucaspius delineatus*, with an increasing number of both confirmed and unconfirmed reports (R.E. Gozlan, personal communication). None of the Ponto-Caspian gobies has yet been reported in the UK.

3.2 Invertebrates

Marine

The skeleton shrimp (*Caprella mutica*), an alien crustacean species discovered colonising the sea lochs of the west Scottish coast (see previous UK report) has been noted on fish farm nets in Shetland. A paper on the first record of this species in the UK has been published (Willis *et al.,* 2004). Subsequent studies by the Scottish Association for Marine Science (SAMS) have established that it is widespread on the Scottish West coast.

An alien prawn species, *Palaemon macrodactylus*, has been discovered in the Orwell Estuary, Suffolk (Ashelby *et al.,* 2004). This species originates from NE Asia and has spread as an accidental introduction, probably via shipping. It has also been introduced into Western North America and, recently, continental Europe. It was first recorded in the UK in December 2001. The prawns are locally abundant in the Orwell. There are also a few records from the Stour Estuary (Essex/Suffolk). No ecological effects are yet apparent. There is the possibility of competition with native prawns or predation on young but no measurable decline in other species has been recorded to date.

The Environment Agency has recently identified specimens (confirmed by a consultant) of the polychaete *Marenzellaria viridis* at Woolwich in the Thames. As far as is known this is the first record of this species for the Thames. The species has been described as invasive and there are accounts of it in the Baltic as having reached levels of being around 90% of the fauna present.

Freshwater

An alien crayfish species is reported from the River Waveney, Suffolk. Identification is yet to be confirmed, but it is not signal crayfish. Two separate records 2 miles apart suggest that there might be a breeding population. The means of introduction are not known but it is a type of species that might have been imported either for ornamental purposes or as food.

Signal crayfish (*Pacifastacus leniusculus*) continue to spread. No further information has been received on Environment Agency initiatives on this alien species in England and Wales (see 2004 report), but English Nature will be funding a study on finding methods for eradication.

3.3 Algae and Higher Plants

Sargassum muticum is continuing to spread northwards up the west coast of the UK. It has been found in Loch Ryan (Dumfries and Galloway) and this is the first record for this species in Scotland. A consultancy team spotted a small population of *S. muticum* in February 2004 whilst surveying Cairnryan for an EIA. A subsequent survey by Scottish Natural Heritage (SNH) has confirmed that the seaweed has become established at several other sites around the loch. SNH issued a press release- 'Alien invader found in Scotland for first time' in order to raise awareness of this find in the hope that further sightings can be reported. It has since been found around Great Cumbrae (Scottish Island). SNH hope to undertake a fuller survey in 2005. *S. muticum* continues to spread along the Welsh coast.

During 2004, the presence of *Heterosiphonia japonica* at Alturlie Point near Inverness in the inner Moray Firth was confirmed. This is the first occurrence of this species in Scotland. Investigations were made following complaints regarding detrimental effects on a salmon netting station. There were some problems over correct identification initially, and the species was confused with *Halurus flosculosus*. The Scottish Association for Marine Science (SAMS) eventually confirmed that it was *H. japonica*. This species had previously not been recorded further north than Wales. It was first record in Europe in 1994 and established populations are also found in the Netherlands, Spain, France and Norway.

4.0 LIVE IMPORTS AND TRANSFERS

4.1 Fish

Imports of rainbow trout eggs into the UK were 46.1 million in 2003 (22 million into England and Wales, 24.1 million into Scotland). This represents a substantial (39%) decrease on the total number of eggs imported in 2002 (75.8 million). Imports into Scotland actually increased slightly (by 2.9 million) but fell to only 40% of the level of the previous year in England and Wales. These eggs came mainly from the USA, as well as from disease-free sources within

ICES boundaries including Denmark, Northern Ireland, and the Isle of Man. Imports from South Africa declined substantially. Over 33 t of live eels were imported from France, Holland and Spain, although the latter supplied just one consignment.

Imports of Atlantic salmon eggs into Scotland were 21.2 million in 2003. This represents a small (6%) decrease from the previous year. These eggs came mainly from Iceland and other EU member states, with small quantities from Australia and the USA. Eggs were also imported from Norway for the first time, as sources here are now available. Scotland also received 2.6 million salmon parr and smolts from other EU member states.

4.2 Invertebrates

The hatchery on Guernsey sent half a million pacific oyster seed to shellfish farm sites in England and one and a half thousand native oysters were imported into England from Ireland for comparative trials on bonamia resistance.

Imports of non-native species of live bivalve molluscs and crustaceans for human consumption continues. There are strict controls to prevent them being deposited into the wild, through both disease control and wildlife legislation. About 4.4 thousand tonnes were imported from elsewhere in the EU and less than half of this amount from third countries in 2003. This includes 974 t of live Canadian/American lobsters.

A 90 mm female *Homarus americanus* was caught offshore of Felixstowe, Suffolk on 2nd July 2004. Experts at CEFAS Lowestoft confirmed identification. This is the first report of this species being found in the wild for two years.

5 LIVE EXPORTS TO ICES MEMBER COUNTRIES

5.1 Fish

In 2003, a total of 2.2 million Atlantic salmon ova were exported from Scotland. This continues a declining trend since the year 2000, to a level that is just 6% of the exports in that year. All the 2003 exports were to other EU member states; for the first time, none of the exported ova went to Chile in 2003.

5.2 Invertebrates

Specific information on seed shellfish for relaying is only available where exports are to EU Approved Zones. Pacific oyster seed produced in UK hatcheries were exported to Eire, Jersey and Guernsey and seed *Mytilus edulis* were sent to Guernsey and Jersey. The UK is a net exporter of live shellfish for human consumption and almost all of the 50 000 tonnes of trade goes elsewhere in Europe.

7 MEETINGS

7.1 Research initiatives

7.1.1. A PhD student (Leif-Matthias Herborg) at the University of Newcastle is working on ‘Chinese mitten crab *Eriocheir sinensis* in the United Kingdom’ Current records in the UK are for the Thames (and all its tributaries), Humber (Ouse and Wharf), Tees, Tyne, Ardur, Teign, Chelmer, Rother, and the Mersey estuary.

7.1.2. The Department for Environment, Food and Rural Affairs (Defra) proposes to fund research on a gap analysis of existing monitoring schemes (for the background to this see ‘Consultation on Government response to working group report of the review of non-native species policy’ at http://www.defra.gov.uk/corporate/consult/nnspecies-policy/responses.pdf.

7.1.3. The Department of Environment, Food and Rural Affairs (Defra) has been funding research on the assessment of risks associated with non-native fish species (*e.g.* Copp *et al.,* 2005a). A broader-ranging project was funded in 2004 to develop a risk assessment scheme for assessing all non-native plants and animals in the UK. The final report was submitted in January 2005 by a consortium consisting of CABI-Bioscience, the Centre for Environment, Fisheries & Aquaculture Science (CEFAS), the Centre for Ecology & Hydrology CEH), Central Sciences Laboratory (CSL), Imperial College, and the University of Greenwich (including the National Research Institute). The generic scheme was derived from the most recent, but as yet unpublished, European and Mediterranean Plant Protection Organisation (EPPO) protocols. The UK scheme includes social, economic and environmental impact assessments as well as invasiveness risk screening sub-routines (adapted from Pheloung *et al.,* 1999) as part of this hazard identification section. The framework, which Defra will be using to identify species to be added to UK legislation, also includes receptor and pathway risk assessment modules.

7.1.4. English Nature is funding research on control methods for topmouth gudgeon, as well as work on bullfrogs. The Environment Agency is planning to carry out a trial eradication of topmouth gudgeon from a water body in Cumbria (northwest England).

7.1.5. The Scottish Association for Marine Science (SAMS: www.sams.ac.uk) has work underway on seven alien species, including *Caprella mutica*. Two NERC funded PhD studentships are investigating: 1) distribution, introduction vectors and dispersal mechanisms, environmental tolerance and population dynamics; and 2) environmental/ecological implications and interactions with native species.

7.1.6. A consortium of research institutes led by SAMS and funded by the Esmee Fairbairn Foundation have established a programme 'Conserving native biodiversity by raising awareness of invasive species' as the first UK-wide co-ordinated research programme to look at the impacts of a selection of non-native marine invaders on indigenous species and ecosystems. (See www.marlin.ac.uk/marine_aliens for further information).

7.1.7. Collaborative research between CEH-Dorset and CEFAS on non-native fishes has expanded from small-bodied species to address the pathways of introduction and dispersal; an initiative funded through the EC project 'ALARM', led by CEH.

7.1.8. Post-doctoral studies (funded under the EC Marie Curie Programme) began in January 2004. This two-year study aims to assess the risks and to understand the processes of invasion by non-native fish species within and between river catchments. The EC post-doc has attracted support from the UK Environment Agency and the Natural Environment Research Council in a collaborative study with the University of Exeter (Prof. M.A. Brown) on pikeperch *Sander lucioperca* dispersal dynamics, including laboratory experiments to assess: 1) the development of salinity tolerance in pikeperch; 2) the frequency and duration of pikeperch incursions into saline waters via otolith microchemistry analysis; and 3) the salinity tolerances of sunbleak and topmouth gudgeon. The EC post-doc has also been complemented by collaborative work on pumpkinseed *Lepomis gibbosus* in the form of post-graduate studies (Villeneuve, in preparation) supervised by Prof. M.G. Fox of Trent University and funded through Prof. Fox's Canadian research grants with additional support from a NATO Collaborative Linkage Grant to Dr. G.H. Co (CEFAS). The joint field studies have been examining variations in the growth (Copp *et al.,* 2004) and life history traits (Villeneuve *et al.,* 2005) of pumpkinseed in streams of southern England (East and West Sussex). Current field studies are examining pumpkinseed dispersal patterns, habitat use and interactions with native fish species, in particular brown trout *Salmo trutta* and European eel *Anguilla anguilla*.

7.2 Policy initiatives

7.2.1. The Joint Nature Conservation Committee (JNCC) has produced a database inventory of non-native species for the UK overseas territories. It encompasses some, but limited marine and aquatic species. The report is currently in preparation (Varnham, 2005).

7.2.2. An English Nature contract to carry out an audit of non-native species in England (including freshwater, coastal and marine species) has just been awarded to a consortium led by CEH that includes CEFAS, CSL and NBN. The database will include reference to ICES marine zones for marine and coastal species.

7.2.3. The All-Ireland Review of Invasive Alien Species, conducted by Queens University at Belfast and incorporating information form Northern Ireland has been prepared but is not yet signed off at ministerial level.

7.2.4. Scottish Natural Heritage (SNH) published a similar audit in 2001; this is to be put into a web-based format. The report is available on the SNH web site (http://www.snh.org.uk/trends/seas/default.asp).

7.2.5. The UK Biodiversity Research Action Group (BRAG) has a Non-Natives Species Sub-Group that is specifically looking at gaps in research needed to inform UK policy and practice. The main recommendations from this group will contribute to the European Platform-BRAG.

7.2.6. Defra are currently holding discussions within government on the establishment of a co-ordinating mechanism to ensure that work on non-natives is carried out in a co-ordinated and strategic manner.

7.2.7. Defra has been developing a Code of Practice with the horticultural sector – this includes consideration of the disposal of pondweeds, which can disrupt riparian ecosystems. It is hoped that the Code will be launched this spring (2005).

7.2.8. The Water Framework Directive TAG is further progressing their Risk Assessment system in 2003 (water bodies at risk of not meeting the required ecological status due to non-native species).

7.2.9. In the recently proposed European Index of Biotic Integrity developed by the EC project FAME, the impairment of a river system was found to be best assessed by using all fish species present, *i.e.* including non-native species (Schmutz *et al.,* 2004).

7.2.10. Through the Global Invasive Species Programme (GISP), CABI is also involved in developing new toolkits for (1) best practice on islands, and (2) pathways.

7.2.11. The Wildlife Conservation Research Unit is involved in an Upper Thames tributaries project, which integrates numerous studies, including impacts of invasive species.

7.3 Meetings

7.3.1. Defra has a UK Forum on Invasive Non-native Species, being held in London on 3 March (for UK stakeholders).

7.3.2. UKPopNet is organising two workshops on non-native invasive species: (1) the role of species in biological invasions and range expansion (CEH, January 2005), and (2) linking science, policy and ornamental horticulture to prevent plant invasions (University of York, March 2005). See http://www.ukpopnet.org/ for further information.

7.3.3. A further UKPopNet workshop concerned with identifying the top biodiversity research questions takes place between 15–17 February 2005: prioritising research questions for policymakers and practitioners.

7.3.4. The Annual Meeting of the British Ecological Society (BES) in Hatfield, Hertfordshire, 5–7 September 2005, will include a session on ‘Freshwater diversity: ecosystem function, invasive species and conservation’

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NATIONAL REPORT
United States of America
2004

Compiled by Judy Pederson and Greg Ruiz

1 Laws and Regulations

U.S. Congress has not passed new legislation on aquatic invasions since the reauthorization of the Non-indigenous Species Act (NISA) of 1996 which expired in 2002. However, several new bills are before Congress, a few of which are receiving attention. One relates directly to ballast water (Senate Bill 363) and two complementary proposed bills have been introduced by the Senate (S. 770, number not yet assigned but entered on April 15, 2005) and the House of Representatives (H.R. 1592) also address aquatic (and marine) non-indigenous species issues.

The Ballast Water Management Act of 2005 (S.B. 363) focuses on managing ballast water and proposes standards for ballast water discharge that are more strict than those proposed by the International Maritime Organization (IMO). This bill may be merged with the S. 770 and H.R. 1592 (numbers may change) which also includes a section on managing ballast water but extends its provisions to prevention from all pathways, including research into pathways, support of state management plans, screening of commercial organisms, authorizing rapid response funds, creating education and outreach programs, and developing prevention and control strategies. Another bill has been submitted to codify the National Invasive Species Council that was formed through an Executive Order in 1999 and covers non-indigenous species issues in all ecosystems (terrestrial, aquatic, and marine).

It is likely that these bills will be merged a compromise bill proposed. Passage is not guaranteed.

The U.S. Coast Guard is preparing an Environmental Impact Statement (EIS) that will propose standards and a process for evaluating standards and environmental effects of proposed alterative technologies. The EIS is required as part of the National Environmental Protection Act.

A recent court ruling will require the US Environmental Protection Agency to include ballast water discharge under the National Pollution Elimination Discharge System permits. This ruling applies to a West Coast state and may be appealed. It would not necessarily apply to all of the U.S.

The U.S. Coast Guard has initiated a program to facilitate evaluation of technologies for ballast water treatment. A facility has been built in Key West, Florida which can be used for testing proposed alternative technologies that are ready to be put on ships. The tests are “impartial”, the results will be legally binding, and the outcomes will be used to evaluate whether the technology meets the standards under a US Coast Guard process for acceptance. Application is made to the U.S. Coast Guard for installing a system, which will be reviewed and accepted or not. Ships that have been accepted into the program will be grandfathered with respect to future standards.

Several states have regulations and programs to manage ballast water and are in various stages of implementation.

2 Deliberate Introductions and Transfers

Invertebrates

Crassostrea ariakensis in eastern North America

The introduction of *Crassostrea ariakensis* into tidal waters of the Chesapeake Bay was approved and implemented in 2004 when 800 000 oysters were deployed. These were removed in February 2005 from the test sites. Of 7600 oysters tested, four had the ability to reproduce, but the odds are purported to be low (no number given) that fertile oysters were close enough to reproduce.

The Virginia Seafood Council was given approval to continue to grow sterile oysters at ten sites in mesh bags inside submerged cages. It will follow similar protocols to the previous experiment. The oysters are triploids and deemed to be free of parasites. However, environmental groups are concerned that they may cause problems in the ecosystems beyond competition with native oysters. In addition, although *C. ariakensis* appears not to be susceptible to diseases, it is not tolerant of pollution, especially low oxygen.

Other Molluscan Species

As indicated in previous reports, several non-native mollusks are grown along the Pacific coast, including the oyster *Crassostrea gigas*, mussel *Mytilus galloprovincialis*, and clam *Tapes philippinarum*. Along the Atlantic coast the oyster, *Ostrea edulis* continues to be cultured at several sites. Detailed information about the scale of aquaculture for these species, and possible movement of aquaculture products – regionally, nationally, and internationally, remains elusive.

3 Accidental Introductions and Transfers

(Information on most of the newly reported species given below were provided by Drs. Amy Benson and Pamela Schofield, U.S. Geological Survey, Gainesville, Florida)

Invertebrates

Atlantic Coast

Didemnum sp. In 2000, a survey in Massachusetts reported that a species of *Didemnum* was first identified in New England waters. Upon examination of archived samples, *Didemnum* sp. was present in Boothbay Harbor, Maine in 1993 and the Damariscotta River, Maine in 1988 (identifications by Gretchen Lambert, Friday Harbor Labs, Washington). The species is very abundant in biomass and is growing aggressively along both the Pacific and Atlantic coasts, occurring abundantly in both shallow and deep water in the northeastern U.S. The current range is much greater than reported last year. Species identification is unknown and previous species names that were assigned (*e.g. D. vexillum* and *D. lahillei*) are not being used in the U.S., although species nomenclature in New Zealand assigned different species names to organisms from Georges Bank and New Zealand. Given the uncertainty in nomenclature, *Didemnum* sp.'s geographic origin is unknown, although molecular studies indicate that 18S is similar in organisms collected from the Atlantic and Pacific coasts, Japan and New Zealand. However, additional molecular studies are being conducted to confirm or refute that these are the same species.

Didemnum sp. was reported as covering 70% of a 75 km^2 area in Georges Bank prime Atlantic scallop and groundfishing area. This is the first report of an introduced species in an area near the continental shelf break. Commercial vessel traffic and fishing vessels traverse and visit this area. A recent Workshop on Ascidians held in Woods Hole, Massachusetts (April 21–22, 2005) highlighted ongoing research on *Didemnum* sp. and other introduced ascidians.

Crassostrea ariakensis, the Suminoe oyster, was used in a research project in Roanoke and Pamilico Sounds, North Carolina where it was accidentally released in 2004.

Perna viridis. The range for this species has increased and can be found from Titusville north to Jacksonville (about 210 km). This is an expansion of its range from the first report of its introduction in Tampa Bay, Florida (Gulf of Mexico coast).

Charybdis hellerii. The first report in Florida's Gulf Coast of this Indo-Pacific crab was from Bradenton in 2004. It was previously only reported on Florida's Atlantic Coast.

Mytella charruana. The Charru mussel was first collected near a power plant in Jacksonville, Florida in 1986, but appeared to disappear. It was collected in 2004 in Mosquito Lagoon near Titusville, Florida. The mussel is a native of the east coast of South America.

hyllorhiza punctata. No new information on this species for 2004.

Caprella mutica. This species was observed in samples during a 2003 rapid assessment survey in locations from Portland, Maine to Mystic, Connecticut. It can be very abundant locally.

Ficopomatus ushakovi and *Hydroides diramphus*. No new information on these species.

Pacific Coast

Littorina littorea. No new information is provided for this gastropod species.

Hydroides diramphus. No new information for this polychaete species

Fish Species

Platax orbicularis. In June 2004, three orbiculate species of batfish were reported off Molasses Reef in the Florida Keys. Two of the three species were captured and taken to the Florida aquarium, but *P. orbicularis* has been sighted in the area.

Salmo salar. In 2003 and 2004, Atlantic salmon were captured in Ketchikan, Alaska. They are believed to be escapees from fish farms and are a concern that they may outcompete native species.

Pterois volitans. The lionfish has been observed off the coast of North Carolina since 2000 and were sighted again in 2004. Anecdotal information suggests that young fish were also observed suggesting the lionfish may be breeding.

Cephalopholis argus. In December 2004, a peacock hind was reported off Boca Raton, Florida.

Algae and Higher Plants

Three different Asiatic species or strains of *Porphyra* have been reported from Long Island Sound and the Gulf of Maine. These are cryptic species and have been confused with other native taxa. No further details were reported by Art Mathieson (University of New Hampshire, New Hampshire).

Undaria pinnatifida and *Ascophyllum nodosum*. No new information has been reported for any of these algal species.

Caulerpa taxifolia. No new reports of its reappearance.

Parasites, Pathogens and Other Disease Agents

None reported for 2004.

4 Selected Recent Publications in 2004

Froese, R. and D. Pauly. Editors. 2004. FishBase. World Wide Web electronic publication. www.fishbase.org, version (09/2004)

Morton, A. 2004. A salmon sleuth's disturbing find. The Tyee. November 21, 2004.

Semmens, B.X., Buhle ER, Salomon AK, Pattengill-Semmens CV. 2004. A hotspot of non-native marine fishes: evidence for the aquarium trade as an invasion pathway. Marine Ecology Progress Series, 266: 239–244.

Washington Department of Fish and Wildlife. 2004. Commercial production of Atlantic Salmon, escapes and recoveries in Washington State. Washington Department of Fish and Wildlife.

Annex 4: National Report for Guest Countries

NATIONAL REPORT

Italy

2004

Prepared by Anna Occhipinti-Ambrogi

SUMMARY: Findings of NIS in Italian marine waters are reported. A revision of the list of NIS found in Italian waters in he last decades, together with an annotated catalogue of algae, have been produced. Some information is available for species that are enlarging their distribution in Italian waters. Some specific research projects have been concluded and the results allow a better understanding of the situation of Italy in the context of the Mediterranean Sea.

1.0 LAWS AND REGULATIONS

Italy, Croatia and Slovenia have established an interministerial Trilateral Ballast Water Management Sub Commission for the Adriatic Sea, in recognition of the need to promote a concerted action on the introduction and transfer of marine organisms through ships' ballast waters and sediments in the Adriatic. The Sub Commission provides technical and scientific support for the implementation, in the Adriatic Sea, of the International Convention for the Control and Management of Ship's Ballast Water and Sediments, signed at IMO (International Maritime Organisation) on February 2004.

The Sub Commission is presently reviewing existing and future pressures, addressing issues related to ballast waters risk assessment and working on the identification of criteria for the designation of a ballast water exchange area in the Adriatic Sea, with reference to the provision set in Regulation B-4.2 of the International Convention.

2.0 DELIBERATE RELEASES

2.1 Fish

2.2 Invertebrates

The impact of harvesting on Manila clam beds in the Lagoon of Venice has been further studied with particular reference to the effects on macroalgal biomass and water transparency, that are still continuing to decline (Sfriso *et al.,* 2003 a,b).

Moreover, *Tapes philippinarum* is progressing southwards along the Italian coast of the Adriatic Sea: numerous individuals have been found in the harbour of Ancona and in the muddy sands close to the artificial breakwaters of Senigallia (C. Solustri, pers. comm.).

3.0 ACCIDENTAL INTRODUCTIONS AND TRANSFERS

3.1 Fish

The following species have been added to the list of NIS for Italian coasts.

Siganus luridus has been recorded for the first time in Italy from the Linosa and Lampedusa islands near Sicily. (Azzurro and Andaloro, 2004; Azzurro *et al.,* 2004a, b).

One juvenile specimen of the sandbar shark *Carcharhinus plumbeus* was recorded for the first time from the southern Tyrrhenian Sea. The specimen has been collected in an area of the Sicilian coast where trawling is banned except for scientific purposes. Morphometrics and meristics data are given (Consoli *et al.,* 2004).

New information was made available for the following species that have been already reported in the previous years.

From 1994 to 2002, 80 lesser amberjacks, *Seriola fasciata*, were caught in Sicilian waters, where the population is well established. *S. fasciata* has been recorded in 2002 for the first time in Sardinian waters, near Oristano (Andaloro *et al.,* in press). Also *Seriola carpenteri* (Pizzicori *et al.,* 2000) has established stable populations. A third species, *Seriola rivoliana*, has been found only occasionally (Castriota *et al.,* 2004).

Fistularia commersonii is a lessepsian species recorded for the first time in 2000 along Israeli coast; subsequenly it has been found in the Eastern Mediterranean. The first individual of *Fistularia commersoni* in Italy has been caught in the waters of Lampedusa island in December 2002, followed by 10 other records (5 in Italian waters) from the Sicily straits (Fiorentino *et al.,* 2004, Azzurro *et al.,* 2004b, c). The first finding in the Western Mediterranean occurred in the Gulf of Castellamare in November 2003 (C. Pipitone, pers. comm.).

3.2 Invertebrates

The following species have been added to the list of NIS for Italian coasts.

Aplysia dactylomela (Scuderi and Russo, in press) have been recorded for the first time from Italian waters, from a marine reserve area in Sicily.

New information was made available for the following species that have been already reported in the previous years.

Further records of *Melibe viridis* (syn. *Melibe fimbriata*) have been reported by Scuderi and Russo (2003) from Sicily and by Mastrototaro *et al.,* (2004) in the North-Western Ionian Sea. It can be considered a definitively resident species in the opistobranch fauna of the semi-enclosed bays of Taranto, where most specimens of *M. viridis* were observed during diurnal foraging activity and associated with anaspideans species, like native *Aplysia depilans* and the lessepsian immigrant *Bursatella leachii* (Carriglio *et al.,* 2004).

The arcid bivalve *Anadara demiri* appears to have gained full status as a component of the Adriatic Sea coastal benthic community despite its very recent first entry, three years ago (Morello *et al.,* 2004).

The diet of the mytilid *Brachidontes pharaonis* has been studied by Sarà *et al.,* 2003.

The distribution and biology of the whelk *Rapana venosa* in the Northern Adriatic Sea has been investigated. The maximum density has been found in the area of Cesenatico (Emilia Romagna coast). The reproductive potential has been estimated (Savini and Occhipinti Ambrogi, 2004a, b)

Numerous clams, *Mercenaria mercenaria* have been collected in the brackish embayment of Goro, in the Po River Delta region (M. Turolla, pers. comm.)

The eastern Pacific isopod *Paracerceis sculpta* has been recorded in the Gulf of Olbia, Sardinia (Munari pers. comm.).

The American mud crab *Dyspanopeus sayi* has established a population in the North Adriatic brackish environment of the Valli di Comacchio (Munari pers. comm.), and it has been observed to feed on the Asian bivalve *Musculista senhousia* (Mistri, 2004).

The subtropical crab *Percnon gibbesi*, already known from Sicily, is rapidly expanding towards North being recorded in islands of Ischia and Procida and along the coast of Campania at Gaeta (Russo and Villani, in press).

The stolidobranch ascidian *Polyandrocarpa zorritensis* was detected, for the third time in the Mediterranean, in the harbour of Taranto. Colonies develop vigorously on all hard substrata in shallow water and now represent one of the most important elements of the local fouling community. The morphology of the larva, and a vascular budding mechanism of replication, similar to that known to occur in the Botryllinae, were both observed for the first time (Brunetti and Mastrototaro, 2004).

3.3 Algae and Higher Plants

The following microalgal species have been added to the list of NIS for Italian coasts:

Prorocentrum mexicanum, a dinoflagellate producing toxins in culture, was found in the coastal waters of Southern Adriatic by Cabrini (in press) for the first time in summer 2001. The occurrence of the dinoflagellates *Ceratoperidinium* cf. *yeye* and *Centrodinium* sp. in the Gulf of Trieste (Northern Adriatic Sea) was reported for the first time in the summer of 2003 (Virgilio *et al.,* in press).

Trichodesmium erythreum is a colonial cianobacterium also found in Sicily (Barone, 2004), where it has formed in 1990 a large bloom of several km^2 causing sea scum.

In ballast water sample coming from Port Said (Egypt), the macroalga *Ulva ohnoi* (Ulvales, Chlorophyta) was identified. This species was described for the first time in Japan (Hiraoka *et al.,* 2003) and not yet in the Mediterranean. For that reason, even if the species was not found in the field, it represents a new record for the Mediterranean.

A list of accepted alien macrophytes occurring in the Mediterranean Sea has been published by Cormaci *et al.* (2004). Of each species, a brief description, world and Mediterranean distribution, the chorology and the possible vector are given. The list consists of 52 Rhodophyta, 15 Ochrophyta, 13 Chlorophyta and 1 Monocotyledones for a total of 81 taxa at specific and infraspecific level and 3 taxa at generic level. Several taxa currently considered as introduced in literature are not included, justifying the exclusion for considering them as non-introduced or non valid taxa.

Consequently some of the species that have been quoted in the previous WGITMO Italian National Reports should be reconsidered in this respect.

Asparagopsis taxiformis might have a pre Tethian origin and is probably to be considered as cryptogenic. It is now in an expansion phase, it was mentioned before from the Italian peninsula and three sites of Sicily and it has been found in 2001 near Trapani along the east coast of Sicily (Barone *et al.,* 2003).

New information was made available for the following species that have been already reported in the previous years:

An *Alexandrium catenella* bloom occurred in the Olbia harbour (Sardinia) in 2002, ending with the exportation of high cell densities out at sea, raising concern for the possible PSP toxins contamination (Vila *et al.*, 2004).

The red alga *Hypnea cornuta* and the green alga *Codium fragile* ssp. *tomentosoides* have been added in 2000 to the alien flora of Taranto (Cecere and Petrocelli, 2004; Cecere *et al.*, 2004).

Undaria pinnatifida in the Lagoon of Venice is still playing an important role in the algal community in the canals of the historical city centre (Curiel *et al.*, 2003, 2004).

The colonization of the green alga *Caulerpa racemosa*, ten years after it began to spread in the Mediterranean Sea, has been reassessed. The alga has been documented along the coasts of 11 states, developing on all kind of substrata, both in polluted and in unpolluted areas, between 0 and 70 m. The colonisation of *C. racemosa* invasive variety in the northern coasts of the

Mediterranean Sea, from French to Croatia, concerns approximately 600 km of coastline (Piazzi *et al.*, 2003; Piazzi *et al.*, in press).

The feasibility of manual eradication of *Caulerpa racemosa* has been evaluated through experimental removals of the alga from patches of different sizes in 4 habitats. Manual removal alone is not sufficient to prevent regrowth from fragments left in the sites; a combination of destructive methods of control, such as a mechanical scraping and the use of a benthic vacuum, may enhance the probability of success and result in the best habitat conservation (Ceccherelli and Piazzi, in press).

Physiology of Caulerpa *racemosa* has been studied in the area of Naples (Raniello *et al.*, 2004).

Genetic polymorphism has been compared between putative native (Red Sea) and introduced (Mediterranean) populations of the marine angiosperm *Halophila stipulacea* through rDNA ITS region (ITS1-5.8S-ITS2) sequence analysis. A high degree of intraindividual variability of ITS sequences was found (Ruggiero and Procaccini, 2004).

7.0 MEETINGS, Conferences, Symposia or Workshops on Introductions and Transfers

The "Gruppo Alloctoni of the Italian Society of Marine Biology", coordinated by Anna Occhipinti-Ambrogi, has produced an updated list of introduced marine species in Italy on a poster presented at 39th EMBS (European Marine Biology Symposium), Genoa, Italy, 21–24 July 2004.

Two reviews of non indigenous mollusks in the Mediterranean have been presented at international conferences in Bern (Switzerland) and Sligo (Ireland) by Scotti *et al.* (in press a, b).

The research program coordinated by ICRAM (Central Institute for Marine Environmental Research, Rome) has been completed in September 2004, producing a baseline study on the identification of non-indigenous species along the coasts of Italy. It has been performed by ICRAM, in collaboration with many Universities, on behalf of the Ministry of the Environment, in application of the Protocol on Specially Protected Areas of Mediterranean Interest of the Barcelona Convention and of Article 8 h of the *Convention on Biological Diversity*. The results comprise a geo-referenced data base and an atlas for 8 animal and plant taxa. Also aquarium and aquaculture species have been considered. Additionally a tissue bank has been formed at ICRAM. During the project 12 grants have been awarded to young researchers to enhance taxonomic expertise.

The European project 'Algal Introduction to European Shores' (ALIENS) (funded by EC) was concluded in January 2005. Member states involved were Italy, Spain, France, Portugal and United Kingdom. The aim was to improve knowledge on macroalgal introductions by studying their distribution, ecophysiology, genetic variation and vectors in order to assess the relative importance of local versus global impacts and the differences in susceptibility to invasion throughout European seas. The group of the Stazione Zoologica 'A. Dohrn' of Naples (Italy) was involved in:

i) Survey of introduced macroalgae in the Gulf on Naples. In the Gulf of Naples, *C. racemosa* showed a wider spreading than. Their spatial distribution were independent to anthropogenic impacts. A total of 193 taxa were identified and 4 non native species were found: *Caulerpa racemosa var. cylindracea, Asparagopsis taxiformi, Acrothamnion preissii, Womersleyella setacea.*

ii) Impact on native communities by invaders exclusion. Removal of *Asparagopsis* caused a significant decrease of erect species percent cover only for horizontal substrate, with a simultaneous increase of turf's cover. The removal of *Caulerpa* did not show any evident effects on the native algal community.

iii) Introduction of allochthonous species in ballast waters in the Gulfs of Naples and Salerno (Soria, 2004; Flagella, 2004)

iv) Temperature responses in growth and photosynthesis under culture conditions. *Asparagopsis taxiformis* demonstrated that this species was well acclimated to the thermal local environment and it could occur in colder areas of the Mediterranean, as no mortality was detected at lower thermal range (10°C). The studied population of *C. racemosa* var. *cylindracea* seemed to respond differently depending on season (winter or summer) (Flagella, 2004).

v) Phylogenies inferred from mitochondrial, plastid and nuclear DNA sequences from specimens of *Asparagopsis taxiformis* and *A. armata*, obtained throughout their distribution range, showed that *A. taxiformis* was distinct from its sister species *A. armata*. The latter lacked phylogeographic structure, which corroborated the species' recent history of introductions. In contrast, *A. taxiformis* consisted of at least three and probably four genetically distinct lineages suggestive for cryptic species.

A research project on the distribution and reproductive potential of *Rapana venosa* in the Northern Adriatic Sea, funded by the Ministry of Environment, has been terminated in 2004.

A project on the monitoring of alien species in the Taranto inlets has been funded by the Ministry of Education and Research.

A research program funded by the Region Tuscany on biodiversity will be devoted to the problem of non-indigenous species.

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It has been prepared according to the guidelines for ICES WGITMO National Reports; it updates the Italian status presented in Cesenatico, March 2004.

Prepared by Anna Occhipinti-Ambrogi - Ecology Section, Dept. "Ecologia del Territorio" University of Pavia, Via S.Epifanio,14 - I-27100 Pavia, Italy, February 2005

The following people provided information for the preparation of this report:

Franco Andaloro
Rossella Barone
Marina Cabrini
Giulia Ceccherelli
Maria Cristina Buia
Luca Castriota
Ester Cecere
Mario Cormaci
Daniele Curiel
Monia Flagella
Giovanni Furnari
Cristina Gambi
Giuseppe Giaccone
Erika Magaletti
Anna Maria Mannino
Francesco Mastrototaro
Michele Mistri
Daniela Petrocelli
Carlo Pipitone
Dario Savini
Fabrizio Serena
Adriano Sfriso
Cristiano Solustri
Edoardo Turolla

Annex 5: Draft Species Alert Report *Undaria pinnatifida*

Alien Species Alert: *Undaria pinnatifida* (wakame or Japanese kelp)

Draft compiled by

Inger Wallentinus, Dep. Marine Ecology, Marine Botany; Göteborg University,

P.O. Box 461, SE 405 30 Göterborg, Sweden, E-mail: Inger.Wallentinus@marbot.gu.se

1 Introduction

The Japanese kelp *Undaria pinnatifida* (Harvey) Suringar 1873, is native to the NW Pacific, and first turned up on another continent (for details see below), as an unintentional introduction when Japanese oysters were brought to the French Mediterranean coast. In the early 1980s it was intentionally introduced from the Mediterranean for farming in Brittany, N France, from where it later dispersed to other European countries. In the late 1980s it was recorded both from New Zealand and Australia, being brought by shipping from Asia, which was also the vector for its spread to Argentina in the early 1990s. In the early 2000s it occurs on all continents except – so far – in Africa.

The size of this canopy species and its beltforming growth pattern, its great tolerance for surviving adverse conditions and its high affinity to grow on artificial substrates, has made it one of the main target species for biosecurity (see also *e.g.* GISD, 2005; Hewitt *et al.,* 2005). Fletcher and Farell (1998) listed eight characters, which contribute to its success:

* Ability to rapidly colonize new or disturbed substrate (pioneering species)
* Ability to colonize a wide range of artificial structures
* Ability to colonize a wide range of substrate, including plants and animals
* Fast growth rate resulting in sporophytes with a large canopy
* Large reproductive output, where spore release may occur all year round
* Plants may be present all year
* Wide physiological tolerances for temperature, light and salinity
* Wide vertical distribution

In a paper ranking specific traits of 113 seaweeds introduced into Europe for the three main categories: dispersal, establishment and ecological impact, *U. pinnatifida* overall was the third most invasive species (Nyberg and Wallentinus, 2005). When ranking introduced marine animals and algae with the highest human, economic and environmental impacts for all species already in Australia, *U. pinnatifida* would rank ninth, if the maximum scores were used (Hayes *et al.*, 2005).

However, *U. pinnatifida* is also the third most harvested and cultivated seaweed, being used for human consumption (*e.g.* Yamanaka and Akiyama, 1993; Zemke-White and Ohno, 1999; Wu *et al.*, 2004). It is also used as food item for *e.g.* cultured abalone.

Voisin and coworkers (2005), by using two intergenic noncoding mitochondrial loci, studied within-species genetic variation of ***U. pinnatifida***. Twenty-five haplotypes were found over the whole dataset (333 base pairs, 524 individuals, and 24 populations). The native range showed striking population genetic structure, stemming from low diversity within and high differentiation among populations, a pattern not observed in the introduced range of this species. Contrary to classical expectations of founding effects associated with accidental introduction of exotic species, most of the introduced ***Undaria*** populations showed high genetic diversity. At the regional scale, genetic diversity and sequence divergence showed contrasting patterns in the two main areas of introduction (Europe and Australasia), suggesting different processes of introduction in the two regions. Gene genealogy analyses pointed to aquaculture as a major vector of introduction and spread in Europe but implicate maritime traffic in promoting recurrent migration events from the native range to Australasia. The multiplicity of processes and genetic signatures associated with the successful invasion confirms that multiple facets of global change, *e.g.*, aquaculture practices, alteration of habitats, and increased traffic, act in synergy at the worldwide level, facilitating successful pandemic introductions.

2 Identification

PHYLUM:	HETEROKONTOPHYTA
Class:	Phaeophyceae
Order:	Laminariales
Family:	Alariaceae
Genus:	Undaria
Species:	*pinnatifida*

Old synonyms:
Alaria pinnatifida Harvey 1860
Ulopteryx pinnatifida (Harvey) Kjellman 1885

Like other kelps in the order Laminariales the species has a heteromorphic, diplohaplontic life cycle (Figure 1) with a large sporophyte and separate, microscopic female and male gametophytes. In most areas the sporophyte reaches a length of 1 to 2 or even 3 metres (Okamura, 1926; Peréz *et al.*, 1984; Hay, 1990; Sanderson, 1990; Floc'h *et al.*, 1991; Hay and Villouta, 1993; Casas and Piriz, 1996; Castrich-Fey and L'Hardy-Halos, 1996; Castrich-Fey *et al.*, 1999a, 1999b), but is usually less than 1 metre in the Mediterranean Sea (Boudouresque *et al.*, 1985, Curiel *et al.,* 1998, 2001), on the Spanish coast (Santiago Caamaño *et al.*, 1990), in some populations in New Zealand (Hay and Villouta, 1993; Brown and Lamare, 1994) and Victoria, Australia (Campell and Burridge, 1998), as well as in waters with high turbidity (*e.g.* Floc'h *et al.*, 1996; Curiel *et al.,* 2001). The sporophyte has a yellowish-brown to brown, membraneous to leathery lamina, becoming greenish olive when drying. The stipe, forms with short or long stipes can occur together (Castrich-Fey *et al.*, 1999a) is lighter in colour and attached by root-like hapters as for most other European kelps. The ca 50–80 cm broad lamina

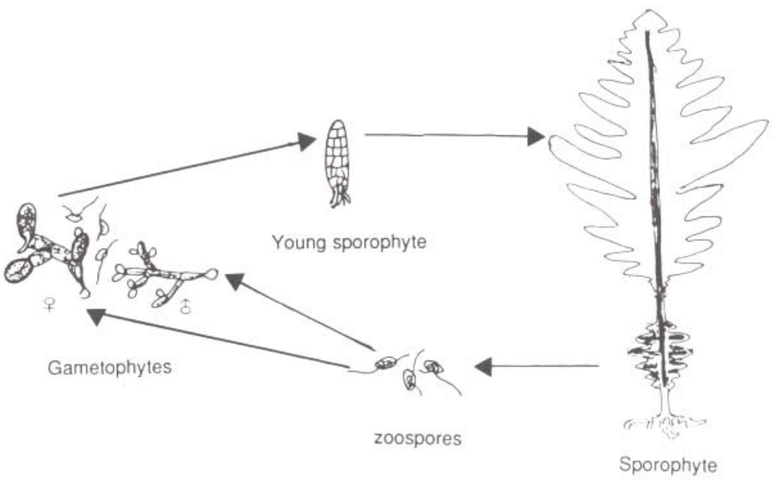

Figure 1. The life cycle of *Undaria pinnatifida*.

is pinnate, but the forming of lobes can sometimes be suppressed (Okamura, 1926) with an evident midrib all way through, which can be up to 1–3 cm wide. The growing zone is located between the top of the stipe and the lamina, making the top of the lamina the oldest part. The basal part of the sporophyte develops two undulated, winglike, frilly sporophylls (one along each side of the stipe, but they may become interleaved and look like one unit) with zoosporangial sori, producing millions of spores per gram tissue (Saito, 1975).

Photosynthesis slows down and growth stops in most areas at high water temperatures (see below) when most of the lamina deterioate, and the stipe and holdfast usually disappear during the end of summer (Saito, 1975; Boudouresque, *et al.,* 1985; Brown and Lamare, 1994; Casas and Piriz, 1996; Oh and Koh, 1996; Castrich-Fey *et al.,* 1999b), but may also persist (Hay and Villouta, 1993; Thornber *et al.*, 2004). Some introduced populations have two to several generations during a year, *i.e.* both small and large sporophytes are found together (Hay, 1990; Floc'h *et al.*, 1991. Castric-Fey *et al.*, 1993; Hay and Villouta, 1993; Casas and Piriz 1996; Castrich-Fey *et al.,* 1999b). The species is not known to reproduce vegetatively by fragmentation. However, asexual reproduction through unfertilized eggs, which can develop into parthenogenetic sporophytes, has been recorded in laboratory experiments (Yabo, 1964; Fang *et al.*, 1982). Recently a technique using mass cultivation of gametophytic clones has been developed to produce new young sporophytes for cultivation (Wu *et al.*, 2004).

The microscopic gametophytes (Figure 1) are very difficult to spot in the field. The female plants consist of only a few cells bearing the oogonia and the males of some more, smaller cells bearing antherida. The gametophytes may have a dormancy period and thus act as a seed bank (Thornber *et al.*, 2004; Hewitt *et al.,* 2005), especially at low light, and are capable of surviving adverse conditions as thick-walled resting stages (Saito, 1975). After fertilization young sporophytes develop, at first attached to the female gametophyte. Very young sporophytes (<10 cm) lack a midrib, but from a size of about 1 cm they are distinguishable from those of other kelps through their glandular cells (Yendo, 1911; Okamura, 1926; Castrich-Fey *et al.*, 1999a) appearing as small dark dots visible at close inspection.

The species include at least two morphological forms f. *typica* Yendo and f. *distans* Miyabe & Okamura, the latter with a longer stipe and sporophylls, which often do not reach all the way up to the lamina (Okamura, 1926). Stuart and coworkers (1999) studied the effects of seasonal variation in growth rate on the morphology of *U. pinnatifida* to define the form of *U. pinnatifida* growing in Otago Harbour, New Zealand, by using correspondence analysis. They found that the variation in the morphology of *U. pinnatifida* was largely accounted for by varying growth rates and that it was equivocal to define the form of *U. pinnatifida* growing in Otago Harbour, since morphological characteristics of both f. *typica* and f. *distans* could be found at different times of the year. It has been discussed, if these forms may also be genetically different (Hay and Villouta, 1993, Castrich-Fey *et al.*, 1999a).

There are two other species of the genus: *U. undarioides* (Yendo) Okamura 1915, occurring in Japan, and *U. crenata* Y-P Lee & JT Yoon 1998, described from Korea. A third species, *U. peterseniana* (Kjellman) Okamura 1915, has later been moved to the genus *Undariella* (Guiry and Nic Dhonncha, 2005). These species might be misidentified as *Undaria pinnatifida*, but they are not known to have been introduced to other regions.

The grown-out sporophytes of *Undaria* are very characteristic with an evident midrib and can hardly be misidentified in European waters. The only other European kelp with a midrib in the lamina is the much more narrow and up to 4 m long plant of *Alaria esculenta* (L.) Greville 1830, with an entire lamina not split into pinnate lobs, although the lamina might look lobed in an eroded state. The two species are also easy to separate by the form of the sporophylls. *Alaria* has several thick, leaflike sporophylls at the base of the stipe, protruding from each side, being much different from the undulated "frills" of *Undaria.* Undulated, winglike sporophylls along the stipe are also developed on the Atlantic kelp *Saccorhiza polyschides* (Lightfoot) Batters 1902, which often grows together with *U. pinnatifida* in European waters. However, that kelp lacks a midrib and has a lamina deeply cleft into many linear, vertical segments. Furthermore, its characteristic bell-shaped, warted basal area above the disc with short attaching hapters differs much from the long, branched root-like hapters of *Undaria* and other kelps. For very young *Undaria* sporophytes without a well-developed midrib see above about the special gland cells.

In other areas the kelp *Ecklonia radiata* with a lobed lamina, but lacking a midrib, might be mistaken for *U. pinnatifida*. (to be expanded incl. pictures)

3 Biology in the Native Range

Undaria pinnatifida is native along the northwestern Pacific shores: along most of the coasts of Japan, excl. N and E Hokkaido (Okamura, 1926; Saito, 1975), Korea (Kang, 1966), some northeastern parts of China (Tseng, 1981; Zhang *et al.,* 1984) and in southeast Russia in Peter the Great Bay near Vladivostok (Funahashi, 1966, 1974; Prestenko, 1980) and in the Okhotsk Sea (Zinova, 1954). In 1981 it was intentionally introduced to Taiwan from Japan for farming (Liao and Liu, 1989).

3.1 Current status, population demographics and growth rate

Most of the recent literature from that area deals with farmed *U. pinnatifida*, and thus more information is needed for densities, population dynamics and growth rates of wild plants.

At the northern distribution limit of the species in Peter the Great Bay, the Sea of Japan, Russia, the growth, morphology, alginate yield and composition of *U. pinnatifida* was studied from March to August by Skriptsova and coworkers (2004) who found an average sporophyte growth rate of 2–5% d^{-1} and that sporulation caused changes in morphology, alginate yield and composition.

3.2 Natural history (tolerance limits for abiotic factors) in native region

Substrate and depth

According to Saito (1975) *U. pinnatifida* grows naturally at rocks and reefs from ca. 1–15 m depth. On the coast of Hokkaido, Japan, Agatsuma and coworkers (1997) found that areas grazed by sea urchins, constituting coralline flats, after removal of sea urchins were recolonized in order by attaching diatoms, small annual algae such as *Ulva pertusa* and *Polysiphonia morrowii*, large annual algae such as *Desmarestia viridis* and *Undaria pinnatifida*, and small perennial algae such as *Dictyopteris divaricata*, followed by the large perennial alga *Sargassum confusum*.

Temperature

Since *U. pinnatifida* is widely distributed along the Japanese coasts the growing and maturing times differ due to temperature (Saito, 1975) and he considered optimal growth of young sporophytes to be between 15 and 17 °C, whereas old thalli grew better at somewhat lower temperatures. Akiyama and Kurogi (1982) gave a total range of 4–25 °C for growth of sporophytes from NE Honshu, Japan, where plants appear in October-November and disappear in July-August, but they may stay until September (-October) in some northern areas (Kurogi and Akiyama, 1957). On the east coast of Korea the growing period is stated to be between December and June (Koh, 1983). In NE Honshu, Japan, maturation of zoospores occur in March to July at a temperature range of 7–23°C (Akiyama and Kurogi, 1982), while Saito (1975) stated that zoospore release needed a ten-day average temperature of ≥14 °C and that 17–22 °C was optimal. The microscopic gametophytes could survive temperature range of –1–30 °C (Saito, 1975) and he stated that growth was possible between 15–24 °C. However, according to Akiyama (1965) it was possible for gametophytes to grow, mature and release male gamets in a total temperature range of 5–28°C, but that their optimum was at 15–20 °C.

Light

The light saturation levels of photosynthesis in sporophytes vary with season (Matsuyama, 1983; Oh and Koh, 1996) ranging from around 120–500 µE m^{-2} s^{-1} (Matsuyama, 1983: Figure 1) or even around or below 100 µE m^{-2} s^{-1} (Oh and Koh, 1996). The light compensation point (I_c), *i.e.* below which no net photosynthesis occurs, is very low and only amounts to around some few µE m^{-2} s^{-1} (Wu *et al.,* 1981; Matsuyama, 1983; Oh and Koh, 1996) and it has very low respiration rates (Oh and Koh, 1996). The gametophytes are able to survive in darkness for at least seven months (Kim and Nam, 1997), and continuous darkness between 17–25° C was recommended by them as the best way of preserving gametophytes. Experiments in Japan showed that gametophytes and very young sporophytes exposed to 50–100% direct sunlight and from 16–28% and upwards of natural UV radiation died within hours (Akyiama, 1965). He also found that in some populations gametophytes matured under both long and short nights, while others needed long nights.

Salinity

Most of the experiments reported in the literature have been performed in normal seawater, but salinities above 15‰ Cl (> 27 PSU) was quoted by Saito (1975) as necessary for growth of sporophytes and gametophyte development, although zoospores could attach above 10‰ Cl (>19 PSU).

Nutrients

Tests with slow-leaking fertilizers (ammonium) increased both yield and number of harvests in Japanese farms (Ogawa and Fuijita, 1997). In spring a low supply of inorganic nitrogen was found to decrease the growth rate (Yoshikawa *et al.*, 2001). In experiments with juvenile sporelings Wu and coworkers (2004) found that inorganic nutrient concentrations around 300 μmol nitrate-N l^{-1} and 20 μmol phosphate-P l^{-1} were sufficient to maintain a high daily growth rate.

3.3 Reproduction

For relation of temperature to reproductive stages see above. According to Saito (1975) current velocities above 14 m s^{-1} make the zoospores drift away from the substrate and any establishment then depends on if the spores come across a new surface to settle on within 1–2 days.

3.4 Ecological impact

In many native areas *U. pinnatifida* is just one of many large canopy species often growing together with others and thus there is little information available on its impact. In southern Korea, Kim and coworkers (1998) examined shelf, crest and drop off areas and found the maximum species diversity to occur during the winter with the large algae, including *Gracilaria textorii, Ecklonia cava* and *Undaria pinnatifida*, becoming particularly abundant in spring. As autumn approached the cover of large perennial species decreased. *Sargassum horneri, S. confusum, Undaria pinnatifida* and *Myagropsis myagroides* had high cover in the crest habitat, while the subtidal shelf habitat showed an assemblage of bushy or thin-bladed forms such as *Ulva pertusa, S. thunbergii* and *Corallina officinalis*.

3.5 Grazers and disease agents

Along the SE Korean coast seaweed farms have been attacked by harpacticoid copepods (*Thalestris* sp.), punching holes in the fronds as well as by amphipods (*Ceinina japonica*) making tunnels in the midrib (Kang, 1981). He also reported of green spots accelerating the decaying of the plants and being caused by many different bacterial strains. A white rot disease, caused by the phycomycet *Olpidipopsis* can attack cultivated *Undaria* plants in Japan (Akiyama, 1977).

3.6 Utilization and aquaculture

A thorough description of the farming of *U. pinnatifida* in Japan was given by Saito (1975), although the techniques used probably has changed much since then. Akiyama and Kurogi (1982) reported that the harvest of natural plants had decreased since cultivation, which was described in detail, increased during the 1970s, which then produced about 5-10 kg per metre line. Production and erosion of the commercially mass-cultured kelp *U. pinnatifida* f. *distans* were investigated in spring 1998 in Otsuchi Bay, NE Japan (Yoshikawa *et al.*, 2001). Steady growth in total kelp length was observed from January to March, with rates of 1.1–1.8 cm day^{-1}. Erosion rates of the thalli were consistently low in January and February, but increased to 0.5 cm day^{-1} in March, and were comparable to the growth rate in April. Biomass erosion represented 30–40% of production in March and over 80% in April. The greater erosion in April was attributed to a low supply of dissolved inorganic nitrogen and aging of the alga, leading to that 81% of total net production could be harvested while 19% was lost due to erosion. In terms of nitrogen, 33% of total production was eroded, while 67% was harvested.

Tseng (1981) reported that most populations utilized today in China were introduced for aquaculture during the 1930s from Japan to Dalian and in the early 1940s plants were brought from Korea to Qingdao (Tseng, 2001). *U. pinnatifida* is now the third most important cultivated species in China (Wu and Meng, 1997; Wu *et al.*, 2004) and experiments with tip-cutting of the lamina has shown an increase in production by 9 % (Wu and Meng, 1997). Clones of gametophytes are produced to enhance production of young sporophytes (Wu *et al.*, 2004). During the 1990s Chinese scientists were engaged in developing genetically modified seaweeds, among them *U. pinnatifida* (Qin *et al.*, 2004), by using promotors causing transient expression of the GUS reporter gene, such as CaMV35S, the Ubiquitin promotor from maize and two from unicellular algae the amt and fcp promotors, of which they reported the first and last ones to be more efficient in kelp than in other algae. Also the SV40 promotor from simian virus, causing a uniform expression of the *lacZ* reporter gene, worked in *Undaria* as well as in *Laminaria japonica* (Qin *et al.*, 2004). Furthermore, they have also used foreign genes to induce zygotic sporophytic formation of gametophytes and it seems that some of those GMO plants also had been cultivated in the sea.

In 1981 it was intentionally introduced to Taiwan from Japan for farming (Liao and Liu, 1989).

Skriptsova and coworkers (2004) considered the conditions to be favourable for farming of this species at its northern distribution limit in Peter the Great Bay, the Sea of Japan, Russia, with the optimum month for harvesting in June. Highest alginate content (51% d. wt) was obtained from blades, with lower values for sporophylls and midribs, with an increase occurring before sporulation.

In Korea *U. pinnatifida* thallus have been used traditionally to promote maternal health, which works through the seaweed's scavenging effect of free radicals (Han *et al.*, 2002).

4 Non-native Distribution

4.1 The Mediterranean Sea

4.1.1 Date and mode of introduction and source region

The first European record of *U. pinnatifida* is from the Thau lagoon at the French Mediterranean coast in 1971, most likely as a result from imports of Japanese oysters (Peréz *et al*., 1981; Boudouresque *et al.*, 1985; Floc'h *et al.*, 1991; Wallentinus, 1999). This vector has also resulted in establishment of several other unintentionally introduced Japanese algae in that area (Boudouresque *et al.*, 1985; Verlaque, 1996, 2001; Wallentinus, 1999). It later spread outside the lagoon (Boudouresque *et al.*, 1985), and was in 1988 found close to the Spanish coast at Port Vendres (Floc'h *et al.*, 1991), but so far it has not been reported from the Spanish Mediterranean coast (Wallentinus, 1999; Guiry and Nic Dhonncha, 2005).

It occurs in Venice since 1992 (Curiel *et al.*, 1994, 1998, 2001), and was first recorded along the banks in Choggia, a site where oysters are cultivated, and thus might be due to an unintentional introduction with mollusc for farming, even though shipping cannot be excluded as a vector (Floc'h *et al.,* 1996), since it grows in several dock areas (Curiel *et al.*, 1998). In 1998 the species was found in the polluted Mar Piccolo, at Taranto, in the Ionian Sea, S Italy, probably having arrived there by oysters imported from France (Cecere *et al.*, 2000; Occhipinti Ambrogi, 2002).

4.1.2 Current status, population demographics and growth rate

According to Verlaque (2001) it was still occurring in the Thau lagoon in the late 1990s. In Venice, Curiel and coworkers (2001) considered it to be continuously expanding in the canals in 1999 and it was observed to be abundant in the canals in the city in spring 2004 (Wallentinus pers. obs.). In Venice along the canals a density of more than 10 plants m^{-2} could be found, most of them 50–80 cm long, but reaching up to 2 m in more current exposed areas, while at low current sites they only were 20–30 cm long with 1–3 indivuals m^{-2} (Curiel *et al.,* 2001). At Giudecca island densities were around 100 plants m^{-2}, reaching a peak in biomass of >1 kg dw m^{-2} in May.

4.1.3 Natural history (tolerance limits for abiotic factors) in the region

Substrate and depth

It can be found on both stones (patchy to dense) and artificial substrate including supporting structures used in aquaculture (Peréz *et al.,* 1981; Boudouresque *et al.*, 1985; Floc'h *et al.,* 1991) and embankments of the canals in Venice, there being confined to the upper 1.5 m below LWM (Curiel *et al.,* 1998, 2001).

Temperature

No introduced populations so far seem to have reached the upper temperature limit of 30 °C for survival of gametophytes (Akiyama, 1965), and gametophytes from the Mediterranean had an upper survival limit of 29.5° C (Peters and Breeman, 1992). However, high summer temperatures lead to a lower growth rate of the sporophytes. On the French Mediterranean coast the sporophytes appear in autumn (November) with a maximal growth in March and sporophytes disappear in July, with zoospores being released in May-June (Peréz *et al.*, 1981, 1984; Floc'h *et al.,* 1991). In Venice young sporophytes appear in December and become dominant in February, with a maximum in April–May, and occur until July when they become senescent (Curiel *et al.*, 1998, 2001). The water temperature range of the area is between 5 and 26 °C. They also reported that fertility is at the peak in spring, while only senescent plants occur in July.

Salinities

Salinities of 27 PSU can occur occasionally in the Thau lagoon, but are usually higher (Verlaque, 1996). In Venice the species grows also in waters with a salinity, which occasionally can be as low as around 20 PSU, although mainly in waters above 28 PSU (Curiel *et al.*, 2001). This seems to be the lowest salinity in which it has become established. Considering its establishment also in the less saline parts of Venice, adaptation to slightly brackish water cannot be ruled out.

Nutrients

In Venice *U. pinnatifida* is found growing close to discharges of urban waste waters and thrives in nutrient-rich polluted water (*e.g.* Curiel *et al.*, 1998, 2002) as it also does in southern Italy (Cecere *et al.,* 2000). Prosperous growth among farmed mussels and oysters also indicates enhancement by nutrients, which are recirculated by these animals.

4.1.4 Reproduction

The species is reproductive in the areas where it has been recorded (see also 4.1.3). On the French Mediterranean coast the sporophylls are mature from May to July (Peréz *et al.*, 1981, 1984, Floc'h *et al.,* 1981). In Venice in the inner canals plants may not become fertile (Curiel *et al.,* 2001).

4.1.5 Ecological impact

On the French Mediterranean coast it mostly co-occurs with species of *Sargassum, Cystoseira, Gracilaria* and *Dictyota* (Peréz *et al.,* 1981; Boudouresque *et al.,* 1985). In the lagoon of Venice *U. pinnatifida* has gradually expanded along the banks of the canals, both at Chioggia and Venice, and has become the dominant species (mainly from February to July) in the local algal community (Curiel *et al.,* 2001). The kelp has colonised the main canals and, subsequently, the small inner ones. Several co-occurring species decrease between April and June-July when *U. pinnatifida* becomes dominant.

4.1.6 Grazers and disease agents

The main grazer in the Thau lagoon seems to be sea urchins (Peréz *et al.,* 1981; Boudouresque *et al.,* 1985). In Venice grazing pressure on *U. pinnatifida* seems very low (Curiel *et al.,* 2001).

4.1.7 Utilization and aquaculture

There were less successful trials of cultivation on the French Mediterranean coast, which were not continued. It does not seem to be utilized in Italy.

4.1.8 Management and Control

In Venice eradication made during the fertile period, in fact, permitted *U. pinnatifida* development during the following year, but when eradication was performed after the reproductive period recolonisation started two years later. A significant decrease in the surface covered by other species has been observed in Venice and thus in order to limit its spreading, mechanical eradications should be done on a large spatial scale and before the zoospores release (Curiel *et al.,* 2001).

4.2 European Atlantic coast

4.2.1 Date and mode of introduction and source region

In France *U. pinnatifida* was transferred from the Mediterranean by IFREMER scientists for farming in northern France at three sites around Brittany in 1983 at the islands of Groix and

Ushant and in the Rance estuary (Peréz *et al.,* 1984; Floc'h *et al.,* 1991) after less successful trials in the Mediterranean. Later some new sites were used, also by CEVA, (Peréz *et al.,* 1984; Floc'h *et al.,* 1991; Castric-Fey *et al.,* 1993; Hay and Villouta, 1993; Wallentinus, 1999). In 1987 it was found reproducing in the wild at the farming site on Ouessant (Floc'h *et al.,* 1991, 1996), later also in other districts at St. Malo and in the Rance estuary, (Castric-Fey *et al.,* 1993; Hay and Villouta, 1993; Castrich-Fey and L'Hardy-Halos, 1996; Castrich-Fey *et al.,* 1999a, 1999b), even in areas where farming had been abandoned. A record in 1998 from the harbour of Calais, northern France (Stegenga, 1999) might also be due to shipping, as well as the records in the harbours of Brest and Grandville in northwestern France in the early 1990s (Floc'h *et al.,* 1996).

In northern Spain it was reported from Ria Ariosa in 1990 (Santiago Caamaño *et al.,* 1990), probably as a result of oyster movements and later from other parts of northern Spain (for references see Hewitt *et al.,* 2005). Through farming it has later been spread along the N Spanish Atlantic coast down to the Portuguese border and thus it can be expected to arrive in Portugal in the near future (José Rico, pers. comm.).

In southern U.K. it was recorded in 1994, probably spread by vessels from France or the Channel Islands (Fletcher and Manfredi, 1995; Fletcher and Farrell, 1998) and it later spread to other sites on the south coast and has been confirmed on the Channel Islands (Eno *et al.,* 1997). A thorough review on the occurrence and ecology of the species in the UK and in the North Atlantic was given by Fletcher and Farrell (1999), who stated that it probably had arrived in England with small boats, since all records were from isolated marinas, having visited Brittany, France and then being anchored in marinas on the English south coast. They also presented details on when different areas were colonized and reported that the local dispersal was slow amounting to ca. 750 m^2 in 3, and 2000 m^2 in 4 years and that the main dispersal was by small boats in coastal traffic. During 1998 it occurred between Brighton and Torquay, a distance of 270 km that was reached in shorter period of time than for *Sargassum muticum.*

In March 1999, for the first time in the Netherlands, 60 cm long sporophytes of *U. pinnatifida* were recorded on shells in an oyster pond near Yerseke, and in May the same year one plant was found near Strijenham, both sites in the Oosterschelde (ICES, 2000). 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 N side (Stegenga, 1999), the latter so far the northernmost sites in Europe. *U. pinnatifida* was also found in smaller densities in the saltwater Lake Grevlingen, probably being transported there by oyster pots. In the Oosterschelde it grows mainly on *Crassostrea gigas* but also on mussels, and being slippery, *U. pinnatifida* causes problems for fishermen to retrieve the oysters and the pots need to be cleaned before harvest (ICES, 2001). Although no vector was stated oyster and mussel harvesting is common in the Oosterschelde (Stegenga, pers. comm.), but shipping probably cannot be ruled out with several ships entering the area.

In 1999 the species was also reported from Zeebrugge, Belgium (Dumoulin and De Blauwe, 1999), and was still present at the marina of Zeebrugge in 2003, but had not spread since 2000, and was grazed by coots (*Fulicra atra*) (ICES, 2004).

4.2.2 Current status, population demographics and growth rate

In the St. Malo area the populations increased during 1996–1997 after a period with decrease following heavy grazing (Castric-Fey *et al.,* 1999a). The same scientists (Castric-Fey *et al.,* 1999b) found a maximum growth rate of 2.13 cm per day (average 1.56 cm per day) and a maximum plant size of 150 cm, the thalli weighing 1.47 kg ww. They found the maximum longevity of plants to be 7.5 months and that plants recruited in spring lived on average for ca. five months, while those appearing in winter lived for six months.

On the English south coast plants grow quite large (>2 m in length, ca 1 kg ww) and biomasses may reach up to 25 kg ww m^2.

4.2.3 Natural history (tolerance limits for abiotic factors) in the region

Substrate and depth

In W Brittany, France, *U. pinnatifida* has been found both on rocks, growing together with native large canopy species, down to 18 m depth, and on lines in mussel farms, down to 5 m depth (Floc'h *et al.,* 1991). It can also be found up to +1.5 m and seems to have a preference for artificial substrate (Floc'h *et al.,* 1996). Further east on the French coast in the St. Malo and Dinard area, it was also common on periodically overturned cobbles and boulders, and grew mainly in the lower littoral and upper sublittoral zones (Castric-Fey *et al.,* 1999a), but could also be found down to 12 m depth (Castric-Fey *et al.,* 1993).

In S England, 4 years after its introduction, it still in that area and mainly occurs on vertical sides of floating structures such as pontoons, hulls of small boats, buoys, ropes and tyres as well as on the ascidian *Styela clava* and very seldom at materials having a fixed position in the water, which probably is due to the sediment load and high turbidity in the water there. In the Torquay marina, however, it growths also on fixed objects and has colonized walls where native kelps such as *Laminaria digitata* and *L. saccharina* occur, and in places also together with *Saccorhiza polyschides*, scattered fucoids and *Sargassum muticum* (Fletcher and Farrell, 1998). They also stated that it is more common than native species in sheltered and turbid areas and that in more exposed areas the competition from native canopy species is quite high.

Temperature

Lowest temperature for sporophyte recruitment in the Dinard area, N France, was 5 °C and highest 20 °C (Castrich-Fey *et al.,* 1999b), but they found that the peaks in recruitment occurred during October and May-June, at temperatures of 13–17 °C, with two generations succeeding each other during a year. They found sporophytes all year round with a mixture of young and old ones, but most plants deteriorated in late summer, and that the sporophylls could appear all year through and they could also be seen fully grown all year through. According to Floc'h and coworkers (1991) sporophytes can appear all year round with release of zoospores from May until late autumn. On the south coast of England plants grow tall and occur almost all year through, with some senescens in late summer (Fletcher and Farrell, 1998).

Salinity

Most reports of introductions are from areas having salinities well above 30 PSU (*e.g.* in St. Malo, N France a mean of 34 PSU, with a range of 31–35; Castric-Fey *et al.,* 1999b). Some populations also exist at lower salinities and 27 PSU can occur during February in Spain (Santiago Caamaño, 1990).

Nutrients

As on the Mediterranean coast it has also in N France been found growing close to discharges of urban sewage plants (Castrich-Fey *et al.,* 1999a, 1999b).

4.2.4 Reproduction

For appearance and maturity see 4.2.3.

4.2.5 Ecological impact

In the study of Floc'h and coworkers (1996) *U. pinnatifida* was only sporadically found on rocky substrates, whether denuded from native algae or not and seemed to be less competitive versus the native, opportunistic kelp *Saccorhiza polyschides* which was the one dominating on the rocks. However, they found it co-occurring with the native fucoid *Himanthalia elongata*. Since it prefers artificial substrate, the negative effects might be mainly on the economic side as a fouling organism. On the English south coast, Fletcher and Farrell (1998) did not report on any ecological impact on native seaweeds, although they did co-occur in some areas. On the whole they considered the final outcome on rocky substrates less predictable and that it mainly will establish in the shallow sublittoral, but having a low competitive ability there, although it probably will be a major fouling alga in harbour areas. They also pointed out that since *U. pinnatifida* grows even in areas with high sediment load and lower salinities, where less native vegetations occurs, it may even be beneficial to the ecosystem by providing a nursery ground for small fish and shelter for macrofauna. In Belgium Dumoulin and De Blauwe (1999) reported that the thalli of *U. pinnatifida* often were overgrown by fouling ascidians (especially *Botryllus schlosseri)*, bryozoans, hydroids and small seaweeds, which may enhance the decay of the lamina.

4.2.6 Grazers and disease agents

The main grazers on the coast of Brittany, France, are fish and crustaceans and the grazing pressure on the sporophytes is quite high (Floc'h *et al.,* 1991; Floc'h pers. comm.). In Belgium birds may be important grazers (ICES, 2004). In S England there are hardly any grazers on *U. pinnatifida* (Flecher and Farrell, 1998).

4.2.7 Utilization and aquaculture

At least one company is cultivating *U. pinnatifida* in N France, in the St. Malo area, where it is farmed in the sea on long-lines (C-Weed Aquaculture 2005). Unintentionally introduced populations of established wild populations of *U. pinnatifida* have been harvested for wakami products in northern Spain. It is also cultivated in northern Spain as far south as close to the Portuguese border (ICES, 1993; Rico pers. comm.).

4.2.9 Management and Control

When *U. pinnatifida* was first recorded on the English south coasts all plants found were removed, but since plants were already fertile eradication failed and new plants appeared (Fletcher and Farrell 1998). In the Netherlands efforts have been made to clear *U. pinnatifida* because it hinders mussel harvest (Wetsteyn in ICES, 2001).

4.3 New Zealand

4.3.1 Date and mode of introduction and source

The species was been reported as introduced by Japanese ships to New Zealand at Wellington 1987 and Timaru 1988 (Stapleton, 1988; Hay 1990), and spread by local coastal traffic to Oamar in 1988 and Lyttelton 1989 (Hay, 1990; Hay and Villouta, 1993), and later also to the harbours of Otaga, Porirua, Picton and Napier (Hay and Villouta, 1993). Further dispersal by coastal traffic was predicted already in 1990 (Hay, 1990) and plants fouling ships' hulls were found to survive a voyage of more than 4000 km and during that time (about a month) had grown 10–20 cm. He also concluded that drifting mooring buoys and towed navigational buoys can be responsible for dispersal directly or by infested vessels as well as the cleaning of ships' hulls at the seaside with pressure hoses.

Dispersal of zoospores by water movements might be limited, since no plants were found on the opposite side of a New Zealand harbour until ships fouled with *Undaria* where moved and anchored there (Hay, pers. comm.). Trailed boats may also disperse the species into new waters, due to the extreme tolerance and survival of the microscopic gametophytes for days up to a month in small crevices (Hay 1990, pers. comm.), making many new areas susceptible, especially if the boats are left with a constant water line at the new site for the time it takes sporophytes to mature.

4.3.2 Current status, population demographics and growth rate

The overall distribution has not changed and it has not been recorded from the Fiordland, the Chatham Islands nor from the Sub-Antarctic islands (ICES, 2004).

4.3.3 Natural history (tolerance limits for abiotic factors) in the region

In New Zealand the lowest temperatures for sporophyte recruitment are 7–8°C (Hay and Villouta, 1993; Stuart and Brown, 1996), and plants occur throughout the year. At some localities in New Zealand salinity values can in extreme cases be as low as 22–23 PSU, while usually being higher (Hay, pers. comm.). In a New Zealand study (Dean and Hurd, 1996) nutrient kinetics were measured, the values resulting in about the same uptake rates for nitrate as for other kelp species.

4.3.4 Reproduction

Studies in New Zealand (Forrest *et al.,* 2000) have revealed that, although zoospores may be viable for 5-14 days, spore dispersal from *Undaria* stands primarily only has occurred at the scale of metres to hundreds of metres, while spread at the scales of hundreds of metres to kilometres must depend on dispersal of fragments or whole sporophytes.

4.3.5 Ecological impact

Forrest and Taylor (2002) emphasized the difficulties of assessing the impact of an invasive species.

4.3.6 Grazers and disease agents

In New Zealand the grazers are mainly abalone, sea slugs, crustaceans and some fish (Hay and Luckens, 1987; Hay, pers. comm.).

4.3.7 Utilization and aquaculture

In New Zealand a pilot farming programme has been undertaken in areas already being colonized by *U. pinnatifida* (Anon., 1998). Furthermore, established wild populations of *U. pinnatifida* have been harvested (*e.g.* Sinner *et al.,* 2000; Forrest and Blakemore, 2003).

4.3.8 Management and Control

In New Zealand, where *U. pinnatifida* has spread around the coasts since the late 1980s, the main emphasis has been on trying to stop it from entering the Sub-Antartic and the Chatham Islands. Thus when a fishing vessel with *U. pinnatifida* on the hull sank near a remote island in 2000 the Biosecurity Act forced an eradication of the plants from the hull and a monitoring of the area for three years (ICES, 2004; Wotton *et al.,* 2004). Great efforts have also been made to clear *U. pinnatifida* to protect the biodiversity but often with limited success (*e.g.* Sinner *et al.,* 2000; Stuart and Chadderton, 2001).

4.4 Australia

4.4.1 Date and mode of introduction and source

The species was first recorded in eastern Tasmania (Rheban-Triabunna) in 1988 presumably brought in ballast tanks of Japanese ships, where it later has spread along the coast (Sanderson, 1990; AQIS, 1994), and further dispersal to other coastal areas were predicted in 1990 (Sanderson, 1990). The dispersal rate was estimated to 10 km $year^{-1}$, but secondary introductions have also occurred in Tasmania since some areas are more than 40 km apart (Hewitt *et al.,* 2005). In 1996 it was reported from Port Philips Bay, Victoria, Australia, probably coming with ships from Japan or New Zealand, since the plants had a different form than the Tasmanian population (Campell and Burridge, 1998; Campbell *et al.,* 1999). In 1997 it was reported from a marine reserve south of Hobart, Tasmania (Hewitt *et al.,* 2005).

4.4.2 Current status, population demographics and growth rate

No change has been seen in its distribution in Australia since the late 1990s (ICES, 2004) and in 2002 *U. pinnatifida* was reported to have spread 150 km north and 80 km south of the initial site (Hewitt *et al.,* 2005 and references therein). In Tasmania, Valentine and Johnson (2003) found that disturbance of native canopy algae was crucial for the establishment of *U. pinnatifida*, while very few plants grow when there was a large cover of natives. Furthermore, the timing of the disturbance was important and highest *Undaria* densities were found when clearing was done just before the sporophyte growth started in winter. The response of *U. pinnatifida* to a natural disruption of a native algal canopy was examined after a significant dieback of a common native canopy forming macroalga (*Phyllospora comosa*) on the east coast of Tasmania (Valentine and Johnson, 2004). They found that *U. pinnatifida* sporophytes established at high densities (6.75 +/- 1.99 stipes m^2) in dieback areas, but remained rare or entirely absent in control areas where the native canopy was intact, confirming the importance of disturbance events for the successful establishment of high densities of *U. pinnatifida*. When sea urchins were removed, Valentine and Johnson (2005) found an average biomass of ca 55 g dw m^2 (5.2 plants). Hewitt and coworkers (2005) estimated growth rates from width of the stipe by using correlation to total length and found that plants on average grew 12 mm day^{-1} (ranging from 2–47 mm day^{-1}) in transects where *Undaria* had been removed, while they grew 24 mm day^{-1} (ranging from 12–41 mm day^{-1}) in control areas (figures not comparable due to differences in time). They measured the maximum growth over 30 days to 1.41 m (removal transects) and 1.23 m in controls.

4.4.3 Natural history (tolerance limits for abiotic factors) in the region

Substrate and depth

On the eastern Tasmanian coast *U. pinnatifida* mainly occupies the sheltered to moderately exposed sublittoral, where it is a conspicuous seaweed mainly found in sea urchin grazed areas covering 100% of the rocks (Valentine and Johnson, 2005). Hewitt and coworkers (2005) reported it from both rocks and boulders as well as growing in low abundances on sand and seagrass leaves.

Temperature

In Tasmania sporophytes appear in August (Australian early spring) and disappear in late summer (December) with a peak in growth in November (Sanderson, 1990; Valentine and Johnson, 2005). For releases of zoospores see 4.4.4. In Port Phillip Bay, Victoria, sporophytes grow rapidly from winter (July) through to spring (September) and become scenescent in early summer with no sporophytes left in January (Campbell *et al.,* 1999).

Light

Photosynthetic performance, dark respiration, pigment concentration, tissue nutrient concentration and fresh: dry weight ratios were measured in juvenile and adult sporophytes of *U. pinnatifida* throughout the growing season from Port Phillip Bay (Campbell *et al.,* 1999). They found that photosynthetic rates (15–42 mg O_2 g^{-1} dw h^{-1}) of sporophyte stages were higher on a dry weight basis in spring compared to in summer coinciding with rapid growth of juvenile sporophytes in spring. Higher dw:fw ratios of adult sporophytes were found compared to young sporophytes. The seasonal trends in P_{max} and alpha on a Chl *a* basis in juvenile plants are explained by higher pigment (Chl *a, c*, fucoxanthin) concentrations in spring than summer. Differences in pigment content and their ratios between sporophyte life stages may be indicative of light adaptation by juvenile plants. Lower saturated light requirement (I_k) and compensation points (I_c) were observed in spring compared to summer plants and lower I_k values of juvenile sporophytes compared to adult sporophytes was also found during spring. Spring and summer compensation points in this study mostly ranged from 7.63–15.49 µmol m^{-2} s^{-1}. Low I_k and I_c, and high P_{max}, alpha, and pigment content may enhance the capacity of juvenile *Undaria* to utilise low photon flux rates. No seasonal differences were found between respiration rates on a dry weight basis or between respiration in young and adult sporophytes. Respiration rates normalised to Chl *a*, were 2-3 times higher in summer in both young and adult stages.

Nutrients

In Port Phillips Bay, Victoria, Campbell and coworkers (1999) found that the C:N ratios were higher in summer in both juvenile and adult sporophytes indicating N limitation in summer, and generally higher in juveniles pointing to a higher accumulation of reserve carbohydrates. Low N:P ratios in spring and summer for both stages also suggested N limitation. The overall high N availability in Port Phillip Bay and the low light adapted physiological characteristics provide *U. pinnatifida* with a competitive advantage over other fast growing macroalgae.

4.4.4 Reproduction

Reproductive phenological studies (Schaffelke *et al.,* 2005) were undertaken in Tasmania to provide much-needed quantitative information to support pest management. Zoospore release was limited to the larger size classes of the annual sporophytes (> 55 cm length) for most of the growing season, with the proportion of mature sporophytes increasing towards the end of the season. Small sporophytes with mature sporophylls were not observed until late in the growing season, i.e. after November. The maximum zoospore release of *U. pinnatifida* was 62 * 10^3 zoospores cm^2 sporophyll tissue h^{-1}, corresponding to a maximum release of 4.3 * 10^8 zoospores $sporophyte^{-1}$ h^{-1}, being similar or lower compared to other kelps. The two largest size classes released the majority of zoospores. Tagged *U. pinnatifida* individuals released zoospores for about three months before becoming senescent and disintegrating. Hypothetically, the smallest mature sporophyte would have a stipe width of 0.6 cm, corresponding to about 33 cm in total length, with a sporophyll circumference of 7.6 cm and a sporophyll biomass of 0.2 g. The zoospore release of an assemblage of introduced *U. pinnatifida* at the study site was estimated as 2 * 10^9 zoospores m^{-2} h^{-1} in January (summer in the southern hemisphere). Management efforts involving the manual removal of *U. pinnatifida* to control this species could be rationalized by concentrating on the removal of only larger sporophytes (> 55 cm), potentially resulting in significant cost savings. Hewitt and coworkers (2005) suggested that a seed bank of microscopic stages with a significant longevity seems likely, since sporophytes reappeared early in season also when all sporophytes had been removed and few plants were fertile.

4.4.5 Ecological impact

Edgar and coworkers (2004) studied the effects of algal canopy clearance on plant, fish and macroinvertebrate communities on eastern Tasmanian for blocks cleared of fucoid, laminarian and dictyotalean algae in comparison to controls. Removal of canopy-forming plants produced less change to biotic assemblages than reported in studies elsewhere, with the magnitude of change for fish and invertebrate taxa lower than variation between sites and comparable to variation between months. The introduced *U. pinnatifida* exhibited the only pronounced response to canopy removal amongst algal taxa, with a fivefold increase in cleared blocks compared to control blocks. Marine reserves are suggested to assist reef communities resist invasion by *U. pinnatifida*, through an indirect mechanism involving increased predation pressure on sea urchins and reduced formation of urchin barrens that are amenable to *U. pinnatifida* propagation.

4.4.6 Grazers and disease agents

The main grazers in Tasmania are sea urchins (Sanderson, 1990; Valentine and Johnson, 2005). To answer the questions about the mechanisms enabling *U. pinnatifida* to persist on the sea urchin (*Heliocidaris erythrogramma*) 'barrens', Valentine and Johnson (2005) made a factorial manipulative experiment over a 30-month period. The dense stands of *U. pinnatifida* on sea urchin barrens suggest that disturbance in the form of grazing by sea urchins prevents recovery of native canopy-forming species. By using treatments comprising all possible combinations of +/- urchins, +/- *U. pinnatifida* and +/- enhanced native algal spore inoculum, they found that the sea urchin *H. erythrogramma* can have a significant impact on *U. pinnatifida* abundance. The response was most dramatic in the 2001 sporophyte growth season, when sea urchins destructively grazed *U. pinnatifida* sporophytes in experimental plots on the urchin barren. In other years, when there was higher recruitment of *U. pinnatifida* sporophytes, urchins reduced sporophyte abundance, but did not prevent development of a *U. pinnatifida* canopy. Removal of sea urchins resulted in a slow increase in cover of understorey red algae, but only limited recovery of native canopy-forming species. In treatments where both sea urchins and *U. pinnatifida* were removed, cover of canopy-forming species did not exceed 6% over the study period. Thus, in the absence of sea urchin grazing, there was no evidence of inhibition of *U. pinnatifida* by native algae. While the intensity of sea urchin grazing may directly influence the extent of the *U, pinnatifida* canopy, recovery of native canopy-forming species was apparently influenced by a combination of factors including sea urchin grazing, depth and, most importantly, the degree of sediment accumulation on the rocky substratum. The manipulations showed that removal of sea urchin grazing that ostensibly facilitated replacement of native canopy-forming algae by *U. pinnatifida* did not result in recovery of native canopy-forming algae.

4.4.7 Utilization and aquaculture

Unintentionally introduced populations has been commercially utilized in Tasmania (AQIS 1994).

4.4.8 Management and Control

Removal experiments were carried out to at the Tinderbox Marine reserve, south of Hobart, Tasmania, to reveal if eradication by divers were sufficient in significantly reducing the *Undaria* sporophyte abundances which it did when carried out on a monthly bases (Hewitt *et al.,* 2005; see more under section 7). Because of the possibilities of a seed bank of microscopic stages they considered it necessary to find a treatment to remove those persistent stages.

4.5 Argentina

4.5.1 Date and mode of introduction and source

The species is assumed to have arrived with cargo or fishing vessels from Korea or Japan into the Neuvo Gulf, Argentina in 1992 (Casas and Piriz, 1996; Orensanz *et al.,* 2002; Casas *et al.,* 2004), where it was recorded close to the international dock at Puerto Madryn in central Patagonia. During the first two years it had spread along ca. 2 km of the coast (Casas and Piriz 1996).

4.5.2 Current status, population demographics and growth rate

Close to Puorto Madryn, Casas and coworkers (2004) found that *U. pinnatifida* could make up 65% of the total seaweed biomass with on an average 2.88 ±1.18 kg ww m^2. In 1999 it had spread ca. 20 km to the north and 18 km to the south of Puerto Madryn (Orensanz *et al.,* 2002) and they also reported that it had been recorded at Caleta Malaspina, ca 500 km to the south, where it may pose a serious threat to economically utilized seaweeds. It may also pose a threat to the marine park at Golfo San José, north of Nuevo Gulf (Orensanz *et al.,* 2002). They also predicted that it, due to the benign water temperatures, would spread further along the coast.

4.5.3 Natural history (tolerance limits for abiotic factors) in the region

In the Nuevo Gulf sporophytes can be seen in the sublittoral from 2 to 15 m depth at an annual temperature range of around 8.7–18 °C (Casas and Piriz, 1996). They found it growing on various substrates such as rocks, boulders, wharf pilings, on the hull of a wrecked ship and on ascidians in not too exposed conditions. Also in this area *U. pinnatifida* seems to be enhanced by discharges of secondary treated sewage plants (Torres *et al.,* 2004).

4.5.4 Reproduction

The recruitment occurs in autumn (April–May) and by summer (December) the plants become senescent (Casas and Piriz, 1996; Casas *et al.,* 2004) and only midribs, sporophylls and holdfasts remained during the late S hemisphere summer (January–February). Sporophylls occurred from winter (July–August) to summer, but were seen only on plants larger than 70 cm (Casas and Piriz, 1996). They also reported that small, young sporophytes were seen together with large ones.

4.5.5 Ecological impact

In south Patagonia, Argentina, its dominance has also changed the composition of beach-cast seaweeds and since 1998 it has replaced *Ulva* spp., which has decreased in the beach-cast, as have native species such as *Gracilaria gracilis* and *Macrocystis pyrifera* (Piriz *et al.,* 2003). The results of a 7 month manipulative experiments in Nuevo Gulf with removal of *Undaria pinnatifida* (to be precautious no additions were used in non-colonized areas) showed that it in comparison to controls significantly reduced the species richness and diversity of native seaweeds (Casas *et al.,* 2004). Orensanz and coworkers (2002) considered *U. pinnatifida* to rapidly be modifying the nearshore benthic communities in central Patagonia, since it is the only kelp species and the native seaweeds are relatively small, and the holdfast may cover other vegetation and the canopies reduce light. Furthermore, when being dislodged and dragged along the bottom by the tides also other species may be lost by this disturbance.

4.5.6 Grazers and disease agents

According to Orensanz and coworkers (2002) *U. pinnatifida* could be a potential food item for the native gastropod *Tegula patagonica,* and the sea urchins *Arbacia dufresnii* and *Pseudechinus magellanicus*.

4.5.7 Utilization and aquaculture

It was suggested (Casas and Piriz, 1996; Orensanz *et al.,* 2002) that it could be attractive for local industries to use *U. pinnatifida*, but there are no reports of any utilization from these areas.

4.5.8 Management and Control

Orensanz and coworkers (2002) emphasized that it may become a threat to the economically important species such as the red algae *Gracilaria gracilis, Gigartina skottsbergii* and the brwon alga *Macrocystis pyrifera*. However, there seems to have been no trials to eradicate *U. pinnatifida* and it was considered a futile enterprise (Casas and Piriz, 1996; Orensanz *et al.,* 2002).

4.6 California and Mexico

4.6.1 Date and mode of introduction and source region

In the US, *U. pinnatifida* was first recorded in Los Angeles Harbor in 2000 (Silva *et al.,* 2002; Thornber *et al.,* 2004) and was later found at several sites in S California. In 2001 it had been established at Santa Barbara Harbor, Cabrillo Beach at San Pedro and at Channel Islands Harbor at Oxnard and at Santa Catalina Island, there growing down to 25 m depth, and as far north as Monterey Bay, (Silva *et al.,* 2002). It probably had arrived with shipping. In 2003 it had increased its abundance in the Monterey area (ICES, 2004). Thornber *et al.* (2004) predicted a further spread along the coast, where small boats could be an important vector. Silva and coworkers (2002) considered it possible that *U. pinnatifida* could establish from at least Baja California (see below) to British Columbia, Canada, especially in sheltered partially sheltered waters.

In September 2003 *U. pinnatifida* was found growing attached to small rocks on a sandy bottom in the subtidal zone at 12–14 m depth at Todos Santos Islands, in Baja California, Mexico. The population consisted of 15 sporophytes, with an average length of 50 cm and with mature sporophylls (Aguilar-Rosas *et al.,* 2004).

4.6.2 Current status, population demographics and growth rate

The population ecology of both macro- and microscopic stages of the species has been studied in Santa Barbara harbour, where two different recruitment pulses were seen in one year, depending on temperature (Thornber *et al.,* 2004). They found great differences in survival to maturity, size and growth rate and they considered these variations in demography, as well as in grazing pressure, to be important for the future spread of *U. pinnatifida* along the Pacific coast of North America. By using tagged plants and the punch-hole technique they found growth rates in autumn to vary between 1–14 cm week^{-1}, with a maximum of 25 cm week^{-1}, until the plants became 15 weeks old, when growth was negligible. At Monterey, having colder water currents, they saw that recruitment might be continuous with an overlap of generations.

4.6.3 Natural history (tolerance limits for abiotic factors) in the region

Silva and coworkers (2002) described populations from shallow waters in harbours on various artificial substrates down to at 25 m depth at Santa Catalina Island where it grew on polychaete tubes on sandy bottoms, but also on tires at 6 m depth. In S California *U. pinnatifida* occurs in shallow, wave-protected areas, mainly on floating docks in harbours at a temperature range of 12–21 °C (Thornber *et al.,* 2004). They found recruits on concrete, on solitary ascidians, old *Undaria* holdfasts and on plastic used for tagging the plants. Both field data and laboratory experiments suggested that warmer water inhibited the development and survival of the gametophytes. Furthermore, they noted that zoospore release occurred at lower temperatures than those Saito (1975) claimed to be necessary. At Santa Catalina Island in California, Thornber and coworkers (2004) reported that *U. pinnatifida* grew together with several other kelps, including *Macrocystis pyrifera* and *Pelagophycus porra*. At Long Beach, S California, it grew on steep subtidal banks among a dense stand of *Ulva* sp. (Silva *et al.,* 2002).

4.6.4 Reproduction

At Santa Barbara there are two distinct recruitment periods, a small one in autumn from August until September in densities of up to 0.8 individuals m^2, plants surviving until February, and a larger one from February to May in densities of up to 3 individuals m^2, plants surviving until mid-June. Both recruitment periods seemed to be triggered by cold water (< 15 °C), with a lag period of about eight weeks. In the laboratory they found that zoospores settled after three days and after eight days they had developed into gametophytes, with higher densities at

13 compared to at 21 °C. The time from recruitment to maturity could be as short as four weeks, with a mean of six weeks, and plants as small as 17 cm were found to be fertile.

4.6.5 Ecological impact

So far the ecological impact seems to have been small, in many areas the species is still manly found in harbours, and even when growing together with other kelps at Santa Catalina Island, those were not yet negatively affected (Thornber *et al.,* 2004). They also suggested that the impact might become stronger in the colder waters further north, where the *Undaria* populations could persist all year round, compared to further south were there are gaps between the generations.

4.6.6 Grazers and disease agents

In Santa Barbara harbour Thornber and coworkers (2004) found that almost all plants recruited during winter–spring were quite heavily grazed by the native, common kelp crab, *Pugettia producta*s, while only half of the population recruited during autumn. The high grazing pressure in spring prevented most of the plants becoming fertile and the crabs could quite efficiently control the population dynamics in spring. The only other grazers noted were occasionally amphipods. By using laboratory experiments they found that *U. pinnatifida* was as much eaten as the otherwise preferred food *Macrocystis pyrifera*, and that the crab preferred the lamina of *U. pinnatifida* before the sporophylls.

4.6.7 Utilization and aquaculture

There are no reports of any utilization of the introduced populations in these areas.

4.6.8 Management and Control

There has been some eradication in minor areas such as in the harbour of Santa Barbara (Silva *et al.,* 2002; Thornber *et al.,* 2004) and in the harbour of Monterey (Hewitt *et al.,* 2005).

5 Limited records, not suggestive of established introductions

There have been no published reports on records of the species from areas where it has not later become established.

6 Prospects of further invasions

Europe (cf. Floc'h *et al.,* 1991; Hay 1990): All the rest of England, Wales, Isle of Man, Scotland with the Orkneys and Hebrides, Ireland, the North Sea coast; all the rest of France, Spain and Portugal; presumably all the rest of the Mediterranean area; presumably also the western coasts of Scandinavia.

Atlantic and Pacific warm and cold temperate coasts of North and South America (cf. Orenanza *et al.,* 2002; Silva *et al.,* 2002), warm and cold temperate coasts of Africa, all the rest of the warm and cold temperate coasts of Australia (cf. AQIS, 1994; Sanderson, 1990) and most of New Zealand.

Brackish water areas may be less at risk, if salinities are well below 18 PSU. The high affinity for artificial substrate also makes areas with sediments susceptible, although soft substrate is not colonized, and plants could also grow there on shells and polychaete tubes. Disturbed rocky shores are likely more at risk than those with a dense perennial vegetation, if not too exposed (Hay and Villouta, 1993).

7 Prospects for control and management where introductions occur

Since the microscopic gametophytes are very tolerant and not visible to the naked eye, eradication is extremely difficult. Studies on effects of herbicides and antifouling paint have shown that some antifouling paints are efficient in stopping zoospore germination or cause gametophyte mortality, while some herbicides are not (Burridge and Gorski, 1997). However, patches not painted (*e.g.* covered by supporting structures during painting) or single corroded plates may develop dense lumps of sporophytes (Hay, 1990). Hulls of ships should only be cleaned out of the water and organisms be dumped out of the reach of the sea (AQIS, 1994). Since sporophytes have been found surviving and growing on the hulls for voyages over 4000 km (Hay, 1990) they should be removed before sporophylls are developed (in some cases sporophylls are small and difficult to see) to avoid seeding of other areas. If fertile, detached plants should be kept in containers (see also Hewitt *et al.,* 2005), when removed to avoid release of zoospores, since slightly dried sporophylls which are reimmersed release zoospores very quickly (Saito, 1975).

Gametophytes can survive temperatures around 30°C for up to 10–40 days (Kim and Nam. 1997), and thus high temperature treatment is needed for cleaning boat hulls, and one must be reassured that the hot water penetrates into crevices and other openings. Gametophyte survival in small moist crevices in the hulls, anchor wells etc. can make them survive even dry docking as well as transportation on land for days up to at least about a month (Hay, 1990; pers. comm.). Since they can stand darkness for over seven months (Kim and Nam, 1997), ballast transport is also a plausible vector, especially as the gametophytes may form thick-walled resting stages (Saito, 1975), with a potential of surviving also in the sediment. High temperatures, well above 30°C, thus are needed to be a treatment option for ballast water. Exposure to UV light may also be an efficient treatment for growing gametophytes (cf. Akyiama, 1965), although it is not known if this affects the thick-walled resting stages.

Also pontoons, towed buoys or drifting objects such as plastics, ropes etc. may contribute to the dispersal and should taken out of water and cleaned more efficiently than just by scraping off plants (cf. Hay, 1990) or be disposed of, when carrying *Undaria* plants. Manual eradication e.g. tried in Italy has not been successful (Curiel *et al.,* 1998).

According to Hewitt and coworkers (2005) the ability to make decisions as to when and where a response should occur is limited by knowledge of the efficacy and costs. They evaluated manual removal of *U. pinnatifida* sporophytes in a new incursion in the Marine Reserve in Tasmania over a 2.5 year study period, removing plants from a 800 m^2 area, on a monthly basis to minimise the likelihood of maturation of sporophytes and subsequent release of zoospores. While manual removal appears to have significantly reduced the number of developing sporophytes, the persistence of hot spots through time suggests that either microscopic stages (zoospores, gametophytes or sporelings) create a seed bank that persists for longer than 2.5 years or selective gametophyte survival in microhabitats occurs. In order for manual removal of *U. pinnatifida* to be effective a long-term commitment to a removal activity needs to be coupled with vector management and education initiatives to reduce the chances of re-inoculation and spread, with monitoring (and response) on a larger spatial scale for the early detection of other incursion sites, and with a treatment to remove persistent microscopic stages.

McEnnulty and coworkers (2002) made a thorough literature review on options of how to get rid of established introduced macroalgae. They also discussed if disease agents and endophytic algae could be an option, but considered that too little is known about any host specificity, and many organisms may be harmful also to native seaweeds, especially kelps.

In aquaculture proper quarantine treatment, allowing only release of the next generation, should be used to avoid that mussels or oysters act as vectors. New rules for free trade and movements of shellfish for fattening between disease-free coastal areas within Europe may bring in *U. pinnatifida* from areas where it occurs, and might especially be a threat for the Irish and British coasts, where such movements have frequently occurred. Farming of *Undaria* should not be considered in areas where it does not yet grow (Anon., 1998), nor should lines and supporting structures in aquaculture be moved from sites with *Undaria* to areas where it does not occur (AQIS, 1994; Hay 1990).

Great care should be taken not to perform scientific experiments in the field or in open flow-through systems in areas where the species does not yet occur. Also material brought in for demonstrations should be carefully disposed of on land, especially when plants with sporophylls are used.

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Annex 6: Non-indigenous species in the North Sea Region as input to REGNS

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Table 1 Non-indigenous aquatic species in the North Sea region and adjacent waters including established species and occasional records – in alphabetical order. Details on species in bold and underlined are provided in the following Annex.

Acartia tonsa
Acipenser sp. (non-native, hybrids)
Agardiella subulata
Ascophyllum nodosum
Asparagopsis armata
Alaria esculenta
Alexandrium leeii
Alexandrium minutum
Ammothea hilgendorfi
Anguillicola crassus
Anothrichum furcellatum
Antithamnionella ternifolia
Antithamnionella spirographidis
Aphelochaeta marioni
Aplidium normanni
Atyaephyra desmarestii
Balanus amphitrite
Balanus eburneus
Balanus improvisus
Bonamia ostreae
Bonnemaisonia hamifera
Bougainvillia macloviana
Brachynotus sexdentatus
Bugula neritina
Callinectes sapidus
Caprella macho
Cereus peduculatus
Chattonella cf. *verruculosa*
Chelicorophium (=*Corophium*) *curvispinum*
Clavopsella navis
Clymenella torquata
Codium fragile ssp. *tomentosoides*
Colpomenia peregrina
Corambe batava
Corbicula fluminalis
Cordylophora caspia
Corethron criophilum
Corophium sextonae
Corynophlaea umbellata
Coscinodiscus wailesii
Craspedacusta sowerbyi
Crassostrea angolata
Crassostrea gigas
Crassostrea virginica
Crepidula fornicata
Dasya baillouviana
Devaleraea ramentacea
Diadumene cincta
Dreissena polymorpha
Elminius modestus
Ensis americanus (=*directus*)
Eriocheir sinensis
Eunapius carteri
Eusarsiella zostericola
Fibrocapsa japonica
Ficopomatus (=*Mercierella*) *enigmaticus*
Fucus evanescens
Gammarus tigrinus
Garveia franciscana
Gonionemus vertens (=*murbachi*)
Gracilaria vermiculophylla
Gymnodinium aureolum
Grateloupia doryphora
Grateloupia luxurians
Haliplanella luciae (=*lineata*)
Haplosporidium armoricanum

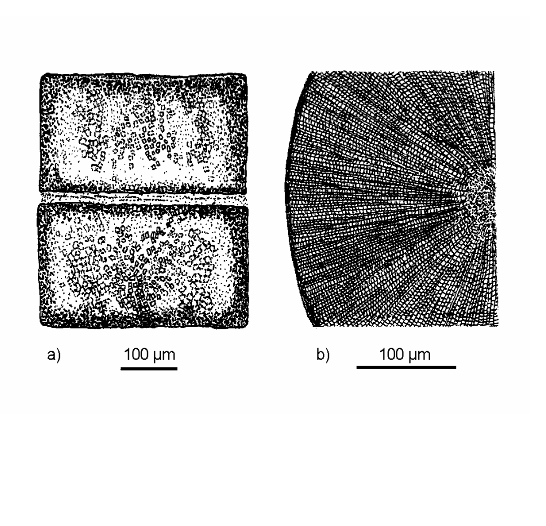
Hydroides dianthus
Hydroides elegans
Hydroides ezoensis
Idotea metallica
Janua brasiliensis
Laminaria ochotensis
Lepas anatifera
Lepas fascicularis
Limulus polyphemus
Lithoglyphus naticoides
Marenzelleria* cf. *viridis
Marenzelleria cf. *wireni*
Marteilia refringens
Mastocarpus stellatus
Mercenaria mercenaria
Microphthalmus similis
Mya arenaria
Mytilicola orientalis
Mytilicola ostreae
Mytilopsis (=*Congeria*) *leucophaeta*
Nematostella vectensis
Nemopsis bachei
Neosiphonia (=*Polysiphonia*) *harveyi*
Nereis (=*Neanthes*) *virens*
Odontella (=*Biddulphia*) *sinensis*
Orchestia cavimana
Orconectes limosus
Palaemon longirostris
Pectinatella magnifica
Petricola pholadiformis
Physella acuta
Pileolaria berkeleyana
Pleurosigma simonsenii
Polysiphonia senticulosa
Polysiphonia harveyi
Porphyra cf. *insolita*
Portumnus latipes
Potamopyrgus antipodarum (=*jenkinsi*)
Proasellus coxalis
Prorocentrum minimum
Prorocentrum redfieldii
Rhithropanopeus harrisii
Rhizosolenia indica
Sabellaria alveolata
Sargassum muticum
Spartina anglica
Styela clava
Teredo navalis
Thalassiosira hendeyi
Thalassiosira punctigera
Thalassiosira tealata
Tharyx killariensis (=*marioni*)
Undaria pinnatifida
Urosalpinx cinerea
Vibrio vulnificus
Victorella pavida

Annex 7: Selected impacting introduced species in the North Sea Region as input to REGNS

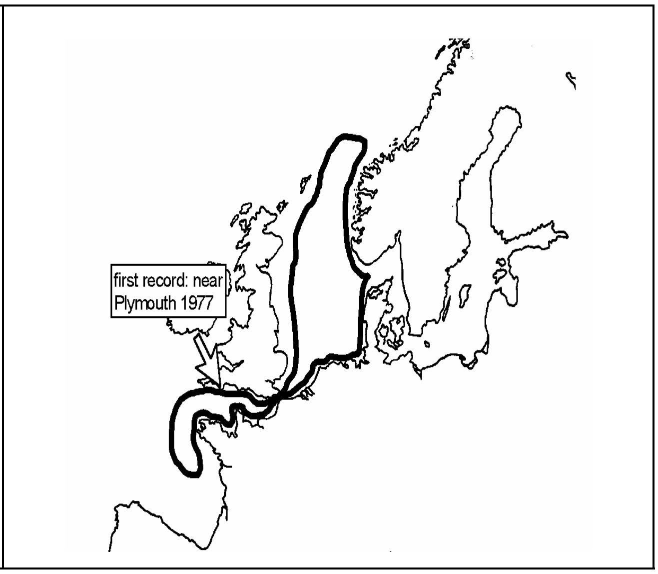
Note: The following case histories of impacting invaders in the North Sea region were published in 1999: Gollasch, S., Minchin, D., Rosenthal H. and Voigt, M. (eds.) 1999. Exotics Across the Ocean. Case histories on introduced species: their general biology, distribution, range expansion and impact. Logos Verlag, Berlin. 78 pp. ISBN 3-89722-248-5.

Coscinodiscus wailesii (Gran & Angst 1931), Bacillariophyceae, Centrales, Coscinodiscaceae

Author: I. **Laing** , Ministry of Agriculture, Fisheries and Food, Fisheries Laboratory, Benarth Road, Conwy, Gwynedd LL32 8UB, United Kingdom, Wales. (i.laing@cefas.co.uk)



Coscinodiscus wailesii **(after [13]). a) Girdle, b) valve face with scattered labiate processes.**



Location of known blooms of *C. wailesii,* not the overall distribution.

Impact:

(* = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial)

RESOURCES/ENVIRONMENT			USES OF THE SEA		
Commercial stocks	***	Forms dense blooms, up to 90 % total algal biomass [1].	Fisheries	***	Clogging of fishing nets with extensive mucus [5].
Other biota	***	Large size, not easily grazed by zooplankton [1, 2].	Aquaculture	***	Clogging of cages [5]. Strips nutrients, reducing availability to algae food species and affects seaweed culture [6].
Human health	?		Water abstractions	-	
Water quality	**	Decay of bloom causes anoxia [3, 4].	Aquatic transport	-	
Habitat modification	**	Produces copious mucilage, which can aggregate, sink and blanket seabed [5].	Tourism	-	

Vulnerable habitats: Blooms may occur in coastal waters, in some cases cells may advected from frontal areas further offshore. Benthic habitats, especially in fishery and aquaculture areas, could be affected.

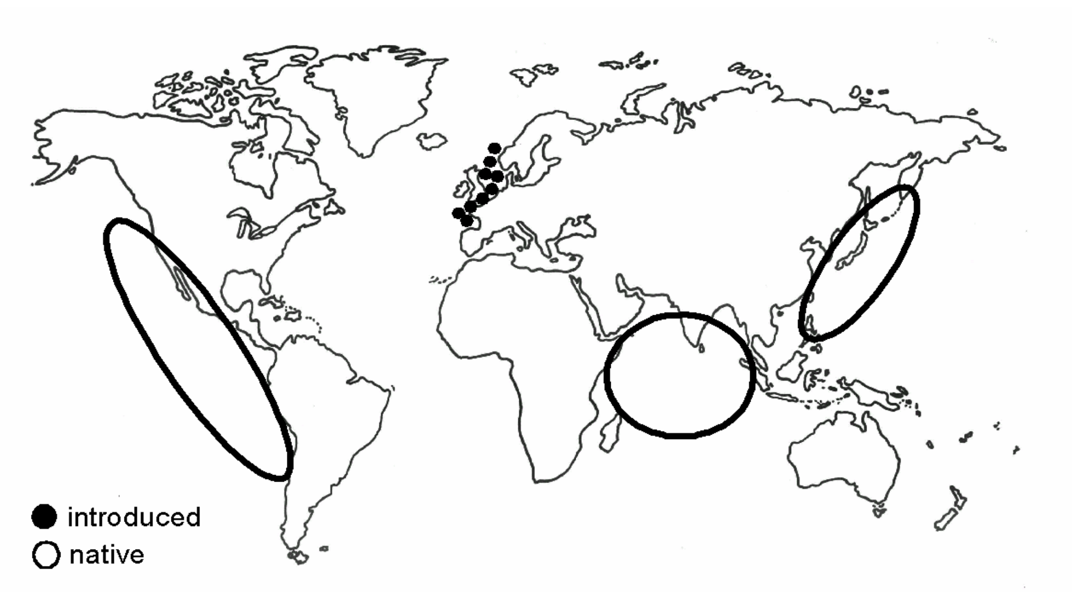
Biology: Forms resting cells, found in sediments. About 70% of the resting cells rejuvenate, given adequate light, temperature and nutrients [7], and most finish their first cell division within 48 hours. Continues to multiply by binary division. A doubling of biomass in 70 h is estimated. Cells produce copious mucilage as blooms develop.

Identification: Large (320–350 □m diameter) centric diatom. Cell shortly cylindrical, valves circular, striated, with bi-labiate processes. Valve flat, mantle 50 □m, meeting valve face at right angles. Markedly rectangular outline in girdle view[5, 8].

Generalised life history: Forms resting cells, found in sediments. These are distinguished from vegetative cells as the cytoplasm of resting cells is partially separated from their frustules and is concentrated in the centre of the cell. When isolated resting cells are incubated at 20^{0}C under continuous illumination of 65 µmol m^{-2}s^{-1}, these cells show a quick response of morphological change into vegetative cells. About 70% of the resting cells rejuvenate and about 80% of the rejuvenated cells finish their first cell divisions within 48 hours. This diatom can survive under dark conditions for long periods (at least 15 months) and can rejuvenate rapidly with adequate light, temperature and nutrients [7]. A doubling of biomass in 70 h could be estimated on the basis of data from four successive field surveys in the German Bight in 1991. Results from laboratory cultures under comparable conditions confirm this rate [1]. The field data also showed 8–10 times lower copper and 10–20 times lower cadmium and zinc accumulation in *C. wailesii*, compared to concentrations found in native phytoplankton species.

Relative abundance: Can double in biomass in 70 h, reaching 1400 µg carbon l^{-1}.

Worldwide distribution: Native to Indian and Pacific Oceans. Introduced to Europe (English Channel, Atlantic coast of France, Frisian Islands, Helgoland, Norway).



World-wide distribution of *Coscinodiscus wailesii.*

Range Expansion in Europe: First detected in the English Channel (near Plymouth, Devon) in 1977 (as *Coscinodiscus nobilis* Grunow) [5]. Origin unknown. Spread rapidly to Atlantic coast of France by 1978 and Norway by 1979 [12].

Invasion patterns: Not known.

Abiotic factors:

Temperature	Tolerates low temperatures. Blooms sustained over autumn / winter months [1, 4].
Salinity	Tolerates full salinity.
Oxygen	Causes anoxia – see above.
Others	Survives long periods without light (> 15 months [7]). Tolerant of heavy metals [1].

Further likely areas for colonisation: Eastern seaboard of America, Australasia.

Main vectors: Probably ballast water transport, as resting cells have been found in ballast tank sediment samples [9] and cells can survive long dark periods [7]. It has also been suggested that importation of shellfish (oysters) could be a vector, with the cells being carried within the gut/pseudofaeces of the animals [10, 11].

Control measures/management options: None.

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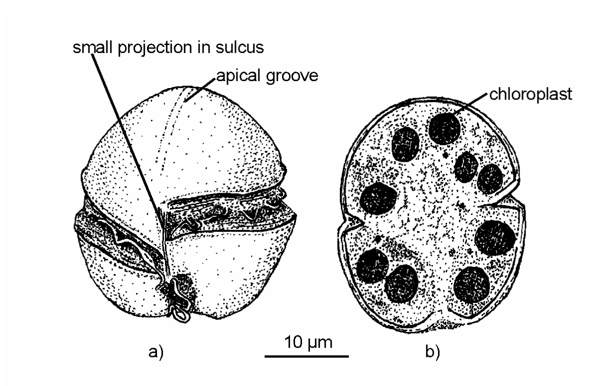
Gyrodinium aureolum (Hulburt), Gymnodiniaceae, Dinophyceae

Author: Elspeth **Macdonald**, FRS Marine Laboratory, PO Box 101, Victoria Road, Aberdeen AB11 9DB, Scotland, UK., (macdonaldem@marlab.ac.uk)



Gyrodinium aureolum **[4]. a, b) Ventral view.**

Locations of known blooms, not the overall distribution of the species.

Impact: * = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial

Resources/Environment			Uses of the Sea		
Commercial stocks	*	When dense blooms. May be toxic to fish. Related species may cause shellfish toxicity.	Fisheries	*	When dense blooms. May be toxic to fish. Related species may cause shellfish toxicity.
Other biota	*	Blooms can have deleterious effects on other biota	Aquaculture	*	Can form dense blooms. May be toxic to fish and shellfish. Caged fish cannot escape blooms.
Human health	?		Water abstractions	?	
Water quality	*	Blooms may discolour water	Aquatic transport	?	
Habitat modification	?	Blooms may affect benthos.	Tourism	*	Blooms may discolour water
Special considerations			Others	?	There is much still to be learned about this species.

Vulnerable habitats: Blooms may occur in coastal waters, in some cases cells may be advected from frontal areas further offshore. Benthic habitats in the vicinity of blooms may be affected.

Biology: Generally most abundant during summer and autumn months, less so during winter and spring when the water column is well mixed. It is not known whether resting cysts are formed. May overwinter as low numbers of motile cells, and may form blooms during summer-autumn months when physical and physiological conditions are favourable. Blooms commonly occur in stratified waters and at frontal regions, and in many cases, are thought to be advected into coastal waters from offshore. It is likely the species could survive in any temperate area where the environmental conditions were suitable. May be capable of producing substances which are allelopathic, and experimental studies have shown that the growth of these dinoflagellates can actively repress the growth of other algae, especially diatoms[2].

Main synonyms: The taxonomy of this species has, for several years, been closely linked to other similar dinoflagellates, namely *Gymnodinium mikimotoi* Miyake et Kominami ex Oda and *Gymnodinium nagasakiense* Takayama et Adachi. *G. aureolum* and *Gym. mikimotoi* have in the past been considered as separate species, and it has also been proposed that they are conspecific, with *Gym. mikimotoi* being the senior synonym [3]. However, a recent revision of the taxonomy has proposed that *G. aureolum* and *Gym. mikimotoi* are separate species, and that the latter is the senior synonym of *Gym. Nagasakiense* [4]. It has been suggested that European strains of *G. aureolum* are morphologically more similar to *Gym. mikimotoi* than to the original description of *G. aureolum* from the USA, but that the genetic, biochemical and toxicological characteristics are not similar to *Gym. mikimotoi* [5]. The taxonomy of these species is clearly complex and more changes may be proposed in the future.

Identification: An athecate (naked) dinoflagellate, not easily identified at the light microscope level, hence the taxonomic confusion and associated uncertainties over nomenclature and synonyms. Size ranges from 20–40 µm long and 13–36 µm wide [4]. The cells may be dorso-ventrally flattened (although the extent of this varies between populations from different geographic areas) and can be identified by morphological features including position, size and shape of the girdle and sulcal groove, cell thickness and the position and shape of the nucleus. The presence of an apical groove on the epicone and shape of chloroplasts are other distinguishing features [3,4,5]. Identification must be made on live cells.

Generalised life history: In British and Irish waters, blooms have often been associated with stratified temperate waters during summer months, and have been very closely correlated to frontal regions around the south west coast of the UK [7]. The first report of mortalities of aquatic organisms linked to this species was during a large bloom off the Norwegian coast in 1966 [6]. Off the south west coast of Ireland, blooms of this organism are commonly associated with frontal regions between upwelled water and stratified shelf water, where the cells may accumulate, and can act as a source of red tides into shallow, coastal embayments [8]. Upwelling also appears important in the blooms forming off the coast of Norway. Off the Swedish west coast, blooms have been linked with high salinity water (>27 psu) resulting not from upwelling, but from the inflow of surface Skaggerak water [9]. Generally, it seems that blooms form in offshore waters and are transported to coastal areas by physical processes. Studies off the western English Channel suggest that blooms are sustained by ammonium [10]. Ammonium may be supplied from *in situ* or extraneous detrital sources, allowing blooms to form even when nutrient levels are apparently low.

Blooms have been linked to mortalities of fish and benthic biota [11,12,13]. Some reports have suggested that these mortalities were due to anoxia rather than to production of toxins [14] but more recently, a bioactive compound called gymnodimine has been derived from *G. mikimotoi* cells from New Zealand during neurotoxic events [15].

Reproduction: Can reproduce by both sexual and asexual means.

Relative abundance: As is common with most planktonic species, numbers are very variable as is it's relative contribution to the total phytoplankton population. Cell concentrations of > 1 million cells l^{-1} can be sufficient to cause discoloured water and mortalities of fish and benthic biota. In some cases, blooms of 10 million cells l^{-1} have been recorded [1].

Similar species: The dinoflagellate originally known as *Gyrodinium aureolum* was first described from the north-eastern USA and initial observations in Europe were in Norwegian waters [6]. Although appearing to be morphologically similar, European populations of *G. aureolum* do show some morphological and genetic differences from Pacific *Gym. mikimotoi*. Once regarded as conspecific [3], it has now been proposed that they are separate species [4]. The synonyms and confusion over the taxonomy of these species are very important and must be considered in any literature searches.

There has been much debate over the taxonomy and nomenclature of this organism. *Gymnodinium* and *Gyrodinium* cells are often distorted when preserved, making it difficult to distinguish them to species level. Examination of live material is necessary.

Worldwide distribution: *G. aureolum, Gym. mikimotoi* and related species are widely distributed throughout temperate seas. Blooms have been reported from Australia, New Zealand, Asia and many parts of Europe including the UK, Ireland, Denmark, Norway and the Iberian peninsula.

Range Expansion in Europe: First observed in European waters off the Norwegian coast in 1966. Since then, it has become a common member of the European phytoplankton community.

Invasion patterns: Since initial observations in Norway, appears to have spread rapidly throughout Europe. As it is a fragile species which may be distorted or destroyed by fixatives, it may have been overlooked or misidentified in earlier studies, so it is not clear how the species has spread.

Abiotic factors:

Temperature	5-22°C[1], varies with geographic region - very widespread species.
Salinity	12-35 psu[1], varies with geographic region - very widespread species.
Preferred substrate	
Oxygen	Can cause anoxia in the benthos when bloom declines.
Preferred depth	
Exposure to air	
Time of year; hydrography	Summer-autumn; stratified water. Favours stratified and frontal regions. Often utilises regenerated N (as ammonium) from earlier diatom bloom.

Further likely areas for colonisation: The organism is known to be widespread.

Main vectors: If indeed this species was introduced, the vector is not known.

Control measures/management options: Aquaculture losses from blooms of this species may be minimised by rapid warning and advisory systems in conjunction with local contingency plans in areas where blooms are known to occur [11].

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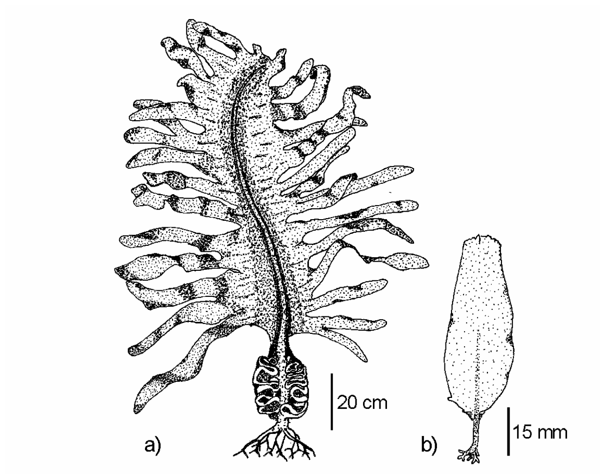
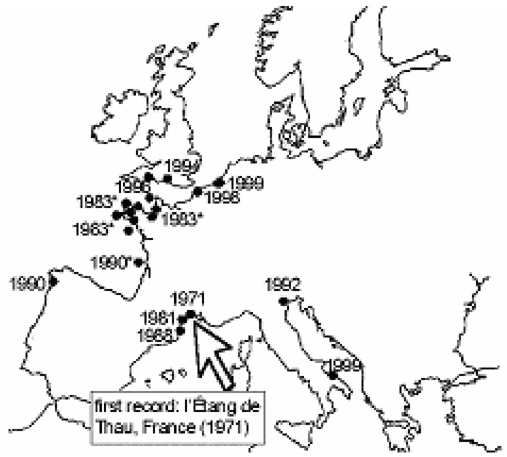
Marine Brown Seaweed: *Undaria pinnatifida* (Harvey) Suringar, Laminariales, Phaeophyceae

Author: Inger **Wallentinus**, Dep. Marine Botany, Göteborg University, P.O.Box 461, SE 405 30 Sweden, (Inger.Wallentinus@marbot.gu.se)



***Undaria pinnatifida*. a) Mature plant, b) young specimen (after photos of WALLENTINUS).**



Known coastal distribution of *Undaria pinnatifida*. *: Brought for cultivation.

Impact:(* = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial)

RESOURCES/ENVIRONMENT			USES OF THE SEA		
Commercial stocks	$	Commercially harvested or farmed in some areas.	Fisheries	*	Canopy hinder fishermen spotting abalone.
Other biota	* or $	Competing with other seaweeds. Eaten by many grazing animals.	Aquaculture	** or $	Fouling on lines, cages, also growing on molluscs or competing for space. Used to feed abalone.
Human health	$	Nutritional value when eaten.	Water abstractions	?	May grow on openings of water intakes.
Water quality	$	Take up nutrients (as all plants) which are removed if harvested.	Aquatic transport	**	Fouling on boats, buoys etc., including costs for cleaning.
Habitat modification	* or $	Large canopies change habitat, reduce light and water movements. Provide shelter for animals.	Tourism	*	Detached plants can accumulate on beaches (also native species do).

Vulnerable habitats: Especially areas not densely covered by other seaweeds, if not too exposed, harbours, marinas or aquaculture sites. If salinities are high enough (generally above 27‰) it may become established in all warm and most cold temperate areas of the world. Easily spread by fouling on boats especially when moored for long periods, by cleaning of hulls or by drifting objects. May survive also on trailed boats as microscopic gametophytes standing darkness for months and very tolerant to drying out and to high and low temperatures. Spread by movements of molluscs.

Biology: The life cycle consists of two stages. A large (ca. 0.5–3 m) annual sporophyte with a lobed lamina and an evident midrib (different morphological forms exist) is attached by root-like hapters to rock, stone, wood, shells, tunicates or sometimes plants and also to most artificial substrates (ropes, boats, buoys, pontoons, concrete, plastic, glass *etc.*). Undulated wing-like sporophylls at the basal part (stipe) of the plant produce zoospores (can be several millions from one plant) which grow into microscopic (only a few cells each) separate female and male gametophytes, not possible to see in the field nor to separate from other kelps. After fertilization of the eggs in oogonia at the top of the female gametophytes, new sporophytes grow out within some weeks, the time to maturity depending on temperature and light. In the native and most other areas recruitment occurs once a year while some of the introduced populations have successive year round generations. Old plants loose the blade before they die and in most areas plants disappear during the end of summer. Like all seaweeds they need light to carry out photosynthesis and take up nutrients by the entire thallus surface.

Identification: The sporophyte reaches a length of 1–2 or even 3 metres in most areas [7, 10, 15, 17, 18, 24, 25, 28], but is usually less than 1 metre in the Mediterranean Sea [4, 12], on the Spanish coast [29], in some populations in New Zealand [18] and Victoria, Australia [6], as well as in areas with high turbidity [16]. The stipe (forms with short or long stipes can occur together [10]) is attached by root-like hapters as for most other European kelps. The leathery to membraneous lamina is yellowish-brown to brown, becoming greenish olive when drying, and pinnate (the forming of lobes can sometimes be surpressed [24]) with an evident, up to 1–3 cm wide midrib all way through. Very young sporophytes (<10 cm) lack a midrib but from a size of about 1 cm they are distinguishable from those of other European kelps through their glandular cells [10, 24] visible at close inspection as small dark dots. The species includes at least two morphological forms f. *disticha* and f. *distans*, the latter with a longer stipe and sporophylls often not reaching all way up to the lamina [24]. These forms may be genetically different [10, 18]. Two other, rather similar species of the genus occur in Japan [24, 27].

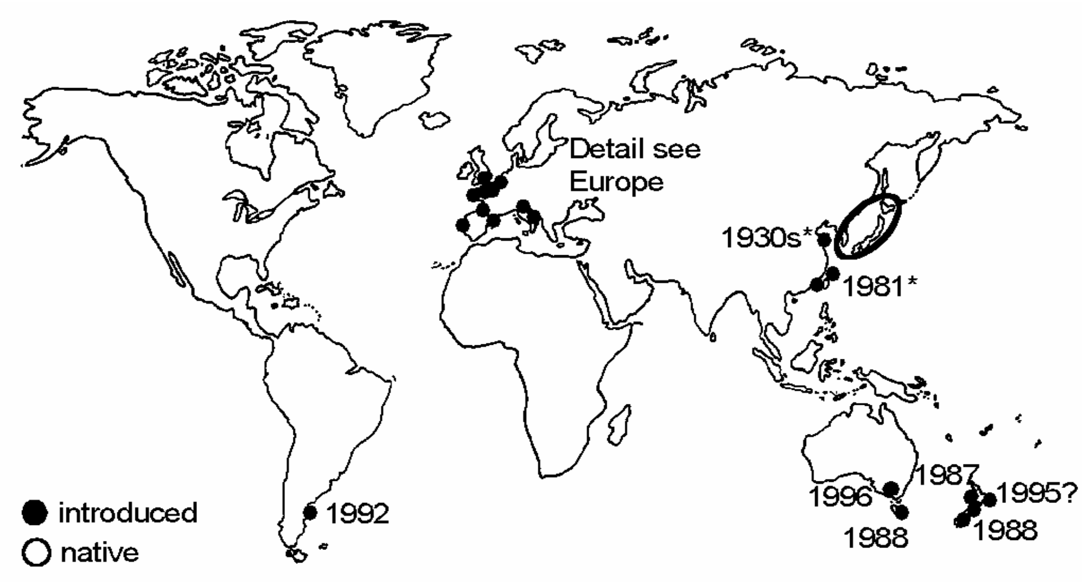
Generalised life history: The species has a heteromorphic life cycle with a large sporophyte and separate microscopic female and male gametophytes. The growing zone is located between the top of the stipe and the lamina, making the top of the lamina the oldest part. The basal part of the sporophyte develops two undulated, winglike sporophylls (one along each side of the stipe, but they may become interleaved and look like one unit) with zoosporangial sori, producing millions of spores per gram tissue [27]. Photosynthesis slows down and growth stops in most areas at high water temperatures when most of the lamina deterioates, and stipes and holdfasts usually disappear during the end of summer [4, 6, 7, 11, 23, 27], but may also persist [18]. Some introduced populations have successive recuitment during the year, *i.e.* both small and large sporophytes occur together [7, 8, 11, 15, 17, 18]. The microscopic gametophytes are very difficult to spot in the field. The female plants consist of only a few cells bearing the oogonia and the males of some more, smaller cells with antherida. The gametophytes may have a dormancy period especially at low light, and are capable of surviving adverse conditions as thick-walled resting stages [27]. After fertilization sporophytes develop, at first attached to the female gametophyte. The species is not known to reproduce vegetatively by fragmentation, but asexual reproduction through unfertilized eggs, developing into parthenogenetic sporophytes, has been seen in laboratory experiments.

Relative abundance: Plant densities are very variable depending on environmental factors and season. Maximum densities in introduced populations are around 200–250 plants m^{-2} [4, 18] and biomasses of more than 10 kg wet weight m^{-2} have been recorded [18]. The longevity of a single sporophyte can be up to 222 days [11] and growth rates of 1–2 cm per day have been measured for young plants [11, 33]. Many authors discuss the risk of *Undaria* outcompeting native European seaweeds. Having an annual apperance it may mainly compete with other large annuals such as *Saccorhiza polyschides* [8, 14, 16]. Clearing experiments in Brittany, France [16], showed that most previously denuded rocks were recolonized by native kelps and not by *Undaria* and that the annual species *S. polyschides* in fact became the dominant species on these rocks. Later those sites recovered to fully natural species composition dominated by perennial kelps. It has been pointed out that if *Undaria* colonizes areas without other large canopy species, its size may have large ecological consequences, incl. shading of smaller understorey species [14, 18]. However, some animals may even be attracted to it for shelter [8] and high grazing pressure on the sporophyte by sea urchins [3, 8, 15, 17, 28], molluscs such as *Gibbula* or abalone [3, 9], copepods and gammarids [20] or fish [3, 15] may contribute to reduced population densities in some areas [10].

The success of *Undaria*. may be due to that it in many ways behave as an opportunistic species. Its preference for disturbed or artificial surfaces [14, 15, 18, 28], more than one generation per year (see above), a wide tolerance to environmental factors (light, exposure *etc.*) and rapid growth up to 10 times as high as for most kelps [6] also gives competitive advantage [18] but nutrient limitation may occur [6].

Worldwide distribution: *Undaria pinnatifida* is native along the northwestern Pacific shores: most of the coasts of Japan, Korea, some eastern parts of China, southeast Russia near Vladivostok [for references see 15, 17, 24, 27, 31].

The species is reported as introduced by Japanese ships to New Zealand (Wellington 1987 and Timaru 1988 [17]), and spread by local coastal traffic to Oamar in 1988 and Lyttelton 1989 [17, 18], and later also to the harbours of Otaga, Porirua, Picton and Napier [18]; to eastern Tasmania (Rheban-Triabunna) in 1988 presumably in ballast tanks of Japanese ships [3, 28], where it later has spread along the coast [3]; with cargo or fishing vessels from Korea or Japan into the Guelfo de Neuvo, Argentina in 1992 [7]. For France, Spain, Italy and Taiwan, see below. In 1994 it was recorded in southern U.K. probably spread by vessels from France or the Channel Islands [14] and has later spread to other sites on the south coast and been confirmed on the Channel Islands [13]. In 1996 it was reported from Port Phillip Bay, Victoria, Australia [6], probably coming with ships from Japan or New Zealand (Hay, pers. comm.). In 1999 the species was reported from Belgium (Zeebrugge) and in the Dutch Oosterschelde region (Yerseke, Stavenisse and Strijenham, [30, STEGENGA, pers. comm.]), so far the northernmost sites in Europe. A record in 1998 from Calais, northern France [30] might also be due to shipping, as may the records in the harbours of Brest and Grandville in northwestern France in the early 1990s [16].



World-wide distribution of *Undaria pinnatifida.* *: Brought for cultivation.

Range Expansion in Europe: The first European record from the French Mediterranean coast in 1971 (l'Étang de Thau) most likely was a result from imports of Japanese oysters [4, 15, 25, 32]. It later spread outside the lagoon [4], and was in 1988 found close to the Spanish coast (Port Vendres [15]), but so far has not been reported from the Spanish Mediterranean coast [32]. It was first farmed in the French Mediterranean and was transfered by IFREMER for farming in northern France at three sites around Brittany in 1983 [15, 25]. Later some new sites were used [8, 15, 18, 25, 32]. In 1987 it was found reproducing in the wild at one farming site (Ouessant [15, 16]), later also in other districts (St Malo, Rance estuary, [8, 9, 10, 11, 18]. In 1990 it was reported from Ria Ariosa, northern Spain [29], probably as a result of oyster movements. Since 1992 it occurs in Venice [12], which might be due to mollusc farming, but shipping cannot be excluded as a vector [16] as it grows in several dock areas [12]. *Undaria pinnatifida* arrived near Bari in a lagoon of the southern Italy in 1999 (MEINESZ pers. comm.). For U.K., Belgium and The Netherlands, see above.

Invasion patterns: Since long-distance and coastal shipping is likely to play such a large role for dispersal along the coasts, true dispersal rates are difficult to achieve and many areas show disjunct populations. In Australia a dispersal rate of 2–3 km per year have been estimated for eastern Tasmania [3] where currents may be the most important agent and in Argentina about 1 km per year [7]. The survival of zoospores have been estimated to be at least 1–2 days which could give a potential dispersal distance of 100 km in tidal currents [17].

Unintentional introductions emphasize the need of proper quarantine treatment in aquaculture, and only the next generation should be released to avoid that molluscs act as vectors. New rules for free trade and movements of shellfish for fattening between disease-free coastal areas within Europe may bring in *Undaria* from areas where it grows, and might especially be a threat for the Irish and British coasts not yet colonized and where such movements have frequently occurred (cf. *Sargassum muticum*).

Abiotic factors:

Temperature	Temperature has been a key factor estimating the risk of establishment, focusing on minimum values [see 15, 18]. The lowest temperature given for zoospore release in Asia was 5 °C [15], the highest 23°C and a range for gametophyte maturity and fertilization of 5–28°C, with a full range of gametophyte survival from -1 to 30°C [1]. Lowest temperatures for sporophyte recruitment in introduced populations are in northern France 5°C [11] and in new Zealand 7–8°C [18]. No introduced populations so far seem to have reached the upper temperature limit. Gametophytes from the Mediterranean had an upper limit of 29.5°C [26]. Most studies have shown better growth rates at lower temperatures and optimum can be as low as 5–10°C with no growth below 3°C [33], but more often the optimum is 10–20°C [15]. The summer decline of sporophytes in many areas are due to high sea temperatures, with an upper limit for growth of 25°C [15, 18].
Salinity	Mostly found in salinities above 27‰, which is considered necessary for growth, but zoospores can attach above 19‰ [27]. The lowest salinities in which the species is established is in Venice 20‰ (Curiel pers. comm.), 22–23‰ in extreme cases in New Zeeland (Hay, pers. comm.) and 27‰ occuring during February in Spain [29]. Growth in the less saline parts of Venice, shows that adaptation to brackish water may occur.
Light and depth distribution	The different life stages have different optimum ranges for light. The light saturation levels of photosynthesis in sporophytes vary with season, being as low as 100–150 µE m-2 s-1 [6, 23] . The light compensation point, i.e. above which net photosynthesis occur, is as low as around 8–15 µE m-2 s-1 and plants have very low respiration rates [6, 23]. The gametophytes are better preserved and able to survive in darkness for at least seven months [21] enabling long distance transports in ballast water tanks. Gametophytes and very young sporophytes exposed to 50–100% direct sunlight and 16–28% of natural UV radiation died within hours [1]. In some populations gametophytes matured under both long and short days, while others needed short days [1]. The highest densities are often close to the surface with a total depth range from the lower intertidal to about 12 m, sometimes 18 m depth [7, 8, 15, 16, 17, 27]. The sporophytes have better tolerance to low light levels than many native kelp species [6, 8, 18], making Undaria more competitive.

Further likely areas for colonisation: Europe [cf. 15, 17]: All the rest of England, Wales, Isle of Man, Scotland with the Orkneys and Hebrides, Ireland, the North Sea coast; all the rest of France, Spain and Portugal; presumably all the rest of the Mediterranean area; presumably also the western coasts of Scandinavia. Atlantic and Pacific warm and cold temperate coasts of North and South America, warm and cold temperate coasts of Africa, all the rest of the warm and cold temperate coasts of Australia [cf. 3, 28] and most of New Zealand.

Brackish water areas are less at risk, if salinities are well below 18‰. The high affinity for artificial substrate also makes harbours, marinas, aquaculture sites and areas with sediments susceptible, although soft substrate is not colonized. Disturbed rocky shores [10, 18, 27] ore heavily grazed areas [17, 28] are likely more at risk than those with a dense perennial vegetation, if not too exposed [18]. Both in northern France and in Venice it is found growing close to discharges of urban waste waters [10, 11, 12]. Prosperous growth among farmed mussels and oysters also indicates enhancement by nutrients recirculated by these animals.

Main vectors: Anchored and deballasting ships, drifting mooring buoys and towed navigational buoys can be responsible for dispersal directly or by infesting vessels, as well as the cleaning of ships' hulls at the seaside with pressure hoses [17]. Dispersal of zoospores by water movements might be limited, since no plants were found on the opposite side of a New Zealand harbour until ships fouled with *Undaria* where moved and anchored there (Hay pers. comm.). Plants fouling ships' hulls have been found to survive a voyage of more than 4000 km and during that time (about a month) had grown 10–20 cm [17]. Trailed boats may also disperse the species into new waters, due to the extreme tolerance and survival of the microscopic gametophytes for days up to a month in small crevices [17, Hay pers. comm.], making new areas susceptible, especially if the boats are left with a constant water line at the new site [17] for the time it takes sporophytes to mature. The species was moved to China from Korea for farming already in the 1930s [31] and in 1981 to Taiwan from Japan [22]; for France see above. Unintentionally introduced populations (see above) has been commercially utilized in Spain [19] and in Tasmania [3]. In New Zealand a pilot farming programme has been undertaken in areas already having *Undaria* [2].

Control measures/management options: Since the microscopic gametophytes are very tolerant and not visible by the naked eye eradication is extremely difficult and manual eradication tried in Italy has not been successful [12]. Studies on effects of herbicides and antifouling paints have shown that some antifouling paints are efficient in stopping zoospore germination or cause gametophyte mortality, while some herbicides are not [5]. However, patches not painted (*e.g.* covered by supporting structures during painting) or single corroded plates may develop dense lumps of sporophytes [17]. Ships' hulls should only be cleaned out of the water and organisms be dumped out of the reach of the sea [3]. Since sporophytes have been found surviving and growing on the hulls for voyages over 4000 km [17] they should be removed before sporophylls are developed (in some cases sporophylls are small and difficult to see) to avoid seeding of other areas. If fertile, detached plants should be kept in containers when removed to avoid release of zoospores, since slightly dried sporophylls which are reimmersed release zoospores very quickly [27]. Since pontoons, towed buoys or drifting objects such as ropes , plastics *etc.* also contribute to the dispersal they should preferably be taken out of water and cleaned more efficiently than just by scraping off plants [cf. 17] or be disposed of, when carrying *Undaria* plants.

Gametophytes could survive temperatures around 30°C for up to 10–40 days [21], and thus high temperature treatment is needed for cleaning hulls, and one must be reassured that the hot water penetrates into crevices and other openings. Gametophyte survival in small moist crevices in the hulls, anchor wells *etc.* make them survive even dry docking as well as transportation on land for days up to at least about a month [17, HAY, pers. comm.]. Since they can stand darkness for over seven months [21], ballast transport is a likely vector, especially as the gametophytes may form thick-walled resting stages, with a potential of surviving also in the sediment [3]. Exposure to UV light can be efficient on growing gametophytes [cf. 1], although it is not known if this affects the thick-walled resting stages.

Farming of *Undaria* should not be considered in areas where it does not yet grow [2], nor should lines and supporting structures in aquaculture be moved from sites with *Undaria* to areas where it does not grow [3, 17]. Proper quarantine treatment is needed in aquaculture to prevent unintentional introductions with molluscs and movements of molluscs from disease-free areas avoided if *Undaria* grows there.

Information on colonized sites should be distributed and great care taken not to perform scientific experiments in the field or in open flow-through systems in areas where the species does not yet occur. Also material brought in for demonstrations should be carefully disposed of on land, especially when plants with sporophylls are used.

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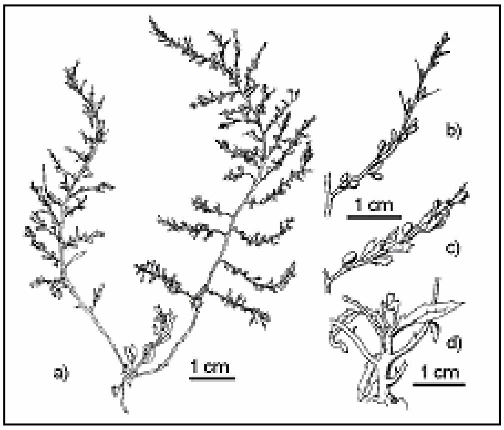
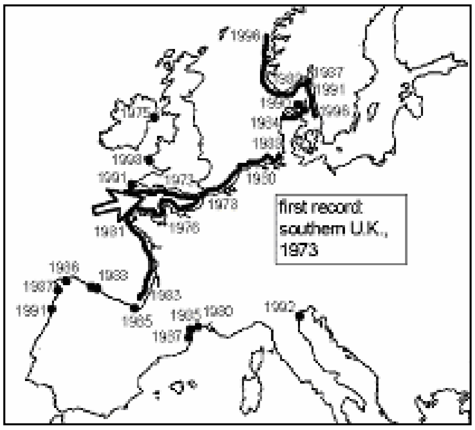
Sargassum muticum (Yendo) Fensholt, Sargassaceae, Fucales, Phaeophyceae

Author: Inger **Wallentinus**, Dep. Marine Botany, Göteborg University, P.O.Box 461, SE 405 30 Sweden, (Inger.Wallentinus@marbot.gu.se 30 Sweden, (Inger.Wallentinus@marbot.gu.se)



Sargassum muticum **[after 46]. a) Winter morphology, b) detail branch: summer morphology, c) winter morphology, d) detail: perennial primary shoot.**



Known coastal distribution of *Sargassum muticum.*

Impact: (* = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial)

Resources/Environment			Uses of the Sea		
Commercial stocks	?	Commercial uses tried without much success.	Fisheries	* or $	Clog and foul nets, hinder to sport fishery. Attract fish.
Other biota	**	Competing with other seaweeds. Seagrass beds may be secondarily affected by habitat changes.	Aquaculture	**	Foul ropes, lines, bags etc., grow on molluscs and may drift away. Difficult to spot oysters.
Human health	?	Can harbour epiphytic invertebrates causing allergy.	Water abstractions	*	Drifting plants may block water intakes.
Water quality	*	Dense canopies accumulate silt.	Aquatic transport	**	Entangle in boat propellers, tricky manoeuvring in beds, foul pontoons and piers.
Habitat modification	* or $	Large, long canopies change the habitat, reduce light and water movements. Shelter for animals	Tourism	**	Sandy bays can become dense algal beds. Detached plants accumulate on beaches.

Vulnerable habitats: Especially sheltered to semi-exposed areas not densely covered by other seaweeds, harbours or aquaculture sites. Sandy areas with small stones, pebbles and shells, or free patches in seagrass beds. It may become established in all warm and cold temperate areas of the world in not too exposed areas, also in brackish water (at least in salinities above 16‰). Enhanced by polluted and nutrient-rich waters, but does not tolerate desiccation. Easily spread by drifting fertile branches or transfer of molluscs.

Biology: The life cycle consists only of the large pseudo-perennial plant, up to 5–10 m long. The long, annual branches have numerous small (<0.5 cm) round air-bladders, making plants stand upright in the water or float on the surface, and small leaf-like branches. Attached by a disc-shaped holdfast to rocks, stones, pebbles, artificial substrates (ropes and mariculture structures, glass, plastic, metal *etc.*) and also to shells, barnacles, tunicates and occasionally seaweeds. Plants on pebbles or shells often drift away. The lateral branches detach in summer-autumn in cold waters, leaving only a short perennial stem with coarse, broad leaf-like branches which overwinter. In warm waters long plants may persist all year. Even small pieces of holdfasts can regenerate branches.

Reproduce by the <1 cm long receptacles producing both eggs and spermatozoids. Thus one single plant can multiply with a potential for many millions of germlings. Fertility depends on temperature, in summer-autumn in cold waters, may occur all year in warm waters. The small embryos remain on the receptacles until rhizoids are developed, giving a competitive advantage. After detaching they sink and reattach immediately to any surface encountered by the rhizoids and develop a new plant with a holdfast. Old germlings loose ability to reattach.

Identification: The up to 5–10 m long plant [3, 13, 29] is attached by a disc-shaped holdfast, which can regenerate [23]. In the basal region it has a short perennial stem (3–4 cm, often branched], and some broad leaf-like branches with a midrib [7, 13, 37, 45]. The long, thin primary laterals and those of higher order bear many small leaf-like branches and numerous small (<0.5 cm) stalked, round or slightly pear shaped, air vesicles. Colour varies from dark brown (especially in winter and in nutrient-rich areas) to pale, almost yellowish. The air vesicles make the plants stand upright in the water or float on the surface. *Sargassum muticum* was previously ranked as a form, *S. kjellmanianum* f. *muticus*. The species *S. kjellmanianum* Yendo, which is dioecious (cf. below), is now renamed *S. miyabei* Yendo [45] but the old name is still in use, especially in Asia [13], and thus may include both species. The genus *Sargassum* has about 400 species [45], several of which are very difficult to separate, especially if not fertile and without a holdfast.

Generalised life history: The life cycle only has one stage: a large pseudo-perennial plant. Every late winter/ spring/ early summer, depending on temperature, annual laterals grow out, but in some warmer areas the plants can have such branches and be fertile all year through [19, 29]. At rather exposed sites the size is usually smaller [14, 19, 40, 43] and plants often broken. At senescence (late spring/ summer/ early autumn, depending on temperature), the laterals detach, but they can survive and even grow while floating free and loose vegetative branched may even become reproductive [17]. In late autumn/ winter only the perennial holdfast and short stem with some broad leaf-like branches remain.

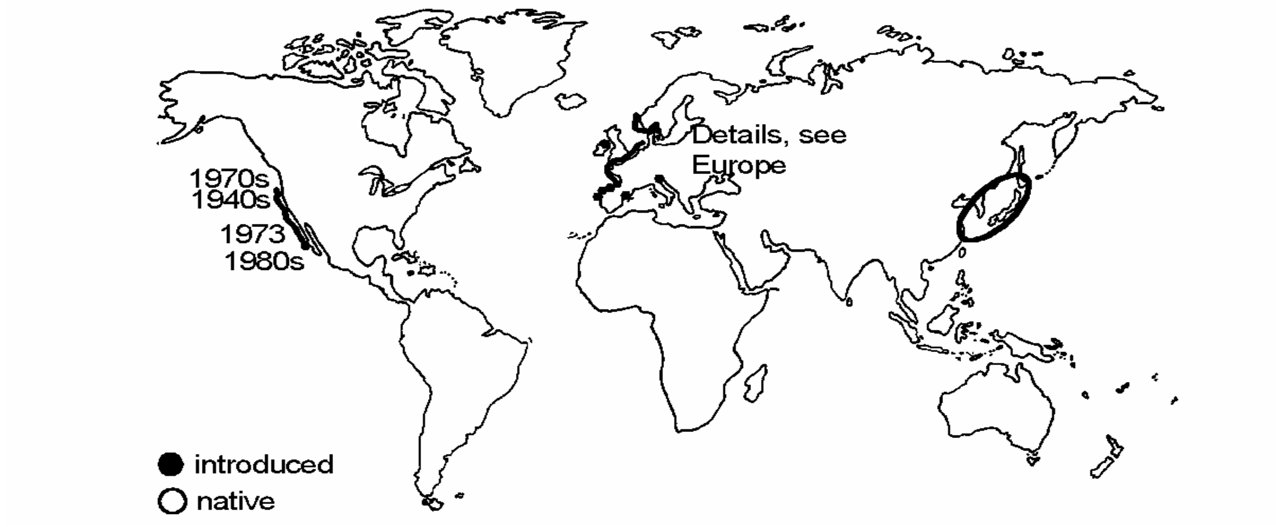
Less than 1 cm long, cigar-shaped receptacles develop in single where the ”leaf” attach to the branch, but can also sit on top of the branches [7, 45]. Receptacles have both oogonia and antheridia producing eggs and spermatozoids in small separate cavities (conceptacles), visible as dark dots (monoecious plant). The plant is self-fertile, thus one is enough to multiply with potentially millions of germlings [29]. Fertilization occurs when eggs are still attached by a mucilage stalk and the young embryos remain attached to the receptacles until 16–32 cells large (hardly visible by the eye), and rhizoids are developed [22]. They then detach from the receptacles, sink and reattach immediately to any surface by a cement of acid polysaccharides on the rhizoids, and later develop an holdfast. Reproduction occurs in winter-spring in the native area [16, 45] and in introduced populations in early spring/ summer/ early autumn depending on a combination of number of days above a certain temperature [16]. Fertile plants can occur all year through in Mexico and southern US [19, 29]. Germling dispersal only occurs within some few metres from the parent plants [2, 17] thus recruitment depends on drifting plants. Some other *Sargassum* species can develop vegetative embryos on rhizoids which grow out to new plants [33].

Relative abundance: Plant densities are very variable depending on environmental factors and season. Maximum densities up to 130–300 per m² have been recorded [1, 5, 21], and weights up to 2.7–4.2 kg ww m-2 [12, 42], or nearly 1 kg dw [5, 14]. Maximum growth rates may reach 2–4 cm per day in the field [27, 29, 43] and up to 7 cm (depending on season and part of the plant) in laboratory experiments [27]. *Sargassum muticum* exhibits several opportunistic characters [8, 20, 36, 39, 43] such as rapid colonisation of free space, a large number of propagules, incl. cast off branches, rapid growth of young germlings [24], high photosynthetic rates, while respiration rates still are low [21, 35]. Being monoecious with self-fertilization and keeping the young embryos on the adults, highly increases the chances of establishment, and the perennial base secures the continued existence of the plant. Also other species of the genus *Sargassum* may have the characters being typical of an invasive species [33]. Flourishing growth in mussel and oyster cultures points to nutrient enhancement. It also grows in polluted waters [12] and seems to be favoured by high nitrate concentrations [3]. The holdfasts withstand a high drag [17, 22] as do very small germlings. In Sweden it grows well in a strong current created by discharged cooling water from a nuclear power plant (J. Karlsson, pers. comm.).

S. muticum has in several cases been found to be a superior competitor and the large size of the plants during spring/ summer effectively blankets the light for understorey species [1, 5, 12, 22, 39], especially when the summer branches are floating on the water surface. Dense populations may reduce the light intensities down to 2 μE s^{-1} m^{-2} [5] or 97% of surface value [12]. Accumulation of silt among densely branched specimens further reduce the possibilities for other species to survive [6, 8, 12] as do occupation of space [39]. Thus several perennial species have shown decreased abundance or poor recruitment in areas with dense cover of *Sargassum muticum, e.g.* kelps [1, 4, 6, 29], fucoids [4, 5, 18, 38, 39], and also filamentous and foliose algae may loose in competition [8, 14, 39]. In exposed areas *S. muticum* looses against native turf-forming and foliose species which occupy space, since it needs open areas to settle [2, 17, 21]. When colonizing areas without large canopy species it may also attract various invertebrates important as fish food [29, 44] and even fish such as eels [8, 44].

The snail *Lacuna*, amphipods and sea urchins are grazers on the American Pacific coast, which in summer can remove more tissue than is grown [31]. In the Mediterranean sea urchins can be heavy grazers [3]. However, in general grazing pressure is not able to surpress established populations, and in spring grazing cannot keep pace with the growth [31]. High contents of phlorotannins [3, 31] may also deter some grazers. Periwinkles graze heavily on [20] or physically remove [31] young germlings and gammarids often occur on adults [7]. Intact but killed germlings were found in fecal pellets of sea cucumbers [29]. Several exotic animals have been reported on introduced *S. muticum* [3, 13] and the total number of animals may be more than 700 per 100 g ww [31].

Worldwide distribution: *Sargassum muticum* is native on the northwestern Pacific shores: Japan, Russia, Korea, China (for references see [13, 45]). In the north-eastern Pacific it was first recorded in 1944 around the Strait of Georgia, British Columbia, presumably brought by Japanese oysters before 1940 [37], but not present in the early part of the century. It was found in Oregon in 1947 and in Washington in 1953, also areas with imports of oysters from Japan [37]. The spread further south the Pacific US coast may be due to drift of vegetative branches becoming fertile [17], and it was recorded in 1973 in California and Mexico [19, 41]. Now occurring northwards to south-east Alaska (references in [13]) and southwards to the Mexican San Ignacio Lagoon where it in the 1990s is one of the dominant algae [32]. For Europe, see below.



World-wide distribution of *Sargassum muticum.*

Range Expansion in Europe: The first introduction into Europe has been a question of much debate, attached plants first recorded in southern U.K. in 1973 [10, 20] while not found until in 1976 at the Atlantic French coast [3, 10]. Many consider the latter to be the primary introduction area by imports of oysters from British Columbia or Japan in the 1960s [see *e.g.* 3, 13, 20] and that drifting plants brought it to U.K. It was further spread along the English south coast [10, 13, 18] and in 1998 found in southern Wales (C. Eno, pers. comm.). Drifting spread plants northwards to the Netherlands, in 1980 found attached on Texel and in the southern parts [10, 12, 13, 34]. In Scandinavia attached plants were first recorded in western Limfjorden, Denmark, as early as in 1984 [36, 41, 42, 43 and refences therein], where it later has spread all the way to the Kattegat coast [41, 42] and also to the north coast [41]; in 1987 in Sweden [28, 41] and later spread by drift to the middle part of the Kattegat coast [28]; in 1988 in Norway [36] and later spread to north of Bergen in 1993 [26] and Rogaland in 1996 (H. Botnen pers. comm.). In 1988 it came to Helgoland, Germany [41] and in 1993 to the island of Sylt, northern Waddensee (A. Chapman, pers. comm.). The first record in Northern Ireland in 1995 [4] most probably is due to import of oyster from the Channel Islands since *S. muticum* grew on old oyster bags. Southwards, it in 1983 reached southern France [3] and was recorded in northern Spain in 1985 [21]. It has since spread to several places on the Spanish north and northwest coast [21, 39, 40] and was recorded in northern Portugal in 1991 [20, R. Melo, pers. comm.]. New imports of Japanese oysters to l'Étang de Thau, the Mediterranean, resulted in records of attached plants in 1980, together with several other introduced species [5, 13, 41], but so far it has not been reported from the Spanish Mediterranean coast. The establishment in the lagoon outside Venice in 1992, where also two other introduced species occur [14] probably also is related to commercial transfer of molluscs.

Invasion patterns: Since drifting plants and branches play such a large role for dispersal, many areas at first show disjunct populations, often starting in bays accumulating debris [17, 28]. Dispersal rates have been estimated to 10 km per year in Limfjorden [42], and around 50 km per year in Sweden (J. Karlsson, pers. comm.), while large jumps were seen along the north-eastern Pacific shores [17, 19]. In some areas saturation (all suitable habitats occupied) may occur after the first expansive phase, when the increase rates stop, being about 6 years in the Netherlands [12] and southern England [8], 11 years in Limfjorden [38] and 15 years in France [3]. On the other hand the Swedish populations did not seem to have reached that phase after 9 years [28].

Unintentional introductions emphasize the need of proper quarantine treatment in aquaculture, and only the next generation should be released to avoid that molluscs act as vectors. New rules for free trade and transfers of shellfish for fattening between disease-free coastal areas within Europe may bring in *S. muticum* from areas where it grows, and might especially be a threat for the Irish and British coasts, where such transfers have frequently occurred (suggested vector for Northern Ireland, [4]). Experimental work in areas where the species already occurs can result in locally higher densities around *e.g.* field stations (own obs.).

Further likely areas for colonisation: Europe: All the rest of England, Wales and Ireland, Isle of Man, Scotland, the islands of Orkney, Shetland and the Hebrides, the Faroe Islands, the Danish North Sea coast, all Kattegat coasts, the Norwegian northwest and north coasts, southern Iceland. All the rest of Spain, Portugal, and the Mediterranean Sea. How far into the brackish Baltic Sea area it may progress is less easy to predict since different salinity tolerance limits have been reported (see above) incl. reduced fertilization. Also the northern distribution limit is difficult to predict depending on risks for ice scouring and low growth rate at low temperatures, which may make it less competitive. Cold and warm temperate Atlantic coasts of Canada and USA, South America, Africa, Australia and New Zealand.

Disturbed rocky shores, if not too exposed, are likely more at risk than those with a dense perennial vegetation [2, 39, 40]. Settling and growth on small stones, shells and most artificial substrates also makes areas with sediments susceptible (incl. ports and aquaculture sites), but soft substrate is not colonized. Eelgrass beds may also deteriorate, when there is a clearing of the beds by e.g. natural population dynamics or storms [15].

Abiotic factors:

Temperature	Growth rates of germlings, adults and receptacles increase with temperature, with optimum round 25°C, but growth also at 30°C [24, 25]. More vigerous growth in warm areas [19, 29] incl. El Niño [1] and cooling water from a nuclear power plant [28]. A multiplicative number of degrees and days are needed for receptacle initiation [16]. No growth at 0°C [30], but plants survive winters with ice cover and temperatures below 0°C [12, 28] as well as exposure to air at -1.5°C for one hour [30]. Plants in the upper intertidal often have damaged tissues [8, 29].
Salinity	Salinity is the key factor for dispersal into brackish waters. Most introduced populations grow in areas with salinities above 20‰. The southernmost Swedish area [28] has a surface salinity of 16–20 ‰. In the brackish Limfjorden, Denmark, it is mainly found above 25‰, but may occur in slightly lower salinities (T. Wernberg-Møller pers. comm.). On a Canadian shore influenced by melting water and with surface salinities down to 8.6‰, plants only occur below 6–10 m [30]. In Venice only found in the outer area and not in the brackish canals [14]. Lowest salinities for germling growth in laboratory test are around 5–6‰, older ones being more tolerant, but no fertilization seen below 17–20 ‰ [24, H. Steen pers. comm., cf. also 30], but receptacles can grow down to 8.5‰ [25]. Thus some part of the reproductive cycle is disturbed and spermatozoids may be especially vulnerable [25] or the rhizoids cannot attach with their mucilage.
Light and depth distribution	Optimum light for growth differs between germlings and adult plants. The former have growth optimum around 45 µE s-1 m-2 the youngest ones even have high mortalitie rates between 90-175 µE s-1 m-2 , older ones being more tolerant to high light [24]. Around 160-190 µE s-1 m-2 is saturating for photosynthesis, varying with season, [35] and compensation levels are around 12-32 µE s-1 m-2. Gamete maturity mostly requires long-day conditions [25], but receptacles kept in darkness can produce viable gamets [25]. Germlings are able to survive, but not grow, for several weeks in darkness (data by Chritchley in [24]]. Most populations are best developed close to surface, but a depth of around 6–15 m is not uncommon [28, 29], maximum 24–25 m [10, 30], depending on turbidity, available substrate, grazing and competition. Assimilated products can be transpored along the fronds [20], making plants less vulnerable to the high shelf-shading beneath the canopy [12] and turbidity.

Main vectors: Most introduced populations originate from **imports of oysters and mussels,** dispersing later as drifting branches. In the Netherlands it was proven that imported oysters can act as a vector for the species [9] and they discussed the risk of storage of live oysters for consumption in basins at the seaside. There are no proofs of the species being established by shipping activities, but it reached one site on a Channel Island entangled in the stearing gear of a yacht [10]. If hull fouling would be a vector for dispersal, this requires that germlings attach at a very young stage, since old plants do not reattach [17, 30]. However, branches may entangle in other hull fouling species and if being or becoming fertile may release germlings to new sites. Although not tolerating drying out for any longer period [30], plants might survive in heaps of wet fishing nets or ropes, anchor wells etc. since it could survive some days in open oysters bags transported on land for two days [9]. Receptacles and small germlings probably can survive in darkness in ballast tanks (see above), but they may loose the ability reattach. Large plants often lift smaller pieces of substrate and drift away [8, 29, own obs.], acting as vector also to deeper bottoms (”walking stones” [29]).

Control measures/management options: Since secondary introductions by drifting plants is a major vector, control is almost impossible. Several methods, both mechanical and chemical have been tried to eradicate this species [3, 11, 13] without success and a need for repeated croppings. Mechanical treatment even has helped spreading branches to new areas [3, 11, 13]. It is a nuisance in aquaculture [3, 4, 23, 37] growing on lines, supporting structures and oyster bags. The potentially toxic dinoflagellate *Prorocentrum lima* is often found in large quantities in the canopies (M. Kuylenstierna pers. comm.) and if coming into water being filtered by molluscs may cause DSP. Proper quarantine treatment is needed in aquaculture to prevent unintentional introductions with molluscs. Transfer of molluscs from disease-free areas with *S. muticum* should be avoided as well as moving of ropes and other structures, since in late autumn and winter the small plants are hard to see, and objects epiphytized with large plants should preferably be taken out of the water. Storage of live oysters for consumption in basins at the seaside could be a potential risk [9], and shells should be carefully inspected. Commercial harvests of *Sargassum* have been attempted and used *e.g.* as fertilizers [3], but no large scale operations are started. Nets with *Sargassum* may also be used to clean water and as artificial reefs [44].

The effect on fishery is mainly by clogging and fouling nets and floating plants is a hinder to sport fishery [10] and in shallow areas manoeuvering of small boats in dense stands becomes difficult or plants get stuck in the propellers. Propellers should be inspected and removed plants should always be dumped on land. Removal of large fouling species on ships' hulls reduces the risk of having *Sargassum* branches entangled.

Information on colonized sites should be distributed and great care taken not to perform scientific experiments in the field or in open flow-through systems in areas where the species does not yet occur. Also material brought in for demonstrations should be carefully disposed of on land.

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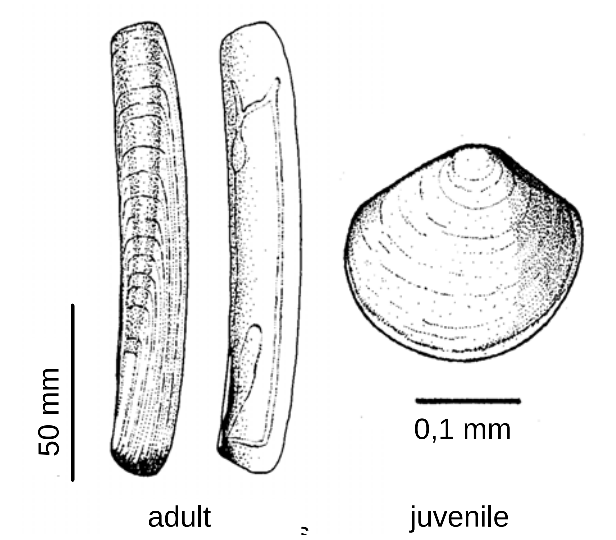
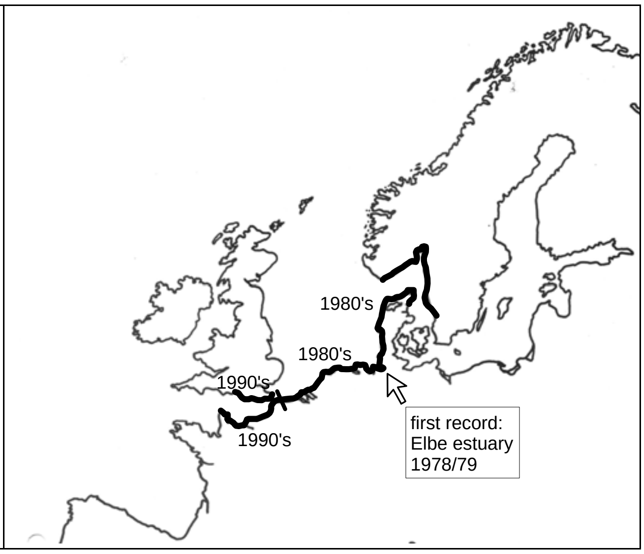
Ensis directus (Conrad, 1843), Solenidae, Bivalvia

Author: M. **Voigt**, Environmental Consultant, Kampst. 7, 24601 Stolpe, Germany (m.voigt@netsurf.de)



Ensis directus [7].



Known distribution including range expansion (in decades) of *Ensis directus*.

Impact:

(* = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial)

RESOURCES/ENVIRONMENT			USES OF THE SEA		
Commercial stocks	*	Dense populations may change community structure of the benthic fauna.	Fisheries	**	Damage of bottom-drawling nets
Other biota	*	Competition for space and food.	Aquaculture	*	
Human health	*	Bacterial infections of injuries, resulting form cuts	Water abstractions	*	
Water quality	-	-	Aquatic transport	-	-
Habitat modification	**	Dense populations may have an impact on the sediment structure by their burying activities.	Tourism	*	When stepped on, the shells can cause deep cuts.
Special considerations	?		others	?	

Vulnerable habitats: Temperate subtidal and intertidal areas with clean sand substrates [1].

Biology: The free-swimming larvae are distributed by currents in spring. Secondary dispersal of post-larval stages in summer. The juveniles settle on clean sands in the lower zone of the intertidal areas, where they burrow in the sediment and filter-feed on algae. They live near the surface, but are able to disappear rapidly to great depth when disturbed. *E. directus* is also able to swim or use byssus threats for drifting [4, 6]. They show a diurnal rhythm, being more abundant in the water column at night [6].

A length of about 6 cm is reached after the first winter. The life-span is up to 5 years [4]. The maximum sizes 16–17 cm [3].

E. directus prefers muddy, fine sand with small amounts of silt in the low and subtidal zones in bays and estuaries [3, 4]. Birds seems to be the only predator (in Europe: Oystercatchers *Haematopus ostralegus,* in America: *Larus delawarensis*) [4].

Main features for identification: Large, up to 16 cm long and 2.5 to 2.8 cm wide. Shell above the diagonal line reddish or brown, inside at posterior end red-brown to red-violet zones. Posterior adductor muscle scar very close to pallial sinus (only 2–3 mm distance), even in adults.

Identification: Large, up to 16 cm long and 2,5–2.8 cm wide shell. The colour of the shells differs from all native species. Shell above the diagonal line reddish or brown (white or specked in native species), inside at posterior end red-brown to red-violet zones. Dorsal and ventral margins almost parallel. Anterior end rounded, posterior end truncate. Pallial sinus not symmetrical, dorsal half indented [7]. While the adults of the jack-knife clams can easily be distinguished, specialist advice is required to identify juveniles. Larval stages (pelagic veliger) are difficult to identify to species level.

Generalised life history: The life cycle of the species is well known. The free-swimming larvae are distributed by currents in spring. The annual postlarval settlement starts in the Wadden Sea in summer (May or June). The juveniles settle on clean sands in the lower zone of the intertidal areas, where they burrow in the sediment. The survival of recruits is limited to areas below the level of mean low tides [3]. Migrating juveniles are mostly 1–3 mm long, occasionally up to 5 mm [6]. *E. directus* shows a retarded growth in the 1^{st} year (size: 30–50 mm), faster growth the 2^{nd} year [4]. They reach about 6 cm in length after the first winter. The life-span is up to 5 years [4]. The maximum sizes are 16-17 cm [3].

Relative abundance: Densities of juveniles amount to several tens or hundreds/m^2 [3], dense populations of thousands/m^2 may develop [2]. The biomass and production values are as high as >10 g AFDW/m^2 [3].

World-wide distribution of *Ensis directus*.

Worldwide distribution: Native in the western Atlantic from southern Labrador to South Carolina [4, 7]. Introduced to the German North Sea coast in 1978/79, since then rapidly spreading in the North Sea to Denmark, Sweden, Norway, The Netherlands, Belgium and to northern parts of France [1].

Range Expansion in Europe: First strong year-class in Europe (German Bight, Elbe-Estuary) originated in 1979, larvae were transferred with ballast water of tankers from the east coast of the USA in 1978 [1]. Possibly introduction earlier than 1978/79: few small *Ensis* found on tidal flats in the Dutch Wadden Sea near Terschelling in 1977 [3]. Since than, the species has spread rapidly in the North Sea. Extension along the coasts of Germany and western coast of Denmark in 1981. First record from the north (Kattegat) and east Danish coast in 1982. It had reached the Ems-Estuary in 1981, Texel and Schiermonnigkoog (NL) and the complete Dutch coast in 1982. First record of the Belgian coast in 1986. Adults were reported from France in 1991 [1].

Invasion patterns: The free swimming larvae spread with the currents along the coast, occupying the free niche of clean sand in lower intertidal flats in the Wadden Sea.Furthermore, post larval stages may re-enter the water column for secondary dispersal in summer [6] for a period of up to 6–8 weeks [Armonies, pers. com]. The survival of recruits is limited to areas below the level of mean low tides [3].

Abiotic factors:

Temperature	Temperate. Low winter temperatures seems to limit development [2].
Salinity	Tolerates relatively low salinities, occuring in marine and estuarine areas [3].
Preferred substrate	Unstable clean fine sand with small amounts of silt [3, 4].
Oxygen	Habitats showed oxidized layers from 3 cm to more than 30 cm [4].
Preferred depth	3–18 m [4, 5].
Exposure to air	Habitats were characterised by mean exposure times of 2.5-3.5 h. [4].

Further likely areas for colonisation: Temperate subtidal and intertidal areas. The areas of *E. directus* are relatively exposed with a general low level of macrozoobenthos. Such poorly populated areas present an 'empty' niche for well-adapted species like *E. directus* [3].

Main vectors:

The free swimming larval stages and post-larval stages can be transferred with the ballast water of tankers.

The free-swimming larvae are also distributed by currents in spring. Secondary dispersal of post-larval stages in summer.

E. directus is able to swim or use byssus threats for drifting [4, 6].

Control measures/management options: A control of *Ensis directus* can only be achieved by changing the ballast water of ships in offshore areas or by filtration and /or preventive desinfection of the ballast water, respectively.

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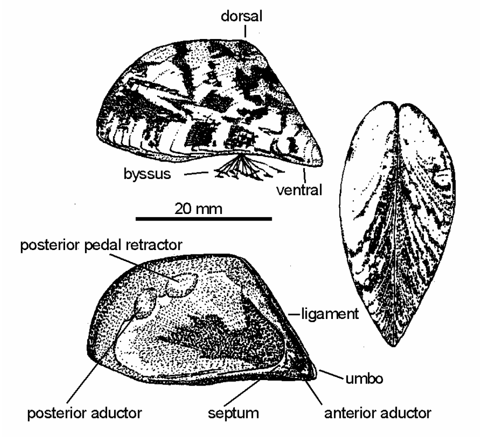
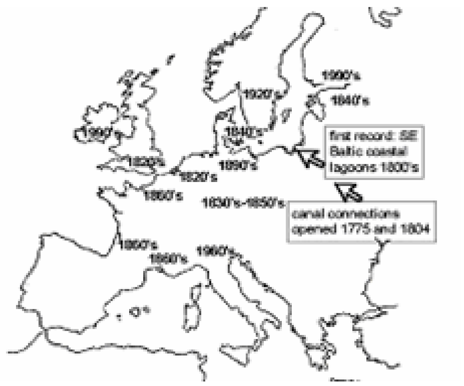
Dreissena polymorpha (Pallas, 1771) Dreissenidae, Bivalvia

Authors: Sergej **Olenin**, University of Klaipeda, Centre for System Analysis, Manto 84, Klaipeda. Lithuania (s.olenin@samc.ku.lt), Martina **Orlova** (OMI@zisp.spb.su) and Dan **Minchin** (minchin@indigo.ie)



Dreissena polymorpha.



Known inland and brackish water distribution including range expansion (in decades) of *Dreissena polymorpha.*

Impact:

(* = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial)

Resources/Environment			Uses of the Sea		
Commercial stocks	$?	Food for commercial fish Alterations of fish communities	Fisheries	**	Interference with fishing gear
Other biota	** $	Competition for space and food Food for birds	Aquaculture	**	Fouling of cages
Human health	*	Cuts to bathers feet	Water abstractions	*** **	Fouling of water intake pipes Taintrip of water
Water quality	* ?	Bioaccumulation of pollutants May encourage toxic algae	Aquatic transport	**	Fouling of ship hulls and navigational constructions
Habitat modification	*** *	Changes in bottom sediments Reduced plankton abundance by filtration	Tourism	? *	Changed environment Reduced angling catches

Vulnerable habitats: Estuaries, rivers and lakes, particularly where there are firm surfaces suitable for attachment.

Biology: A mature female may produce up to 1 000 000 eggs per year. The newly hatched larvae are free swimming, they are distributed by currents in summer–autumn. The juveniles settle, attaching to various firm surfaces including each other. Their life span varies from 2 to 19 years. The largest size known is 50 mm. Mussels of different ages form dense colonies. They feed by filtering microscopic plankton organisms < 53 µm and organic particles from the water. Small molluscs are used by different fish species (*e.g.* cyprinids: roach, carp etc and eel). *D. polymorpha* is capable of becoming established in all temperate regions of the world in rivers, lakes, estuaries and brackish water sea areas.

Identification: Shell is triangular (height makes 0.40–0.60 of length), convex (convexity makes 0,45–0,65 of length and 0,90–1,15 of height) [11]. In front view, the dorsal margin of valves meet to form an angle of about 90°. The ventral edge is flattened with a clear byssal notch one third of ist lenght from from apex. Umbonal ridges very prominent, almost parallel with ventral margin. Up to 50 mm [14]. Greenish, brownish-yellowish with clear dark and light coloured (”zebra”) zig-zag banding. There are 5 basic, genetically dependent shell colour morphs in European populations: ”Dilutus” (light), ”Obscurus” (dark), ”Arctuatus” (arcs-like), ”Radialis” and ”Commixtus” (so-called ”zebra” pattern) with many variations [3]. Shell shape and coloration are highly variable, depending on substrate, depth, and density of aggregations. Reference material may be found at the Palaeontological Institute (Andrusov’s collection, Moscow, Russia), Zoological Institute (Logvinenko’s collection, St. Petersburg, Russia), Ac. of Natural Sciences (American and Dnieper materials, Philadelphia, USA).

Generalised life history: *Dreissena* are unisexual molluscs appearing equally as males and females in populations. Fertilisation takes place externally. Synchronised spawning occurs once > 8 mm [13] and is influenced by water temperature. A mature female may produce one million eggs per year. Spawning begins at 12–15ºC, and can be profuse at 18–20ºC; and may take place over a period 3–5 months [12]. Then develop into free-swimming larvae, which sattles as a pediveliger at 200–240µm. There may be some secondary settlement mussels being carried on mucus threads up to some mm [13]. In summer they may grow 0.6 mm per week [4]. The high reproductive capability of zebra mussels and secondary settlement and ability to survive in air for several days under damp conditions can faciliate its dispersal. The period of reproduction of *D. polymorpha* varies in Europe, Russia and North America [4, 12, 13, 15]. *D. polymorpha* life span may vary from 2–3 to 17–19 years [14, 17].

Relative abundance: Mussels form dense colonies, encrusting surfaces (*e.g.* walls of docks) to 10 cm thick. Mussel densities up to 4 millions individuals/m² are known [20], and a biomasse to 12 kg/m² [24]. In general, *D. polymorpha* shows a typical *r*-strategist pattern. The overwinter mortality of young-of-the-year and 1-y-old mussels is very high, and by the spring, numbers are greatly reduced [10]. Following periods of great abundance there can be a phase where densities are low. Highly alkaline water is far and pH 8.0+ and where levels of calcium carbonate in water are high.

Worldwide distribution: Native to the drainage basins of the Black, Caspian and Aral Sea [22]. Introduced to north-west Russia, central and western Europe, Scandinavia, Britain, Ireland and North America.

World-wide distribution of *Dreissena polymorpha*.

Range Expansion in Europe: The spread of *D. polymorpha* from the Black Sea and Aralo-Caspian Sea basins has largely taken place in the past 200 years [cf. 13]. How the initial expansion took place is unclear. The zebra mussel may have penetrated via the Oginskij Canal (completed in 1804) from Dnieper to the River Neman and further to the Curonian Lagoon, SE Baltic [cf. 18; 6; 1971; 22]. In which case the Black Sea is their probable origin.However [1, 21] it may have come via canals using the Volga and its tributaries and lakes Onega and Ladoga at the beginning of the 18th century and so originate from the Caspian region. Outside of the Baltic Sea region it was found in England, in London docks in 1824. By 1827 it was found in the mouth of Rhine, and 1838 in Elbe River [16, 13]. During the 19th century the zebra mussel occupied most of inner water systems of western and central Europe, in 1920s it appeared in Sweden [8], in 1960s it was found in alpine lakes around the Alps, and reached Ireland by 1994[13,14]. In 1990 it was reported from brackish water in the eastern part of the Gulf of Finland after being present for 150-years in the nearby freshwater lake Ladoga [2].

Invasion patterns: There is a great amount of genetic variation within this species. This feature may faciliate the mussel to rapidly colonise new habitats and adapt to new environments [23]. The high reproductive output and ability to extend their planktonic stage enables rapid dispersal downstream. Larvae and adults can be distributed in ballast water as fouling on ship and boat hulls, navigation buoys, fishing vessel wells; industrial activities such as transport of timber or river gravel; fisheries such as fish stocking water, fishing equipment, *etc.* [5]. The overland transport of zebra mussels by small trailered boats has been repeatedly implicated in inter-lake dispersal [13].

Abiotic factors:

Temperature	Can survive temperatures 0-30 ºC; lower limit for feeding is 5ºC; spawning occurs at 12–20ºC [9].
Salinity	Prefers fresh waters, occurs also in brackish water areas with salinity up to 7 ppt (Baltic Sea) [2].
Oxygen	Able to tolerate low oxygen content in water for several days.
Substrate	Stones, reeds, shells, wood, ships hulls, hydrotechnical constructions, glass, etc.
Depth range	Occurs from the lower shore to depths of 12 m in brackish parts of sea [2] and to 60 m in lakes [7].
Organic	Prefers moderately productive (mesotrophic) water bodies [4].

enrichment	
Exposure to air	Survive out of water under cool damp conditions up to three weeks [14].

Further likely areas for colonisation: Further range expansions are expected in fresh water and some brackish areas in temperate latitudes of the Northern Hemisphere. Future expansions to South America, South Africa, Australia and New Zealand is possible.

Main vectors: Ballast water of ships, Boat hulls, Transport of timber or river gravel, Larval dispersal [5] and overland transport [14].

Control measures/management options: Control of *Dreissena polymorpha* overseas transfer can only be achieved by mid-ocean exchange or by suitable disinfection of ballast water. Appropriate control measures (inspection, removal of attached mussels, drying, etc.) should be taken to minimise risk of inoculation by transfer of boats, fishing gears, movements of live-fish transport vehicles, *etc.* from the infected water bodies within a watershed or between river basins.

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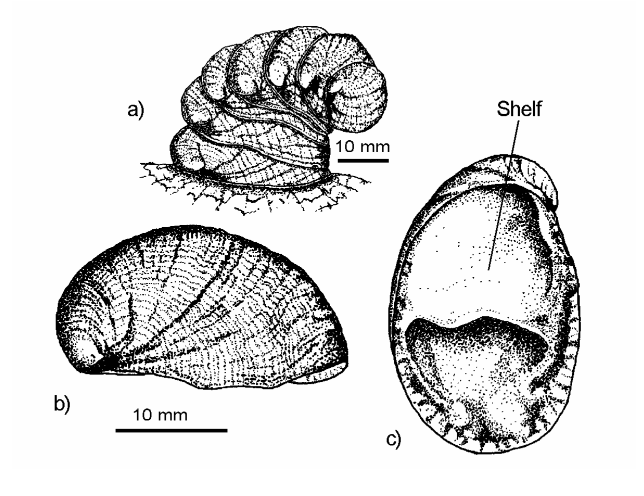
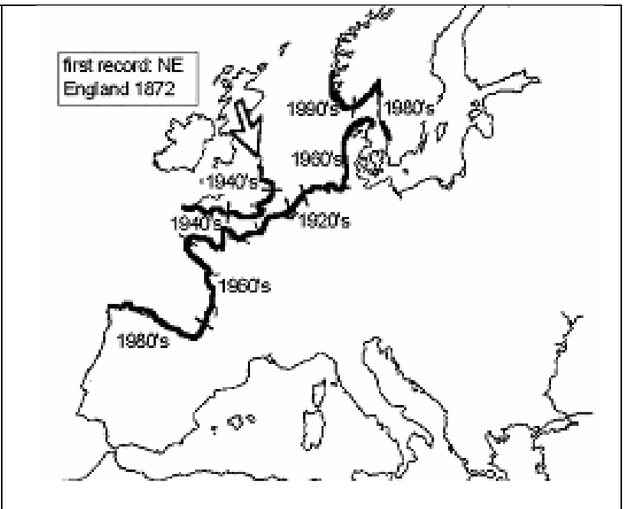
Crepidula fornicata (Linneaus, 1758), Calyptraeidae, Gastropoda

Author: Dan **Minchin**, Fisheries Research Centre, Department of the Marine, Abbotstown, Dublin 15, Ireland (minchin@indigo.ie)



***Crepidula fornicata*. a) Chain of seven limpets on oyster, b) outside, c) inside.**



Known coastal distribution of *Crepidula fornicata*.

Impact:

(* = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial)

Resources/Environment			Uses of the Sea		
Commercial stocks	***	Trophic competition	Fisheries	**	Reduced growth
Other biota	**		Aquaculture	***	Reduced growth
Human health	?		Water abstractions	?	Possible fouling
Water quality	**	Reduced food in water	Aquatic transport	?	
Habitat modification	***	Changes in benthos	Tourism	*	Changed environment
Special considerations			Others	$	Shells can provide settlement surfaces for oysters

Vulnerable habitats: Enclosed bays, estuaries and shallow channels in oyster growing areas and ports, from lowest water to about 10 m or more in depth, particularly where there are shells, stones or rock.

Biology: Hatches as a free-swimming larvae. It develops firstly into a crawling male and seeks to attach to the shell of a female, where it remains. The male stage, which normally lasts two years, gradually transforms to become a female and further males may become attached in turn to form chains of individuals of up to about 12, with the oldest limpet at the base. About one individual a year is added to a chain. Individuals can attain about 50 mm x 25 mm after 4–5 years. Females may produce 200 000 eggs annually with up to three broods of larvae per year in northern Europe. Solitary males may become females earlier and may be capable of self-fertilisation. It is potentially capable of becoming established in all warm temperate and Mediterranean regions of the world in estuaries and marine inlets. Native to the east-coast of North America.

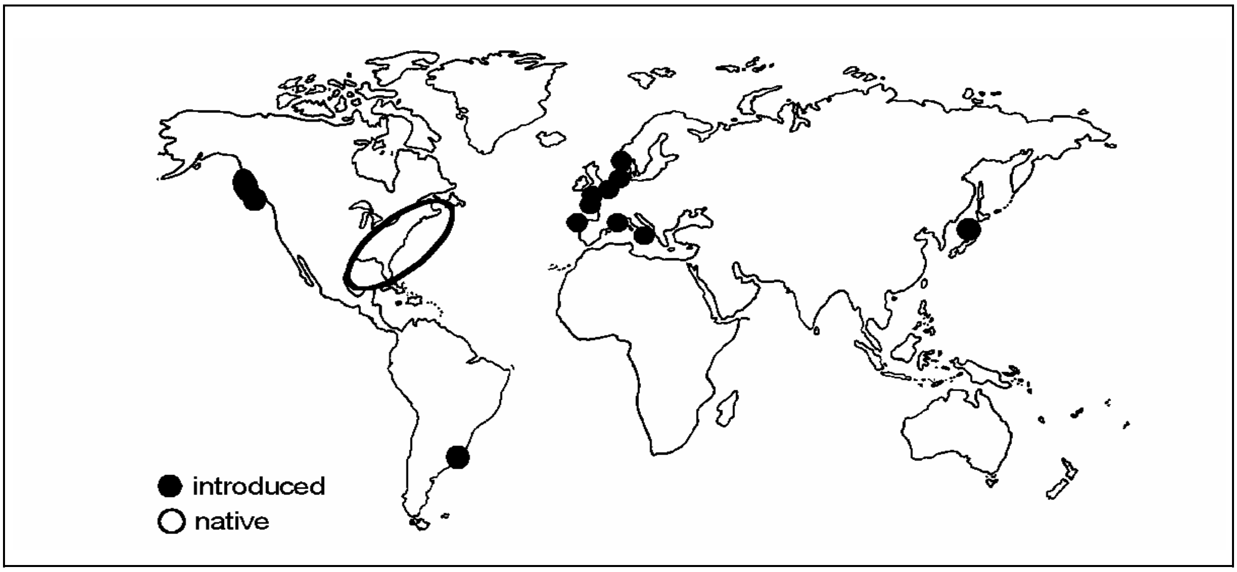
Identification: Attains 50 x 25 mm. Shell oval and arched, cap shaped, with a highly reduced spire set posteriorly and to the right. The last whorl is greatly expanded and limpet-like. The innermost surface has a dark brown pocket with a thin white shelf to protect the visceral mass (10). The outer shell may have pale red-brown indistinct stripes or blotches and conspicuous growth lines. Shell may be flattened and may be corrugated if attached to a ribbed bivalve. Individuals may be attached to each other to form a chain.

Generalised life history: Lives nine or more years, takes ~ 4–5 years to attain full size. Hatches as a pelagic veliger and later settles on hard surfaces, usually shells or stones. Develops into a male which is mobile for ~2 years, searches for a female, then attaches so that it can fertilise the female below. The male will transform to become a non-wandering female. A male may then attach to form an asymmetric chain (of up to 12 individuals) due to the genital apertures being on the same side (20). The first individual in the chain holds the entire chain to the substratum and if detatched is normally nable to reattach. Consequently chains may be found either lose or attached. When old individuals expire, they are sequentially replaced by the next individual in the chain, and new males may attach at the chain apex. In this way a chain can remain for many years. Its biology is well studied (10).

Reproduction: The oldest individuals at the bottom of a chain are females and the youngest, the males, at the top. Those in-between may be transforming to the female state, the full female stage being apparent at about three years. Following settlement the developing gonad contains spermatogonia and oogonia, but the oogonia do not become prominent during the male development phase (9). The male becomes functional once the vesicula seminalis is filled with sperm. A penis extends and inserts the sperm into the mantle cavity and pallial oviduct of the underlying female. Females may annually produce 200 000 eggs, depending on their size, and may produce up to three broods of larvae a year on the south coast of Britain (5). Solitary males become females earlier and may be capable of self-fertilisation (4). The male stage normally lasts about two years.

Relative abundance: Shells of slipper limpets can form drifts on the sea-floor and may obscure the underlying sediment with densities to 1750 m^{-2} (18). The biology of this species principally relies on the formation of attachment of successive individuals, forming chains. The species can become abundant over tens of years from the time of introduction.

Worldwide distribution: Native to the east coast of North America from the St Lawrence to northern Mexico (9). Introduced to southern France, Sicily (2) and the North American Pacific coast and Japan (11). In the southern hemisphere only reported from Uruguay (16).



World-wide distribution of *Crepidula fornicata*.

Range Expansion in Europe: First European record, Liverpool Bay, England in 1872 and imported with *Mercenaria mercenaria* L. from the east coast of North America; but subsequently died out (14). Probably imported to Britain and Ireland in barrels from the late 1870's (15). First recorded as established on SE coast of Britain (Brightlingsea) in 1893 (6). It was confined to the SE coast of England until 1932 the first records appeared in the Helford River, SW England (5). Later in 1946 were again found, and in the following years became abundant, and was in the Fal in 1947. It had reached Weymouth, SW England by 1939 becoming locally abundant there. Specimens were recovered near the Tyne (E. coast) in 1936. In 1946 were recorded from Northumberland and subsequently on nearby shores (4). Presently known from the Bristol Channel and shells are known from Bardsey Island, North Wales (18). Although there were many direct importations from Long Island Sound to Ireland, and some records from there, no populations remain (15) although a population may have been established for a short time in Clew Bay, W. Ireland.

First records from continental Europe were on the shore at Ostende, Belgium, in 1911 (9) and on a Dutch shore in 1926. Many were found in the Oosterscheldt in 1929 and were abundant there in 1933 (12). It is also present in the German Bight (Helgoland and Wadden Sea) and the Limfjord, Denmark . It reached the Skagerrak and Kattegat by 1935. First records from France were from Hermanville, Normandy in 1949 and found later that year in Brest (4). By 1979 it had become a serious competitor of oysters and was found in the Baie de Seine. It reached Point Saint Gildas, La Loire and Marennes-Oleron by 1969–70 (13). In northern Europe presently ranges from Vigo, Spain (16) to SW coast of Norway (19) and is likely to expand further.

Invasion patterns: Areas where slipper limpets become abundant are often preceded by reports of single individuals or small numbers of chains. These reports should be taken seriously and removal of all slipper limpets at this stage should be considered. It appears that new populations can be generated by small inoculations. They are readily spread attached to oysters and shipping to new localities and so become rapidly dispersed. The available evidence suggests that some slipper limpets may become detatched from vessels while under way. Once established they remain in abundance, no post-colonisation declines have been reported that can be attributed to population amelioration.

Abiotic factors:

Temperature	Normally found in bays and estuaries where they may be exposed to frosts and high summer temperatures exceeding 25ºC.
Salinity	Tolerates brackish water for short periods.
Preferred depth	Occurs from the lower shore and known to depths of 60 m.
Exposure to air	Survives out of water under cool damp conditions for several days.
Others	Able to colonise areas with turbid water.

Further likely areas for colonisation: The species has a wide range of tolerance of temperature and is readily transferred with oysters and with local movements of shipping. The potential range of this species is expected to include the southern coastline of Australia, Tasmania and New Zealand, South Africa and South America, where, should it appear, have serious economic consequences for aquaculture, fisheries and native biodiversity.

Main vectors:

Associations with transfers of oysters (4, 6, 15).
Attachment to the hulls of barges, commercial ships and naval vessels (4).
Attachment to harbour structures moved elsewhere (4).
Attached to flotsam (12).
Contained in ships' ballast water (8).
Larval dispersal (19).

Control measures/management options: The cultivation of oysters in bags on trestles will considerably reduce the impact of slipper limpets. However, trophic competition with oysters will remain unless the slipper limpets are removed by dredging. They should be removed from marine bivalves which are transferred for relaying in areas outside of their present range; but it is best not to make such transfers. In areas outside of their range, when removed from the hulls of ships, while in dry dock, they should be destroyed and not returned to the water. New records should be immediately reported to the appropriate authority, it may be possible to control or eradicate them at this time.

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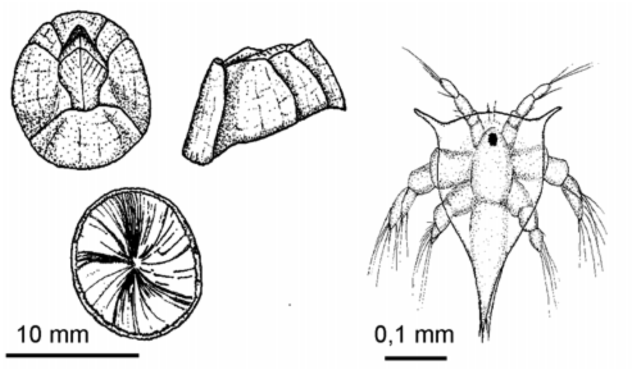
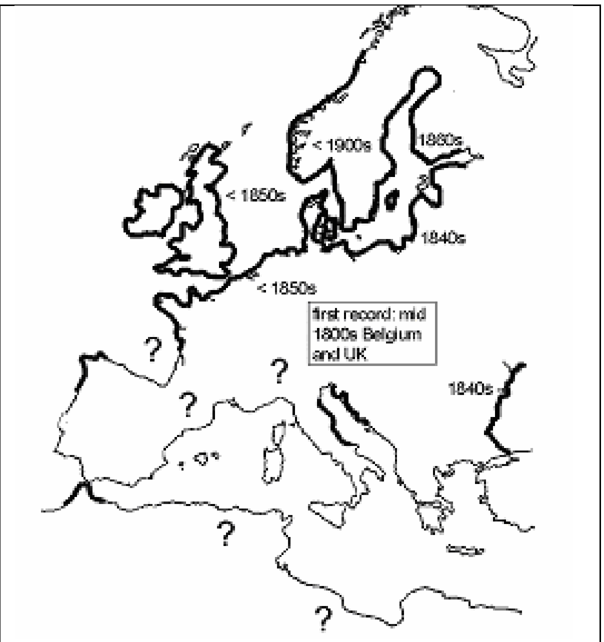
Balanus improvisus (Darwin 1854), Balanidae, Cirripedia

Author: Erkki **Leppäkoski**, Dept. Of Biology and Husö Biological Station, Åbo Akademi University, Turku/ Åbo, Finland, (eleppakoski@abo.fi)



***Balanus improvisus*. Adult [39] and nauplia [40].**



Known coastal distribution of *B. improvisus*.

Impact:

(* = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial)

Resources/Environment			Uses of the Sea		
Commercial stocks	***	Fouling of blue mussels and oysters	Fisheries	-	
Other biota	**	Competition of space and food	Aquaculture	***	Fouling of cages
Human health	**	Sharp shells	Water abstractions	***	Fouling of water intake pipes and heath exchangers
Water quality	$	Filter feeding	Aquatic transport	***	Fouling of boat and ship hulls and navigational constructions
Habitat modification	**	Changes in substratum	Tourism	**	Sharp shells

Vulnerable habitats: Brackish water bays and estuaries to shallow marine habitats (max. 6 m depth) with hard substrata (stones, rocky shores and man-made constructions such as break-waters and ships). The species is also found as fouling on macroalgae, crustaceans and molluscs. It is widely distributed indicating its potential of becoming established from warm temperate to tropical regions.

Biology: *Balanus improvisus* are hermaphroditic sessile crustaceans. They reach maturity at 6–8 mm size. Several broods per year; two broods in the Baltic Sea, one brood only in very diluted water (32]. Free swimming nauplius larvae hatch in water and live in the plankton for 2–5 weeks (1–2 weeks in optimum conditions and temperatures around 14°C; [12] and pass seven larval stages of which the last one (0.5 mm long cypris larvae) settle on hard substrates.

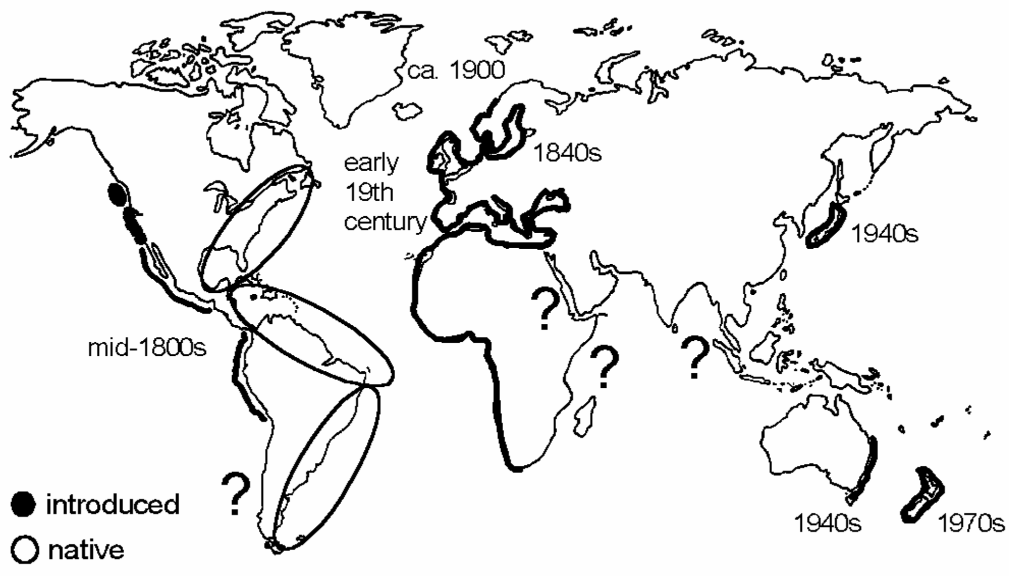
Identification: Shell white or grey, wall typically conical, very smooth; walls never folded longitudinally. Shell opening diamond-shaped, slightly toothed. Radii very narrow with rounded edges. Base radially calcareous (base of *B. crenatus* lacks this star-like ornamentation; base of *B. balanoides* is membranous), flat and thin, permeated by pores that do not generally run to the very centre of the basal plate [6, 25, 27]. *B. eburneus* differs from *B. improvisus* by its striate scutum when adult [29].

For identification keys, consult [2, 25] for larval stages, and [25, 27] for adults. Young individuals are easily confused with *B. crenatus* (which lacks the distinct adductor ridge on the scutum plate, typical of *B. improvisus*; [27]). The larvae of *B. improvisus* are most likely to be confused with those of *B. amphitrite* and *Elminius modestus*, and are very difficult to distinguish [16].

Generalised life history: The life history *of B. improvisus* is well understood. In Dutch waters settlement takes place in August-September [3], in the northern Baltic from late June to October; maximum in July-August [35], in the S Baltic early to mid-June; a less pronounced peak in August-September [31]. Settlement is influenced by light (larvae are positively phototropic), flow velocity, quality of the substratum, chemical cues, predators etc. [7, 12]. The normal age seems to be 17–19 months [27]. High degree of genetic similarity amongst populations sampled in the Baltic, the British Isles and North America [10]. Many populations of *B. improvisus* are unstable; destroyed by ice erosion in the Baltic Sea.

Relative abundance: Barnacle densities vary from some tens to 4370 ind/dm^2 [31].*B. improvisus* is capable of marked habitat alteration through the construction of dense crusts on hard surfaces and secondary hard substrates [28]. One of the main effects of the barnacle is facilitation of other organisms. In dense populations of *B. improvisus*, associated species such as midge larvae, copepod crustaceans and juvenile bivalves increase compared to adjacent sites without crusts [22].

Worldwide distribution:



Worldwide distribution of *Balanus improvisus.*

Range Expansion in Europe: The first European records are given for Belgium and southern UK in the mid 1800s. Decades later it was found in the Baltic up to Finland and the western Black Sea. Since the 1900s it is widespread in Europe and established populations in Norway, France, northern Portugal and north-western coasts of Spain. Further findings were recorded from the Adriatic coasts of Italy. The distribution along the southern Mediterranean coasts is widely unknown.

Invasion patterns: An Atlantic, Old World [19, 34] or, most likely, American [5, 22] species, widely distributed around the world but its distribution is patchy.

B. improvisus is transmitted by ships as a fouling organism or in ballast water; it is common in biofouling communities world wide. Thus chance rather than distance plays the greatest part in determining whether an estuary becomes invaded [12]. Its presence in ports, adult longevity (up to 4 years [9]), the sessile habits, ability to self-fertilise (cross-fertilisation is the rule [11]), mass larval release, wide range of salinity tolerance and gregarious settlement are particularly useful in distant dispersal [12].

B. improvisus became established in Western Europe in the 19th century [37]. In the mid-1800s, it was known in a few European localities only (British Isles, possibly one locality in Belgium [6]. It was first recorded in the Baltic Sea in 1844 at Königsberg (presently Kaliningrad [14, 24]). From this hypothetical dispersal centre it spread very rapidly and became common, especially in ports. It is thought to have invaded most of its present area of occurrence in the 1870s or, at latest, before the turn of the century. There were very few records from the Swedish east coast before the 1920s [14]. Until the second half of the 20th century it was not found north of the Åland Islands [24], while in the 1990s, *B. improvisus* has been recorded up to the Northern Quark (64^{o}N) [23].

B. improvisus has been found in the Black Sea since 1899 [15]. When the Volga-Don Canal was opened in 1952, it penetrated into the Caspian Sea and become, in places, dominant species to 1976 [17].

Theoretically *B. improvisus* is able to disperse, transported by currents, some 30-70 km per generation along the British coast [12]; spread 30 km/year, at minimum, in the Baltic Sea in the late 1800s [23].

Abiotic factors:

Salinity	A truly brackish-water species. Of all the estuarine barnacles *B. improvisus* can be found furthest inland where it avoids competition with native species [9, 12]. *B. improvisus* succeeds in fresh water as well as in normal sea water; maximal larval settlement is found in mid-salinities; does not reproduce in fresh water [7, 13, 38]. Extremely euryhaline, tolerates salinities from nearly zero to 40^{o}/oo[20, 27]. Activity optimum at 6–30^{o}/oo [25].
Oxygen	Mortality 50 % within 4 weeks at 1 mg oxygen/l [35].
Substrate	Adults live on rocky shores, boulders, pilings, buoys, ship hulls, wood, seaweed, shells, crustaceans etc.
Depth range	Generally from the surface down to 6 m, but has been found as deep as 161 m [27, 29].
Organic enrichment	Tolerant to pollution and eutrophication; preference for organically enriched sites in ports with good foraging conditions (filter feeder on detritus and phytoplankton [25, 31, 36].
Exposure to air	Lives up to the splash zone, does not tolerate desiccation [1].
Current	Maximum settling at velocities 1 m/s, abundant up to 3 m/s [35].

Further likely areas for colonisation: Brackish waters, estuaries, lagoons, canals and harbour areas world-wide.

Main vectors: Transported as a fouling organism on ship's hulls, or as planktonic larvae in ballast water; also common as an epibiont on imported oysters [4].

Control measures/management options: Antifouling paints, chlorine treatment of water intake pipelines during the most intensive settling period (0.1–0.5 mg/l) [35], increased temperature (tolerates 36°C for 30 hours [35]), oxygen deficiency (*e.g.*, one of parallel pipelines closed for 3–4 weeks [35]). Mid-ocean exchange of ballast water might be ineffective.

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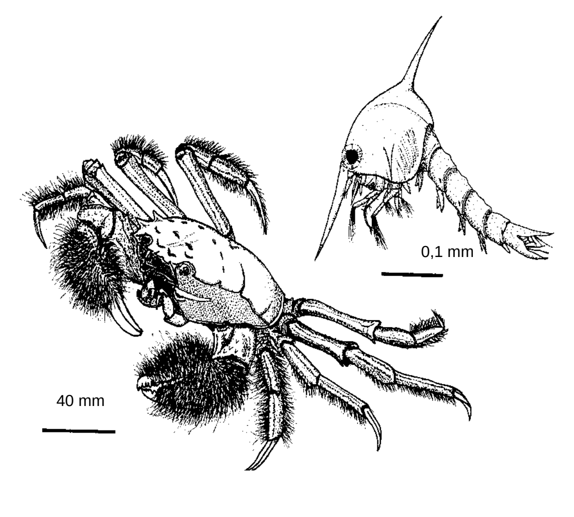
*) refers to the distribution maps

Eriocheir sinensis (Milne-Edwards, 1854), (Brachyura, Decapoda)

Author: Stephan **Gollasch**, Institut für Meereskunde, Düsternbrooker Weg 20, 24105 Kiel, Germany (sgollasch@aol.com)



Eriocheir sinensis. **Adult and zoea-larvae.**

Known coastal distribution of *Eriocheir sinensis.*

Impact: * = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial

RESOURCES/ENVIRONMENT			USES OF THE SEA		
Commercial stocks	**	Crabs are preying upon native species and after mass occurrences native species were locally driven extinct	Fisheries	***	Crabs feed on fishes caught in traps and nets. Nets will be damaged.
Other biota	**	Competition for space and food.	Aquaculture	**	In freshwater ponds the crabs feed on the cultured fish and their food.
Human health	?	Second intermediate host for human lung fluke parasite in Asia.	Water abstractions	**	Clogging of water intake filters during mass occurrences
Water quality	?		Aquatic transport	?	In some countries imported for human consumption.
Habitat modification	***	Burrowing activities of crabs result in damages of dikes, river banks and port installations.	Tourism	$/*	(tourist attraction during mass migration)
Special considerations			Others	$	Recently exported for re-stocking purposes from Germany to China.

Vulnerable habitats: This migrating species occurs in rivers, estuaries and marine habitats of cold-temperate to tropical climate areas from lower shorelines to about 10 m in depth. This species is tolerant to highly polluted water.

Biology: The life-cycle of the predominantly night active Chinese Mitten Crab is characterised by migrations in waters with changing salinities. Larvae develop in marine waters. Their upstream migration (in spring) is aided by currents in estuaries. During rising tides larvae migrate into the water column and are carried upstream. Young crabs and young adults actively migrate upstream. In their native distribution living crabs have been found 1400 km upstream the river Jangtsekiang. Two year old adults migrate downstream to the marine conditions in summer. This movement may take several months during which they become reproductively mature. Crabs live in burrows in the banks of rivers. It feeds on a wide variety of plants, invertebrates, fishes and also detritus. Snails and clams are the main food.

Identification: The square shaped carapace of adult crabs, clearly distinguishes it from other European brachyuran crabs. It can attain a carapace width of 5 cm. Males have a hair-like covering on the claws forming mitten-like claws. The colour varies from yellow to brown, rarely purple and red.

Generalised life history: Although the life history of *E. sinensis* has been well studied in previous years, studies on population DNA have not been undertaken and so it is not possible to separate populations and determine their origin.

Chinese Mitten Crabs are night active and undergo migrations along estuaries and rivers. Most crabs live for two years rare species grow older. After one year the crabs attain full size. Crabs hatch as a zoea and develop to the settlement of the megalopa. Larval stages occur in marine and estuarine regions of rivers and move upstream aided by tidal currents by means of vertical migration. Young crabs and young adults actively migrate upstream following settlement. In their native distribution in China crabs have been found 1400 km upstream the river Jangtsekiang.

The diet of the crabs includes a wide range of plants, invertebrates, fishes and also detritus. Gastropods and bivalves are the predominate food component [1, 12, 21, 22].

Reproduction: Two year old adults migrate downstream in summer and reach marine conditions after several months during which they became mature. In the marine environment the life-cycle completes after reproduction.

Relative abundance: Conditions in China and Europe are similar and this may explain its successful invasion in Northern Europe from 1912. As there are no migrating native decapods in estuarine waters and rivers of the North Sea there has been little competition for the invader. Because of favourable conditions, little competition and an abundant food supply the crabs became abundant in German waters during 1930s–40s. More than 21 million juveniles were caught (approx. 240 000 kg) in the German rivers Elbe, Ems, Havel, Saale and Weser during their upstream migration in 1936 [20, 22]. Following the late 1940s their abundance decreased because of increased water pollution in German rivers. The water pollution may have effected the abundance of the crabs prey. The Chinese Mitten Crab itself is able to tolerate heavily polluted waters. Crab populations in the Netherlands and the United Kingdom showed similar developments, but in much lower numbers.

Following the recent improvement of the water quality in rivers [25] crabs have again become abundant in European rivers. Similar patterns have taken place in the Thames river (Clarke pers. comm.) and in Dutch waters (Wolff pers. comm.). In spring 1998, 850 kg of juveniles (ca. 75 000 crabs) were caught in the river Elbe by hand in two hours only (Strauch unpubl. data.). The daily catch could amount to 2000 kg of juveniles (180 000 crabs). Such numbers are comparable to or even higher than in the mid 1930s (up to 2500 kg of crabs caught per day).

World-wide distribution: Area of origin are waters in temperate and tropical regions between Vladivostock (Russia) and South-China [19, 23], including Japan and Taiwan. Centre of occurrence is the Yellow Sea (temperate regions off North-China, see open circle on world map) [21]. Records outside Europe: Mediterranean Sea, Black Sea, Great Lakes, and San Francisco Bay (see solid dots on world map) [Saizev pers. comm., 4, 5, 6, 7, 10, 17, 27].

World-wide distribution of *Eriocheir sinensis.*

Range Expansion in Europe: It was first recorded from the German river Aller in 1912 and may have been released with ballast water discharges. Its establishment was influenced by the suitable conditions of climate and salinity and the lack of competition from other species. Before the arrival of *E. sinensis* in European waters, no native brachyuran crab migrated between brackish and freshwater habitats.

Specimens have been found 700 km upstream the Elbe in Germany. The species probably spread into the Baltic Sea via the Kiel Canal (German coast 1926). The greater abundance in Europe is in the German rivers Elbe and Weser [1, 3, 9, 12, 16, 19, 23, 26, 28, 29, 30].

Invasion patterns: Chinese Mitten Crabs have become abundant in some polluted estuaries. Occasionally individuals have been found beyond their currently established populations and such appearances may well proceed their subsequent establishment where conditions are suitable. Frequent observations are made about the edge of the North and Baltic Seas. It is unlikely that the species is able to attain self-sustaining populations in the Baltic Sea.

Abiotic factors:

Temperature	Highly tolerant species occurs in climates of tropical to cold-temperate regions; the temperature tolerance goes down to the freezing point.
Salinity	High salinity tolerance is shown by the migration into marine, brackish and freshwater habitats.
Oxygen	High tolerance towards low oxygen conditions.
pH	High tolerance towards the pH value.
Exposure to air	On their migrational routes crabs may be exposed to air for several hours. Crabs even cross dikes and streets.

Further likely areas for colonisation: Regions where further establishment is possible may be characterized by cold-temperate to tropical regions with estuarine habitats. Highly contaminated waters do not appear to exclude their establishment.

Main vectors: Introducing vectors are **shipping** (**ballast water** and **hull fouling** of vessels) and imports of living species for **aquaria** and for **human consumption** [4, 8, 11, 15, 23]. Range extensions are likely following t he active migration of larvae and adult species via rivers and canals [2, 3, 14, 18, 27].

Control measures/management options: Trapping of crabs has not been found to be effective in controlling damage by crabs in river banks and from crabs feeding on trapped fish or in commercial pond aquaculture. Crabs have been used as bait for eel fishing, to produce fish meal, cosmetic products and for human consumption [6, 13, 22, 24].

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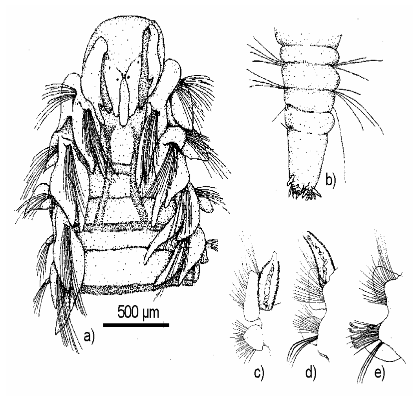
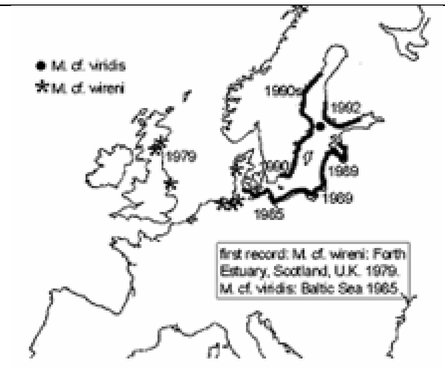
Marenzelleria cf. *viridis* (Verrill, 1873) Annelida, Polychaeta, Spionidae

Authors: Darius **Daunys**, Coastal Research and Planning Institute, Faculty for Natural Sciences, Klaipeda University, Manto 84, LT 5808, Klaipeda, Lithuania, Michael L. **Zettler** Baltic Sea Research Institute, Seestr. 15, D-18119 Rostock, Germany, and Stephan **Gollasch** (sgollasch@aol.com)

Two forms of *Marenzelleria* recently named as Type I and Type II (sibling species) were identified after genetic and morphological studies of North Sea and Baltic Sea populations [1, 2, 3]. In several morphological features they corresponded to the diagnosis of *M.* cf. *wireni* (Type I) and *M.* cf. *viridis* (Type II) [3].



***Marenzelleria* cf. *viridis* (after [3]). a, b) Dorsal view, anterior & posterior end, c-d) different setigers.**



Known distribution of *Marenzelleria* cf. *viridis* and *M.* cf. *wireni*.

Impact: * = possibly harmful, ** = harmful, *** = very harmful, ? = not known, $ = beneficial

RESOURCES/ENVIRONMENT			USES OF THE SEA		
Commercial stocks	?		Fisheries	$	Potential food source for ground living fish [4].
Other biota	* $	Competition for food and space with native *Corophium volutator*. Feeding on larvae of native species. In the presence of *Marenzelleria* spp. the local benthic production may increased up to ten fold [5].	Aquaculture	*	Competition for food of aquaculture organisms.
Human health	?		Water abstractions	?	
Water quality	?		Transport	?	
Habitat modification	$ *	Burrowing activities during mass occurrences may change the upper layer of the sediment: improving the oxygen content [6], but high numbers of tubes may pose sediment trap like effects.	Tourism	?	

Vulnerable habitats: *M.* cf. *wireni* (type I) colonizes soft bottom habitats in coastal zones with high salinities (meso-haline to polyhaline) or habitats with high salinity fluctuations. In contrast *M.* cf. *viridis* (type II) prefers oligohaline to mesohaline conditions and was not found in the western Baltic with its higher salinities [2, 3]. Suboptimal conditions may be tolerated. During hypoxic conditions the worm´s metabolism can switch to anaerobic energy production and individuals survive low oxygen and high sulphide concentrations [7, 8, 9].

Biology: *M.* cf. *viridis* has a life span of approx. 3 years. Many individuals reach sexual maturity after one year [10]. Benthic adult worms inhabit vertical mucus lined burrows [6] and feed on sediment particles, planktonic, meiobenthic organisms [11, 12] and resuspended organic material [13]. In the Baltic the breeding takes place in autumn [14, 15]. Gametal development takes 4–5 months [14], although the period of spawning varies between years and different locations. Fertilised eggs occur in the water column and subsequent larval development is entirely pelagic [16]. The larvae usually grow until 16–17 setigers, when they metamorph to benthic juveniles [17]. Highest densities in the Baltic Sea are over 50 000 ind./m² with a wet weight biomass of 100–400 g/m² in the Darss - Zingst Bodden Chain [5].

Identification: Two forms of *Marenzelleria* named as Type I and Type II (sibling species) were identified after genetic and morphological studies of the North Sea and Baltic Sea populations [1, 2, 3]. In several morphological features they corresponded to the diagnosis of *M.* cf. *wireni* (Type I) and *M.* cf. *viridis* [Type II) and were described by Bick and Zettler (1997). Specimens of *M.* cf. *viridis* are up to 157 mm and 315 setigers long [15] with maximum width 3.2 mm [3]. The anterior margin is broadly rounded and usually notched medially. Palps are short and, in fixed specimens, do not extend posteriorly beyond setiger 10. Maximum number of branchiaete setigers up to 65 and less than one third of total number of setiger. Lamella in the notopodium is initially elongate with the tip pointing distinctly dorsally. Posteriorly it becomes rounder, then appears square and then triangular on the last setigers. All setigers bear capillary setae, superior dorsal of them the notopodium are longest. Bidentate hooded hooks are present in both branches of the parapodium. Neuropodial hooks short and beyond setiger 48. Specimens have less than 20 hook-bearing branchiaete setigers. Anus terminal and surrounded by up to 8–10 relatively short anal cirri besides small anal papilla.

Diagnostic features to distinguish adult *Marenzelleria* cf. *viridis* and *M.* cf. *wireni* (after 3).

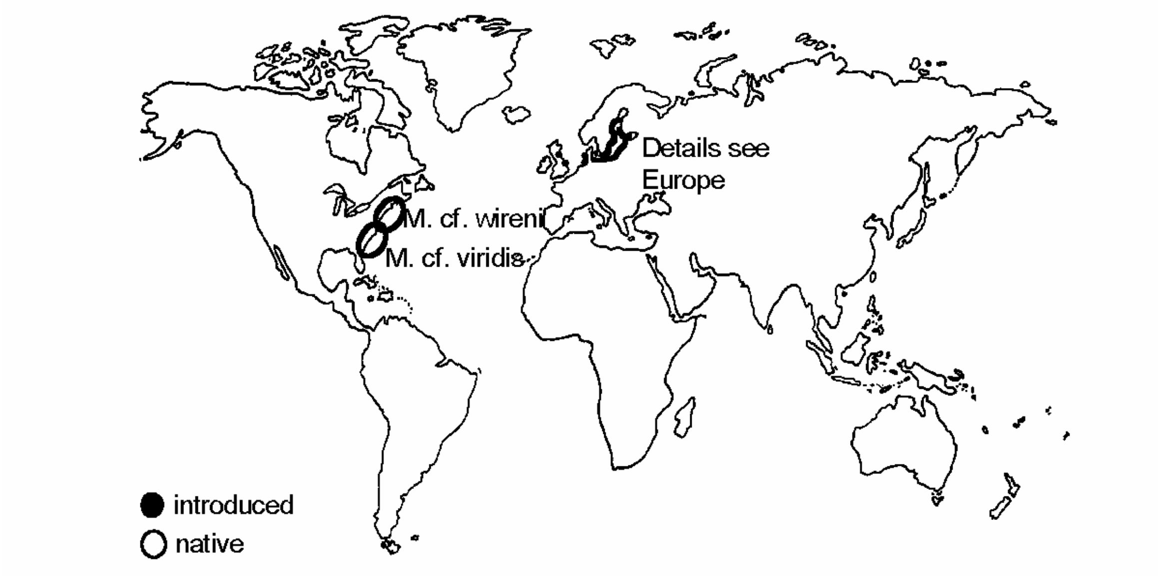
TAXONOMIC FEATURE	*M.* CF. *VIRIDIS* (TYPE II)	*M.* CF. *WIRENI* (TYPE I)
Nuchal organ	up to setiger 3	up to setiger 2
Number of branchiate setigers	max. 65	max. 130
Neuropodial hooded hook	not beyond setiger 48	not beyond setiger 42 or 46
Number of branchiate setigers with hooks	< 20	> 20
Number of anal cirri	8–10 (rather short)	12–16 (rather long)

Generalised life history: *Marenzelleria* cf. *viridis* has a life span of approx. 3 years. Many individuals reach sexual maturity after one year [10]. Benthic adult worms inhabit vertical J- or L-shaped, mucus lined burrows [6]. Adults feed on sediment particles, planktonic and meiobenthic organisms [11, 12]. However, in the Baltic several observations show, that most important food sources are fresh phytoplankton, resuspended organic material [13] and detritus containing diatoms (Jankauskiene pers. comm.). A switch to deposit feeding occurs in the absence of sufficient food content in the water column [12].

Reproduction: *M.* cf. *viridis* shows a sexual reproduction. Breeding was observed in autumn in the south-western Baltic [14] and the south-eastern Baltic [15]. Gamete development takes 4–5 months [14], although the period of maturity for spawning varies between years and different locations. The mature oocytes are discus-shaped about 155–170 µm in diameter with 10–18 cortical alveoli around the yolk [16]. Fertilised eggs occur in the water column and the subsequent larval development is entirely pelagic [16]. After the yolk reserves were consumed and development reaches the 3-setigers stage the larvae become planktotrophic. Larvae selectively feed on algae mainly smaller than 20 µm. [18]. The larvae usually grow to the 16–17 setiger stage before they undergo a metamorphosis into juveniles with a benthic life mode [17].

Relative abundance: Highest densities in the Baltic Sea are >50 000 ind./m² with a wet weight biomass of 100–400 g/m² in the Darss-Zingst Bodden Chain [5]. Even relative low densities of adults of *M.* cf. *viridis* increase the total macrofauna biomass in poor communities at least in one order of magnitude [15]. With a mean density of 300 ind./m² the surface of the *Marenzelleria*-tubes (up to 25 cm in depth) covers 0.45 m². In the upper sediment layer (0–25 cm) *Marenzelleria*-tubes form a fraction of nearly 11%.

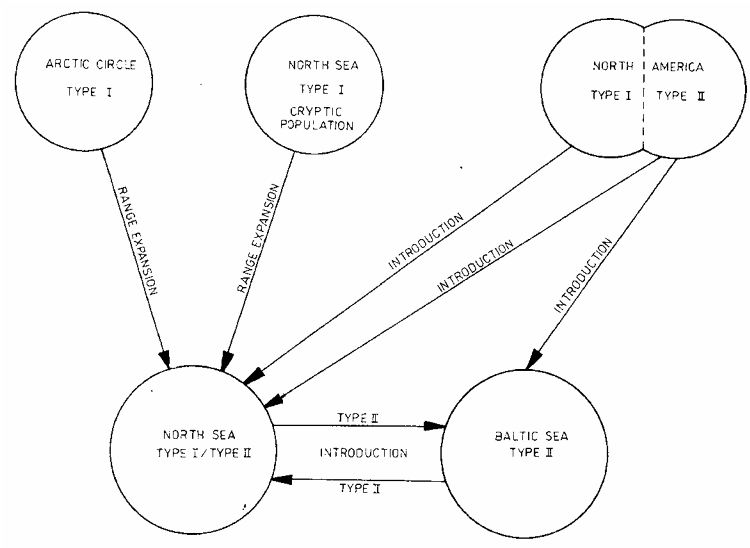
Worldwide distribution: The world-wide distribution of the genus *Marenzelleria* is restricted to the northern Hemisphere [22]. The native region of *M.* cf. *viridis* (Type II) is the Atlantic coast of North-America: Currituck Sound (USA, North Carolina), Trippe Bay (Chesapeake Bay), Chester River (USA, Virginia and Delaware) and Ogeechee River (USA, Georgia). The Chesapeake Bay and Currituck Sound were identified as the most probable origin of *M.* cf. *viridis* in Europe [1]. *M.* cf. *wireni* (Type I) is native to the following North American regions: Great Sippewisset Salt Marsh, Barnstable Harbour (USA, Massachusetts), Westport River and Cape Henlopen (USA, Delaware) [2].



World-wide distribution of *Marenzelleria* cf. *viridis* and *M.* cf. *wireni*.

Range Expansion in Europe: The first dense population in Europe was recorded from the Forth Estuary (Scotland) in 1979. The specimens collected were identified as *M. wireni* [19]. The spread of the species was documented by further records in the estuaries of Tay (Scotland) [20], Humber (England), Ems (The Netherlands and Germany), Weser, Elbe (Germany) and the Ringköping Fjord (Denmark) [21, 22]. In 1985 the first specimens of *Marenzelleria* cf. *viridis* were found in the Baltic Sea [23]. By 1992 it occurred at several coastal areas along the Baltic up to the Finnish coast [5, 22]. *Marenzelleria* cf. *viridis* was found at Umeå near Stockholm, Sweden, too [33]. The species distribution is restricted to coastal waters, estuaries and shallow bays.

Invasion patterns: The species is often described as motile [12, 24, 5]. Its spread is often associated with dispersal and/or long development of planktonic larvae. Even eggs developed up to pre-trochophore stage are capable of small swimming movements using apical cilia [16]. Recruitment of pelagic larvae, which could be transported into a new habitats by currents may lead to successful establishment of local populations. Colonisation by benthic juveniles and adults also may occur if recruitment of pelagic larvae is limited [32, 15]. Surface movements or swimming (spiral motion) of adult worms may occur in response to physical disturbance [12]. Nocturnal swimming of worms with ripe gametes was also observed in Lafayette River (USA, Virginia) and is therefore most probably associated with reproduction [31]. The transport as larvae in the ballast water of ships is likely. However, in Europe it may have expanded its range from the Arctic or from a cryptic population in the North Sea.



The origins and possible immigration routes of the European *Marenzelleria* spp. (after [2]).

Abiotic factors: Limiting factors for species distribution varies in different areas within the Baltic. Unsuccessful recruitment and low densities in the offshore areas of the Pomeranian Bay and Arkona Basin were attributed to food limitation [32]. Absence of juveniles, low densities and distribution of adults, and statistically significant changes in fitness of *M.* cf. *viridis* specimens in the Curonian lagoon are likely to be related to the extremely low mean annual salinity values (0.1–1.8 psu) [15]. However, in the Gulf of Riga the highest densities were found near the outflow of the three largest rivers [25]. In the south-eastern Baltic the species was found between 1.5 and 55 m depth [26], whereas in the Arkona Basin the lower limit did not exceed 30 m [13]. In the south-western Baltic *M.* cf. *viridis* invades depths between 0.2 and 30 m. Observation of a single adult specimen in the Bornholm Basin at a depth of 90 m was reported by Kube *et al.,* (1996). *M.* cf. *viridis* is resistant to higher concentrations of hydrogen. However if exposed to anoxia the species shows only a moderate resistance compared to other marine polychaetes [27, 7, 8]. Laboratory investigations showed that the species may efficiently use oxygen during hypoxia, which might indicate the ability for successful spread to habitats with frequently reduced oxygen conditions [9]. Complete local species extinction after severe anoxia and the ability to withstand short term hypoxic events was confirmed by field observations [32]. Species re-establishment depends on the success of the larval recruitment and immigration ratio of adults [32, 15].

Abiotic factors:

Temperature	Highly tolerant towards lower temperatures in oligohaline and mesohaline habitats [28].
Salinity	Highly tolerant to very low salinities and their temporary fluctuation [29]. Failed to reach maturity within 5 months at salinites >25 psu and gametes were less ripe than usual below 1.5 psu [16]. No successful larval development was observed below 5 psu from the egg to the benthic juveniles. However the 4-setiger larvae are able to metamorphose into the benthic life mode above 3.5 psu [16]. Adults prefer oligo- to mesohaline habitats [13, 8] and are more resistant than juveniles [29].
Oxygen	Tolerant to short term oxygen deficiencies [32, 8]. One of the best adapted species to long-term oxygen deficiencies among marine and brackish polychaetes [29].
Hydrogen sulphide	Detoxification mechanisms and survival in long-term sulphide exposure have been shown [7, 9]. The survival rate was not reduced in the presence of sulphide [28] and *M*. cf. *viridis* is better adapted than *M*. cf. *wireni* to cope with higher sulphide concentrations [30].

Further likely areas for colonisation: The species has a wide range of tolerance of salinity and temperature. The potential range of this species is expected to include boreal regions, South America, the southern coastline of Australia, Tasmania and New Zealand and South Africa.

Main vectors: Recruitment of pelagic larvae transported into a new habitats by currents may result in the successful establishment of local populations, supported by the long pelagic larval phase (>3 weeks) [17, 16]. Colonisation of benthic juveniles and adults may occur, if recruitment of pelagic larvae is limited [24, 15]. The North Sea species (*Marenzelleria* cf. *wireni* type I) could have been introduced as a larvae in the ballast water of ships or it may have expanded its range from the Arctic or from a cryptic population in the North Sea [2, 21]. It is more than likely that *M.* cf. *viridis* (type II) was introduced into the Baltic via a human mediated vector [2]. As *M.* cf. *viridis* (type II) also exists in the Elbe river (North Sea region), the species could have colonized the Baltic from the North Sea region or vice versa [2].

Control measures/management options: Not known.

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Annex 8: Summary of PICES XIIIth Annual Meeting, Session S5 Summary

PICES XIIIth Annual Meeting

Session S5 Summary

Session S5 (I-day MEQ Topic Session, co-sponsored by ICES)

Natural and anthropogenic introductions of marine species

Co-convenors: William P. Cochlan (U.S.A./PICES), Yasuwo Fukuyo (Japan/PICES) and Stephan Gollasch (Germany/ICES)

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Species introductions are among the most prevalent of human activities affecting natural ecosystems. In the marine environment, introductions, including most aquaculture initiatives, have resulted in both positive and negative effects. The transport of invasive species, such as phytoplankton, is thought to stem from range extensions associated with fluctuating oceanographic conditions (*e.g.*, El Niño), severe storm events (*e.g.*, typhoons), and human activities (*e.g.*, ballast water). The impact of transport processes on species distributional changes in North Pacific waters is not fully understood. Relative to the terrestrial environment, the study of introductions, and the potential for new species to become invasive, is in its infancy in marine systems. Emerging work includes introduction vectors, life history characteristics of invasive species, ocean conditions responsible for invasions, ecosystem resistance to invasion, and potential for eradication or mitigation of introductions once established. This session will seek to answer three fundamental questions: 1) What is known about different transport mechanisms? 2) What is the magnitude of ecological and economic effects arising from the transport of species? and 3) What steps can be taken to minimise real or potential effects of existent and future invasive species? The current session is particularly timely given that the IMO Ballast Water Management Convention was signed in February 2004, and is now awaiting ratification.

Summary of presentations

The session consisted of eleven oral presentations and one poster, representing authorship from five PICES nations: Canada, Japan, Korea, Russia and the United States, and six non-PICES nations: Australia, Germany, Ireland, Italy, Mexico and New Zealand, as well as ICES. Despite the broad range of invasive topics selected for this session, the attendance was modest. A late cancellation of one oral presentation permitted careful discussion and additional questions for each of the talks; an opportunity well received by those in attendance. The session's presentations were organised around 1) the case histories of invasives, including both pelagic and benthic organisms 2) descriptive and mathematical analyses of invasive vectors and their relative importance in various marine systems, and 3) management of invasion vectors, followed by discussion of any aspect of the session and consideration of future workshop ideas.

After brief introductory remarks by one of the co-convenors (S. Gollasch), the first invited speaker (G. Hallegraeff; Australia) discussed the role of ship's ballast water in spreading harmful algal bloom (HAB) species in Australian coastal waters, including the presence of culturable *Pseudo-nitschia* diatoms and *Pfiesteria piscisida* dinoflagellates in ballast waters. His presentation also discussed the special problem of invasive cysts, methods to determine if these invasive cysts have firmly established themselves in new environments, and the treatments to remove invasive species in ballast waters or destroy their viability. The next two speakers continued with case histories of invasive species, including the seaweed *Undaria pinnatifida* and their molecular identification (S. Uwai; Japan), and a Russian study of the invasive success of benthic species (polychaetes and phoronids) in the more ecologically stressed and contaminated regions of the Peter The Great Bay (T. Belan).

Majorie Wonham (Canada), our next invited speaker, discussed the various hypothesis used to describe the apparent increase in marine biological invasions. Using existent data sets (from six independent marine systems), she demonstrated that often more than one model (linear, exponential and exponential) can describe temporal invasion trends, and outlined the difficulty of interpreting species invasions without consideration of both introduction rates and survival probabilities. Stephan Gollasch (invited ICES speaker), posed the question whether ballast water was the key vector for aquatic species invasions. His presentation reviewed the relative importance of the various vectors for species introductions in twelve marine regions around the world, and demonstrated that hull fouling, ballast water and aquaculture were the most important vectors in all regions considered. However, his analysis also showed that relative importance of these vectors is regionally specific, and that hull fouling, not ballast waters, was the dominant vector in 60% of the regions considered; a conclusion which suggests that increased international regulation of ballast water introductions will not necessarily eliminate or decrease species invasions in all regions. Dan Minchin (Ireland) continued with the theme of vectors, and showed the importance of small craft, (open boats, yachts and cruisers) in transporting invasive species, and how their relative importance has appeared to increase with the growing number of citizens capable of owning and operating such craft. His analysis also demonstrated the importance of marinas as exchange points for invasives from the primary vector of shipping to the secondary vector of small craft which further increase their range extension to areas inaccessible by shiping alone.

Yasuwo Fukuyo (Japan) in a series of back-to-back presentations outlined the IMO Ballast Water Management Convention, its history and articles, and most importantly the challenges present in obscure wording (*e.g.*, viability) and the availability of reliable scientific methods to support the performance standards outlined in the Convention. A very promising technique (Special Pipe) designed in Japan to terminate ballast water organisms using shear stress and cavitation was described, and its tests of efficacy presented. Jennifer Boehme (U.S.A.) outlined a verification system to ensure that mid-ocean ballast water exchange procedures are actually conducted based on the optical characteristics of chromophoric dissolved organic matter (CDOM) present in the original ballast water. She showed that statistics could be effectively used to discriminate the variability of CDOM florescence in various oceanic and coastal regions, and that such an analysis could offer a verification system independent of port salinity. Scott Godwin (U.S.A.) outlined recent efforts to identify and control species introductions associated with hull-fouling - the principle invasive vector in Hawaiian waters, using a risk-management approach based on a relative fouling risk associated with various vessels and the dynamics of their arrival in Hawaiian ports. The final oral presentation by Stephan Gollasch was an introduction to the history, practices and work products resulting from the ICES efforts on the introductions of marine organisms. He concluded with a number of suggestions including the establishment of a PICES Working Group on Species Invasions (not limited to HABs), and the reciprocal attendance of PICES and ICES members at their annual meetings and working sessions. He urged PICES member countries to follow the 'ICES Code of Practice for the Introduction and Transfer of Organisms' when planning species introductions, and emphasised the need for both regional and global networks to most efficiently deal with biological invasions, given that an invasive species could originate from a non-PICES nation.

The session was concluded by a lively discussion led by Dr. Fukuyo where representatives of all PICES member countries in attendance agreed upon the establishment of a 'Working Group on Marine Invasive Species.' Such a working group will serve as a means to create awareness of the species invasion problem, encourage additional scientific research on the issue, and enhance funding opportunities dealing with marine invasive initiatives in PICES member countries, and eventually may support the timely ratification and implementation of the IMO Ballast Water Management Convention.

Annex 9: Recommendations to the Council

WGITMO recommends that the working group meet at least two days in Oostende, Belgium in the week starting with March 13th 2006 in conjunction with the meeting of the ICES/IOC/IMO Working Group on Ballast and other Ship Vectors (WGBOSV) to:

a) synthesise and evaluate National Reports,
b) prepare a report for rapid response and control options,
c) prepare a report summarizing introductions and transfers of marine organisms into the North Sea and wherever possible their consequences as input to the 2006 meeting of REGNS (Regional Ecosystem Study Group for the North Sea),
d) prepare a 10 year summary of National Reports (1992-2002)
e) plan Aliens Species Alert reports including evaluation of impacts and increasing public awareness,
f) development guidelines for rapid response and control options.

Supporting information:

Priority:	The work of the Group is essential to prevent future unintentional movements of invasive and/or deleterious aquatic species including disease agents and parasites with the legitimate trade in species required for aquaculture, table market, ornamental trade, fishing and other purposes and to assess the potential of species moved intentionally to become a nuiscance in the area of introduction. Commercial movements of organisms increase over time highlighting that a very high priority must be given to the development and implementation of precautionary actions to avoid unwanted impacts. Appropriate protocols are outlined in the Code of Practice. Vectors others than shipping and effects of invasive species are purview of WGITMO. The work of this Group supports the core role of ICES in relation to planned introductions and transfers of organisms.
Scientific Justification:	The work is needed for the working group to maintain an overview of relevant activities in Member Countries and other areas from which species could be spread to Member Countries and to contribute to REGNS. The work on rapid response and control options will provide guidance on what to do in case a new species is recorded. The preparation of Aliens Species Alert Reports including an evaluation of impacts will contribute to the REGNS ToRs. Further work is needed to keep the Code of Practice on the Introductions and transfer of marine organisms up-to-date. As a result of this initiative the comprehensive appendices of the Code, published on the Internet, may need to be updated.
Relation to Strategic Plan:	
Resource Requirements:	Normal meeting facilities provided by host country and participation of national members.
Participants:	WGITMO members and invited experts from, *e.g.*, Australia, New Zealand, Mediterranean countries that are not members of ICES, representatives of relevant PICES WGs. WGITMO recommends to invite experts with relevant expertise to contribute to the Aliens Species Alert reports and experts from countries which have developed/are developing rapid response plans.
Secretariat Facilities:	None required
Financial:	None required
Linkages to Advisory Committees:	ACME
Linkages to other Committees or Groups:	WGHABD, WGEIM, WGBOSV, WGAGFM, WGMASC Mariculture Committee.
Linkages to other	Recognising the potential risk from introductions of aquatic species into the

Organisations:	coastal waters, inland seas and waterways of Member Countries through freshwater routes, WGITMO urges ICES to encourage and support joint meetings between WGITMO and EIFAC, in addition to a continued dialogue between WGITMO and BMB, PICES, IMO, IOC, EU, HELCOM, EIFAC, BMB, CIESM.
Cost share	ICES 100 %