Advisory Committee on the Marine Environment **ICES CM 2001/ACME:07**
Ref.: E+F

REPORT OF THE

ICES/IOC/IMO STUDY GROUP ON BALLAST AND OTHER SHIP VECTORS

Barcelona, Spain

19–20 March 2001

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

TABLE OF CONTENTS

Section **Page**

1 TERMS OF REFERENCE

The first meeting of the ICES/IOC/IMO Study Group on Ballast Water and Other Ship Vectors (SGBOSV) was held in Barcelona, Spain, 19–20 March 2001 with 28 participants from Belgium, Canada, Estonia, Finland, Georgia, Germany, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, the United Kingdom, the United States of America, and representatives from the International Maritime Organization (IMO) and the International Chamber of Shipping (ICS) (Annex 1).

The ICES/IOC/IMO SGBOSV is a follow up initiative of the ICES/IOC/IMO Study Group on Ballast Water and Sediments (SGBWS), which was established by ICES Council Resolution in 1996 (ICES C. Res. 1996/3:10). In the 1999 report, the SGBWS recommended during its meeting in Llandudno, United Kingdom, that the group should be re-named ICES/IOC/IMO SGBOSV thereby taking into account the fact that there are more ship-mediated vectors of species transportation than ballast water and ballast tank sediments. It was further recommended that the ICES/IOC/IMO SGBOSV be established for a period of not less than five years.

The first meeting of the ICES/IOC/IMO SGBOSV was chaired by S. Gollasch (Germany) with S. Raaymakers, representing the IMO, as co-Chair and Tracy McCollin (Scotland) acting as Rapporteur.

A sense of the continuing high interest in this field since SGBWS met for the first time in March 1997 in La Tremblade, France, can be gained by noting that the 1997 meeting had 19 participants, while the present meeting had 28 participants. This meeting was the third largest SGBWS/SGBOSV meeting ever convened with nearly every ballast water research group in the world being represented.

The terms of reference for 2001 (ICES C. Res. 2000/2ACME07) are:

a) Assess the many different types of ship vectors (including, but not limited to, the list presented in the 2000 SGBOSV Report), with specific attention to determining which of these vectors have been quantitatively sampled in recent years, and whether data exist to assess their relative importance across a spectrum of vessel types, voyage lengths, voyage routes, seasonal changes, and other pertinent variables;

b) Prepare a detailed review, with emphasis on activities in ICES Member Countries, but with attention to other global activities, on the:

    i) status of ballast water and sediment biological and ecological research, through the participation of representatives from Member Countries and invited scientists from major ballast water research groups in the world;
    ii) development of ballast water control and management technologies;
    iii) relationship between ballast water movement and the invasion of exotic marine organisms, including updates on the latest global ballast-mediated invasions, particularly in relation to those species that are now invasive in other regions of the world and that are ballast-transportable but have not yet arrived in Member Countries.

2 CONCERNS OF COOPERATING PARTIES

Dr S. Gollasch reviewed the long-term interests of ICES and its Working Group on Introductions and Transfers of Marine Organisms (WGITMO) in species invasions, as well as the related interests of other ICES working groups, such as the Working Group on Harmful Algal Bloom Dynamics (WGHABD, Chair in 2001: Dr K. Kononen, Finland), the latter group meeting in Dublin, Ireland.

As early as 1979 the ICES WGITMO expressed concern about and focused attention on ballast water-mediated transportation and release of exotic species. It has been a frequent topic of review, and an ICES-only study group on ballast water convened for a one-day session in 1991 in Helsinki to review the status and interest in ballast water science at that time. As unintentional introductions came more and more into focus the WGITMO meetings spent increasing time on this issue and the SGBWS was established by ICES Council Resolution in 1996 (ICES C. Res. 1996/3:10).

S. Raaymakers then reviewed the interests of the International Maritime Organization (IMO) relative to the intersessional activities regarding future developments of ballast water management provisions and associated control issues. These activities included the adoption in November 1997 of IMO Assembly Resolution A868(20) together with Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic

Organisms and Pathogens. In adopting these guidelines, the IMO Assembly agreed that every effort should be made by the IMO Marine Environment Protection Committee (MEPC) regarding the development of legally binding provisions in the form of a stand-alone instrument (Convention) on ballast water management. This instrument, together with implementation guidelines for consideration, is to be prepared with a view to adoption by a Diplomatic Conference in the year 2003. He further indicated that the IMO, with funding provided by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP), has initiated the Global Ballast Water Management Programme (GloBallast). The overall objective of the programme is to reduce the transfer of harmful marine species in ships' ballast water, by assisting developing countries to implement existing IMO voluntary Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens (Assembly Resolution A.868(20)). The programme is also assisting developing countries to prepare for the new international convention on ballast water currently being developed by IMO (further details below).

The Study Group agreed to ask ICES to re-establish the contact to the IOC to seek interest for close cooperation in the future and to enable a representative to join the next SGBOSV meeting in 2002.

3 CURRENT RESEARCH ACTIVITIES ON BALLAST WATER AND SEDIMENTS

The major part of the two-day meeting was spent hearing presentations and discussions on ICES Member Country and global research and management activities on ballast water and sediments as a vector for the transportation, inoculation, and introduction of exotic aquatic organisms. A significant amount of time was also invested in continuing the assessment of different types of ship vectors, with specific attention to determining which of these vectors have been quantitatively sampled in recent years and discussing the relationship between ballast water movement and the invasion of exotic marine organisms, including updates on the latest ballast-mediated invasions globally (see below).

Further, the activities of ICES Member Countries with regard to the development of ballast water control and management technologies were discussed.

The global assessment and review of the status of ballast water and tank sediment biological and ecological research should continue (a) as new technologies and other ship improvements develop, (b) because new or recently launched research initiatives are under way in ICES Member Countries and the IMO, and (c) so as not to lose the momentum of this effective working group. Of special concern is the increase in new records of harmful algal bloom and disease agents, pathogens and viruses that are likely to have been transported with ballast water.

The following paragraphs provide details of the presentations given at the 2001 SGBOSV meeting.

3.1 Ballast Water Science

<u>Update on ballast water management activities at IMO</u>

S. Raaymakers

The International Maritime Organization (IMO), the specialised agency of the United Nations that administers the international regulatory regime for maritime safety and protection of the marine environment from shipping-related impacts, has been working to address the problem of harmful aquatic organisms and pathogens carried in ships' ballast water for over ten years.

The IMO Marine Environment Protection Committee (MEPC) formed a Ballast Water Working Group in 1992 and released voluntary guidelines for ballast water management in 1993. These were reviewed, strengthened and adopted as IMO Assembly Resolution A.868(20) *Guidelines for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens.*

These guidelines, while only voluntary, currently constitute the only internationally recognised set of best management practices for addressing the ballast water problem.

The guidelines contain recommendations for minimising the uptake of harmful aquatic organisms and pathogens in ballast water, minimising build-up of sediment in ballast tanks, ship-board ballast water management plans and ballast water exchange at sea, record keeping and reporting requirements and port-based management procedures.

Under the guidelines, ballast water exchange at sea constitutes the main management measure for minimising the transfer of harmful aquatic organisms and pathogens. However, it is widely recognised that this approach is subject to significant safety, operational and bio-effectiveness limitations and constitutes an interim, risk-minimisation measure only, until more effective solutions are developed.

While the current guidelines have been in place since 1997, IMO member countries are also developing a new convention on ballast water management, which will provide an international regulatory regime that is mandatory rather than voluntary. Negotiations and drafting are at an advanced stage and it is anticipated that a Diplomatic Conference may be held in 2003 to adopt the new convention.

Finally IMO, with funding provided by the Global Environment Facility (GEF) through the United Nations Development Programme (UNDP), has initiated the Global Ballast Water Management Programme (GloBallast). This programme is aimed at reducing the transfer of harmful marine species in ships' ballast water, by assisting developing countries to implement existing IMO voluntary guidelines on ballast water and to prepare for the introduction of the new ballast water convention.

The GloBallast programme aims to achieve this by providing technical assistance, capacity building and institutional strengthening to remove barriers to effective ballast water management arrangements in six initial demonstration sites. These six sites are Sepetiba, Brazil; Dalian, China; Mumbai, India; Kharg Island, Iran; Saldanha, South Africa and Odessa, Ukraine. The initial demonstration sites are intended to be representative of the six main developing regions of the world, as defined by GEF. These are, respectively, South America, East Asia, South Asia, Middle East, Africa and Eastern Europe. As the programme proceeds, it is intended to replicate these initial demonstration sites throughout each region.

Mnemiopsis leidyi in the Caspian Sea

M. Bilio

After the occurrence of the comb jelly *Mnemiopsis leidyi* in the Black Sea in the early 1980s, it is now the turn of the Caspian Sea to be invaded by this organism. There is evidence that *M. leidyi* has been observed here from as early as 1999. Since the mass occurrence of the ctenophore in the Black Sea in the 1980s coincided with a 90 % decline of the very important commercial anchovy fishery, considerable concern was raised among the Caspian littoral countries that their kilka and other fisheries could be similarly affected. The TACIS/UNDP/GEF Caspian Environment Programme has, therefore, embarked on the organisation of a workshop aiming to review the current situation and formulate an action plan. The three-day workshop in Baku, Azerbaijan has been announced for 24–26 April 2001 and will assemble invited local and foreign scientists with pertinent expertise. The intention is to submit the action plan to the competent national authorities as well as to international funding agencies.

Final Results of EU Concerted Action "Introductions with Ships"

H. Rosenthal

Until recently, the importance of ballast water as a major transfer vector that could affect aquatic ecosystem stability and modify biodiversity was not generally recognised. Despite considerable research effort (national and international), there has been virtually no consideration of the effectiveness or standardisation of ballast water sampling methodology in order to monitor the effectiveness of control measures.

One key objective of the Concerted Action (CA) was to test monitoring systems for sampling ballast water. Two major intercalibration workshops compared sampling techniques. The variation in ship construction and access to tanks require the development of a "tool box" approach rather than singling out one method, thereby combining qualitative and quantitative sample analysis for plankton species composition and abundance. The two intercalibration workshops delivered results that will allow better comparisons of ship sampling studies around the world.

The second key issue was to gain more insight into species composition in ballast water during ship voyages. This was achieved by ocean-going workshops (OGWs). The data obtained from five OGWs, using the "tool box", originated from European voyages (three OGWs) and inter-ocean voyages (two OGWs). In total, approximately 700 samples were collected during more than 100 days at sea. More species and specimens were found in recently loaded ballast water, and communities were in general similar to those in the sea water where ballasting took place. The largest number of phytoplankton species found was 52, including potentially toxic species. At most, 40 zooplankton taxa were found. During the voyage the abundance and diversity of phytoplankton and zooplankton species remained fairly stable for 3–4 days, followed by an exponential decline. In some cases no living zooplankton were found after nine days, in others about 10 % of the taxa survived, remaining viable for 25 days (i.e., voyage Hong Kong—Hamburg). Sampling showed that in calm conditions phytoplankton exhibited a vertical zonation in ballast tanks. During rough weather, mixing occurred which caused an increase in mortality. For the first time in ballast water studies, traps were used with bait and light as attractants, catching taxa not previously seen in the net samples. The effect of mid-ocean exchange (MOE), recommended by the International Maritime Organization (IMO), was studied. In many cases, the number of taxa increased rather than declined, while densities of specimens were diluted.

A public awareness campaign was launched, which involved preparing a video, a leaflet, flyers, press releases, newsletter articles of International Aquatic Societies, an Internet homepage (visit the homepage at: http://members.aol.com/sgollasch/sgollasch/index.htm) and several posters. A book on case histories, listing species previously introduced to European waters, was prepared especially to provide information for harbour and regulatory authorities.

Assessment of potential control measures (treatment) to reduce risks arising from ballast water releases included the evaluation and development of guidelines for ballast water treatment options.

All participants provided input on references (e.g., grey literature, governmental reports, internal reports from harbour authorities, interim project reports) into a database kept by the coordinator. The Concerted Action reviewed and considered shipping studies both within and outside the EU. This provided a more balanced view of the state of the art and also enabled the intercalibration workshops to consider and compare sampling methods as used throughout the world.

It is recommended that the EU take advantage of the well-developed expertise within the network of the CA partners to gain momentum in an area where global solutions are urgently needed.

The Canadian ballast water research programme

M. Gilbert

A three-year research programme on the ballast water-mediated introduction of non-indigenous aquatic species in Canadian waters was initiated in 1999. The overall objective of this programme was to provide scientific advice and tools needed to support the management of this issue in Canada. Specific objectives included: 1) the characterisation of the foreign maritime traffic in some areas of Canada and the associated biological communities in ballast waters; 2) the assessment of the ballast water survival of transported organisms and their viability in the receiving environment; 3) the testing of the efficiency of offshore ballast water exchanges in reducing risks for ballast water-mediated introductions; and 4) the evaluation of the suitability of current backup zones for ballast water exchanges on the East and West Coasts.

Within this programme, three studies are currently being conducted in the Estuary and Gulf of St. Lawrence. The first study deals with the suitability of having a backup zone for ballast water exchange in the Gulf of St. Lawrence in terms of risks for local introductions in this ecosystem. A three-dimensional prognostic model of circulation in the Estuary and Gulf was used to simulate the dispersion of phytoplankton and zooplankton that would be discharged with ballast water exchanges in the backup zone. The second study focuses on plankton survival in ballast waters during transoceanic voyages and its objectives are: 1) to assess shipping routes which pose highest risks for ballast water-mediated introductions in the Estuary and Gulf of St. Lawrence; and 2) to determine the effects of offshore ballast water exchanges on plankton diversity, abundance, and condition in ballast tanks. This study, which is part of a Canada-Germany collaborative research initiative, was accomplished onboard a commercial ore carrier during two routine voyages between the ports of Rotterdam (The Netherlands) and Sept-Îles (Canada) in the fall of 1999 and 2000. The third study for the Estuary and Gulf of St. Lawrence aims at completing an inventory of locally introduced marine species through a port survey (five major ports sampled in 1998) and through a questionnaire survey of individuals involved in marine studies in the Estuary and Gulf (currently in progress).

In the Bay of Fundy (Atlantic Canada), work is currently in progress to assess risks for ballast water-mediated introductions in this area with particular emphasis on phytoplankton, especially species harmful to aquaculture. In the Great Lakes, the main focus of research on ballast water is on the development of criteria for chemical treatment, particularly with regard to residual ballast water in ships entering the Great Lakes in a NOBOB (no ballast on board) situation. Finally, on the West Coast (British Columbia), several projects are being conducted to assess ecological risk for colonisation by non-indigenous species associated with ballast water discharges in the Strait of Georgia, Juan de Fuca Strait and the Pacific Coast, including: 1) modelling the dispersion of discharged ballast water; 2) sampling ballast water of ships entering British Columbia ports and assessing the effects of ballast water exchanges; and 3) the analysis and interpretation of literature data on ecological characteristics of selected non-indigenous species likely to be introduced in British Columbia ports.

Results of this Canadian Programme are being fed into the Canadian Ballast Water Working Group, created under the auspices of the Canadian Marine Advisory Council of Transport Canada (CMAC, www.tc.gc.ca/cmac), to provide scientific input into the management of the ballast water issue in Canada, including the recent revision of Guidelines for the Control of Ballast Water Discharge from Ships in Waters Under Canadian Jurisdiction.

Research on *Cercopagis pengoi* in the Baltic Sea and Great Lakes

H. Ojaveer

Cercopagis pengoi was first discovered in the Gulf of Riga and the Gulf of Finland in 1992 (first found along the southern coast of the Gulf of Finland in the port area of Muuga Bay; Ojaveer *et al*., 2000). By the mid-1990s, the species had colonised most of the Gulf of Finland and Gulf of Riga. In 1997, the species was reported from the Stockholm archipelago and appeared in the Baltic Proper (the Gotland Basin; Gorokhova *et al*., 2000). In 1999, the species was spreading further north to the Gulf of Bothnia and south to the Gulf of Gdansk (Uitto *et al*., 1999; Zmudzinski, 1999; Naumenko and Polunina, 2000; Ojaveer *et al*., 2000; K.-E. Storberg, pers. comm.). *Cercopagis pengoi* invaded Lake Ontario during 1998 (MacIsaac *et al*., 1999), probably from the Baltic Sea (Cristescu *et al*., 2001). In North America, *C. pengoi* also invaded Lake Michigan and at least six lakes in the Finger Lakes region of New York State during 1999, and one additional lake in the region during 2000 (MacIsaac, 2001).

Up to now, most studies have been directed to revealing spatio-temporal distribution of the species, including vertical and seasonal distribution. In other investigations, the high degree of variability of *C. pengoi* in relation to gender, reproductive cycle, and geographic origin (Baltic Sea, Great Lakes and Caspian Sea) has recently been documented (Grigorovich *et al*., 2000). It should be noted that animals in Lake Ontario (Great Lakes) are significantly smaller than those in the Baltic Sea and Caspian Sea.

In both newly colonised areas (Baltic Sea and Great Lakes), two morphological forms of *Cercopagis* have been found. The "spring form", having up to four barbs on the caudal process each of which is curved toward the body and a remarkably shorter caudal process that lacks the characteristic loop, could be taxonomically keyed as *Cercopagis* (*Apagis*) *ossiani*. The typical form (occurring in summer) is characteristic of the species *C. pengoi*. Makarewicz *et al*. (2001) were able to show that *C. ossiani* and *C. pengoi* are genetically identical and represent hatching egg and parthenogenetic generations of one species (*C. pengoi*). Similar unusual morphs have been reported in the Baltic Sea (Simm and Ojaveer, 1999).

Long-term investigations on *C. pengoi* are being carried out in the Gulf of Riga (Baltic Sea). These have revealed a linear increase in abundance since the first year of detection (1992–1999). Concomitant to invasion of *C. pengoi*, population abundance of the small-sized cladoceran *Bosmina coregoni maritima*, has significantly decreased. Broadly similar results were obtained by Barbiero *et al*. (2000) in Lake Ontario. The invasion of *C. pengoi* has led to changes in the diet of several fishes. Although the long-term mean share of *C. pengoi* in the diet of the most abundant planktivorous fish in the Gulf of Riga—herring, *Clupea harengus membras*, smelt, *Osmerus eperlanus*, and three-spined stickleback, *Gasterosteus aculeatus*, was low (<10 %), the species constituted up to 100 % of the contents of fish stomachs in some shallow coastal ecosystems during the warm season. The introduction may prove beneficial to commercial fisheries production if it enhances the transfer of previously less-utilised mesozooplankton production to planktivorous fishes (Ojaveer *et al*., 2000). However, through biofouling of fishing gear, *C. pengoi* has a direct economic impact on the fishing industry (Panov *et al*., 1999).

Alien invasive species issues at the expert meeting in preparation of the sixth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA-6) of the Convention on Biological Diversity (CBD)

H. Ojaveer

The meeting took place on the Isle of Vilm (Germany) on 18–19 January 2001. With regard to alien species matters, three documents were under discussion:

1) Progress report on matters identified in decision V/5, paragraphs 5, 11 and 14, and an analysis of national reports - UNEP/CBD/SBSTTA/6/6;
2) Comprehensive review on the efficiency and efficacy of existing measures for their prevention, early detection, eradication and control UNEP/CBD/SBSTTA/6/7;
3) Options for future work - UNEP/CBD/SBSTTA/6/8.

In summary, national reports indicate that the effect of invasive alien species is a very important issue for biodiversity management, but the ability for most countries to address the issue is extremely limited and, therefore, both national capacity-building and facilitation of collaborative efforts are clearly important areas to be tackled. Most countries that submitted a report informed that only major species of concern have been identified and that most countries had some measures in place (SBSTTA/6/6).

Attention to marine invasion issues in these three documents as well as during the meeting was rather weak. This is partly due to the fact that only very few participants in the meeting were familiar with these problems. However, in the report of the expert meeting, the following important proposals for amendments in SBSTTA/6/8 were made (Korn *et al*., 2001):

a) The International Maritime Organization (IMO) resolution A.868 (20) 1997 on ship's ballast water has not yet been ratified by a sufficient number of members. Amendment of Recommendation 3: (...) ratify the revised IPPC and the IMO Resolutions;
b) Hull fouling is a vector as important as ballast water, but is inadequately addressed by the IMO Recommendation. Amendment of Recommendation 4: (...) but notes that hull fouling is insufficiently addressed.

The Ballast Water Problem. Growing Concerns in Georgia

A. Shotadze

Ballast water concerns are being addressed through the Waste Management Sector of the Georgian National Environmental Action Plan. Monitoring of ballast water is conducted according to IMO recommendations A.868(20) and Georgian Water Law. In Batumi Port, vessels without segregated tanks arriving with dirty (or clean) ballast must transfer the water to the port's treatment plant. Georgia aims to establish a data management system to control ballast water, train personnel in water analysis and establish laboratories, develop surveys including mapping of biotopes in different areas of the Black Sea, and develop a decision support system for waste and ballast water management.

Settlement of microorganisms in ballast tanks — outlook for a spatio-temporal analysis of ship-associated transfers.

N. Hülsmann, B. Galil and R. Baier

Among ballast water and ballast sediments, a third component exists in ballast tanks: the biofilm layers associated with tank-internal surfaces. This component appears as a biofouling strata of microbes and—at least in its outer parts—of associated heterotrophic protists. Initial results on the biodiversity of such protistan communities were obtained by using artificial surfaces (glass, silicon-coated glass, polystyrene, painted metal-plates, etc.) deposited in cargo holds used as temporary ballast tanks and in dedicated ballast tanks of container vessels. The time span of exposure to ballast water was between two weeks and three months. The microfauna settling on these surfaces shows the same proportions as obtained from ballast sediments: sarcodines, heterotrophic flagellates and ciliates show nearly the same diversity. However, initial analyses demonstrate that the biodiversity registered from biofouling communities may be much richer than those associated with the tank-internal water column or inorganic/organic ballast sediments.

Reducing risk of exotic species establishment and transmissions in port regions

D. Minchin

The International Maritime Organization Guidelines provide a means for reducing the risk of importing unwanted species that might become established. Unfortunately these guidelines do not provide many measures for reducing the risk of secondary types of spread. The undertaking of surveys in ports to identify the main oceanographic features and the distribution and abundance of exotic species may provide a basis for reducing risk. By small alterations to ship ballasting and de-ballasting behaviour, or altering berthing sites, especially during periods when larval stages of exotic species are abundant in the plankton, a significant reduction of risk may be possible. Such precautionary measures will also need inputs from state managers, industrialists, ships' masters and port authorities. Surveys in port regions will identify species that may have a high risk of transmission and known harmful impacts. By adopting a precautionary approach as a port-donor of exotic species, rates of transmission worldwide could be reduced. Additional measures of managing the non-shipping vectors in port regions may be important. Reducing vector overlap may assist in reducing secondary-type spread. These vectors could include aquaculture, marinas and holding ponds for maintaining living products.

Ballast water research in Dutch ports

B. Wetsteyn and M. Vink

The objectives of the Dutch ballast water sampling programme were to determine:

1) which organisms are imported with ballast water in vessels entering Dutch ports;
2) do these organisms survive in Dutch surface and port waters?

Between November 1998 and November 2000, 37 ballast tanks were sampled on board 30 vessels: 12 container vessels, 9 multi-purpose vessels, 5 chemical tankers and 4 bulk carriers. The sampling was carried out in the ports of Rotterdam (20 ships), Amsterdam (6 ships) and Vlissingen (4 ships). Of the vessels sampled, transoceanic container ships and bulk carriers carried the largest amounts of ballast water. On container ships and multi-purpose ships samples were taken at the ballast pump, whereas chemical tankers and bulk carriers were sampled via opened manholes or deck overflows in the case of chemical carriers.

Of the 37 samples 26 originated from one discrete port or route, 17 of which were located within Europe. There were nine samples with a worldwide mix of origins and two samples were from an unknown source. Almost all of the mixed samples originated from large container vessels.

The temperature of the ballast water ranged from 7 ^{o}C to 24 ^{o}C and samples from the receiving port water ranged between 5 ^{o}C to 25 ^{o}C. The difference between ballast water and port water temperature varied between –6.5 ^{o}C and +5.0 ^{o}C and for 75 % of the temperature combinations the difference was within the range ± 2 ^{o}C.

The salinity of the ballast water samples ranged from 0.1 to 37.2 psu; 12 % of the samples originating from one source were classified as fresh (salinity < 0.5 psu), 46 % as brackish (0.5–30 psu) and 42 % as sea water (30–40 psu). The salinity of the receiving port water samples ranged from 0.3 to 28.6 psu, 4 % of the samples being fresh and 96 % brackish.

In ballast water samples, distinction was made between species analysed to species, genus or group level. A total of 120 phytoplankton (84 diatom and 28 autotrophic dinoflagellates), 37 microzooplankton (22 heterotrophic dinoflagellates and 8 rotifers) and 12 mesozooplankton (4 cladocerans and 8 copepods) were determined to species level. Most species had previously been identified from the Dutch phytoplankton monitoring programme. However, a number of potentially toxic species, amongst them five dinoflagellates, and three non-native dinoflagellates and one non-native copepod, were found in the ballast water samples.

In the receiving port water samples, 71 phytoplankton (55 diatom and 13 autotrophic dinoflagellates) and 17 microzooplankton (15 heterotrophic dinoflagellates) were determined to species level. Mesozooplankton species were not recorded in the (small) 1-litre samples.

Media of different salinities (5, 15 and 30 psu), incubated with ballast water, always resulted in growth of approximately 5 to 20 phytoplankton species. There was no significant relationship between the number of cultured species and salinity difference (salinity of the medium used minus salinity of ballast water). Even with a salinity difference of ±30 psu between the ballast water and the medium, 5 to 10 phytoplankton species were successfully cultured. Incubating ballast water in GF/F filtered port water always resulted in the growth of 5 to 20 phytoplankton species.

It is concluded that living plankton are imported into Dutch ports with ballast water. The plankton in the ballast water included toxic and non-native species and it is probable that some of the organisms contained within the discharged ballast would be able to survive in Dutch surface and port waters.

A short update on two species introduced to Norwegian waters:

"*Dasysiphonia* sp." and "*Caprella* sp."

A. Jelmert

Two species not previously described in Norwegian waters have been found during the last four years: a red algae described as *Dasysiphonia* sp. (Lein, 1999), and a caprellid crustacean, tentatively described as *Caprella mutica* (Heilscher, 1999). They are thought to be introduced by shipping activities based on circumstantial evidence:

1) They are both North Pacific species, not previously described in European waters;
2) They were found in Western Norway, but not along the coast between the Netherlands and Norway;
3) Western Norway receives large volumes of ballast water from the Netherlands.

The *Dasysiphonia* sp. has also been described as "*Heterosiphonia japonica*", but both names could be considered provisional, as the entire family Dasyaceae is under revision. The "*Dasysiphonia*" appear to have spread both northward and southward. By February 2001 it was found east of Lindesnes, the southern cape of Norway. This is opposite to the flow direction of the dominating coastal current. Its exact northern limit of migration is under study, and a paper will be published in the near future.

Caprella mutica has been found at Kvitsoey, which is close to the city of Stavanger. There seems to be some disagreement on the species name, and the species could be similar to *C. acanthogaster*.

Oil export from northern Russia along the Norwegian coast

A. Jelmert

In western Siberia and offshore in the Pechora Sea, considerable oil fields have been found and are now under development. For various reasons, some of the transport to European customers is planned via ships.

Cooperation has been established between the Russian company Gasproms and the German company Wintershall to develop the Prirazlomnoye field in the Pechora Sea. Owing to shallow waters, the size of the ships collecting cargo has to be limited to approximately 20 000 DWT. A further development further offshore requires ships up to 80 000 DWT. A fleet of shuttle ice-class tankers is planned to provide a large oil terminal in the Pechenga fjord, not far from the Varanger fjord, with oil. Ordinary VLCCs are planned to transport the oil from the terminal to Rotterdam.

The transported volume is expected to increase from the current approximate 200 000 t annually to approximately 36 million tonnes annually in 2004 when the oil terminal is finished.

Ship activities of this scale represent a considerable potential for the introduction of non-indigenous species into the area.

Basic principles in a Norwegian proposal for ballast water treatment standards

A. B. Andersen and A. Jelmert

It is suggested that representative biological organisms (model organisms) can be chosen based on functional criteria as well as taxonomic affiliation. Selection of representative species for each model group and the number of model groups required should reflect the different groups of marine organisms. The selected species must be well described and specified with respect to both species and strain. The cultivation conditions prior to the test as well as the method for assessing viability has to be clearly defined. The selected organisms should be easy to cultivate and handle, i.e., they must be robust. They should be non-pathogenic and preferably belong to species with a fairly global distribution. The organisms must be readily available from culture collection.

The suggested approach is based on the basic principles that are widely applied in ecotoxicity testing. An acceptance criteria profile can be established based on an allowable level of the selected species in the model groups. This allowable level can be expressed as a model group concentration or a total quantity (e.g., expected number of individuals) in the ballast water tank. The aim is to develop a test that is suitable to assess whether various treatments successfully reduce the number of specimens in the defined *model groups* to an acceptable level.

Acceptance levels for which treatment methods have to comply can then be developed for each organism group. The proposed principles can be used to assess the effect of any category of treatment options or methods (or combination of methods) that are currently in use or under development independently of the functional nature of the methods. It will also be suitable as a conceptual compliance mechanism for alternative treatment methods, and to validate or refine treatment methods during development.

The proposed approach is flexible and can be adapted to meet different requirements as reflected by the two-tier approach and differentiation between new and existing tonnage.

Preliminary results and future perspectives of the Port of Barcelona's Ballast Water Programme

A. Palau

The Port Authority of Barcelona is a public institution that manages operations in the Port of Barcelona. In 1995, the Environmental Service was created within the framework of the Port Authority to provide for environmental planning, regulation and control of different activities carried out in the port. The Environmental Service is currently carrying out a study entitled "Programme to Control the Introduction of Unwanted Species", the final objective of which is to improve port management in preventing the introductions of harmful non-indigenous species in the western Mediterranean.

The programme consists of two phases, the first aims to determine the introduction vectors and the aim of the second phase is to draw up regulations to manage these vectors in order to minimise the possibility of species being introduced. The first phase of the project is currently under way and is further divided into three separate areas of study:

- Ballast water. This part of the project began in 1999.
- Fouling, including TBT. This part of the project began in 2000.
- Other vectors. Planned to start in 2001.

The main aim of the first phase of the study was to gain more information about the quantity of ballast water released into the Port of Barcelona and to do this, the following methods were employed:

- to carry out a voluntary questionnaire study to estimate the volume and origin of the ballast water discharged into the port;
- to perform statistical analyses of the data obtained from the questionnaires and extrapolate them to the total number of ships that called at the port in 1999.

The questionnaire was sent to all types of vessels except warships, passenger ships and ships coming from the Balearic Islands during April 1999 and September 1999. A total of 2366 (54.7 % of all vessels entering the port) were sent the questionnaire during this time period and 25 % replied. The results showed that 17.5 % of ships calling at Barcelona discharged ballast and approximately 740 000 tonnes of ballast water were discharged into the Port of Barcelona in 1999. Half of the ballast water transported in ship's tanks was from the western Mediterranean, the other half came mainly from the Northern Pacific Ocean (Asia), the European coast of the North Atlantic and the Indian Ocean. The residence time in the tanks was also investigated and it was found that 70 % of ballast water had been in the tanks less than 30 days and could therefore contain living organisms, as many species have been shown to survive in ballast tanks for longer than 30 days. Over half (53 %) of ballast water discharged into Barcelona port had originated from the western Mediterranean.

The results of the first phase of the study indicated that, owing to the amount of ballast water discharged, the origin of the water and the short time the majority of the ballast water had been in the tanks before discharge, there is a high probability that unwanted species are being introduced into Barcelona waters. The second phase of the study is now being carried out and ten vessels chosen on the basis of their origin will be sampled by August 2001. This will provide qualitative analysis of the ballast water. Samples are taken to identity any virus or bacteria present in the tanks and to determine the specific composition of phytoplankton and zooplankton within the tanks.

Swedish Research Proposal "AQUALIENS"

I. Wallentinus, E. Willen and M. Appelberg

Swedish EPA new project area: Aquatic alien species—where and why will they pose a threat to the ecosystems functions and economy? (AQUALIENS)

AQUALIENS will emphasise the need for:

i) assessment of risks on the ecosystem level for organisms having specific functions or characteristics;
ii) identifying what categories of aquatic ecosystems are the most vulnerable and for which type of organisms;
iii) economic analyses of direct and indirect costs (cost/benefit and other analyses) associated with introduced species.

Aquatic ecosystems present better chances of survival and dispersal of introduced species and are difficult to monitor and thus should be treated separately from terrestrial ecosystems from a risk point of view. The emphasis of this project area will be on risks at the ecosystem level. Risk assessment will be based on differences in the tolerance of the organisms for certain factors in combination with the functions of the organisms and special characteristics giving advantages. Data from literature will be supplemented with experimental studies (especially for young stages of the life cycle). "Hidden" knowledge on local and regional levels will be actively collected. No field experiments will be carried out unless a species is already established in the area. Criteria for the susceptibility of an area will be analysed for various kinds of water and tested with "hindcasts" for different types of ecological risk analyses/assessments. If possible, quantitative risk analyses with different levels of uncertainties will also be applied. For new populations and for GMO having increased fitness, model simulations will be tested. Information to scientists, authorities and the general public is an important component, which will be highlighted in order to decrease the dispersal of introduced species.

Investigations into ballast water exchange in regional seas

T. McCollin and E. Macdonald

In order to reduce the introduction of non-indigenous or potentially harmful organisms transported in ballast water, the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) is currently drafting ballast water management guidelines. The guidelines recommend ballast water exchange on "deep sea" voyages. This excludes many European shipping journeys but, owing to the lack of alternative ballast management methods, it is likely that ballast exchange will also be utilised as a management method in regional seas. There has been little work carried out on the effectiveness of ballast water exchange in regional seas.

Earlier studies carried out by Macdonald and Davidson (1998) showed that ballast water exchange in the North Sea and Irish Sea appeared less effective at reducing the diversity and abundance of phytoplankton. Mid-water exchange increased the diversity of diatoms and dinoflagellates in 69 % and 85 % of cases, respectively, and abundance increased in 31 % and 85 % of cases. If there is to be a requirement for in-transit exchange of ballast water in regional seas then it is important that the effects of such an exchange are better understood. A three-year project at the Marine Laboratory in Aberdeen will aim to:

- carry out a detailed assessment of the efficiency of in-transit exchange in the North Sea and Irish Sea on planktonic organisms in ships' ballast tanks;
- assess the survival of planktonic organisms whilst on passage in ballast tanks.

Contact has been made with a shipping company that has a policy of carrying out ballast exchange who has agreed to allow research staff to work on board a bulk carrier, the "Yeoman Bank". The vessel carries rock from the west coast of Scotland to ports within Northern Europe and is always in ballast on the return trip to Scotland. The research staff joins the vessel at ports within Northern Europe and aims to obtain several types of samples:

- Water samples are taken from the ballast tanks before, during and after exchange for phytoplankton, zooplankton and salinity analysis.
- Part of the water pumped on board during the exchange process is diverted through a Chelsea data logger to measure, at pre-determined time intervals, the temperature, salinity, conductivity, transmittance and fluorescence of the water before it enters the ballast tanks.

- A towed instrument known as U-Tow will be deployed just prior to ballast water exchange and retrieved just after. U-Tow will take plankton samples at set intervals.
- Data from the GPS navigation system are used to record the location of the vessel during exchange and this is merged with the data from the SDAS data logger to allow generation of detailed analysis of the hydrographic condition throughout the ballast exchange process.

To date eight cruises have been successfully completed. Future work includes development of a database, further analysis of the samples and more cruises to obtain samples from all seasons.

<u>Evaluating bioeffectiveness of flow-through mechanical ballast water treatment systems (cyclonic separation and UV, and filtration and UV) at the pilot- and full-scales</u>

A. A. Cangelosi, I. T. Knight, M. Balcer, D. Wright, C. Blatchley, D. Reid, N. Mays and J. Taverna

International guidelines and United States law direct ships to manage ballast water to reduce unintentional organism transfers, but the only method currently available to ships, open ocean ballast water exchange (BWE), has serious limitations. Treatment alternatives that are as or more effective than BWE have been proposed, but few have been subject to comprehensive bioeffectiveness tests and there is no standard measure of bioeffectiveness. Comprehensive experiments were conducted to describe and compare the bioeffectiveness of two commercially available ballast treatment combinations: a cyclonic separator (CS) and ultraviolet radiation (UV) system (Hyde-Optimarin), and automatic backwash screen filtration (ABSF) and UV (Ontario Hydro Technologies and Hyde-Optimarin). This paper characterises results from the field tests, and explores ballast treatment characterisation and comparison issues, generally.

The bioeffectiveness of CS and UV was evaluated at two time intervals following treatment (0 hours and 18–24 hours), two treatment contexts (MV “Regal Princess” installation at 880 GPM, and a barge-based platform at 1500 GPM), and varied physical/chemical water conditions (Pacific Northwest coastal, and two Lake Superior locations). CS and UV results show effectiveness at killing zooplankton, and attenuating phytoplankton and bacterial growth. Both CS and UV contributed to zooplankton mortality, while UV alone was the dominant component contributing to phytoplankton and bacteria inactivation. The shipboard system, which treated water on uptake and discharge, elevated zooplankton mortality two and a half fold relative to controls. Delayed mortality effects on zooplankton were measurable following treatment during ballasting, while immediate zooplankton mortality was evident upon treatment during deballasting, indicating that the intake treatment, storage in a ballast tank, and a slower pump rate upon discharge could contribute to zooplankton susceptibility to the treatment. Live density of zooplankton in treated water decreased by over 90 % relative to intake in the shipboard application (compared to 55 % in the controls). The intake-only treatment on the barge platform (1500 GPM) elevated zooplankton mortality 51 % relative to controls. These findings represent a conservative estimate of zooplankton inactivation as latent mortality caused by the discharge treatment and reproductive effects were not measured, and moribund individuals were counted as live.

CS and UV reduced chlorophyll *a* and bacteria as well, but the CS did not contribute significantly to this effect. Initial chlorophyll *a* concentrations relative to controls were not altered through acute effects of the system such as removal or bleaching on either platform. Storage of the water for 18 hours in a catchment or ballast tank prior to sampling did not alter this finding. The system did reduce algal growth and accelerated die-off relative to controls. Chlorophyll *a* concentrations in incubated samples collected 18 hours following treatment were nearly 60 % lower than controls. The system also reduced microbial and MS-2 coliphage concentrations, with UV absorbency strongly influencing system performance. The mean inactivation due to treatment was approximately one log (90 %) for bacteria and 1.3 log (95 %) for coliphage MS-2 at Two Harbors (UV transmittance over 90 %/cm), while the mean inactivation due to treatment was approximately 0.1 log (25 %) for bacteria and 0.3 log (50 %) for MS-2 in Duluth (UV transmittance 30–45 %). The mean reduction due to one pass through the treatment system on the MV “Regal Princess” was 82 %, but retention for less than two hours in the ballast system raised concentrations of culturable bacteria 1.45 Log higher than levels immediately following treatment. Bacterial regrowth and/or repair during 18–24 hour retention in the ballast tank raised bacterial concentrations 2.62 Log. Treatment reduced bacteria concentrations over twice as effectively during discharge than during ballasting.

These results are compared to the effectiveness of ABSF and UV based on barge-platform tests only. UV in combination with ABSF yielded higher (by nearly twice) reductions in live zooplankton than CS and UV, and equivalent reductions in algal and bacterial growth. ABSF alone consistently reduced macrozooplankton by over 95 %, and microzooplankton (rotifers) by over 80 % relative to controls. The ABSF alone caused up to 30% (average 20 %) reduction in initial concentrations of chlorophyll *a*. The treatment achieved much higher reductions in concentrations of specific algal taxa such as dinoflagellates (>97 %). The ABSF did not cause an increase in the number of smaller algal fragments due to break-up. However, the ABSF alone may enhance algal growth slightly during retention following treatment through selective removal of grazers, but the increase was not statistically significant. The ABSF alone did not reduce total culturable bacteria, but did reduce attached bacteria concentrations. The effects of ABSF in combination with UV on total culturable bacteria were not different from those of CS and UV.

Clarification of physical/chemical parameters governing treatment performance, and a common performance metric (reduction and inactivation in specific terms) are critical accompaniments of comparable ballast treatment system effectiveness assessments. Understanding the interactions between ballast water treatment processes and ships' ballast systems and the receiving system are necessary to differentiate biologically meaningful treatment effectiveness and ostensible treatment effectiveness.

Figure 3.1. Relative efficiency of filters at removing total zooplankton. Tests carried out on M/V "Algonorth".

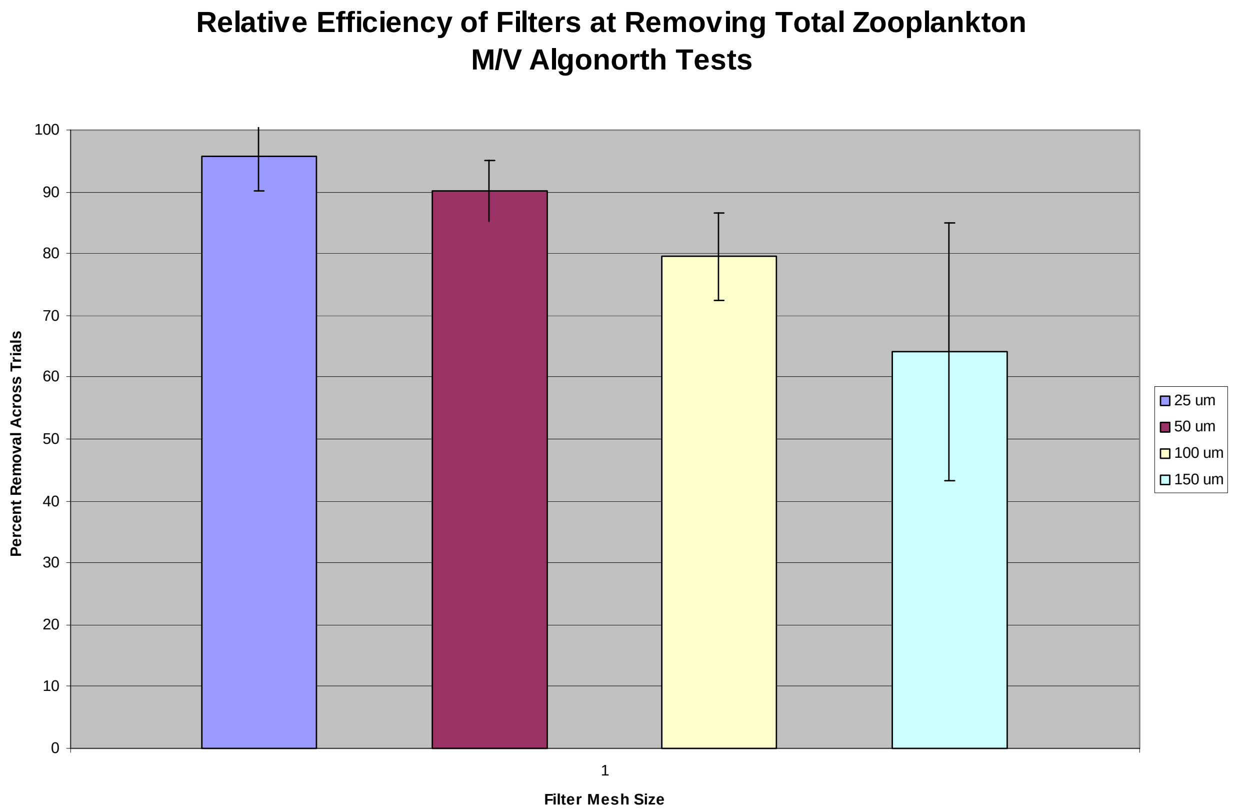
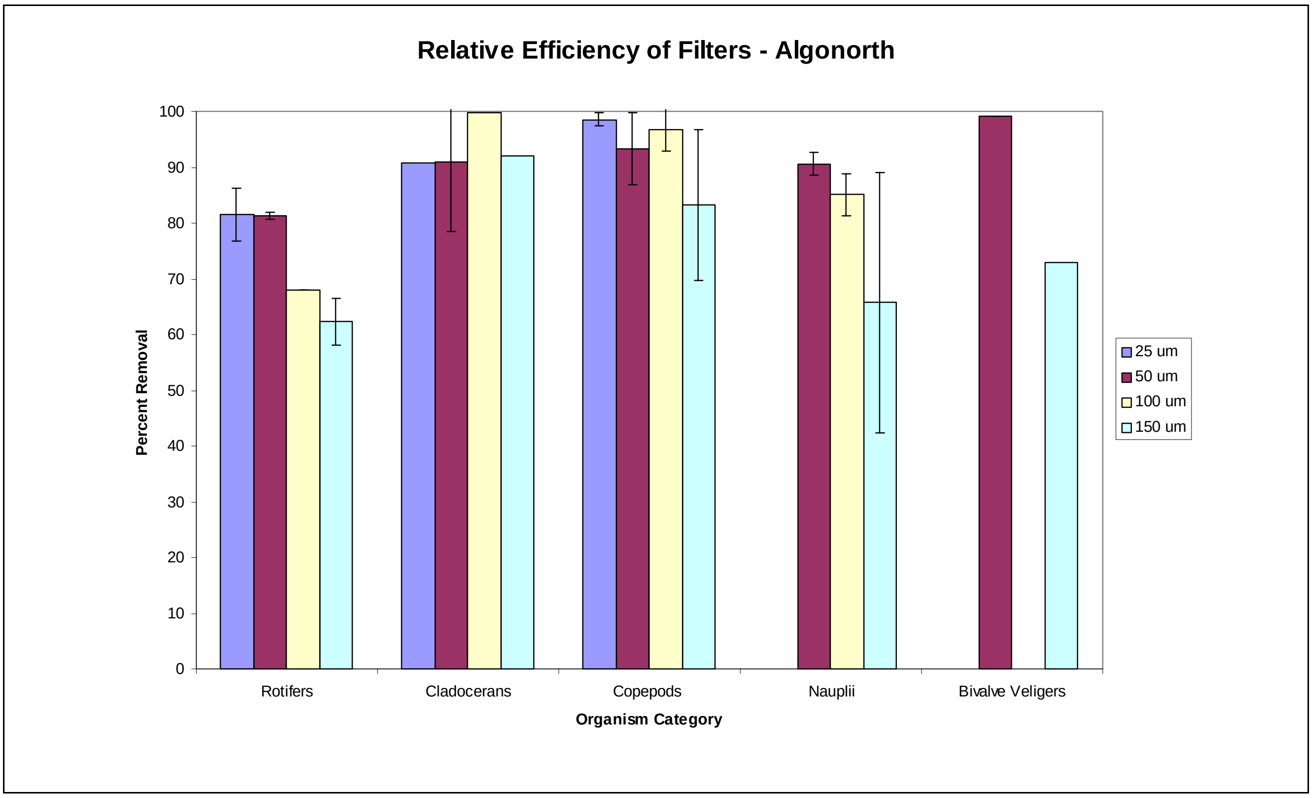


Figure 3.1.2. Relative efficiency (percent removal of organisms) of filters with different mesh-sizes. Tests carried out on M/V "Algonorth".



Tracking sources, patterns, and effects of coastal marine invasions

G. Ruiz, A. W. Miller, B. Steves, P. Fofonoff, and A. Hines

The Smithsonian Environmental Research Center (SERC), located on the shore of Chesapeake Bay, is a national center within the U.S. for research in the area of non-native species invasions in coastal ecosystems. A primary goal of SERC's Marine Invasion Research Laboratory is to provide the fundamental science that is critical to develop effective management and policy in this topic area.

As a national center, SERC's Marine Invasion Research Laboratory provides synthesis, analysis, and interpretation of invasion-related patterns for the country. Under the National Invasive Species Act of 1996, the U.S. Coast Guard and SERC created the National Ballast Water Information Clearinghouse to collect and analyse national data relevant to coastal marine invasions. Established at SERC in 1997, the Clearinghouse measures:

Nationwide Patterns of Ships' Ballast Water Delivery and Management

All commercial ships arriving to all U.S. ports from overseas report information about the quantity, origin, possible control measures for their ballast water—a primary mechanism for transfer of non-native marine species throughout the world. SERC is expected to receive roughly 60 000 such reports per year. Every two years, SERC provides a detailed analysis and report to the U.S. Coast Guard and Congress on the patterns of ballast water delivery by coastal state, vessel type, port of origin, and season. A key issue is the extent to which ships undertake ballast water exchange, a management technique to flush potential invaders out of the tanks prior to arrival in U.S. waters. This analysis is used by the U.S. Coast Guard and Congress to assess national needs with respect to ballast water management.

Rates and Patterns of U.S. Coastal Invasions

SERC has developed and maintains a *national database of marine and estuarine invasions* to assess patterns of invasion in space and time. This database compiles a detailed invasion history of approximately 500 different non-native species of plants, fish, invertebrates, and algae that have invaded coastal states of North America. Among multiple uses, the database identifies which species are invading, as well as when, where, and how they invaded; it also summarises any existing information on the ecological and economic impacts of each invader. Over the long term, this database will help assess the effectiveness of various management strategies (such as ballast water management, above) in reducing the rate of invasions. More broadly, this information is a valuable resource for many user groups—from resource managers and scientists to policy-makers and industry groups.

At the core of each component is an extensive database. These two databases are designed explicitly as research and management tools to:

- Characterise patterns of invasion in space and time according to species, taxonomic group, transport mechanism (or vector), habitat, latitude, and a suite of biological characteristics;
- Identify ecological and economic impacts of known or potential invaders;
- Develop predictions and risk analyses about patterns and effects of invasion, based upon empirical data (above);
- Evaluate management strategies to prevent invasions by particular species and vectors.

Importantly, the two databases are designed to operate synergistically. The database of established invaders is used for vector analysis, identifying the relative strength of various vectors in space and time. Analysis of current data indicates that shipping has been responsible for most marine invasions in the United States, the rate of new invasions appears to be increasing, and this increase is driven largely by the shipping vector (Ruiz *et al*., 2000). The role of shipping and the apparent increase in invasion rate has also been reported for a number of individual estuaries within the U.S. (e.g., Mills *et al*., 1993; Cohen and Carlton, 1998; Ruiz *et al*., 2001). Ships are now being asked to implement management strategies, including ballast water exchange and alternative technologies, to reduce the risk of future invasions. The database on shipping serves to characterise the immediate effectiveness of this programme, tracking the rate of compliance and types of management strategies used, whereas the database on reported invasions is designed to measure the long-term response in the actual rate of invasions. This latter aspect is key to assessing the efficacy of management activities and providing feedback for future management and policy decisions.

A fundamental obstacle in measuring patterns and rates of invasion, however, has been the lack of standardised surveys, to provide robust baseline data (Ruiz *et al*., 2000). SERC has initiated a programme of field surveys to detect new invasions, as well as measure contemporary patterns of invasion, for 15–20 different bays throughout the country. The intent is to expand this programme to include additional regions within and outside of North America, establishing core sites for intensive and long-term measures. Toward this end, we have initiated surveys in Australia and have begun to pursue parallel measures through collaboration in other countries.

More broadly, we wish to develop an international network of collaborators, to build complementary and comparative measures of invasion patterns and vector operation. Such a network would greatly enhance information needed for both management and understanding of invasion processes. A key tool in building such a network is the creation and interaction of parallel databases, expanding access to information across many geographic regions, habitat types, and taxonomic groups.

3.2 Treatment and Management Measures for Ballast Water

United Kingdom compliance with ballast water regulations

S. Welch, I. Lucas, J. Hamer

Ports and harbours often act as “hot spot” areas for introductions and establishment of non-native marine organisms. The knowledge regarding the occurrence, distribution and abundance of non-indigenous species in ports and harbours in the UK is extremely limited.

The University of Wales, Bangor has been contracted by the Department of the Environment, Transport and the Regions to develop a port sampling programme which would be able to provide a baseline record of the occurrence of alien species in major ports and harbours within the UK.

Six ports have been targeted: Liverpool, Cardiff, Milford Haven, Southampton, Felixstowe and Teeside, on the basis of their locations, current knowledge, type of port and volume of traffic using that port.

The project will be completed by March 2002.

Objectives:

- To review current survey procedures within the OSPAR region and develop a port sampling programme that will complement existing information and any on-going surveys being carried out within the Convention area.
- To provide a baseline record of the occurrence, distribution and abundance of alien species in major UK ports and harbours.
- To evaluate the present status of alien species in UK ports and harbours.
- To provide recommendations for the structure of future monitoring programmes with regard to OSPAR and IMO requirements and suggest areas of development for future monitoring practices.

<u>What the industry can do and will do, and what it cannot do in regard to ballast water treatment</u>

A. Bilney

The International Chamber of Shipping is an association of national shipowner associations; it is intended as a central point for discussion, the sharing of owners' views and development of industry positions, then expressing those positions during negotiations with governments which are making international laws affecting ships.

Ballast water is fundamentally a quarantine problem and solutions to the problem of introducing non-native species must draw on existing successful quarantine practices, e.g., fumigation of cargo, deratisation of ships. Precautions against aquatic organisms can and will be accepted in the same way.

What ships can presently do is keep records of their own ballasting and deballasting, and be up to date with the administrative demands of port states. It is mutually advantageous for ships and ports to exchange such information. But ships cannot currently comply with a law prohibiting discharge of any living foreign organism in ballast water, or requiring ballast water to be completely sterilised. The tools to do these things do not exist, and the consequences of trying to do them with the wrong tools will probably cause more harm to the environment.

The shipping industry is reliant on the work of groups such as SGBOSV to identify what needs to be done and to set a performance standard. It is necessary to develop requirements for sampling methods to test compliance and also to decide who should carry out compliance monitoring, e.g., ship, port state, flag state, etc. An international body may be needed to give approval of a system, as the WHO in Geneva does for human inoculation.

What shipowners need is the freedom to trade worldwide once their ships meet an approved standard. This meeting, and the others at IMO in the next few weeks, must set that standard for ballast water.

<u>Methodological approach to develop standards for assessment of harmful aquatic organisms in ballast water</u>

A. B. Andersen, H. L. Behrens and G. P. Haugom

There is a recognised need for the development of a standard test regime and some generally accepted criteria against which all treatment methods, or combination of methods (chemical, biological, mechanical, physical or others), can be tested in order to achieve acceptance. Such a test regime should also be suitable for verification of the effect of selected treatment methods in operation. The aim of this paper is to present a methodological approach that can help provide definition criteria for ballast water standards or norms, is suitable for the assessment of ballast water treatment methods standard(s) and does not eliminate methods of treatment.

The assessment of a specific treatment option must include a number of items: implications affecting the vessel, implications of an occupational nature, implications to the environment, and efficiency and reliability as a countermeasure against unwanted harmful transfer of aquatic organisms. This proposal only caters for the latter of the above issues.

There are various approaches that can be selected to assess the effect of a ballast water treatment method against some identified criteria. It might, for example, be considered necessary to perform extensive sampling before and after treatment. The sampling would then be followed by detailed biological analysis of the samples to identify the presence of potentially harmful organisms both before and after treatment. To enable an assessment of the efficiency of the treatment method and a comparison with other treatment methods, the reduction in the presence of potentially harmful organisms would have to be expressed quantitatively, for example, as a density reduction.

To obtain a generally accepted standard suitable for the comparison of different treatment methods, a common biological basis needs to be developed.

Outline of suggested methodology

It is suggested that representative biological organisms be determined by defining groups of organisms. Acceptance levels, for which treatment methods have to comply, can then be developed for each organism group. Hereafter, the chosen organism group is referred to as a *model group*. To represent criteria which prevent ballast water organisms from establishing and/or reproducing in a ballast water recipient port, the *model groups* have to meet a range of criteria, and it is anticipated that all *model group* species will be robust, and that the most resistant species and life stages will be highly represented.

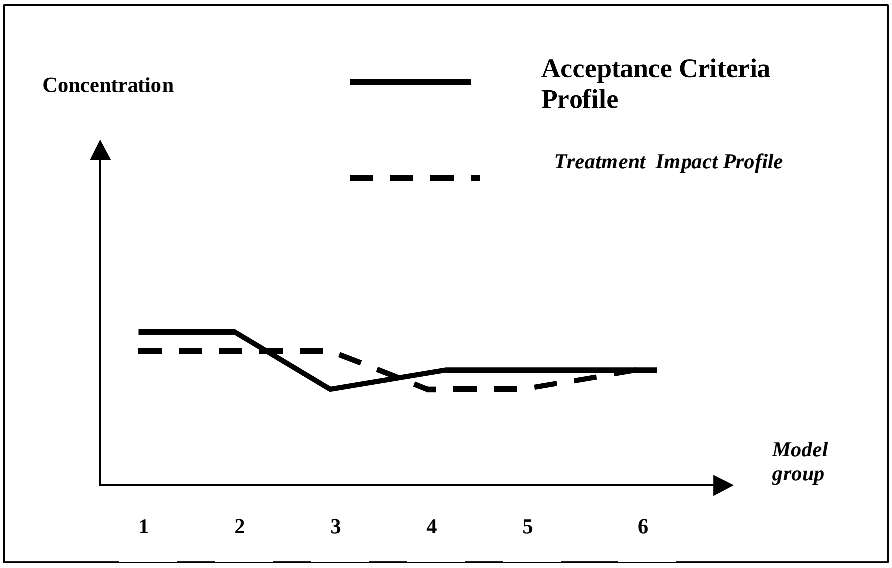
The purpose of each selected organism group is to serve as a model for one group of organisms reflecting how this group resists ballast water treatment. This does not necessarily require a typical ballast water organism. Ballast water treatment systems can be assessed both through pilot-scale (0.1–10 m^3 water) and full-scale tests.

Development of Acceptance Criteria

A standard for assessment of ballast water treatment methods needs to be founded on a set of clear, well-defined and (preferably) widely agreed acceptance criteria. The acceptance criteria may be related to the mortality rate following treatment, e.g., concentration of living representative species in the different *model groups*. An introduced or proposed treatment method will be assigned a treatment impact profile with reference to application details (e.g., dose-response relationships) for the representative species. Critical factors may be whether one representative species can be selected for testing for each model group, or whether a number of species has to be selected to obtain satisfactory test results.

The requirement for safety factors in the acceptance criteria needs to be further evaluated as part of the work required to develop commonly agreed acceptance criteria.

Figure 3.2.1. Hypothetical results for testing of a treatment method.



Discussion

The use of *model groups* outlined here can provide the basis for the selection of a standardised approach to assess the efficiency of proposed ballast water treatment methodologies. Although this approach is far less labour intensive than a full biological assessment of the actual ballast water, the testing of the effect of a treatment method on the survival of species from all model groups mentioned in Table 3.2.1 will still be an extensive, laborious and time-consuming process. Further work to select suitable test organisms, and to minimise the number of different test organism species, will therefore be important. The final selection of *model groups* and test organisms should be based on international consensus.

Table 3.2.1 Possible model groups and examples of some suitable test species representing these groups.

Model Group	**Sub-groups (systematic group)**	**Test Species**
Phytoplankton	Dinoflagellates	
	Diatoms	*Skeletonema costatum, Phaeodactylum tricornutum*
Crustaceans	Crabs	
	Shrimp	*Artemia salina*
	Copepods	*Acartia tonsa*
	Amphipods	*Corophium volutator*
Rotifers		*Brachionus plicatilis*
Polychaetes		
Molluscs	Mussels	
	Gastropods	
Fish		Turbot (*Scophtalmus maximus*)
Echinoderms		
Ctenophores		
Coelenterates		
Bacteria		*Vibrio fischeri*
Viruses		

The presented *model group* approach will require calibration against general biological data and defined hazardous species. Further work will be required to standardise ballast water sampling methods to enable efficient and consistent utilisation of the proposed methodology for testing of ballast tanks.

It is known that bacteria respond to most chemicals through mechanisms similar to those of higher organisms. Testing of the effect of ballast water treatment methods by using simple organisms like bacteria can therefore provide a fast, less-complicated and far less-expensive testing regime. This also means that it will be possible to perform a much larger number of tests.

It is therefore suggested that microbial biosensors be selected as a test organism. Microbial biosensors can, if required, be genetically modified to represent selected groups of hazardous organisms. This approach will provide a rapid, low-cost methodology with reproducible results suitable for testing and verification of the effect of various transfer prevention techniques.

The proposed *model group* approach can be developed into a set of standard tests to determine the efficiency of proposed risk reducing measures for different groups of hazardous species. The methodology might also be used as a verification tool to test whether applied reduction measure(s) have the expected effect before a vessel with ballast water from a "high risk area" is allowed to de-ballast. The methodology can be used to express expected survivability of defined harmful aquatic species.

To summarise, the methodology will, when fully developed, be suitable for: (a) general testing and verification of the efficiency of new ballast water treatment methods, (b) spot tests on vessels' ballast water tanks to screen for harmful aquatic species, (c) verification of the efficiency of a treatment method for single transfers, vessels or ballast tanks, and (d) screening to determine whether a vessel should be allowed to de-ballast.

Significant further work will be required in the process to detail the proposed approach and to develop and fully test the biological basis for the selection of model groups and test species.

3.3 References Cited

Avinski, V. 1997. *Cercopagis pengoi* – a new species in the eastern Gulf of Finland ecosystem. In: Proceedings of the final seminar of the Gulf of Finland year 1996. March 17-18, Helsinki, Finland. Edited by J. Sarkkula. Suomen Ympäristökeskus, Helsinki. pp. 247–256.

Barbiero, R.P., Little, R.E. and Tuchman, M.L. 2000. Results from the USEPA's biological open water surveillance program of the Laurentian Great Lakes: III. Zooplankton. *J. Great Lakes Res.* (submitted).

Cohen, A., and Carlton, J. 1998. Accelerating Invasion Rate in a Highly Invaded Estuary. Science 279: 555–558.

Cristescu, M., Hebert, P.D.N., Witt, J., MacIsaac, H.J. and Girgorovich, I. 2001. An invasion history for *Cercopagis pengoi* based on mitochondrial gene sequences. Limnology and Oceanography. In press.

Gorokhova, E., Aladin, N. and Dumont, H.J. 2000. Further expansion of the genus *Cercopagis* (Crustacea, Branchiopoda, Onychopoda) in the Baltic Sea, with notes on the taxa present and their ecology. Hydrobiologia 429: 207–218.

Grigorovich, I.A., MacIsaac, H.J., Rivier, I.K., Aladin, N.V. and Panov, V.E. 2000. Comparative biology of the predatory cladoceran *Cercopagis pengoi* from Lake Ontario, Baltic Sea and Caspian Sea. Archiv für Hydrobiologie 149: 23–50.

Heilscher, S. 1999. Stefan Heilscher, University of Freiburg, pers.communication.

Korn, H., Stadler, J., and Dinter, W.P. 2001. Report on the expert meeting in preparation of the sixth meeting of SBSTTA, January 18–19, 2001. German Federeal Agency for Nature Conservation, 38 pp.

Krylov, P.I. and Panov, V.E. 1998. Resting eggs in the life cycle of *Cercopagis pengoi*, a recent invader of the Baltic Sea. Archiv für Hydrobiologie Special Issues Advanced Limnology 52: 383–392.

Krylov, P.I., Bychenkov, D.E., Panov, V.E., Rodionova, N.V. and Telesh, I.V. 1999. Seasonal dynamics and distribution of the Ponto-Caspian invader, *Cercopagis pengoi* (Crustacea, Cladocera), in the Neva Estuary (Gulf of Finland). Proceedings of the BMB 15 and ECSA 27 Symposium. Hydrobiologia : 227–232.

Macdonald, E.M. and Davidson, R.D. 1998. The occurrence of harmful algae in ballast discharges to Scottish ports and the effects of mid-water exchange in regional seas. *In* 'Harmful Algae'. Reguera, B., Blanco, J., Fernandez, M.L. and Wyatt, T. (Editors). Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, 220–223.

MacIsaac, H.J. 2001. *Cercopagis pengoi*: Another Ponto-Caspian invader in the Great Lakes. http://www.cs.uwindsor.ca/users/h/hughm/private/cercopagis.html

MacIsaac, H.J., Grigorovich, I.A., Hoyle, J.A., Yan, N.D. and Panov, V. 1999. Invasion of Lake Ontario by the Ponto-Caspian predatory cladoceran *Cercopagis pengoi*. Canadian Journal of Fisheries and Aquatic Science 56: 1–5.

Makarewich, J.C., Grigorovich, I.A., Mills, E., Damaske, E., Cristescu, M.E., Pearsall, W., LaVoie, M.J., Keats, R., Rudstam, L., Hebert, P., Halbritter, H., Kelly, T, Matkovich, C., and MacIsaac, H. 2001. Distribution, fecundity and dispersal of *Cercopagis pengoi* (Crustacea, Cladocera) - a new exotic zooplankter in the Great Lakes basin. Journal of Great Lakes Research (in press).

Mills, E., Leach, J., Carlton, J., and Secor, C. 1993. Exotic Species in the Great Lakes: a History of Biotic Crises and Anthropogenic Introductions. Journal of Great Lakes Research 19: 1–54.

Naumenko, E.N., Polunina, Yu.Yu. 2000. New cladocera species – *Cercopagis pengoi* (Ostroumov, 1891) (Crustacea) in the Vistula Lagoon of the Baltic Sea. ICES C.M. 2000/U:14.

Ojaveer, E., Lumberg, A. and Ojaveer, H. 1998. Highlights of zooplankton dynamics in Estonian waters (Baltic Sea). ICES Journal of Marine Science 55: 748–755.

Ojaveer, H. and Lumberg, A. 1995: On the role of *Cercopagis pengoi* (Ostroumov) in Pärnu Bay and the NE part of the Gulf of Riga ecosystem. Proceedings of the Estonian Academy of Science, Ecology 5(1/2): 20–25.

Ojaveer, H., Kuhns, L.A., Barbiero, R.P., and Tuchman, M.L. 2001. Distribution and Population Characteristics Of *Cercopagis pengoi* In Lake Ontario. Journal of Great Lakes Research, in press.

Ojaveer, H., Leppäkoski, E., Olenin, S. and Ricciardi, A. (submitted). Ecological impact of Ponto-Caspian invaders in the Baltic Sea, European inland waters and the Great Lakes: an inter-ecosystem comparison.

Ojaveer, H., Simm, M., Lankov, A. and Lumberg, A. 2000. Consequences of invasion of a predatory cladoceran. ICES C.M. 2000/U:16.

Panov, V.E., Krylov, P.I. and Telesh, I.V. 1999. The St. Petersburg harbour profile. *In* Initial risk assessment of alien species in Nordic coastal waters. Edited by S. Gollasch and E. Leppäkoski. Nordic Council of Ministers, Copenhagen, pp. 225–244.

Ruiz, G., Fofonoff, P., Carlton, J., and Hines, A. 2001. Invasion History of Chesapeake Bay. Report to U.S. Fish and Wildlife Service.

Ruiz, G., Fofonoff, P., Carlton, J., Wonham, M., and Hines, A. 2000. Invasion of Coastal Marine Communities in North America: Apparent Patterns, Processes, and Biases. Annual Review of Ecology and Systematics 31: 481–531.

Simm, M., and Ojaveer, H. 1999. Occurrence of different morphological forms of *Cercopagis* in the Baltic Sea. Proc. Estonian Acad. Sci. Biol. Ecol. 48:169–172.

Telesh, I.V., Bolshagin, P.V. and Panov, V.E. Quantitative estimation of the impact of alien species *Cercopagis pengoi* (Crustacea: Onychopoda) on the structure and functioning of plankton community in the Gulf of Finland, Baltic Sea. Doklady Biol. Sci (in press).

Telesh, I.V., Litvinchuk, L.F., Bolshagin, P.V., Krylov, P.I, and Panov, V.E. 2000. Biological characteristics of the Ponto-Caspian species *Cercopagis pengoi* (Crustacea, Onychopoda) in the Baltic Sea. *In* Species introducers in the European seas in Russia (G.G. Matishov, V.V. Denisov, A.D. Chinarina, V.S. Zenzerov and E.G. Berestovsky, eds.) Kola Science Centre RAS, Apatity, pp. 130–150 (in Russian).

Uitto, A., Gorokhova, E. and Välipakka, P. 1999. Distribution of the non-indigenous *Cercopagis pengoi* in the coastal waters of the eastern Gulf of Finland. ICES Journal of Marine Science 56 (Suppl.): 49–57.

Zmudzinski, L., 1999. *Cercopagis pengoi* (Cladocera) conquered the southern Baltic Sea. Baltic Coastal Zone. Institute of Biology and Environmental Protection. University of Education, Slupsk, 1998/1999, 2: 95–96.

4 CONCLUSIONS AND FINDINGS

The following is a summary of the major conclusions and findings, as agreed upon by meeting participants. These are based upon the reports which were presented and reviewed in detail at the meeting, as well as upon substantive and extended discussions arising from the presentations.

4.1 Assess the Many Different Types of Ship Vectors

Shipping is certainly a vector of very great importance for species invasions globally, but it is difficult to prove that a species was introduced by shipping, although this is very likely in many cases. The relationship between hull fouling versus dispersal by ballast (water or sediment) as vectors needs to be better estimated, especially in the future when a TBT ban may increase dispersal on the hulls, particularly if more species-specific antifouling paints (based on chemicals inhibiting settling for certain important fouling organisms, e.g., barnacles) are developed.

It is becoming clear that increasing attention needs to be paid to fouling communities on ships' hulls and in sea chests. Recently undertaken summaries of non-native species in, e.g., the North Sea and certain areas of Australia and USA revealed the importance of hull fouling as a vector for invasions as historically the number of non-native species likely to have been introduced by hull fouling of ships is greater than ballast water-mediated introductions. However, it is important to note that in some cases it remains unclear whether the species could have arrived as adult individuals in ship's fouling or as larvae in the ballast water. Further, it is unclear whether hull fouling is currently the most important vector of species introductions or whether it was more important in the past (wooden sailing ships).

The movement of heavily-fouled vessels and other marine platforms is of growing concern. Examples include exploratory platforms, the movement of swim docks, and the movement of vessels that have been anchored for long periods of time in one region.

To estimate the relative importance of shipping as a vector we also need to have better quantitative estimates on the role of other vectors. Furthermore, a particular species (e.g., the Japanese kelp *Undaria pinnatifida*) may have been introduced by several vectors (in this case both shipping and aquaculture, unintentionally as well as intentionally) making it difficult to estimate the relative importance of each vector. Drifting might in many cases be the main vector for further dispersal (secondary introduction) from the first point of introduction, and could probably be an important vector of species dispersal.

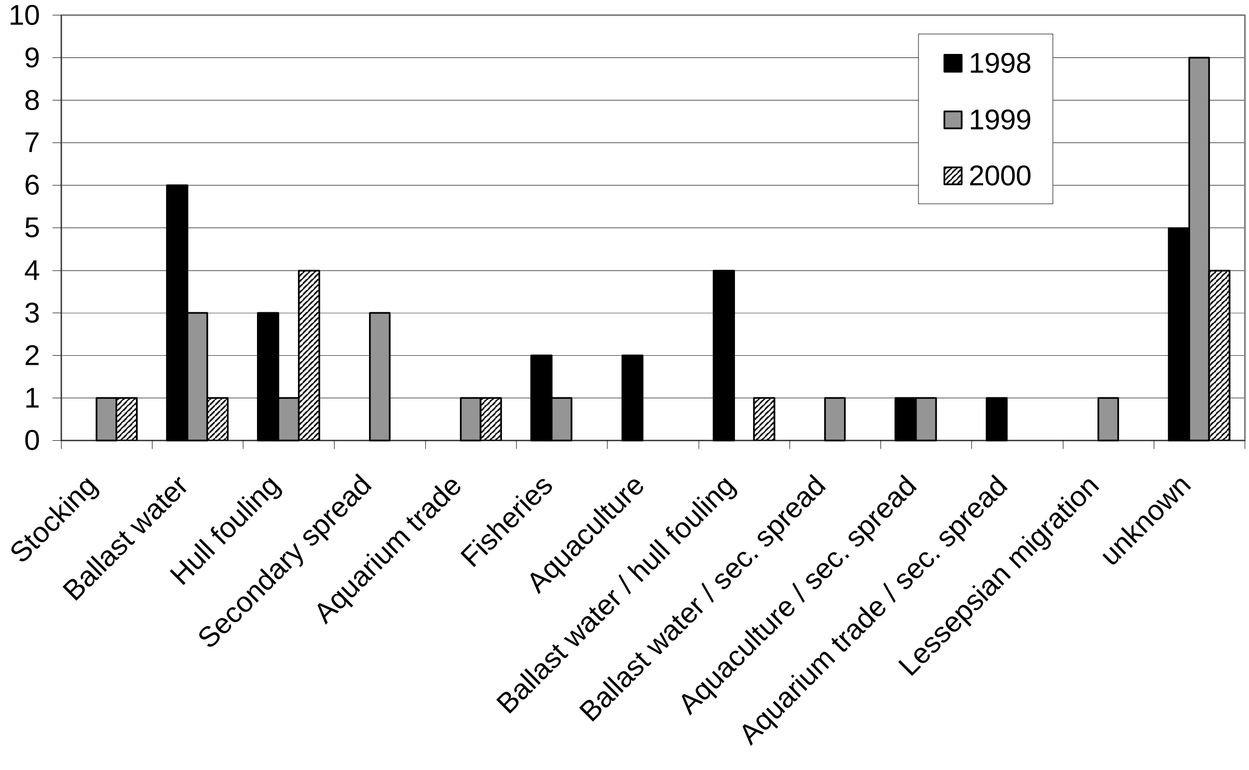
An assessment of different types of ship vectors, with specific attention to determining which of these vectors have been quantitatively sampled in recent years, was undertaken. It was agreed that no data exist to assess the relative importance of vessel types, voyage lengths (see Section 4.2.1, below), voyage routes, seasonal changes, and other pertinent variables to assess future species invasions.

To further demonstrate the importance of vectors for species invasions details on the most likely vector of introduction for recent species invasions were compiled. From Figure 4.1.1 and Table 4.1.1 (see below), it can clearly be seen that the most common introducing vectors are ballast water, hull fouling and the secondary spread of previously recorded invasions from neighbouring areas. However, it has to be noted that for many newly recorded species the transportation vector remains unknown, as several vectors seem likely for certain species invasions.

Table 4.4.1. Summary of first records of aquatic non-native species (not limited to ICES Member Countries) according to introducing vectors since 1998 (see Sections 4.2.2.1 to 4.2.2.3 for details)

Vector	Total
Stocking	2
Ballast water	10
Hull fouling	8
Secondary spread	3
Aquarium trade	2
Fisheries	3
Aquaculture	2
Ballast water / hull fouling	5
Ballast water / sec. spread	1
Aquaculture / sec. spread	2
Aquarium trade / sec. spread	1
Lessepsian migration	1
Unknown	18
Total	58

Figure 4.1.1. First records of aquatic non-native species (not limited to ICES Member Countries) according to introducing vectors since 1998 (see Sections 4.2.2.1 to 4.2.2.3 for details).



4.2 Status of Biological and Ecological Research on Exotic Species in Ballast Water and Sediment

The abundance and diversity of species in ballast water have been examined by many studies around the world over the past 25 years. The enormous amount of data generated by these studies is too vast to be considered in great detail here. The details on European shipping studies given below were taken from a summary report submitted to the Canadian Journal for Fisheries and Aquaculture Sciences (CJFAS) as "Life in Ballast Tanks" (Gollasch *et al*., in prep.).

4.2.1 European shipping studies

The results of European research activities are summarised here by outlining the objectives of some of these studies, and by focusing on the diversity of taxa determined from ballast water and tank sediment samples. In total 1508 samples (1219 ballast water, 289 tank sediment) were collected from 550 ships. The total number of taxa determined during the 13 European shipping studies reviewed was 990. The diversity of species found included, e.g., bacteria, fungi, protozoans, algae, invertebrates of different life stages including resting stages, and fishes with a body length up to 15 cm. Invertebrates (Crustacea, Mollusca and Polychaeta) and algae form the majority of species found. The most frequently found taxa identified by 8 shipping studies were diatoms, harpacticoid copepods, rotifers (but not all were identified to species level) and the diatom *Skeletonema costatum*. The second most frequently identified taxa in 7 studies were *Ditylum brightwellii*, *Chaetoceros* sp., *Navicula* sp., *Thalassionema nitzschioides*, *Thalassiosira* sp. (Bacillariophyceae (Diatoms)), and *Temora longicornis* (Copepoda, Calanoida) and calanoid copepods and larvae of Gastropoda, Bivalvia and Polychaeta.

Belgium (Université Libre de Bruxelles)

The investigation entitled "Study of the Potential Role of Transportation of Ships Ballast Water on the Geographical Extension of Blooms of Toxic Algae" was carried out at the Université Libre de Bruxelles. The main results of the study were that risks do exist concerning the introduction of non-indigenous toxin-producing phytoplankton species into European waters with ballast water or sediment discharges. It is recommended to implement ballast water management guidelines at an international level (Vanden Boeck, 1995).

Denmark (University of Aarhus, Institute of Biological Sciences, Dept. of Marine Ecology)

A joint project between Lithuania and Denmark has recently begun to regularly sample the Ro-Ro Ferry "Urd" (Scandlines), running between Aarhus/Aabenraa (Denmark) and Klaipeda (Lithuania). The main objective of the study is to assess the survival of plankton organisms en-route. It is planned to regularly sample the ship before departure in the port of Aarhus and after arrival in the port of Klaipeda (and vice versa). Additionally, it is planned to sample ships that arrive from outside the Baltic Sea (Christensen, Dept. of Marine Ecology, Institute of Biological Sciences, University of Aarhus, Finlandsgade 14, DK-8000 Aarhus C, Denmark, personal communication).

England (Maritime Research Centre, Southampton Institute, United Kingdom)

A research studentship assessed the transport of phytoplankton in the ballast water of vessels using the Port of Southampton. The project aimed to establish whether ballast water was a potential source of exotic phytoplankton species to the Southampton Water estuary, and also whether the number of cells and taxa could be correlated to factors including the area of origin, age and selected physical and chemical properties of the water. All of the samples collected originated within the northern hemisphere, and two-thirds were from European waters (Belson, Maritime Research Centre, Southampton Institute, East Park Terrace, Southampton, SO14 0YN, United Kingdom, personal communication).

England and Wales (School of Ocean Science, University of Wales, Bangor)

Between 1996 and 1999, samples were taken from ships arriving at English and Welsh ports. The aim of the study was to investigate the range of organisms present in ships' ballast tanks and assess variation in ballast water organisms in relation to geographic origin and season (Hamer *et al*., in press; McCollin *et al*., 1999). A further objective was to assess the potential risk of the introduction of organisms in ballast water and sediment to English and Welsh waters. Ships were sampled at 20 ports throughout England and Wales. The majority of ballast water sampled originated from ports in the northern hemisphere (McCollin *et al*., 1999).

France (IFREMER, Station de La Tremblade)

A pilot study to sample ship's ballast water and tank sediments was carried out in spring 2000 and focused on phytoplankton and bacteria arriving in French ports (D. Masson, IFREMER, Station de La Tremblade, 17390 La Tremblade, France, personal communication).

Germany 1 (Institute for Marine Research, Kiel, and University of Hamburg)

The first European shipping study was undertaken in Germany (Gollasch, 1996), the purpose of which was to conduct a thorough taxonomic assessment of planktonic and benthic organisms found in ballast water tanks with additional samples taken from ship hulls (Lenz *et al.*, 2000). The vessels investigated were selected according to type of vessel (e.g., container ships and bulk carriers) and sea areas covered by their voyages. The majority of samples originated from tropical and warm-temperate regions (Gollasch, 1996; Lenz *et al.* 2000).

Germany 2 (Institute for Marine Research, Kiel, and University of Hamburg)

A follow-up study was carried out from 1998–1999. The key objective was to sample ballast tank sediments (Wittling, Institut für Hydrobiologie und Fischereiwissenschaft, Universität Hamburg, Zeiseweg 9, DE-22765 Hamburg, Germany, personal communication).

Lithuania (University of Klaipeda)

A study started in 1999 in Klaipeda, involving sampling ballast water and examining hull fouling on ships in dry docks (Olenin, Coastal Research and Planning Institute, Manto 84, 5808 Klaipeda, Lithuania, personal communication).

The Netherlands (National Institute for Coastal and Marine Management, Middelburg and AquaSense/Tripos, Amsterdam)

During a pilot project in the years 1995 and 1996, in cooperation with the Smithsonian Environmental Research Center (USA), phytoplankton and zooplankton samples were taken from cargo holds of bulk carriers travelling between the ports of Maryland and Rotterdam. One key objective was to assess the viability of organisms after an oceanic voyage (Tripos, 1997).

In 1998 desk studies were carried out to estimate the amount and origin of ballast water carried to and from the Netherlands and to assess the risks of the introduction of non-indigenous species into Dutch coastal waters (AquaSense, 1998a, 1998b).

Since 1999 samples have been collected on board ships in the ports of Rotterdam, Vlissingen-Oost and Amsterdam. The objectives include documentation of the diversity of plankton organisms and their survival potential in Dutch waters.

Norway 1 (UNIFOB, Section of Applied Environmental Research, Bergen)

In 1996, a project entitled the Sture Project was launched. The aim of the study was to investigate the potential of unintentional introductions of non-indigenous aquatic species to Sture via ships' ballast. All ships sampled arrived from ports outside Norway (Botnen *et al,*. 2000).

Norway 2 (IMR, Bergen and University of Bergen)

Between July 1998 and April 1999, ballast water and sediment samples were collected from 6 ships entering the harbour of Mongstad (western Norway) of which one ship was redirected to the port of Sture (western Norway). The emphasis of the study was to identify the microbial component of species in ballast tanks. The faecal bacterium *Escherichia coli* was found in one vessel out of six, while the cholera bacterium *Vibrio cholerae* was not detected in the two ships analysed for its presence (Jelmert, Institute of Marine Research (IMR), Austevoll Aquaculture Research Station, N-5392 Storebø, Norway, personal communication).

Scotland (FRS Marine Laboratory, Aberdeen)

Between May 1994 and December 1996, ballast water was sampled from vessels arriving in Scottish ports. The aim of the study was to investigate planktonic organisms in ballast water and sediment, with special emphasis on harmful and potentially toxic phytoplankton (Macdonald, 1998; Macdonald and Davidson, 1998).

Sweden (Department of Marine Botany, Göteborg University)

A pilot project entitled “Risks associated with introduction of non-indigenous organisms to Swedish waters by water/sediment in the ballast tanks of ships” was carried out in 1996. The study focused on phytoplankton and on culturing sampled raw material. Cultures were performed to compare initial findings in the ship samples with cultures established from resting stages contained in the untreated samples (Persson, 2000; Persson *et al.*, 2000).

Gaps in our scientific knowledge are numerous for, e.g., tolerance limits (e.g., for survival in darkness among auto-trophic taxa), behaviour and feeding patterns, shifts between life cycle stages (especially cyst formation and excystments among phytoplankton and other forms with resting stages), microbial activities. At least for some phytoplankton species, cyst formation is enhanced in darkness and with reduced nutrient levels. All quantitative estimates still need to be improved, especially for sediment-living organisms, where quantitative sampling events still are few and hard to relate to any objective unit, since sediment layers may differ quite substantially even within one ship.

European Union Concerted Action

This recently completed European-wide Concerted Action (EU CA) included five Ocean Going Workshops (OGW) that were undertaken to assess the survival of zooplankton organisms in ballast water en-route. The OGW were undertaken in European waters and during inter-oceanic voyages. In total, 705 samples were collected during more than 100 days at sea (Rosenthal *et al.*, 2000).

References

AquaSense 1998a. Ballast water. Overview of available data and estimation of possible risks. AquaSense, Amsterdam, Rep. No. 1162.

AquaSense 1998b. Risk assessment ballast water. Ecological and economic consequences, frequency analysis and measures. AquaSense, Amsterdam, Rep. No. 1290.

Botnen, H.B., D. Evensen and P.J. Johannessen. 2000. Ballastvann, paradis for blindpassajerer – resultater fra Sture prosjektet. IFM-rapport. Rep. No. 2.

Gollasch, S. (1996): Untersuchungen des Arteintrages durch den internationalen Schiffsverkehr unter besonderer Berücksichtigung nichtheimischer Arten. Diss., Univ. Hamburg; Verlag Dr. Kovac, Hamburg, 314 pp. (thesis, Ph.D.)

Hamer, J.P., Lucas, I.A.N. & McCollin, T.A. (2001) Harmful dinoflagellate cysts in ships' ballast tank sediments: potential for introduction into English and Welsh ports. Phycologia. (in press)

Lein, T.E. 1999. A newly immigrated red alga (‘Dasysiphonia’, Dacyaceae, Rhodophyta) to the Norwegian coast. Sarsia 84: 85–88

Lenz, J.; Andres, H.-G.; Gollasch, S. & Dammer, M. (2000): Einschleppung fremder Organismen in Nord- und Ostsee: Untersuchungen zum ökologischen Gefahrenpotential durch den Schiffsverkehr. UBA Project Water: 102 04 250, Umweltbundesamt, Berlin, Texte, 5, 273 pp. (plus various appendices and attachments)

Macdonald, E.M. (1998). Dinoflagellate resting cysts and ballast water discharges in Scottish Ports. ICES Coop. Res. Rep. No. 224 Ballast Water: Ecological and Fisheries Implications ICES; Copenhagen. pp.24–35.

Macdonald, E.M. and Davidson, R.D. 1998. The occurrence of harmful algae in ballast discharges to Scottish ports and the effects of mid-water exchange in regional seas. *In* ‘Harmful Algae’. Reguera, B., Blanco, J., Fernandez, M.L.

and Wyatt, T. (Editors). Xunta de Galicia and Intergovernmental Oceanographic Commission of UNESCO, 220–223.

McCollin, T.A., Hamer, J.P. and Lucas, I.A.N. 1999. Final Report: Marine Organisms transported in ships' ballast. Report submitted to Ministry of Agriculture, Fisheries and Food. Project Code AE1114. pp. 18

Persson, A (2000) Raw cultures - a useful tool in search for organisms producing resting stages. Conf. Abstr. 9th Intern. Conf. on Harmful algal blooms, Tasmania 7-11th February 2000, p. 1999 (Abstr) in press in the Conf Proc.

Persson A, Godhe A, Karlson B (2000) Dinoflagellate cysts in recent sediments along the Swedish west coast. Botanica Marina 45: 69–79.

Rosenthal, H., Gollasch, S. & M. Voigt (eds.) 2000: Final Report of the European Union Concerted Action "Testing Monitoring Systems for Risk Assessment of Harmful Introductions by Ships to European Waters" Contract No. MAS3-CT97-0111, 72 pp (plus various appendices).

Tripos 1997. Ballastwateronderzoek. Voortgangsverslag 1997. Rep. No. 97.T0011.

Vanden Boeck, A. 1995. Etude des rôles potentiels des translocations par eaux de ballast de navires dans l'expansion géographique des efflorescences d'algues toxiques. Mémoire de licence en Géograpahie, Université Libre de Bruxelles.

4.2.2 Recent (since 1998) first records of non-indigenous species from SGBOSV countries

There is a considerable number of nuisance pest species that are serious problems for global marine resources, particularly fisheries and mariculture. Updates on the latest invasions globally (not limited to shipping vectors) are given in Figure 4.2.2.2 and Table 4.2.2.2, particularly relative to those species that are now invasive in other regions of the world and that are ballast-transportable (see Sections 4.2.2.1 to 4.2.2.3 for details).

In total 24 species were first recorded in 1998, 22 in 1999, and 12 in 2000. It has to be noted that first records of invasions usually appear with some delay in the literature as, e.g., the publication process and taxonomic analysis are not made promptly after the first sightings of species. Therefore, no trend should be seen in the decreasing numbers of invasions from 1998 to 2000 as more records are expected to be reported in the near future. Further, this list does not claim to be complete as members of the SGBOSV mainly report first records on a regional basis and based on their field of expertise.

The large number of first records of macroalgae, Bryozoa and Cnidaria indicate that ballast water should not be seen as the only vector for species invasions, as these life forms are unlikely to have been transported inside ballast tanks. However, it should be noted that many of the species listed below (e.g., Pisces, plankton algae, viruses, Ctenophora, Crustacea and Mollusca) are likely to have been transported in the ballast water of ships and that phytoplankton and pathogens are of particular concern as they have the potential to harm humans either directly or by affecting aquaculture and/or fisheries, thereby indicating the urgent need for effective ballast water treatment and/or management measures.

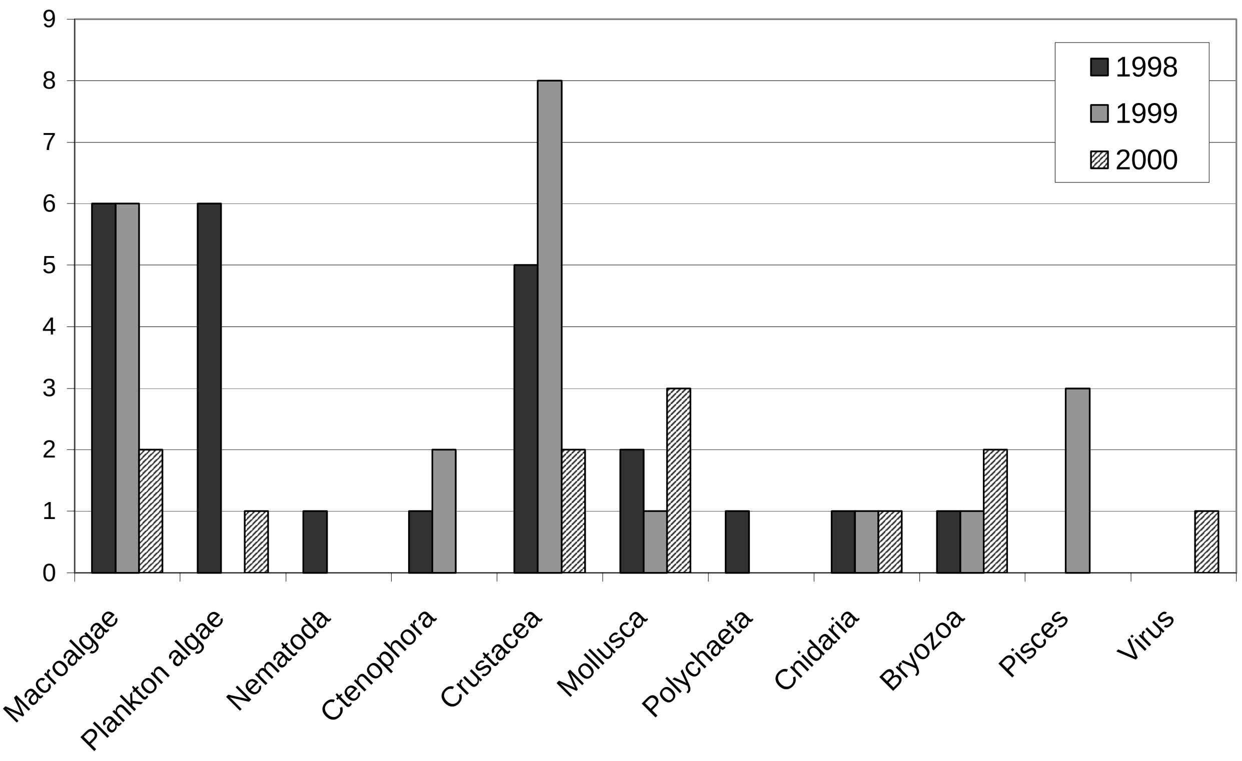
More research on the historical and modern distributions of many of these pest species is critical and should be carried out in the very near future with the emphasis on assessing the invasion potential of these organisms and potential impacts in other Member Countries.

It is recommended that a standard approach to study the invasion pattern of introduced aquatic species be developed in order to, e.g., find similarities and to support the assessment of the importance of introducing vectors.

Table 4.2.2.2. Summary of first records of aquatic non-native species (not limited to ICES Member Countries) according to taxa since 1998 (see sections 4.2.2.1 to 4.2.2.3 for details).

Taxon	**Total**
Macroalgae	14
Plankton algae	7
Nematoda	1
Ctenophora	3
Crustacea	15
Mollusca	6
Polychaeta	1
Cnidaria	3
Bryozoa	4
Pisces	3
Virus	1
Total	58

Figure 4.2.2.2. First records of aquatic non-native species (not limited to ICES Member Countries) according to taxa since 1998 (see Sections 4.2.2.1 to 4.2.2.3 for details).



4.2.2.1 Recent first records of non-indigenous species in 1998

Species (including higher taxon)	First record	Population status (established, common, etc.)	Impact or potential impact	Likely introducing vector	Native range
Acrochaetium balticum Rhodophyta	Netherlands, 1998	unknown	unknown	unknown	Baltic Sea
Agardhiella subulata Rhodophyte	Netherlands, 1998	unknown	unknown	unknown	North America
Alexandrium catenella Phytoplankton	Catalonia, Spain, 1998	established	potentially causing harmful algal blooms	ballast water	unknown
Anguillicola crassus Nematode	Ireland, 1998	common locally	parasite	living imports, secondary introduction	Japan
Asperococcus scaber Phaeophyta	Netherlands, 1998	unknown	unknown	unknown	Mediterranean Sea
Beroe cucumis Ctenophora	Black Sea, 1998	common	unknown	ballast water	USA, Atlantic Coast
Caprella acanthogaster (=*C. mutica*, = *C. macho*) Amphipoda	Belgium, 1998	established range extension	unknown	fouling ballast water?	Indo-Pacific
Caulerpa taxifolia Alga	Tunisia and Croatia, 1998	established	competition	Aquarium trade, secondary spread	France
Cercopagis pengoi Cladocera	USA, Great Lakes, 1998	established	competition	ballast water	Ponto-Caspian Region
Chatonella cf. *verruculosa* Raphidophyta	Kattegat, Skagerrak, 1998	established	potentially causing harmful algal blooms	ballast water	unknown
Cochlodinium polykrikoides Toxic microalga	Canada (West coast), 1998	increasing	fish kills (salmon farming)	possibly ballast water	Korea?
Codium fragile subsp. *tomentosoides* Chlorophyta	Belgium, 1998	established, secondary introduction	habitat modification	oyster imports?	unknown
Corbula gibba Mollusca	Belgium, 1998	established	unknown	ballast water, fouling?	unknown
Desmarestia viridis Phaeophyta	Italy, 1998	unknown	unknown	unknown	unknown
Echinogammarus ischnus Amphipoda	USA, Great Lakes, 1998	established	unknown	ballast water	Ponto-Caspian Region
Ectocarpus siliculosus Alga	Venice, Italy, 1998	unknown	competition	fishing	unknown
Eriocheir sinensis Decapoda	Ukraine, 1998	occasional records	predation, competition, habitat modification	ballast water / hull fouling	China

Species (including higher taxon)	**First record**	**Population status (established, common, etc.)**	**Impact or potential impact**	**Likely introducing vector**	**Native range**
Ficopomatus enigmaticus Polychaeta	Ireland, 1998	established	small fouling impact	hull fouling / ballast water	Indo-Pacific
Haliplanella lineata Anthozoa	Belgium, 1998	established, range extension	unknown	oyster imports?	Pacific
Megabalanus tintinnabulum Cirripedia	Belgium, 1998	occasional records	unknown	fouling	Cosmopolitan
Mytilopsis sp. Bivalvia	Darwin, Australia, 1998	established population was eradicated by chemical treatment	fouling problems	ship hull, pleasure boats	unknown
Punctuaria tenuissima Alga	Venice, Italy, 1998	established	competition	fishing	unknown
Tricellaria inopinata Bryozoa	Southern England, 1998	established	competition	ship hull	Indo-Pacific
Undaria pinnatifida Phaeophyta	Southern Italy, 1998	unknown	unknown	unknown	Japan

4.2.2.2 Recent first records of non-indigenous species in 1999

Species (including higher taxon)	**First record**	**Population status (established, common, etc.)**	**Impact or potential impact**	**Likely introducing vector**	**Native range**
Acipenser stellatus Pisces	USA, Great Lakes, 1999	unknown	unknown	stocking	unknown
Beroe ovata Ctenophora	Black Sea, 1999	unknown	unknown	ballast water	USA, Atlantic Coast
Bugula neritina Bryozoa	Belgium, 1999	occasional records	unknown	fouling on yachts	unknown
Carcinus maenas Crustacean	Canada (West coast), 1999	rare specimen (not established)	unknown	secondary introduction from US Pacific Coast	unknown
Caulerpa taxifolia Alga	Australia (near Sidney), 1999	unknown	unknown	unknown (aquarium trade?)	Mediterranean Sea strain
Cercopagis pengoi Cladocera	Poland, 1999	established	predation on zooplankton	secondary introduction	Ponto-Caspian region
Crepidula fornicata Gastropoda	Norway, 1999	unknown	unknown	unknown	North America
Daphnia lumholtzi Cladocera	USA, Great Lakes, 1999	established	unknown	ballast water	Africa, India, Australia
Dasysiphonia sp. Rhodophyta	Norway, 1999	unknown	unknown	unknown	unknown
Hemigrapsus sanguineus Decapoda	Netherlands, 1999	occasional finding, not observed in 2000	unknown	unknown	West Pacific
Hemimysis anomala Mysidacea	Belgium, 1999	established? range extension	unknown	unknown	Ponto Caspian region
Homarus americanus Decapoda	Norway, 1999	unknown	unknown	unknown	North America
Maeotias inexpectata Cnidaria	Estonia, 1999	unknown	possibly predation on zooplankton	ballast water	Ponto-Caspian region
Mnemiopsis leydii Ctenophora	Caspian Sea, 1999	unknown	unknown	ballast water, secondary introduction	North American east coast
Olisthodiscus luteus Raphidophycea	Norway, 1999	unknown	unknown	unknown	unknown
Orchestia cavimana Amphipoda	Estonia, 1999	established	unknown	secondary introduction	Northern Africa
Percnon gibbesi Decapoda	Sicily, Italy, 1999	established	competition	fishing	Atlantic
Pisodonophis semicinctus Pisces	Italy, 1999	unknown	unknown	unknown	Atlantic Ocean

Species (including higher taxon)	**First record**	**Population status (established, common, etc.)**	**Impact or potential impact**	**Likely introducing vector**	**Native range**
Polysiphonia morrowii Rhodophyta	Italy, 1999	unknown	unknown	unknown	unknown
Sargassum muticum Phaeophyta	Belgium, 1999	established, first record of attached specimens	habitat modification	oyster imports/ secondary introduction	Japan
Stephanolepis cf. *dispros* Pisces	Italy, 1999	unknown	unknown	possibly Lessepsian migrant	Red Sea, Indo-West-Pacific
Undaria pinnatifida Phaeophyta	Netherlands, 1999 (Sporophytes)	spreading fast since 2000	problems with harvesting/dredging of oysters	unknown	Japan

4.2.2.3 Recent first records of non-indigenous species in 2000

Species (including higher taxon)	First record	Population status (established, common, etc.)	Impact or potential impact	Likely introducing vector	Native range
Anadara demiri Bivalvia	Italy, 2000	unknown	unknown	unknown	unknown
Bugula simplex Bryozoa	Belgium, 2000	established? range extension	unknown	fouling on yachts	unknown
Caprella acanthogaster Amphipoda	Norway, 2000	unknown	unknown	unknown	Indo-Pacific
Caulerpa taxifolia Alga	USA, San Diego, 2000	eradication effort in progress	competition	unknown (aquarium trade?)	Mediterranean Sea strain
Dreissena polymorpha Bivalvia	Canada (West Coast), 2000	not found in the environment, but on boat hull trailered from Michigan	unknown	boat hull and cooling system	unknown
Gymnodinium catenatum Dinoflagellate	Black Sea, 2000	unknown	harmful algal bloom, PSP	ballast water	unknown
Hemigrapsus penicillatus Decapoda	Netherlands, 2000	at one location, females carrying eggs about to hatch	unknown	unknown	Northwest Pacific
Phyllorhiza punctata Cnidaria	USA, Gulf of Mexico, 2000	established	unknown	unknown	Tropical Pacific
Rapana thomasiana Gastropoda	France (Atlantic coast), 2000	occasional records	predation	hull fouling, ballast water, live oyster imports	Far East
Tricellaria inopinata Bryozoa	France, the Netherlands, 2000	established	competition	ship hull	Indo-Pacific
Tricellaria inopinata Bryozoa	Belgium, 2000	occasional records, range extension	unknown	fouling on yachts	unknown
Undaria pinnatifida Phaeophyta	Belgium, 2000	occasional record established? range extension	habitat modification	fouling on yachts	Japan
Viral haemorrhagic septicaemia (VHS) Virus	Finland and Baltic Sea, 2000	first observation	disease of rainbow trout in fish farms	unknown. Herring stocks suspected.	unknown

4.3 Understanding the Complexity of the Ballast Environment

The ballast tank (and ballasted cargo hold) environment is a complex one: physical and chemical parameters can change over time and geography, in different types of vessels, between different tanks on any one vessel, and within a single tank. Sampling these variables can represent the same challenges as sampling the biota. Understanding these variables is fundamental to understanding how the ballast environment promotes or depresses biological transfer.

Other variables that contribute to the complexities of understanding ballast processes are water age, trophodynamics (energy flow, predator-prey interactions, prey availability for visual predators in a dark environment, etc.) within the system.

Numerous important research questions remain:

- How do these complexities eventually relate to the scale of inoculation of non-indigenous species?
- Why do some populations of organisms increase and others decrease in ballast systems?
- With a more sophisticated understanding of ballast dynamics, could we manipulate those factors that depress biotic success?

4.4 Development of Ballast Water Control and Management Technologies

It has so far been concluded that no single or simple solution exists for shipboard treatment of ballast water. However, a combination of techniques might at least be partially effective and feasible in terms of economic and shipboard constraints. With current technology these would most likely comprise some form of mechanical removal of organisms followed by a physical or chemical treatment method.

Ballast water management procedures have been investigated to a certain extent but insufficient research has been carried out to assess the effectiveness of applicable ballast water treatment techniques. Shipboard treatment of ballast water is considered preferable to land-based reception/treatment facilities. Particular emphasis should therefore be placed on the evaluation of potential options for shipboard treatment that should be undertaken by future SGBOSV meetings with the aim to contribute to relevant related working groups (e.g., IMO Marine Environment Protection Committee, Ballast Water Working Group). In close cooperation and possibly by inviting experts from relevant authorities (e.g., IMO and ICS), SGBOSV should continue to assess currently implemented and planned ballast water control and management technologies.

A quarantine system does not provide an absolute barrier to prevent the introduction of unwanted non-indigenous species. It is also assumed that no single treatment process is likely to achieve the required inactivation or removal of unwanted organisms. A two-stage approach seems to be most likely. After an initial (e.g., mechanical) treatment process, an additional (e.g., physical) treatment process or a technique involving manipulation of the environmental conditions within the ballast tank could provide a solution.

At this stage various methods of ballast water treatment and management that have been put forward (see the IMO Assembly Resolution A.868(20)) and are described as a “tool box” from which the most practical (easy and safe to apply, not damaging existing ship installations such as ballast tank coating, isolators and sealing rings), cost effective, safe and environmentally sound combination should be selected.

To date three different types of techniques to treat ballast water onboard ships have been suggested (a) mechanical technologies; (b) physical treatments; and (c) chemical treatments.

Mechanical technologies are based on particle size or specific weight to separate or remove organisms and/or sediment mechanically from the water. Methods that have been considered include filtration, cyclonic separation, centrifugation, continuous deflective separation, sedimentation/flotation, high pressure pumping and ballast exchange.

Physical treatment techniques use different susceptibilities of organisms to render them harmless: electrolytically generated copper and silver ions, ultraviolet radiation, de-oxygenation, heat treatment, cooling treatment, electric pulse and pulse plasma techniques, acoustic systems, and magnetic fields.

Chemical treatment technologies have been discussed, but the potential negative effects of long-term accumulation of residuals are of concern. Methods include hypersalination/salinity adjustment, chlorination, ozonation, anti-fouling compounds inside ballast tanks, pH adjustment and addition of chlorine dioxide, peroxide, sodium and calcium hypochlorite as well as other biocides.

The option to use land-based facilities to treat the ballast water has not been excluded from the theoretical tool box, but might only be an option to treat smaller volumes of ballast water. One of the main concerns is the need for pipework of enormous dimensions. Alternatively, reception facilities may be installed on a treatment vessel that could then be moved from ship to ship to collect and treat the ballast water.

4.4.1 Ballast management: The ballasting and deballasting process

The International Maritime Organization's (IMO) Marine Environment Protection Committee (MEPC) has had a specific interest in the field of unwanted species introduced by ballast water since 1973 when the International Conference on Marine Pollution adopted Resolution 18, drawing attention to the transport of aquatic organisms and pathogens around the world in ships' ballast tanks.

Management strategies, techniques, and approaches of ballast water uptake should receive more research effort, specifically in relation to minimising the uptake of organisms within donor regions. The IMO Assembly Resolution 868(20) "Guidelines for the Control and Management of Ship's Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens" lists precautionary practices to reduce the number of organisms taken onboard by pumping in the ballast water (e.g., avoid ballasting at night when bottom-dwelling organisms may rise up in the water column or in very shallow water, where propellers may stir up sediment). Further approaches in this regard should receive the benefit of detailed feasibility and practicability studies.

Similar strategies should be more thoroughly explored relative to where ballast is released within an estuary or harbour, if it was not successfully exchanged in the open ocean. For example, every effort should be made to minimise or prohibit release of ballast water in close proximity to mariculture or aquaculture activities.

Australia was the first country to bring the ballast water problem into focus and has played a key part in proposing the development of control mechanisms for the introduction of ballast water since the early 1990s. In 1990 (MEPC29/WP.8) Australia, Canada, Denmark, Germany, Japan, Norway, USA and the International Chamber of Shipping (ICS) submitted a paper to consider in greater depth the problems raised by Australia on the need for controls to be introduced on the discharge of ballast water from overseas vessels entering Australian ports.

The Marine Environment Protection Committee (MEPC) of IMO formed a working group to consider research information and solutions proposed by Member States of the IMO and non-governmental organisations. The working group concluded that voluntary guidelines were the appropriate first step in addressing this problem. MEPC adopted guidelines by resolution in 1991 and in 1993 these were adopted by the IMO Assembly under Resolution A.774 (18) entitled "International Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships Ballast Water and Sediment Discharges". In 1997 the IMO Assembly adopted Resolution A.868 (20) "Guidelines for the Control and Management of Ship's Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens". This IMO Assembly Resolution is extremely important for the development of provisions to address this international, worldwide problem. The guidelines, which aim to limit the movement of organisms by ballast water world-wide, include measures such as informing ships or marking areas where ballast water uptake should be avoided due to the presence of harmful algal blooms and known unwanted contaminants, precautionary procedures when taking on ballast water in shallow areas, ballasting with fresh water, discharging ballast water and sediments to onshore facilities (if available) and exchanging ballast water at sea. IMO Assembly Resolution A.868 (20) also recommends an exchange of ballast water in open oceans as far as possible from the shore.

The mid-ocean exchange of ballast water is believed to be currently the most reliable method of minimising the risk of transfer of unwanted organisms. Compared with coastal waters, deep ocean waters contain fewer organisms and species occurring in open ocean waters are generally not able to survive in coastal zones and vice versa. If safety permits, all the ballast water should be released until suction is lost. Stripping pumps or eductors should be used if possible. Where the flow-through method is employed in open ocean by pumping ballast water into the tank or hold and allowing the water to overflow, at least three times the tank volume should be pumped through the tank. This method is non-polluting and inexpensive in comparison to other potential treatment and management measures. Where open-ocean exchange is not possible, requirements developed within regional agreements may be applicable, particularly in areas within 200 nautical miles from shore.

In 1995 the MEPC Ballast Water Working Group produced a first draft of a set of legally binding regulations which could form a new IMO Convention. It was agreed that the diplomatic conference to adopt an IMO Convention on Ballast Water should not be arranged before 2003.

Ballast exchange is a dynamic and complex process: it is important to understand which tanks or holds were exchanged, how much water was exchanged, when the water was exchanged, where it was exchanged, etc., in order to begin to assess the effectiveness of the exchange process. It has to be noted that some shipping studies on the water exchange revealed a higher density of, e.g., phytoplankton algae after a mid-ocean exchange of ballast water compared to the density of cells in the ballast water prior to exchange.

It is recommended that an assessment of the effectiveness of the mid-ocean exchange of ballast water be undertaken based on the results of several ongoing ballast water programmes (e.g., the GloBallast Programme and activities at the Smithsonian Environmental Research Center (SERC)) and shipping studies that review ballast water exchange relevant to species composition and numbers of individuals in the ballast water before and after the exchange.

4.4.2 Regulations regarding ballast water control and/or management currently in place worldwide (not limited to ICES Member Countries)

So far, no universal and regionally broad (global) agreement on ballast water treatment and/or management measures has been reached. However, a limited number of concerned countries have implemented mandatory or voluntary guidelines for ships calling at ports under their jurisdiction. The following provides details of ballast water regulations currently in place. Details given are based upon the knowledge of the SGBOSV and do not claim to be complete:

A Implementation of the IMO Resolution A.868(20) on a <u>mandatory</u> basis:

Australia. The requirements affect all ships entering Australian ports from overseas. Ballast water reporting forms have to be completed by all vessels longer than 25 metres. Australia is planning to implement new ballast water management arrangements based on risk assessment (see below) in summer 2001.

Canada. The Great Lakes ports and the Vancouver Port Corporation have introduced a ballast water exchange programme. All vessels arriving at the British Columbia Ports of Vancouver, Nanaimo and Fraser River must exchange ballast water in mid-ocean prior to entering Canadian waters. Where en route management has not been possible, no ballast water is to be discharged into the harbour until samples have been taken and analysed by the harbourmaster representative. If ballast water is assessed as unacceptable after sampling, it has to be kept on board or the ship is required to depart from port and has to exchange its ballast in an outgoing current. For Great Lakes, see USA below in this section.

Chile, selected ports only. All ships coming from abroad that carry seawater ballast should exchange their ballast water a minimum of 12 nautical miles from the coast.

Israel. Ships calling for Eilat must carry out exchange outside the Red Sea when practicable and ships visiting the Mediterranean ports must exchange in the Atlantic Ocean. Vessels failing to comply will not be permitted to exchange ballast water in Israeli waters.

New Zealand, all ports. If vessels cannot provide documented evidence of the origin of the ballast water and require to discharge, the ballast water should be discharged into an onshore facility or should be treated or sampled prior to discharge. Where en route management was not possible, discharge will be permitted if it can be shown that weather conditions and/or vessel design precluded safe exchange, given that the ballast water was not loaded in certain areas.

Ukraine, selected ports only. Ballast water should be exchanged immediately after entering the Black Sea.

United Kingdom, selected ports only.

United States of America (including Puerto Rico, US Virgin Islands, Guam, American Samoa, and US Trust Territory of the Pacific Islands). Ballast water management is mandatory as well as record-keeping and reporting. All ships bound for the Great Lakes and/or the Hudson river above the George Washington bridge entering from outside the US and Canadian Exclusive Economic Zones and all ships that operate in other waters of the United States need to follow the regulation, except certain tankers and passenger ships that are equipped with ballast water treatment systems.

The California State Commission has introduced its own ballast water management requirements. In the Port of Oakland ships need to report that ballast water management was undertaken. Ballast water originating within 200 nautical miles west of the coast of North America (between Baja California in the south and Alaska in the north) does not require treatment.

B Implementation of the IMO Resolution A.868(20) on a voluntary basis:

Canada. Ballast management is voluntary except for the ports in Vancouver, Nanaimo and Fraser river and the Great Lakes (see above).

Sweden

C Considerations to implement the IMO Resolution A.868 (20) in their legislation:

Georgia, Ireland, Spain and the **Netherlands**

D Chlorination of ballast water from certain resource regions:

Argentina, port of Buenos Aires only. Chlorination of ballast water from certain regions.

Brazil, selected ports require the treatment of ballast water with calcium hypochlorite and chlorine.

Chile, selected ports. Where no proof of ballast water exchange is available, chemicals (sodium hypochlorite or calcium hypochlorite) must be added to ballast water prior to deballasting in a port.

E Discharge to reception facilities

Georgia. In the Port of Batumi, vessels without segregated tanks arriving with dirty (or clean) ballast must transfer the water to the port's treatment plant.

United Kingdom. Scapa Flow Port (Orkney Islands) all ships wishing to discharge ballast at Flotta Terminal are required to discharge to shore reception facilities, with exemptions for certain vessels.

5 RISK ASSESSMENT, DECISION SUPPORT SYSTEMS, AND TARGET SPECIES

A particular interest was voiced with regard to gaining a greater understanding of donor regions as an important aspect of risk assessment. It was noted that obtaining such information must be a two-way process: donor ports should attempt to provide information on species of concern that departing vessels may take on in ballast, whereas receiving ports should also seek to obtain such information from the donor ports. It is critical to maintain updated information through continuing port surveys, since the non-native biota of many ports and harbours are under constant change, due to plankton blooms, new invasions, water quality changes, and other factors.

The Australian Quarantine and Inspection Service (AQIS) is planning on implementing the ballast water risk assessment approach on 1 July 2001 (www.aqis.gov.au/docs/bulletin/ab1200_13.htm). From July 2001, new arrangements for managing the risk to Australia from exotic marine pests will apply to all international vessels whether or not they carry ballast water or intend to discharge in Australian waters.

The new regulations have received widespread support from stakeholders in government and the shipping industry. Australia's current requirements for ballast water management are voluntary with three mandatory aspects, including reporting by vessels as to whether they undertook voluntary ballast water exchange at sea, providing access to safe onboard sampling points, and the requirement to discharge sediment only on land.

The mandatory aspects of the new arrangements will include:

- accurate reporting to AQIS regarding ballast water arrangements as a mandatory requirement under the Quarantine Act 1908. Vessels that do not carry ballast water will still be required to undertake mandatory reporting to AQIS;
- if required, undertaking exchange and/or other treatment and management options as directed by AQIS before discharging ballast water in Australia;

- re-submission and/or updating of ballast water information provided when details for the voyage have altered;
- mandatory access to safe onboard ballast sampling points;
- disposal on land of sediment resulting from ballast tank and/or hold cleaning in accordance with AQIS requirements; and
- no discharge of ballast water within Australian waters without written permission from a Quarantine officer.

After the new arrangements are implemented in July, international vessels intending to discharge ballast water in Australian waters will be able to manage their ballast water en route by:

- using the Australian Ballast Water Decision Support System by lodging ballast water information at the "last port of call" or en route, and determining tanks posing a high risk to intended ports of discharge; and/or
- undertaking an independent treatment procedure of ballast water (exchange or other comparable method accepted by AQIS) before entering Australian waters.

The Decision Support System (DSS) performs a tank-by-tank risk assessment based on information supplied by the ship's master, and allows international vessels to determine before they arrive in Australian waters if their ballast water poses a risk of introducing exotic marine pests. Tanks identified as carrying high risk ballast water will require treatment and/or management by a method acceptable to AQIS, including:

- exchange of ballast water at sea through sequential exchange, flow-through or dilution;
- non-discharge of high risk ballast tanks;
- tank-to-tank transfer, preventing discharge of high risk tanks' ballast water; and
- comparable treatment options as they are developed.

To ensure accurate reporting by ships' masters of their uptake and ballast water management arrangements, AQIS will verify information and will advise masters about the records that must be maintained.

The obvious alternative to a species-specific approach (see DSS above) is that proposed in the 1996 WGITMO report, i.e., the environmental matching assessment between recipient and donor ports. Environmental matching alone will not provide a progressive assessment and will necessarily become more conservative with additional information from successful incursions. The environmental match between port regions will not necessarily represent the biological capabilities of the species. In contrast, a species-specific approach will become less conservative as information becomes available.

The appropriateness of risk assessment and risk management approaches relevant to ballast water management should be reviewed in the future, with consideration of the recent implementations of mandatory risk assessment procedures by some jurisdictions.

6 RELATIONSHIP BETWEEN BALLAST WATER MOVEMENT AND THE INVASION OF EXOTIC MARINE ORGANISMS

6.1 Ballast Water Movements

Huge volumes of ballast water (> 10 billion tonnes) are moved around the world annually, and the amount is likely to increase with increasing global commerce. Extensive data sets on ballast water volumes, and the life in ballast water and sediments, are now being developed for many regions of the world and are beginning to fill in this global picture. However, a direct relationship between ballast water movements and the invasion of exotic marine organisms cannot be drawn as the amount of ballast water transported and discharged does not necessarily indicate a high risk of future invasions, whereas factors such as the duration of the voyage, and the origin of ballast water from areas with matching climate and salinities on both ends of the ship's voyage may be of greater importance.

Further, it is important to obtain data on both imported and exported ballast water, to capture a picture of a port system as both a receiver and a donor area.

6.2 Development of Biota En-route

Previous en-route sampling studies showed a rapid decline in plankton concentration during the initial part of the voyage. In addition, the diversity and number of specimens decreased with increasing duration in the ballast tank. Nevertheless, investigations showed that at the end of most trips, some species were still alive at low densities. The greatest decrease in numbers of organisms occurred during the first week of the voyages. It is not clear if the decreased density of specimens and species during the voyages is due to a high mortality rate or due to migration of individuals to greater depth inside the tank, beyond the depth to which the sampling methods were effective. In general, it is assumed that the decreasing numbers of species and individuals towards the end of voyages indicate a reduced survival rate over time owing to such factors as the absence of light in the ballast tanks, negative impacts of the fluctuating environmental conditions during voyages through different climatic zones, “sloshing” of the water in the tank caused by the motion of the ship having an adverse effect on delicate plankton organisms or limited food supply. Furthermore, the ship’s pumps used to pump ballast water onboard may damage fragile and gelatinous organisms.

However, many ballast water studies have also shown that some living organisms were found in ballast water that had been inside the tanks for weeks or months. Even water held in ballast tanks for 116 days contained living specimens. In addition to the “long-term” survival of some organisms in ballast tanks, some species may form resting stages or cysts enabling survival during periods of unfavourable conditions. Resting stages found inside the tanks indicate that some organisms may change their life mode inside the tanks, although it is often not clear whether resting stages are formed by organisms inside the tank or are pumped in as resting stages. However, organisms which are able to form resting stages in their life cycle may survive prolonged periods in ballast tanks whilst other species that are more fastidious or delicate may not.

A surprising observation not previously documented was the considerable increase of a copepod population during a voyage from Singapore to Germany. Concentrations of adult *Tisbe graciloides* at the start of the voyage were 11 individuals/100 litres and 1040 individuals/100 litres after 15 days. Clearly, while most species may incur significant population reductions while living in ballast water, some species find the conditions suitable for survival and population growth.

7 SAMPLING THE BIOTA IN BALLAST WATER AND BALLAST SEDIMENTS

Work on international intercalibration of ballast water and sediment sampling methods has been continued, including discussions (1) on cooperative research programmes and databases, and (2) on the results of ongoing research on new ballast management technologies. Standardised sampling techniques of ballast water are of particular interest, especially to assess the effectiveness of ballast water treatment and management options carried out to reduce the risk of future species invasions.

Sampling ships is different from sampling the environment, as sampling access is not always straightforward, and is highly variable between ships. One needs to deal with several obstacles, such as cargo overlaying the manhole preventing direct access to the ballast water, and support frames installed to stabilise the ballast tanks that make it difficult to gain access to the very bottom of the ballast tank. Sampling equipment can also become stuck inside the tanks.

Due to the problems encountered when sampling ballast water, results can be regarded as a minimum qualitative and quantitative assessment of the biological content of ballast water. This is apparent when considering the increase in identified species when ballast water already sampled with nets appears to contain more species when the same tanks are additionally sampled with traps or the samples are cultured in the laboratory. The application of a wider range of sampling methods would possibly increase the range of species found in ballast water, but most shipping studies are limited by practical constraints and time available for sampling.

It was noted that there are two general questions associated with the sampling of ballast water and sediments to determine their biotic content:

1) what do various methods of sampling (nets, pumps, etc.) yield in the way of specific types and densities of organisms? and
2) what specific methods should be used to sample target organisms?

Relative to these approaches, it is also important to distinguish between sampling programmes that focus on scientific research (academic questions) and sampling programmes that focus on compliance monitoring of required ballast water treatment and/or management measures.

Global intercalibration of sampling techniques is to be emphasised and encouraged, as well as encouraging global performance standards for ballast water treatment and/or management measures.

8 INTERNATIONAL COOPERATION AND EDUCATION, PUBLIC AWARENESS

Continued international cooperation, through joint multinational research projects, is fundamental to grasping the global scale of ship-mediated transports of non-indigenous species and to understanding the latest and newest concepts and views on ballast water treatment and/or management measures.

Dissemination of information on the science, policy, and management strategies of ballast water and sediments should be as broad as possible, and particular efforts should be made to keep the public, the political world, and the shipping community abreast of this rapidly expanding and changing field. In particular, dissemination of information on ballast water and on measures that may be taken to reduce the rate of spread of invaders should be made through relevant publications in public non-scientific journals (e.g., maritime trade journals) and the establishment of a SGBOSV homepage. SGBOSV recommends compiling and developing appropriate material for use on it's web page at the next meeting and that the homepage be established by ICES shortly after the next meeting in 2002.

9 RECOMMENDATIONS

There was a very strong and unanimous consensus by the Study Group that further meetings of the group within a one-year time frame would be of extraordinary value. The participants felt that significant new levels of cooperation, understanding, and intercalibration of research had been achieved both among ICES Member Countries and on a global level (further noting that a great deal of the ballast water arriving in ICES Member Countries originates outside the ICES arena). Close cooperation with relevant, recently launched initiatives, especially the Global Ballast Water Management Programme (GloBallast) and the Global Invasive Species Program (GISP), offer the unique opportunity to improve the effectiveness and efficiency of SGBOSV efforts in this field through increased cooperation and communication.

It was thus recommended that the ICES/IMO/IOC SGBOSV convene again in Sweden (exact location to be announced), from 18 to 19 March 2002 to:

a) continue the global assessment and review of the status of ballast water and tank sediment biological and ecological research, through the participation of representatives from ICES Member Countries, the IMO, IOC and of invited scientists from all major ballast water research groups in the world;

b) continue the evaluation of the development of ballast water control and management technologies to contribute to relevant related working groups (e.g., IMO Marine Environment Protection Committee, Ballast Water Working Group);

c) continue to assess currently implemented and planned ballast water control and management technologies;

d) continue the review of recent ship-mediated invasions globally, particularly relative to those species that are now invasive in other regions of the world but have not yet arrived in SGBOSV participating countries, for the purpose of updating the status of invasions to be used in awareness-raising efforts;

e) continue the global assessment of the significance of hull fouling and other non-ballast shipping vectors of aquatic bio-invasions, taking into account that the ban of TBT-containing antifouling paints may be potentially conducive to fouling species invasions;

f) seek to cooperate with ongoing ballast water programmes (e.g., the GloBallast Programme and activities at the Smithsonian Environmental Research Center (SERC)) to especially review ballast water exchange studies and provide a definitive picture of the utility of this practice to reduce the risk of species transportation, and identify appropriate further research;

g) review the appropriateness of risk assessment and risk management approaches relevant to ballast water management, considering recent implementations of mandatory risk assessment procedures by some jurisdictions;

h) compile and develop appropriate material for use on the SGBOSV web page to be established by ICES;

i) develop a standard approach to study the invasion pattern of introduced aquatic species.

ANNEX 1: LIST OF PARTICIPANTS

Name	Address	Telephone no.	Fax no.	E-mail
Bilio, Martin	Am Hirschsprung 10 D-61462 Koenigstein Germany	+49-6174-931676		Martin.Bilio@t-online.de
Bilney, Alec	International Chamber of Shipping (ICS) 12 Carthusian Street London EC1M 6EZ United Kingdom	+ 44-171-417-8844	+44-171-417-8877	alec.bilney@marisec.org
Blasco, Dolors	Institut Ciences del Mar Paseig Joan de Borbo 08039 Barcelona Spain			
Cangelosi, Allegra	Northeast Midwest Institute 218 D St. SE Washington, D.C. 20003 USA	+ 1-202-544-5200	+ 1-202-544-0043	acangelo@nemw.org
Gilbert, Michel	Dep. of Fisheries and Oceans, Maurice Lamontagne Institute PO Box 1000 850 Rue de la Mer Mont-Joli, Quebec G5H 3Z4 Canada	+1-418-775-0604	+1-418-775-0718	gilbertm@dfo-mpo.gc.ca
Gollasch, Stephan (Co-Chair)	Institute for Marine Research more prompt reply if you write to Duesternbrooker Weg 20 Bahrenfelder Straße 73 a 20146 Kiel 22765 Hamburg Germany	+49 431 597 3916	+49 431 565876	sgollasch@aol.com
Huelsmann, Norbert	Free University of Berlin, Institute of Zoology Königin-Luise-Str. 1-3 14195 Berlin-Dahlem Germany	030-838-53921 or 53926	030-838-53916	hulsmann@zedat.fu-berlin.de
Jelmert, Anders	Institute of Marine Research from June 1st: Austevoll Aquaculture Research Station Floedevigen Research Station 5392 Storebö 4817 HIS Norway	+47-56-180342 +47-3705-9000	+47-56-180398 +47-3705-9011	anders.jelmert@imr.no
Kerckhof, Francis	Management Unit of the North Sea Mathematical Models 3 e en 23 e Linie Regimertsplein 8400 Oostende Belgium	+32-59-24-2056	+32-59-70-4935	f.kerckhof@mumm.ac.be
Kieser, Dorothee	Department of Fisheries & Oceans, Pacific Biological Station 3190 Hammond Bay Road Nanaimo, B.C. V9R 5K6 Canada	+1-250-756-7069	+1-250-756-7053	kieserd@pac.dfo-mpo.gc.ca

Name	Address	Telephone no.	Fax no.	E-mail
McCollin, Tracy	FRS Marine Laboratory PO Box 101, Victoria Road Aberdeen, AB11 9DB United Kingdom	+44-1224-876544	+44-1224-295573	mccollint@marlab.ac.uk
Minchin, Dan	Marine Organism Investigations 3 Marina Village Ballina, Killaloe, Co Clare Ireland	+353-86-60-80-888		minchin@indigo.ie
Noeland, Sam Arne	Det Norske Veritas, Environmental Advisory Services Veritasveien 1 N-1322 Hövik Norway	+47-67578182	+47-67579911	Sam.Arne.Noland@dnv.com
Occhipinti, Anna	University degli Studi di Pavia, Sezione Ecologia Dipartimento di Genetica e Microbiologia Via Sant Epifanio 14 27100 Pavia Italy	+39-0382-304610	+39-0382-528496	occhipin@unipv.it
Ojaveer, Henn	Estonian Marine Institute Viljandi Rd. 18b 11216 Tallinn Estonia	+372-6-281-584	+372-6-281-563	henn@sea.ee
Pages, Francesc	Institut de Ciencies del Mar (CSIC) Placa del Mar S/N 08039 Barcelona Spain	+34-93-221-6416	+34-93-221-7340	fpages@icm.csic.es
Palau, Augusti	Port de Barcelona Tram VI, Sector 6 08039 Barcelona Spain	+34-93-298-2100	+34-93-298-2129	agusti_palau@apb.es
Raaymakers, Steve (Co-Chair)	International Maritime Organization (IMO) Global Ballast Water Management Programme (GloBallast) Programme Coordination Unit 4 Albert Embankment London, SE1 7SR United Kingdom	+44-20-7587-3251	+44-20-7587-3261	sraaymak@imo.org
Ribera, Maria	Laboratori Botanica, Facultat de Farmacia Universitat de Barcelona 08028 Barcelona Spain	+34-93-402-4490	+34-93-403-5879	ribera@farmacia.far.ub.es
Rosenthal, Harald	Institute for Marine Research Duesternbrooker Weg 20 20146 Kiel Germany	+49-431-597-3916	+49-431-565876	
Ruiz, Greg	Smithsonian Environmental Research Center P.O.Box 28 Edgewater, Maryland 21037-0028 USA	+1-443-482-2227	+1-443-482-3420	ruiz@serc.si.edu

Name	**Address**	**Telephone no.**	**Fax no.**	**E-mail**
Shotadze, Anna	Georgia Ministry of Environment Convention Inspection Office for Protection of the Black Sea N6, 9th April Street Batumi Georgia	+995-222-7-2850	+995-222-7-2850	[c/o]: bs@basri.net
Sparrevik, Erik	Swedish National Board of Fisheries Box 423 40126 Gothenburg Sweden	+46-317-43-0329	+46-317-43-0447	erik.sparrevik@fiskeriverket.se
Tengiz, Bejaneishvili	Batumi, Oil Terminal LTD Mayakolvskaie Str. 4 Batumi Georgia	+995-222-76685 or 76006	+995-222-76685 or 76006	TengoB@yardex.ru
Urho, Lauri	Finnish Game and Fisheries Institute P.O. Box 6 00721 Helsinki Finland	+358-205-751-258	+358-205-751-201	lauri.urho@rktl.fi
Vila, Jordi	Port de Barcelona Tram VI, Sector 6 08039 Barcelona Spain	+34-93-298-2100	+34-93-298-2129	
Wallentinus, Inger	Department of Marine Botany, University of Göteborg P.O. Box 461 405 30 Göteborg Sweden	+46-31-7732702	+46-31-7732727	inger.wallentinus@marbot.gu.se
Wetsteyn, Bert	National Institute for Coastal and Marine Management P.O. Box 8039 4330 EA Middelburg The Netherlands	+31-118-672-302	+31-118-651-046	l.p.m.j.wetsteyn@rikz.rws.minvenw.nl

ANNEX 2: AGENDA

INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA (ICES)
INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION (IOC)
INTERNATIONAL MARITIME ORGANIZATION (IMO)

ICES / IOC / IMO STUDY GROUP ON BALLAST WATER AND OTHER SHIP VECTORS

First Meeting, Barcelona, Spain

Chairs: S. Gollasch and S. Raaymakers
Rapporteur Tracy McCollin

Monday, 19 March 2001

9:00 Opening of the Meeting

Welcoming Remarks (S. Gollasch, S. Raaymakers)
Parc Cientific of Barcelona (J. Bellavista)
Authorities of the Port of Barcelona (J. Oriol)
Marina Mercante Organism (J. Villanueva)
Logistics (telephone, FAX, photocopying, etc.) (M. Ribera)
Introduction of Participants and Guests (Name, Institution, Nature of Interest)

10:00 Review of Terms of Reference (see above)

Review of the Agenda (see below): changes, corrections, additions
Report Deadline

10:15 A. Palau: Preliminary results and future perspectives of the Port of Barcelona's Ballast Water Programme
10:30 S. Raaymakers: Update on progress of IMO Ballast Water Working Group and related matters

10:50 Coffee break

11:20 G. Ruiz: Review and update of ballast water research activities at the Smithsonian Institution
11:50 M. Gilbert: Results from Canadian ballast water programme
12:30 B. Wetsteyn: Ballast water research in Dutch ports

1:00 Group Photo

1:10 - 2:30 Lunch

2:30 Announcements
2:45 T. McCollin: Investigations on Ballast Water Exchange in regional seas
3:00 N. Hülsmann, B. Galil & R. Baier: Settlement of micro-organisms in ballast tanks – outlook for a spatio-temporal analysis of ship-associated transfers. Presentation given by N. Hülsmann
3:20 The Global Ballast Water Management Programme (GloBallast)
3:55 H. Ojaveer: Research on *Cercopagis pengoi*, a recent invader of the Baltic Sea and the North American Great Lakes
4:05 A. Jelmert: The current status of the introduced *Caprella mutica* and *Dasysiphonia* sp. and the cryptogenic *Scolelepis korsuni* in Norwegian waters

4:15 Coffee Break

4:35 D. Minchin: Current toxic phytoplankton affairs and planned monitoring in Ireland
4:45 D. Minchin: Reducing risk and management following port surveys
5:00 I. Wallentinus: New Swedish research initiative on introduced species, funded by the Swedish Environment Protection Agency

5:05 A. Jelmert: Current practice and future plans for massive transport of oil/petroleum products from Northern Russia along the Norwegian coast
5:20 Review of Tomorrow's Agenda; Questions
5:30 Adjournment of Day 1

Tuesday, 20 March 2001

9:00 Opening of Day 2

Announcements

9:10 S. Gollasch, H. Rosenthal, H. Botnen, M. Crncevic, M. Gilbert, J. Hamer, N. Hülsmann, C. Mauro, L. McCann, D. Minchin, B. Öztürk, V. Onofri, M. Robertson, C. Sutton, and C. Villac: Comparison of world-wide ballast water sampling techniques. Presentation given by H. Rosenthal
9:30 A. Shotadze: Update on Georgian activities
9:40 M. Bilio: *Mnemiopsis* in the Caspian Sea
10:00 G. Ruiz: Invasion Pattern in US waters
10:10 A. Bilney: What the industry can do and will do, and what it cannot do in regard to ballast water treatment
10:20 A. Jelmert: Update on the supersaturation method

10:40 Coffee Break

11:10 A. Cangelosi, I. Knight, M. Balcer, D. Wright, R. Dawson, C. Blatchley, D. Reid, N. Mays & J. Taverna: Lessons learned through comparative evaluation of physical/mechanical ballast treatment systems at two scales. Presentation given by A. Cangelosi
11:40 A. Jelmert: A Norwegian proposal on ballast water treatment standards
12:00 A. Cangelosi: Draft approach to ballast water treatment standards developed by the State of Washington and its collaborators
12:30 H. Ojaveer: Invasive alien species issues at the expert meeting in preparation of the sixth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA-6) of the Convention on Biological Diversity
12:40 Round table discussion (**lunch break 1:00 - 2:00)**

Agenda item: Importance of shipping as vector for species invasion

Assessment of the many different types of ship vectors with specific attention to determining which of these vectors have been sampled in recent years, and whether data exist to assess their relative importance for species invasion.

Agenda item: Status of biological and ecological research on ballast water and sediment
Express your view on information gaps: What needs to be done? Where to go?

Agenda item: Status of the development of ballast water control and management technologies
Give details whether your country has ballast water control and/or management measures implemented on a voluntary or mandatory basis?
In case not, are authorities aware of the problems related to species invasions?
Are measures to control and/or manage ballast water and other ship vectors planned?

Agenda item: Assessment of relationship between ballast water movement and the invasion of exotic marine organisms, including updates on the latest ballast-mediated invasions globally.

3:00 Summary of Findings of Study Group and recommendations
3:30 Concluding Remarks
Planning of next meeting
3:45 Adjournment of the first Meeting of the SGBOSV

ANNEX 3: RECOMMENDATIONS

There was a very strong and unanimous consensus by the Study Group that further meetings of the group within a one-year time frame would be of extraordinary value. The participants felt that significant new levels of cooperation, understanding, and intercalibration of research had been achieved both among ICES Member Countries and on a global level (further noting that a great deal of the ballast water arriving in ICES Member Countries originates outside the ICES arena). Close cooperation with relevant, recently launched initiatives, especially the Global Ballast Water Management Programme (GloBallast) and the Global Invasive Species Program (GISP), offer the unique opportunity to improve the effectiveness and efficiency of SGBOSV efforts in this field through increased cooperation and communication.

It was thus recommended that the ICES/IMO/IOC Study Group on Ballast and Other Ship Vectors [SGBOSV] (Co-Chairs: S. Gollasch, Germany, and S. Raaymakers, IMO) meet in Sweden at a venue to be decided from 18 to 19 March 2002 to:

a) continue the global assessment and review of the status of ballast water and tank sediment biological and ecological research, through the participation of representatives from ICES Member Countries, the IMO, IOC and of invited scientists from all major ballast water research groups in the world;

b) continue the evaluation of the development of ballast water control and management technologies to contribute to relevant related working groups (e.g., IMO Marine Environment Protection Committee, Ballast Water Working Group);

c) continue to assess currently implemented and planned ballast water control and management technologies;

d) continue the review of recent ship-mediated invasions globally, particularly relative to those species that are now invasive in other regions of the world but have not yet arrived in SGBOSV participating countries for the purpose of updating the status of invasions to be used in awareness-raising efforts;

e) continue the global assessment of the significance of hull fouling and other non-ballast shipping vectors of aquatic bio-invasions, taking into account that the ban of TBT-containing antifouling paints may be potentially conducive to fouling species invasions;

f) seek to cooperate with ongoing ballast water programmes (e.g., the GloBallast Programme and activities at the Smithsonian Environmental Research Center (SERC)) to especially review ballast water exchange studies and provide a definitive picture of the utility of this practice to reduce the risk of species transportation, and identify appropriate further research;

g) review the appropriateness of risk assessment and risk management approaches relevant to ballast water management, considering recent implementations of mandatory risk assessment procedures by some jurisdictions,

h) compile and develop appropriate material for use on the SGBOSV web page to be established by ICES;

i) develop a standard approach to study the invasion pattern of introduced aquatic species.