Advisory Committee on the Marine Environment **ICES CM 2003/ACME:04**
Ref. E, F

REPORT OF THE

Working Group on Introductions and Transfers of Marine Organisms

Vancouver, Canada
26–28 March 2003

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Contents

1 Opening of the meeting and introduction

The 2003 meeting of the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO) was held from 26–28 March at the University of British Columbia (UBC) city campus, Vancouver, Canada, hosted by Dorothee Kieser, Department of Fisheries and Oceans (DFO) for Canada and with Stephan Gollasch (Germany) as Chair. In total 18 participants from Belgium, Canada, France, Germany, Ireland, Italy, New Zealand, Norway, Sweden, Russia, and the United States of America attended the meeting (see Annex 2, List of Participants).

The meeting was opened at 9am on Wednesday 26 March 2003 with welcoming remarks from Dr. Laura Richards, DFO Regional Director of Science and with Stephan Gollasch welcoming participants, particularly new members who had not previously attended WGITMO meetings. The participation of PICES and the potential for cooperative links between ICES and PICES on matters of interest to WGITMO were highlighted. The local host, Dorothee Kieser, DFO also welcomed participants and gave an overview of local arrangements.

The Chair forwarded the very positive feedback from ICES on the progress made at last year's meeting to the Group. This in particular refers to the preparation of the Alien Species Alert report on *Rapana venosa* (veined whelk), to be published as *ICES Cooperative Research Report,* and the efforts made to update the Code of Practice and its Appendices. The Group very much appreciated these positive comments and noted that the very long working hours at last year's meeting were spent well.

This meeting was the 25th Anniversary of reconvening WGITMO meetings. A list of previous meeting venues is included in the meeting Agenda (Annex 1). Key activities and outcomes of the 25-year history of the group were outlined by Harald Rosenthal (Germany), who had the longest active WGITMO membership of all attendees at the Vancouver meeting (see Section 4 below).

The meeting was arranged in a series of plenary sessions with several sub-group drafting sessions to consider the Directory of Dispersal Vectors (entitled "Vector pathways and the spread of exotic species in the sea"), to review and modify the Appendices of the Code of Practice, to draft the Alien Species Alert Report on the Red King Crab, *Paralithodes camtschaticus,* and to summarise the National Reports submitted. The full Working Group considered the outcomes of the sub-group sessions and other recommendations of the meeting at a final session of the meeting.

2 Terms of reference, adoption of agenda, selection of rapporteur

2.1 Terms of Reference

The terms of reference (ToR) of the 2003 meeting (Annex 3) were reviewed and the Agenda was structured to allow each ToR to be addressed. This required preparation of papers and reports by members for presentation at the meeting, and these are contained in the Annexes of this report. The Chair expressed his thanks to the WGITMO members for preparing these reports and papers for consideration at the meeting.

CM 2002/2ACME06The Working Group on Introductions and Transfers of Marine Organisms [WGITMO] (Chair S. Gollasch, Germany) will meet in Vancouver, Canada from 26–28 March 2003 to:

a) collect and provide a synthesis and evaluation of National Reports;

b) review, edit and finalise the Appendices in the form of Technical Guidance Notes for the Code of Practice on Introductions and Transfers of Non-indigenous Marine Organisms;

c) provide a synthesis and evaluation of annual updates on the spread and impact of exotic species, including information from countries that are not members of ICES;

d) continue the development of a proposal for the dissemination of relevant material for public information via the ICES website, with special emphasis on the Code of Practice Appendices;

e) meet with the North Pacific Marine Science Organization (PICES);

f) continue work on the Summary of National Reports 1992 to 2001 for ultimate publication as a CD-ROM together with the annual reports during the period covered;

g) finalise the *ICES Cooperative Research Report* on the "Directory of Dispersal Vectors of Exotic Species";

h) collect information on impacts which intentional introductions may have on the receiving environment (e.g., Red King Crab in Norway) with the option to consider such species for an "Alien Species Alert" report.

2.2 Status of the terms of reference

The finalisation of the Directory of Dispersal Vectors (entitled "Vector pathways and the spread of exotic species in the sea") and the completion of the Appendices of the Code of Practice were given the highest priority at the 2003 meeting in Vancouver, Canada. In addition a working draft of an Alien Species Alert Report on the Red King Crab *Paralithodes camtschaticus* was produced and National Reports submitted were summarized. However, other objectives could not be achieved due to time limitations (e.g., the Summary Report on Species Introductions 1992–2001).

The status of the Terms of Reference is as follows:

a) completed for 2003 (Annexes 4–6);

b) continued. The Technical Guidance Notes of the Code of Practice as submitted with the WGITMO report 2002 were considered as too detailed and adjustments were made accordingly (see Annexes 7–13);

c) completed for 2003 (further below and Annex 15);

d) completed for 2003 (Annexes 7–15);

e) completed for 2003 (further below);

f) partly completed at previous WGITMO meetings. Due to time limitations not addressed in great detail at the 2003 meeting (further below);

g) completed (Annex 14);

h) partly completed (Annex 15), to be completed in 2004.

2.3 Adoption of the Agenda

The agenda of the meeting was considered and adopted. The agenda is attached as Annex 1.

2.4 Selection of Rapporteur

As in previous meetings, Dorothee Kieser (Canada) was appointed as rapporteur.

3 Review of the 2001 WGITMO report

The group reviewed last year's meeting report intersessionally. Errata to the 2002 WGITMO report:

- It is recommended to reformat Figure 10.2.3 on page 12 "First records on non-indigenous species in 2001 based on data of National Reports considered at WGITMO 2002". The world map (bottom of page 12) was formatted as the background drawing of the boxes and arrows (top of page 12).
- Further, one box in Figure 10.2.3 should read "Italy, Salerno. *Dispio uncinata*". However, the current version does not show the species name "*uncinata*".

4 Other relevant information

4.1 25th Anniversary Meeting of WGITMO

Using the opportunity of the 25th Anniversary Meeting of WGITMO, key achievements of the Working Group since 1979 were summarized by Harald Rosenthal (Germany). The extended summary of his presentation includes major steps in the development of the working group from the 1970s to the 1990s (Annex 19).

4.2 Database on Introductions and Transfers

Harald Rosenthal (Germany) presented an overview of a database which contains some 16,500 entries relevant to species movements taken from sources, both peer reviewed and from the grey literature in many countries and languages. A summary of the database entitled “Transplantations and Transfers of aquatic organisms and their implications for aquaculture and ecosystems” is presented in Annex 16.

4.3 ICES Advisory Report on *Rapana*

WGITMO noted with great appreciation the resolution 1ACME01 as adopted at the 2002 ICES Annual Science Conference to prioritise the publication of the Alien Species Alert report on *Rapana venosa* (veined whelk), prepared by the WGITMO in 2002, in the *ICES Cooperative Research Report* series. The estimated number of pages is 20.

WGITMO asks ICES to consider to update this report with new findings of *Rapana venosa* individuals near Vendee, southern Brittany (France) (see French National Report).

4.4 Rapid response

Discussions at the meeting revealed the lack of rapid response strategies when new species are recorded. WGITMO suggests preparing a discussion paper in the future to consider rapid response and control options of new invaders. The work on rapid response and control options (contingency plans) may provide guidance on what to do in case a new species is recorded. This may include eradication strategies, monitoring advice and international cooperation, i.e., notification of neighbouring countries and joint efforts.

4.5 Proposal for an Inter-Basin-Transfer of Sturgeons

The Society to Save the Sturgeon (SSS), a non-profit organisation founded in 1994, aiming at the restoration of the sturgeon populations in Central Europe currently is carrying out a project for the restoration of sturgeon populations in German waters. The member of the board and project manager, Joern Gessner, presented a proposal to WGITMO during the Vancouver meeting.

Recent evidence from archaeological, morphological and genetic studies has proven that North American Atlantic sturgeon *Acipenser oxyrinchus* became established in the Baltic Sea and its tributaries approximately 1000 years b.p. These surprising results were discussed at an international workshop in June 2002. The recommendation of the workshop provided the basis for a decision by the SSS and the German Federal Agency for Nature Conservation which is hosting the project to diversify the initial attempt to protect and re-establish *Acipenser sturio* in Germany. The current plan is to commence the restoration plans for the Baltic with *A. oxyrinchus* and for the North Sea and its tributaries with *A. sturio*. Therefore, the SSS proposed a plan to transfer brood-stock of North American *A. oxyrhinchus* under the new Code of Practice as a basis for the future restoration activities for the species in the Baltic Sea.

WGITMO noted this project with great interest and will follow up future developments focussing on the planned movement of North American sturgeon into European waters.

5 National Reports (ToR a)

As recommended by ICES in 2001, the National Reports were prepared and distributed intersessionally in order to allow maximum time for discussion of other ToRs at the meeting. National reports were received from eleven Member

Countries: Belgium, Canada, Estonia, Finland, France, Germany, Ireland, Norway, Sweden, the United Kingdom, and the United States of America (Annex 4). For the first time ever a National Report was provided by New Zealand (observer status) (Annex 5). As in previous years Italy (guest status) submitted a National Report (Annex 6).

National reports were briefly presented following the opening of the meeting on Wednesday.

5.1 Summary and highlights of National Reports (ICES Member Countries, countries with observer and guest status)

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

5.1.1 New laws and regulations

According to the National Reports submitted for this year's meeting some countries have made changes or are intending to make changes to their laws and regulations. A brief overview is presented in the Table 5.1.1.1 below. Additional detail can be found in the individual National Reports. Please note that this table is not comprehensive as not all ICES Member Countries made National Reports available to WGITMO (Annexes 4–6).

Table 5.1.1.1. 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 new legislation
Canada	A National Aquatic Invasive Species Plan is being developed to address the threat of aquatic invasive species and the movement of species within Canada and internationally.
Estonia	New "*Nature conservation act"* has been prepared and should be submitted for approval to the Parliament in 2003.
Finland	No new legislation reported
France	Two proposed new regulations: 1) harmonised animal health rules for the importation, from third countries, of live molluscs, their eggs and gametes; 2) harmonised animal health rules for the importation, from third countries, of live fish, their eggs and gametes.
Germany	Germany actively contributes to the development of the IMO Ballast Water Convention
Italy	The Ministry of Environment has signed a research contract with ICRAM (Central Institute for Marine Environmental Research, Rome) to acquire a database and other instruments to be used in the implementation of measures to prevent introduction of alien species, in application of the Barcelona Convention - Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean.
Ireland	No new legislation reported
New Zealand	Two Regulations govern the introduction of all non-indigenous organisms: 1) The Hazardous Substances and New Organisms Act 1996; and 2) the Biosecurity Act 1993.
Norway	No new legislation.
Sweden	There was no new Swedish legislation during 2002.
United Kingdom	An extended list of species pertaining to the Import of Live Fish (England and Wales) Act (1980) is expected to take effect in February 2003. The UK Environment Agency put into place a ban in 2002 on the use of live bait in sport angling. This ban is expected to aid in controlling the spread of non-native fish species in waters of Northern England.
USA	National Aquatic Invasive Species Act introduced into US House of representatives and to Senate. Ballast water management regulations enacted in Maryland, Michigan, Oregon, Rhode Island, Virginia, Washington, New York and California.

5.1.2 Accidental introductions and transfers

The following species were listed as accidental introductions and transfers in the National Reports submitted for the 2003 meeting. Some of the species listed below have been reported in previous years. Where the reports indicated a first record, species are shown in bold (Table 5.1.2.1). Please note that further first records of non-indigenous species are provided in the SGBOSV 2003 meeting report and annexes thereto. A comprehensive list of first records of non-indigenous species is attached to the Handbook of Dispersal Vectors (Annex 14).

Table 5.1.2.1. Species listed as accidental introductions and transfers in the National Reports submitted for the 2003 meeting. First recorded species in bold.

Reported by:	***Species***
Belgium	*Crassostrea gigas, Ensis directus, Crepidula fornicata, Elminius modestus, Mytilopsis leucophaeta, Dreissena polymorpha, Cordylophora caspia,* ***Callinectes sapidus****, Caprella mutica, Ficopomatus engimatus, Megabalanus tintinnabulum, Megabalanus coccopoma, Tricellaria inopinata, Undaria pinnatifida*
Canada	*Homarus americanus, Salmo salar, Carcinus maenas, Nuttalia obscurata, Styela clava,* ***Botryllus schlosseri****, Ciona intestinalis, Codium fragile,* ***Haplosporidium nelsoni, Haplosporidium costale***
Estonia	***Hypothalmichthys nobilis****, Neogobius melanostomus, Maeotias marginata, Cergopagis pengoi, Marenzelleria viridis*
Finland	European sheatfish virus*, Anguillicola crassus*
France	*Crepidula fornicata, Austrovenus stutchburii, Ocinebrellus inornatus, Rapana venosa,* ***Homarus americanus****, Caulerpa taxifolia, Corella eumyota*
Germany	*Hemigrapsus penicillatus, Crassostra gigas, Mya arenaria, Anguillicola* sp.*, Eriocheir sinensis, Dreissena polymorpha, Portumnus latipes, Teredo navalis, Mastocarpus stellatus*
Ireland	*Dreissena polymorpha, Ficopomatus enigmatica, Sargassum muticum, Azolla filiculoides, Myriophyllum aquaticum, Lagarosighon major, Crassula helmsii, Hydrocotyle ranunculoides, Elodea nuttalia, Nymphoides peltata, Anguillicola crassus, Pseudodactylogyrus anguillae, P. bini, Bonamia ostrea*
Italy	*Tapes philippinarum,* ***Seriola rivoliana****, Clytia hummelinki, Leiochrides australis, Ophryotrocha japonica,* ***Chrisallida fisheri, Aplysia dactylomela****, Anadara inaequivalvis, Anadara demiri, Musculista senhousia, Percnon gibbesi, Ceramium bisporum, Batophora* sp.*, Hypnea cornuta, Caulerpa racemosa & C. taxifolia*
New Zealand	*Arenigobius bifrenatus, Favonigobius exquisites,* ***Acentrogobius pflaumi****, Parioglossus marginalis, Charybdis japonica, Didemnium vexillum,* ***Paracorophium brisbanensis****, Codium fragile, Undaria pinnatifida, Caulerpa taxifolia, Gymnodinium catenatum, Dasys* spp.*, Griffithsia crassiuscula, Polysiphonia subtilissima*
Norway	*Crepidula fornicata, Chionoecetes opilio, Caprella mutica, Homarus americanus, Sargassum muticum, Dasysiphonia* sp.
Sweden	*Acipenser baeri, Acipenser gueldenstaedti, Acipenser ruthenus, Huso huso, Ctenopharyngodon idella, Cyprinus carpio, Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Hucho hucho, Oncorhyncus clarki, Oncorhyncus gorbuscha, Oncorhyncus kisutch, Oncorhyncus mykiss, Oncorhyncus nerka, Salvelinus fontinalis, Salvelinus namaycush, Micropterus dolomieu, Micropterus salmoides, Gyrodactylus salaris, Ceropagis pengoi, Marenzelleria viridis,* ***Eriocheir sinensis****, Anguillicola crassus, Coscinodiscus wailesii, Fucus evanescence, Sargassum muticum, Bonnemaissonia hamifera, Dasya baillouviana, Colpomenia peregrina, Codium fragile*
United Kingdom	*Pseudoraspora parva, Acipenser ruthenus, Leucapius delineatus, Stizostedion lucioperca, Silurus glamis, Crepidula fornicata, Perophora japonica, Alexandrium minutum, Sagassum muticum, Eriocheir sinensis,* **Spring viraemia of Carp virus**
USA	***Alcyonidium*** **sp.**, *Didemnium* sp., *Undaria pinnatifida, Caulerpa taxifolia, Porphyra suborbiculata*

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

It has to be noted that the figures and tables in this section of the report do not claim to be fully comprehensive as not all ICES Member Countries 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.

Data on commercial species movements were provided by Canada, Estonia, Finland, Germany, Ireland, Sweden, and United Kingdom. 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 5.1.3.1 and 5.1.3.2).

As in 2001, this year's commercial movements were dominated by various fish species, followed by molluscs, crustaceans and plants. On a species level, the most commonly moved organisms in 2002, as in 2001, were Atlantic salmon, *Salmo salar*, followed by rainbow trout, *Oncorhynchus mykiss* and Pacific oysters, *Crassostrea gigas.*

Table 5.1.3.1. Species exported by ICES member countries according to the National Reports submitted for the 2003 meeting.

Exporting country	Species
Canada	*Salmo salar, Salvelinus alpinus, S. fontinalis, Oncorhynchus mykiss, S. fontinalis x S. alpinus*
Estonia	Various fish
Finland	Rainbow trout
Germany	*Mytilus edulis*
Ireland	*Salmo salar, Carassius* sp, *Leusicus idus, Mytilus edulis, Crassostrea gigas, Haliotus tuberculata, Haliotis discus hannai*
Sweden	*Oncorhynchus mykiss, Salmo* sp., *Mytilus* spp. Scallops
United Kingdom	*Salmo salar, Crassostrea gigas, Mytilus edulis*

Table 5.1.3.2. Species imported by ICES member countries according to the National Reports submitted for the 2003 meeting.

Importing Country	Species
Belgium	Various
Canada	*Tapes philippinarum, Crassostrea gigas, C. sikamea, Mytilus galloprovincialis, M. edulis, Placopecten magellanicus, Ostrea edulis, Crassostrea virginica, Mya arenaria, Mercenaria mercenaria, Argopecten irradians, Spisula solidissima, Oncorhynchus mykiss, Salmo salar, Oroechromis niloticus, Acipenser transmontanus, Haliotis rufenscens, Homarus americanus, Strongylocentrotus drobachiensis, S. purpuratus*
Estonia	Various fish
Finland	*Anguilla anguilla, Oncorhynchus mykiss, Acipenser sturio, Silurus glanis,* various invertebrates
France	*Crassostrea gigas, Mercenaria mercenaria, Tapes philippinarum, Mytilus edulis, M. galloprovincialis*
Germany	Various fish including *Cyprinus carpio* (koi) and other carp, several sturgeon species (incl. *Acipenser baeri), Salmo salar, Oncorhynchus mykiss, Mytilus edulis,* various live crustaceans
Ireland	Various aquatic plants, *Crassostrea gigas, Nereis* sp., *Salmo salar, S. trutta, Oncorhynchus mykiss, Hippoglossus hippoglossus, Psetta maxima, Hypocamidae*, various ornamental carp
Norway	*Salmo salar, Hippoglossus hippoglossus, Scopthalmus maximus*
Sweden	*Anguilla anguilla*, Lobster, crab, *Mytilus* spp.
United Kingdom	*Salmo salar, Oncorhynchus mykiss, Crassostrea gigas, Tapes philippinarum, Homarus americanus,* various bivalves

The following table (Table 5.1.3.3.) summarises live imports and exports of aquatic species according to higher taxa and area of origin based on National Reports considered at the meeting. Ornamental trade is excluded.

Table 5.1.3.3. Summary of live imports and exports of aquatic species according to National Reports submitted to WGITMO 2003. Ornamental trade excluded. (cr = crustacean, fi = fish, mo = molluscs, pl = plants, Aus = Australia, Bel = Belgium, Can = Canada, Cze. R = Czech Republic, Den = Denmark, Est = Estonia, Fin = Finland, Fra = France, Ger = Germany, Hun = Hungaria, Ice = Iceland, Ind = Indonesia, Ire = Ireland, Ita = Italy, Lat = Latvia, Net = the Netherlands, Nor = Norway, Pol = Poland, Por = Portugal, Rus = Russia, S. Afr = South Africa, Spa = Spain, Swe = Sweden, UK = United Kingdom, USA = the United States of America).

	Import (limited to ICES member countries)													
Exporting country	**Bel**	**Can**	**Est**	**Fin**	**Fra**	**Ger**	**Ire**	**Net**	**Nor**	**Pol**	**Rus**	**Swe**	**UK**	**USA**
Aus							fi							
Bel														
Can					fi	cr fi		fi		fi		cr mo	cr	fi
Cze. Republic						fi								
Den			fi			fi mo	fi		fi			fi mo	fi	
Est								fi	fi		fi		fi	fi
Fin			fi								fi			
Fra						fi	fi mo					mo	fi	
Ger	mo							mo				fi		
Hun						fi								
Ice		mo					fi		fi					
Ind							pl							
Ire					fi mo	cr fi						cr	fi mo	
Ita					mo	fi						fi		
Net					mo	fi						fi mo	fi	
Nor						cr						cr fi mo		
Pol						fi								
Por														
Rus						fi								
Spa					mo				fi					
S. Afr.													fi	
Swe						fi								
UK			fi		cr mo		fi mo		fi			fi mo		
USA		fi mo										cr mo		

The country with the highest number of source regions in commercial species imports in 2002 was Germany (12 source regions (13 in 2001)) followed by Sweden with 10 (11 in 2001). Most other importing countries import species from fewer than 6 source regions (Table 5.1.3.3).

Figures 5.1.3.1 and 5.1.3.2 provide an overview on movements of *Salmo salar* (eggs, fry, juveniles and adults) and *Crassostrea gigas* (all life stages) based on National Reports considered at the meeting. Tables 5.1.3.4. and 5.1.3.5. on this matter provide more details.

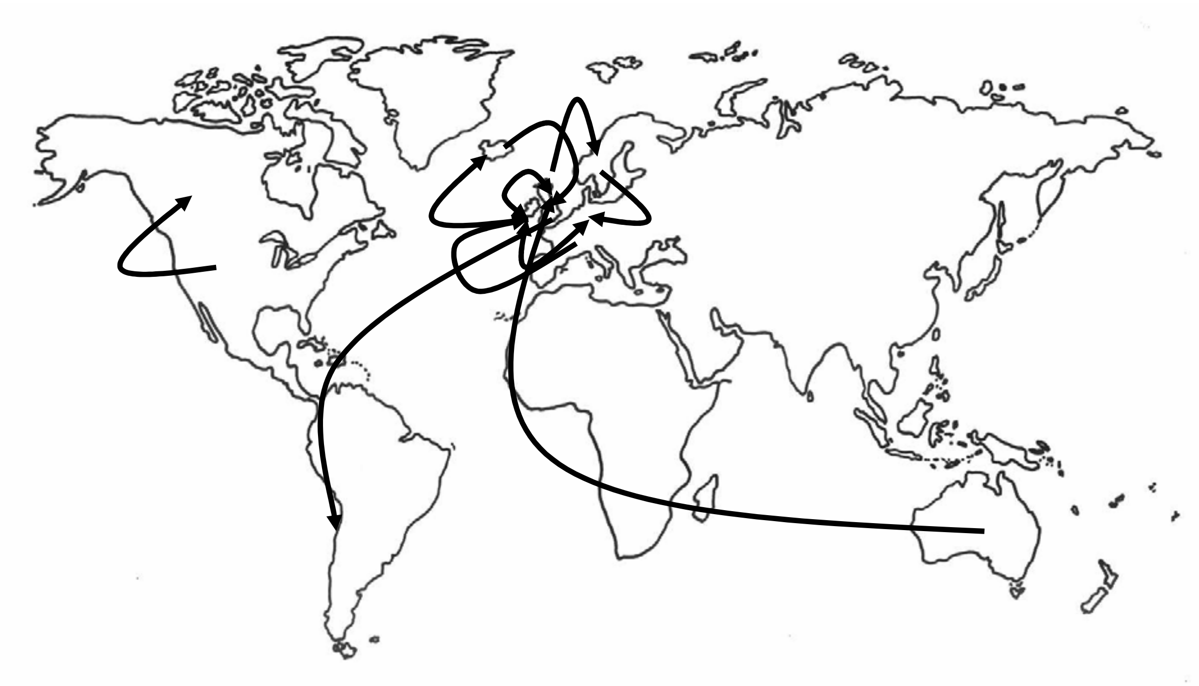

Figure 5.1.3.1. Movements of Atlantic salmon, *Salmo salar* (eggs, fry, juveniles and adults) based on data of National Reports considered at WGITMO 2003.

Table 5.1.3.4. Movements of Atlantic salmon, *Salmo salar* (as taken from the National Reports considered at WGITMO 2003).

Life stage	Donor Country	Recipient Country
Eggs	UK	Chile
	UK	Ireland
	Ireland	UK
	Ireland	Germany
	Iceland	UK
	EU Member Countries	UK
	Australia	UK
Juveniles	UK	Ireland
	EU Member Countries	UK
Adults	Sweden	Germany
Unknown	USA	Canada
	Ireland	Iceland
	UK	Ireland
	France	Ireland
	Germany	Ireland
	Faroe Islands	Norway

Figure 5.1.3.2. Movements of *Crassostrea gigas* (all life stages) based on data of National Reports considered at WGITMO 2003.

Table 5.1.3.5. Movements of Pacific oysters, *Crassostrea gigas* (as taken from the National reports considered at WGITMO 2003).

Life stage	Donor Country	Recipient Country
Spat	USA	Canada
Unknown	Ireland France UK Ireland	France Ireland Ireland UK

5.2 Conclusions

- WGITMO agreed to restructure the format of the National Report to ease the reporting, documentation and synthesis of the spread and impact of introduced species, and to better address transfers/introductions of pathogens, disease agents and parasites;
- The very detailed information provided by the Italian participant was greatly appreciated by WGITMO;
- Other non-ICES Member Countries may be encouraged to make information on non-indigenous species under its jurisdiction available to WGITMO;
- WGITMO asks ICES to encourage member countries to track the importation of live seafood, bait, ornamentals and other organisms at a minimum on a genus level and at a species level wherever possible for inclusion in the National Reports to assess the risks associated with their importation;
- ICES is asked to urge member countries and other jurisdictions 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 expressed significant concern that the live importation of species for consumption may negatively impact indigenous species and their environment. An example of this is the finding of the American lobster *Homarus americanus* in the natural range of the European lobster *Homarus gammarus*. ICES is asked to encourage Member Countries to consider legislation to prohibit the release of species into the natural environment unless the risks associated with such releases have been reviewed and are considered minimal, according to the Code of Practice.

5.3 Recommendations

- WGITMO recommends that future annual meetings include an opportunity for the participation from non-ICES countries (e.g., PICES, Mediterranean countries and other international organizations, such as CIESM) on the basis of their expertise on species that are invasive elsewhere and that may be of concern to ICES member countries.
- It is recommended that this ToR should remain on the agenda of WGITMO.

6 ICES Code of Practice (ToR b)

The body of the Code of Practice was not discussed at the 2003 meeting of WGITMO as the version submitted in 2002 is still considered up-to-date. However, the modification in the Preamble and in the Section on Genetically Modified Organisms was briefly reviewed by the Group. No other comments as provided intersessionally were made.

6.1 Conclusions

- Participants will intersessionally prepare a list of agencies, universities, and other institutions in their home countries which may be interested in the Code of Practice. These agencies can be asked to distribute the information.

6.2 Recommendations

- ICES is invited to consider the above-mentioned list after completion when distributing the printed version of the Code of Practice.

7 Technical Guidance Notes for the Code of Practice (ToR b)

A draft version of the Technical Guidance Notes of the Code of Practice were prepared at the 2002 meeting of WGITMO. The purpose of these notes is to provide advice to all stakeholders involved in and planning species introductions, especially in jurisdictions which have not developed country specific regulations and safeguards. If information is provided to WGITMO, it will assist the ICES Working Group in assessing the risks associated with the proposed species introduction.

The completion of the Technical Guidance Notes for the Code of Practice was given the highest priority at the 2003 meeting. Plenary discussions and drafting sessions contributed to the completion of this ToR. The group started early in the day, shortened the lunch and coffee breaks and worked long hours. This resulted in enormous headway.

Subsequently, the principles of the Technical Guidance Notes for the Code of Practice were discussed paragraph by paragraph and rewritten accordingly during drafting sessions.

Following the meeting in Vancouver WGITMO continued to finalise the Technical Guidance Notes for the Code of Practice until the deadline to deliver the meeting report.

As a result, new versions of the Technical Guidance Notes for the Code of Practice were agreed upon and are attached to this report as Annexes 7–13.

7.1.1 Prospectus (Appendix A of the Code)

The prospectus was reviewed to avoid duplication of requirements. Its comprehensive format was adjusted to the minimum as essentially needed to assess proposed species introductions (Annex 8).

7.1.2 Risk Review (Appendix B of the Code)

A new simplified version is attached as Annex 9.

7.1.3 Quarantine (Appendix C of the Code)

The quarantine section was substantially rewritten and shortened. The new simplified version is attached as Annex 10.

7.1.4 Monitoring (Appendix D of the Code)

WGITMO appreciated that ICES judged this contribution as well written and concise. This Appendix was slightly modified by providing a tentative schedule for the provisions of the monitoring reports. Further guidance is given for follow-up monitoring initiatives in case a project is terminated (Annex 11).

7.1.5 Flowchart (Appendix E of the Code)

WGITMO agreed to keep the flowchart as it provides details on the decision-making process. The Group further agreed that the version provided last year is confusing and a new version was drafted at the meeting (Annex 12).

7.1.6 Case study (Appendix F of the Code)

The case study on *Patinopecten yessoensis* (introduced in Ireland) was restructured and repetition was avoided wherever possible. As a result a shorter version (approx. 8 pages) was prepared and is attached to this report as Annex 13.

7.2 Conclusions

- The Technical Guidance Notes for the Code of Practice are considered to be complete.

7.3 Recommendations

- In order to allow a maximum of flexibility and to avoid frequent reprinting of the Code of Practice following future adjustments, WGITMO suggests not to include the detailed Appendices in the printed version, but to make these available via the Internet to ensure that Appendices are current and that the most recent information is included. WGITMO plans to frequently review the Appendices and to provide a new version (if needed) to ICES with its annual meeting reports.
- WGITMO asks ICES to establish a relevant homepage in the near future.
- It is recommended that this ToR should remain on the agenda of WGITMO for annual review and improvement. This could possibly be done intersessionally with a brief discussion at the meeting summarizing the intersessional activity.

8 Spread and impact of exotic species (ToR c)

An update on ship-mediated biological invasions was reviewed by the Study Group on Ballast and other Ship Vectors (SGBOSV). Extended abstracts are available in the 2003 SGBOSV meeting report.

The significance of the impact of non-indigenous species was discussed in great detail using the case history of *Paralithodes camtschaticus, Rapana venosa* and information provided in National Reports. Details of the discussion are reflected in the Advisory Report on *Rapana venosa* (as provided last year), the Alien Species Alert Report on Red King Crab *Paralithodes camtschaticus* (see Annex 15) and in the summary of National Reports (see Section 5 above).

WGITMO expressed its concern of the finding of the American lobster *Homarus americanus* in the natural range of the European lobster *Homarus gammarus*. This species is imported alive for consumption by several ICES Member Countries (see National Reports).

Further, first records of various non-indigenous species are reported in National Reports considered at the meeting (Table 5.1.2.2 in Section 5.1.2 and Handbook of Dispersal vectors in Annex 14).

WGITMO took note of a recently (2002) published book which attempts to summarise aquatic species invasions in Europe. The geographical scope stretches from Irish waters in the west to Volga River and the Caspian Sea in the east, the Mediterranean Sea in the south and the Arctic in the north. It should be noted that not all parts of Europe could be covered, as for some regions no relevant data were known (see Table A18.1 in Annex 18). WGITMO considered the section on impacts posed by certain invaders. However, this account was believed to deliver patchy information only.

8.1 Conclusions

- First records of non-indigenous aquatic species were again reported from ICES Member Countries.

- The identification of trends is difficult to carry out on a yearly basis. WGITMO intends to include a relevant section into the summary of National Reports 1992 to 2001 (ToR f). However, in last year's WGITMO meeting report, where this information was summarized the first time, twenty new species were first recorded. In this year's report the number of new invaders is 14 (9 reported from ICES member countries, 3 from Italy, and 2 from New Zealand) (Annexes 4–6 and Handbook of Dispersal vectors in Annex 14). Please note that this summary does not intend to be fully comprehensive as not all ICES member countries made National Reports available to WGITMO. Further, previous case histories have shown that a timelag occurs when reporting new invaders. Therefore, a trend analysis cannot be drawn from these data at this stage.
- The importance of certain transport vectors is addressed in the directory of dispersal vectors (Section 12 of this report and Annex 14).

8.2 Recommendations

- It is recommended that this ToR should remain on the agenda of WGITMO.

9 Dissemination of relevant material for public information (ToR d)

WGITMO agreed that public awareness is of crucial importance to avoid species introductions and to slow down the spread of previously established non-indigenous species. This material could be made available on the Internet. The Internet-based information could be updated frequently and used to widely distribute material being developed by WGITMO. WGITMO suggests making the ICES Code of Practice and its Appendices available via the WGITMO homepage to increase awareness of the existence of the Code. It is suggested that not all contracting parties to ICES use the Code when introducing new non-indigenous species as policy makers and other relevant stakeholders are unaware of this Code. As the Code is not a legally binding instrument, awareness is believed to be crucial.

9.1 Conclusions

Using the Internet WGITMO recommends to:

- provide background information on WGITMO's history and its current activities (Annex 19);
- announce meetings of WGITMO;
- provide links to relevant supporting entities including, but not limited to other ICES groups, such as SGBOSV, WGHABD and EIFAC, PICES, CIESM, BMB, IOC, IMO's Ballast Water Working group and the GloBallast Programme;
- provide links to WGITMO meeting reports;
- make the Code of Practice and its Appendices available;
- include the Advisory Report on *Rapana venosa* on the WGITMO homepage and future reports as developed (e.g., the Alien Species Alert Report on Red King Crab *Paralithodes camtschaticus*);
- take account of the increasing activities in ornamental trade and further indicate the risks involved when releasing species, e.g., from hobby aquariums into the wild.

9.2 Recommendations

- ICES is asked to consider the establishment of a WGITMO homepage making available the above-mentioned material;

- It is recommended that this ToR should remain on the agenda of WGITMO and that relevant new material may be made available via the Internet as developed by WGITMO.

10 Interaction with PICES (ToR e)

J. Stein, Chair of PICES MEQ (Marine Environmental Quality Committee), was invited to join WGITMO as guest. He reported that the interaction with WGITMO was largely informative. The problem of dealing with biological invasions is not yet addressed by a PICES working group, although PICES WG15 on harmful algal blooms has an interest in this field as outlined by M. Taylor, the Co-Chair of this group, who joined the SGBOSV meeting in 2003.

The upcoming PICES annual meeting in Seoul, Korea, was drawn attention to. The PICES representative strongly encouraged that a member of WGITMO attend the meeting.

Several proposals regarding future interactions were made (Annex 17). A particularly attractive suggestion was expressed for a joint PICES/ICES workshop or working group on the particular problems of planned and/or accidental species introductions. It was suggested that an interaction may support the application of the Code of Practice, especially in non-ICES Member Countries. Further, interest to interact with SGBOSV was expressed. WGITMO members were invited to attend the next PICES meeting in Honolulu in 2004.

10.1 Conclusions

- The interaction with PICES is seen as essential noting that several invaders already present in ICES member countries originate from PICES Member Countries;
- Special attention may be drawn to the Pacific oyster *Crassostrea gigas,* one of the most commonly moved species for aquaculture purposes in the world;
- Mutual benefits may arise due to cooperative activities between ICES and PICES;
- Cooperating with PICES member countries may result in spreading the knowledge on the Code of Practice further.

10.2 Recommendations

- It is recommended that this ToR should remain on the agenda of WGITMO.

11 Summary of National Reports 1992 – 2001 (ToR f)

WGITMO agreed that a summary of National Reports 1992–2001 could serve as a starting point for an *ICES Cooperative Research Report (CRR)* and started to prepare relevant material (see WGITMO Report, 2002). WGITMO took the earlier summary of National Reports as a guiding document, but agreed to restructure its approach for the 1992–2001 summary.

11.1 Conclusions

- WGITMO agreed to focus on North Atlantic waters when preparing the summary report, and agreed that other regions may only be included when relevant to the North Atlantic seaboard;
- WGITMO further agreed to structure the summary report by grouping neighbouring countries. This approach is in contrast with the previous summary report where countries were listed in alphabetical order;
- Three facilitators for the intersessional activity volunteered to address certain taxonomic groups: plants: I. Wallentinus (Sweden), fish: D. Minchin (Ireland), and invertebrates: Stephan Gollasch (Germany).

11.2 Recommendations

- It was agreed by WGITMO that intersessional activities are essentially needed to address this ToR at next year's meeting.

12 Directory of Dispersal Vectors of Exotic Species (ToR g)

The Directory of Dispersal Vectors (entitled "Vector pathways and the spread of exotic species in the sea") outlines the principal vectors that are likely to result in further non-indigenous species spread including both introductions and translocations. The document intends to review the current state of knowledge concerning various vectors of species introductions, provide a brief overview of the potential risks associated with each category of vectors and identify significant knowledge gaps. Although we have a reasonable understanding of the vectors, assigning vector strengths can be difficult and largely depends on local or regional trading activities, and political and socio-economic circumstances. Not all vectors continue to operate and some become more significant at specific times.

Some vectors may transport fundamentally different sets of organisms (e.g., mussels attached to hull, species nestling within hull fouling or on fouling organisms, species burrowing into the mussel shells, and pathogens or microalgae inside the mussels). Conversely, some species may be spread by several different vectors (e.g., larval mussels may be transported in the ballast water; adult mussels as hull foulers; in intentional movements for aquaculture or as accidental aquaculture associates).

12.1 Conclusions

- The directory of dispersal vectors of exotic species was restructured and improved. The final draft report (entitled "Vector pathways and the spread of exotic species in the sea") is attached for the consideration of ICES (Annex 14).

12.2 Recommendations

- WGITMO suggests to publish the directory of dispersal vectors entitled as "Vector pathways and the spread of exotic species in the sea" in the *ICES Cooperative Research Report* series.

13 Alien Species Alert Report (ToR h)

At last year's meeting the preparation of an ICES Alien Species Alert Report on Red King Crab *Paralithodes camtschaticus* was recommended. Experts in this field were invited: Lis Jörgensen and Jan Sundet (Norway) as well as Igor Manushin (Russia). These experts prepared, with the help of WGITMO, a draft Alien Species Alert Report on the Red King Crab *Paralithodes camtschaticus* intersessionally. This draft was considered and approved by WGITMO with minor additions on the last day of the meeting. The group wishes to express sincere thanks to all three experts who worked long hours during evenings and early mornings.

The lobster *Homarus americanus* was considered by WGITMO as a new candidate species for a future Alien Species Alert Report. It is questionable whether or not this species is established in European ICES member countries. However, several records were reported in previous years. The Alien Species Alert Report may be used to create awareness, i.e., not to release American lobsters in European waters. WGITMO has the hope that an establishment of this species in European ICES member countries may be avoided by taking appropriate measures. The Alien Species Alert Report may be used as public awareness material to avoid future releases of *Homarus americanus* and thereby reduce the risk of establishment of this species in European waters.

13.1 Conclusions

- ICES is invited to consider the publication of an Alien Species Alert Report on the Red King Crab *Paralithodes camtschaticus* as a printed document in the *ICES Cooperative Research Report* series.
- ICES is further asked to make this report available via the Internet.

13.2 Recommendations

- The draft Alien Species Alert Report on Red King Crab *Paralithodes camtschaticus* (attached as Annex 15), will be finalised at next year's meeting;
- It is recommended that this ToR remain on the agenda of WGITMO as new invaders are likely to occur in ICES member countries in the future;
- WGITMO suggests to consider the American lobster *Homarus americanus* as a candidate species for another Alien Species Alert Report.

14 Recommendations to ICES Council

The recommendations from this year's meeting to the ICES Council were discussed in detail, approved by WGITMO and are provided in Annex 20 of this report.

15 Adjournment of the meeting

Recommendations from the 2003 meeting of WGITMO were discussed in detail and approved shortly before adjournment of the meeting on Friday March 28. Italy invites WGITMO to hold its 2004 meeting in Cesenatico and the suggested meeting dates are 24–26 March 2004.

Stephan Gollasch, as Chair, thanked all WGITMO members, guests and observers for their dedicated work, including the intersessional activity, and further thanked the Department of Fisheries and Oceans (DFO), Canada for hosting the 2003 WGITMO meeting, especially the host Dorothee Kieser (DFO) as well as all other helping hands that worked very hard during the meeting and spent endless hours to prepare the meeting. He also extended his most sincere gratitude and thanks to the rapporteur, Dorothee Kieser (Canada) who did a magnificent job of keeping the meeting and Chair organized, with the especially challenging task of collecting all contributions to the meeting report.

16 Annexes

Annex 1 Agenda

Vancouver, Canada 2003, March 26–28

25th Anniversary Meeting

Previous WGITMO Meetings

1970–1973 London

Reconvening WGITMO Meetings

1 1979 Conwy, Wales
2 1980 Nantes, France
3 1981 Sete, France
4 1982 La Coruna, Spain
5 1983 Bergen, Norway
6 1984 Halifax, Canada
7 1985 Gothenburg, Sweden
8 1986 Gdynia, Poland
9 1987 Brest, France
10 1988 Edinburgh, Scotland
11 1989 Dublin, Ireland
12 1990 Halifax, Canada
13 1991 Helsinki, Finland
14 1992 Lisbon, Portugal
15 1993 Aberdeen, Scotland
16 1994 Mystic, USA
17 1995 Kiel, Germany
18 1996 Gdynia, Poland
19 1997 La Tremblade, France
20 1998 The Hague, Netherlands
21 1999 Conwy, Wales
22 2000 Parnu, Estonia
23 2001 Barcelona, Spain
24 2002 Gothenburg, Sweden
25 2003 Vancouver, Canada

Wednesday, March 26th

9.00 am

- Welcoming remarks and housekeeping issues
- Review of the Terms of Reference
- Adoption of the Agenda
- Errata of 2002 WGITMO Meeting Report
- 25 WGITMO A brief review on key activities (H. Rosenthal, Germany)
- Rosenthal's Literature Database on Aquaculture and Invasive Species. A Guide to its Use (H. Rosenthal, Germany).
- Potential for ICES/PICES Collaboration (J. Stein, USA) **(ToR e)**

10.45 am – 11.15 am Coffee break

- National Reports, Highlights **(ToR a)**
  Special emphasis on annual updates on the spread exotic species during your oral introduction of the National Report **(ToR c)**
  Belgium
  Canada
  Estonia
  Finland
  France
  Germany
  Ireland

1.00 pm – 2.30 pm Lunch

- National Reports, Highlights **(ToR a)** (continued)
  Italy
  New Zealand
  Norway
  Sweden
  United Kingdom
  USA
- *Rapana* Report to be published as CRR, update needed?
- New CRR on Red King Crab? (L. Jörgensen, J. Sundet, Norway) **(ToR h)**
- Invasion databases – what role ICES may play (G. Ruiz, USA).
- Code of Practice (CoP)
  ICES feedback
  New/update definitions
- Introductions of North American Sturgeons for restocking purposes in Europe. Comments on the possible application of the ICES CoP (J. Gessner, Germany)

4.00 pm – 4.30 pm Coffee Break

- Review of Code of Practice Appendices **(ToR b)**
- Distribution of draft material for Vector Handbook **(ToR g)**
- Guidance on the preparation of draft material for National Report Summary 1992 to 2001 **(ToR f)**

6.00 pm Adjourn of day 1

Thursday, March 27th

8.30 am

- Code of Practice Appendices **(ToR b)**
  Drafting session

10.45 am – 11.15 am Coffee break

- Consideration of draft material for Vector Handbook **(ToR g)**
  Group Discussion
- Consideration of draft material for National Report Summary 1992 to 2001 **(ToR f)**
  Group Discussion

1.00 pm – 2.15 pm Lunch

- Code of Practice Appendices **(ToR b)**
  Results of morning drafting session

4.00 pm – 4.30 pm Coffee Break

- Drafting session (continued)

6.00 pm Adjourn of day 2

Friday, March 28th

8.00 am

- Results of drafting sessions
  Group Discussion
- Compilation of agencies, universities, and institutions to announce the CoP

10.45 am – 11.15 am Coffee break

- Material to be included in the WGITMO homepage **(ToR d)**
- Final discussion on Code of Practice Appendices
- WGITMO Recommendations
- Concluding Remarks
- Planning of next meeting

1.00 pm Adjournment of the 25th Meeting of WGITMO

Annex 2 List of participants

Group photo of WGITMO 2003 participants.

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Annex 3 Terms of Reference

2ACME06 The Working Group on Introductions and Transfers of Marine Organisms [WGITMO] (Chair S. Gollasch, Germany) will meet in Vancouver, Canada from 26–28 March 2003 to:

a) collect and provide a synthesis and evaluation of National Reports;

b) review, edit and finalise the Appendices in the form of Technical Guidance Notes for the Code of Practice on Introductions and Transfers of Non-indigenous Marine Organisms;

c) provide a synthesis and evaluation of annual updates on the spread and impact of exotic species, including information from countries that are not members of ICES;

d) continue the development of a proposal for the dissemination of relevant material for public information via the ICES website, with special emphasis on the Code of Practice Appendices;

e) meet with the North Pacific Marine Science Organization (PICES);

f) continue work on the Summary of National Reports 1992 to 2001 for ultimate publication as a CD-ROM together with the annual reports during the period covered;

g) finalise the *ICES Cooperative Research Report* on the "Directory of Dispersal Vectors of Exotic Species";

h) collect information on impacts which intentional introductions may have on the receiving environment (e.g., Red King Crab in Norway) with the option to consider such species for an "Alien Species Alert" report.

Annex 4 National Reports (ICES Member Countries)

BELGIUM, 2002

(Prepared by Francis Kerckhof)

1.0 Laws and regulations

There is no new legislation to report.

2.0 Deliberate releases

2.1 Fish

Restocking by the Sea Fisheries Department (CLO-SFD, Oostende, Belgium) of turbot (*Scophthalmus rhombus),* off-spring from fish from the French Atlantic coast, and sole (*Solea solea)* continues. Only two hundred individuals of each species were released in 2002, but the prospects for 2003 are better.

A private company in Turnhout cultivates sturgeons, mainly with the aim to produce caviar. Therefore the Siberian species *Acipenser baeiri* is used. In 2002 the first results, 150 kg of so called "Royal Belgian Caviar", have been successfully commercialised. Experiments with *A. gueldenstaedti,* also for the production of caviar, are ongoing. Two other species, *A. stellatus* and albino *A. ruthenus,* are elevated as ornamental species. Finally there are experiments ongoing with the American "shovelnose" *Scaphirhynchus platorynchus* from the Mississippi basin.

3.0 Accidental Introductions and transfers

Several non-indigenous species like *Crassostrea gigas*, *Ensis directus*, *Crepidula fornicata*, *Elminius modestus* constitute now an important, and in some cases even a dominant, part of the Belgian marine fauna. 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.

3.2 Invertebrates

Mytilopsis leucophaeata (*=Congeria cochleata*): present in the harbour of Antwerp, causing nuisance by the obstruction of water intake pipes of some chemical plants. After an alteration in the water influx resulting in a salinity drop, *Dreissena* has replaced *Mytilopsis*. *Cordylophora caspia,* a ponto-caspian hydroid of brackish water, is another species that causes nuisances at the same locations. A study is ongoing at the University of Gent, with the aim to find a possible biological control of the problems caused by these species.

Callinectes sapidus: an adult male was fished in November 2002 off Oostende.

Caprella mutica: first recorded in 1998. Present on several buoys marking the entrance to the harbour of Zeebrugge. Also recorded from the marina of Zeebrugge. On these locations the species is still present. In April 2002 specimens of *C. mutica* were present on a buoy lying in the entrance to the harbour of Oostende, indicating a spreading, possibly due to shipping (fouling) – *Caprella* has no free-living larvae – between the harbours of Oostende and Zeebrugge.

Ficopomatus enigmaticus: this species was in 2002 more abundant in the harbour of Oostende, forming reef like structures on several submerged substrates.

Megabalanus tintinnabulum: this cosmopolitan barnacle was recorded in 1998 for the first time autochthonous in the southern North Sea, on buoys off the Belgian coast (Kerckhof and Cattrijsse, 2002). As in previous years, also in 2003 specimens have been found in low numbers on buoys off the Belgian coast.

Megabalanus coccopoma: This species proved to be already present on buoys off the Dutch coast in 1976 and 1977 but was apparently not properly recognised. During a survey of 56 buoys off the Belgian coast between 1997 and 1999 (Kerckhof and Cattrijsse, 2002) this species was found on several occasions. Also in 2003 specimens of

M. coccopoma were present on a buoy off the Belgian coast. *M. coccopoma* is originally described from the Central American Pacific coast by Darwin in 1854. Apparently it is spreading into other regions e.g. Brasil. However, the Indopacific species, *M. rosa*, described in 1917 by Pilsbry, might be in fact the same species. Studies are ongoing to investigate the true identity of *M. rosa*. If *M. rosa* is proved to be a junior synonym of *M. coccopoma*, this would put another light on the origin and spreading of *M. coccopoma*. Thus an Indopacific origin of the species – and of the North Sea specimens – might be possible.

Tricellaria inopinata: this species was first observed in 2000, in the marinas of Oostende and Blankenberge. During 2001 it has not been observed anymore on these locations, but it was present in the marina of Zeebrugge. All these observations concerned rather isolated specimens on pontoons. But in November 2002 many colonies were present on the hull of a yacht that lay in the marina of Nieuwpoort. Thus after the first observations in Belgium this species is still present and apparently also spreading. Rather surprisingly this species was found in September 2001 on several objects and on a branch of *Fucucs vesiculosus*, stranded on the Belgian coast, together with other species of southern origin (De Blauwe, 2003). This could be a further indication of the establishment and spreading of this species in the Channel region.

Hemigrapsus spec.: although sought after, this species is not recorded yet from Belgium.

3.3 Algae and higher plants

Sargassum muticum, Codium fragile subspecies *tomentosoides:* After a presence for some years in the Spuikom of Oostende, there have been no records any more of either species since 2002. This is probably due to changes in the water regime of the pond.

Undaria pinnatifida: After the first record in 2000, this species is still present in de marina of Zeebrugge, but apparently not spreading.

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.

8.0 Bibliography

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CANADA, 2002

(Prepared by: Dorothee Kieser)

1.0 Laws and regulations

In previous years we reported on the development and completion of the National Code on Introductions and Transfers of Aquatic Organisms. The Code is now in its 18-month review period. The topic of intentional introductions for stock rebuilding will be incorporated into the Code.

Under Canada's biodiversity strategy, a National Aquatic Invasive Species Plan is being developed by Environment Canada together with the Canadian Council of Fisheries and Aquaculture Ministers to address the threat of aquatic invasive species and the movement of species within Canada and internationally. It will include aquatic vertebrates, invertebrates and plants. It will contribute to the national initiative to reduce introductions through ballast water and sediments.

2.0 Deliberate releases and planned introductions

Planned Introductions of Finfish and Shellfish

All regions expect the pattern of importations to remain similar to previous years.

In addition, there is a growing interest in the importation of Mitten crab (*Eriocheir sinensis*) for human consumption. To date they are prohibited from importation under Canada's Food Inspection Agency Regulations.

2.1 Finfish

Pacific Region

Under the Canada-US Transboundary agreement, 4.7 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.

Illegal introductions of lobsters (likely *Homarus americanus*) led to the finding of a large specimen in Vancouver Harbour. This species was outplanted intentionally in a BC inlet several decades ago, but did not become established.

2.2 Invertebrates

Pacific Region

As in previous years, the BC shellfish industry imported seed for the main culture species: *Tapes philippinarum*, *Crassostrea gigas*, *C. sikamea* and *Mytilus galloprovincialis* and *M. edulis* for aquaculture. These molluscs are primarily used for beach seeding and grow-out on open water structures. All imports originate from health certified facilities.

Atlantic Region

Limited activities are undertaken by private and provincial (NB, PEI) shellfish hatcheries with Giant sea scallops, *Placopecten magellanicus,* (enhancement), European Oysters, *Ostrea edulis*, (aquaculture), American (Eastern) Oysters, *Crassostrea virginica,* (aquaculture), Soft-shell clams, *Mya arenaria,* and Hard-shell clams, *Mercenaria mercenaria*, (enhancement and aquaculture), Bay Scallops, *Argopecten irradians,* (aquaculture), Surf Clam, *Spisula solidissima,* (aquaculture). Samples of broodstock and seed usually screened for inter-provincial relay, and in some cases for intra-provincial relay.

3.0 Accidental introductions and transfers

3.1 Fish

Pacific Region

Atlantic salmon continue to be introduced into British Columbia as a result of escapes from aquaculture facilities. In 2002, a total of 9282 Atlantic salmon were reported to have escaped in BC. Juvenile Atlantic salmon were first discovered in BC in 1996, since then a total of 367 juveniles have been observed or captured in twelve different river or lake systems. The majority of the discoveries are assumed to be escapees from adjacent hatcheries and lake-pen rearing sites. However in 1998, twelve juvenile Atlantic salmon were recovered from the Tsitika River on the North-east coast of Vancouver Island which appeared to be feral. These fish were subjected to otolith microstructure analysis using a double-blind test structure and were found proven to be of wild origin. These are the only fish to be tested in this fashion. Subsequent surveys in 1999, by BC Ministry of Environment, Lands, and Parks (MELP), discovered populations of juvenile Atlantic salmon that are believed to be feral in the Adam River and Amor de Cosmos Cr. In 2000 MELP, Fisheries and Oceans Canada and BC Ministry of Fisheries conducted an extensive survey for Atlantic salmon in BC. During the course of the survey, eight juvenile Atlantic salmon were observed in the Amor de Cosmos Creek and three in the Tsitika River. In 2001 and 2002 Fisheries and Oceans Canada partnered with coastal First Nations to mount the most extensive survey for Atlantic salmon in freshwater ever in BC. No juvenile Atlantic salmon were discovered during those surveys. Even with the dramatically increased survey effort of the last three years, the counts of adult Atlantic salmon in freshwater have declined from 131 in 2000 to 40 in 2002. Further indication that the abundance of Atlantic salmon in BC is more likely related to the number which escape rather than those produced by natural propagation.

3.2 Invertebrates

Pacific Region

A single male green crab (*Carcinus maenas*) was found during 2002 at the same latitude as earlier findings. Judging from the size of the animal, it may have come from the1997–1998 cohort.

Varnish clams (*Nuttalia obscurata*) have expanded their range. If this species proves to be cold tolerant, it may become widespread on BC's Central Coast. There is now a small, successful commercial fishery for the species.

No additional information is available on the mussel, *Musculista senhousia.*

Atlantic Region

Club Tunicate (*Styela clava*): The club tunicate is indigenous to Asia and was introduced to the Pacific coast of North America in the early 1920s. It was first reported in Georgetown Harbour, PEI, in 1999. The tunicate has since spread to the Montague River, Brudenell River, St. Mary's Bay, Murray River, Malpeque Bay and the Orwell/Vernon area - all major mussel production areas of PEI. The initial introduction is believed to have occurred with commercial ship movements in Georgetown Harbour. Subsequent spread may have been through natural dispersion, fouling of fisheries gear, leisure boating and aquaculture activities. To reduce the further spread of this exotic tunicate, transfers of all shellfish from affected areas have been restricted through the Introductions and Transfers Committee process. The tunicate is causing serious economic losses to the mussel production industry of PEI and, if uncontrolled, has the potential to spread and significantly impact biodiversity and mussel production throughout the southern Gulf of St. Lawrence. Since the time it was introduced it has spread to several economically significant mussel production areas of PEI, including St. Mary's Bay, Murray River and Malpeque Bay. The club tunicate reduces mussel productivity and increases costs associated with defouling on site, as well as at the processing plant. The tunicate also impedes seed collection and relay for grow out, as well as transfers for open-effluent processing. Another impact is the seasonal die-off of the tunicates and associated environmental degradation.

Golden Star Tunicate (*Botryllus schlosseri*): This colonial tunicate was first identified from St. Peters Bay, PEI in 2001. This was a new finding for the Gulf of St. Lawrence, as the most northern finding previously reported was the Bay of Fundy. There were only very small numbers of the tunicate seen and small numbers were reported from St. Peters Bay again in 2002.

Ciona intestinalis: This tunicate from Northern Europe has been in North American since at least the early 1900s. *Ciona* has become a problem in the Yarmouth, NS area. As with *Styela clava*, it is a solitary tunicate that occurs in great clumps on ropes, floats, mussel socks - basically everything related aquaculture. Transfer is mainly as an encrusting organism.

***Codium fragile* and Green crab:** Please see Attachments 1 and 2.

MSX: The first outbreak of MSX disease, caused by the parasite, *Haplosporidium nelsoni*, was confirmed in Cape Breton oysters in October 2002. Because it is an OIE-listed disease, the finding was reported to the world body immediately. Contingency plans were developed to minimize the spread of the parasite and are being refined as new information becomes available. Movements of oysters and, where of concern, other shellfish such as mussels, have been restricted.

The initial source of the infections has not yet been determined. It could have originated from ballast water, illegal shipment of oysters from infected areas, via pleasure craft, or other vectors.

Currently the disease is limited to a small area in the Bras d'Or Lakes in Cape Breton.

SSO: During surveys for MSX a second Haplosporidian was detected in the Maritimes. SSO caused by *Haplosporidium costale* was found in 4 sites in PEI and 1 site on the Gulf coast of NS. No mortalities have been associated with these findings.

4.0 Live imports

4.1 Finfish

Pacific Region

The following freshwater species were imported: White sturgeon (*Acipenser transmontanus*) for stock enhancement in the Columbia River drainage, Tilapia (*Oreochromis niloticus*) for aquaculture and for human consumption, and Rainbow trout (*Oncorhynchus mykiss*) for bioassays.

Atlantic Region

Imports of Vertebrates and Invertebrates

Common Name	Genus and species	Exporting Country
Rainbow trout	*Oncorhynchus mykiss*	USA (various sources)
Atlantic salmon	*Salmo salar*	USA (Washington State)
Moon jellyfish	*Aurelia autira*	USA (Massachusetts)
Stimpson Surf Clam	*Mactromeris polynyma*	USA (Alaska)
Cuttlefish	*Sepia officinalis*	USA (Massachusetts, Texas)
Red Abalone	*Haliotis rufescens*	Iceland
Sea Scallop	*Placopecten magellanicus*	USA (Massachusetts)

As well, the following inter- and intra-provincial transfers took place:

Common Name	Genus and species
Haddock	*Melanogrammus aeglefinus*
Halibut	*Hippoglossus hippoglossus*
Cod	*Gadus morhua*
Atlantic wolffish	*Anarhicas lupus*
Winter flounder	*Pseudopleuronectes americanus*
Arctic Charr	*Salvelinus alpinus*
Brook trout	*Salvelinus fontinalis*
Rainbow trout	*Oncorhynchus mykiss*
Atlantic salmon	*Salmo salar*
Speckled trout	*Salvelinus fontinalis*
Brown trout	*Salmo trutta*
Striped bass	*Morone saxatilis*

4.2 Invertebrates

Pacific Region

In addition to the entry above, 1 male green crab was imported from the West Coast of the USA into a research quarantine unit. Tunicates (unknown species) were also imported for research.

Atlantic Region

The following importations and transfers took place:

Common Name	Genus and species
American oysters	*Crassostrea virginica*
European oyster	*Ostrea edulis*
Blue mussels	*Mytilus edulis*
Quahog	*Mercenaria mercenaria*
Sea scallop	*Placopecten magellanicus*
American lobster	*Homarus americanus*
Green sea urchin	*Strongylocentrotus drobachiensis*
Sea urchin	*Strongylocentrotus purpuratus*

5.0 Live exports to other countries

Pacific Region

Vertebrates

Aquaculture use:

Arctic charr eggs were exported from the Yukon to China, France, Italy, Austria and the USA.

Aquarium use:

Common Name	Genus and species	Importing Country
Kelp greenling	*Hexogrammus decagrammus*	France
Striped perch	*Embiotica lateralis*	France
Pile perch	*Rhachochilus vacca*	France
Kelp perch	*Brachyistius frenatus*	France
Copper rockfish	*Sebastes caurinus*	France
Painted greenling	*Oxylebius pictus*	France
White-spotted greenling	*Hexagrammos stelleri*	France
Red Irish Lord	*Hemilepidotus hemilepidotus*	France
Tiger rockfish	*Sebastes nigrocinctus*	Holland, France
Black rockfish	*Sebastes melanops*	Holland, France
Wolf eel	*Anarrichthys ocellatus*	Holland, France
Ratfish	*Hydrolagus collei*	France

Invertebrates

Aquarium use:

Common Name	Genus and species	Importing Country
Pink star	*Pisaster brevispinus*	France
Rose star	*Crossaster papposus*	France
Rainbow star	*Orthasteria koehleri*	France
Plumose anemone	*Metridium senile*	France
Giant Green surf anemone	*Anthopleura xanthogrammica*	Holland, France
Fish-eating anemone	*Urticina piscivora*	Holland, France
Crimson anemones	*Cribrinopsis fernaldi*	Holland, France
Strawberry anemone	*Corynactis californica*	Holland, France
Batstar	*Asterina miniata*	Holland, France
Sunflower star	*Pycnopodia helianthoides*	Holland, France, Portugal
Pisaster star	*Pisaster ochraceus*	Holland, France
Spiny star	*Hippasteria spinosa*	Holland, France
Cookie star	*Ceramaster patagonicus*	Holland, France
Northern Kelp crab	*Pugettia producta*	Holland, France
Hermit crab	*Paguridae* sp.	Holland, France
Lined chiton	*Tonicella lineata*	Holland, France
Hairy chiton	*Fusitriton oregonensis*	Holland, France
Swimming anemone	*Stophia didernon*	Holland, France
Rocks with mixed benthos		Holland, France
Giant Pacific octopus	*Enteroctopus dofleini*	Portugal, Kuwait

Atlantic Region

Vertebrates

Aquaculture use:

Common Name	Genus and species	Importing Country
Atlantic salmon	*Salmo salar*	USA
Brook trout	*Salvelinus fontinalis*	USA, Germany, France
Rainbow trout	*Oncorhynchus mykiss*	USA
Arctic charr	*Salvelinus alpinus*	USA, Germany, France, Poland
Brook trout X Arctic charr	hybrid	Germany

Attachment 1 to Canadian National Report 2002

Codium fragile* (Suringar) Hariot, 1889 ssp. *tomentosoides

Native range: Japan

Introduced range: Europe, both coasts of North America, Australia, and New Zealand. The first record in eastern North America was near New York in 1957.

Habitat: Attached to hard substrate, shells, lines, floats, other plants or macroalgae, usually in waters < 15 m deep. *Codium* has a wide salinity (17 to 40 ppt) and water temperature (–2 to 27.5° C) tolerance. It spreads by fragmentation (drift), parthenogenetic "swimmers", and as a hitchhiker during shellfish transfers, on hulls of boats, fishing gear, etc. The subspecies frequently occurs in sheltered habitats in close proximity to vectors of transport (e.g., harbors, aquaculture facilities), so its potential for human-mediated transport is likely higher than that of species living on wave-exposed shores. Ballast water transfer is not a prominent vector for gametes but could spread fragments of plants.

History in Atlantic Canada: *Codium* has a patchy distribution. It was first identified in Atlantic Canada at Graves Shoal, Mahone Bay, Lunenburg County, NS, in December 1991, and was widely distributed throughout Mahone Bay and eastward as far as Prospect Bay in Halifax County. There has been limited northward dispersal along the Atlantic shore of Nova Scotia - *Codium* has not spread north of Halifax, ~40 km from its first point of introduction in Atlantic Canada. Large populations occur in Mahone Bay, St. Margaret's Bay and at Cape Sable Island. *Codium* has not been seen in the Bay of Fundy except for a population in St. Mary's Bay, in southwestern Nova Scotia. In the Gulf of Maine, where *Codium* is abundant and widespread, no attached plants have been found north of Chamberlain, ME.

Codium has, however, spread extensively and rapidly throughout the southern Gulf of St. Lawrence, following its discovery in Caribou Harbor, NS, in August 1996, in shallow (1 m) waters associated with a former oyster lease. Rooted plants were detected at an oyster aquaculture site in Lennox Channel, Malpeque Bay, PEI, in December 1996. Currently, it is extensively but patchily distributed throughout the southern Gulf of St. Lawrence. Rooted populations occur on the mainland between Caribou and Shippagan, NB, as well as on locations at either end of Prince Edward Island. It has not been reported from the Magdalen Islands, northern Gulf of St. Lawrence, or insular Newfoundland.

Documented effects: The documented effects of *Codium* in Atlantic Canada differ between the southern Gulf of St. Lawrence and the Atlantic coast. In the southern Gulf of St. Lawrence, much of the concern has been associated with its effect as a fouling organism on aquaculture and wild fisheries for bivalves, especially American oysters. Oyster collection by hand tonging was very difficult when *Codium* was present, oysters are being washed ashore because of the buoyancy of attached *Codium*, and even reports of irritation of the hands and eyes of growers handling mussel lines overgrown by *Codium*. The common practice in PEI of cutting *Codium* from the shells and tossing it back into the water during oyster harvest and cleaning promotes dispersal, as does moving oysters to different bays for depuration. An additional concern in the southern Gulf of St. Lawrence is where *Codium* attaches to eelgrass, *Zostera marina.* Fast-growing *Codium* traps gases, pulls up the whole eelgrass plant, which is then cast up on the shore and may die. Recent observations suggest that damage to eelgrass by green crab, *Carcinus maenas*, creates gaps in eelgrass beds that are subsequently colonized by *Codium.*

Off southeastern Nova Scotia, *Codium* has spread rapidly to become a dominant and persistent component of seaweed assemblages in the rocky low intertidal to subtidal zones, often replacing entire kelp beds to a depth of 15 m. *Codium* is an unattractive, unpalatable, and poor quality food for green sea urchin. Green sea urchin is commercially fished off southeastern Nova Scotia and they exhibited no gonad development when fed a *Codium* diet. In the Gulf of Maine, *Codium* has replaced *Laminaria* as the principal canopy component; in response, *Laminaria* appears to be shifting its center of abundance below the *Codium* zone. There is no evidence that grazers control *Codium* anywhere in its range. A large contribution of *Codium* tissue to the detrital food chain may occur in winter; assuming that decomposing thalli are not toxic to detritivores.

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Attachment 2 (to Canadian National Report 2002)

***Carcinus maenas* (Linnaeus, 1758) – Green crab**
Synonym: *Carcinides maenas*

Native range: Eastern Atlantic coast from Norway to Mauritania.

Introduced range: both coasts of North America, and South Africa, Australia, and Japan. It was first reported in eastern North America in 1817.

Habitat: Outside of southern Gulf of Saint Lawrence (sGSL), wide range of nearshore habitats along the western Atlantic Coast from rocky intertidal to subtidal > 10 m depths. In sGSL, current habitat selection resembles preferred habitat type of native range; i.e., upper reaches of marine bays and estuaries and brackish embayments (especially in beds of the eelgrass *Zostera* or macroalgae). Green crab's use of the substantial flats in the middle and outer estuaries and along exposed coastline in the sGSL is not high (so far).

History in Atlantic Canada: The first report in Canadian waters was from Passamaquoddy Bay in July 1951 where it quickly colonized the Bay of Fundy. In 1954, a specimen was found at Wedgeport, NS, the first Canadian sighting outside the Bay of Fundy. The spread of green crabs along the Atlantic coast of Nova Scotia was not well documented but they were first observed in St. Georges Bay in the eastern end of the southern Gulf of St. Lawrence in 1995. The first report in PEI, in the early fall of 1998, was described as a "heavy concentration" in some bays at the eastern end of the Island. The rate of dispersal has been rapid, with range expansions exceeding 100 km/yr. In 2000, green crabs were found in Hillsborough River. An isolated green crab sighting in Malpeque Bay, PEI, in November 2000, apparently has not resulted in establishment of a viable population. Green crab continue to spread in the sGSL; in 2002, the distribution on the mainland expanded to Port Elgin, NB, and Victoria, PEI, – both sites are about mid-way up Northumberland Strait. So far, green crab has not colonized the Magdalen Islands.

Documented effects: Based on its ecology elsewhere in its range, the green crab is predicted to have a major effect, as an ecosystem engineer, on communities of the southern Gulf of St. Lawrence. Preliminary results from 24 estuaries of the sGSL during the summer of 2001 indicate a significant reduction in the species richness of nearshore fish communities, and in the biomass of eelgrass, in estuaries with green crabs. It is an efficient burrower and, where there are numerous feeding pits, clam production has declined. Indeed, green crabs were implicated as a major factor in the collapse of the soft-shell clam (*Mya arenaria*) industry in Maine during the 1950s.

Green crab is an effective shallow-water predator. Green crab prey on at least 158 genera in 19 phyla. Reduced densities of total invertebrate prey have been reported in the presence of green crab; however, molluscs are a preferred prey. In the intertidal zone, bivalves such as *Mya arenaria* and *Mytilus edulis* were the most important food item – algae, gastropods and crustaceans were of lesser importance. Feeding experiments have demonstrated that green crab will also feed on young oysters and quahogs. Thus, as a predator, green crab clearly can have a strong negative effect on mollusc populations, especially those used in bivalve aquaculture. However, suspension culture of blue mussels (and other species) largely eliminates green crab predation. New techniques will be needed for bottom culture or attempts to enhance populations of burying bivalves (e.g., soft-shell clams and quahogs) will have to be abandoned.

In the field, <u>Cancer</u> crab remains have been found in some green crab stomachs; however, there is no evidence of predation on lobster. Based on laboratory studies, large green crab were able to feed on very small lobsters but only if no cover was present. The many similarities in diet among green crabs, rock crabs and lobsters indicate that, in food-limiting situations, these species could compete for food types such as bivalves, gastropods, polychaetes and crustaceans. Adult lobsters and rock crabs prey on all sizes, including adult, green crabs, and all sizes of green crabs are particularly vulnerable to predation and cannibalism when molting. Thus green crab can become an important prey species when it naturalizes in a location.

<u>Indirect nuisance effects</u>: In recent years, there have been several complaints that green crab interfere with the commercial eel trapnet fishery on PEI (crabs fill the nets). In Maine and, more recently, in Bay of Fundy, lobster fishermen complained that the crabs were filling their near-shore pots and eating the bait.

<u>Positive effects</u>: In southern Europe, there is a commercial fishery – up to 900 tonnes/year harvested in France, Portugal and Spain. Indeed there is evidence that green crab populations in Portugal actually have declined due to overfishing. In response to the appearance of green crab in PEI, a small number of nuisance control permits have issued to provide green crabs for use in developing cost-effective meat extraction techniques.

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ESTONIA, 2002

(Prepared by Henn Ojaveer and Jonne Kotta, Estonian Marine Institute, University of Tartu)

1.0 Laws and regulations

New "*Nature conservation act"* has been prepared and should be submitted for approval to the Parliament in 2003. In this act, alien species are considered under the paragraph 51 in seven points as follows:

§ 51 Re-introduction and Taking from the Wild

(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 environmental authority of a county of the Ministry of the Environment in agreement with the landowner or possessor.

(4) 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.

(5) Animals of a native species and captive-bred specimen of an alien species can be re-inhabited into a place, where animals are taken for re-inhabiting and with the permission of the environmental authority of re-inhabiting.

(6) Re-inhabiting of alien species that endanger the natural balance on islands and to other isolated ecosystems for breeding in artificial conditions is prohibited.

(7) 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 45.

2.0 Deliberate releases

Official data for 2001

Salmon (*Salmo salar*)	in total 278, 829, including:
	0-group individuals 60, 886
	1-year old fish 184, 173
	2-year old individuals 33, 770
Whitefish (*Coregonus lavaretus*)	0-group individuals 142, 100
Sea trout (*Salmo trutta trutta*)	0-group individuals 50, 800
	2-year old fish 32, 800
Pike (*Esox lucius*)	ca 1 million at larval stage

Preliminary data for 2002

Salmon (*Salmo salar*)	in total 230, 000
Whitefish (*Coregonus lavaretus*)	0-group individuals 172, 000
Sea trout (*Salmo trutta trutta*)	0-group individuals 30, 000
	2-year old fish 40, 000
Pike (*Esox lucius*)	ca 2 million at larval stage.
Pikeperch (*Stizostedion lucioperca*)	0-group individuals 12, 000

3.0 Accidental introductions and transfers

In 2002, two new alien fish species were found in Estonian waters.

The bighead carp ***Hypophthalmichthys nobilis*** (Richardson, 1845) (Cyprinidae, Pisces). The species is native to lowland rivers of the north China plain and south China. One individual (male, Tl 63 cm, Tw 3.7 kg) was found in Pärnu Bay, the NE part of the Gulf of Riga in September, 2002. The species has been imported to Latvia in the 1960s or later and until now, two other recorded findings from the Gulf of Riga (near river mouths of Salaca and Daugava) are known. The probable vector for invasion is migration from neighbouring areas/countries (e.g., Latvia?).

The round goby ***Neogobius melanostomus*** Pallas 1811 (Gobiidae, Pisces). The species is native to the Ponto-Caspian region and invaded the Baltic Sea in the early 1990s. One individual (male, Tw 85 g, Tl 18 cm) of the species was found by commercial fishermen in Pärnu Bay, the NE part of the Gulf of Riga in April, 2002. The likely vector is migration as the species has also been found in Lithuanian waters (S. Olenin, pers. comm.).

3.2 Invertebrates

The hydromedusae ***Maeotias marginata***, native to the Ponto-Caspian region, was first found in Estonian waters (Väinameri Archipelago, western Estonia) in 1999. Presence of the species was confirmed in this region also in 2002: two specimens were caught in one sampling site (A. Põllumäe, pers. comm.).

Density of the ***Cercopagis pengoi*** population has increased exponentially in the NE part of the Gulf of Riga during the first ten years of invasion (1992–2001). Presence of *Cercopagis* in the plankton community tended to last longer over the years by shifting its population development to earlier time. Significant correlations between phytoplankton and zooplankton densities were broken after the invasion of *Cercopagis* since when the zooplankton community is likely to be regulated by the introduced species rather than phytoplankton dynamics, both at multi-annual and seasonal scales. For instance, the annual mean abundance of *Bosmina* was significantly lower and development of copepod *nauplii* (the main food of fish larvae) has substantially changed during the seasonal course after the invasion of *Cercopagis*. Negative relationship between the density of zooplankton and herring larvae developed after the invasion of *Cercopagis*. This suggests that the major shift in zooplankton community resulted in the food reduction for herring larvae, but potentially also for larvae of other commercial fish species. Consumption of *Cercopagis* by herring, *Clupea harengus membras*, and smelt, *Osmerus eperlanus*, increased with increasing of fish size suggesting that *Cercopagis* redirects energy from larval and smaller fish to larger fish. Although the size specific consumption of *Cercopagis* was not found for the second abundant pelagic (non-commercial) fish - sticklebacks, *Gasterosteus aculeatus* and *Pungitius pungitius*, these species likely face competition with the alien predatory cladoceran for the same food resource – *Bosmina* in the warmest months. The results indicate that the introduction of an effective intermediate predator has repercussions in the whole pelagic food web (Kotta *et al.,* 2003, Ojaveer *et al.,* submitted).

Since 1985 the spionid polychaete ***Marenzelleria viridis*** has invaded large parts of the Baltic Sea. In deeper soft-bottom habitats (>10 m) a marked long-term decrease of the native amphipod *Monoporeia affinis* has been noted and is presently associated with the establishment of the polychaete. One plausible explanation is that the polychaetes and the amphipods are competing for food resources as both are deposit feeding animals and likely to share similar food resources. Interspecific competition for food between the polychaete and the amphipod was studied in a laboratory experiment. It was concluded that lower amphipod growth in the presence of *M. viridis* was caused by competition for food and is likely to affect the population of *M. affinis* in deep soft bottom habitats of the northern Baltic Sea (Kotta and Olafsson, 2003).

Grazing rates of ***Dreissena polymorpha*** were estimated in the Gulf of Riga during May and July 1996. It was concluded that the populations of benthic suspension feeders in the littoral zone of the Gulf of Riga constitute an important sink for primary production, especially during summer (Kotta and Møhlenberg, 2002).

3.3 Benthic macrovegetation

In the Baltic Sea the species number, distribution area and biomass of the charophytes have significantly reduced in the recent decades. Although eutrophication triggers their initial decline, the mechanism of the final extinction of the charophyte population is not fully understood. In situ experiment was performed to study the role of the mesoherbivores *Idotea baltica*, *Gammarus oceanicus* and *Palaemon adspersus* in the removal of the charophytes in the northeastern Baltic Sea. The studied invertebrates preferred ***Chara connivens*** to *C. tomentosa*. Low consumption of *Chara connivens* may reflect its non-native origin. The experiment suggests that under moderately eutrophicated conditions the grazers are likely not control the charophyte populations. However, the grazers have potential to eliminate the charophytes in severely eutrophicated systems under the stress of filamentous algae (Kotta *et al.,* subm.).

4.0 Live imports

Country	*Fish*	*Quantity (kg)*
China	ornamental freshwater fish	20.2
Czech Republic	ornamental freshwater fish	30.0
Denmark	*Oncorhynchus apache* and *O. chrysogaster*	150.0
Denmark	unidentified fish	25.0
Finland	ornamental freshwater fish	68.5
Finland	unidentified fish	9603.0
Germany	ornamental freshwater fish	43.5
Taiwan	ornamental freshwater fish	50.0
United Kingdom	eel (*Anguilla anguilla*)	138.0

5.0 Live exports to ICES member countries

Country	*Fish*	*Quantity (kg)*
Latvia	unidentified fish	1580.0
Netherlands	unidentified fish	27.5
Norway	unidentified fish	41.0
Russian Federation	unidentified fish	11.1
United Kingdom	unidentified fish	22.0
United States	unidentified fish	20.5

Live exports to other countries

Country	*Fish*	*Quantity (kg)*
Bahamas	unidentified fish	110.8
Cyprus	*Oncorhynchus apache* and *O. chrysogaster*	53.8
Malta	unidentified fish	22.0
Saint Vincent and the Grenadines	unidentified fish	5.1

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

On 21–23 May, 2002 Ministry of the Environment of Estonia, together with US Embassy in Tallinn and Global Invasive Species Program organised in Tallinn a workshop on establishment of regional database on invasive alien species in Baltic Sea Countries. As a result of this workshop a working group was composed who prepared the project proposal for creating such a database. The project proposal was completed in March 2003 and will be submitted for financing to The Nordic Council of Ministers, but also to other potential money donors (e.g., GEF).

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FINLAND, 2002

(Prepared by Erkki Leppäkoski and Lauri Urho)

1.0 Laws and regulations
2.0 Deliberate releases and planned introductions
2.1 Fish

Deliberate releases into the Baltic Sea were (including rivers draining into the Baltic) for fisheries and fish stock enhancement purposes in 2001 (2002 data not yet available) as follows:

0.1 million newly hatched and 3.7 million older salmon (*Salmo salar*),

0.1 million newly hatched and 1.4 million older sea trout (*Salmo trutta* m. *trutta),*

38.7 million newly hatched and 7.5 million one-summer-old whitefish (*Coregonus lavaretus*).

As in previous years, veterinary authorities allowed the import of elvers (*Anguilla anguilla*) to be released in natural waters.

3.0 Accidental introductions and transfers
3.1 Parasites, Pathogens, and Other Disease Agents

European sheatfish virus (ESV), one of the viruses causing EHN, was isolated for the first time in Finland in 2002. Few sheatfish (*Silurus glanis*) died within 2 weeks after they were imported from Germany. Transfer restrictions of live fish are in place at the farm. Live fish have not been transported to other farms or natural waters since arrival of the sheatfish. Farm uses re-circulated, ozone treated lake water heated by waste heat from a paper and pulp mill factory. Effluent water of the farm runs through the sewage treatment plant of the factory. Therefore risk of the spread of the virus to other farms and natural water is practically eliminated. Plans to empty and disinfect the whole unit are in progress.

For the first time, *Anguillicola crassus* was found in eleven (out of the 45 studied) eels ascending to three rivers in Finland in 2002. Since the beginning of the 1980s more than 1,500 eels introduced into lakes have been checked for the parasite, but so far *Anguillicola crassus* have not been found in introduced eels (Tulonen, 2002).

4.0 Live imports

4.1 Fish

- Eels (*Anguilla anguilla*) for ongrowing at farms for human consumption and to be stocked in natural waters;
- Rainbow trout (*Oncorhynchus mykiss*), sturgeon (*Acipenser sturio*) and sheatfish (*Siluris glanis*) for ongrowing at farms and for human consumption;
- Tropical aquarium fish.

4.2 Invertebrates

As in previous years, aquarium shops and some restaurants and stores have imported live tropical marine animals such as oysters, lobsters and crabs for sale or consumption. Since it is obvious that these animals cannot survive in natural Finnish waters, no authorization by the Veterinary department is required.

5.0 Live exports

5.1 Fish

- Rainbow trout to Russia and Estonia;

All exports to countries outside EU are not systematically collected.

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FRANCE 2002

(Prepared by Laurence Miossec and Philippe Goulletquer)

1.0 Laws and regulations

Two projects of new regulations are now in discussion in Brussels. One of them concerns harmonised animal health rules for the importation, from third countries, of live molluscs, their eggs and gametes, for further growth, fattening or relaying, including the question of live molluscs and mollusc products for immediate human consumption or further processing before human consumption.

The second project establishes harmonised animal health rules for the importation, from third countries, of live fish, their eggs and gametes, intended for farming in Community, live fish of aquaculture origin and products thereof, intended for immediate human consumption or further processing before human consumption.

2.0 Accidental introductions and transfers

2.1 Molluscan

Crepidula fornicata

This species has been introduced by stages. The most important one was in the 1970s, associated with the introduction of the Japanese oyster, *Crassostrea gigas* after high mortality of Portuguese oysters *Crassostrea angulata*. A research program (LITEAU), funded by the French Ministry of the Environment, was developed in 2000 for a three-year period to better understand the species proliferation mechanisms and the impacts on marine environment and specially commercial shellfish industry. At the end of the project, the main results are

1) the biomass of *Crepidula fornicata* was evaluated in four pilot sites, Bay of Arcachon (155 metric tons), Bay of Marennes Oleron (5000 metric tons), Bay of Brest (18,500 metric tons) and Bay of St Brieuc where the colonisation is recent but the stock is the most important with 250,000 metric tons. These differences should be related with dredging and trawl activities which modify sea bottom by making lines where *C. fornicata* population could find good conditions to increase;
2) With an efficient reproductive strategy and a 10-year longevity, *C. fornicata* is a sustainable invasive species;
3) A spatial competition exists between this species and commercial shellfish (e.g., scallops) but the feeding competition is low or not direct.

Austrovenus stutchburii

This veneridae, native from New Zealand, was observed on piles of rubbish with oysterbreeders in Vendée, south Loire river on Atlantic coast. Hundred of animals were recorded, dead but with still putrid flesh. Their origin is unknown.

Ocinebrellus inornatus

Two research programs, funded for one of them by "Conseil Général de la Charente Maritime" and for the other by the French Ministry of the Environment (INVABIO programme, Bachelet, 2002), were started in 2001 to assess the impact of an exotic population of Japanese oyster drill *Ocinebrellus inornatus* on the structure and the functioning of the invaded ecosystem along the French Atlantic coast, specially in the Marennes-Oleron Bay. The first results highlighted (Garcia-Meunier *et al.,* 2002a; Sauriau, 2002):

1) Although the American and the French populations of *Ocinebrellus inornatus* came from the same origin from a genetic point of view, the timing of introduction is still under evaluation. Population dynamics studies are currently developing on that matter;
2) The drill density as the oyster mortality was higher in bottom culture areas than in off bottom culture areas but this mortality was not fully correlated with *Ocinebrellus inornatus*;
3) The discrimination between *Ocinebrellus inornatus* and the native species *Ocenebra erinacea* is easy for adults but requires specific molecular markers for juveniles (Garcia-Meunier *et al,* 2002b);
4) This exotic species was recorded further north, in Fouras, Ré Island, the Bay of Bourgneuf, the Gulf of Morbihan in Brittany, probably transferred through oyster exchanges;
5) Few actions are proposed to eradicate this species (i.e., burning of eggs, collecting, soaking of oyster stocks, in inland tanks before transfer, into fresh water).

Moreover, a recent study emphasizes that there is no competition for food between the invasive species and the native species of drill, nor for egg substrate. The reproductive strategies are different (Martel, pers.comm.).

Rapana venosa

A report, published in November 2002, synthesised the most recent available information on *Rapana venosa* biology in France (Joly *et al.*, 2002). Biological observations on reproduction and hatching conditions of Rapana whelk, maintained in captivity, were realised. Under laboratory conditions, in 2002, larvae settlement was observed and juveniles reached a size of a few hundred µm.

In the wild, as far back as 1997, 13 adult specimens have been officially identified by Ifremer in Southern Brittany. All specimens were collected in the bay of Quiberon and related to commercial transfers of Manila clams from Italy (Laguna of northern Adriatic) as by-catch.

Two specimens of Rapana, identified as *Rapana venosa*, were found in a race-way of a shellfish farm, located in Vendée area, south of the Loire river. In a recent past, this farm used to import Manila clams from Italy. No evidence was established that this species was released in the open sea in this area.

2.2 Crustacean

A lobster fisherman from Asnelles (Normandy) caught a Canadian lobster (*Homarus gammarus*) in one of his lobster pots. This crustacean, a 1.135 kg weight and 155 cm long male, does not currently inhabit the French coasts.

2.3 Algae and plants

Caulerpa taxifolia

A new campaign, called Califa 2000, was carried out in September 2000 to assess the distribution of *Caulerpa taxifolia* and *Caulerpa racemosa* in the rade of Hyères, Porquerolles island included, and rade of Toulon (Méditerranean sea, south of France). Results, in publication (Belsher *et al.*, 2003), highlighted that these two species are present in these areas. *C. taxifolia* was observed between –2 and –15 metres and *C. racemosa* between –20 and –30 metres. Each species could be jointly found with the native species *C. prolifera*. This expansion has been probably facilitated by yacht anchoring.

2.4 Chordate

Corella eumyota, a southern hemisphere solitary ascidian never before reported from the northern hemisphere, has been observed in Summer 2002 in two sites in Brittany (France), Perros Guirrec and Camaret-sur-mer and, now, can be considered as established (Lambert C.C. and Lambert I.M., California State University, Fullerton, pers. comm.). This species is widespread in the southern hemisphere. It is common in southern Australia, all of New Zealand, South Africa and South America. The vector of introduction is unknown.

3.0 Live imports

The shellfish farming industry imported Pacific cupped oyster for direct marketing from Ireland, clams (*Mercenaria mercenaria*) from the UK and Manila clams (*Ruditapes philippinarum*) from Italy, blue mussel (*Mytilus edulis*) from The Netherlands and Mediterranean mussel (*Mytilus galloprovincialis*) from Italy and Spain.

A French national census concerning shellfish culture was carried out in 2002, including estimate of shellfish fluxes. This will allow estimates of shellfish transfers at the European level from French companies.

4.0 Meetings, conferences, symposia or workshops on Introduction and Transfers

INVABIO meeting concerning the multidisciplinary programs on invasive species will be organised by the French ministry of Environment, in Paris on 11–12 March 2003. More information will be available at the workshop in Vancouver.

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GERMANY, 2002/2003

(Prepared by S. Gollasch and H. Rosenthal)

Highlights of National Report

No new accidental introductions were reported. Germany reported on the status of following, previously introduced non-indigenous species: *Crassostrea gigas, May arenaria, Anguillicola* sp*., Dreissena polymorpha, Eriocheir sinensis, Portumnus latipes, Teredo navalis, Mastocarpus stellatus* and associated species.

Activities on aquaculture and restocking focused in 2001 on eels, sturgeon and salmon. Ornamental trade of freshwater and marine organisms is becoming increasingly 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 Belgian and Dutch markets.

NEOBIOTA, a research consortium on biological invasions launched in 1999, continues its work.

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)) for the mutual benefit of working groups, concerted action relevant to invasions and to gather data on impacts of non-indigenous species. At present the network includes 87 (58 in 2001) experts from 27 (21 in 2001) countries.

Aquaculture and ballast water issues become more and more important. It is discussed to take advantage of 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.).

1.0 Laws and regulations

Germany actively contributes to the development of the IMO Ballast Water Convention (see below).

3.0 Accidental Introductions and Transfers

No new accidental introductions were reported from German marine or brackish waters in 2002. However, 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. Danish colleagues are aware of *Hemigrapsus´* eastwards spread, but have not found any specimens yet.

The following paragraphs present news of previously reported non-indigenous species.

3.2 Invertebrates

Crassotrea gigas

The oyster farm located on the island of Sylt in the North Sea is continuing its operation (rack culture). In 2002 the company operated at about the same production level, marketing about 1 million oysters in Germany. Some of the production also went to the Belgian market. As reported earlier, logistic problems in seeding the German oyster farm in the spring (during one year at the end of the 1990s), seed oysters (*Crassostrea gigas*) had to be "parked" for a few days (up to two weeks) outside the hatchery in Ireland. Due to this event and perhaps due to other (not reported) activities, the following non-target species were transmitted into the Wadden Sea: *Sargassum muticum*, *Ascophyllum nodosum*, *Aplidium nordmanni* and *Styela clava* (see previous German National Reports). These unintentional introduced species are well established near the oyster farm now and constantly spread further.

Culturing the Pacific Oysters resulted also in some settlement outside the farm. These oysters must have reached maturity and must have spawned in consecutive years, allowing the dispersal of planktonic larvae. As there is not much hard substrate in the German Wadden Sea to settle mussel beds, the adjacent Wadden Sea areas became the first foothold for the resulting spat. The oysters showed good growth and seem to have reached maturity and spawning must now have taken place repeatedly. As of 2001 no impact of the Pacific Oyster on native species has been reported (Diederich, 2001; Reise, pers. comm.).

Recently completed field studies document the spread of the Pacific Oysters in the Wadden Sea (Diederich, 2001). In 2002 the range extension was noticeable and oysters overgrow the mussel beds at increasing densities. So far, it is difficult to assess the costs for the mussel farmers to clean the mussels from spat oysters. There may be a switch to oyster production, however, this is not so easy to achieve as potential markets require a critical mass of production and the mix of oysters and mussels on the bottom plots may cause prohibitive costs as the process is labour intensive.

Mya arenaria

A new project on the origin of *Mya arenaria* was launched by the Alfred-Wegener-Institute (project coordinator Matthias Strasser). *Mya* specimens from different source locations world-wide will be analysed and compared.

Anguillicola sp.

The reported level of the swimbladder nematode infestation remains unchanged (up to 90 % of the caught eels are infested). In eutrophic freshwater lakes of northern Germany the ruffe (*Gymnocephalus cernuus*) continuous to act as reservoir of *A. crassus*. In some areas the infestation rate varies greatly from year to year.

Dreissena polymorpha

As in many other countries the Zebra Mussel continuously spreads. Companies in Hamburg harbour continue to suffer from fouling in water intakes and pipelines (as reported last year). The suspected re-introduction of Zebra Mussel to Europe from areas where it was transmitted several decades ago (e.g., Great Lakes and Mississippi River basin) is still debated. A project proposal addressing this issue in cooperation with other European countries has so far not been granted and the study has therefore not started. However, several institutions along major German rivers (e.g., Magdeburg, Elbe River; Berlin, Spree River) continue to observe the occurrence and intensity of fouling at several monitoring stations. The spread of the species to new European localities (i.e., Spain, range extension in Italy since the 1990s) is of concern. However, the source of the Spanish population is still unknown.

***Eriocheir sinensis*, Chinese Mitten Crab**

Data were collected and will be analysed soon to possibly identify some criteria which might trigger the mass developments of this species in certain German River estuaries. The information gathered so far clearly indicates certain cyclic phenomena. It is suspected that these are linked to some larger climatic fluctuations in coastal habitats.

Portumnus latipes

In 2002 no new records have been registered. There have been occasional records in German waters, possibly due to natural spread from warmer European regions.

Teredo navalis

The alien species continues to cause massive damage to local harbours, especially marinas, and continues to be a significant problem in the Baltic Sea area (Mecklenburg-Vorpommern and Schleswig-Holstein coasts), causing damages of several million US$ per year. A study has been initiated in 2002 to identify the mechanisms of reproductive modes in the Baltic, including genetics to identify local populations and population interchange. Preventive measures are presently studied by several institutions, considering the use of alternative substances replacing wood and, toxic paints (specifically preventing larval settling on wood surfaces). However, all of these measures are expensive.

Mastocarpus stellatus

M. stellatus (Gigartinales, Rhodophyta) is a cold-temperate amphioceanic North Atlantic intertidal red seaweed. Although the island of Helgoland (North Sea) lies within its biogeographical region, the species never colonized the island. There are a few single records from the 19^{th} century (Bartsch and Kuhlenkamp, 2000; Kuhlenkamp, pers. comm.), partly of doubtful nature. The first record of attached plants which established a stable population was in 1983 on basaltic rocks in the western part of the island (Kornmann and Sahling, 1994). The plants probably became established unintentionally after field experiments with Icelandic strains a few years earlier. Within 20 years this species became very prominent on all man-made and natural hard substrata around the island and meanwhile also entered the red sandstone wave-cut platform. It forms extensive stands especially on exposed sites and the spreading of the species substantially changed the appearance of some intertidal biotopes during recent years (Bartsch and Tittley, in prep.). The impact of the plant is still unresolved. Initially *Mastocarpus stellatus* probably colonized macroalgal free substrata, but quantitative studies are missing. The further spread of the algae downshore suggests that climax spread is not yet reached.

A proposal to the Earth Watch Institute, Oxford (www.eartchwatch.org/europe) is in preparation. The project is planned for a three week summer period in 2004 on Helgoland. Project aim of this baseline study is to map the extension and performance (individuals per m^2, size, reproductive state) of three invasive species *(Mastocarpus stellatus, Sargassum muticum, Codium fragile*) and of four autochthonous species potentially impacted by the invaders (*Fucus vesiculosus, F. serratus, Chondrus crispus, Halidrys siliquosus*). GIS based maps of the extent of the seven species will be prepared.

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4.0 Live Imports
4.1 Fish

Aquaculture and powerplants

Several aquaculture facilities have been in operation for decades using warm water effluents of powerplants. Species are cultured for the aquarium industry (ornamental species: koi carp, gold fish and sterlett), human consumption (Asian carp, *Tilapia* species) and restocking (glass eels). The total annual production was approximately 250 tonnes.

Glass eels are imported from various countries (e.g. France, Italy, Ireland, Netherlands, and Sweden) according to the ICES Code of Practice. With a weight of 25 g the individuals are used for restocking German inland waters. This activity has continued in 2002.

Several Sturgeon species are still imported from Russia by local farmers for small-scale culture, among them is the Siberian sturgeon *Acipenser baeri*. On and off there are records of captures of escapees although these are rare events. The most recent report on the distribution of records along German North Sea and Baltic coasts has recently been published by Arndt *et al.,* 2002. Figure A4.1 depicts the records collected so far.

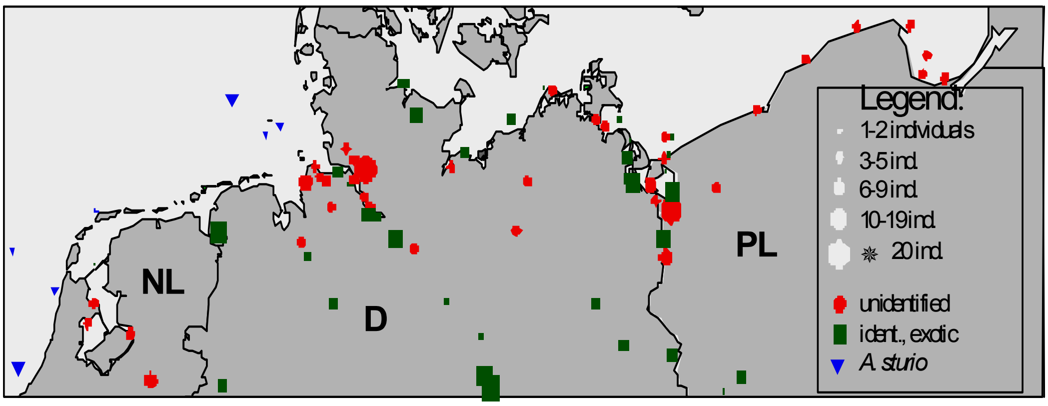

Figure A4.1. Distribution of sturgeon catches in the North and Baltic Seas and their tributaries between 1981 and 2000. The symbol size represents the number of catches, the shape indicates the group of species (circle = unidentified non-indigenous; square = identified non-indigenous species; triangle = *A. sturio*) (Arndt *et al.,* 2002).

The continuous reproduction and import of live sturgeon species for aquaculture and pet-trade has resulted in increased availability of sturgeons on the market. As a consequence the fish have been transferred into many open water bodies of Central and Western Europe (Gessner *et al.,* 1999; Arndt *et al*., 2000; Rochard *et al*., 2001). According to fishermen the number of sturgeon caught in natural water bodies exceeds the reported ones by far.

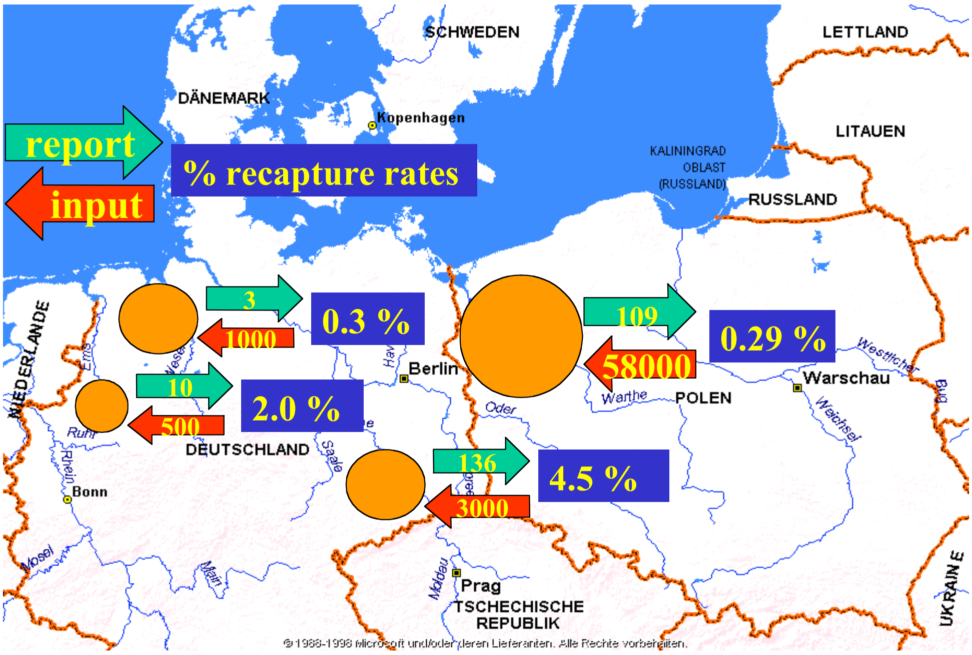

Figure A4.2. Estimated accidental and/or deliberate introductions of sturgeons in the Ems (A), Weser (B), Elbe (C) and Odra (D) rivers catchment areas compared with catch reports. Input = known accidental or deliberate releases by sturgeon farmers or anglers. Report = reported catches of sturgeons by fisherman and anglers (data sources: J. Gessner, pers. Communication, Anonymous, 1987, Astynski, pers. Communication; J. Filipiak, pers. Comm.; Society to Save the Sturgeon archives. (after Arntz *et al.,* 2002)).

A new trade for juvenile sturgeons has developed to serve the pet fish industry in several parts of the country. Juvenile sturgeons are increasingly placed in garden ponds. Once reaching a certain size, these are not always killed but often released into natural water bodies. Figure A4.1 shows the increasing records of various sturgeon species in German waters. Figure A4.2 shows the presently known activities in transferring and re-capturing various sturgeon species in central Europe.

A total of 338 sturgeons of various species and hybrids were reported in Central European waters since 1981 until today. The main catches (nearly 90 %) were reported from coastal waters and large rivers such as the Odra, Elbe, Weser, and Rhine.

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Imports of **salmonid species** continued in the year 2002 at a comparable level to previous years. It is extremely difficult to trace the routings and quantities of live fish trade in several regions as there is no mechanism to collect these data. As in previous years, the rainbow trout was imported mainly from Denmark, the Netherlands, Poland, and the Czech Republic. Substantial quantities were transferred by trucks to local farmers and wholesalers not only to the northern States of Germany but also down to the south (Bavaria). The tonnage of trout imported overall varied over the past few years between 15,000 and 19,000 tonnes. Live **Atlantic Salmon** were imported from Sweden for human consumption in an unknown quantity.

Common carp is another species that is regularly imported alive. While during the 1980s the tonnage was gradually declining from about 4,400 tonnes (1980) to 1,400 tonnes (1989), imports increased again (sources: Poland, Hungary, Czech Republic) to 3,150 tonnes (1997) and the level presently is around 5,000 tonnes (2001).

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. It is estimated that several 10,000s German hobbyists run sea water aquariums. Germany is one of the top three importers following USA and Japan. Annually 6 million fish are imported predominantly from the Philippines, Indonesia, Thailand, Singapore and Hawaii.

At present, a survey on trading of live marine animals by Public Aquaria and Oceanaria has been started at the Institute for Marine Science, Kiel, the results of which are still not yet available. Although the Kiel aquarium itself displays mainly indigenous species, several exotics are also regularly imported to attract the public by colourful tropical marine life. Located at the Baltic Sea, a wide spectrum of the North Sea fish fauna is also displayed.

There are several other public aquaria along the German coast that certainly display a similar spectrum of species and the Kiel example may also serve as a model for others around the European coastal institutions within the ICES area.

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. *Homarus* spp. are regularly imported live for markets in various parts of the country. Depending on the season, shipments originate mainly from Canada, Ireland and Norway. Trading ports in which live lobsters are held in tanks are Hamburg and Bremen.

5.0 Live exports to ICES Member Countries

Live Blue Mussel (*Mytilus edulis*) production is, to a large extent, targeted for the Belgian and Dutch markets.

The former Biologische Anstalt Helgoland continues to operate its service to deliver (mainly European-wide) local species to research and other institutions. It is unknown if the ICES Code of Practice or other quarantine measures apply.

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

7.1 New Research Proposals

7.1.1 UFZ Centre for Environmental Research Leipzig-Halle

Dr Stephan Klotz (UFZ Centre for Environmental Research Leipzig-Halle) intends to submit a research proposal to the European Union on biological invasions, likely involving 10 partners. The main focus was set on terrestrial freshwater invasions at a meeting in January 2003.

7.1.2 Ballast Water Research Cooperation Canada – Germany

A new project proposal on the use of satellite imagery to identify regions free of algal blooms for ballast water exchange was submitted.

7.2 Meetings

7.2.1 NEOBIOTA group

This new German group on biological invasions is a research consortium with the objective to co-ordinate responses to the ever increasing problems caused by the invasion of non-native plants, animals, fungi and micro-organisms (see last year's National Report). An international workshop was held in autumn 2002. This was the 2nd International Conference of the German Working Group on Biological Invasions entitled NEOBIOTA BIOLOGICAL INVASIONS: CHALLENGES FOR SCIENCE. The meeting was held on October 10–12, 2002 in Halle. Most of the presentations were concerned with terrestrial species, a few with freshwater introductions. One session dealt with marine introductions and several WGITMO members were invited to deliver the following talks:

- Rosenthal, H. Introduction and spread of aquatic organisms through shipping and aquaculture: Case histories from coastal and marine habitats;
- Rosenthal, H.: Annotated Bibliography on Transplantations and Transfers of Aquatic Organisms and their Implications on Aquaculture and Ecosystems;
- Minchin, D.: Predicting the risk of aquatic invasions, challenges for management;
- Botnen, H.: Unintentional transfer of marine species to Norwegian waters and risks associated with them.

7.2.2 Braunschweig Meeting

A workshop will be held in May 2003 entitled "Biological diversity and invasive species – Documentation, Monitoring and Risk Analysis".

7.2.3 Bremerhaven Meeting

A workshop will be held in June 2003 entitled "The Maritime Environment, International Conference and Exhibition" and includes a Session on Ballast Water and Waste Water Treatment aboard Ships and in Ports.

7.2.4 Marine Environment Protection Committee 48 (MEPC48), International Maritime Organization (IMO), Ballast Water Working Group (BWWG)

The number of submissions for consideration of the BWWG remained high indicating the increasing awareness regarding ballast water issues. A Diplomatic Conference on the planned Ballast Water Convention is scheduled for early 2004. To further enable good progress at MEPC48 an intersessional meeting of BWWG is scheduled for March 2003.

7.2.5 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 22 October 2002 within its Marine Environment Protection Committee (Working Group 2.11.4).

The objective of this new working group is to develop standards for ballast water treatment. Standards considered for its work include:

- Perfomance standard for ballast water treatment systems;

- Ballast water discharge standard;
- Test set-up for ballast water treatment systems;
- Sampling standard for approval of ballast water treatment systems;
- Standard for a test medium (including, but not limited to salinity, temperature and test organisms) to approve ballast water treatment systems.

The DIN working group was launched with the intention to submit standards for the consideration of relevant EN and/or ISO working groups.

Three other working groups in the Marine Environment Protection Committer of the German Standardization Authority focus on oil-water separation, test set ups and certification of oil barriers and other measures to reduce negative impacts of oil spills as well as waste treatment of ships.

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7.3 European Research Network on Aquatic Invasive Species (ERNAIS)

Initiated by Vadim Panov, Russia, Germany co-coordinates ERNAIS. For ERNAIS objectives see earlier National Reports. At present the network includes 87 (58 in 2001) experts from 27 (21 in 2001) countries (www.zin.ru/projects/invasions/gaas/ernaismn.htm).

7.4 Ballast Water treatment

Three projects testing ballast water treatment measures are under way in Germany.

7.4.1 Bremen Ballast Water Project

The project is funded by the City of Bremen (Germany) and will summarize the up-to-date information on ballast water treatment options (Phase 1, completed July 2002). Phase 2 (scheduled to start in spring 2003) includes practical tests of port water operating selected treatment options. During Phase 3 (scheduled to begin in summer 2004) full scale tests onboard vessels are planned. It is hoped that a marketable ballast water treatment unit will be the outcome of this project.

7.4.2 Berkefeld/RWO Project

This project as launched in autumn 2002 with a similar approach as the Bremen Project.

7.4.3 Hamann Wassertechnik

Hamann Wassertechnik developed a ballast water treatment unit based on a three step approach (hydrocyclone followed by filtration and chemical treatment). Intensive testings are completed and a prototype unit will be installed on a ship for full scale testings this year.

7.5 Offshore wind parks

Large scale offshore wind parks are planned off the German Baltic and North Sea coasts. A research programme to test modern aquaculture techniques in conjunction with these wind-mills has been launched in 2002 (AWI = Alfred Wegener Institute Bremerhaven in cooperation with the Biologische Anstalt Helgoland). The newly man-made hard substrates in the area where soft bottom habitats prevail offer the opportunity for aquaculturists to use an infrastructure (e.g., service platforms) which they otherwise would not be able to afford. Therefore, these platforms should be designed to: a) enable the easy attachment of structures that allow colonization with native hard bottom species; and b) establish new maritime users, e.g., aquaculture sites for oyster and macroalgae cultures (although initially mainly native species will be considered during the test phase, it is anticipated that non-indigenous species such as the Pacific oyster may be included in the trials.).

7.6 New Course of Studies

The University of Bremerhaven is ready to launch a new course of studies related to biological invasions with a technical focus. Targeted students include naval architects and technicians. It includes:

- Naval architecture
- Offshore wind parks
- Shipping, ports and waterways (including ballast water issues)
- Harvesting marine components for pharmaceutical products
- Products for human consumption
- Aquaculture, ornamental trade and fishing (including exotic species, quarantine measures etc.).

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IRELAND, 2002

(Prepared by Dan Minchin)

2.0 Deliberate releases

2.2 Invertebrates

The abalone *Haliotus tuberculata,* and *Haliotus discus hannai*. All seed are hatchery produced in Ireland and then cultivated in barrels on longlines, some have been exported to Northern Ireland.

The Pacific clam *Venerupis philippinarum*. Production is based on Irish hatchery seed, no imports of seed are known. Cultivation is on screened trays and then buried in the substratum beneath mesh. Cultivation takes place on all Irish coasts. The Pacific oyster *Crassostrea gigas*, is produced in Irish hatcheries and is supplemented with imports from registered hatcheries in France and the UK (including Guernsey). No half-grown oysters were imported from France as in some previous years.

2.3 Algae and higher plants

The red alga *Asparagopsis armata* was first recorded in Ireland in 1939 having arrived accidentally. The species is presently in culture on longlines in Ard Bay, on the west coast. It is produced for its volatile halocarbons used in cosmetics and is the only farm where production takes place (Morrisey *et al*., 2001). The plant has two conspicuous life history stages, the Falkenbergia tetraspore phase known in the wild in Ireland from the north west and south coasts whereas the gametophyte stage is known only from the west and south coasts.

3.0 Accidental introductions and transfers

3.2 Invertebrates

Dreissena polymorpha: The zebra mussel continues to spread in Ireland, three new river systems and nine further lakes have been colonised and recorded in the last year. It is likely that there are many other lakes that have become infested as a result of movements of angling boats (see separate report).

Ficopomatus enigmatica: This serpulid worm fouls the hulls of craft and structures within the Kilrush lagoon on the Shannon Estuary. The population was first noticed in 1998 and the population still exists and can be moderately abundant locally but is not known to form reefs in Ireland.

3.3 Algae and higher plants

Sargassum muticum: This brown alga was first recorded in Ireland in 1995 from the NE Irish coast in Strangford Lough and was probably present a few years before its discovery. In 2001 a plant fragment of 1.5m was found on the SE coast in the fishing harbour and marina of Kilmore Quay. In 2002 there were notable stands present. Also in 2001 the species was found both on the south-west coast in Kenmare Bay where it became locally common in 2002 and on the west coast in Bertraghboy Bay. A new population was recorded from the NW coast in 2002 from Drumcliffe Bay. It is suspected that oyster movements may have been responsible for its establishment on the south and west coasts. Its presence in Kilmore Quay may have been due to natural drift or carried there by leisure craft.

3.4 Parasites, pathogens and other disease agents

Anguillicola crassus: The nematode parasite, surrounding the airbladder of the freshwater eel *Anguilla anguilla* causing it to become inflamed. *Anguillicola crassus* was first identified from the Waterford area (south coast) in 1997. In 1999 it was found on the lower Shannon River in Lough Derg. It was recorded from the Erne Catchment in 1999. This species appears to be expanding, however, its future impact in Ireland remains unknown. It was probably introduced to Ireland by its infective stage being released in water used to refresh eels in viviere trucks making collections in Britain before arriving in Ireland. However, it is possible that the infective stage could be carried with copepods released with ships' ballast water or with water associated with imported fish for stocking rivers.

Pseudodactylogyrus anguillae and *P. bini* are gill flukes of the eel *Anguilla anguilla. P. anguillae* was first found in eels in the west of Ireland (McCarthy and Rita, 1991) but is now more widely distributed and in Lough Erne has a prevalence of >60 %. *P. bini* has also been found in Lough Erne with a prevalence of >80 % (Copley and McCarthy, 2001). The species was probably introduced with adult eels *A. japonica* imported from Taiwan. It has spread through much of northern Europe arriving only recently in Ireland.

Bonamia ostreae: This protozoan was first recorded in Ireland in 1987 in Cork Harbour in native oysters *Ostrea edulis*. It subsequently spread to Clew Bay and Galway Bay on the west coast. It has recently been discovered in Achill Sound, close to Clew Bay.

4.0 Live imports

4.2 Aquatic plants

Species	Numbers of plants	Supplied from
Alternantherna bettzicklana	20	Indonesia
Alternantherna lilacina	10	Indonesia
Alternantherna ocipus	20	Indonesia
Alternantherna reinckii	10	Indonesia
Ammannia gracilis	20	Indonesia
Bacoma amplexicaulis	10	Indonesia
Bacopa monnieri	10	Indonesia
Caboma aquatica	10	Indonesia
Echinodorus latifolius	10	Indonesia
Echinodorus pervensis-amazonicus	20	Indonesia
Elodea densa	10	Indonesia
Eustralis stellata	10	Indonesia
Hemigropsis sp.	10	Indonesia
Hydrocotyle leucocephala	20	Indonesia
Hygrophila lacustris	10	Indonesia
Hygrophila polysperma	40	Indonesia
Hygrophilia corymbosa	20	Indonesia
Hygrophilia salicifolia	10	Indonesia

Species	Numbers of plants	Supplied from
Hygrophilia siamensis	20	Indonesia
Lilaeopsis novae-zelandiae	10	Indonesia
Limnophila aromatica	30	Indonesia
Limnophila sessiflora	10	Indonesia
Ludwegia arcuata	10	Indonesia
Ludwegia repens-palustris	20	Indonesia
Micranthemum umbrosum	10	Indonesia
Nomaphila angustifolia	10	Indonesia
Nomaphila sp.	10	Indonesia
Physostegia purpurea	20	Indonesia
Rotala nanjenshan	20	Indonesia
Rotala wallichif	10	Indonesia

Note: Plants imported from other European Union countries are not recorded.

4.3 Invertebrates

Pacific oyster seed continues to be imported from France and the UK.

Species	Numbers (consignments)	Origin
*Crassostrea gigas (*hatchery*)*	17,400,000 (11)	France
*Crassostrea gigas (*hatchery*)*	36,665,000 (54)	England
*Crassostrea gigas (*hatchery*)*	10,185,000 (14)	Guernsey
Crassostrea gigas	2.75mt (3)	England
Neries sp.	426kg (1)	England

Pacific oysters from hatcheries in France were imported to Waterford, Cromane, Cork harbour, Carlingford, Achill, Kinsale, Ring, Kilorglin, Claddaduff and Dungarvan.

4.4 Fish

Species	Numbers (consignments)	Origin
Oncorhynchus mykiss eggs	14,000 (6)	Isle of Man
Oncorhynchus mykiss eggs	1,700,000 (4)	Denmark
Oncorhynchus mykiss eggs	200,000 (1)	England
Oncorhynchus mykiss eggs	1,320,000 (5)	N. Ireland
Oncorhynchus mykiss	306,230 (13)	N. Ireland
Oncorhynchus mykiss	100,000 (1)	Wales
Salmo salar eggs	3,286,500 (6)	Scotland
Salmo salar juveniles	1,957,000 (2)	Scotland
Salmo salar	6,650,000 (5)	Iceland
Salmo trutta	1800 (2)	Northern Ireland
Hippoglossus hippoglossus	1,200 (1)	Isle of Man
Psetta maxima fry	50,000 (1)	France

5.0 Live exports to ICES member countries and other areas

Species	Numbers/weight (Consignments)	Destination
Mytilus edulis	5,500 mt	Northern Ireland
Crassostrea gigas	1,880 kg	England
Haliotus tuberculata	1,800 individuals (2)	Northern Ireland
Haliotus discus hannai	2,000 individuals (2)	Northern Ireland

Species	Numbers (Consignments)	Destination
Salmo salar eggs	8,270,000 (15)	Scotland
Salmo salar eggs	271,400 (3)	England
Salmo salar eggs	102,000 (1)	Germany
Salmo salar eggs	100,000 (1)	Wales
Salmo salar eggs	10,000 (1)	Northern Ireland
Salmo salar 2–9g	869,600 (6)	Scotland
Salmo salar fry	300.000 (1)	Northern Ireland
Salmo salar 65g	250,000 (2)	France*
Salmo salar 37–95 g	1,018,000 (10)	Scotland*
Salmo salar 60–80 g	295,000 (2)	Shetlands*
Salmo salar 2.50 kg	360 (2)	Northern Ireland
Carassius auratus	1	Wales
Carassius auratus	1	England
Leuciscus idus	2	Wales

*Well boats carried salmon to France (2), Scotland (4) and the Shetlands (2).

7.0 Meetings

1. Shipfouling and Biological Invasions. Special session of the 11th International Marine Corrosion and Biofouling Congress, 21–26 July 2002, San Diego, California (D. Minchin)
2. Commission Internationale pour l'Exploration Scientifique de la mer Méditerranée Workshop on Alien marine organisms introduced by ships in the Mediterranean and Black seas, Istanbul, Turkey 6–9 November 2002 (D. Minchin)
3. 11th International Conference on Aquatic Invasive Species. Alexandria, Virginia, 25 February to 1 March 2002 (F. Lucy and M. Sullivan).
4. Biological Invasions: challenges for science. 2nd International Conference of the German Group on Biological Invasions NEOBIOTA Halle, Germany 10–12 October 2002 (D. Minchin).
5. Marine Environment Protection Committee 48th Session. 26 June 2002, London, England (R. Boelens).

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Report prepared by Dan Minchin with assistance from: Fiona Geoghegan, Maria Lyons-Alcantara, Keelan Doyle, Lucy Watson, Stefan Kraan, Nadine Landy, Neil Campbell and Peter Jones.

NORWAY, 2002

(Prepared by Anders Jelmert)

1.0 Laws and regulations

No new laws or regulations regarding matters relevant to WGITMO have been suggested or passed in 2002.

2.0 Deliberate releases

2.2 Invertebrates

The red king crab *Paralithodes camtschatica* continues to extend its range westward and northwards into the Barents Sea. (Supplements from Jan Sundet, IMR)

3.0 Incidental introductions and transfers

3.2 Invertebrates

Slipper limpet (*Crepidula fornicata*). No signs of further migration northward from the Kvitsøy area of the slipper limpet have been reported.

Snow crab (*Chionoecetes opilio*). No further information on catches of the snow crab has been obtained.

Caprellids collected close to the city of Ålesund were found to be *Caprella mutica* Schurin 1935 as judged by habitus observation (A.Jelmert, I.M.R.).

Six confirmed and a couple of non-confirmed specimens of the American lobster (*Homarus americanus*) were found last year bringing the total numbers of confirmed Norwegian cases up to 17 specimens. Five large males were found in the vicinity of Ålesund, and one female was found close to the southern cape of Norway (near the city of Farsund).

3.3 Algae and higher plants

Sargassum muticum is well established in the southern part of the Norwegian coast (Skagerak). It has now also established itself in the inner basin of "Oslofjord". The alga is found in fairly large quantities along the southwestern coast in Rogaland and Hordaland. *Sargassum muticum* has reached the "Sognefjord", but no confirmed reports further north have been obtained. No obvious increase in areas where it has been established, except that it now seems able to grow between the native *Fucus* species. (Jan Rueness, Univ. of Oslo, Pers., Comm.)

The red alga "*Dasysiphonia* sp*"* has apparently extended its geographical range substantially during 2002 and is now recorded north of Ålesund and E. of Arendal. The species grows aggressively in the sub-littoral zone below 4–6 m. (Jan Rueness, Univ. of Oslo, Pers., Comm.).

4.0 Live imports

4.1 Fish

22,100 salmon (*Salmo salar*) from the Faroes;

154,000 halibut (*Hippoglossus hippoglossus*) fry from Iceland;

1,175 turbot (*Scopthalmus maximus*) from Great Britain, Spain and Denmark;

6,157 **aquatic** (not specified salt/fresh water or species) fishes for aquaria. (2,500 from France, 2 from G.B., 35 from Germany and 3620 from USA.

4.2 Invertebrates

No import of marine invertebrates recorded by the veterinary inspection service.

5.0 Live exports

No records.

Report prepared by: Anders Jelmert, Flødevigen Research Station, Institute of Marine Research, Norway.

SWEDEN, 2002

(Prepared by Inger Wallentinus)

1.0 Laws and regulations

There was no new Swedish legislation during 2002.

Sweden has not yet implemented the IMO Guidelines waiting for the new convention text. However, Swedish ships' owners have been informed about the present IMO Guidelines and been asked to as much as possible follow these to get experience from the procedures.

Swedish authorities are working on implementing the EU directive "Establishing a Framework for Community Action in the Field of Water Policy" (2000/60/EC) and in that context it has been discussed if introduced species should be notified for coastal areas in relation to reference values and deviations from those. The directive does not as such include introduced species, but this might be one way to get a focus on this issue.

2.0 Deliberate releases

2.1 Finfish

Most finfish released yearly in Sweden are native species, especially smolt of Baltic salmon (*Salmo salar*), of sea trout (*Salmo trutta*) but also pike-perch (*Sander lucioperca*), the latter also into Baltic bays. There are also yearly releases of eel (*Anguilla anguilla*) as well as transfer of small adult eels from the Swedish west coast into the Baltic Sea. In freshwater there is also a release of rainbow trout (increasing amounts) and American brook charr (decreasing amounts) for sport fishery (put and take). Carp and other cyprinid fish have also been introduced in freshwater to graze down excessive benthic vegetation.

A compilation of deliberate releases of fish in Sweden during 1995 to 2001 (based on numbers permitted) is under way (Susanna Pakkasmaa, National Board of Fisheries), where information has been collected from almost all county councils. The main emphasis is on releases to freshwater and the study also includes comparisons of lakes with established rainbow trout (much released) versus North American brook charr (established in many areas).

3.0 Accidental introductions and transfers

3.1 Finfish

There are still NO reports of *Neogobius melanostomus* from Swedish coastal waters, despite its common occurrence in the Bay of Gdansk, at some sites in northern Germany and a record from Estonia in 2002.

2.1 + 3.1 Deliberate and accidental introductions of finfish

The table below (compiled from Kullander, 2002) lists all introduced fish species found in Sweden. Some may, however, just be single records while others are well established. Deliberately released species are underlined.

Species underlined = deliberately introduced in Sweden	Family *=established	Habitat (M=marine, B= brackish, F=freshwater)
Acipenser baeri	Acipenseridae	B
Acipenser gueldenstaedti	Acipenseridae	B
Acipenser ruthenus	Acipenseridae	B, F
Huso huso	Acipenseridae	B
Ctenopharyngodon idella	Cyprinidae*	F
Cyprinus carpio	Cyprinidae*	F
Hypophthalmichthys molitrix	Cyprinidae[?]	F
Hypophthalmichthys nobilis	Cyprinidae[?]	F
Hucho hucho	Salmonidae	F
Oncorhyncus clarki	Salmonidae*	F
Oncorhyncus gorbuscha	Salmonidae	B, F
Oncorhyncus kisutch	Salmonidae	B, F
Oncorhyncus mykiss	Salmonidae*	B, F
Oncorhyncus nerka	Salmonidae	F
Salvelinus fontinalis	Salmonidae*	F
Salvelinus namaycush	Salmonidae*	F
Micropterus dolomieu	Centrarchidae	F
Micropterus salmoides	Centrarchidae	F

3.2 Invertebrates

The introduced species getting most public attention during 2002 was the ectoparasite *Gyrodactylus salaris* (trematode skin flukes) found in 2001 on rainbow trout farmed in cages in the lake Södra Bullaren (province of Västergötland close to the Norwegian border). The lake discharges into two Swedish/Norwegian rivers with salmon (Enningdalsälven and Långevallsälven). *Gyrodactylus* can survive for some time in brackish but very short time in marine waters. The parasite is native in the eastern part of Sweden where the salmon populations are little affected. However, it has caused declines in some salmon populations on the Swedish west coast, where it turned up during the late 1980s. It is considered a great problem in Norway where native salmon die or often are heavily affected (more than 10,000 parasites have been found on one single young fish), although some may survive and get rid of the infections as do salmons from the Swedish lake Vänern. During 2002 the Fishery Board came out with recommendations to sport fishery associations to clean equipment and boats before being used in new waters and not to clean out fish in other waters nor to move them or water to other sites. This case went all the way up to the ministries and Norwegian activists also came in and slaughtered farmed fish. It was later recognized through laboratory studies that the Norwegian salmon populations in those rivers were sensitive to attacks from the parasite and the Swedish county council finally closed the farm site and forbid further farming of salmonoid fish at that site after 1 December 2002.

According to a survey last summer (July–September 2002), the crustacean *Cercopagis pengoi* was present along the Swedish coast between Gävle (southern Bothnian Sea) and Oxelösund (northern Baltic proper). There are no reports of this species further south nor further north along the Swedish east coast. So far it has not been found in the lake Mälaren, but the highest densities occurred just outside the lake in the bay Himmerfjärden. However, the distribution is very patchy and densities are generally low (up to 100 ind m^{-3}; Elena Gorokhova, Stockholm Univ., pers. comm.). Fish diet analyses have shown that *Cercopagis* is readily consumed by herring and sprat within the size range commonly found during August-September, i.e., 5–15 cm for sprat and 5–25 cm for herring (Fagerberg, Hansson, Gorokhova, in prep.). Large fish exhibit a positive selectivity for *Cercopagis*.

In the central part of the Swedish coast of the Baltic proper (the province of Småland) the polychaete *Marenzelleria* cf. *viridis,* known in Swedish waters since 1990, has not increased in abundance and normally occurs in quite low densities (<250 ind m^{-2}, during 2002 maximum 69 ind m^{-2}). However, at some stations it was as abundant as the native polychaete *Nereis diversicolor*. On the south coast (Hanöbukten) *Marenzelleria* occurred at more than 50 % of the monitoring stations but still mostly below 100 ind m^{-2} (Stefan Tobiasson, Kalmar Univ., pers. comm.). In the northern part of the Baltic proper (Askö-Landsort area, ca. 70 km south of Stockholm) it continues to increase in abundance and has also dispersed to new sites (Emil Olafsson, Stockholm Univ., pers. comm.). During 2002 it has continued to move north and a fully grown specimen was found in the very innermost part of the Bothnian Bay at Rånefjärden about 30 km north of the town Luleå (Kjell Leonardsson, Umeå Univ., pers. comm.). There have been no changes in the Öresund area, SW Sweden, where mostly single specimens are found at shallow stations (Peter Göransson, Miljökontoret, Helsingborg pers. comm.). There are still NO reports of *Marenzelleria* from the Swedish west coast.

Single records of the Chinese mitten crab are now and then turning up and in the summer of 2002 a large female was found in a river in Skåne, southern Sweden (probably more single captures are made but not reported). There are NO reports of mass occurrences.

There were NO reports of American lobster in 2002 and the previously reported specimens are still waiting to be positively identified by DNA (samples are left for that) (Mats Ulmestrand, Inst. of Marine Research, Lysekil, pers. comm.).

In freshwater there is still much problem with illegal introductions of the American crayfish (carrying the crayfish plague) also in waters which still have native crayfish. Amongst others it has been illegally introduced into the lake Stora Le, which continues into SE Norway. Thus there is a risk that the American crayfish may move further into Norwegian water systems, where it had not occurred before.

The swimbladder parasite *Anguillicola crassus* in eel occurs in both fresh and brackish water. It can be found in high prevalences in most freshwater lakes that have eel (H. Wickström, National Board of Fisheries, pers. comm.) and occurs in high prevalences also along the coast at least as far north in the Baltic as to Östergötland, and possibly further where eels occur (Jan Andersson, National Board of Fisheries, pers. comm.). (For more details, see 2002.)

There has been much work carried out trying to identify natural substances that may hinder settling of the long-since introduced barnacle *Balanus improvisus*. Some of these studies have been successful and anti-barnacle compounds (catemines) are patented (Hans Elwing, Göteborg Univ., pers. comm.). The goal is to elucidate any commercial use including antifouling paints. More research will be carried out within the newly started research programme "Marine Paints" financed by the foundation MISTRA.

3.3 Algae and Higher Plants

Phytoplankton

The introduced diatom *Coscinodiscus wailesii*, which came to the Swedish west coast in the 1980s was during late autumn 2002 a prominent part of the phytoplankton community in northern Kattegat and southern Skagerrak, but did not build up any blooms. In contrast to previous years there was NO real bloom in 2002 of the raphidophyte *Chattonella* (cf. *verruculosa* occurring in two morphological forms, first blooming in the N Kattegat, the Skagerrak and adjacent parts of the North Sea in 1998) but it could be found in concentrations of up to 30, 000 cells l^{-1} in May (Bohuskustens Vattenvårdsförbund).

Macroalgae

Details on the distribution and survival of the brown alga *Fucus evanescens* were given in the WGITMO Report 2002 and have been published in an international journal (Wikström *et al.,* 2002).

There have been NO major changes reported for the distribution or abundance of the Japanese brown alga *Sargassum muticum* along the Swedish west coast (the southernmost record of attached plants is still from the middle part of the province of Halland) nor of any of the other introduced macroalgae (*Bonnemaissonia hamifera, Dasya baillouviana, Colpomenia peregrina, Codium fragile,* on the Swedish west coast and *Chara connivens* in the province of Uppland on the Swedish east coast).

The red alga *Dasysiphonia* reported from Norway in 1999 and spreading (see Norwegian National Report), has NOT been recorded in Sweden, although looked for.

Studies are under way to see if there are any active substances in the introduced red alga *Bonnemaissonia hamifera,* as well as in other native red algal species, which can affect settlement and growth of other organisms incl. bacteria. The goal is to elucidate any commercial use incl. antifouling paints (Gunnar Cervin, Göteborg Univ., pers. comm.).

4.0 Live imports during 2002 (for EU countries amounts may be underestimated)

4.1 Fish

For consumption/processing

	Eel from:	Salmon from:	Carp from:
	metric tonnes	**metric tonnes**	**metric tonnes**
Norway	84		
Italy	48		
Denmark	20	1	2
The Netherlands	16		
Germany	3		12
Belgium	2		
U.K.	1		
Finland		9	

Ornamental fish (not specified)

	Freshwater species from:	Marine species from
	metric tonnes	**metric tonnes**
Singapore	16	
The Czech Republic	14	
Israel	7	
Thailand	6	
Brasil	5	
Indonesia	4	2
Sri Lanka	3	1
Colombia	3	
Vietnam	3	
Hong Kong	2	
Denmark	2	
China	1	
Germany	1	
Nigeria	1	
Peru	1	
USA	1	

Live invertebrates for consumption/processing

	Scallops from:	Oysters (*Ostrea* + *Crassostrea)* from:	*Mytilus* from:
	metric tonnes	**metric tonnes**	**metric tonnes**
Norway	169		258
U.K.	51		2
Denmark	11	3	1
USA	6		
Armenia	1		
Belgium	1		
Canada	1		
The Netherlands		15	5
Ireland		10	
France		2	3

	Lobsters from:	*Perna* from:	Various invertebrates from:
	metric tonnes	**metric tonnes**	**metric tonnes**
Canada	137		
USA	16		
The Netherlands	11	1	
Denmark	2	6	1
Germany			1
Indonesia			1

5.0 Live exports during 2002 (for EU countries amounts may be underestimated)

5.1 Fish for consumption/processing

	Eel to:	Rainbow trout to:	Carp to:
	metric tonnes	**metric tonnes**	**metric tonnes**
Denmark	186		1
The Netherlands	101		
Germany	15		
Finland		132	

Ornamental fish (not specified)

	Freshwater species to:	Marine species to
	metric tonnes	**metric tonnes**
Norway	85	4
Finland	4	226
Denmark	2	
Germany		2

5.2 Live invertebrates for consumption/processing

	Mytilus to:	Scallops to:
	metric tonnes	**metric tonnes**
The Netherlands	149	34
Norway	70	
Belgium	41	57
Denmark	41	1
Germany	38	8
Finland	27	1
France	11	
Italy		46
Spain		16
Luxemburg		2
U.K.		1

	Perna to:	Oysters (*Ostrea + Crassostrea)* to:
	metric tonnes	**metric tonnes**
Norway	39	6
Finland		1

7.0 Others on introductions and transfers of marine organisms

Research projects

The Swedish EPA decided in 2002 to start the research programme "AquAliens - Aquatic alien species - where and why will they pose a threat to the ecosystem and economy?" (co-ordinator Prof. Inger Wallentinus, Göteborg university, http://www.aqualiens.tmbl.gu.se). The programme is sceduled to run for five years and is built up on eight different projects distributed among four different universities at: Göteborg (GU), Lund (LU), Stockholm (SU) and Swedish university of Agricultural Sciences (SLU at Uppsala and Umeå) as well as scientists at the National Board of Fisheries (FiV at Öregrund and Drottningholm).

The main emphasis is to develop tools for risk assessment/quantitative analysis (LU) and to use them for the different organism groups and types of waters, including heterogeneity in space and time as well as stochastic events. The programme encompasses different organism groups for which patterns in characters and tolerance ranges for different abiotic variables will be studied, as will the ecological impact of the different species and which types of waters are most vulnerable. Groups included are: Macroalgae in marine and brackish waters (GU), Vascular freshwater plants (SLU at Uppsala), Invertebrates (mainly the pelagic cladoceran *Cercopagis*, SU) and Fish in brackish and freshwater (FiV at Öregrund + SU). The vulnerablitity of different waters will also indirectly include the risks posed by discharges from ballast tanks and dispersal of hull fouling organisms, but the ballast water issue is otherwise not directly addressed. Species of direct economic importance are addressed by one group dealing with freshwater fish used in aquaculture (SLU at Umeå), and another with the impact on American signal crayfish on native crayfish (incl. the parasitic crayfish plague, FiV at Drottningholm). There is also an interdisciplinary aspect including economics (SLU at Uppsala) especially if economics can help in reducing the risks of new introductions. One item of vital concern is also to inform specific target groups (associations as well as local and regional authorites) and the general public of the problems introduced species may cause and to come up with recommendations to reduce the risks, partly in cooperation with museums and organisations.

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THE UNITED KINGDOM, 2002

(Prepared by Ian Laing and Gordon H. Copp)

1.0 Laws and regulations

An extended list of species pertaining to the Import of Live Fish (England and Wales) Act (1980) is expected to take effect in February 2003.

The UK Environment Agency put into place a ban in 2002 on the use of live bait in sport angling. This ban is expected to aid in controlling the spread of non-native fish species in waters of Northern England.

2.0 Deliberate introductions and transfers

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; 250 tonnes were harvested in 2001. There are no reports of recruitment of this species elsewhere. The ormers (*Haliotis tuberculata*) imported from Guernsey to assess the potential for cultivation have performed well at sites in south-west England and there is interest in hatchery rearing some seed from this stock.

3.0 Accidental introductions and transfers

3.1 Fish

Freshwater

Topmouth gudgeon, *Pseudorasbora parva*, a small cyprinid fish originating from Asia, thought to have been first imported to England by an ornamental fish dealer in Hampshire during the mid-1980s has established in several locations across England (Gozlan *et al.,* 2002), and dense populations have recently been discovered in still-water fisheries of Cheshire and Cumbria. These releases are thought to have occurred through the use of the species as live bait.

Sterlet, *Acipenser ruthenus,* and possibly hybrids thereof, of Ponto-Caspian origin have been imported to the UK in recent years mainly for ornamental purposes. A few specimens have been observed in the River Frome (R.E. Gozlan, personal communication), Dorset (southwest England). The probable vector was release by aquarium and/or garden pond enthusiasts who found the fish had reached a size too large to suit their facilities.

Sunbleak, *Leucaspius delineatus*, a Ponto-Caspian species, was intentionally introduced into a still-water fishery in England in 1986 along with some other European fish species, probably for ornamental/aquarium purposes. Sunbleak have subsequently spread in the UK (Farr-Cox *et al.,* 1996), and in particular in southern England. For example, in 2001–2002 they were observed in the upper reaches of the River Test (Hampshire) and the River Stour (Dorset) as well as in a still water in the upper part of the River Frome (Dorset). They have overrun the Somerset Levels, occurring in very high abundance in some still waters (Gozlan *et al.,* 2003). A report in Araujo *et al.* (1999) of *Leuciscus souffia* occurring in the upper Thames estuary has since been put into great doubt, given the species' ecological requirements (upland streams), and was probably a Sunbleak – the two species having generally similar appearance.

Pikeperch, *Stizostedion lucioperca*, has been reported in the Thames catchment for some years since its illegal introduction by anglers to a lake on the upper course of the River Lee, a tributary of the Thames (Kirk *et al.,* 2002). In 2002 at least one specimen was captured during government monitoring surveys.

Wels catfish, *Siluris glanis*, is cited in the recent paper by Kirk *et al.* (2002) as having been recently (1995–2001) observed in the Thames. This species is known also to have established not only in the Thames but also in the River Arun catchment (south coast of England).

3.2 Invertebrates

The slipper limpet is reported to have spread as far north as the Isle of Cumbrae.

The Chinese mitten crab has extended its range (L-F. Herbourg, personal communication), appearing in two Yorkshire rivers (north of England). There are reports of an epidemic of liver fluke amongst those in the Chinese community in London who have consumed raw mitten crabs caught in the Thames. The crab is a carrier for cysts of this pathogenic parasite.

The Japanese colonial sea squirt, *Perophora japonica*, reported as being found in the Fleet lagoon in the report for the 2002 ICES WGITMO and originally recorded in Plymouth (Baldock and Bishop, 2001) was found in Milford Haven for the first time last year. This is the first record for Wales.

3.3 Algae and Higher Plants

A strain of the alga *Alexandrium minutum*, isolated from the Fleet Lagoon, Dorset, has been found to have an unusual toxin profile, new to the UK but similar to that of strains found in South Australia and France.

There is concern over the spread of *Sargassum muticum* into the Menai Strait SAC. The Countryside Council for Wales is considering how to deal with it.

3.4 Parasites, pathogens and other disease agents

An illegal consignment of large carp was intercepted at the Channel Tunnel terminal. The fish, which had been purchased in Belgium, were found to be carrying the killer virus, Spring Viraemia of Carp (SVC). This was the first time this particular strain of the SVC virus (previously found in Moldova) has been identified in the UK. The fish were not allowed to enter the UK and were humanely destroyed.

4.0 Live imports and transfers

4.1 Fish

Imports of rainbow trout eggs into the UK were 66.7 million in 2001 (45.1 million into England and Wales, 21.6 million into Scotland). This represents a slight (4 %) decrease on the total number of eggs imported in 2000 (69.7 million). As in previous years, these came mainly from South Africa, as well as from disease-free sources within ICES boundaries including Denmark, Northern Ireland, and the Isle of Man. There were 63 consignments of live eels imported from Holland (mainly) and France, for human consumption.

Imports of Atlantic salmon eggs into Scotland were 20.6 million in 2001. This represents a four-fold increase over the previous year. These eggs came mainly from Iceland and other EU member states, with smaller quantities from Australia. Scotland also received 2.4 million salmon parr and smolts from other EU member states.

4.2 Invertebrates

The hatchery on Guernsey sent 7 shipments of Pacific oyster seed and two shipments of Manila clam seed to shellfish farm sites in England. One shipment of half-grown Pacific oysters was imported from Ireland, for the first time, for on-growing in the Thames estuary. Three Scottish sites imported Pacific oyster seed from Guernsey and a total of 11 tonnes was re-laid.

Imports of live American/Canadian lobsters, oysters and other bivalve molluscs for human consumption continue. There is a substantial trade in live imports of hard shell clams for human consumption, much of which is transhipped to the near continent, especially France. This activity, together with storage of Canadian lobsters in water at near coastal facilities, is licensed. A report of a large American lobster, caught by a fisherman in the English Channel, appeared in the press. This lobster was named 'Rocky' and placed in a public aquarium in Portsmouth.

5.0 Live exports to ICES member countries

5.1 Fish

In 2001 a total of 11.2 million Atlantic salmon ova were exported from Scotland. Exports to other EU member states decreased by 66 % to 8.5 million. Exports to Chile fell by 73 % to almost two and three quarter million, the lowest level observed. Overall, exports were down by 68 % based on the 2000 figure.

5.2 Invertebrates

Pacific oyster seed were produced in UK hatcheries and 66 consignments were exported to Ireland. Nine consignments of seed *Mytilus edulis* were sent to Guernsey and five to Northern Ireland. One consignment was rejected and returned by the Northern Ireland authorities on the grounds that there was slipper limpet mixed with it. This introduced species is considered to be absent from Northern Ireland.

7.0 Meetings

Research initiatives

In 2002, the UK Government Department of Environment, Food & Rural Affairs (Defra) commissioned the Centre for Environment, Fisheries & Aquaculture Science (CEFAS) to carry out research on the risks and impacts of non-native fishes, primarily freshwater but including diadromous species, leading to the development of a risk assessment framework. This project has taken on an international perspective and has attracted support in the form of a Collaborative Linkage Grant from NATO to examine the use of life history traits as predictors in the risk assessment of non-native freshwater fishes. The commission research includes doctoral studies on the ecological and fish disease impacts of the Sunbleak, supervised jointly by CEFAS, the Centre for Ecology & Hydrology (CEH) and the Hull International Fisheries Institute (HIFI).

A Defra-funded study carried out at the School of Ocean Sciences, University of Wales Bangor investigated sampling in UK ports with a view to detecting and identifying non-native species (UK Compliance with Ballast Water Regulations). Ports sampled included Milford Haven and Cardiff in Wales and also Teesside, Liverpool, Felixstowe and Southampton. No new species were recorded but some quantitative information was collected on the non-natives that were found. Copies of a summary and the final report are on the Defra web site, currently at http://www2.defra.gov.uk/research/Project_Data/More.asp?I=WT06021&SCOPE=0&M=CFO&V=UCWBOS.

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UNITED STATES, March 2003

(Prepared by J. Pederson and G. Ruiz)

1.0 Laws and Regulations

The National Aquatic Invasive Species Act of 2003 was introduced in both the U.S. House of Representatives and the U.S. Senate in March 2003. The bill has several components that are different from the current regulations and international guidance. The bill would require all ships (transoceanic and coastal vessels) to report all ballast water, treatment, and management practices and to install approved ballast technologies on ships built in 2006. All ships would be required to treat ballast water by 2011. It would authorize $170 million to screen new introductions to determine if they would become pests before being introduced. Special provisions of the bill would provide a process for rapid response that is intended to facilitate agency approvals, often a detriment to timely responses. Although this bill was introduced at the last session, it was not acted upon before Congress adjourned and was re-introduced this year.

The U.S. Coast Guard has proposed the following timeline for the Federal Ballast Water Program; there are two phases – a proposed rulemaking phase (approximately 9 months before the final rule) and a final rule: incorporating penalties for not submitting ballast water report form, final rule by fall 2003; mandatory national ballast water management (including ballast water exchange), final rule summer 2004; ballast water treatment standard, final rule by fall 2004; protocol for installation of experimental treatments on board vessels, interim rule in winter 2002.

New laws and regulations on the introduction of marine organisms had the most activity at the state level. Several states have ballast water legislation, (e.g., Great Lake states, Pacific coastal states, and Maryland) making it a challenge for shippers to meet the geographically different requirements. Under current legislation, the U.S. Coast Guard has the authority to enforce mandatory requirements.

The following state regulations on ballast water management that have been enacted are:

Maryland, Ballast Water Regulations enacted July 8, 2002. These regulations: 1) apply to all ships entering Maryland waters regardless of the point of origin; 2) require mandatory reporting; 3) assess a fine of $500; 4) provide for exemption claims for vessels not discharging in Maryland waters; and 5) provide a 6-month "grace" period to first time violators.

Michigan, Determinations for Effective Ballast Water Management, was enacted August 6, 2001. This law has a time frame for assessing whether ballast water management practices are meeting three Great Lakes shipping associations' guidelines. If vessels do not comply, businesses which use them are not eligible for grants, awards or loans.

Oregon, Act to Commence Process of Developing a Ballast Water Management Program (Oregon Revised Statues, Chapter 722), enacted July 2001. This act includes mandatory ballast exchange of vessels prior to entering the Exclusive Economic Zone (EEZ), ballast water exchange of all vessels entering state waters (50°N-40°N latitude) although the distance off shore is not defined.

Rhode Island – Act to Commence Process of Developing a Ballast Water Management Program – report back to General Assembly in 2002 (Rhode Island Statutes, Title 46, Waters and Navigation, Chapter 46-17.3).

Virginia – Ballast Water Discharge Reporting Regulations (VAC 20-395) (enacted 2001). This act covers: 1) voluntary ballast water management guidelines; 2) mandatory filing requirements; and 3) mandatory record keeping requirements.

Washington – Aquaculture Disease Control (including Ballast Water Management and Control) (Chapter 220 –77 WAC); signed into law April 1, 2002. The ballast water programme requires all vessels (including those coming up the coast) over 300 gross tons to report and conduct a ballast water exchange at least 50 miles offshore and all vessels entering the EEZ to exchange before the 200 nm limit. In addition an interim treatment standard is set with a goal of 95% remove/kill zooplankton and 99 % remove/kill plankton and bacteria.

New York – is in the process of proposing legislation requiring sterilization of all discharges by vessels.

California passed a Ballast Water Bill on January 1, 2000. This law will sunset 1 January, 2004 and a report is being prepared to evaluate its effectiveness. A new programme is expected to take its place.

2.0 Deliberate Introductions and Transfers

2.1 Fish

Pterois volitans (Scorpaenidae). The lionfish, *Pterois volitans*, is a common aquarium fish that is associated with reefs in its native range in the Indo-Pacific, western Australia, and Malaysia to southern Japan, south to Lord Howe and throughout Micronesia. As reported previously, it has been deliberately released from aquaria off the coast of Florida. It is a voracious predator, may reproduce, and expand its range and with its venomous spines may decimate native species within the reef system. It has been reported from several popular dive sites off the coast of the southern United States and may have been deliberately released by those in the industry.

2.2 Invertebrates

Commercial shellfish culture is a major source of new non-native introductions and associated pathogens. Species cultured along the Pacific Coast, include the oyster *Crassostrea gigas*, mussel *Mytilus galloprovincialis*, and clam *Tapes* *philippinarum*. Along the Altantic coast the oyster, *Ostrea edulis* was cultured at several sites and continues to be introduced to new embayments. *Haplosporidium nelsoni* is spreading and believed to have been introduced from ballast water. In addition, it may be spread through aquaculture introductions.

A proposed introduction of *Crassostrea ariakensis* into tidal waters of the Chesapeake Bay is being advanced at an experimental scale to further test the performance of these oysters and to evaluate commercial feasibility. The Virginia Seafood Council has developed a plan to grow approximately 1 million oysters among 10 specific commercial shellfish operations in the lower Chesapeake Bay. This plan, which calls for the use of triploid oysters, has undergone 2 panel reviews by the Chesapeake Bay Program and is the focus of a study by the National Research Council. The planned introduction is highly controversial, due to the desire to revive a once-productive oyster fishery in the Chesapeake and the potential risks associated with use of a non-native species (see Appendix 1). The decision and legal authority to proceed resides with the state of Virginia, and it appears the field "trials" of triploid oysters will commence in summer 2003; any oysters used in such trials are to be monitored over time and removed prior to reaching maturity.

3.0 Accidental Introductions and Transfers

3.2 Invertebrates

Atlantic Coast

Alcyonidium sp. This past year (2002) a new bryozoan was observed growing on aquaculture fish pens near the Isle of Shoals and the Coast Guard Pier in New Castle off the coast of New Hampshire. The invading bryozoan, tentatively identified as an *Alcyonidium* sp. seems to be established in New Hampshire but recently has been preyed upon by a native nudibranch leaving only small fragmented colonies over the winter, thus its establishment over the long-term needs to be verified.

Didemnum sp. was a newly described introduction in last year's report. It is aggressively and rapidly spreading and has been observed in New Hampshire subtidally and attached to floating docks.

3.3 Algae and Higher Plants

Undaria pinnatifida (Phaeophyta).Although this is not a new siting, *Undaria pinnatifida* has expanded its range from Southern California to Monterey.

Caulerpa taxifolia (Chlorophyta). Despite aggressive eradication efforts, it is not clear that *C. taxifolia* has been eradicated along the California coast where it was identified last year.

Porphyra suborbiculata (Rhodophyta). *Porphyra suborbiculata* is a red alga that is probably native to the Western Pacific (China and Japan) and found ranging from Mexico, New Zealand and Australia. Using molecular and morphological data, Broom *et al.* (2002) examined the taxonomy of three species of *Porphyra*. Their new reassessment of the taxonomy suggests that *P. lilliputiana* from New Zealand and *P. carolinensis* from North Carolina and Waterford Connecticut (Long Island Sound) were conspecific with *P. suborbiculata* from the Pacific. Ship fouling (of small thalli) was the likely vector.

3.4 Parasites, Pathogens and Other Disease Agents

Responses to this section generally report on the new introductions of pathogens, parasites, or other disease agents, but a recent paper focuses on another aspect of parasitism (in the broadest sense), namely that many introduced species have fewer parasites (or about half the number) in the non-native habitat than in the natural habitats. For example, an animal may have 16 parasites in its native habitat, but often brings less than three to new areas. This may allow them to outcompete native species that carry a heavier parasite load. The authors suggest that parasites may be important in regulating populations and should be examined as control options for managing or controlling invasions.

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Appendix 1 to US National Report

Overview of status and controversy surrounding introduction of the Asian Oyster *Crassostrea ariakensis* in Chesapeake Bay, Virginia, USA
(after Ruiz and Carlton, 2003)

The Chesapeake Bay has historically supported a large commercial oyster fishery, based upon the native oyster *Crassostrea virginica*. Since the late 19th century, production of the native oysters has declined dramatically. Today, the oyster fishery harvest is approximately 1 % of its historical peak. The decline in oyster harvest has had a large economic and social impact in the region, and is also thought to have resulted in major shifts in the foodweb, chemical cycling, and nursery habitats from many organisms (see Kennedy *et al.,* 1998 and references therein for discussion).

The decline in the native oyster population (standing stock) is attributed to a combination of factors, including overfishing, habitat alteration, sedimentation, and diseases (Kennedy *et al.,* 1998). A large effort exists within the region to restore the native oyster population and a viable commercial fishery (Leffler, 2002). It appears that diseases are the primary deterrent to recovery. The native oyster is infected by two protistan parasites, *Haplospordium nelsoni* (MSX) and *Perkinsus* spp. (Dermo), which can cause very high (>90 %) mortality in some years. Both parasites emerged as a major source of mortality in the mid-20th century. The reason for the emergence of both diseases was unclear, and both parasites were new to science when first discovered. More recently, genetic analysis indicates that one of the parasites (MSX) is not native to the region, and was introduced with the Asian oyster *Crassostrea gigas* (Burreson *et al.,* 2000), although this non-native host oyster did not become established.

Simultaneous with current efforts to restore the native oyster, there has been some exploration about the possible use of a non-native oyster to restore an oyster fishery to the region. In the past few years, this effort has focused on another Asian oyster, *Crassostrea ariakensis*. Various lines of research suggest that this oyster could perform well in waters of the Chesapeake, exhibiting relatively high rates of growth and survivorship under local environmental conditions, even when challenged with the local parasites (Calvo *et al.,* 2000).

Based upon these results, a plan to test commercial feasibility of this oyster in Virginia waters is being advanced. The plan calls for introduction of approximately 1 million juvenile oysters for grow-out at multiple sites in the lower

Chesapeake Bay. This plan calls for the use of triploids in the field-based trials to minimize the chances of reproduction and establishment of feral populations.

Various concerns exist about the uncertainty associated with this pilot introduction, as well as the potential for a rapidly expanding population (Thompson, 2001; Chesapeake Bay Programme, 2002, 2003; Leffler, 2002). These concerns are highlighted in a recent review by Leffler (2002) as follows:

- First, the initial plan called for use of triploids created by chemical treatment, whereby a subset of the oysters would remain diploid and others could revert to this state. A revised plan calls for use of mated triploids. Reproduction and population establishment of the oyster, using this approach, is a possibility. Should this occur, no one can predict whether this non-native oyster would affect the native oyster (or other species) through a variety of mechanisms, whether it would have a similar or different functional role compared to the native oyster, and how it may alter the Chesapeake ecosystem. This species appears physiologically capable of spreading outside of the Chesapeake, from New England to the Caribbean. However, little is known about the biology and ecology of *C. ariakensis* in its native range or elsewhere, to provide clues (let alone robust predictions) about the possible consequences of introduction.
- Second, independent of the oyster itself, the possibility of introducing organisms exists. The proponents have followed recommended protocols for intentional introductions of marine organisms (ICES, 1995), including use of at least second- generation organisms that were reared in the laboratory and screened for known pathogens. This approach serves to prevent transfer of many organisms, which are associated with the initial imports. However, the screening is limited to known pathogens, and little is known about this oyster (above). The identity and effects of most microorganisms, some of which are transferred vertically from parent to offspring, remain unknown. Thus, despite these protocols, some microorganisms from the original source are likely to be introduced with *C. ariakensis*. It remains a challenge to assess the potential consequences of such transfers of microorganisms into the Chesapeake.

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Annex 5 National Report of New Zealand (Observer status)

(Prepared by Chad Hewitt)

Summary

In New Zealand the introduction and transfer of marine organisms is managed using the Hazardous Substances and New Organisms Act and the Biosecurity Act. There are over 150 marine species that have been accidentally introduced to New Zealand. The Ministry of Fisheries is implementing a programme of port baseline surveys and targeted surveillance.

Laws and regulations

In New Zealand two pieces of legislation govern the introduction of all non-indigenous organisms. The Hazardous Substances and New Organisms Act 1996 governs the deliberate introduction of new organisms (including genetically modified organisms) using criteria including the effect on the environment. Very few approvals have been given since the Act came into force. The Biosecurity Act 1993 governs all accidental (or illegal) introductions and the deliberate introduction of organisms that are not new to the country.

The Biosecurity Act deals with quarantine inspection at the border, and management of scheduled "unwanted organisms" (pests and diseases) within the country. Under this Act, Import Health Standards (IHS) guide the importation of risk goods. Risk goods cannot be imported if there is no IHS covering them. The definition of "risk goods" includes any organism or substance that it is reasonable to suspect constitutes or contains organisms that may cause harm to natural or physical resources or human health in New Zealand. Ballast water is an example of a risk good. The IHS for ballast water requires that approval is obtained before ballast water is discharged. The main method of gaining approval is by demonstrating that the ballast water has been exchanged en route to New Zealand in an area free from coastal influences, preferably on the high seas. There is also an IHS for ornamental fish and marine invertebrates, which lists permitted species for importation and quarantine requirements.

The Biosecurity Act enables the Ministry of Fisheries to act to prevent the spread of any pest or unwanted organisms. Such actions are directed by the Chief Technical Officer for Marine Biosecurity (CTO), who has statutory powers under the act. The CTO is Dr Chad Hewitt (chad.hewitt@fish.govt.nz).

Deliberate releases

Historically, three species of *Spartina* and quinnat salmon, *Oncorhynchus tshawytscha*, became established after being introduced deliberately to New Zealand. Seven other deliberately introduced species did not become established (Cranfield *et al.,* 1998). Information on recent deliberate introductions is not available.

Accidental Introductions and Transfers

Cranfield *et al.* (1998) reported 148 species that were introduced to New Zealand accidentally. Nearly 70 % of these are thought to have been introduced as hull fouling organisms (Cranfield *et al.,* 1998). Since 1998 there have been a number of additional introduced or cryptogenic species reported. These are listed below. Port baseline surveys currently under way will document any additional introductions. The identification of specimens collected during port surveys is ongoing.

Fishes

Four new species of goby have been discovered in New Zealand. *Arenigobius bifrenatus* (bridled goby) was first reported in 1996. This introduced species is native to Australia. The cryptogenic goby *Favonigobius exquisites* was first discovered in 2001. Another new goby species from northern New Zealand was identified in 2002. This species was provisionally identified as *Acentrogobius* (cf) *pflaumi*, a native to Japan and Korea with small populations (possibly introduced) in NSW, Australia. However, it may be another species, thought to be Australian. Its identity will be confirmed through a research programme on New Zealand gobies. A dart goby *Parioglossus marginalis* was reported from Great Barrier Island in northern New Zealand. The introduction status of this species is unknown.

Invertebrates

Cranfield *et al.* (1998) reported 129 invertebrate species that have been introduced accidentally to New Zealand. Since this report was published the species listed below have been detected.

Charybdis japonica

The swimming crab *Charybdis japonica*, a native of Japan, Korea and Malaysia, was first discovered in New Zealand in 2000. *C. japonica* is currently distributed in estuarine areas east of Auckland in the North Island. The crab is already well established and eradication or containment is not considered feasible.

Didemnum vexillum

In October 2001, an undescribed species of *Didemnum* was reported in large quantities from wharf piles in Whangamata Harbour in the Bay of Plenty. The same species was subsequently discovered covering a barge that was transferred from Whangamata to the Marlborough Sounds (New Zealand's primary marine farming region). This species has since been formally described as *Didemnum vexillum* (Knott 2002) and thought to be a New Zealand native, however continuing controversy exists between taxonomists.

Paracorophium brisbanensis

The corophiid amphipod *Paracorophium brisbanensis* was identified from Tauranga Harbour in 2002 (Stevens *et al.,* 2002). This species was previously recorded only from the eastern coast of Australia and was probably introduced to New Zealand by shipping (Stevens *et al.,* 2002).

Algae

Cranfield *et al.* (1998) identified 19 species of adventive seaweeds in New Zealand. In addition, ***Codium fragile* ssp. *tomentosoides*** was reported from Waitemata Harbour in 1975. Port baseline surveys have detected one new species of introduced alga, ***Dictyota furcellata***. Although this species was previously collected in Manakau Harbour it was not identified until it was also collected from Tauranga Harbour during the port survey in March 2002.

Undaria pinnatifida

Undaria was probably introduced into New Zealand in ballast water in the late 1980s and has since spread around the coast. Given the high costs of attempting to eradicate *Undaria* and the limited success to-date, Central Government's approach to *Undaria* management is to slow its spread around the mainland and reduce the chances of it reaching remote locations such as the Sub-Antarctic and Chatham Islands. This is in addition to other initiatives implemented by a number of regional councils and the aquaculture industry to manage *Undaria* in their areas. On March 2000, a fishing vessel with *Undaria* on its hull sank near a remote New Zealand island. Using the Biosecurity Act, the Ministry of Fisheries ordered the vessel to be moved to reduce the risk of *Undaria* getting from the vessel to the island. Although attempts to salvage the vessel were unsuccessful, the powers of the Biosecurity Act enabled an adaptive management approach to be undertaken whereby a three year monitoring and eradication programme was put in place. This programme appears to have eradicated *Undaria* from the vessel.

Caulerpa taxifolia

In February 2002 *Caulerpa taxifolia* was found in a marine aquarium exhibit at the Auckland Zoo. Molecular analyses indicated that it was closely related to tropical strains of *C. taxifolia* and not any invasive strain. Investigations revealed that the plant was purchased from a local aquarium supply several years previously when "live" (untreated) rocks and corals were imported from tropical locations by the aquarium trade. This practice has since been banned. A survey of other commercial aquariums and retail outlets failed to uncover any additional *C. taxifolia*; however an education programme was implemented to inform marine aquarium enthusiasts of our concerns about the species.

Gymnodinium catenatum

The toxic dinoflagellate *Gymnodinium catenatum* was discovered in New Zealand in May 2000. This species had not previously been recorded in New Zealand.

***Dasya* spp.**

An unknown species of *Dasya* was collected from Nelson during the port survey. It has not yet been determined whether this species is a new introduction or an undescribed native species.

Range Extensions

Port surveys have also reported a significant range extension for *Griffithsia crassiuscula*, and one new locality for *Polysiphonia subtilissima*. *Codium fragile* ssp. *tomentosoides* may have increased its range; however difficulties in distinguishing this species from the native *C. fragile* ssp. *novae-zelandiae* mean that any spread cannot be confirmed until further research is undertaken.

Live Imports

Information was not available.

Live Exports to ICES Member Countries

Information was not available.

Planned Introductions of Introduced Species

Information was not available.

Meetings, Conferences, Symposia or Workshops on Introductions and Transfers

NIMS 2002: the 2nd National Workshop on Marine Biosecurity

The Cawthron Institute hosted the second National Marine Biosecurity Workshop in Nelson on 20–21 March 2002. Dr Andrew Cohen from the San Francisco Estuary Institute gave the keynote address. Other workshop speakers were from the shipping industry, the Ministry of Fisheries, Yachting New Zealand, port companies, regional councils, ocean and coastal law, mussel farmers, commercial divers, and science providers.

In-country activities

Surveys

Baseline surveys

The Ministry of Fisheries (MFish) commissioned baseline surveys of the marine organisms in those ports and marinas where exotic marine species are most likely to arrive. The objective was to identify and record what marine life presently exists at the ports, including exotic species that have already become established. Monitoring will then be able to detect new introductions of exotic marine species to enable a response if necessary. This information will also be used to measure the effectiveness of our border controls.

The ports of Wellington, Nelson, Picton, Timaru, Tauranga, Lyttelton and Taranaki were surveyed over the southern hemisphere summer of 2001–2002. The remaining ports selected (Auckland port and marina, Opua port and marina, Northland port, Whangarei marina, Gisborne, Napier, Otago, and Bluff) are being surveyed this summer. Port surveys are based on the CRIMP protocols.

Targeted surveillance

MFish is also implementing a risk-based surveillance programme for marine pests to enable rapid response to incursions. The surveillance is targeted at the following species, which are likely to establish in New Zealand and have the potential to significantly affect our marine environment:

Asterias amurensis (Northern Pacific seastar)

Caulerpa taxifolia
Carcinus maenas (European shore crab)
Eriocheir sinensis (Chinese mitten crab)
Potamocorbula amurensis (Asian clam)
Sabella spallanzanii (Mediterranean fanworm)

The initial focus is on eight harbours (Whangarei, Waitemata, Tauranga, Wellington, Nelson, Lyttelton, Otago, and Bluff) that have been identified as high-risk on the basis of:

- their past history of invasion;
- current international shipping movements;
- the variety of habitats available; and
- restricted exchange of water with oceanic environments.

Two techniques are being used to refine the sampling programme. Hydrodynamic models simulate where discharged ballast water and the larvae of pest species are most likely to be dispersed to within each harbour. This is combined with detailed information on the distribution of preferred habitats of the target species. The field programme of surveillance began in earnest in October 2002.

Public surveillance network

A public surveillance network (involving the public, recreational divers, marine researchers, marine industry workers (e.g., marine farmers), and other government departments) provides additional monitoring in a broad range of areas. A series of identification guides is being produced and distributed to these groups.

Survey Reports

Progress and final reports will be posted on the Ministry of Fisheries website www.fish.govt.nz.

Technical Reports

The Ministry of Fisheries will publish the results of port baseline surveys and other marine biosecurity research in a technical report series.

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Annex 6 National Report for Italy (Guest status)

(Prepared by Anna Occhipinti)

SUMMARY: The report updates the findings of NIS in Italian marine waters. One new species of fish, five invertebrates and three algae were added to the list. Some of the already established species have enlarged their distribution and ecological research has been performed on various species, particularly, *Caulerpa taxifolia*, *C. racemosa*, *Tapes philippinarum* and *Musculista senhousia*.

1.0 Laws and regulations

The Ministry of Environment has signed a research contract with ICRAM (Central Institute for Marine Environmental Research, Rome) to acquire a data base and other instruments to be used in the implementation of measures to prevent introduction of alien species, in application of the Barcelona Convention - Protocol concerning Specially Protected Areas and Biological Diversity in the Mediterranean.

2.0 Deliberate releases

2.1 Fish

2.2 Invertebrates

The ecological impact of the introduced species *Tapes philippinarum* has been studied in the North Adriatic lagoon of Goro. Bartoli *et al.* (2001) report that benthic fluxes of oxygen uptake and nutrients release are stimulated by the high densities of clams in the lagoon (over 2000 ind. m^{-2}).

Melia *et al.* (2002) describe a model for the oxygen turnover in the lagoon in the areas where the clams are farmed. Densities over 500 ind.·m^{-2} can promote hypoxia (DO<2 mg $O_2 \cdot L^{-1}$) in June and September, while densities over 1000 ind.·m^{-2} determine a chronical hypoxia (minima of DO<1 mg $O_2 \cdot L^{-1}$) during the whole summer.

Preliminary results from Bartoli *et al.* (2002) indicate that the presence of clams stimulate significantly oxygen production, growth and nitrogen content in *Ulva* thalli; this means that farmers should carefully consider the cultivable lagoon surface and the sustainable densities of *Tapes* to prevent macroalgal excessive growth.

The impact of clam fishing on the bottom sediments and benthic community structure has been studied in the Northern Adriatic Lagoon of Marano by experiments using a mechanical dredge (Orel *et al.,* 2002). Sediment resuspension by clam fishing is considered the main cause affecting phytoplankton distribution and composition in the Lagoon of Venice (Facca *et al.,* 2002).

The effects of the environmental stress on *Tapes philippinarum* in the Lagoon of Venice have been assessed by Venier *et al.* (2002) by means of genetic analysis.

3.0 Accidental introductions and transfers

3.1 Fish

An update of the Indopacific and Atlantic immigrant fishes in the Mediterranean has been published (Orsi Relini, 2001) commenting on the recent list by Golani *et al.* (2002) in the CIESM atlas of exotic species.

One specimen of Almaco jack *Seriola rivoliana* has been recorded for the first time in the Mediterranean Sea. It was caught in a purse seine off Lampedusa Island in June 2000 and it is listed as a new alien fish from the Atlantic Ocean (Castriota *et al.,* 2002).

3.2 Invertebrates

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

The tropical Hydroid *Clytia hummelinki* was found along the Calabria and Apulian coasts (Boero *et al.,* 1997) and its population has been increasing since then (Boero, 2002).

Leiochrides australis is a species of Capitellid Polychaete from Australia found on rock bottoms and Posidonia roots in different localities of the Tyrrhenian, Adriatic and Ionian Sea a few years ago (Gravina *et al*., 1996). *Leiochrides* sp. was not included in previous lists of Italian non-native species; in the Mediterranean it had been reported outside Italy, being probably transported by ships.

The Polychaete *Ophryotrocha japonica* was found in 1999 in Ravenna harbour and subsequently in several brackish water sites (Simonini, 2002). It was recently recorded also in the harbours of Ancona and Genova. The population biology, including larval and early benthic stages, has been studied by Simonini and Prevedelli (in press). Until now, outside its native area it has been recorded only in Italy, but it is likely that it has been overlooked, due to its resemblance with other small species.

Chrisallida fisheri (Gastropoda: Pyramidellidae) has been reported for the first time in Italy from the beach of Pescara (Middle Adriatic); the species is common in the Red Sea and Eastern Mediterranean (Mazziotti *et al.,* 2002).

Several individuals of *Aplysia dactylomela* (Gastropoda, Opisthobranchia, Aplysiomorpha) were found in 2002 in the Island of Lampedusa, off Sicily (R. Chemello, personal communication). The species was known in the circumtropical region but it had never been recorded beyond the Canary Islands and Capo Verde Islands.

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

An update of the distribution in the Adriatic Sea of the mass invader bivalves *Anadara inaequivalvis*, *Anadara demiri* and *Musculista senhousia* (Morello *et al.,* in press) showed that the first one is rather stable, notwithstanding annual fluctuations, while the other two species, introduced more recently, are actively expanding. The life cycle, growth rate and secondary production of *Musculista senhousia* in a Lagoon of the Po River Delta are described by Sgro and Mistri (2002) and Dal Zotto and Mistri (2002).

The distribution of the crab *Percnon gibbesi* is expanding outside Sicily towards the Tyrrhenian coasts of Calabria and Sardinia (A. Mojetta, personal communication).

3.3 Algae and Higher Plants

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

Ceramium bisporum (Ceramiales, Rhodophyta), was recorded for the first time in the Mediterranean along the coast of Tuscany (Sartoni and Boddi, 2002).

Batophora sp. (Daycladales, Chlorophyta), found near Taranto (Ionian Sea), is the first record of this genus in the Mediterranean (Bottalico *et al.,* 2002).

Hypnea cornuta (Gigartinales, Rhodophyta), found in the Mar Piccolo of Taranto (Ionian Sea), is the first record in Italy (Cecere and Petrocelli, 2002).

One species is still under debate: *Lomentaria hakodatensis* Yendo, found in Venice and already quoted from various localities of the Mediterranean and the Atlantic. It is questionable if it is a synonim of *L. firma* Zanardini, described earlier from the Adriatic (D. Curiel and M. Cormaci, personal communications).

One species has to be deleted from the Italian list of NIS algae: *Radicilingua thysanorhizans*, as pointed out by Ribera Siguan (2002).

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

Caulerpa racemosa (Caulerpales, Chlorophyta), has expanded in the Adriatic (Otranto and Monopoli: Bottalico *et al.,* 2002), in the Tyrrhenian (Calabria: Cantasano, 2002) and the Ligurian Sea (Cinque Terre: A. Molinari, personal communication).

The studies on the interaction of the two *Caulerpa* species between themselves (Piazzi and Ceccherelli, 2002) and with the native algae (Ceccherelli *et al.,* 2002; Piazzi *et al.*, 2003) and seagrass (Ceccherelli *et al.,* 2001; Ceccherelli and Sechi, 2002) have been continued.

A genetic study on the population of the seagrass *Halophila stipulacea* introduced in Sicily (Procaccini *et al.,* 2001) showed high intra-individual variability and could not detect phylogeographic affinities with the native Red Sea population.

An update of the ecology of introduced algae in the Mediterranean, including a revised list of Italian NIS list has been published (Giaccone, 2001).

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

The study group of the Italian Society of Marine Biology on invasive species has met at Castelsardo (Sardinia) on 6 June 2002 and has set the basis for the preparation of this report.

An historical appraisal of human influence in the introduction of marine algae in the Mediterranean has been published by Giaccone (2002).

The current status of aquatic introductions in Italy (Occhipinti Ambrogi, 2002) is being updated continually: additions and deletions to the list of Italian NIS are proposed by various authors. Inconsistencies with the CIESM Atlas of exotic species are mainly due to the inclusion in this latter of single findings.

During the UNEP expert meeting of the Regional Activity Centre for Specially Protected Areas and biodiversity (RAC/SPA) held in Barcelona on 24–26 October 2002, Italy has contributed to the preparation of the Action Plan concerning species introductions and invasive species in the Mediterranean Sea.

During the CIESM workshop on alien marine organisms introduced by ships in the Mediterranean and Black seas held in Istanbul on 6–9 November 2002, a synthesis of the Northern Adriatic situation has been described by Occhipinti Ambrogi (2002). In the Northern Adriatic mass development of introduced species is very frequent, in relation both to the active ship movements and to environmental stress and this basin is becoming a donor area for further spread towards other areas of the Mediterranean.

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Note: This report is the outcome of a special working group of the Italian Marine Biology Society (SIBM) on a voluntary basis. It does not reflect an official position or knowledge of the relevant Italian Government bodies.

It has been prepared according to the guidelines for ICES WGITMO National Reports; it updates the Italian status presented in Göteborg, March 2002.

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Annex 7 Preamble for Appendices of the Code of Practice

Preamble (to the Appendices of the ICES Code of Practice)

The ICES Code of Practice (COP) on the Introductions and Transfers of Marine Organisms 2002/3 provides the main principles on how to reduce the risks of dispersal and negative impact of intentionally introduced species. The COP includes trade and commercial practice. The printed COP should be used together with the Appendices A–F (available on the internet. Although the COP is not legally binding, it should be used as a precautionary approach, where stricter regulations do not apply in countries involved. Furthermore, the best available scientific information should be used for background information and evaluation of the potential risks. The Appendices A–D should apply to all new introductions and whenever applicable to transferred organisms. They describe what information is needed to evaluate the proposal in order to decrease the potential risks of the species in question.

Annex 8 Appendix A of the Code of Practice—Prospectus

Prospectus
INFORMATION REQUIREMENTS

This information is used to conduct the biological risk review of proposed introductions of marine organisms (see Appendix B). The information provided should be based on a thorough literature review on the life history of the species proposed for introduction, its habitat and its general interactions with other species and potential interactions with species native to the release site. In addition, information on the potential to spread into other sections of the environment is needed. Included in the prospectus should be precautions and a management plan as well as a monitoring plan (Appendix D). The proponent has to design an appropriate monitoring programme that will document impacts in the receiving environment.

The prospectus also needs to include a contingency plan in case immediate eradication of the introduced species needs to be carried out.

Wherever possible, information is to be supported with references from the scientific literature, and notations to personal communications with scientific authorities and fisheries experts. Applications lacking detail may be returned to the proponent for additional material, resulting in a delay in assessing the proposal.

For some proposals, e.g., routine introductions/transfers, the information requirement may be reduced significantly. The regulatory authority of the country and/or WGITMO should be consulted in such cases. It is possible that there may be concurrent proposals taking place or knowledge of a previous attempt in which case this information can be provided and so reduce the time and cost of this part of the project. As introductions are intended to cover a wide range of situations (e.g., aquaculture, fisheries, restoration of habitat, re-introductions of a similar population/species to replace expired populations, genetically modified organisms, biological control) all of the requirements made below will not necessarily apply and additional requirements may be necessary so as to reduce the risk of an unwanted impact and to protect the proponent from not having acted appropriately.

PROSPECTUS OUTLINE

A.1 Executive Summary (to be provided by the proponent)

Provide a brief summary of the document including a description of the proposal, the organism(s) being proposed for introduction, the potential impacts on native species and their habitats and mitigation steps to minimize the potential impacts on native species.

A.2 Introduction

1) Name (common and scientific [taxonomic group, genus and species] and commonly used synonyms) of the organism(s) being proposed for introduction or transfer;
2) Describe the distinguishing characteristics of the organism and how it may be distinguished from similar species in its area of origin and proposed area of introduction. Include a scientific drawing or photograph;
3) Record where the species was introduced previously and describe the ecological effects on the environment of the receiving area (predator, prey, competitor, and/or structural/functional elements of the habitat, mass occurrences);
4) Describe the nature of the planned activities using the candidate species and alternate strategies should the original plan not achieve the expected results;
5) Describe the objectives and rationale for the proposed introduction, including an explanation as to why such an objective cannot be met through the utilization of an indigenous species;
6) What is the geographic area of the proposed introduction? Indicate if the proposed area of introduction also includes contiguous waters that may have suitable habitat. Include a map;
7) Describe the numbers of organisms proposed for introduction (initially, ultimately). Can the project be broken down into different sub-components; if so, how many organisms are involved in each sub-component?
8) Describe the source(s) of the stock (facility) and genetic stock (if known);
9) Briefly describe the quarantine facility for the target species to be introduced (details to be provided under Appendix C).

A.3 Life History Information on the Species to be Introduced or Transferred (For Each Life History Stage)

1) Describe the native range and range changes due to introductions;
2) Describe the physiological tolerances (water quality, temperature, including turbidity, oxygen, and salinity) at each life history stage (from early life history stages to adult, and for reproductive development) including any resting stages. What factors limit the species in its native range?
3) Describe the habitat preferences and tolerances for each life history stage including water depth, substrate types and adaptability to different habitats;
4) Describe the mode(s) of reproduction (including any asexual stages, i.e., fission) and natural triggers and artificial means for conditioning and spawning, or other forms of reproduction. Include duration of the pelagic stages (if present);
5) Describe how the species becomes dispersed and if there is any evidence of local or larger scale seasonal or reproductive migration(s);
6) Describe the feeding methods and food preferences for each life history stage. In case of algae describe the light and nutrient preferences;
7) Describe the growth rate and lifespan and where possible extrapolate likely rates of growth in the introduced area based on information from its native range and where it has become introduced;
8) Describe the known pathogens and parasites of the species or stock including epibionts and endobionts. Are there specific taxonomic groups that pose a risk? Is it a known carrier of pathogens or life history stages of harmful stages? Will it act, in its new environment, as an intermediate host for unwanted species?
9) Are any other species required for the presence of the introduced species to be successful?
10) List nearest populations and indicate why the potential source population is being considered over other sources (e.g., disease-free status of source population).

A.4 Interaction with Native Species

1) What habitat(s) will the introduced species be likely to occupy in the proposed area of introduction?
2) Will it compromise the existence of any protected species/species population?
3) Which native species are likely competitors or have a similar ecological function? Is local extinction of any native species or stocks possible as a result of the proposed introduction?
4) What will the introduced species eat/consume in the receiving environment? Will this predation/consumption cause any adverse impacts on the receiving ecosystem (e.g., impacts of the introduced species on the spawning substrata of local species)?
5) Will the introduced species establish itself in the proposed area of introduction or will annual stocking be required? (This question applies to species in open culture systems);
6) Can the introduced species hybridize with native species?
7) What is the potential for survival and establishment of the introduced species from closed culture systems should it escape?

A.5 Receiving Environment and Contiguous Waterbodies

1) Provide information on the receiving environment and contiguous water bodies such as hydrodynamics, seasonal water temperatures, salinity, turbidity, dissolved oxygen, pH, nutrients, pollutants, substrate and other relevant variables. Do those parameters match the tolerances/preferences of the species to be introduced, including conditions required for reproduction?
2) List species composition (the principal aquatic vertebrates, invertebrates and plants) of the receiving waters;
3) Are any of the species in the receiving environment known to be susceptible to the diseases and parasites found to affect the introduced species in its native range?
4) Describe the natural and/or man-made structures relied upon to prevent or enhance the spread of the introduced organisms to adjacent waters. Include flow rates and direction of flow that might distribute the introduced species;
5) Will the introduction compromise aquatic protected areas?
6) Are there any potential impacts on habitat or water quality as a result of the proposed introduction?

A.6 Precautions and Management Plan

1) Describe the management plan for the proposed introduction or transfer. This should include, but not be restricted to, the following information:
   a) details of the disease certification status of stock to be imported. Include information on stage of introduction (e.g., eggs, sperm, juveniles, etc.);
   b) setting-up of an independent national scientific advisory team;
   c) disease monitoring plan proposed for the introduced stocks following introduction or transfer;
   d) precautions taken to ensure that no unnecessary associated biota accompany the shipment;
   e) who will be permitted to use the proposed species and under what terms and conditions;
   f) the nature of the pilot and pre-commercial phases including a contingency withdrawal plan; (include the implications if nothing is done?)
   g) description of the quality assurance plan for the proposal; and
   h) precautionary measures that need to be met for each phase of development.

2) For closed contained systems, describe the chemical, biophysical and management precautions being taken to prevent accidental escape of any target as well as non-target taxa to recipient ecosystems. Provide details of the water source, effluent destination, effluent treatments, local drainage and proximity to storm sewers, predator control, site security, precautions to prevent escapes (see Appendix C, Quarantine).
3) Describe contingency plans to be followed in the event of an unintentional, accidental or unauthorized liberation of the species from rearing and hatchery facilities or an accidental or unexpected expansion of the range deduced at the pilot or later stages. Also, describe a contingency plan to address the finding of a disease agent of significance (e.g., exotic disease agent to the area of introduction).
4) If this proposal is intended to create a fishery, give details of the objective. Provide a realistic assessment of the socio-economic impact of such a fishery. Give details of a management plan, and, if appropriate, include changes in management plan for species, which will be impacted.

A.7 Business Data

1) Provide the legal name of the owner and company, the aquaculture licence number and the business licence (if applicable) or the name of the government agency or department with a contact name, telephone, fax and e-mail information.
2) Provide realistic indication as to the economic viability of the proposed project, having studied other similar projects.

A.8 References

1) Provide a detailed bibliography of all references cited in the course of the preparation of the Proposal and Appendices.

2) Provide a list of names, including addresses, of scientific authorities and fisheries experts consulted and listed in the information provided.
3) Include taxonomic identification literature.
4) Refer to web-pages and other sources of information for further information (further reading).

Annex 9 Appendix B of the Code of Practice – Risk Review (Draft version developed at 2003 WGITMO meeting)

The spreadsheet below was developed to assist in the review and final assessment of risks associated with introductions and transfers. Each box of the spread-sheet is linked through the numbers (e.g., A.3.6) to the information requested in the information requirement (see Appendix A Prospectus).

WGITMO recommends that the final conclusion of the risk assessor(s) (group of experts to be formed according to the proposal) be presented as a narrative report giving details justifying the conclusions reached.

Based on the information provided by the proponent of the request, the risk assessor(s) can rank the **risk estimate** as:

3 = high probability
2 = medium probability
1 = low probability
0.1 = no data

In addition the quality of the available data is assessed as **uncertainty estimate**:

4 = very certain
3 = reasonably certain
2 = reasonably uncertain
1 = very uncertain
0.1 = no data

Table A9.1. Risk assessment table outlining the risk estimate and the uncertainty estimate (* Number and letter code refers to information requirements of the Prospectus (see Appendix), nis = non-indigenous species).

Assessment parameter	**Risk estimate**	**Uncertainty estimate**
Estimate of probability of the organism successfully colonizing and maintaining a population in the intended area of introduction		
Adequate food resources, A3.6*, A.3.7		
Habitat suitability, A.3.3		
Biotic resistance, A3.9		
Abiotic resistance, A3.2		
Can reproduce, A.3.2, A.4.5		
If organism escapes from the area of introduction, estimate the probability of its spreading		
Ability for dispersion, A2.6, A.3.5		
Estimated range of probable spread, A.2.6, A.3.5		
Human intervention to retard, enhance spread, A.5.4		
Likely areas of further colonization, A.5.5		
Ecological magnitude on native ecosystems both locally and within the drainage basin		
Predation effects on native species, A.4.4		
Prey availability, A.4.4		
Habitat availability, A.4.1		
Does nis enter or alter native habitats, A.4.4, A 5.5		
Does nis affect quantitatively or qualitatively the availability of food for native sp., A.4.4		

Assessment parameter	Risk estimate	Uncertainty estimate
Does nis prey on species of concern, A.4.2		
Genetic impacts on self-sustaining stocks or populations		
Does nis encounter or enter species of concern, A.4.3		
Does nis affect the survival of local species A.4.3, A.4.2		
Does nis affect the reproduction of local species, A.4.2, A4.4, A 4.6		
Does nis affect the genetic characteristics of local stocks, A.4.6		
Probability of establishment estimate of a pathogen or parasite		
Estimate probability that a pathogen or parasite may be introduced and may encounter susceptible organisms or suitable habitats, A.3.8, A.5.3, A5.10		
Ecological impacts on native ecosystem		
Impacts within drainage basin, A.5.1, A.5.2		
Disease outbreak, A.5.3		
Reproductive capacity reduction, A.5.7		
Habitat changes, A.4.4, A.5.7		
Mitigation factors (Note: Risk is lowered if the following are achieved)		
Health inspection certification, A. 6.1 a		
Pre-treatment for parasites, diseases, and parasites, A.6.1a		
Inspection for fellow travellers A.6.1d		
Disinfection prior to discarding water in which organisms arrived, A.6.1.c		
Vaccination, A. 6.1.a		
Disinfection of eggs, A. 6.1.a		
Importation as milt or fertilized eggs only, A. 6.1.a		
Use of quarantine for incoming organisms, (used as broodstock). Release F1 progeny only, provided no pathogens, parasites, or fellow travellers appear (Appendix C)		

Summary and final conclusions (narrative report) to be provided by risk assessor(s).

Annex 10 Appendix C of the Code of Practice – Quarantine

QUARANTINE

Quarantine is the separate holding, rearing, or both, of taxa in a facility or site, under conditions which prevent the escape or other movement of these taxa and associated organisms (i.e., disease agents, pathogens, epi-/endobionts) out of the location. Different periods of quarantine and security level may be required depending on the risk of introducing reportable disease agents or previously undetected disease agents of concern. Although most quarantine systems target only the containment of disease agents and parasites, non-pathogenic epi-/endobionts may also require that a target species is held in quarantine, because such organisms may still pose a threat to the ecosystem. This makes it necessary to keep a target species in quarantine long enough to detect all non-target species, even if no pathogens or disease symptoms are found.

During the quarantine period, the imported/transferred aquatic organisms are held in a quarantine unit. To accomplish this, general principles which apply to all quarantine units for aquatic species are given below. The individual construction and approval of the unit and the length of the quarantine period remain with the operator and the jurisdiction into which the introduction or transfer takes place. The quarantine duration needs to take into account the life history of the imported aquatic organism.

For the operation of an effective quarantine unit, the operators will need to take the topics below into account when constructing and maintaining the quarantine unit.

Effluent and Waste Disposal

All effluent and wastes generated within a quarantine facility should be treated in a manner that effectively destroys all disease agents and associated organisms/taxa. To ensure continuous operation and complete containment, quarantine effluent treatment systems should be equipped with fail-safe backup mechanisms.

Treated effluent and waste may contain substances deleterious to the environment (e.g., active disinfectants). The discharge should therefore be disposed of in a manner that minimizes environmental impact.

A detailed documentation of effluent and solid waste treatment should be prepared, listing the operational personnel responsible for treatments and timing; monitoring of the system to ensure effective operation and act as early warning system for possible failures is useful. Details of the information that should be monitored are provided below (under heading Record Keeping).

Physical Separation

Quarantine for aquatic organisms requires that the imported/transferred organisms are separated from other organisms in a system to ensure containment of animals and disease agents, to prevent entry by birds and other animals, to prevent entry by unauthorised personnel, and to prevent disease agents and contaminants from entering the quarantine unit.

Personnel

Access to a quarantine facility should be restricted to trained, authorised personnel. Footwear, hands, and any material used within the facility need to be disinfected (presented below under heading Disinfection) before exit from the facility.

Equipment

Upon receipt, all life-stages, tanks, water, shipping containers, and equipment in contact with the imported species—including the transport vehicles—should be handled to ensure that there is no escape of the individuals or associated disease agents and/or fellow travellers from the facility. All shipping and packing material should be disinfected or burned.

All equipment and supplies used within a quarantine facility should be disinfected in a manner that will effectively destroy disease agents before removal from quarantine.

Mortalities and Disposal

Daily records of mortalities should be maintained and be available for inspection, where required.

All mortalities should be kept on site. No mortalities, body parts or shells should be discarded without approved treatment to ensure complete disinfection. Heat treatment such as autoclaving or chemical sterilization can be employed.

The cause of mortalities should be determined in a timely manner by a veterinary practitioner or laboratory trained to investigate diseases and parasites of the imported aquatic organism.

Inspection and Testing

Regular inspections for reportable disease agents should be carried out. If a reportable disease agent, or previously undetected disease agent, is identified in any life-history stage of animals in a quarantine facility, actions necessary to control the disease should be taken. These actions may include destruction of all animals in the facility and disinfection of the facility.

Following removal of all life stages of the taxon from the quarantine facility, further monitoring and testing of the aquatic organisms for reportable disease agents or non-pathogenic epi-/endobionts and imposition of additional restrictions is recommended. As outlined in the ICES Code of Practice, "only progeny of the introduced species may be transported into the natural environment" and then only under certain conditions.

Duration

The required duration of quarantine will vary according to the aquatic taxon, seasonality of pathogens of concern, rearing conditions, and reason for quarantine containment.

RECORD KEEPING

All quarantine and isolation facilities and sites should maintain accurate records of the following:

- entry/exit times of personnel, all of whom should have authorization for access;
- numbers of mortalities and method of storage or disposal;
- effluent and/or influent treatments and monitoring of residuals;
- sample submissions to a laboratory to test for diseases and parasites of the imported organisms as well as for non-pathogenic epi-/endobionts; and
- any abnormal conditions affecting quarantine/isolation operations (power outages, building damage, serious weather conditions, etc.).

DISINFECTION

The general principles pertaining to disinfection of aquaculture facilities (hatcheries, holding facilities, land-based ponds, etc.) involve the application of treatments in sufficient concentrations, and for sufficient periods of time, to kill all harmful organisms which otherwise would gain access to surrounding aquatic ecosystems. Since the inherent toxicity of disinfectants prohibits safe use in open-water or in flow-through systems, disinfection can only be applied with reasonable control within hatcheries, tank or isolated pond-holding facilities. It is recommended that all disinfectants be neutralised before release into the surrounding environment and facilities based on seawater deal with the residual oxidants produced during chemical disinfection.

The disinfectants and concentrations should be based on complete seawater sterilization and are applicable to routine disinfection for facility maintenance, as well as quarantine disinfection.

In case of an emergency such as the finding of an imported disease agent or parasite, sufficient disinfectant should be available to enable a treatment of the entire facility.

The World Animal Health Organization (Office International des Epizooties) has provided information on the disinfection of fish farms (see: International Aquatic Animal Health Code, 2002, Office International des Epizooties 2002 - www.oie.int).

A model for quarantine for both freshwater and marine systems can be found in the Australian AQIS system. (The import conditions for live fish may be found on www.aqis.gov.au/icon).

Annex 11 Appendix D of the Code of Practice – Monitoring

Monitoring

This Appendix is aimed at the proponent of the project. In previous projects reviewed by WGITMO (e.g., *Porphyra* sp. introduced from Japan to the State of Maine to produce "nori"), the proponent supplied the WG with information on the introduction for several years. Monitoring, as described below, allows the commercial, research and other use of non-indigenous species in as safe a way as possible while ensuring that measures can be taken if the imported species appears to have a significant negative impact in the area of introduction.

Reports should be prepared prior to release (the baseline survey), after the pilot phase (usually 1 year), and annually for several years after the introduction. One of the final products of the monitoring programme should be a predictive model that describes the long-term ecosystem impacts. The monitoring should be increased in scale to accommodate future expansion.

The purpose of the monitoring programme is to verify that the introduction is performing according to the proposed prospectus for release of the organism. Thus, the monitoring should address issues related to three separate phases during the introduction process: 1) a "baseline" survey which includes information from survey(s) undertaken prior to the beginning of the introduction, especially if field data are not available; 2) monitoring during pilot phase release; and 3) subsequent monitoring. The key to the monitoring programme is to identify relevant elements and key indicators to provide verification that the predictions in the prospectus are correct.

The monitoring schedule depends upon the life cycle of the organism and its abilities to spread. A pre-baseline survey should include relevant information and be supplemented where possible with data from the receiving environment. The following approach is adapted from Managing Troubled Waters, the Role of Marine Environmental Monitoring, National Research Council, Washington, D.C. published in 1990 that can serve as a model for developing the monitoring plan. The purpose of the monitoring programme is to establish a pre-baseline survey of relevant components, a monitoring activity during the pilot phase to evaluate deviations from the expected responses, and a subsequent monitoring programme to evaluate long-term changes.

The monitoring plan should be focused on the resources at risk. This information should have been included in the Prospectus (Appendix A). Information on select species most likely to be impacted (e.g., prey, competitors, potential species for hybridization) and/or potential physical alterations (seasonal changes in currents, light, etc.) should be part of the pre-baseline survey. These data should be included in the subsequent two phases to evaluate that the predictions were accurate.

The proponent should develop a conceptual model appropriate to each pilot project (e.g., use the *Patinopecten yessoensis* in Appendix F of the Code of Practice as an example) and highlight the issues of concern with an endpoint of acceptability or unacceptability; see Box 1 below for some examples. The monitoring plan should include caution levels and warning levels based on the information given in Appendix A of the Code of Practice. Caution levels are deviations from predicted behaviours of the introduced species and may require additional evaluations or additional monitoring. Warning levels are higher levels of concern and should result in a focused study to evaluate the likelihood of not meeting expectations outlined in the prospectus. Caution and warning levels should derive from the risk assessment and be identified in the prospectus.

A caution level recognized during the monitoring phase may result in the need for additional studies to be carried out, with acceptable results, before the next stage of the introduction into the environment is acceptable. A warning level or a decision from the regulatory agencies in the importing country may discontinue the project. If issues are satisfactorily addressed, the project may proceed to the next step (e.g., further releases, or expansion of the project). Issues that may trigger caution/warning levels and respective mitigation action include:

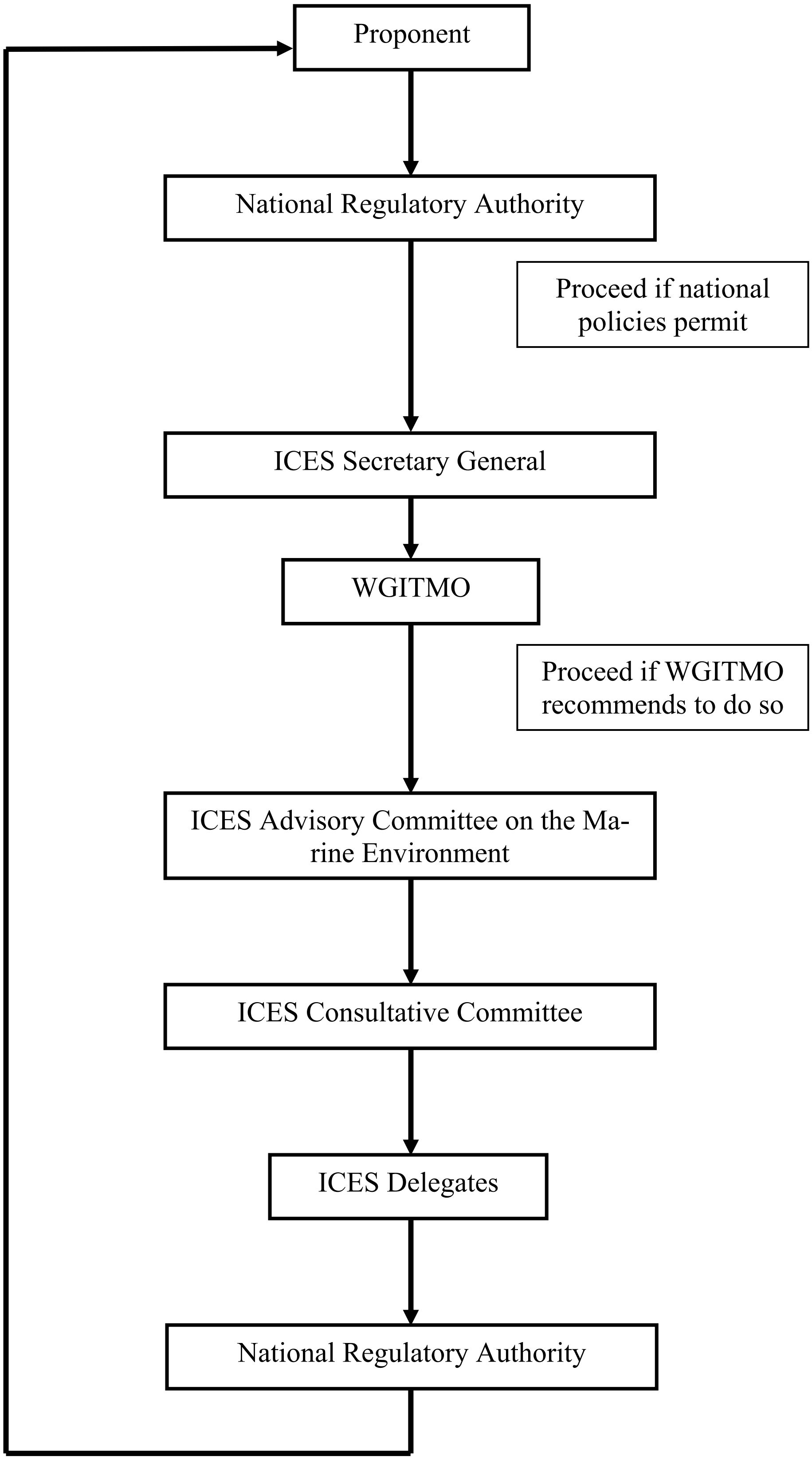
1. Establishment in nearby areas (if not acceptable within prospectus): the requirement is to monitor nearby areas at an appropriate time frame after reproduction and/or dispersal by fragmentation;
2. Competition with other species for resources (e.g., food/habitat): Initiate the laboratory studies needed (e.g., recirculating tank studies to examine behaviour, stomach contents and habitat preferences of juveniles and adults);
3. Unanticipated spread of pests and diseases: Depending on the type of pathogen detected and the stage of the introduction, the proponent should gather information on the presence of pathogens in the source population;

4. Mass mortalities: Because mass mortalities may be related to cultivation practices, the culture practice itself should be self-monitoring and part of the pilot project proposal. If mass mortalities occur, they should be examined for pathogens, pest, and diseases to ensure that new pests and diseases are not being unintentionally released;
5. Evidence for hybridization: The proponent should initiate monitoring of reproductive and early juvenile periods of native and introduced species in the laboratory and field to check for evidence of hybridization;
6. The proponent should gather evidence of establishment outside the known tolerance levels as based on known physiological information (taken from initial prospectus). Gather data on environmental conditions and re-evaluate the risk assessment.

Box 1: Negative hypotheses that may aid direction for monitoring of an introduction.

1. The expected growth is not realised and so the species is unlikely to be profitably used.
2. The species appears outside intended area of introduction.
3. The species will significantly alter normal trophic pathways.
4. The substratum will be altered.
5. The species becomes elusive to capture.
6. The species is susceptible to native parasites, pests and/or diseases.
7. The species is readily consumed by native predators.
8. Reproductive development is not synchronised.
9. Species is prone to translocation by natural vectors (i.e., storms).
10. The species acts as an intermediary host for a pathogen/pest.
11. Consumers do not wish to purchase the intended product.

Annex 12 Appendix E of the Code of Practice – Flowchart



A CASE HISTORY OF THE INTRODUCTION OF THE JAPANESE SCALLOP FROM JAPAN TO IRELAND USING THE ICES CODE OF PRACTICE ON THE INTRODUCTIONS AND TRANSFERS OF MARINE ORGANISMS

Introduction

The Japanese scallop, *Patinopecten yessoensis* (Jay), was introduced to Ireland following requests by an Irish fish and shellfish processor, the promoter, to cultivate the species on the southeast coast of Ireland. The earliest discussions took place in late 1988 at which time it was agreed to follow the procedure set forth in the revised ICES Code of Practice of 1988. The use of the Code was rigorously tested by Irish Department of the Marine (DOM) and by the ICES Working Group on the Introduction and Transfers of Marine Organisms (WGITMO) and was subsequently modified based on the experience of this introduction. Two meetings of WGITMO in 1989 and 1990 were required before the modified project was deemed acceptable by ICES for the project to proceed. Progress reports were submitted at following annual meetings of the WGITMO and continued until 1994.

This contribution consists of two chapters A, the Management of the introduction of the Japanese Scallop from Japan to Ireland and B, the Scientific Assessments.

Chapter A

MANAGEMENT OF THE INTRODUCTION OF THE JAPANESE SCALLOP FROM JAPAN TO IRELAND

1988–1989: Initial Discussions

In early 1989 a leading processor of fish and shellfish, the promoter, made a formal request for developing a Japanese scallop (*Patinopecten yessoensis*) aquaculture business on the Irish Coast. The project was first discussed with scientists of the Irish Department of the Marine (DOM), in November 1988, at which time the ICES Code of Practice was adopted as the protocol for proceeding with the proposed introduction. The promoter's initial plan was to introduce spat for direct release into the sea at a later stage following clearance from pathogens and parasites. However, the Code does not permit the release of the original broodstock imported. The spat would need to be cultured to maturity to produce an F1 progeny, which then could be released, and only if no parasites or pathogens were associated with this F1 generation. Thus, based on the Code, the initial proposal to introduce spat following a short period of quarantine was rejected by the Irish Minister for the Marine, on the advice of the scientists examining the proposal.

A further proposal based on the introduction of hatchery-reared eyed umbonate larvae (the stage before settlement) to quarantine, which at a subsequent time could be released to culture in the sea, was discussed. There was uncertainty about whether this would be permissible, because the larvae could be classified as the original import (i.e., comparable to brood stock) being released to the sea. This proposal was based on what had become at this time standard practice for the international transmission of the eyed umbonate larvae of the Japanese oyster, *Crassostrea gigas*. Thus, the principle of transferring eyed oysters had already been established but the Irish DOM considered this an unacceptable approach for *P. yessoensis* unless these were to be used as broodstock.

The ICES Secretary General was informed about the intended project to introduce the Japanese scallop to Ireland and the DOM sought the advice on this matter through the Working Group on Introductions and Transfers of Marine Organisms (WGITMO).

1989

At the WGITMO meeting in Dublin in May 1989, the planned introduction of *P. yessoensis* to Ireland was described. A presentation was made by the promoter as to the reason for the introduction, based on economic projections and known ease of culture. The following documents were provided in advance of the meeting:

- Status report on the Japanese scallop, *Patinopecten yessoensis* (Jay), with reference to the Proposal for introduction into Irish waters: with a review of its biology, culture techniques and possible consequences of introduction.
- Information relating to the biology, fisheries and cultivation of scallops, together with supporting documentation on the species to be introduced and for the biology of the native scallop and inspection and certification requirements to evaluate the potential risk of introducing unwanted pathogens.

The WGITMO members wished to discuss the project further with their national experts before commenting, but did not oppose the introduction of adult broodstock to Irish waters provided that the correct quarantine measures were adhered to. A number of questions were raised:

1. Unexplained mass mortalities of scallops in culture in Japan
2. Genetic risk to native commercial scallops
3. Possible competition with other scallops
4. Possible introduction of other organisms with the scallops
5. Would Japanese scallops thrive in Irish waters?
6. Would Japanese scallops become established outside Irish waters?

These questions required further consideration and the DOM endeavoured to answer these questions for the 1990 WGITMO meeting. A study visit to Japan to address these areas of concern took place in advance of the 1990 meeting and at the expense of the promoter.

1990 Assessing Information

In January–March 1990, letters of concern relating to the introduction were published in Irish national newspapers. A United Kingdom agency sought further clarification about the importation. The DOM endeavoured to collate further relevant literature and carry out a risk assessment of such an introduction that included a study visit, by DOM staff, in Japan in March–April 1990. At the same time, a quarantine facility was constructed under the supervision of the DOM by the promoter.

At the June 1990 WGITMO meeting in Halifax, Canada, additional support for information already presented in 1989 and from the study-visit in Japan was presented to address the concerns endorsed by the ICES Council.

In addition further presentations included statements on the layout of the quarantine facility, procedures to be employed at this facility, health certification of the source facility, histological studies, and administrative matters and policy.

Following two days of discussion, WGITMO reported to the ICES Council (ICES, 1991):

The Department of the Marine, Ireland, has submitted to the Council a request for advice on the introduction of Japanese scallops, Patinopecten yessoensis*, to open waters of Ireland. Steps outlined in the ICES Revised Code of Practice have been followed meticulously by the Department. The following advice is offered by the Working Group to go forward to Council:*

The Working Group,

(1) does not oppose the continued development of Patinopecten *culture in Ireland, in the form of field trials that would assess their survival, growth, and gametogenesis in open waters pending verification of a pathogen-free F1 progeny and hatchery brood, including the stock destined for open release.*

(2) finds that upon careful examination of available scientific evidence assembled by Ireland, commercial-scale development of Patinopecten yessoensis *populations in the open sea will very likely lead to the establishment of natural (wild) populations and possibly their eventual (albeit slow) spread,*

(3) urges that Ireland should provide to the Working Group annual records of release sites, dates, and numbers as part of their national report, and carefully monitor the occurrence, extent, micro habitats, health and concomitant ecological relationships, if any, with native biota, of wild populations if such become established (with a particular focus on any competitive interactions with the native scallops).

While the appraisal of the proposal was in progress, the DOM permitted the importation of the first broodstock consignment to the quarantine facility in April 1990. This was on the understanding that these, and their progeny, would remain in quarantine until such time as definitive advice on the overall proposal was received from ICES. It was necessary to import the broodstock at this time (their normal reproductive period), so that larvae could be produced at the quarantine facility because otherwise the project would be delayed a year. ICES, following the 1990 Statutory Meeting, informed DOM that they did not oppose the development of field trials subject to the condition that there would be status reports of the project presented to the WGITMO for review.

1991 Summary of Report to WGITMO

The main points in the status report submitted to the WGITMO in June 1991 were:

- Histological studies, using 150 Japanese scallops produced in each batch of scallops at the quarantine facility, in the spring of 1990, showed no indication of disease or parasitic organisms. The scallops in quarantine were then released to the wild in pearl nets on longlines.
- Comparative growth between the native scallop *Pecten maximus* and the Japanese scallop, *P. yessoensis,* of the 1990 year-class took place in pearl nets at the longline site at varying densities 20:40:80:160 per pearl net. Both species suffered shell distortions and interrupted growth and had high mortalities (about 90%). There was poor growth with dense fouling of pearl nets from hydroids, tube-building amphipods, sponges, and bryozoa. Some native scallop *Aequipecten opercularis* had settled on the outside of the pearl nets.
- Japanese scallops of the 1990 spawning, released to the sea, did not show any indication of reproductive development.
- Twenty males and 51 female broodstock of *P. yessoensis* were imported in March 1991 from the same source as the previous broodstock. These spawned and produced a settlement after 20–28 days; the higher survival and reduced larval period indicated a better condition than in 1990.

1992 Summary of Report to WGITMO

The 1992 report was as follows:

Three introductions of adult broodstock were brought into quarantine under the supervision of the Department of the Marine. Scallops were released from quarantine in September 1990 and were held in hanging culture near Carnsore Point on the south-east coast alongside native scallops (Pecten maximus). *Of this year class, 118 remain. Samples of these animals taken in April did not show any pathological condition or parasite loading.*

In March 1991 the quarantine facility was re-opened in advance of receiving 20 male and 51 female broodstock. The adults came from Utatsu Bay in Miyagi Prefecture, Japan - the same source as the 1990 introduction. There were five spawnings over a twenty-day period during March and April. All adults, after spawnings, were destroyed. Settlement of larvae took place 20–28 days after spawnings. In June there were noticeable mortalities of spat following strong south-easterly winds that caused large amounts of algal debris to accumulate on the shore close to the sea water intake. At this time scallop mortalities were high and the rate of growth declined. There was a Vibrio infection of the mantle margin and all spat were then destroyed. On no occasion did scallops from the 1991 year-class leave quarantine.

There will be no importation of broodstock in 1992.

In 1994 the project was terminated, the longline holding the F1 broodstock was torn from its moorings in a storm. The longline was recovered but all of the scallops were dead.

Although the project ultimately failed, given different circumstances it could have been successful. The onshore quarantine laboratory was made secure in advance of any consignments. Adult broodstock were imported close to breeding condition. Sufficient numbers of F1 individuals were produced, but their subsequent culture in the sea on completion of quarantine requirements took place in an exposed area on the insistence of the promoter. On account of the exposed culture site, there was entanglement and fouling of the longline system and shell overlapping that resulted in high mortality. Servicing of the cultures could only take place when the sea-state was suitable, limiting the possibilities for practical management. Despite these difficulties, the procedure adopting the ICES Code of Practice was successfully carried out.

Chapter B

SCIENTIFIC ASSESSMENTS

The ultimate objective of introducing the Japanese scallop *Patinopecten yessoensis* to Irish waters was to develop commercial hanging culture. Initially its survival and growth in a pilot culture scheme would be compared with that of *Pecten maximus*, the main commercial scallop species in Ireland, to determine whether the imported species was suitable for large-scale culture. Sites on the south and west coasts were selected for possible ongrowing following quarantine. All parent *P. yessoensis* were introduced to a quarantine facility on the Southeast coast of Ireland, under the supervision of the Irish Department of the Marine.

Introductions of larvae from Japan, intended to eventually act as broodstock, did not survive. Importations of adults took place in April 1990 and March 1991. These were spawned and the subsequent F1 generations settled. All adults were destroyed following spawning. The young scallops remained in quarantine until the F1 generation of the 1990 importation was released to the sea in September 1990. Those spat produced in the quarantine laboratory in 1991 were destroyed following a large mortality during a period of poor water quality. The surviving 2,500 spat of the 1990 spawning were to form the basis of a parental broodstock on which the project would depend.

The main contents of this document were presented to the Working Group on Introductions and Transfers of Marine Organisms to address their concerns and subsequently by the Mariculture Committee of the International Council for the Exploration of the Sea (ICES) at 1989 meetings. Subsequent developments were reported in the following year. The report was based on studies of the literature, a visit to Japan (to meet with biologists, oceanographers, pathologists and fishermen) and correspondence with internationally recognised scallop biologists, affiliated with the International Pectinid Workshop.

Scallops were sourced from Onagawa Bay, NE Honshu Island in Japan. Here the annual sea temperatures range from approximately 6–22°C.Temperatures at the depths of culture range from 6–20 °C, with cooler and warmer temperatures inshore in winter and summer, respectively (Misu, 1990; Arimoto, 1977).

IMPACT HYPOTHESES (taken from the original assessment)

1. THAT JAPANESE SCALLOPS COULD BECOME ESTABLISHED OUTSIDE IRISH WATERS.

The scallops are to be cultivated in intensive hanging culture. Their growth and reproductive development will be monitored based on spat released from quarantine. The project will proceed on a pilot programme in advance of becoming a commercial production with an option of withdrawing all cultivated scallops should any significant and negative effect be predicted or determined.

Japanese scallops, once mature, have the capability of spawning and small initial releases, on account of the small numbers held in captivity, would provide a small inoculum with a low probability of the species becoming established. This is because the moderate to strong water currents in the culture area would result in a high degree of dispersal of larvae. Increased production of scallops would undoubtedly increase this risk. In tandem ecological studies, including dredging of areas near the culture site should provide sufficient information on the extension of the cultured population to the wild. Because the conditions in Ireland are suitable for growth and reproduction, it is likely that the species will eventually become established in the wild. It is probable that a large source population is required before the establishment of a wild self-reproducing population becomes likely. The critical size of the source population required is not known, but will depend on local hydrographic conditions. For this reason, a small adult biomass is recommended in pilot studies so that a full evaluation of scallop growth and reproductive development can be undertaken, to ensure that its expectations for culture can be realised. All stock held in the wild were held in cages so that, should any unwanted effects be noted, the stock could be removed.

In Japan the establishment of cultivation in new areas is thought to have produced some recruitment to the natural populations in nearby regions, but this has not been quantified. Larval numbers will clearly be dependent on population size, and in Mutsu Bay a direct relationship between spawning stock biomass and settlement onto collectors has been found to exist. Annual settlements are known to be highly variable in most scallop species, however.

2. THAT JAPANESE SCALLOPS MAY COMPETE WITH NATIVE SCALLOP SPECIES

Pecten maximus ranges from Norway to the Canaries but is exploited from Spain to Norway from the lowest tidal level to depths of 180 m. It is found on all Irish coasts, particularly within shallow bays. *P. maximus* is found on a wide range of sediments, from soft mud to coarse gravels, although there would appear to be a preference for sandy mud (Minchin, 1984). These substrata and greater depth range represent a wider distribution than has been described for the Japanese scallop. Should *P. yessoensis* become established in Irish waters, it is expected that it will overlap the range of *P. maximus*. However, it is unlikely that their ranges would coincide. *A. opercularis* is also found over a wide range of substrata, but is more frequently associated with muds and sands to depths of 46 m (Mason, 1983).

P. maximus and *A. opercularis* coexist in European waters with overlapping ranges without apparent detriment. It is expected that *P. yessoensis* would behave in a similar manner should it become established. The only likely competition is expected to be for food, and this may not be significant when compared with the biomass of other filter-feeding organisms present.

It can be deduced from the Japanese literature that the larvae or settled spat of *P. yessoensis* are unlikely to compete with those of Irish pectinids, because spawning takes place in the early spring. However, there may be competition as juveniles or adults, where its distribution overlaps with that of other scallops, but this is not seen in Japan. Studies in tanks, and in the field, of *P. yessoensis* with European native scallop species would be required to determine the interactions, behaviour, and sediment preferences as juveniles and adults.

3. THAT THE INTRODUCTION OF JAPANESE SCALLOPS MAY RESULT IN THE INTRODUCTION OF OTHER ORGANISMS

In NE Honshu, close to the region of the source population of scallops to be introduced to Ireland, movements of coastal and oceanic water masses into the Bay determine the phytoplankton successions (Hashimoto, 1990). In Hashimoto's study in 1989 dinoflagellates did not consist of more than 1.5% of the marine algal counts. Arimoto (1977), who examined the same bay in 1974 and 1975, did find small numbers of *Prorocentrum micans* in the late summer, and recorded the presence of *Dinophysis ovum* and *D. homunculus var. tripos* during the summer and autumn. DSP has occurred close inshore, and scallops (as well as other species) sampled in the summer of 1976 and 1977 were found to be contaminated (Yasumoto *et al.,* 1978). Seed collection areas that supply the cultivation areas also have problems with DSP contamination. Species found associated with this condition are *Dinophysis fortii* and *D. acuminata*, although *D. norvegica, D. rotundata,* and *D. mitra* were all recorded in southern Hokkaido, in 1989 (Hayashi, 1989; Yasumoto *et al.,* 1978). DSP is known to have occurred in this area since 1976, and there were serious outbreaks over the period 1978-1980 (Ventilla, 1982). This species does not appear to interfere with the growth of scallops, and sales can take place provided that the hepatopancreas, in which the toxin accumulates, is removed. PSP contamination is not known from the Miyagi Prefecture, but is known in Funka Bay, an area that has sent scallops for adult cultivation on the Sanriku coast. The problems in Funka Bay in southern Hokkaido are serious and sales of scallops can be restricted for most of the year. The causative organisms are *Alexandrium (Protogonyaulax) tamarense*, which was first recorded in the autumn of 1988, and *A. catenella* (Hayashi, 1989). Here scallops are contaminated from May to October, and restrictions on sales of fresh meat for some localities can extend for as much as 290 days.

All water was filtered, in the Irish quarantine facility, in stages down to 5 μm and then treated with ultra-violet light before being used within the quarantine facility. Sterilisation of all used water was by means of an injected solution of sodium hypochlorite. Wastewater was contained within a 500 gallon drainage tank which, when filled to a predetermined level, activated a pump. The pump was linked to the hypochlorite injection system. The treated water was then held within a series of tanks at 250 ppm chlorine before being neutralised at the point of discharge. The required treatment to destroy algal cysts is not presently known, but the precautions were considered to be adequate at the time for treatment. The tanks also acted as settlement traps and will have contained particles for longer than the minimum residence time of 4.5 hours.

There is considerable fouling of the shell surface of scallops held in hanging culture (Arakawa, 1990). He describes 45 species that attach to the shell; the same species are likely to be found on the shell surface of scallops. Scrubbing the shells prior to transportation can control the majority of these species.

First described in 1971 in Mutsu Bay in sown scallops was a rhizocephalan-like parasite to become known as *Pectenophilus ornatus* (Nagasawa *et al.,* 1988). This parasite attaches in the region of the gill or adductor muscle and is claimed to impede growth. It is presently widely distributed in Mutsu Bay and is also found on the Sanriku coast. It can infest all scallops in a locality and can result in marketing problems (Elston *et al.,* 1985). This species cannot be transferred to the F1 generation using standard quarantine procedures; all scallop parent stock will be destroyed following spawnings.

Branchial rickettsiales-like infections are known in *P. yessoensis* and *Tapes japonica* and have been implicated in myodegeneration and mortality (Elston, 1986).

Prior to introductions, *P. yessoensis* adults were selected by size and condition, and their shells scrubbed. The consignment was met on arrival at customs by an officer of the Irish Department of the Marine who brought the scallops directly to the awaiting and supervised quarantine facility. Following unpacking, all waste was burned and dead tissues buried in lime. Living scallops, and their remaining epibionts, remained in quarantine. Wastewater was treated by chlorination at 250 ppm with a minimum treatment holding time of 4.5 hours.

Following spawning all eggs were sieved, washed, and separated from adults and their water. The original broodstock was then destroyed and the quarantine facility was operated until such time as the F1 or subsequent generations were devoid of known pathogens and parasites, determined by histology, and were in a healthy condition. These measures were considered sufficient to control and eliminate the risk of an introduction of known pathogens or parasites to the sea.

4. THERE WAS CONCERN OVER THE MASS MORTALITIES OF JAPANESE SCALLOPS IN CULTURE IN JAPAN

There was no evidence of any direct pathological implication in scallop mortalities in Japan. The most likely explanation for these mortalities would appear to have been physiological stress due to over-intensive cultivation. Saito (1984) suggested diseases as being one of a number of possible contributory causes of decreased production in Hokkaido following the dramatic twelve-fold expansion in production over the years 1971 to 1977. During this period, annual production rose from less that 6,000 metric tonnes to 70,000 metric tonnes. No evidence is adduced, however, to support this hypothesis. No further information relating to diseases was available during the 1990 visit to Hokkaido. Although mortalities still occur from time to time, the levels of losses that took place since 1972 have not been repeated. The following possible explanations for high mortality were offered:

- During grading scallops are exposed to the air and prolonged exposure can lead to mortality (Hayashi, 1988).
- Scallops handled during the day in the warmer months, and exposed to the sun, have higher mortalities. At temperatures >20°C, handling is normally avoided (Anon., 1980).
- High-density cultivation has continued to result in high mortality (Querellou, 1975; Ventilla, 1982). Scallops from one region had a deformity and browning of the shell margin and pallial atrophy (Mori, 1975). More recently, mortalities have declined considerably as a result of modified longline systems and reduced culture densities.
- Scallops can be drilled through the shell auricles ("ears") to take a monofilament which is then attached to a vertical array of hanging dropper lines suspended from a horizontal subsurface longline. Incorrectly drilled shells often perish (Sasaki, pers. comm.).
- In warmer waters, abnormal sexual development in scallops of less than one year can take place (Osanai, 1975). Development may be incomplete and so result in only partial spawnings at the normal time followed by partial adsorption of the remaining sexual products. Should scallops be held at a low temperature for insufficient time, they will enter the spawning period without full maturation, and this may explain the presence of sexual products found during summer months (Mori and Osanai, 1977). At higher temperatures, the maintenance of gonadal tissue is greater (Mori, 1975). These conditions impose stresses that may result in mortality, particularly if exposed to additional handling.
- *P. yessoensis* is a cold-water species tolerating temperatures from −2 °C to 21 °C. Once temperatures exceed 21 ° C to 24 °C, physiological stress results in reduced growth and often death.
- There is some indication that poor food availability as well as effects of wave action, termed "vibration" causing shell and soft tissue damage leading to mantle retraction, result in high mortalities (Mori *et al.*, 1974).
- Pseudofeces, waste matter and fouling organisms that descend to the seabed in areas of intensive off-bottom cultivation can result in a high organic loading, particularly in those areas where there is low dispersion and result in oxygen depletion (Anon., 1980). This can lead to losses.

5. THAT JAPANESE SCALLOPS MAY HYBRIDISE WITH COMMERCIALLY IMPORTANT EUROPEAN SCALLOPS

There are no known hybrids between *P. yessoensis* and other scallop species found within its range. These include *Pecten albicans, P. sinensis, Chlamys swiftii, C. farreri nipponensis* (Kijima, pers. comm.). *P. yessoensis* has 19 chromosome pairs, three of which are acrocentric, whereas in *P. maximus* there are the same number of chromosomes but 14 of these are acrocentric (Beaumont and Zouros, 1991). *A. opercularis* has 14 chromosome pairs (Rasotto *et al.,* 1981) or 13 (Beaumont and Gryffydd, 1975). Recombination with European species is very unlikely. In Japan both *P. albicans* and *Chlamys farerri* have 19 chromosome pairs.

The expected spawning period of *P. yessoensis* in Irish waters (March and April) is unlikely to overlap that of *P. maximus*. In many coastal areas of Ireland, spawning of *P. maximus* occurs form May to August (Gibson, 1956), except perhaps on occasions within the Irish Sea where spawning has been recorded over a sea temperature range of 7.2–13.7 ° C (Mason, 1958). *A. opercularis* spawn predominantly in the autumn, with smaller spawning peaks in the early spring and summer (Paul, 1978), mainly outside the anticipated spawning time of *P. yessoensis*. The opportunity to hybridise, should this for some reason be possible, is thereby considerably reduced.

6. THAT JAPANESE SCALLOPS ARE UNLIKELY TO THRIVE IN IRISH CONDITIONS

All indications are that conditions in Ireland are favourable, sea temperature ranges fall within the optimum range for the species, and all likely cultivation areas have appropriate salinities.

In Japan development of the gonad begins once sea temperatures fall below 10 °C, and it is important that at least two months of temperatures below 10 °C are maintained (Matsutani, pers. comm.). Sea temperatures below 10 °C are found about Irish coastal areas, and those regions within shallow bays may be expected to have lower and higher temperatures, more closely corresponding to air temperatures. With a rise in sea temperature spawning commences, and lasts approximately one month with no further subsequent spawning until the following year. This is unlike the native European species, which in Irish waters have a number of spawning periods throughout the year, but principally over the period late spring to autumn. In *P. yessoensis* the time of spawning depends on the geographical locality, those farther north spawning later. Spawning at the southern end of the range, in Miyagi Prefecture, takes place in March/April (Sasaki, pers comm.) and in Posjet Bay in the Russian Federation in late May to August (Golikov and Scarlato, 1970). Expectations of spawning in Ireland would coincide with a steady rise in sea temperature in March/April.

The temperature for optimal growth in *P. yessoensis* is 15 °C and at some localities in Japan the depth of cultivation is adjusted to coincide with these temperatures (Sanders, 1973). Throughout the range of *P. yessoensis* in Japan there is a greater range of sea temperature, −2 °C to 24 °C, but scallops are very unlikely to be exposed to such a range in Irish waters. It is very unlikely that sea temperatures will rise as high in Irish waters even inshore. Lowest sea temperatures in Ireland are probably about 2 °C in shallow bays during periods of sustained cold in late winter. Conditions in Irish waters would appear to be optimal for good growth rates for *P. yessoensis*.

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Annex 14 Directory of Dispersal Vectors of Exotic Species

Vector pathways and the spread of exotic species in the sea

Prepared at the 25th meeting of the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO), Vancouver, Canada, 26–28 March, 2003 by Dan Minchin[1]*, Stephan Gollasch[2] & Inger Wallentinus[3]

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Purpose

This document is intended to review the current state of knowledge concerning vectors of species introductions, provide a brief overview of the potential risks associated with each broad category of vectors and identify significant knowledge gaps. It has evolved arising from discussions of the ICES WGITMO (reports found at http://www.ices.dk/iceswork/wgdetailacme.asp?wg=WGITMO) and the SGBOSV (reports: http://www.ices.dk/iceswork/wgdetailacme.asp?wg=SGBOSV). Although we have a reasonable understanding of the vectors, assigning vector strengths can be difficult and largely depends on local or regional trading activities, and political and socio-economic circumstances. Not all vectors continue to operate and some become more powerful at specific times (e.g., Campbell and Hewitt, 1999). In this account an attempt is made to outline the principal vectors that are likely to result in further non-indigenous species spread including both introductions and transfers. Some vectors may transport fundamentally different sets of organisms (e.g., mussels attached to hull, nestling creatures within the mussel clumps, species encrusting on the mussels, species burrowing into the mussel shells, and pathogens or microalgae inside the mussels); conversely, some species may be spread by several different vectors (e.g., larval mussels may be transported in the plankton in the ballast water; adult mussels as hull foulers; as intentional aquaculture species or as associated species accidentally introduced with stock for culture).

1. Introduction

Introduction vectors are the physical means by which species are transported from one geographic region to another (Carlton, 2001). Numerous natural mechanisms contribute to the spread of species and are important for the maintenance of natural populations. Many of these processes, however, are still not fully understood and may contribute to a secondary natural dispersal of non-indigenous species. With the expansion of human populations worldwide, a further means for organisms to spread their range has now increased. This has enabled species to colonise regions beyond their natural ranges. Their ability to colonise is complicated by the changing circumstances in receiving waters and predicted changes to climate (Carlton, 1996).

The spread of exotic species arises from either an initial or subsequent movements and these may operate separately, in tandem, or in series. An initial movement will involve human-mediated dispersal which consists of the inoculation and survival of a species in a locality within a separate, not previously occupied, biological province (most usually this involves a movement between continents, either carried across oceans or hemispheres). Subsequent movements are those from a locality where an initial release has already formed a temporary or sustained population. The spread from this locality may involve the same vector process or other independent vectors. Some of these vectors may be difficult to deduce correctly. In order to manage the spread of a species, the precise vectors involved in its spread need to be fully understood, as well as the probability (= risk) that the species will be introduced by that vector. Unfortunately, once an initial inoculation has taken place, the subsequent spread may take place relatively rapidly. As the species spreads, an increasing number of opportunities are presented to increase its range further. Once established a species will expand using both natural and anthropogenic vectors. These circumstances of spread will also be modified by the mode of life of the species in transit. The expansions of both the Japanese kelp *Undaria pinnatifida* (Wallentinus, 1999a) and the Asian shore crab *Hemigrapsus penicillatus* (Noel *et al*., 1997; Gollasch, 1999) in Europe are examples of species with expanding ranges undergoing secondary spread.

An exotic species recently established also has the potential to extend its range using the natural processes that spread native species according to life history and morphology. Some algae, although detached, remain reproductively fertile, and those that become detached and can trap air or have gas bladders, such as the brown Japanese seaweed *Sargassum muticum* (Wallentinus, 1999b), or have a prolonged or constant planktonic phase, such as the dinoflagellate *Karenia mikimotoi*, and can be rapidly disseminated by wind and currents. Such a rapid spread has been noted for the buoyant brown alga *Colpomenia peregrina*. In contrast, species that are entirely sedentary, such as the Chinaman's hat limpet, *Calyptraea chinensis*, are unlikely to disperse rapidly because they lack a planktonic stage. Tunicates generally have a short planktonic larval phase and so once established may remain locally distributed if not being carried further by hull fouling. The great majority of species, however, will fall between these extremes and given that conditions are suitable their spread will depend on their planktonic duration, behaviour and reproductive characteristics.

In order to reduce the spread of exotic species, international and national cooperation is needed to identify the vectors and contingency approaches to prevent, manage and control these populations. Unfortunately most precautions evolve once the species introductions are recognised and after they have caused economic, social or environmental impact. Consequently, proactive measures by management (e.g., the prevention of introductions) are more likely to be cost-effective. A fundamental understanding of the relative strengths of vectors and the patterns of species transport is necessary to enable effective management. The opportunities afforded to each species by those vectors may be assisted by further factors, such as a rare weather events or releases to specific habitats or changes in food availability, as in the case of eutrophication.

Historically, aquaculture and stock transfers of fish and shellfish may have resulted in the significant transport of species worldwide. Dry and semi-dry ballast is either rarely used or no longer operates with conventional shipping, whereas historically they almost certainly would have resulted in the spread of some species (e.g., the periwinkle *Littorina littorea* to North America (Carlton, 1992), the stonewort *Chara connivens* to coastal areas of the Baltic Sea as well as several seashore plants in Europe (Wallentinus, 1999c, 2002)). Today, shipping activities are believed to be primarily responsible for the majority of modern species introductions. It is estimated that there are more than 480,000 annual ship movements providing the potential for transporting organisms. Further, 2–3 billion metric tonnes of ships' ballast water is transported annually, carrying as many as 4,000 to 5,000 taxa each day. These vectors, together with others, result in a new introduction forming a new population beyond its natural range about every nine weeks. In Europe there are indications that this may be greater, with about one introduction for every three weeks over the period 1998–2000 (Figures 1 and 2, Appendix I; Minchin and Gollasch, 2002).

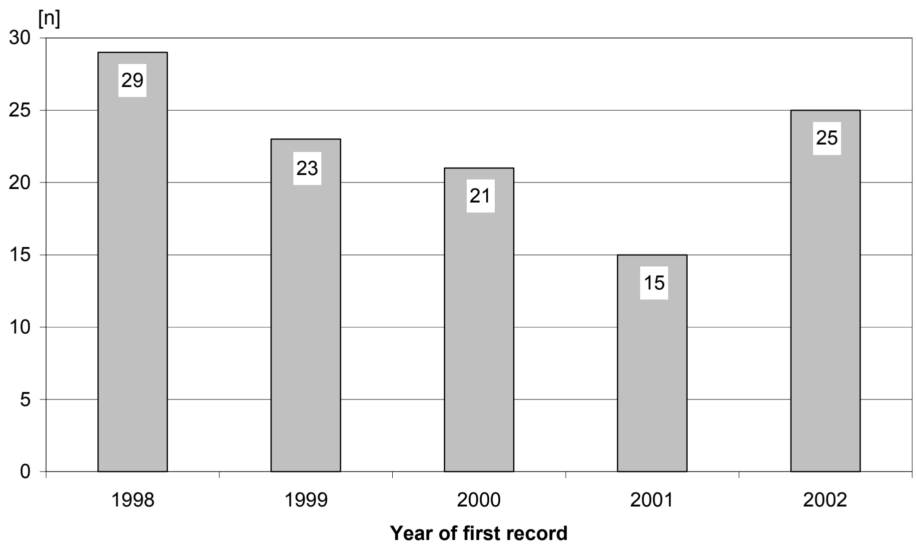

Figure 1. First records of non-indigenous species 1998–2002 world-wide (after SGBOSV and WGITMO Meeting Reports).

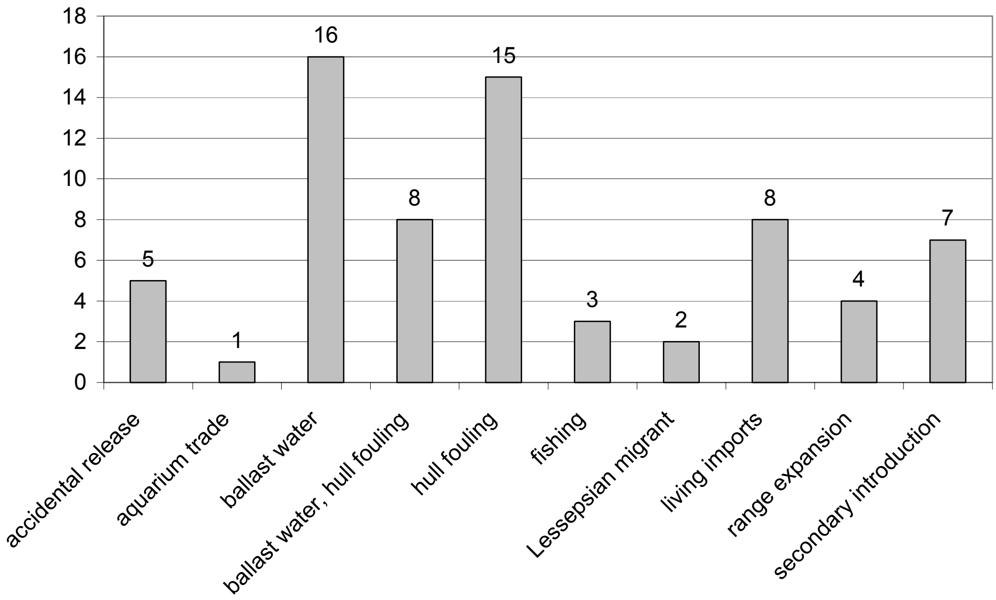

Figure 2. Frequency of first records of non-indigenous species according to likely vector of introduction in 1998–2002 (after SGBOSV and WGITMO Meeting Reports).

2. Vector categories

There are several means of transporting organisms either deliberately or unintentionally (e.g., Carlton, 1988, 1994; Gollasch, 1996; Minchin, 2001). Carlton (2001) has described fifteen main vector categories, Williamson *et al*. (2002) described eight, and Minchin and Gollasch (2002) five. The number of these categories depends on how they are arranged as all accounts take into account a wide range of transmission methods. In this account, seven categories have been defined (Table 1) and some examples of exotic species spread appear in Table 2.

2.1 Ships, moveable structures and other craft

Shipping has been implicated in the transmission of a great number of widely different organisms mainly because of the preponderance of exotic species in port regions and in waterways used by shipping. These organisms include species with either or both planktonic and sessile stages, their epibionts and in all probability their parasites and disease agents. Further, the distribution of micro-organisms by ships may be of importance to the health of some organisms as well as man and, where these impact keystone species, may have significant impacts on habitats. Many unexplained diseases that have taken place worldwide may be associated with ship transmissions.

The conditions that provide succour and enable species to become established are elusive but it must be significant that the majority of species introduced appear to be associated with port regions. The opportunities for species spread in the current decades may have increased because of:

- A greater number of berths in sheltered ports and in estuarine regions, many now situated further downstream to more marine conditions;
- Construction of new berthing regions/ports servicing a specific industry, e.g., exports of graded rock products;
- Overlapping of other activities that may disseminate organisms carried to that region by a primary vector;
- Improvements to water quality in port regions resulting in better conditions for the establishment of those species arriving with ballast water and enabling survival of sufficient numbers to enhance opportunities of their further spread elsewhere;
- Vessels are making more visits to ports; many have shorter journeys;
- Changes in shipping routes result in different volumes of ballast being carried and the volumes transported depend on the nature of the trade. New routes involving one-way transmissions of bulk products may carry elevated risk.

Hulls as a vector: For a long time, before the development of the understanding of biogeography, species will have been carried as either fouling or boring organisms on or in the hulls of vessels used in trade and exploration. Some knowledge of the nature of the species that may have been in transmission at this time is based on the fouling that accumulated on settlement plates attached to the hull of a reconstructed sailing ship from the 16th Century (Carlton and Hodder, 1995). Boring organisms will have been a persistent problem for wooden vessels in these early years of exploration but today, as most vessels have steel hulls, boring organisms are seldom encountered, although some may occur within dense fouling accumulations. Nevertheless, in some world regions there are many wooden craft that are regularly compromised by boring organisms, as in the Indian Ocean (Nagabhushanam and Sarojini, 1997). Generally the fouling and boring biota are managed by aerial exposure, changes in salinity or by applications to the outer hull. For steel hulls applications will also prevent oxidation of the hull and this must be done at varying intervals to maintain the hull and reduce drag. Some structures such as oil rigs are often moved between areas, and when not in service may be held in sheltered bays or fjords. These have the potential to carry large numbers of species that could include exotic species or populations that had become genetically distinct.

When a ship enters dry-dock it is supported on rows of wooden blocks. Although the fouling beneath these blocks is not removed it becomes crushed and so unlikely to survive; but because these areas of the hull cannot be antifouled, when a vessel departs from dry-dock the unpainted area readily develops a fouling community (e.g., Coutts, 1999). Consequently, and irrespective of the antifouling applications used, vessels can develop mature populations of species with a short life cycle soon after arriving back in service. Very often cavities, such as water intake piping, sea-chests and thruster ports may be inadequately cleaned and painted, and projections such as various instruments and crevice areas such as those associated with some rudder designs may be prone to fouling (e.g., Rainer, 1995; Coutts, 1999). Furthermore, species with microscopic life cycle stages, as e.g. gametophytes of the Japanese kelp *Undaria pinnatifida*, only need minute crevices to survive and those gametophytes can even survive on boats out of water for a month (Wallentinus, 1999a). Where in-water hull cleaning takes place, where divers and underwater robots are used to strip hull-attaching organisms, the loosened material will almost certainly contain some viable organisms. When cleaned in dry-dock some of the detached material may be released and may survive.

Many invertebrates and seaweeds, once mature, will respond to changes in temperature by releasing gametes. Such changes in temperature may rapidly take place and promote a profuse spawning. Vessels entering shallow bays may be subjected to abrupt changes in temperature on arrival in port and such changes may occur with unloading of a vessel in thermally stratified water or from diurnal temperature changes (Minchin and Gollasch, 2003). The release of gametes could lead to a formation of a substantial number of zygotes that may form a founder population following the departure of the vessel. Further, as commercial species frequently foul hull surfaces, temperature changes may result in spawning or brood releases of pests and parasites and vertically transmitted diseases and disease agents. Indeed, Howard (1994) implied that the sporozoan disease *Bonamia ostreae* of the flat oyster *Ostrea edulis* may have been carried with oysters that foul barge hulls.

The usage of some antifouling ingredients will create toxic problems particularly for shallow regions with a poor water exchange. In the past toxic effects have been described for copper (e.g., Claisse and Alzieu, 1993), organotin antifoulants (e.g., Lee, 1991) and herbicides used in paints (e.g., Thomas *et al.,* 2001). The discontinuation of organotin biocides in antifouling paints by 2008, developed by IMO, requires that the new generation of paints should be as effective but less toxic to biota. Recent trends in research for developing new types of marine paints have also focussed on natural antifouling substances, such as zosteric acid (Targett, 1997) or halogenated furanones (Denys *et al.,* 1995). Fast moving crafts need to be more efficient in their passage, and for such vessels even small amounts of fouling can result in significant reductions of speed and added usage of fuel. Fouling on slow moving or moored structures does not receive the same attention because such vessels are not required to have the same hydrodynamic performance, and may have a longer interdocking period. For these reasons such structures or crafts are liable to have greater fouling burdens and therefore pose a high risk of exotic species transmission.

Studies on species introductions in Europe (Gollasch, 2002), Australia (Hewitt *et al*., 1999), New Zealand (Cranfield *et al.,* 1998) and USA (Ruiz *et al.,* 1997, 2000; Cohen and Carlton, 1998) suggest that hull fouling continues to be an important means of spreading invasive species. It is seldom possible to be certain of the exact means of transmission, as other possible vectors also need to be evaluated carefully. For example the Japanese kelp *Undaria pinnatifida* has been dispersed unintentionally by both hull fouling and as an epibiont on Japanese oysters, as well as being intentionally introduced to some areas for aquaculture (Wallentinus, 1999a). However, if historical records are included from over a hundred years ago then a large proportion of aquatic species, already introduced, can only have arrived as hull fouling and some with solid ballast.

Solid ballast, ballast water and ballast sediments: Ships to travel safely must be immersed to a specific level to provide better manoeuverability and increased stability by adjusting the amount of ballast on the ship. Vessels carrying cargo will carry small amounts of ballast whereas those without cargo will require greater amounts. Container ships may even add ballast when loading cargo. Historically this involved the use of either sand (including wet sand – semi-dry ballast), gravel and stones, known as solid ballast. In port regions stone ballast was stored in heaps on the shore, known as ballast banks from where it was collected or deposited, and there were regulations to prevent the dumping of solid ballast in ship channels. The loading and unloading of the solid ballast was labour intensive and it was not until the late 1870s that water was extensively used as ballast.

This water is pumped to segregated water tanks distributed along the length of the ship, or in some cases to empty cargo holds. The water is normally taken on board in ports and port regions, inland waterways and in the open ocean. Tanks for holding ballast water will have different configurations according to the ship class and are served by a network of pipes for taking on water and for adjusting water levels between tanks to improve trim. These tanks are filled and drained in different sequences either singly or collectively, according to the loading of cargo (Gollasch, 1996). Consequently the ballast water can be composed of varying salinities and may even be sourced from more than one region and may be subject to either, or both, temperature and salinity stratification. Ballast water when pumped aboard may include a great number and variety of organisms, suspended solids (i.e., sediments) and chemicals and human wastes. The majority of ships take up or discharge at least some ballast water whilst in port and when fully laden some ballast water will remain because most pumps serving ballast tanks are not able to remove all of the water or sediment accumulations.

The volume of ballast water carried can be as much as 30 % of the overall cargo carrying capacity of the ship (Gollasch 1996). The pumping of such large volumes of water takes many hours and has a cost. Consequently, when a vessel undergoes ballast water exchanges at sea, as recommended by the International Maritime Organization (IMO, 1998), the large volumes displaced can result in structural stresses on the hull and any alterations in stability may make it unsafe to undertake such exchanges under certain sea conditions. Three complete changes are recommended to purge >95% of the original ballast water onboard and thereby the biota present, but this may not be sufficient to remove organisms including the resting stages of species that accumulate in the ballast sediments. Currently there are no fully proven sterilisation techniques although several methods, showing various levels of efficacy, are in different stages of development. This presently leaves ballast exchange (i.e., re-ballasting in mid-ocean) as the only current “preventive” management method for controlling the spread of species by ships. Exchanges at sea used to purge and kill organisms are probably most effective when freshwater is exchanged for seawater, or when passing the tropics between two temperate ports.

Planktonic species, including those with short free-living stages, may normally be carried in ships' ballast water. Species that require a substrate to bury within or are otherwise associated with sediments may accumulate in the fine silts to sands within ballast tanks that may be taken on board during ballasting. Although sands are known to occur in ballast tanks, fine sediments are usually suspended in the turbid water in port areas, and following the taking up of ballast settle to form accumulations on the floor of ballast tanks. With the large volumes of water and surface areas available associated with ships, it must be expected that there are many transmissions.

Ballast sampling has provided estimates of about >50,000 zooplankton and 110 million phytoplankton per m^3 (Lenz, *et al*., 2000). In a recent assessment of European ballast studies, there have been approximately 990 species of widely different taxa recorded from the water and sediments of ballast tanks ranging from micro-organisms to fishes (Drake *et al.,* 2001; Gollasch *et al*., 2002). However, the abundance of organisms in ballast tanks is difficult to quantify, because they may not be distributed evenly (Murphy *et al.,* 2002). This may be due to water circulation effects that may cause concentrations. Furthermore, the behaviour of organisms in tanks remains largely unknown. Ballast tank sediments are seldom evenly distributed on the floor of ballast tanks as a result of winnowing effects and often form small drifts against partition walls. The sampling of the soft sediment accumulations has revealed that the cysts of dinoflagellates can occur at densities of 150 to 22,500 cysts/cm^3 of sediment (Hallegraeff and Bolch, 1992). Such cysts as well as resting cells of diatoms can survive very harsh conditions, including anoxia, and can remain viable for ten to twenty or more years (McQuoid *et al*., 2002).

It is difficult to ascribe an invasion as being solely due to a release of ballast water although it would appear that ballast water is almost certainly operating as a vector. Sampling of ballast water is not easily achieved mainly because of problems of access (e.g., Sutton *et al*., 1998; Gollasch *et al*., in press). Yet the evidence is strong because many species known to be capable of invading have been found within ballast tanks (Gollasch *et al*., 2002). It is considered that the large volumes in transmission are likely on some occasions to contain sufficient numbers from which founder populations may evolve (Ruiz, 2002).

Other: Flying craft that land on water also have the capability of transmitting species either as water contained in the pontoons that is subsequently drained or from entanglement. Eno *et al*. (1997) suggested that the red alga *Pikea californica* may have been introduced to the southwest coast of Britain by flying boats originating in California during World War II carried in canvas sea anchors, although other studies have shown this to be less likely (Maggs and Ward, 1996).

Carlton (1979) highlighted this transport mechanism for the introduction of marine species into the inland Salton Sea of California.

2.2 Aquaculture activities

A small number of exotic species contribute to local economies worldwide and further species that have become profitable are likely to be spread in the future. In particular, those species that are highly prized as a food, easily cultivated at high densities, and have a tolerance to changing temperatures and salinities are likely to be favoured for cultivation. However, some biota once introduced can result in serious financial losses (Minchin and Rosenthal, 2002). Should there be stock movements between areas, associated biota may be easily spread. Such movements may be part of current accepted practices.

In particular, the transmission of oysters has resulted in >100 species becoming established in different regions worldwide; examples include the movement of American oysters from Long Island Sound, USA to Britain and Ireland (Minchin, 1996), Pacific oysters from Japan to British Columbia in the early 1900s (Quayle, 1969) both carried as deck cargo and the Pacific oysters flown from Japan to France (Gruet *et al*., 1976). Oysters, because they do not bury in sediments, provide an irregular shell surface in which biota may bore, attach or cryptically hide and close to 50 species of macroalgae have been introduced into Europe as likely epibionts on Japanese oysters (Wallentinus, 2002). Organisms may also be carried in the "liquor" within the mantle cavity or infest or reside within the soft oyster tissues. As stock movements normally are made up of many thousands of individuals, there are adequate opportunities for the spread of any associated biota, particularly when rapid transport will enable the transmission of species that would otherwise expire (Carlton, 1992; Sindermann, 1992; Minchin, 1996). There may be occasions when an industry suffers a serious decline in production following a disease outbreak. Such events may result in importations of disease-resistant stock or of a different species in an attempt to replace this lost production. These circumstances may dictate that a precautionary approach is not adopted and imports consisting of large stocking numbers of several consignments may take place justified by social and political arguments, because a rapid response is needed. A serious potential risk with aquaculture is also the many illegal imports and releases, when imported specimens often are directly placed in the sea and cultured. This not only results in opportunities for the spread of diseases and parasites, but also of epibionts that may pose a threat to the ecosystem. The same ecosystem risks also exist when trade agreements (e.g., EU Directives) allow movement of half-grown shellfish between member states for fattening, with the only requirement they do not come from disease-infested areas.

A large component of the biomass in aquaculture is made up of molluscan species. In the last ten years, several small new parasitic species and unexplained conditions have occurred, and some were associated with elevated temperatures (Myrand and Gaudreault, 1995). Several viruses have also become recognised in recent years (Renault, *et al*., 1994) and occurring in oyster larvae and spat (Nicolas *et al*., 1992; LeDeuff, 1994) and in adult mussels (Jones *et al*., 1996). On the other hand, only one macroalgae (*Undaria pinnatifida*) has been moved in Europe for the purpose of commercial culture (Wallentinus, 2002). Presently, we have less knowledge of the disease organisms carried with seaweeds than for fish and shellfish. Consequently some caution should be exercised when moving seaweeds for culture.

Once a species is successfully cultivated in one world region, it is likely that it will be considered as a suitable candidate for culture elsewhere. This will include those species used for sport fisheries and ornamental species. For example, besides being farmed in cages in many coastal areas, especially in the Baltic Sea, the stocking of rainbow trout *Oncorhynchus mykiss* in lakes, reservoirs and rivers has conferred many advantages for recreational angling throughout much of the world (Lelek, 1996; Löffler, 1996). In many regions these are cultured before their release, as self-sustaining populations may otherwise not take place. Exotic salmonids held in cages in the sea could escape to compete for food or breeding space or may interbreed with different populations. Unless sufficient numbers become released, as in the case of escapes from storm damage, the impacts from such competition may be minimal, unless they carry and spread pests, parasites and diseases. In British Columbia, farmed Atlantic salmon *Salmo salar* escapees show evidence of breeding in one river (Volpe *et al*., 2000).

2.3 Wild fisheries

The development of new fisheries takes place not only in temperate to tropical environments but also in much colder seas. The release of the red king crab *Paralithodes camtschaticus* in Russia in the 1960s resulted in its establishment and expansion to the north coast of Norway (Petryashov *et al*., 2002). Its spread has been aided by both planktonic dispersal of its larvae and by walking juveniles and adults. Dispersal of adults may also result in the spreading of sessile organisms attaching to its carapace. Fishes are likely species to become widely distributed. The rearing of pink salmon *Oncorhynchus gorbuscha* in Russia resulted in vagrants spreading south to Atlantic coasts (Petryashov *et al*., 2002).

Some organisms are readily spread through a trading network that has existed for several decades, and trade in captured live species for human consumption such as the American lobster *Homarus americanus*. American lobsters have been found in several regions in the wild in northern Europe; their presence is thought to have been due to deliberate releases. Some species may be spread because of ethnic food preferences, as may have been the case of the appearance of *Rapana venosa* in France (Goulletquer *et al.,* 2002). Unauthorised imports of live food may also take place as in the case of the Chinese mitten crab *Eriocheir sinensis* that is intercepted at airports in the United States (Carlton, 2001). Many species are available for purchase over the internet and there is good reason to increase public awareness to reduce the risk from such sources.

Secondary spread of species may be enhanced by fishing activities. The expansion of the tropical green alga *Caulerpa taxifolia* in the Mediterranean Sea, where plant fragments were removed by anchors and fishing gear and subsequently were distributed elsewhere (e.g., Relini *et al*., 1998), is likely to continue.

Agreements that involve trading blocks do not usually consider the associated biota that may accompany this trade. This is because restrictions on a product may compromise the trading activity. Accordingly, veterinarians may classify diseases and prevent only those movements that carry the most serious of these diseases or trade from specific geographic regions. This inevitably means that some diseases, considered to be of low priority, can be distributed and the trade may also result in the spread of undescribed or elusive diseases. Veterinarians seldom take account of pest species or epibionts that may result in either compromising culture activities, other commercial activities or the environment.

Additional vectors may be associated with the export of live consignments that may include the use of marine algae or vascular plants used for packing living crustaceans and molluscs. Either the algae, epibionts and other associated organisms could result in their establishment elsewhere, if the packing materials are discharged to the wild (e.g., the Japanese eelgrass being brought to western North America with Pacific oysters (Wallentinus, 1999c)).

Frozen foods intended for human consumption may also have the ability to spread diseases. The white-spot syndrome virus (WSSV) of prawns has spread through much of southeast Asia and may have the ability to infect other prawn species worldwide. If the frozen prawns are used as bait, the virus could get access to new regions (Williamson *et al*., 2002).

2.4 Aquarium industry

Aquarium fishes, invertebrates and plants used in aquaria or ponds are regularly moved and often over great distances. This trade often relies on specific collection points where the numbers accumulate before a sufficient consignment can be made up for export most usually delivered by aircraft. During this holding period, there may be high mortality that may arise following the inability of the species to feed, from negative social interactions and as a result of high densities that may lead to stress and spread of pathogens from sick fish. The accidental or deliberate release from aquaria or ponds are frequent events in freshwater but the formation of populations arising from releases to the sea are rare. Nevertheless, there are some serious diseases that may be spread by the aquarium trade such as epizootic ulcerative syndrome. This is widely distributed in the Indian Ocean and causes high mortality in cultured marine and estuarine fishes. There have been general concerns about the spread of diseases by this trade for some years (Adams *et al.,* 1970). Robertson and Austin (1994) examined exotic fishes to find some organisms that may also be harmful to temperate species such as rainbow trout and salmon. In an earlier study, Shotts *et al*. (1976) found several harmful bacteria in the supporting water in consignments of exotic fish coming from Taiwan, Singapore, Hong Kong and Bangkok.

The great number of fishes used in the aquarium trade are tropical species. These are of interest because of their bright colours or unusual morphology or behaviour and adapt well to stable room temperatures. Normally it is important when transferring these species that prolonged cool periods and sudden changes in temperature are avoided. Tropical species, should they be released to the wild, are unlikely to survive and reproduce in the wild in temperate climates except perhaps in heated water discharges or warm water springs. Movements of species between regions with similar climates are likely to have a higher level of survival provided that the social interactions and food and appropriate habitats are available. Vascular plants used in freshwater aquaria may also survive in brackish coastal areas if released, as has been the case with the Eurasian water milfoil *Myriophyllum spicatum* in Canada and USA (Wallentinus, 1999c)

However, a tropical marine green alga *Caulerpa taxifolia* whilst in culture developed a clone that could survive at lower water temperatures (Meinesz and Boudouresque, 1996; Wallentinus, 1999c). This form was most probably accidentally released from an aquarium in Monaco, where it was first noted to form a meadow. It then spread rapidly to the northern part of the western Mediterranean and later to the Balearic Islands and the Adriatic Sea. *C. taxifolia* has also appeared in two shallow coastal bays in California (Jousson *et al*., 2000; Williams and Grosholz, 2002) and in several locations in temperate Australia (New South Wales and South Australia). The California populations appear to be the invasive clone found in the Mediterranean, while the Australian populations appear to be domestic translocations from native tropical populations in Queensland (Murphy and Schaffelke, 2003). In California attempts to control the populations were instigated soon after discovery and appear to be successful.

2.5 Marine leisure tourism

Bait organisms may be exported beyond their normal range and become discarded alive to the wild to form new populations. Bait worms collected in Korea, Africa and USA are exported to different world regions including Europe by aircraft. There are some examples that distributions of bait act as important vectors. The arrival of the green crab *Carcinus maenas* and the rough periwinkle *Littorina littorea* to San Francisco Bay with bait worms for anglers and exported from Maine may have taken place in this way (Cohen and Carlton, 1995).

Movements of infested fishing gear may also allow species to colonise new regions, as has happened with commercial fishing operations in the spread of *C. taxifolia* in the Mediterranean (Relini *et al*., 1998). Other equipment such as diving gear theoretically could spread fragments both of plants and other species, if not cleaned and dried before used in other waters.

Recreational craft, many of which are held for long periods at marina berths, have the ability to transmit their fouling biota to many world regions once re-engaged in use. Leisure craft may be important in the secondary spread from port regions to remote estuaries and bays. The black striped mussel *Mytilopsis sallei* appears to have been transported to Cullen Bay Marina in Darwin, Northern Territory, Australia by a recreational vessel. *M. sallei* was detected in Darwin in 1999 at densities up to 24,000 individuals m^{-2} fouling all hard substrates (Bax, 1999; Willan *et al.,* 2000). A successful eradication effort was established to rid Darwin of the mussel, costing an estimated AU$2.4 million (Bax, 1999). The bryozoon *Tricellaria inopinata* was almost certainly transmitted as hull fouling by leisure craft from the Venice lagoon to the south coast of Britain (Dyrynda *et al*., 2000).

Small boats may also be carried on trailers and are well understood as being important in overland species transmissions. These may be either carried in the bait wells as larvae or attached to the hulls; on re-immersion the bait wells may be drained and fouling biota may be rubbed off (Minchin and Gollasch, 2003). The trailer may also transmit species carried on snagged plants.

2.6 Research and education

Exotics are held in some research institutions. Those species held captive are not normally reported to regulatory bodies and consequently this information is not easily obtained. Very often the source of these species is associated with a specific geographic region or taxonomic group. The species under study could be obtained from biological suppliers and waste from these facilities may be discharged directly to the wild and on completion of the studies the species may be released, thereby neglecting all the risks for the ecosystem.

The red alga *Mastocarpus stellatus*, native to many other areas in Northern Europe, did not occur on Helgoland Island in the North Sea. This apparent absence led to a study on its colonisation in the wild. It is currently well established on the island and may outcompete some native species (Bischof, *et al*., 2000).

2.7 Others

The existence of old canal systems and new waterways has allowed for the ready transmission of species, either by moving on their own accord or by inadvertently being carried. Very often it remains unclear as to how the transmission took place. There are species flows between the Red and Mediterranean Seas, named Lessepsian immigrants after Lessep who built the Suez Canal. The flow has been mainly composed of Erythrean species (from the Red Sea) (Galil and Zenetos, 2002). Similarly the Kiel Canal connection between the North and the Baltic Seas has resulted in more easterly appearances of the Chinese mitten crab, *Eriocheir sinensis* (Gollasch, 1999) and possibly the shipworm *Teredo navalis* (Hoppe, 2002). In eastern Europe, the building of canals has enabled a transmission and spread of species between the Baltic, Black and Caspian Seas, either by dispersal through the canal system or from being carried by barge transport and ships.

Restoration to stabilise mobile sediments may involve the planting of either cordgrasses *Spartina* spp. on shores or of seagrasses in shallow bays. Some of the species in use may be introduced and those species have in some areas hybridized with native species, resulting in more vigorous and invasive plants, including polyploids.

The large amounts of flotsam and jetsam now appearing on most seas may have some impact as a vector for species, that otherwise may be not be spread (e.g., Barnes 2002). These may be composed of fishing equipment and floating plastics to which a fouling biota may attach. Reuse of old boxes for fish catches may also pose a risk of spreading diseases.

There are also examples of more odd vectors for marine and brackish water plants. The Pacific sedge *Carex kobumugi*, now growing and also planted on shores of the east coast of North America, arrived following the wreck of a ship carrying porcelain. This sedge was used as a packing material laid between the ware and transported in barrels. The plants drifted ashore and became established (Wotton *et al*., 2003). During the 19th century several brackish and freshwater plants came to Great Britain with wool imported from Australia, e.g., the Australian milfoil *Myriophyllum verrucosum* as well as several species of sedges *Cyperus* spp. (Wallentinus, 2002).

3. Management approaches

3.1 Intentional introductions

Most countries have laws or other legal restrictions preventing introductions of marine organisms as such fish and shellfish. However, there are fewer restrictions on bait organisms, aquarium fishes, aquatic plants, and seaweeds, although the spread of the aquarium-grown tropical green alga *Caulerpa taxifolia* in the Mediterranean Sea and its recent appearance in the USA and Australia has resulted in a ban on introducing it or even having it in possession. In USA there are federal restrictions that apply to some aquatic plants; these are mostly freshwater species. For invertebrates of no commercial interest, the situation may be similar to that of seaweeds. Consequently there is a need to widen the categories of organisms for which legal restrictions apply. Nevertheless, when laws exist controlling introductions of organisms from abroad, the movement of species between different parts of the country may still be permitted even though different sea areas may be involved so enabling either distinctly different populations of a species to be spread or enabling expansions of species. Furthermore, some national authorities, normally associated with fisheries development, may grant exemptions to perform introductions for different purposes. Illegal introductions by those involved in culture or stocking operations are not uncommon and thus there is an urgent need to develop public awareness to stop those actions as they can lead to circumstances that may compromise production and may also have impacts on the environment.

It is common for trading blocks, such as the European Community, to replace or overrule national legislation, and controls that have previously existed have been replaced with restrictions only for the most serious diseases/pathogens, parasites, and pests. These actions do not take account of the different biogeographical provinces that may now be enabled to exchange material. Consequently, when target species are moved, there is the likely risk of spreading their associated organisms (on/among/within the target species). Such movements can include undescribed species or those species that have not yet been recognised as being of consequence. Frequent monitoring of areas with such imports (including *in situ* holding facilities) should be considered as a basic management procedure and should be carried out following the arrival of consignments from new regions each year.

The International Council for the Exploration of the Sea's Code of Practice on Introductions and Transfers of Marine Organisms (ICES 1995, 2003) outlines how the risks of introducing a marine species can be considerably reduced. It may be argued that the introduction using these procedures is costly, because it recommends that the original import is not released from quarantine and the filial generation is released and only when histological studies indicate that it is free of potential pathogens. However, the comparatively large numbers of invertebrates and macroalgae introduced as non-target species with oyster movements intended for culture stress the importance of not directly releasing imports to open waters. The main difficulty with implementing the Code of Practice is that it acts as a set of recommendations and is not legally binding. Further there is a general lack of awareness amongst the public and national, regional and local authorities as well as others who make decisions relevant to the Code and why it exists. This does not only apply to introductions for fisheries and aquaculture, but for, e.g., coastal zone management, dune plantations and habitat restorations.

The use of quarantine facilities is a management procedure included in the ICES Code of Practice, and may be demanded by authorities before the species is released. Originally the purpose of the Code was to avoid unintentional introductions of disease agents and parasites. Subsequently the Code became refined and expanded to include genetically modified organisms and environmental issues. However, as stated above, such a procedure should also be used as a precaution to stop the spread of non-pathogenic associated organisms (see also Appendix C to the new ICES Code of Practice, 2003). The management of imported stock or of stock that is to be transferred in the course of normal culture operations has included treatments and recommendations, such as brine dips (Gruet *et al.,*1976, Minchin and Duggan, 1988), have sometimes been applied. However, although some associated species may be exterminated by such a method, most likely it will not affect all organisms.

Scientists have often embraced the idea that an organism being used in pilot trials can be easily eradicated once field experiments or farming tests are completed, as long as the test organisms are removed before they reach maturity. However, storms and other events can result in dispersion and so control can be lost. However, in one case study it was possible to remove the giant kelp *Macrocystis pyrifera* following cultivation trials in French Atlantic waters in the 1970s (Wallentinus, 1999c and references therein). Had it become mature and produced a recruiting population, it could have, on account of its size, resulted in profound changes to shallow-water ecosystems. Consequently, the actions taken by scientists also need to be measured and an awareness among researchers about the reason for using the ICES Code of Practice and its basic ideas could help, because some experiments might be made out of ignorance. A red sign alert in all field stations could be good reminder.

According to the ICES Code of Practice (Appendix B), a basic risk assessment should accompany the introduction proposal. However, in the long term there is a strong need to develop more quantitative risk analyses for better management procedures.

3.2 Unintentional introductions

There are some precautions and management procedures which can be employed for unintentional introductions, although these may be more difficult to apply than for intentional introductions. The awareness required here should include the general public because, e.g., a single person may cause the release and subsequent establishment of a species which may result from releases from aquaria, or of living organisms intended for human consumption. Thus, even though some of the vectors are more difficult to manage than others, there are still many situations where an improved knowledge can reduce movements of exotic species, as in the case of zebra mussels *Dreissena polymorpha* transported via small boats and equipment (Minchin *et al.,* 2002).

Ballast water was recognized by the International Maritime Organization (IMO) as one of the most prominent vectors for unintentional species introductions. The IMO Ballast Water Working Group was established in the early 1990s to prepare a Ballast Water Convention. Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens were adopted as Assembly Resolution 868(20) in 1997 (IMO, 1998). A Diplomatic Conference on the Ballast Water Convention is planned for the beginning of 2004. Since ballast water exchange only minimizes the risks, there is a need to further develop other techniques that may be more effective in eradicating live organisms in ballast water tanks.

The global ban on the highly toxic organotin tributyltin antifouling paints demands the development of non-toxic antifouling paints. Presently there are few effective long-term antifouling applications and consequently a greater biomass of fouling biota may be expected to be in transmission. Many such applications have become specialised for particular craft and for vessels operating at different speeds. Further research on novel methods of hull fouling management will be important in the management of introductions via this vector.

In ports, vectors are likely to overlap because these regions are usually highly urbanized resulting in a wide range of activities. Managing the overlap of vectors in such regions may lead to difficult decisions where some activities may need to be restricted to reduce the risk of species invasions. Studies of exotic species present in ports will almost certainly be beneficial, since there is a risk that ports are acting as donor areas for non-indigenous species to other regions. All relevant activities within the port region should be evaluated where the port may act either as a donor or recipient for unwanted invasives, as was demonstrated for five northwest European port regions by Gollasch and Leppäkoski (1999). Small changes in practice could result in reduced risk. For example, it may be sufficient to reduce the probability of an inoculum becoming established by extending the ballast water discharge trails of ships on entry to a port, and by not allowing removal of hull fouling communities of ships by robots and divers whilst in vulnerable regions.

Australia has used the concept of preventing the arrival of species that have been considered to be of high risk of invasion. This target list has been developed as a precautionary measure to manage those species that may be carried by shipping. This assumes that if such a species is known to be present in the port of departure where it may be taken up in ballast water, the discharge in the arrival area could be denied. However, there are many further species, many of which are microscopic, that also require consideration, because the risk of transmission of many of these is not fully known.

Removal of introduced species has in some few cases been successful, as in the case of the mussel *Mytilopsis sallei* introduction to northern Australia and of the green alga *Caulerpa taxifolia* in California. If detection takes place at an early stage, it may be possible to undertake such measures successfully. In the Mediterranean *C. taxifolia* was already well established and widespread when eradication measures began and so attempts to control it failed. An attempt to remove the Japanese brown alga *Sargassum muticum* following its first appearance in southern UK also failed (Critchley *et al*., 1986). In this case, direct removal was carried out by divers and by adding quicklime, chlorine or copper compounds, as well as the use of black plastic to cover infested areas. Effective responses are important and this underlines the need for a rapid response team and a national forum to enable the appropriate actions to be taken effectively and swiftly for species considered to compromise the health, economy or ecology of aquatic environments. Such actions may need legal support in advance of events. To be able to have such a rapid response, there must be personnel available with legal authority to make decisions. This should be worked out in advance as a strategic plan, including scenarios for which kind of organisms and which areas eradication is allowed, since it is likely to vary by species.

Releases from aquaria (private and/or commercial) have been responsible for the establishment of several exotics. The increased awareness, including the incorporation of the topic in environmental studies in schools and public awareness campaigns, can help to reduce the spread of species. Further, local suppliers of aquatic products have arrangements to take back live unwanted organisms for resale or for destruction. Many supplies are available via the Internet and efforts to involve a greater responsibility in handling living organisms, as occurs in the case of many aquarium institutions, may reduce releases from such sources. The products exported in the aquarium trade need to be certified and regular health inspections would almost certainly reduce unwanted impacts. Any serious and unexplained mortalities should be investigated. The development of protocols in the rearing of aquarium species is likely to evolve and some species that are endangered are likely to be managed in facilities that may assist in conserving species. Although this may aid in conserving marine biodiversity, such facility-raised organisms could also pose some risk of becoming established in the wild.

3.3 Mixed activities

When an exotic species establishes a new population, there may be further opportunities for spread. Ships that berth in sheltered bays or estuaries may also share the harbour region with marinas and the aquaculture facilities rearing molluscs or fishes. These areas may be close to ballast water discharge areas or loading areas. Ships may thus acquire aquaculture fouling organisms on their hulls. The proximity of shipping to aquaculture activities poses an unquantifiable risk that some organism imported by ships will impair survival, compromise growth, or render the nearby cultivated product unmarketable and may render quarantine regulations useless in certain areas (Rosenthal, 1997). Ballasting by ships in ports, for example, may result in loading untreated discharges of human sewage and bacteria, such as *Vibrio cholerae*, that when released may enter the food chain in distant ports through the marketing of oysters cultured nearby.

Also of concern are the discovery of new algal toxins associated with phytoplankton and their apparent spread throughout the world. Elucidating pathways whereby unwanted species are likely to be introduced and providing a monitoring to intercept such introductions is obvious but is seldom practiced. Especially important is to stop introductions of organisms that constitute missing links in a parasite's life cycle. Active search for those organisms and their rapid removal should be given high priority.

To minimize the risks associated with the various vectors, intentional as well as unintentional, there is a great need for more research on the possibilities to use economic incentives. Examples of such studies, for instance identifying all possible means of mitigating risks and ecosystem impacts, calculating their costs, comparing the efficiency performance of different incentive mechanisms (e.g., information campaigns, charges on activities which have high risks or are illegal, producer responsibility [polluter pays principle] etc.), could identify the most effective and cost-efficient means to minimize the risks and prevent the introduction of invasive species.

4. Conclusions

Exotic species will continue to spread. The rate and extent may be determined by reaching a fuller understanding as to how species become transmitted and the efficacy of the measures used to manage them, backed-up with appropriate monitoring and policing. It is clear that in the absence of public awareness programmes many of these management measures will not operate effectively. This is because of the many varied ways in which a species may be spread following arrival. Emphasis should be on the prevention of introductions coming from different world regions because their subsequent spread is more difficult to control. Once a reproducing population evolves, anthropogenic as well as natural dispersal will enable further spread and the potential to expand increases with each new region colonised. It is notable that the great majority of the species introductions appear both in port and aquaculture regions; and there is a general concern that where different human activities overlap, species may be effectively relayed to new regions and so form populations. The full complement of organisms in transit is almost certainly greater than the present understanding and it is likely that micro-organisms, that require a greater study, either ferried with current stock movements or inadvertently transported by other means, will have implications for fisheries, aquaculture and human health. Studies on ships have revealed that ballast water is a significant vector yet recent studies on hull fouling indicate that this is a more important vector in recent times than has been supposed, and is likely to increase with the global ban on TBT. It is inevitable that further trading agreements will result in a further spread of species and will involve the transmission of species between biogeographical provinces. Carriers involved in this trade need to be included in public awareness measures so that discarded or otherwise released organisms used in trade can be managed appropriately. Rapid response measures used in controlling new appearances of a species, if found at a sufficiently early stage, may enable the elimination of a potential founder population, as has been shown in Australia and North America. The management of species spread can be more effectively conducted with a fuller international cooperation than currently operated based upon the enthusiasm of a small number of professionals. This can be achieved by the further development of existing databases with reviews of up-to-date records and mitigation methodologies. Regions that act as potential donors of unwanted species should be encouraged to develop measures to reduce the opportunities of such species being spread.

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Table 1. List of vectors and pathways known or suspected as transport means resulting in new introduced species in coastal areas.

Pathway vector	Vector
Ships, moveable structures (oil platforms, barges, dredgers, floating docks, navigation buoys) other craft (commercial, fishing* and leisure vessels and float planes)	Ballast water and sediments and organisms carrying associated species on/among/within them
	Solid ballast and organisms carrying associated species on/within them
	Hull fouling and the fouling organisms carrying associated species on/among/within them
	Hull projections and cavities (sea chests, thrusters- internal piping and small crevices)
	Hull boring organisms and associated species with and within them
	Aquatic cargo (wells and tanks) and organisms carrying associated species on/among/within them
	Anchor, anchor chains, lockers, moorings, scuppers and bulwarks
	Small craft trailers
(* see also Wild fisheries below)	Dredge spoil
Aquaculture activities	Intentional release and stock movements and associated species on/among/within them
	Accidental release including associated species on/among/within them
	Gear movements (including cages, lines, etc.)
	Discarded or lost nets, floats, traps, etc.
	Discarded containers, live packaging material and/or transport media and associated species on/among/within them
	Discharge of feeds (live, fresh, frozen)
	Release of GMO biota
Wild fisheries	Stock movements and associated species on/among/within them
	Population re-establishment and associated species on/among/within them
	Processing of live, fresh and frozen foods
	Live bait movements and discharges of live packaging material and associated species on/among/within them
	Gear and transport media (water) movements
	Discarded and lost fishing gear
	Discard of target and non-target species (by-catch) when dumped away from site of harvest
	Intentional release of organisms intended as fish food
	Live food for consumption (accidental and intentional releases) and associated species on/within them
Aquarium industry and public aquaria	Intentional releases and associated species on/among/within them
	Accidental releases and associated species on/among/within them
	Organisms associated with rock and sand and associated species on/within them
	Untreated aquarium and waste discharges
	Living food movements for aquarium species and associated species on/ among/within them

Pathway vector	Vector
Marine leisure tourism	Live bait movement and discharges of live packaging material and associated species on/among/within them
	Accidental or intentional transport and release of fishing catch and the discharge of live packaging material and associated species on/among/within these materials
	Diving gear and associated equipment movements
	Fishing gear and associated equipment movements
	Water skiis and other water sport equipment movements
(* see also Ships and Wild fisheries)	Live souvenirs and their associated species on/among/within them
Research and education	Intentional release including field experiments and associated species on/among/within them
	Accidental release and associated species on/among/within them
	Water and waste discharges and flow-through aquaria systems, discharged demonstration material
	Living food movements and associated species on/ among/within for maintained organisms
	Diving gear movement
	Field and experimental gear movement
	Restoration, mitigation and rehabilitation
Others	Alteration of water courses and flow regimes
	Navigation canals
	Irrigation canals (including saline ponds)
	Habitat management (soil/sand/gravel, seagrasses/marshgrasses, plants for dune stabilization, filterfeeders for better water quality)
	Horticulture of plants tolerating brackish water (including their subsequent spreading to coastal areas)
	Biological control
	Municipal and other waste treatment discharges
	Discharged live packing material used for fragile products
	Imported wool with entangled seeds/propagules

Table 2. Examples of exotic species spread in European and North American coastal waters other than by natural dispersal mechanisms. Some of the acting vectors will also involve transport by ship, aircraft and land vehicles.

Principal activity (cf. Table 1)	**Main vectors or means of transmission/establishment**	**Species**
Shipping and floating structures (drilling platforms, dry docks)	Ballast water and sediment*, hull fouling**, cargo***, ships equipment	*Coscinodiscus wailesii* – planktonic diatom* *Mnemiopsis leidyi* – comb jelly* *Ensis directus* – American razor clam* *Balanus improvisus*– acorn barnacle** *Elminius modestus* – Australasian barnacle** *Eriocheir sinensis* – Chinese mitten crab* *Hemigrapsus penicillatus* – Asian shore crab** *Neogobius melanostomus* – round goby* or ***
Recreational vessels	Contamination or fouling of boats****, fishing equipment	*Undaria pinnatifida* – Pacific kelp**** *Dreissena polymorpha* – zebra mussel****
Aquaculture	Imports for culture*, transport equipment**, unintentionally with untreated shell***, host tissues****	*Aeromonas salmonicida*- finfish disease**** *Antithamnion pectinatum* – red alga*** *Sargassum muticum* – brown alga*** *Bonamia ostreae* – oyster disease**** *Anguillicola crassus* – eel nematode**** *Crepidula fornicata* – slipper limpet** or *** *Crassostrea gigas* – Pacific oyster*
Fishing activities New fisheries development	Releases to the wild and spread*	*Paralithodes camtschaticus* – red king crab* *Acipenser* spp., - sturgeon* European and Pacific salmonids*
Stock enhancement	Releases**, infested stock***	*Gyrodactylus salaris* – salmonid ectoparasite*** *Oncorhynchus mykiss* – rainbow trout**
	Equipment transfer, bait fishes, fish food organisms****	*Hemimysis anomala* – opossum shrimp****
Food processing	Untreated waste, disposal of imported produce, exports of tissue	Fish diseases, no confirmed examples
Live food trade	Escapes, releases*, disposal of tissue or contaminated water	*Rapana venosa*- predatory whelk* *Homarus americanus* – American lobster*
Aquarium trade	Escapes*, releases**, disposal of tissue or contaminated water	*Caulerpa taxifolia* – mutant green alga* or ** *Elodea canadensis* – Canadian waterweed* or ** *Pterois volitans* - lionfish* or **
Marine leisure tourism	Live bait,* packaging material**, gear movement	*Fucus spiralis* – flat wrack ** (to the Mediterranean) nereid baitworms*
Research studies	Releases, experiments *in situ**, disposal	*Mastocarpus stellatus* – red alga* (on Helgoland)
Others	Opening of new water links, canals*	*Lophocladia lallemandii* – red alga* *Halophila stipulacea* – seagrass* *Rhopilema nomadica* – scyphozoan *Brachiodontes pharaonis* – mytilid bivalve *Mya arenaria* – soft shelled clam** *Teredo navalis* – shipworm*
	Movements of sediment, aggregates	
	Shore management**	*Spartina* spp. – cordgrasses**
	Biocontrol (suggested and tested organisms, but not known to be released in the sea)***	(*Beroe* sp. – comb jelly for *Mnemiopsis*) *** (Ascoglossan snails for *Caulerpa taxifolia*) ***

Appendix I. First records of non-indigenous species 1998–2002 worldwide including uncertain introductions. Entries are sorted by name of taxa (after National Reports and Abstracts in recent WGITMO and SGBOSV Meeting Reports).

Species (including higher taxon)	**Year of first record**	**Region of first record**	**Population status**	**Impact or potential impact**	**Likely introducing vector**	**Native range**
Acentrogobius (cf) *pflaumi* Fish	2002	New Zealand	unknown	unknown	unknown	Japan and Korea
Acipenser stellatus Fish	1999	USA, Great Lakes	unknown	unknown	stocking	Ponto-Caspian
Acrochaetium balticum Red alga	1998	Netherlands	unknown	minimal	unknown	Baltic
Agardhiella subulata Red alga	1998	Netherlands	unknown	unknown	unknown	North America
Alcyonidium sp. Tentaculata	2002	USA	unknown	unknown	unknown	
Alexandrium catenella Phytoplankton	1998	Catalonia, Spain	established	potentially causing harmful algal blooms	ballast water	unknown
Ampharetidae Polychaete	2001	Gulf of Noto, Sicily, Italy	unknown	unknown	Lessepsian migrants or transferred via ballast water	Indian Ocean
Anadara demiri Bivalve	2000	Central Adriatic	unknown	unknown	hull fouling?	Indian Ocean
Anguillicola crassus Nematode	1998	Ireland	common locally	parasite	living imports, secondary introduction	Japan. NW Pacific
Anguillicola crassus Nematode	2002	Finland	rare	parasite	living imports, secondary introduction	Japan
Aplysia dactylomela Gastropod	2002	Italy (near Sicily)	unknown	unknown	unknown	Circum-tropical
Asperococcus scaber Phaeophyta	1998	Netherlands	unknown	unknown	unknown	Mediterranean
Aurelia aurita Jellyfish	1998	Caspian Sea	unknown	unknown	ballast water?	Cosmopolitan
Batophora sp. Green alga	2002	Italy (Ionian Sea)	unknown	unknown	unknown	
Beroe cucumis Comb jelly	1998	Black Sea	common	unknown	ballast water	North Atlantic
Beroe ovata Comb jelly	1999	Black Sea	unknown	unknown	ballast water	USA, Atlantic Coast
Beroe ovata Comb jelly	2001	Caspian Sea	unknown	unknown	ballast water?	USA, Atlantic Coast
Botryllus schlosseri Tunicate	2002	Canada (Prince Edward Island)	unknown	unknown	shipping?	Asia
Bugula neritina Bryozoan	1999	Belgium	occasional records	unknown	hull fouling	unknown
Bugula simplex	2000	Belgium	established?	unknown	hull fouling	unknown

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Bryozoan			range extension			
Callinectes sapidus Decapod	2002	Belgium (Oostende)	unknown	unknown	unknown	
Caprella mutica Amphipod	1998	Belgium (buoys of Zebrugge harbour)	established	unknown	ballast water, hull fouling?	Coastal waters of East Asia and Siberia
Caprella mutica Amphipod	2000	USA, Massachusetts and Rhode Island	unknown	unknown	ballast water, hull fouling?	Coastal waters of East Asia and Siberia
Caprella mutica Amphipod	2000	Norway	unknown	unknown	ballast water, hull fouling?	Coastal waters of East Asia and Siberia
Caprella mutica Amphipod	2003	West coast of Scotland	established	unknown	ballast water, hull fouling?	Coastal waters of East Asia and Siberia
Carcinus maenas Decapod	1998	Canada (Prince Edward Island)	established?	ecosystem engineer	secondary introduction from Fundy Bay or range expansion	Atlantic Europe
Carcinus maenas Decapod	1999	Canada (West coast)	rare specimen (not established)	unknown	secondary introduction from US Pacific Coast or range expansion	Atlantic Europe
Caulerpa taxifolia Green alga	1998	Tunisia and Croatia	established	competition	aquarium trade, secondary introduction	Mediterranean Sea strain
Caulerpa taxifolia Green alga	1999	Australia (near Sidney)	unknown	unknown	range expansion	native strain
Caulerpa taxifolia Green alga	2000	USA, San Diego	eradication effort in progress	competition	unknown (aquarium trade?)	Mediterranean Sea strain
Ceramium bisporum Red alga	2002	Italy (Tuscany)	unknown	unknown	unknown	
Cercopagis pengoi Cladoceran	1998	USA, Great Lakes	established	competition	ballast water	Ponto-Caspian Region
Cercopagis pengoi Cladoceran	1999	Poland	established	predation on zooplankton	secondary introduction	Ponto-Caspian Region
Charybdis japonica Decapod	2000	New Zealand, Auckland region	established	nuisance to fishers, gets into nets and very aggressive to remove	unknown	Japan, Korea, Malaysia
Chattonella cf. *verruculosa* Phytoplankton	1998	Norway, Sweden (North Kettegat, Skagerrak)	established	potentially causing harmful algal blooms	ballast water?	Pacific?
Chrisallida fisheri	2002	Italy (Adriatic	unknown	unknown	range	Red Sea, eastern

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Gastropod		Sea)			expansion?	Medeiterranean Sea
Cochlodinium polykrikoides Phytoplankton	1998	Canada (West coast)	increasing	fish kills (salmon farming)	ballast water?	Korea?
Codium fragile subsp. *Tomentosoides* Green alga	1998	Belgium	established, secondary introduction	habitat modification	oyster imports?, range expansion	unknown
Corella eumyota Sea squirt	2002	France (Brittany)	unknown	unknown	unknown	Southern hemisphere
Crepidula fornicata Gastropod	1999	Norway	unknown	unknown	oyster imports?	East coast of North America
Daphnia lumholtzi Cladoceran	1999	USA, Great Lakes	established	unknown	ballast water	Africa, India, Australia
Dasya baillouviana Red alga	2002	Germany	unknown	unknown	secondary spread, range expansion	Southern Europe (incl. Mediterranean Sea) and western Atlantic
Dasysiphonia sp. Red alga	1999	Norway	established, spreading	overgrows other algae	unknown	unknown
Desmarestia viridis Brown alga	1998	Italy	unknown	unknown	unknown	unknown
Didemnum sp. Ascidian	2000	USA, Massachusetts and Rhode Island	unknown	unknown	unknown	Japan
Dispio uncinata Polychaete	2001	Gulf of Noto, Sicily, Italy	unknown	unknown	unknown	Atlantic, Pacific and Red Sea
Dreissena polymorpha Bivalve	2000	Canada (West Coast)	not found in the environment, but on boat hull trailered from Michigan	unknown	hull fouling	Ponto-Caspian
Dreissena polymorpha Bivalve	2001	Ebro River, Spain	unknown	unknown	hull fouling, ballast water?	Ponto-Caspain region
Echinogammarus ischnus Amphipod	1998	USA, Great Lakes	established	unknown	ballast water	Ponto-Caspian Region
Ectocarpus siliculosus Alga	1998	Venice, Italy	unknown	competition	fishing	unknown
Epinephelus coioides Fish	2001	Italy	unknown	unknown	unknown	Red Sea
Eriocheir sinensis Decapod	1998	Ukraine	occasional records	predation, competition, habitat modification	ballast water, hull fouling	China
Eriocheir sinensis Decapod	2001	Spain (Guadalquivir Estuary)	established	unknown	ballast water, hull fouling	China
European Sheatfish Virus (ESV)	2002	Finland	unknown	unknown	unknown	
Favonogobius exquisites	2001	New Zealand	unknown	unknown	unknown	Australia

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Fish						
Ficopomatus enigmaticus Polychaete	1998	Ireland (Shannon Estuary)	established	small fouling impact	hull fouling, ballast water	Indo-Pacific
Gymnodinium catenatum Dinoflagellate	2000	Black Sea	unknown	harmful algal bloom, PSP	ballast water	unknown
Gymnodinium catenatum Dinoflagellate	2000	New Zealand	recorded during bloom	unknown	ballast water?	unknown
Haliplanella lineata Anthozoan	1998	Belgium	established, range extension	unknown	oyster imports?	Pacific
Haminoea cyanomarginata Gastropod	2001	Mediterranean Sea	unknown	unknown	Shipping, Lessepsian migrant?	Red Sea
Haplosporidium nelsoni (disease agent causing MSX disease)	2002	Canada (Nova Scotia)	First observation	Disease of oysters	Unknown. Shipping possible	Found along Atlantic coast of USA
Haplosporidium costale (disease agent causing SSO disease)	2002	Canada (Nova Scotia, Prince Edward Island, New Brunswick)	First observation	Disease of oysters	Unknown	Found along Atlantic coast of USA
Hemigrapsus penicillatus Decapod	2000	Netherlands	at one location, females carrying eggs about to hatch	unknown	hull fouling, ballast water?	Northwest Pacific
Hemigrapsus sanguineus Decapod	1999	Netherlands	occasional finding, not observed in 2000	unknown	hull fouling, ballast water?	West Pacific
Hemimysis anomala Mysid	1999	Belgium	established? range extension	unknown	unknown	Ponto-Caspian
Homarus americanus Decapod	1999	Norway	occasional findings	hybridisation	accidental release?	North America, Atlantic
Homarus americanus Decapod	2002	Canada (Vancouver harbour)	unknown	disease transfer	accidental release?	North America, Atlantic
Homarus americanus Decapod	2002	France	unknown	hybridisation	accidental release?	North America, Atlantic
Homarus cf. *americanus* Decapod	2000	Sweden	unknown	hybridization	accidental release?	North America, Atlantic
Hypnea cornuta Red alga	2002	Italy (Ionian Sea)	unknown	unknown	unknown	
Hypophthalmichthys nobilis Fish	2002	Estonia (Gulf of Riga)	unknown	unknown	secondary spread	China
Ianiropsis sp. Isopoda	2000	USA, Massachusetts and Rhode Island	unknown	unknown	unknown	unknown
Isolda pulcella Polychaete	2001	Gulf of Noto, Sicily, Italy	unknown	unknown	unknown	Atlantic and Indian Ocean

Species (including higher taxon)	Year of first record	Region of first record	Population status	Impact or potential impact	Likely introducing vector	Native range
Maeotias inexpectata Cnidarian	1999	Estonia	occasional records	possibly predation on zooplankton	ballast water	Ponto-Caspian region
Megabalanus coccopoma Barnacle	1998	Belgium (on buoys)	occasional records	unknown	hull fouling	Pacific
Megabalanus tintinnabulum Barnacle	1998	Belgium (on buoys)	occasional records	unknown	hull fouling	cosmopolitan
Micropogonias undulatus Fish	2002	Belgium	unknown	unknown	unknown	NW Atlantic USA - Mexico
Mnemiopsis leidyi Comb jelly	2001	Caspian Sea	established?	predator	ballast water?	Western Atlantic
Mytilopsis sallei Bivalve	1998	Darwin, Australia	established population was eradicated by chemical treatment	fouling problems	hull fouling, pleasure boats	unknown
Neogobius melanostomus Fish	2002	Gulf of Riga	unknown	unknown	secondary introduction?	Ponto-Caspian region
Neogobius melanostomus Fish	2002	Lithuania (Curonian Lagoon)	unknown	unknown	secondary introduction?	Ponto-Caspian region
Olisthodiscus luteus Phytoplankton	1999	Norway	unknown	unknown	unknown	unknown
Ophryotrocha japonica Polychaete	1999	Italy (Ravenna harbour)	established, spreading	unknown	unknown	unknown
Orchestia cavimana Amphipod	1999	Estonia	established	unknown	secondary introduction	Northern Africa
Paracorophium brisbanensis Amphipod	2002	New Zealand (Tauranga Harbour)	unknown	unknown	shipping?	Australia
Percnon gibbesi Decapod	1999	Sicily, Italy	established	competition	fishing	Atlantic
Perophora japonica Sea squirt	2001	United Kingdom (Plymouth)	established, spreading	unknown	unknown	Japan
Pfiesteria piscicida Phytoplankton	2000	New Zealand	unknown	potential for fish kill	unknown	possibly native
Pfiesteria piscicida Phytoplankton	2002	Oslo fjord, Norway	unknown	potential for fish kill	unknown	possibly native
Phyllorhiza punctata Cnidarian	2000	USA, Gulf of Mexico	established	unknown	unknown	Tropical Pacific
Pisodonophis semicinctus Fish	1999	Italy	unknown	unknown	unknown	Atlantic Ocean
Polycerella emertoni Gastropod	2000	Greece	unknown	unknown	Shipping	Atlantic
Polysiphonia morrowii Red alga	1999	Italy	unknown	unknown	unknown	unknown
Proterorhinus marmoratus	2002	Netherlands (Waal River)	unknown	unknown	unknown	Ponto-Caspian
Protodorvillea egena	2001	Gulf of Noto,	unknown	unknown	unknown	South Africa

Species (including higher taxon)	**Year of first record**	**Region of first record**	**Population status**	**Impact or potential impact**	**Likely introducing vector**	**Native range**
Polychaete		Sicily, Italy				
Punctuaria tenuissima Algae	1998	Venice, Italy	established	competition	fishing	unknown
Questa caudicirra Polychaete	2001	Gulf of Noto, Sicily, Italy	unknown	unknown	range expansion, ballast water?	Atlantic and Pacific coasts on America
Rapana venosa Gastropod	2000	France (Atlantic coast)	occasional records	predation	hull fouling, ballast water, live oyster imports?	Southeast Asia
Sagartia elegans ssp. *Roseacae* Anthozoan	2000	USA, Massachusetts	unknown	unknown	unknown	Europe
Salmo salar Atlantic salmon	1998	Canada (Vancouver Island)	occasional records	unknown	aquaculture escapes?	Atlantic
Sargassum muticum Brown alga	1999	Belgium	established, first record of attached specimens	habitat modification	oyster imports, secondary introduction	Japan
Seriola rivoliana Fish	2002	Italy	unknown	unknown	unknown	Atlantic
Spring Viraemia of *Carp* Virus	2002	United Kingdom	unknown	unknown	Movement of live fish?	
Stephanolepis cf. *dispros* Fish	1999	Italy	unknown	unknown	Lessepsian migrant?	Red Sea, Indo-West-Pacific
Styela clava Tunicate	1999	Canada (Prince Edward Island)	unknown	unknown	mussel movements	Asia
Tricellaria inopinata Bryozoan	1998	Southern England	established	competition	hull fouling	Indo-Pacific
Tricellaria inopinata Bryozoan	2000	France, the Netherlands	established	competition	hull fouling	Indo-Pacific
Tricellaria inopinata Bryozoan	2000	Belgium (various ports)	occasional records, range extension	unknown	fouling on pleasure craft	Indo-Pacific
Undaria pinnatifida Brown alga	1998	Southern Italy	unknown	competition with other algae, problems with harvesting/ dredging of oysters, habitat modification	unknown	Japan
Undaria pinnatifida Brown alga	1999	Netherlands (Sporophytes)	spreading fast since 2000		unknown	Japan
Undaria pinnatifida Brown alga	2000	Belgium (Zeebrugge)	occasional record established? range extension		fouling on pleasure crafts	Japan
Viral Haemorrhagic Septicaemia (VHS) Virus	2000	Finland and Baltic Sea	first observation	disease of rainbow trout in fish farms	unknown. Herring stocks suspected.	unknown

Annex 15 Draft Advisory Report on the Red King Crab (ToR h)

ICES Alien Species Alert Report on the Intentional Introduction of the Marine Red King Crab *Paralithodes camtschaticus* into the Southern Barents Sea

Prepared at the 25th meeting of the ICES Working Group on Introductions and Transfers of Marine Organisms (WGITMO), Vancouver, Canada, March 26-28, 2003.

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1. Introduction

The Red King Crab *Paralithodes camtschaticus* (Tilesius, 1815) (Reptantia, Lithodidae) is native to the Okhotsk and Japan Sea, Bering Sea and Northern Pacific Ocean. On the Asian side of the Pacific, crabs are found from Korea, along the eastern coast of Siberia and the coasts of Kamchatka peninsula. In the Northeast Pacific and Bering Sea, the Red King Crabs are distributed throughout the Aleutian Island chain, north to Norton Sound, Alaska, and southeast to Great Bay in Vancouver Island, Canada (Figure 1). Russian scientists intentionally introduced larvae, juveniles and adults of this species from western Kamchatka peninsula to the southern Russian Barents Sea over the period 1961–1969. Ten years later, in the 1970s, a reproductive population of Red King Crabs had become established in the receptor region (Orlov and Ivanov 1978). It spread from this location both by natural dispersal of its larvae by coastal currents and by adult migration. This review describes some of the current knowledge of the species in its home range and the introduced population.

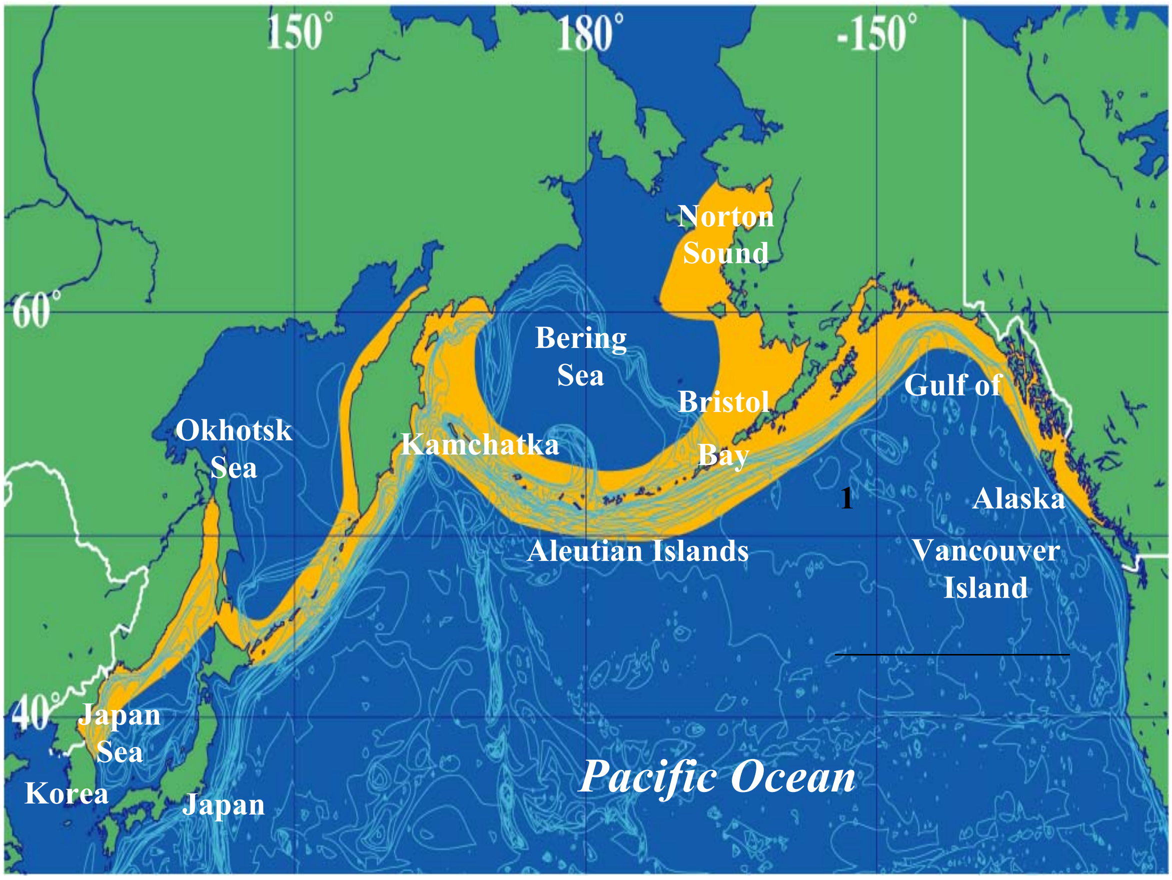

Figure 1. Map showing the native distribution (yellow shaded) along the coasts of Korea, Japan, Russia, Alaska, and Canada.

2. Identification

King Crab is among the world's largest arthropods, having a crab-like morphology and a strongly calcified exoskeleton (Cunningham *et al*., 1992). The King Crab have a fused head and thorax, an asymmetrical abdominal flap, one pair of chelipeds, three pairs of walking legs and an array of antennae and mouth parts (mandible, maxillae and maxillipeds). *Paralithodes camtschaticus* is one of three species of the genus, which inhabit the subarctic North Pacific Ocean and Bering Sea (Table 1).

Characteristics distinguishing the three species of *P. camtschaticus* (Red King Crab), *P. platypus* (Blue King Crab) and *P. brevipes* (Hanasaki Crab) include the shape and number of spines on the posterior and postero-lateral margins, the cardiac and branchial regions of the carapace (Figure 2). *Lithodes maja* is morphologically similar to the King Crab group, but is distinguished from adult *Paralithodes* by the comparatively smaller body size and the bi-fid rostrum. It ranges from the Barents Sea southwards along the coast of Norway and Greenland and to the south coast of Ireland and England.

Table 1. The taxonomic status of the genus *Lithodes*.

Class	Crustacea
Subclass	Malacostraca
Order	Decapoda
Family	Lithodidae
Genus	Lithodes
Species	*Lithodes maja* *Paralithodes camtschaticus* *Paralithodes platypus* *Paralithodes brevipes*

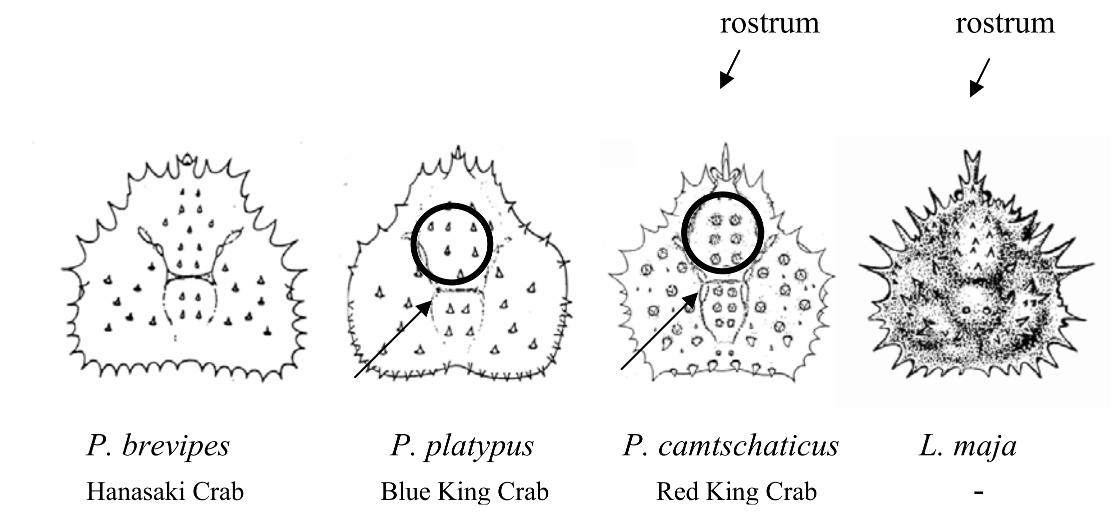

Figure 2. Showing the carapace of four different Lithodidae crustaceans, where *Paralithodes camtschaticus* (Red King Crab), *P. platypus* (Blue King Crab) and *P. brevipes* (Hanasaki Crab) inhabit the subarctic North Pacific Ocean and Bering Sea, while *P. camtschaticus* and *Lithodes maja* the Barents Sea. Characteristics that distinguish the four species include the shape and number of spines on the posterior and postero-lateral margins, the cardiac and branchial regions of the carapace and the rostrum (drawings from Christainsen, 1972 and Fukuhara, 1985).

3. Biology in the native range

3.1 Some basic features

Based on the three largest, reproductively independent, and most productive populations in West Kamchatka, West Okhotsk Sea, and Bristol Bay, Rodin (1989) defined some basic factors. These factors include the complex of biological, geographical and oceanographic features of the habitat of these crabs. The larvae of the Red King Crab develop in the coastal zone and pass through four pelagic stages in about two months. The larvae are passive and may be transported considerable distances by currents. For survival of the young, the larvae must be transported to favourable habitats. The habitat must be temporally synchronised with the spring phyto- and zooplankton and in the upper 15 m of the water column (Shirley and Shirley, 1989). Successful recruitment of the benthic juvenile crab will depend on a well-developed sessile community with dense concentrations and large areas of hydroids, bryozoans, and sponges are needed to support a massive settlement of larvae. The survival in one-year-old Red King Crab is directly related to availability of cover, while dependence on the epifaunal community apparently decreases as crab grow older (2 years).

3.2 Seasonal migration

P. camtschaticus has two migrations, a mating-molting and a feeding migration (Figure 3). The patterns of behaviour are similar off the coasts of Japan, Russia, and Alaska (Marukawa, 1933; Vinogradov, 1941; Powell and Reynolds, 1965). The shoreward migration to shallow waters (10–30 m) takes place in late winter and early spring where they mate and breed (Marukawa,1933; Wallace *et al.,* 1949; Powell and Nickerson, 1965) with the subsequent hatching of larvae at the first zoea stage (Stone *et al*., 1992). The termination of spawning activities is followed by migratory feeding movements of both male and female crabs into progressively deeper water (300 m). Sexes are not found together until the following season (Cunningham, 1969).

Sexually immature crabs (smaller than 120 mm in carapace length), generally remain in shallow water along the coast at 20–50 m depth (Wallace *et al*., 1949) and are seldom associated with adults in deep water.

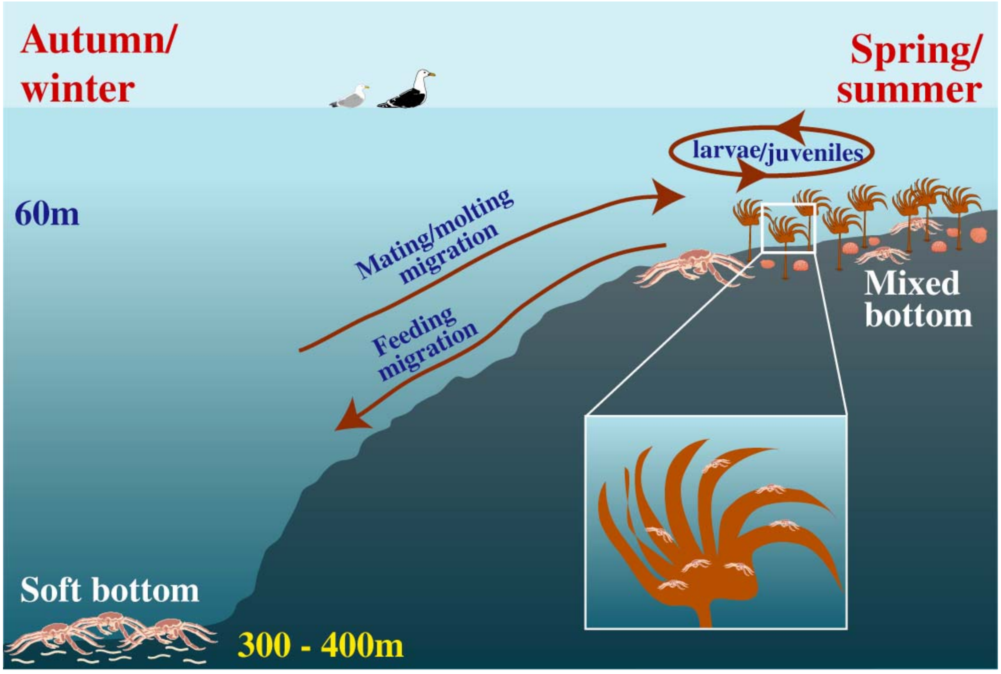

Figure 3. Seasonal migration of *Paralithodes camtschaticus* shows the mating-molting migration in the spring/summer period to varied substrates with benthic communities principally composed of calcified prey organisms, and a subsequent feeding migration in winter/autumn to soft substrate where annelids occur.

3.3 Salinity and Temperature

Little is known of the salinity tolerances of the Red King Crab. In its most northern range (Nome, Norton Sound in Alaska) the crabs occur in the shallow coastal water when ice is present but are, however, absent during the ice-free period (Jewett and Onuf, 1988). The bottom salinity and temperature beneath the ice was 34 ppt and –1.8º C (Hood *et al.,* 1974), but during the ice-free period ranged from 22–24.5ppt and 8.8–11ºC (Rusanowski *et al*., 1987). This suggests that salinity may be responsible for their absence during ice-free periods.

The Red King Crab is known to tolerate temperatures of –1.7 to +11ºC (Rodin, 1989) and this varies according to the life history stages. The West Kamchatka Red King Crab sub-population overwinters on the continental slope where the warmer Pacific Ocean water mixes with the colder waters of the shallow shelf. The migration period from the over-wintering area to shallow water depends on increases of the bottom water temperatures, as well as the physiological conditioning prior to spawning and molting (Rodin, 1989). The geographical extent of the subzero temperatures influence the time of their shoreward migration. In spring, normally May-June, high densities of adults accumulate at 10 m–15 m where temperatures are 2.1ºC. Following reproduction in June and July adults forage at 50m depth at 2ºC. In cold years where the females are unable to penetrate through the cold water layer (–1 to –1.7ºC) and into the coastal zone, the release of larvae takes place at depths of 80 m to 120 m. When this happens the larvae are transported to unfavourable areas and larval mortality is higher (Rodin and Lavrent´yev, 1974). Red King Crab populations at West Kamchatka shelf have strong year classes appearing at approximately 5–7 year intervals (Rodin, 1989). Once temperatures decrease the crabs disperse to deeper water where they overwinter (Rodin 1989).

Fecundity, size and age of maturity, and verage annual growth vary throughout its native range. In the northern areas of the Pacific, the Red King Crab undertakes a spring spawning migration from 200 m–300 m depth to shallow water (10 m–50 m). Here little moulting takes place over the winter, and the hatching of the larvae occurs when the majority of crabs reach the coastal zone in June. Whereas in southern areas with higher temperatures, the spring spawning is widely distributed from the shore to 100 m–120 m depth, winter molting of males is normal and hatching take place in May where females aggregate.

3.4 Life stages and habitat

After hatching the planktonic larvae undergo four zoeal stages and one megalop stage before settling. Settlement in shallow waters (<20 m?) usually takes place on sponges, bryozoans and marine algae (Marakawa, 1933). King crabs <20 mm have no podding behaviour, and remain solitary the first year as cryptically living beneath rocks and stones and in crevices. In the second year (20 mm–25 mm carapace length) podding behaviour is seen (Dew, 1990). After the first two years they migrate to deeper water (20 m–50 m depth) where they congregate in large, tightly packed groups called pods (Powel, 1974).

Adults occur on sand and mud substrata (Vinogradov, 1969; Fukuhara, 1985) and aggregate according to size, life history group or sex. Extensive aggregations where both sexes occur are made during the spring spawning season. Following, the sexes form separate aggregations for the remainder of the year (Fukuhara, 1985). The regions where these spawning aggregations occur can also be found in shallow water where kelp occurs (Powel and Nickerson, 1965). The kelp may provide them with some protection for the females following moulting ecdysis and make them less vulnerable during mating (Jewett and Onuf, 1988). Red King Crab may live 20 years (Kurata, 1961) and reach a carapace length of ~220 mm and a weight of ~10 kg (Wallace *et al*., 1949).

3.5 Feeding activity

The nature of the food consumed varies according to the life history. The pelagic larvae consume both phytoplankton and zooplankton (Bright, 1967) and once settled feed on hydroids, the dominant epifaunal component of the refuge substrate within the Kamchatka shelf region (Tsalkina, 1969). Dew (1990) reported that small crabs >20 mm carapace length feed on sea stars (50 mm–200 mm), kelp, *Ulva* sp., molted king crab exuvia, *Protothace staminea* (clam), *Mytilus edulis* (mussel) nudibranch egg masses, and barnacles. Occasionally crabs were observed dragging around large sea stars during the entire nightly foraging period. These stars were sometimes left near the base of the pod in the morning, and taken up again upon pod breakup.

Post-larvae show three different behaviour patterns: 1) remaining cryptic during daylight and foraging as solitary individuals at night (0 and 1 year-old crabs); 2) less obvious feeding pattern at night and aggregating (1–2 year-old crabs); and 3) feeding either during daylight or night, but principally at night and remaining in groups or becoming solitary (Tarverdieva, 1978). Adults are opportunistic, omnivorous feeders according to what is most readily available in the benthos (Cunningham, 1969). They normally use the most abundant benthic organisms as food, and usually one food group or species is dominant and varies according to region (Kun and Mikulich 1954; Kulikova 1955; Jewett *et al.* 1989). The weight of food consumed includes approximately 86% of taxa that have calcareous shells. These are echinoderms (*Ophiura sarsi*, and *Strongylocentrotus* sp.) and molluscs (*Nuculana radiata*, *Clinocardium californiense*, Buccinidae and Trochidae) (Cunningham, 1969). An increase in the consumption of calcareous benthic animals is found in connection with moulting (Herrick, 1909; Logvinovich, 1945; Fenyuk, 1945). Kulichkova (1955) suggested that crabs need to replace calcium carbonate lost during molting and that molluscs, young clams and barnacles in shallow waters are an abundant resource to fulfil this need. Crabs contain significantly more food in their gut during spring-early summer (Takeuchi, 1959; Jewett *et al*., 1989) when compared with the late summer-fall-winter months (Jewett and Feder, 1982).

It appears that adults have two distinct methods of feeding: 1) grasping and tearing apart larger invertebrates; and 2) sieving organisms using the third maxillipeds following the scooping-up of sediment by the lesser chela. Logvinovich (1945) refers to the frequent occurrence of sediments in the stomachs and intestine of crabs. Foraminifera, minute molluscs, and amphipods found in stomachs probably result from the sieving method of feeding, as these either burrow in or occur on sediments. Remote cameras have shown that the scooping of sand frequently occurred even when there was evident food available (Cunningham, 1969).

Observations on the degree of gut fullness would indicate that crabs browse on food as it is encountered (Cunningham, 1969). At times of moulting, during growth and at times of reproduction, the food intake declines but such pauses do not normally last more than two to three weeks (Kulichkova, 1955) and thereafter they feed avidly (Takeuchi, 1967).

Adult crabs are active and consequently where there are low densities of available food they may swiftly travel, on account of the long legs, to a different and less exploited region where food is more abundant (Somerton, 1981). This ability to range over long distances by walking, up to 3 km–13 km per day (Marukawa, 1933; Vinogradov, 1941) and 172 km in six months (Hayes and Montgomery, 1963) or 426 km during a year (Simpson and Shippen, 1968), enables the adult crabs to exploit considerable areas of sea bottom (Cunningham, 1969).

4. Non-native distribution

4.1 Date and mode of arrival

During the period 1961–1969, 1.5 million zoea I larvae, 10,000 1–3 year old juveniles (50 % females and 50 % males) and 2609 5–15 year old adult (1655=females, 954=males) *Paralithodes camtschaticus* from West Kamchatka, were intentionally released in the Kolafjord in the east Barents Sea (Russia) to create a new and valuable fishing resource in the region (Orlov and Karpevich, 1965; Orlov and Ivanov, 1978). Since then, the crab has spread both east along the Kola Peninsula, and westwards into the Norwegian zone (Figure 4).

Figure 4. Map showing the distribution in the native northern Pacific, Otkhotsk and Bering Sea and the non-native distribution in the Russian and Norwegian southern Barents Sea (yellow shading).

In the Russian part of the Barents Sea the highest densities were observed on both sides of the Rybachi Island during late 1980s and early 1990s. Then during the late 1990s crabs became abundant on the eastern part of the Peninsula. The range up to 2002 included Cape Kanin and the entrance of the White Sea to the east. Further northwards the crab was found on the Kanin Bank and at the Goose Bank. Russian scientists believe that the king crab in the Barents Sea have reached the limits of its eastern distribution (probably due to salinity and temperature).

It was not until 1992 the crab became abundant in Norwegian waters first occurring in the southern areas of Varangerfjord. The general rate of spread of the distribution along the coast of Northern Norway is shown in Figure 5. By 1994 the crab had spread to the northern side of the fjord, and it was caught in Tanafjord for the first time in 1995. At that time it had almost certainly established breeding populations in the coastal waters between Vardø and Tana. Further range extensions were noted in Laksefjord and Porsangerfjord in 2000, and by 2001 fishermen caught several adult crabs west of Sørøya and west of the North Cape. In 2002 crabs were captured close to Hammerfest and three crabs were caught by a longliner at about 120 nautical miles to the North Cape.

4.2 Natural history in receptor region

4.2.1 Larvae

Laboratory studies have shown that larvae survive better at temperatures of 6ºC when compared with 1–3ºC and as sea-temperatures in Norwegian waters are at the higher level it may explain why this species has become a successful invader (Larsen, 1996).

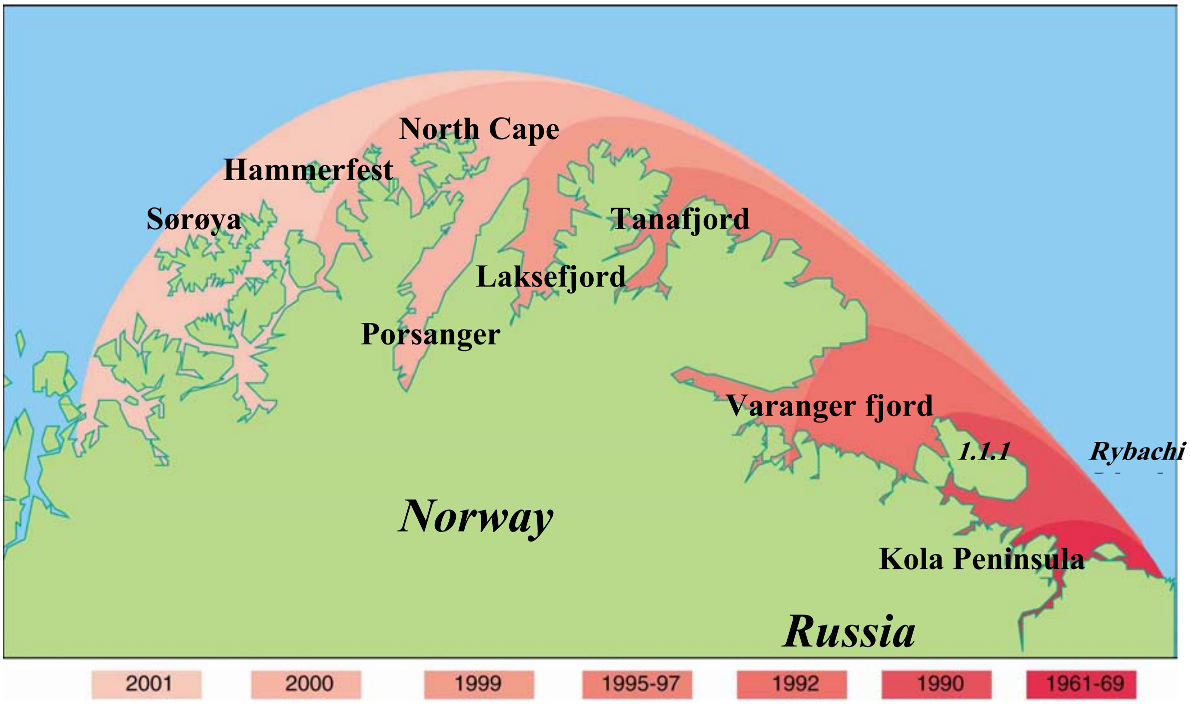

Figure 5. Generalised distribution and spread of Red King Crab from its release region in the Barents Sea.

4.2.2 Adults

In Norway immature and mature crabs migrate westward. Large egg-carrying females are often the first individuals to be obtained in new areas (own observations). The release of brood by these females may greatly enhance their rate of spread. Results from tag-recapture experiments carried out in the Varangerfjord reveal that adult crabs here move only short distances (2–15 nm; 1 nm=nautical mile=1852 m) over a three-year period. It would appear that as the abundance of crabs increases they range further, nevertheless tagged individuals have been found to move over significant distances over short periods of time.

4.2.3 Temperature

In the Okhotsk Sea, where the Red King Crab evolved, the bottom temperature at 100–300 m is ~0ºC. In the Barents Sea and northern part of the Norwegian Sea at 100 m depth the temperature varies from 0 to ~+6ºC in winter. The temperature increases with a southward progression along the coast of Norway. However, temperatures remain low round Svalbard and in the Northern Barents Sea. Laboratory studies have shown a temperature preference by immature crabs for temperatures below 4–6ºC (Hansen, 2002). Hansen (2002) speculated that crabs will spread to elsewhere in northern Norway and may extend further south as the uppermost temperatures are likely to be limiting but remain unknown. He also indicated a northward spread to Svalbard,

4.2.4 Food

The Red King Crab in the Barents Sea region feeds on bivalves and echinoderms in the spring and summer and polychaetes in the winter, in a similar way to native populations and the availability of food for the crab would appear to be the most important factor in limiting its distribution in its new environment (Gerasimova, 1997)

Total index of stomach fullness (organic stomach content (g)/crab weight (g)) (Table 2) of the Red King Crab in the Barents Sea (Manushin, unpublished data) is similar to the Red King Crab population from the North Pacific Ocean (Tarverdieva, 1976, 1978) and indicates that the food availability in the Barents Sea is presently sufficient to support the existing population. However, there would appear to be some changes in the diet from echinoderms to fish over the period 1997–2000 which is probably as a result of crabs feeding on fish discards from fishing vessels (Figure 6).

Consumption of benthos species in the Murmansk region at depths >100 m (calculated as daily stomach content and energy balance of the crab) ranged from 15,000 to 20,000 tonnes per year (Manushin, unpublished data). These data are based on daily consumption for all crab size groups scaled up to a year and includes an estimate of 20 % of the food handled not being consumed.

Manushin (unpublished data) indicates a calculated daily ingestion of 6g organic food for a 3000 g crab, 1.7 g for a 500 g crab at temperatures of 3°C, and 16 g and 3.5 g, respectively, at temperatures of 6°C.

Table 2. Index of stomach fullness of king crab in different areas.

Area	Total index of stomach fullness, $^{o}/_{ooo}$	Predominant food items	References
The Kola Bay	7	Echinoderms	Kuzmin, Gudimova, 2002
The Barents Sea	4-7	Echinoderms	Gerasimova, 1997
The Barents Sea	4-7	Fish	Manushin, unpublished
Western Kamchatka	3.8-18.6	Molluscs	Kulichkova, 1955
Southern Sakhalin	1.3-4.9	Echinoderms	Kulichkova, 1955
The Bristol Bay	4.7	Echinoderms	Tarverdieva, 1978
The Bering Sea	7.0-7.7	Echinoderms	Tarverdieva, 1976
Southern Sakhalin	3.8-4.3	Molluscs	Klitin, 1996

Zhou *et al*. (1998) demonstrated laboratory studies which indicated a daily ingestion of more than 70 g and ~20 g wet weight organic food (squid) per day for 3000 g and 500 g crab respectively (5.4–9.4ºC).

Laboratory studies at temperatures of 5–6ºC by Jørgensen (unpublished data) on mature (1700 g–3000 g) and immature (~500 g) crabs foraging on calcified epibenthic prey species ranging in size from 3–6 cm show they can kill ~300 g and ~150 g prey (scallops *Chlamys islandica* , *Strongylocentrotus droebachiensis*, *Asterias* sp. *or Henricia* sp., *Modiolus modiolus*, *Astarte* sp, *Buccinum undatum*) respectively per day.

Positive identification of food items within stomach analysis may be difficult. Decapods rarely swallow entire animals, but normally tear-away pieces using their chelipeds. The pieces are crushed by the gastric mill and so are pulped on entry to the stomach making food identity difficult. Feeding fragments of prey may be scattered and lost before reaching the mouth. In laboratory studies the valves of large bivalves remained on the tank floor following feeding. Should large molluscs be included in the diet following moulting in shallow water the numbers they destroy in the course of feeding may be underestimated if the volumes in the gut are back-extrapolated.

4.2.5 Feeding behaviour

Feeding observations from laboratory demonstrate high walking activity of the crab and when prey touched the fringes of hairs on the inner edges of the chelipeds and maxilipeds it was drawn in under the body towards the mouth. As also written by Zhou and Shirley (1997) vision appeared to pay little role in foraging. When feeding on bivalves the smaller prey are easily crushed outright by the right larger claw. Once the shell has been crushed, flesh is torn out by the left smaller chela directed to the mouth-parts and ingested. Larger flattened bivalves as scallops were edge-chipped, the valves grasped by the chela and pulled open in order to expose the flesh. Identification of bivalve species from stomach analysis, using flesh, would be a challenge if not impossible. Furthermore Red King Crab foraging may be underestimated when stomach contents are correlated to benthic biomass *in situ*. The laboratory results may demonstrate the susceptibility of native scallop (*Chlamys islandica* Müller, 1776) bed communities to Red King Crab predation (Jørgensen unpublished data). The data-set suggests a mature crab preference of prey sizes larger than 3 cm, and for round prey-bodies a maximum of 6cm height/diameter. Larger round bodies which, after a period, could not be crushed were abandoned for another prey. Flattened prey-bodies as scallops and *Asterias* sp. had no upper limitations and probably no size refuge from predation when both mature and immature crabs are present.

Both mature and immature crabs left valves on the bottom as fragments or as edge-chipped after tearing the bivalve flesh into pieces and consuming it. The laboratory results demonstrate that abundant Red King Crabs could have a significant effect on Norwegian scallop beds (500 g–1000 g scallops/m^2, unpublished data). The actively moving Red King Crab may be capable of not only crushing bivalves, but also picking soft animals and scooping meio- and microorganisms, and will have a non-reversible effects on the bio-diversity of native benthic communities.

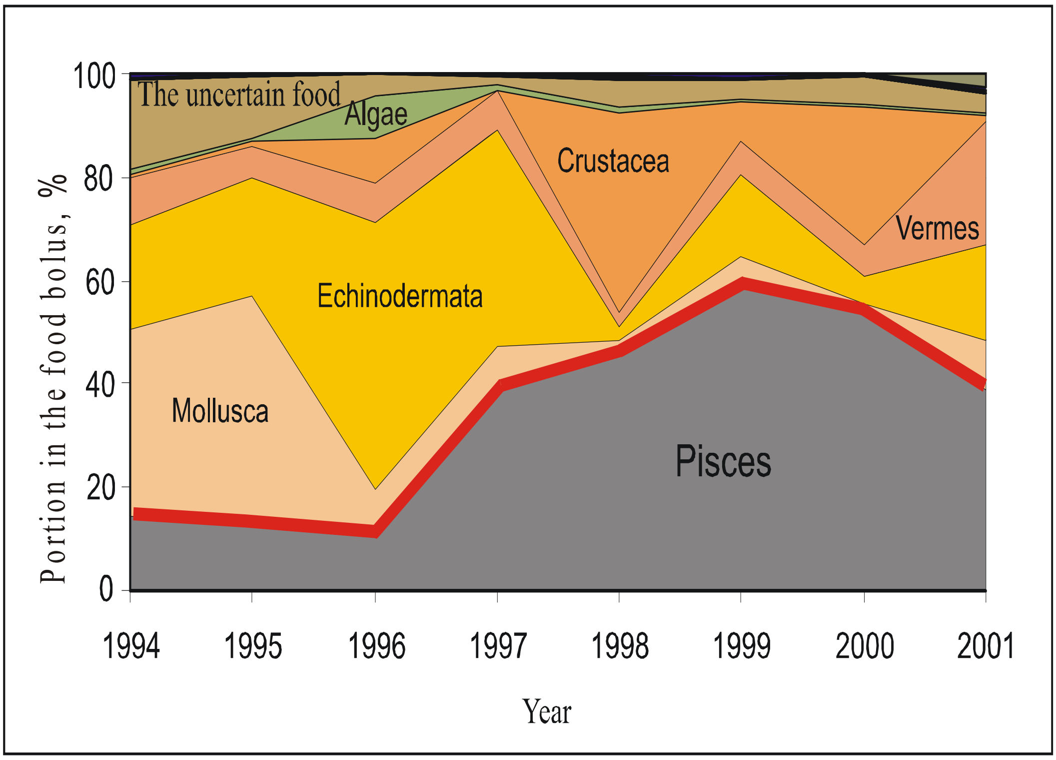

Figure 6. The proportion (%) of fish, molluscs, echinoderms, worms, crustaceans, algae and unidentified items in adult crabs stomachs over the period 1994–2001 from depth greater than 100 m.

4.3 Field assessments of environmental impacts

Scallop beds along the Norwegian coast are used as models for benthic shallow water communities with high availability of calcified prey species recorded from Red King Crab stomach analyses. The scallop beds may represent a potential food reservoir in spring/summer (May–July) for mature migrating Red King Crabs increasing food ingestion to replace recently expended energy. A principal challenge posed in field assessments of environmental impacts is to isolate the effect of interest (predation from Red King Crab) from noise introduced by natural spatial and temporal variability. One way is Before-After, Control-Impact (BACI analysis) presented by Underwood (1992). This design uses comparison sites with one putative impacted and several (minimum two) randomly selected control locations, which not necessarily have to be identical. The sites are monitored at replicated, random intervals of time from before to after the putative impact starts. The logic of the design is that an impact in one site should cause the mean abundance of animals there to change more than expected on average in undisturbed sites. Impacts are those disturbances that cause mean abundance in a site to change more than is found on average. If the magnitude of change in the population is within the resilience of natural populations, the impact gives no cause for concern. Two fjord localities, where one may be impacted within the few next years were localised and have been monitored since 2001. We may need to include at least one more field station to get enough control sites for the monitoring programme.

4.4 Fishery

The Mixed Russian-Norwegian Fishery Commission initiated the fishery for the Red King Crab in the Barents Sea as a research fishery in both national waters in 1994 and at the same time surveys of the crab stock started. Only male crab larger than a fixed carapace length was legal for catch. Today the agreed minimum legal size is 132 mm, but a minimum legal size of 137 mm is practised in Norwegian waters. An overview of the total allowable quotas (TAC) and legal stock estimates is shown in Figure 7. The research fishery for the crab continued until 2002 and the TAC was during that period divided equally between Russia and Norway. In 2002 new agreed fishery regulations were introduced and in Norway the king crab fishery became an ordinary commercial fishery with a Norwegian quota of 100,000 crabs. A total of 124 Norwegian vessels participated in this fishery in 2002. In Russia the king crab fishery is still a research fishery and is carried out from large vessels (~130 m OAL).

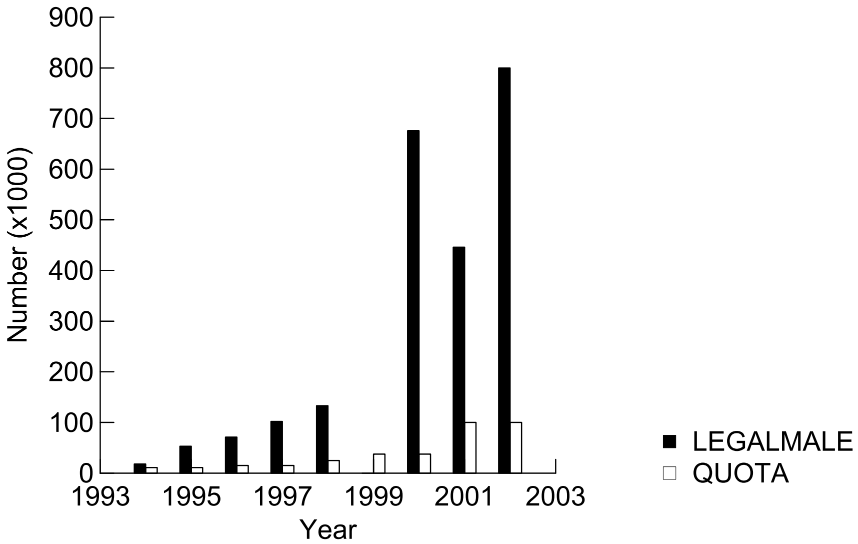

Figure 7. Figure showing estimated stock of legal male Red King Crab (black bars) and the Norwegian annual quota (white bars) in the Norwegian part of the Barents Sea.

Box 1. Ongoing and future research

The Norwegian Ministry of Fisheries has decided to launch a comprehensive research and surveillance programme on the ecological impacts of the king crab in Norwegian waters, in 2003. The research will be carried out of the Institute of Marine Research in cooperation with other research institutions in Norway. The programme is planned to last for at least ten years and the available cost for 2003 is set to NOK 4.7 mill. All planned research will be closely cooperated with Russian research activities in the same field.

The research programme is structured as follows:

I. Basic biology
- Environmental demands of the crab as temperature preferences, habitat preferences etc.
- Potential for spreading based on the environmental conditions in northeastern Atlantic including coastal Norway.
- Studies of population biology of the crab including development of population models.
- Bioenergetic studies of the crab

II. Distribution and spreading
- Development of larvae drift models
- Migration studies of adult crab and developing of models
- Risk analyses for spreading of the crab via ballast water
- Continuous surveillance of the distribution front
- Studies of migration pattern throughout the year

III. Direct and indirect effects on habitats
- Establish time series on zoobenthos composition on soft- and hard bottom both in areas with and without crab. Iso-

lated studies of effects of the crab on bottom fauna.

- Interaction with other (native) species
  i. Qualitative and quantitative effects of food competition
  ii. Study effects of the crab on fish stocks with demersal eggs

IV. Genetic studies

- Comparison with crabs from the origin site (Okhotsk Sea)
- Studies of genetic drift in Barents Sea king crab

V. Observational methodology and data analysis

- Development of new methods (sample design)
- Methods for estimating stock size (acoustic, UTV etc.)

VI. Diseases

- Reveal the role of the crab as a vector for spreading new diseases or diseases harmful for the native fauna.

VII. Parasites

- Study the parasite fauna associated with the king crab in the Barents Sea
- Reveal the role of the crab as vector for spreading native or introduced parasites that may be harmful for the native fauna.

VIII. Translation of Russian literature relevant for the crab as an introduced species.

IX. Workshop 2003

- A workshop will be arranged in Tromsø in June 2003 with invited experts on introduced species. The main aim of the workshop is to draw upon the experience with other introductions in the future management of the crab in Norwegian waters.

4.5 By-catch

For centuries coastal fisheries in northeastern Norway have been carried out with gillnets and longlines. Today, the typical small-scale fisherman uses gillnets in the fjord and the nearshore fisheries for all available species. The concurrent increase in the Red King Crab stock in recent years has resulted in huge by-catch problems, particularly in the gillnet fishery. King crabs impact the longline fishery by removing bait from hooks, thereby reducing catches of targeted fish.

The by-catch of crabs increased steadily from 1997 to 1999, but in 2000–2002 the by-catch rate decreased, and the estimated number in 2002 was only 30 % of that in 1999. This is probably due to a reduction in the cod gillnet fishery. Low abundance of cod have forced the fishers to move further west along the coast of Northeastern Norway in search of cod and thereby reduced the probabilities for by-catches of the crab.

Some available size distribution data for crabs caught in the gillnet fishery shows that few juveniles are caught. Most crabs seem to be larger than 120-mm carapace length (CL). More than 60 % of the crabs caught in gillnet fishery for cod in Varangerfjord are females, while large males dominate the by-catches in the lumpsucker gillnet fishery in early summer.

4.6 Management

The Red King Crab in the Barents Sea is managed as a joint stock between Norway and Russia, and the main body deciding upon management actions is the Mixed Russian-Norwegian Fishery Commission. Therefore, all research on this species is performed in cooperation between the two nations' scientists. The Commission sets a common TAC, which is divided between the two nations dependent on the standing stock in each economic zone.

Box 2. Future management options.

Due to the fact that the crab is well established in the Barents Sea through a period of about 40 years, it will be unrealistic to believe it could be eradicated. We therefore see three management options for the crab in future:

I. Continuation of today's management regime where the crab is managed as a valuable fish stock, and the annual total allowable quota (TAC) is set aiming at a long term sustainable harvesting.

II. Keeping the crab stock at a minimum possible level through deliberate actions. A non-regulated fishery has been proposed to reduce the crab stock in Norwegian waters. We are however, reluctant to such a method due to the fact that it is only large males, which are of any commercial value. It therefore seems necessary to introduce economical incentives such as a reward system to keep the crab stock at a lowest possible level.

III. The Mixed Russian-Norwegian Fishery Commission has asked Norwegian and Russian scientists to submit a suggested western border for the distribution of the king crab in the Barents Sea, based on scientific knowledge. Unless it may be difficult to realize the management implications of such a border, this may well constitute a third option.

Up to now, the main goal of the crab management has been to perform a long-term sustainable harvest of the stock, and this has in many ways influenced the research done (Box 1 and 2).

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Annex 16 Bibliography on Transplantations and Transfers of aquatic organisms and their implications for aquaculture and ecosystems

An electronic bibliography on "Transplantations and Transfers of aquatic organisms and their implications for aquaculture and ecosystems"

Harald Rosenthal, Institute for Marine Sciences, University of Kiel, Germany

1st Test Release, 22nd March, 2003, ICES Working Group on ITMO

25th Anniversary meeting, Vancouver, BC, Canada.

This is the first "restricted test release" (to members of the ICES WGITMO only) of the bibliography on "Implications of Transplantations and Transfers of aquatic organisms and their implications for aquaculture and ecosystems".

Collection of references for this bibliography started in 1985. While about 9000 references dealing with introductions and transfers of aquatic organisms were accumulated until 1998, the present version contains about 16,500 papers from peer review journals, textbooks, conference proceedings (including abstract booklets), internal governmental reports, and leaflets and newsletters of societies and conferences. Case histories reported therein date back to about 1849 and include publications up to February 2003. The listing contains about 35% of grey literature with many of these reports written in languages other than English. Titles are listed in both, the original language (e.g., transcripts from cyrillic letters if Russian or related languages are the origin) and in English (given in brackets). About 3,500 entries originate from documents written in languages other than English (e.g., Japanese, Chinese, German, Spanish and Russian or other Asiatic languages). A large proportion of these originals do not contain an English (or French) abstract nor a transcript or translation of their title.

For about 64 % of the publications an abstract is available on the original data bank but not included in this test release version. These abstracts contain information relevant to the area of interest, although cited papers often include other aspects of the general biology of the species concerned. For about one third of the entries the original document has never been seen and the referenced source may contain errors. The accuracy of the entry is therefore not guaranteed and any assistance that provides corrections or a copy of the original paper is most welcome so that at a later date a full version can be released.

Information extracted from the reference material is structured and presented in support of the ICES Code of Practice on Transfers and Introductions of Non-indigenous Species. This is in an attempt to provide users of the Code with the required background information relevant to the species under consideration, or at least with the option to more effectively and quickly find references relevant to their area of concern.

The Bibliography uses FileMaker Pro (Version 4.1) as the databank software and the screen layout follows a simple design, listing in separate fields a serial number, the names of all authors, the year of publication, the title and source of the reference, and three fields for indices:

- a **species index** (scientific name(s) of species if these are clearly mentioned in the respective paper); over 6,300 species are presently included),
- a **geographic index** (down to location whenever possible: country, county, river, lake, harbour, site, etc.), and
- a **general index** (first record, alien, cryptic, affected, endangered, extinct, species interactions, ecosystem change; the thesaurus contains over 250 terms; it is recognized that this thesaurus is still incomplete and partially inconsistent as it was developed over time with some changes in categorial structures over the years).

Each entry is assigned a serial number. Opening the programme will present the data bank initially in alphabetical order by serial number or by first author's name, however, the entire databank can also be sorted by scientific species name, year of publication and any word contained in either the general index, the geographic index and/or the species index or combinations of all of these.

A special field indicates whether an abstract is available on the full version and extracts from these abstracts can be made available by the author (H. Rosenthal) upon request.

Annex 17 Potential for ICES – PICES Interactions

J. Stein

The five member countries (Canada, China, Japan, Korea, Russia, and the US) of the North Pacific Marine Science Organization (PICES) work to promote and coordinate marine scientific research in order to advance scientific knowledge of the area concerned and of its living resources, including but not necessarily limited to research with respect to the ocean environment and its interactions with land and atmosphere, its role in and response to global weather and climate change, its flora, fauna and ecosystems, its uses and resources, and impacts upon it from human activities; and to promote the collection and exchange of information and data related to marine scientific research in the area concerned. In meeting these objectives interactions with other international organizations is a high priority, particularly on those issues that are global in nature and can thereby benefit from cooperative efforts among international science organizations. The issue of the introduction and transfer of aquatic species is one of the areas where interactions among PICES and ICES could be mutually beneficial.

On the issue of non-indigenous aquatic species cooperative activities between the two organizations could be initiated through the Marine Environmental Quality (MEQ) Scientific Committee of PICES and the ICES Study Group on Ballast and Other Ship Vectors (SGBOSV) and the Working Group on Introductions and Transfers of Marine Organisms (WGITMO). PICES currently does not have a working group on introduced species, but preliminarily has identified the following emerging issues: mechanisms (natural/unnatural) involved in faunal dispersal, improve taxonomy and development of common identification protocols, improve knowledge of marine ecosystem structure, develop marine biodiversity studies.

PICES proposes that the following are options for initiating collaborative activities between the two organizations. To foster exchange of information, ICES members could participate in scientific sessions or workshops at PICES XII. At future meetings, the two organizations could consider holding a joint workshop or scientific session and consider whether it would be beneficial to establish a joint workgroup. Specifically, PICES extends an invitation for a representative of SGBOSV and WGITMO to present a scientific paper(s) at PICES XII in Seoul, Korea. PICES is also interested in the possibility of developing a joint ICES/PICES session on “Harmful Introductions of Phytoplankton” at PICES XIII in Hawaii in 2004.

Annex 18 Aquatic species invasions in Europe

In 2002 a book was published as a first attempt to summarise aquatic species invasions in Europe. The geographical scope stretches from Irish waters in the west to Volga River and the Caspian Sea in the east, the Mediterranean Sea in the south and the Arctic in the north. It should be noted that not all parts of Europe could be covered, as for some regions no relevant data were known (see table below). WGITMO took note of this publication by especially considering the impact of certain invaders.

Table 1. Number of aquatic invaders in European coastal regions.

Region	Number of invaders	Reference
White Sea	5	Berger and Naumov, 2002
Norway including Svalbard	45	Hopkins, 2002
Baltic Sea	103	Weidema, 2000, Leppäkoski *et al.,* 2002, Jazdzewski and Konopacka, 2002
North Sea	80	Reise *et al.,* 2002
Ireland & Britain	79	Minchin and Eno, 2002
Atlantic Coast of Europe (including the French coast of the British Channel)	104	Goulletquer *et al.,* 2002
Mediterranean Sea (plants)	98	Ribera Siguan, 2002
Central and eastern Mediterranean Sea	>350	Galil and Zenetos, 2002, Occhipinti Ambrogi, 2002
Marmara Sea	11	Öztürk, 2002
Black and Azov Seas	53	Gomoiu *et al.,* 2002
Caspian Sea	50	Aladin *et al.,* 2002
The Rhine Delta (Dutch part)	85	van der Velde *et al.,* 2002
German inland waters	35	Nehring, 2002
Caspian-Volga-Baltic Corridor	106	Slynko *et al.,* 2002

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Annex 19 History of WGITMO

25 Years of WGITMO: a Brief Account on Early Activities

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As a fishery-oriented intergovernmental organisation, ICES has been confronted early on with issues related to the introductions of non-indigenous species, in particular diseases and parasites transferred with live transport of fish and shellfish for relaying, stocking, ranching and for fresh-fish markets. During the late 1960s and early 1970s, the need to assess the risks associated with deliberate transfers of species was primarily of concern to the following standing committees:

- the Shellfish Committee,
- the Anadromous and Catadromous Fish Committee (ANACAT), and
- the Fisheries Improvement Committee.

The early years (1970 to 1979)

During the early 1970s, decisions on recommendations regarding introductions and transfers were mainly discussed in the Consultative Committee (based on suggestions originating from the above-cited Standing committees). At that time, several countries were interested in introducing various species, mainly for aquaculture purposes. For example, in 1974 France proposed the introduction of *Macrocystis* sp. to Brittany. This and other cases triggered the need to prepare an initial draft of a Code of Practice, which was circulated for years among Delegates. In its 1975 report the Fisheries Improvement Committee explicitly states that "... the French authorities will seek the advice of ICES, which means that a meeting of a Working Group on the Introduction of Non-Indigenous Marine Organisms will be held in France; phycologists of various countries will be invited to participate." A revised proposal on the *Macrosystis* sp. introduction was submitted by France immediately (Doc C.M. 1975/E:16).

In September 1977, a joint session of the Fisheries Improvement Committee, the Shellfish and Benthos Committee, and ANACAT led to extended discussions on a draft Code of Practice. The respective Council Report states under Agenda item 22 (p68) " ...that the joint session of the three committees considered the report of the 'Working Group on the Pathology of Molluscs and Crustacea of Economic Importance' and endorsed the conclusions of this working group regarding two aspects: (1) there is a need to develop procedures for the containment of epizootics in a country or a limited area, and (2) that protocols should be developed for the interchange and movements of crustaceans and molluscan populations."

Several events pushed the agenda: (a) the rapid spread of *Mytilicola intestinalis* on oyster beds in France and subsequent concern by the UK (Doc. C.M.1977/E.30), and (b) an outbreak of Ulcerative Dermal Necrosis in Sweden in 1975, 1976, 1977 (Doc: C.M. 1977/M:41). After repeated discussions the Council decided that "The Code of Practice to reduce the risks of adverse effects arising from the introductions of non-indigenous marine species should again be circulated to Delegates." Delegates were undecided how to go about the issue and, as a consequence, nothing happened during the 1978 Statutory Meeting, mainly because ICES underwent a restructuring (e.g., Fisheries Improvement Committee was dissolved and two additional Committees established: (a) the Marine Environmental Quality Committee and (b) the Mariculture Committee. The new Chair of Mariculture Committee (Prof. Klaus Tiews) was very concerned about the risks of transferring diseases with mariculture activities and pushed the need for a Working Group on Introductions and Transfers (WGITMO) immediately.

The first report of the Mariculture Committee states: "The future of the WG on the Introduction of Non-Indigenous Marine Organisms was discussed. In view of the plans of some countries to continue introductions it was felt that the WG should be reconvened. It should also discuss the proposals made by the WG on Pathology and Diseases of Marine Organisms on the need to amend the present Code of Practice to reduce the risks of adverse effects arising from the introductions of non-indigenous marine species (see C.Res. 1978/2: 28)". This recommendation triggered the birth of the Working Group in 1979.

The first meeting was held in Conwy, Wales, April 4, 1979 and was actually a joint meeting with the WG on Pathology and Diseases of Marine Organisms. It is interesting to note that the first report of the Working Group (Doc. C.M. 1979/E:22) was considered by 4 Standing committees (!!), although the Working Group officially reported to the Mariculture Committee, indicating the importance of the issue. Items primarily discussed included: 1) the revised Code of Practice, 2) accidental introduction of the Japanese seaweed *Sargassum muticum* into the United Kingdom (Doc C.M.1979/E:18), and 3) the proposed introduction of Pacific Salmon to Europe.

During the Statutory Meeting 1979 (September), the Delegates Meeting had a very close look at the Mariculture Committee report. The minutes indicate that there was considerable discussion, particularly on the Code of Practice: the report was finally endorsed (CR 1979/4:5).

The Council decided to attach the Code of Practice in full length to the Consultative Committee Report. The initial success of the WG and the urgent need to address pressing issues are reflected in the numbers of 1979 Council Resolutions which are briefly listed here:

- **C.Res 1979/4:6** Council should encourage Member Countries to conduct feasibility and environmental impact studies for all species of *Oncorhynchus* prior to any further introductions.
- **C.Res 1979/4:7** Because of the lack of standardisation of procedures, Member countries ...should be encouraged to consider regulations providing control and inspection of marine species considered for introduction.
- **C.Res 1979/4:8** Member Countries should be encouraged to develop national or regional quarantine and inspection facilities for introduced species.
- **C.Res 1979/4:10** Member Countries should be requested to complete the questionnaire on "Statement of the present situation in relation to the introduction of non-indigenous marine organisms" (to be sent to Carl Sindermann, Chair WGITMO).
- **C.Res 1979/4:11** Delegates should be encouraged to send to the Secretariat by Oct. 1980 copies of legislation and regulations in their Countries regarding introductions. This material will be compiled into a summary report by the WGITMO.
- **C.Res 1979/4:12** Attention should be given by ICES member countries to the genetic implications of the introduction of non-indigenous species, particularly the maintenance of genetic diversity during the establishment and proliferation between natural and introduced stocks.

Some highlights of the period 1980–1995

In 1981 the Working Group discussed the Norwegian proposal to introduce Pacific salmon for culture purposes to its coast (WG Report Doc C.M. 1981/F:46). Today this seems to be a request difficult to understand mainly because it is Atlantic salmon which is now successfully transferred to other continents for coastal farming, and not the Pacifics. France had been promoting cage culture of Pacific salmon to Brittany again and the WG proposed strongly that first the potential interactions between Coho salmon and Atlantic salmon should be evaluated in laboratory and field studies.

Since the Soviet Union had extensively transferred species along its coasts, the WG encouraged translation of the Karpevitch book on Transplantations in the UdSSR, however, this project was – unfortunately – never realized.

During the period 1981 and 1982, the WG developed the first protocols for inspection of imports and this was considered an important step to derive meaningful management tools to reduce the risks of transfers of diseases and parasites. Subsequently, the 1982 WG Report (Doc C.M.1982/F:37) included the first "GUIDELINES AND PROTOCOLS" to implement the Code which was presented to the Council by the WG Chair Carl Sindermann.

The Council apparently was again undecided how to handle the matter and responded in its 1982 Report as follows: "The two documents were subject of much discussion" – "more involvement by others (genetics WG) before endorsement", with the result that urgently needed decisions in protecting mariculture were postponed again.

In 1982, the Council encouraged FAO to prepare an inventory called "Worldwide Register of Marine Fish and Shellfish Introductions" and this has triggered a decade of work at FAO headquarters in Rome (mainly led by Dr. Robin Welcome), the result of which can be accessed today as one of the most comprehensive FAO internet databases.

In 1983 the Working Group made – in my view – a very important decision by recommending to join forces with EIFAC (European Inland Fisheries Advisory Commission, FAO) to develop a joint Code of Practice for freshwater and marine systems in order to be harmonize procedures and avoid loop holes that would permit tricky players to circumvent any of the codes in the "grey"- brackish water area.

In 1984 at the Halifax (NS, Canada) WG meeting the Code was specifically adjusted for negotiations with EIFAC while also the Guidelines and Protocols were completed.

The Working Group meeting in 1985 can be considered as one providing foresight and engaging itself in preparatory work for the years to come. Major issues included (a) preparatory work for the planned joint ICES-EIFAC meeting in 1986–1987, (b) initial preparation of a "theme session" on introductions for the Statutory Meeting in 1986 and (c) to build linkages (as observer) with and prepare contributions to the EIFAC Symposium on "Hybridisation, Genetic Engineering and Stocking", France, May 24–30, 1986.

The 1986 WGITMO meeting can be marked as the year of the *Undaria* sp. problem while also a workshop on Pacific Salmon introduction to US East Coast (New Hampshire) was held raising major concern by the Canadians. Because of the recognition by ICES of the increasing number of problems arising from introductions a Council resolution assigning a more permanent role of the working group was adopted in 1986: "The Working Group will assume the long-term responsibility for producing continuing advice to the Council on all matters relating to introductions and transfers" (C.Res.1986/2:35).

Despite the early preparations by the Working Group (since 1985) it was not until 1987 that "The joint meeting of the EIFAC-ICES Working Groups on introductions" was held (June) to advance the document in form of the "JOINT CODE OF PRACTICE". This required quite some "diplomatic interventions" on both sides (ICES and EIFAC) and again, Prof. K. Tiews was here the driving force, who found with Dr. Welcome a dedicated partner in EIFAC-FAO (WG Report Doc C.M.1987/F:35).

Despite these important activities, the Working Group continued to collate and consider ongoing introductions and evaluated (a) the two year ecological study on *Undaria* at Quessant, France by Dr. J.-Y. Floc'h (completion of the project was endorsed), (b) the *Anguillicola crassus* rapid range expansion throughout Europe (which was considered to be an alarming problem for spawning migration of eels), and (c) the IHN (Infectious Haematopoietic Necrosis) occurrence in France, just to name a few.

Most importantly, the Working Group finally managed to have its recommendation endorsed which says, the "Code of Practice" to be published as Cooperative Research Report (C. Res. 1987/1:9), and this is actually the first time the code was officially released.

Furthermore, the long-planned Joint Symposium on case histories of introductions (ICES - EIFAC) was now proposed for the period 1989–1990 and contributions were solicited worldwide (also outside the ICES area). Additionally, the Working Group addressed for the first time in 1987 BALLAST WATER issues and this was also triggered by the records reported for ruffe *(Gymnocephalus cernuus)* and the brackish water flea (*Bythothrephes cederstroemi)* in the Great Lakes. It was Jim Carlton (who was an excellent Rapporteur to the Chair of the WG for many years) who pushed the issue based on his extensive and growing experience from harbour studies and ballast tank inspections. To address case history at the proposed Symposium was also seen as an opportunity to report on new occurrences such as *Sargassum muticum* which was discovered in 1987 along the Swedish west coast.

At this point, one person who has provided leadership for 12 years has to be mentioned: Prof. Carl Sindermann (at the time Director, Sandy Hook Laboratory, New Jersey, USA). In 1990 he retired, handing over a competent and dedicated team with many experts from ICES member countries to his rapporteur, Dr. Jim Carlton.

A new era began under the new Chairman. In 1995, Dr. Jim Carlton presented the "Open Lecture" on ballast water at the ICES Annual Science Conference (Denmark). Since than, this issue is of central concern as all of you witness today where ICES links with IMO, IOC and other organisations to address this issue leading to the establishment of a Study Group on Ballast Water and Sediments (SGBWS) as established by ICES Council Resolution in 1996 (ICES C. Res. 1996/3:10). The recommendation was strongly supported by the Mariculture Committee as marine culture systems are likely to be at risk by the misconduct of other marine resource users, potentially threatening the mariculture industry and rendering all efforts to promote and implement the Code of Practice useless. It was, therefore, appropriate that the Mariculture Committee stated: "The Committee concurred with the Study Group recommendation on the need for guidelines governing the uptake and release of ballast water by ships entering and leaving the ports of ICES Member Countries and for the development of programmes to sample ballast water in newly-arriving ships in order to document the species composition of the non-indigenous animals and plants that were being released into their waters". To address the growing concern of other ship vectors the Study Group was renamed to Study Group on Ballast and other Ship Vectors (SGBOSV) in 1999.

Dr. Jim Carlton handed over the Chairmanship of both WGITMO and SGBOSV to Dr. Stephan Gollasch in 2000. One of the first challenges of the new Chairman was the request of ICES to bring the Code of Practice up-to-date and a substantial revision of the Code was prepared at the WGITMO meeting in 2002 (Sweden). He is guiding the groups in the same professional manner as previous Chairman and both groups suggested to re-elect him at the 25th Anniversary meeting of WGITMO in 2003 (Canada).

I believe it is safe to say that the ICES WGITMO has gained importance and has become a well-known discussion forum for all issues on exotic species. I wish much success for the years to come as the work done by the Group is desperately needed.

Annex 20 Recommendations to the Council

The finalisation of the report on Dispersal Vectors of Exotic Species (entitled "Vector pathways and the spread of exotic species in the sea") and the completion of the Annexes of the Code of Practice were given the highest priority at the 2003 meeting in Vancouver, Canada. In addition a working draft of a Special Advisory Report on the Red King Crab was produced. However, other objectives could not be achieved due to time limitations (Summary Report on Species Introductions 1992–2001).

1. WGITMO unanimously recommends that Stephan Gollasch (Germany) should continue as Chair of WGITMO.

2. WGITMO recommends that ICES develop a webpage introducing the group and its activities. This homepage can make available the Code of Practice and its Appendices, the CRR on *Rapana venosa* and future reports.

3. ICES is asked to establish cooperation with PICES and to consider to send a WGITMO member to the PICES XII Annual Science Conference in Seoul, Korea in Fall 2003 for mutual benefit and the creation of a collaboration pathway.

4. WGITMO recommends that future annual meetings include an opportunity for the participation from non-ICES countries (e.g., Mediterranean countries and other international organizations, such as CIESM) on the basis of their expertise on species that are invasive elsewhere and that may be of concern to ICES Member Countries. The very detailed information provided by the Italian participant was greatly appreciated by the WGITMO.

5. WGITMO asks ICES to encourage member countries to track the importation of live seafood, bait, ornamental species and other organisms at minimum on a genus level, and at a species level wherever possible for inclusion in the National Reports to assess the risks associated with their importation.

6. ICES is asked to urge member countries and other jurisdictions 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.

7. WGITMO expressed significant concern that the live importation of species for consumption may negatively impact indigenous species and their environment. An example of this is the finding of the American lobster *Homarus americanus* in the natural range of the European lobster *Homarus gammarus.* ICES is asked to encourage Member Countries to consider legislation to prohibit the release of species into the natural environment unless the risks associated with such releases have been reviewed and are considered minimal.

8. Participants will intersessionally prepare a list of agencies, universities, and other institutions in their home countries which may be interested in the Code of Practice. These agencies can be asked to distribute the information.

9. WGITMO recommends that the Working Group meet in Cesenatico, Italy from 24–26 March 2004 immediately following the meeting of the ICES/IOC/IMO Study Group on Ballast Water and other Ship Vectors (SGBOSV), to:

a) collect and discuss National Reports including annual updates on the spread and impact of exotic species. This should include information from non-member countries;
b) finalise the Appendices of the Code of Practice;
c) finalise the work on the Summary of National Reports 1992 to 2001;
d) revise the format of the National Reports;
e) finalise the draft Special Advisory Report on the invasion of the Red King Crab *Paralithoides camtschaticus*;
f) consider rapid response and control options of new invaders with the intention of preparing a discussion paper in the future.

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 and fishing purposes. 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. The work of this Group supports the core role of ICES in relation to planned introductions and transfers of organisms.
Scientific Justification:	a) The work outlined above 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. b) The Appendices developed for the Code of Practice in 2002 need to be finalized to explain in detail the information required to judge planned introductions and to allow a wide application of the code. c) This will provide a useful overview of information on introductions and transfers in Member Countries for the past decade outlining trends and summarizing (unwanted) impacts on selected species. d) This work is needed to ease the reporting, documentation and synthesis of the spread and impact of introduced species, and better address pathogens, disease agents and parasites. e) Some introductions have a serious impact on the receiving ecosystem and an analysis of examples of these impacts is useful. f) the work on rapid response and control options (Contingency plans) will provide guidance on what to do in case a new species is recorded.
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., Mediterranean countries that are not members of ICES, members of relevant PICES WGs. WGITMO recommends to invite experts on (a) risk assessment of marine invasions (from, e.g., Australia) for input on the relevant Appendices of the Code of Practice and (b) the Red King Crab in Norwegian waters.
Secretariat Facilities:	None required
Financial:	None required
Linkages to Advisory Committees:	ACME
Linkages to other Committees or Groups:	WGHABD, WGEIM, SGBOSV, WGAGFM, Mariculture Committee. WGITMO requests advice from the Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM) on topics such as: Implications of the farming of polyploid, as opposed to diploid, aquatic organisms because such farming will be part of the future development of aquaculture. Tetraploid and triploid oysters (particularly *Crassostrea*) are already being tested or used for commercial practices. WGITMO seeks advice as to assessments that should be carried out (relative to considerations such as how "sterile" individuals are produced, and whether they maintain their "sterile" state) and any other considerations that should be taken into account before a polyploid can be considered for release to the environment.
Linkages to other Organisations:	Recognising the potential risk from introductions of aquatic species into the 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 (as the meeting venue is on the shores of the Mediterranean Sea).
Cost share	ICES 100 %

Draft Resolution for an ICES Internal Publication (Category 1)

The report on the **Vector pathways and the spread of exotic species in the sea,** edited by S. Gollasch (Germany), Chair of WGITMO as reviewed and approved by the Chair of the Marine Habitat Committee, will be published in the *ICES Cooperative Research Report* series. The estimated number of pages is 25.

Supporting Information

Priority:	This has a high priority for various reasons. This Directory of Dispersal Vectors outlines the principal vectors that are likely to result in further non-indigenous species spread including both introductions and translocations. The document reviews the current state of knowledge concerning various vectors of species introductions, provide a brief overview of the potential risks associated with each category of vectors and identify significant knowledge gaps. Understanding the transport vectors of species is essential when dealing with avoidance measures to reduce future species introductions. There is no recent document available including a comprehensive summary of vectors as outlined in this document.
Scientific Justification:	The forthcoming ICES Cooperative Research Report represents a synthesis of the most recent scientific work on vector importance of species invasions. It was recommended by ACME to publish this account as CRR earlier (e.g. TOR g of WGITMO 2003).
Relation to Action Plan:	The production of publications, especially of high quality, are a fundamental element of the Action Plan.
Resource Requirements:	Publication of this material as a CRR will cost ca 10,000 DKK. The material in the report is fairly straightforward, and therefore no specific additional costs are necessary.
Participants:	
Secretariat Facilities:	
Financial:	Publication costs
Linkages To Advisory Committees:	This product has been endorsed by ACME
Linkages To other Committees or Groups:	SGBOSV, Working Group on Harmful Algae Blooms
Linkages to other Organisations	Organizations that would appreciate this publication include e.g. IMO, IOC, PICES and BMB.