Ballast Water News

Global **Ballast Water** Management Programme

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From the Editor

They say time flies when you're having fun, and despite the range of activities carried out in the last three months, it seems like only yesterday that I was penning issue 8. The major event this quarter was the launch in Tehran of our regional activities for the ROPME Sea Area. The regional conference was an outstanding success, achieving consensus among seven littoral States and a cooperative path forward to address marine bio-invasions on a regional basis. As a tribute to the efforts of the Islamic Republic of Iran in hosting this event, we are extremely pleased to welcome the Iranian Deputy Minister for Transport, Mr. Ahmad Donyamali, as Guest Speaker for this issue, and to include a two-page article on the regional conference.

Another significant achievement this quarter was the commencement of the development of modular training packages on ballast water management, for shipping and port-based personnel. In cooperation with the UN Division of Ocean Affairs and Law of the Sea and the UN Train-Sea-Coast Centres in Brazil and South Africa, a course development workshop was held in Montevideo, Uruguay from 22–30 April.

Efforts were also put into updating the much acclaimed Ballast Water Treatment R&D Directory, with more than 20 new projects coming on-line around the world in the last 12 months. The updated directory is available from http://globallast.imo.org/research/. In recognition of this surge in R&D effort, we feature articles on four such projects in this issue, plus a conceptual framework for setting treatment standards when faced with limited data, as proposed by Dr Tom Waite of the University of Miami.

An updating of the GloBallast web site was also carried out this quarter. A new feature on the revamped site is an E-Forum. We are pleased to extend an invitation to all readers to join the Forum in order to share news and views and submit questions and answers on any aspect of the ballast water problem. We sincerely hope that the GloBallast E-Forum will make a positive and significant contribution to the free exchange of information and the all-important function of open communication, on a global basis. Feedback and suggestions in relation to the E-Forum are also welcome, http://globallast.imo.org/forum/.

Finally, although not reported in detail in this issue, in April the PCU was honoured to participate in an internal workshop held by the World Conservation Union (IUCN) in Gland, Switzerland, to develop the Union's strategic direction on invasive species; and in May to participate in an expert review panel of the Michigan Environmental Science Board, to review research on the treatment of ballast water with biocides in the North American Great Lakes.

Steve Raaymakers
Contributing Editor

From the Programme

.As we pass the two-year mid-point of the GloBallast Programme, the six Pilot Countries have made significant headway in the implementation of programme activities. The national networks are now well established and the in-country activities are progressing steadily. One of the most serious barriers to the effective implementation of ballast water control and management measures was the lack of information about the existence and potentially catastrophic consequences of the transfer of organisms by ships. It has become increasingly evident that this battle has been won. The campaign to raise awareness, initiated by the Programme Co-ordination Unit and continued by the Lead Agencies and Country Focal Points in the field, is now harvesting results. The six Pilot Countries are actively participating in the elaboration of the new IMO Convention on ballast water and two of the Governments involved in the Programme, Brazil and India, have allocated funds from their regular national budgets to support the activities initiated by GloBallast.

The time is now right to share experiences with neighbouring countries. The creation of Regional Task Forces enables GloBallast to increase awareness at a regional level, promote cooperation and to facilitate the eventual replication of Programme achievements across the regions.

Last year's pioneering experience in the Black and Baltic Seas was used this year in organizing the *1st Regional Conference on Ballast Water Management in the ROPME Sea Area*. Delegates from Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates gathered in Tehran, with their Iranian counterparts, to learn of progress made to date at the Khark Island Demonstration Site, to exchange information on ballast water issues and to discuss a Regional Action Plan. At the end of three very productive days the participants endorsed the Action Plan and adopted a Resolution, which inter alia urges IMO, UNDP and the Global Environment Facility to continue their support for addressing the issue of invasive species in ships' ballast water. A high level Conference for the formal approval of the Regional Action Plan will be convened in co-operation with the ROPME Secretariat towards the end of 2002.

Brazil, India and South Africa are currently considering the establishment of similar task forces in their respective regions. The next regional activity under the GloBallast umbrella is, however, scheduled for October this year in Beijing, China. The event is expected to gather delegates from East Asian countries interested in adopting a common strategy for the protection of their marine environment from one of the most serious threats to the world's oceans.

Dandu Pughiuc
Chief Technical Adviser

Ballast Water News is the quarterly newsletter of the Global Ballast Water Management Programme (GloBallast). GloBallast is a cooperative initiative of GEF, UNDP and IMO to assist developing countries to reduce the transfer of harmful organisms in ships' ballast water, through the implementation of IMO ballast water management guidelines.

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Guest Speaker

Mr Ahmad Donyamali

Deputy Minister of Roads and Transportation & Managing Director of Ports and Shipping Organization – Islamic Republic of Iran

Mr. Ahmad Donyamali was appointed as Deputy Minister of Roads and Transportation and Managing Director of the Iranian Ports and Shipping Organization in June 2002.

Prior to this appointment Mr. Donyamali held several posts, including Managing Director of Rah-e-Sahel Company, Managing Director of Anzali Port Special Economic Zone, Founder and Managing Director of Investment & Export Development Company, Technical Deputy of I.R. Iran Railway and Technical Deputy and Board Member of the Ports and Shipping Organization.

I am extremely pleased that during the design phase of the GloBallast Programme, the Islamic Republic of Iran was selected as the Pilot Country representing the ROPME Sea Area. This was due to the criteria set by the Global Environment Facility (GEF) that countries must meet in order to qualify for GEF-funded projects, and the willingness of the Iranian Government to provide the necessary institutional structures and support facilities and to put its own resources into the Programme.

The GloBallast Demonstration Site in I.R. Iran is at Khark Island, one of the largest oil terminals in the world. The port at Khark Island ships more than 88 million tonnes of crude oil per year, representing approximately 85% of Iran's annual export earnings.

The Ports and Shipping Organization (PSO) is the ports authority and maritime administration in Iran and is designated as the lead agency for implementation of the GloBallast Programme in the country. Since approval of Iran's National Workplan in March 2001, PSO, with efficient support from the Programme Coordination Unit at IMO in London, has made good progress with implementing GloBallast activities.

The port baseline survey as the initial step towards long-term biological monitoring, was carried out successfully in both summer and winter. The ballast water risk assessment, the results of which will be decisive in formulating management measures that are required at Khark Island, is well underway. To determine whether there is a need to change existing domestic legislation and regulations relating to ballast water, a complete legislation review has been conducted. The broad-based awareness raising campaign is continuing as an ongoing activity at the national and regional levels.

With activities at Khark Island well underway, our focus is now turning to regional cooperation and replication. Taking into consideration geography, ecology and shipping patterns in the Area, the regional approach is critical and Iran has afforded extremely high priority to regional cooperation.

The ROPME Sea Area is one of the most important areas in the world as far as oil and natural gas are concerned. Holding about 97 billion barrels of oil and 26.7 trillion m^3 of natural gas, the area provides about 50% of world energy requirements. Annually about 12,000 ships enter the region, out of which 8,000 are tankers transferring and discharging large amounts of ballast water. Besides non-living resources the region is endowed with valuable living resources and a great biodiversity of marine species. Fishing remains a major source of nutrition as well as an important economic activity in the region. However, according to ROPME (2000) total fish landings have shown a downward trend since 1992, when they peaked at 531,445 tonnes.

This semi-enclosed water body has witnessed one of the highest economic growth rates in the world over the past few decades, and is already highly stressed by pollution, over-exploitation and rapid development. Addition of invasive marine species could cause irreversible damage. Fortunately ROPME Member States are well aware of such issues and have taken actions to develop regional cooperation for the protection of the marine environment.

As an initial step to address invasive marine species in the region, I am extremely pleased that I.R. Iran was able to host the *1st Regional Conference on Ballast Water Management and Control in the ROPME Sea Area* in Tehran from 17 to 19 June 2002. The conference provided a wonderful opportunity for us to share our experiences under the GloBallast Programme with our colleagues from the Kingdom of Bahrain, State of Kuwait, Sultanate of Oman, State of Qatar, Kingdom of Saudi Arabia, United Arab Emirates as well as the ROPME Secretariat and the shipping and oil industries.

I am confident that the Regional Action Plan that was endorsed at the Conference will be adopted and implemented. The Islamic Republic of Iran is committed to play a key role in forming cooperative relationships with its neighbours to address ballast water transfers in a coordinated and consistent manner and to communicate our experiences gained through GloBallast widely in the region.

Ahmad Donyamali

Explore the ROPME Web Site

www.kuwait.net/-ropmek/

~~~ NEWSFLASH ~~~

IMO Guidelines Now On-Line in six languages

The IMO Ballast Water Guidelines A.868(20) are now available online in Arabic, Chinese, English, French, Russian and Spanish, and can be viewed/downloaded as PDF files.

http://globallast.imo.org/guidelines/

Regional Replication Launched in the ROPME Sea Area

The 1st Regional Conference on Ballast Water Control and Management in the ROPME Sea Area was held in Tehran 17 to 19 June 2002. The Islamic Republic of Iran, as the GloBallast Pilot Country in the region, hosted the conference through its Ports and Shipping Organization.

Conference delegates

With technical activities well underway in the six Pilot Countries, the GloBallast Programme is now beginning to focus on regional replication and cooperation. This is being effected through a series of regional conferences, in order to progress Regional Action Plans (RAPs) for ballast water control and management.

The first such conference was held in Odessa, Ukraine in October 2001, at which a RAP was adopted by the six Black Sea littoral States. This was quickly followed by a similar event for the Baltic Sea, held in Tallinn, Estonia. Delegates resolved to develop a Baltic RAP through the Helsinki Commission and the GEF Baltic Sea Regional Project (see BWN # 7).

The latest region to join forces to combat the threat of invasive marine species transferred in ships' ballast water is the ROPME Sea Area. ROPME stands for the *Regional Organization for the Protection of the Marine Environment*, an inter-governmental organization comprising the Kingdom of Bahrain, Kingdom of Saudi Arabia, Islamic Republic of Iran, State of Kuwait, State of Qatar, Sultanate of Oman and the United Arab Emirates. Iraq is also a member, although currently inactive.

Maritime and environmental experts from the ROPME member States, the regional shipping and oil industries, the ROPME Secretariat and the GloBallast PCU gathered for the Conference in Tehran.

The Conference objectives were:

- To undertake awareness raising about invasive marine species, the ballast water problem and IMO ballast water activities amongst key stakeholders in the Region.
- To establish the current status of invasive marine species and ballast water management arrangements in the ROPME member States.
- To consider and endorse a draft Regional Action Plan.
- To agree on the machinery for implementation and coordination of regional activities.

The Conference was opened by the Iranian Deputy Minister for Transport, affirming the Islamic Republic's commitment to implementing IMO ballast water management arrangements and the importance of regional cooperation.

The Conference proceeded according to a three-day programme. Background presentations were provided by the GloBallast PCU, the I.R Iran described the significant progress made to date at the Khark Island Demonstration Site, and status reports were presented by the other littoral States together with specialist presentations by regional marine scientists and industry experts.

The introduction of alien species via ballast water is only recently becoming a concern for ROPME member States. An estimated 100 ships enter and leave the ROPME Sea Area every day, and approximately 40% of the world's total oil transportation passes through the region. Fleets of the world's largest oil tankers arrive fully laden with ballast water from ports all around the globe, discharging it along with any entrained organisms, prior to loading oil for export. The ROPME Sea Area receives a greater volume of ballast water discharges from crude oil tankers than any other area in the world, and may therefore be characterised as an extremely high-risk area.

Part of the ROPME Sea Area (the boundary extends to include the southern coast of Oman – not shown).

The Conference devoted significant effort to considering the draft RAP and developing recommendations for regional cooperation. During discussions, all countries unanimously agreed that the problem of ballast water and marine bio-invasions must be addressed on a regional basis involving cooperation between all countries in the region. The reasons given for this position were:

- shipping is an international industry and must cross jurisdictional lines to conduct trade.
- The region is largely an enclosed sea and the marine and coastal environments of the littoral States are inextricably linked by natural circulation and currents and by shipping within the region.
- Action by an individual country would therefore be of limited effectiveness.
- There is a strong history of effective regional cooperation on maritime and marine resource management matters.

It was unanimously agreed that regional cooperation on ballast water control and management should be developed and coordinated through existing regional structures and mechanisms, led by ROPME and supported by the industry group RECSO (Regional Clean Seas Organization - formerly Gulf Area Oil Companies Mutual Aid Organization).

Finally, the Conference adopted a Resolution with recommendations covering the following major areas:

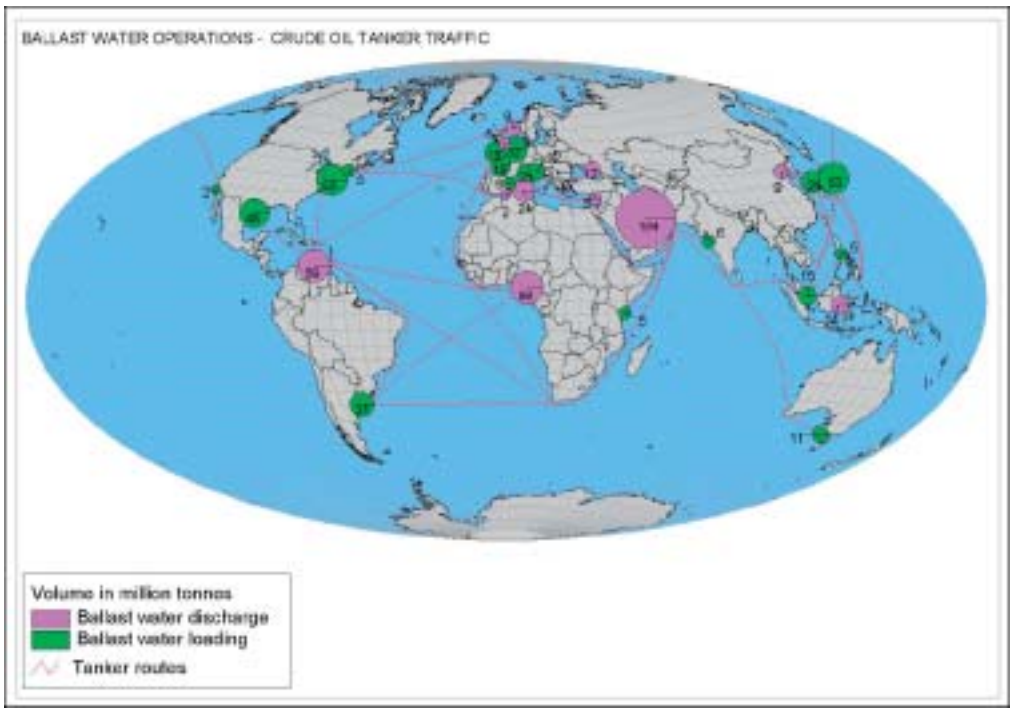
- Endorsement of the draft Regional Action Plan.
- ROPME to coordinate activities under the RAP.
- The establishment of a Regional Task Force.
- Implementation of IMO Resolution A.868(20) within the Region.
- Support for the rapid adoption and entry into force of the new international ballast water Convention, being developed by IMO.

After extensive, detailed and productive discussions, the delegates agreed to endorse the RAP, subject to a number of amendments and clarifications agreed to during the discussions. The Conference agreed to work towards formal adoption of the RAP by the end of 2002 through a high level meeting to be held in Tehran.

Overall, the workshop was proclaimed as a major success by all involved. The GloBallast PCU is now working with stakeholders to progress the RAP. It is hoped that ROPME and its member States will build on the sound foundation achieved by the Conference and take up the challenge of implementing the workshop Resolution and its recommendations.

The GloBallast Programme is deeply grateful for the assistance of the Government of the Islamic Republic of Iran, and in particular the Ports and Shipping Organization, and also the ROPME Secretariat in Kuwait for the excellent support provided in convening the Conference.

SR



Loading and discharge of ballast water by large crude oil carriers for 1996 (Source: DNV).
The ROPME Sea Area received 194 million tonnes of ballast water and may be characterised as an extremely high-risk area.

Training Package Progresses

From 22 to 30 April development of modular ballast water management training packages commenced with a planning workshop in Montevideo, Uruguay.

The Globallast Course Development Team in Uruguay

Training is an essential component of implementing both port-based and shipboard ballast water management arrangements. Currently, there are no standardised, international curricula or model courses relating to IMO ballast water requirements. The development of such training is therefore a key activity of the GloBallast Programme.

In undertaking this task, GloBallast has adopted the UN Train-X methodology. The Train-X system seeks to build sustainable capacity through training. It has been applied by seven different UN agencies in a wide range of subject areas, including but not limited to telecommunications (TrainTel), civil aviation (TrainAir), maritime trade (TrainMar) and coastal and ocean management (Train-Sea-Coast).

The success of the Train-X method derives from its focus on the careful analysis of training needs and learner characteristics, the development of course materials using both specialist course developers and subject matter experts, followed by delivery through performance-based instruction and a process of validation and continuous improvement.

GloBallast has engaged the UN Train-Sea-Coast (TSC) programme to coordinate development of the ballast water training packages. The TSC Centres in the GloBallast Pilot Countries of Brazil and South Africa are undertaking the actual course development. The Uruguay planning workshop mapped-out a full process to complete the modules ready for validation and delivery via maritime training institutes by the end of 2002.

GloBallast would like to specially acknowledge the support provided during the workshop by the Naval Academy of Montevideo (Escuela Naval de la Republica Oriental del Uruguay) and in particular by Captain Alfredo Saint Martin, who assisted the Course Developers in analysing learner characteristics for ships' personnel.

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Aussie R&D Consortium Operational

With funding from the Australian Government's Natural Heritage Trust of nearly AUD$250K and the appointment of a full-time coordinator in May this year, the Australian Ballast Water Treatment Consortium (ABWTC) is now operational in Townsville, Northern Australia.

ABWTC has been developed as a concept over a number of years, and stems from pioneering research carried out by Dr Darren Oemcke at James Cook University from 1995 to 1999. Initiated by the Ports Corporation of Queensland, the Consortium includes the Mackay, Gladstone and Townsville Port Authorities, the Cooperative Research Centre for the Great Barrier Reef (CRC), Amiad International (a major filter manufacturer) and United Water International (a leading water treatment company).

ABWTC will build a pilot treatment plant using existing technologies and off-the-shelf equipment. Based on existing research results the pilot plant will test the following technologies on a 'plug and play' basis; filtration, UV, sonic and other cavitation methods and chemicals.

The pilot plant is being designed so that it can be moved to different ports for testing under various environmental conditions and in southern Australian ports infested by pest species. It will be compact enough to be placed aboard ships for testing in transit.

In addition to the original Consortium partners, the following organisations have become welcome participants, Queensland Department of Primary Industries, Queensland Environmental Protection Agency, the Great Barrier Reef Research Foundation, Gunns (a Tasmanian forestry company), Pasminco Century Zinc (a mining company) and URS (an international consulting company). The project is based at the James Cook University School of Engineering in Townsville, a recognized world centre of marine science and technology. It is administered through the CRC.

With its extremely broad base of partners representing port authorities, regulatory agencies, the scientific community and the private sector from a range of industries, the Consortium is well placed to make substantial advances in testing ballast water treatment technologies. The global market for such technologies is estimated to approach US$10 billion in the next 15 years.

The Consortium is also interested to talk to potential additional partners both from the private sector and government, from within Australia and internationally.

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Setting Standards with Limited Data

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Dr Tom Waite is an internationally acclaimed environmental engineer and a pioneer of ballast water treatment R&D. He is currently Program Director at the US National Science Foundation and Associate Dean of Environmental Engineering at the University of Miami.

Successful invasions of aquatic organisms around the world due to ballast discharges make it clear that all natural ecosystems are vulnerable. Recent data[1] have shown that invasions in the U.S. are increasing at a rapid rate, and that in the marine environment most of these are attributed to members of the Crustacea and Mollusca.

It appears that the most promising solution to this global environmental threat will be to develop effective and hopefully inexpensive shipboard ballast water treatment scenarios. Currently, different types of treatment systems are being evaluated including filtration and screening systems, biocide systems including chemicals, UV radiation and heat and various attempts at modifying the environment such as removing the oxygen from ballast water. In most cases, evaluations have shown that the individual techniques offer promise, depending on the environment, and more importantly, depending on the organisms to be removed.

It has been clear from the beginning that unless treatment standards are established, little progress can be made in the direction of developing reliable, inexpensive and safe ballast water treatment systems. Significant progress is being made at IMO to develop global standards, with an expert correspondence group due to report to the 48th meeting of IMO's Marine Environment Protection Committee in October this year. The US Coast Guard is also coordinating a national process to develop ballast water treatment standards within the US. The development of such standards is however, hampered by lack of data and scientific certainty.

In a recent discussion on this issue with Mr. Tom Sherman, *(Aquacide LLC)* he mentioned that a recent editorial by P. Anand in *Science* (2002)[2] addressed the issue of 'decision making' when science is ambiguous. It turns out that the editorial focused on the need to make logical decisions concerning control of Mad Cow Disease (bovine spongiform encephalopathy, BSE), when little scientific information was available. The author utilized classic decision making techniques under ambiguity, in order to select the most appropriate solution to minimize the risk from BSE. This same thought process may well be applied to the establishment of ballast water treatment standards, when a strong scientific base for selection of an appropriate standard does not exist.

In situations where there is little knowledge concerning actual probabilities of consequences or risks associated with a decision, decisions can be made utilizing classic 'gaming' theories such as 'select the decision that has the best of the worst payoffs'[3]. Anand[4] argues that when uncertainty is extensive, the most important issue is the consequences of different actions. He further argues that we should treat consequences with the same level of rigor that we would treat an analysis utilizing probabilities or predictable risks.

Utilizing this classic approach, the consequences of selecting different types of ballast water treatment standards may be estimated. In so doing, international bodies can select an approach from several alternatives, based on a logical process. Table 1 shows a matrix of possible actions for establishing ballast water standards. Obviously doing nothing is one option, and on the other end of the spectrum is the option of removing all organisms from ballast water, or effectively dealing with a sterile medium.

Other actions would be to utilize treatment levels observed with ballast exchange, which vary widely and therefore provide a poor benchmark, or inactivation of surrogate organisms as a basis of treatment efficiency. In this latter case, two options may be considered, one where 'high risk' organisms are selected, based on previous history as invaders, or because the scientific community believes they have some attributes of being potentially invasive. The other category of surrogate species would be those that are selected without any knowledge of their invasive capability, but rather represent different groups of organisms found throughout the world. In this case, surrogate organisms would be selected mainly because of their representativeness and ease of culturability (see MARTOB article, page 9).

When the possible actions in Table 1 are contrasted against the risk state of invasion, estimates of outcome can be made for each case, i.e. 1 being the best possible outcome and 0 being the worst. For example, in the case of 'doing nothing', when ballast water has a high risk of invasion, represents the worst possible outcome. Conversely, if the ballast water is indeed safe and nothing is done, this is the best possible outcome, as there are no financial penalties. Comparing this action to the removal of all organisms from ballast water, the outcomes will be reversed, as the best possible outcome is to remove all of the organisms from ballast water at high risk. Of course, it is also the worst possible action when the ballast water is actually safe. Ballast exchange, because of its highly

variable efficiency at removing organisms, will not have as good an outcome when treating 'high risk of invasion' ballast water. In the case where removal of high risk organisms is contrasted against removal of non-related surrogate species, it is assumed that removal of high risk organisms will have a better outcome.

According to Knight[3] an appropriate selection process, although somewhat conservative, is to select the 'maximum of the minimum outcomes', that is the best of the worst outcomes. Referring to Table 1, this selection would mean that the best action is to remove high risk or surrogate organisms. On the other hand, some strategists argue that utilization of the 'maximum of maximum outcomes' will identify an action that has the highest and best possible result. In this case, the selection would be; do nothing, remove all of the organisms or remove the high risk organisms. As noted earlier, the action of doing nothing has its only advantage in the situation where the ballast water is truly safe. While this is a logical scenario, for our case of ballast water treatment, it is generally assumed that no water is totally safe. Considering the case of removing all of the organisms from ballast water, which would be the best outcome for 'high risk' ballast water, the costs associated with attempting such treatment are probably not realistic. Therefore, these two (albeit logical) action items probably should not be considered as reasonable solutions even though, as an action, they do suggest the highest possible payoff.

It is seen that by utilizing a decision making process in the presence of ambiguity, some insight can be gained with respect to directions for generating ballast water treatment standards. For example, by utilizing the 'maxi-min' approach a defensible option would be to utilize selected organisms as markers for treatment efficiency. If organisms of significant risk for invasion can be defined, then this approach becomes even more meaningful. In the case where an attempt is made to get the best possible payoff from the action, (discounting the 'do nothing' or 'remove all organisms' option), then the best approach would once again be to remove high risk organisms.

In conclusion, even though the scientific community is still working to determine actual risks and probabilities associated with invasions and therefore, solutions via treatment options, decisions can be made based on an evaluation of consequences of decisions. The example described here, utilizing an 80 year old process, used extensively in public policy and economic decision making, suggests that the most appropriate route is to generate standards based on the inactivation of representative organisms, either associated with previous invasions or resembling organisms with the potential to invade.

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Table 1: **Deciding on Standards for Shipboard Treatment of Ballast Water: Matrix of Possible Actions**

Ballast Water Risk	Do nothing	Remove all organisms	Ballast exchange at sea	Remove 'high risk' species	Remove 'surrogate' species
High Risk of Invasion	0	1.0	0.8	0.9	0.7
Low Risk of Invasion	0.5	0.3	0.7	0.8	0.6
Safe	1.0	0	0	0.2	0.3
Maximum	1.0	1.0	0.8	0.9	0.7
Minimum	0	0	0	0.2	0.3

1 = best outcome
0 = worst outcome

Max. of Minimum (best of worst outcomes) = Remove 'High Risk' or 'Surrogate' organisms.

Max. of Maximum (highest best possible payoff) = Do nothing, or remove all, or remove 'High Risk' organisms.

NB: The values in the table are arbitrary and are for illustrative purposes only. In particular, the values inserted for ballast exchange at sea are not based on any firm quantitative assessment, and given the wide variability of the biological effectiveness of this technique, are extremely difficult to provide with any degree of certainty.

References for this article are listed on Page 11.

Biocides Tested for the Great Lakes

The Great Lakes of North America have suffered some of the most well known aquatic bio-invasions, and several groups in the area are searching actively for better solutions to address this severe problem.

The MV Federal Yukon

BMT Fleet Technology Limited and ESG International have conducted a series of tests using chlorine and copper as ballast water biocides. This work was undertaken for the State of Michigan, Department of Environmental Quality, to explore immediate options for the control of invasive species into the Great Lakes.

The project was not designed to determine whether specific standards for biocidal efficacy could be achieved, as such standards do not currently exist. However, the Michigan regulators posed some practical questions for chlorine and copper:

- Are they effective in killing biota?
- Can they be safely handled?
- Are the ultimate discharge concentrations environmentally acceptable?
- Do they damage ballast tanks?
- Do they work with sediment present?
- Are they practical, economical and available?

The project comprised three parts:

- Shipboard testing on the *MV Federal Yukon*.
- Toxicology testing in the biological laboratory.
- Corrosion testing in the material laboratory.

Shipboard trials were conducted during a typical saltwater and freshwater round trip between Lisbon (Portugal), Antwerp (Belgium), Burns Harbour (Indiana) and Superior (Wisconsin). The ship was fitted with a prototype Biomatic copper ion generator capable of dosing the ballast tanks directly. For the chlorine tests deck mounted tanks were modified to enable manual dosing with sodium hypochlorite.

The field tests indicated that sodium hypochlorite dosed to a total residual chlorine (TRC) level of ~10 ppm significantly reduced (>90%) zooplankton and bacteria levels relative to the controls after a two-hour treatment. Copper treatment at less than 0.2 ppm was shown to be capable of reducing zooplankton levels.

Laboratory tests were conducted on freshwater and saltwater fish, invertebrates, algae and bacteria, in conditions that simulate those in a ballast tank. Hypochlorite was effective at killing the majority of species tested at less than 10 ppm. Higher levels were required to kill encysted life stages. The lethal concentration values of the majority of species tested in copper varied considerably. Tests also demonstrated that the presence of sediment negatively impacts biocide performance.

Corrosion tests were also conducted on the ballast tank coating systems and steel. Effects were not quantifiable in terms of life expectancy.

Several operational issues were identified during the conduct of the study. These include:

- There are safety issues surrounding the carriage of commercial concentrations of hypochlorite on ships. These are overcome by generating sodium hypochlorite on-board.
- Acceptable chlorine levels can be achieved through de-chlorination at discharge, but there are discharge concerns associated with copper.
- The removal of bottom sediment from ballast tanks and suspended sediment in incoming ballast water would improve the efficacy of both biocides.

Economic models of typical on-board installations based on a bulk carrier trading into the Great Lakes were investigated. It was shown that the life cycle cost of an onboard sodium hypochlorite system would increase the required daily charter rate by US $207. To use manufactured sodium hypochlorite stored in a tank on-board would cost $125 per day. The life cycle cost of a copper ion generator similar to that installed on the Federal Yukon would be $48 per day.

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Editors Note:

The study results have not been published and are subject to peer review.

~~~ NEWSFLASH ~~~

Updated R & D Directory Now On-Line

http://globallast.imo.org/research/

MARTOB Makes Progress

The European Commission is partially funding a three year project entitled ***On Board Treatment of Ballast Water and Application of Low-Sulphur Marine Fuel (MARTOB)****. The project involves 25 partners from eight European countries and has been underway since April 2001.*

Nereis virens – used as a test species

One of the many objectives of MARTOB is to assess the biological effectiveness of selected ballast water treatment technologies, and shore based test trials are now underway.

The treatment technologies included in the project are high temperature thermal treatment, UV, ultrasound, ozone, oxicide, de-oxygenation, advanced oxidation (a combination of ozone, UV and catalysts) and hurdle technologies (combinations of the above).

The overall aim of the trials is to compare the efficiency of the different technologies at removing or killing organisms i.e. the biological effectiveness of the treatment. For reasons of logistics and consistency it was decided to bring all the prototype treatment technologies to one location (University of Newcastle in the UK). The first trials took place during June 2002 and analysis of the results is now underway.

A major part of the project has been the development of a set of standard procedures and protocols for assessing the biological effectiveness of the treatment technologies. Such standard protocols do not currently exist, although a variety of options have been suggested by various R&D groups around the world. In order to compare the efficiency of the treatment methods in a meaningful way, the trials have to be carried out under the same conditions for each treatment technology.

Many of the proposed protocols have suggested using a "standard ballast water " with a mix of known densities of species, representative of those likely to be found in ballast water. The MARTOB project collated and reviewed information regarding proposed protocols from various sources. Taking these into account as much as possible, the following organisms were selected to compose a representative biological group; from the phytoplankton the diatom *Thalassiosira pseudonana* and the dinoflagellate *Alexandrium tamarense*, and from the zooplankton the harpacticoid copepod *Tisbe* sp, the calanoid copepod *Acartia* sp. and nectochaete larvae of the polychaete *Nereis virens*.

During the trials a "standard" seawater is made up with a known density of each of the organisms. This water is then treated using the various treatment technologies and the biological effectiveness of each treatment will be assessed using a variety of methods. These include a staining technique to distinguish dead from live material, chlorophyll *a* analysis, flow cytometric analysis (see 'Singapore' article below) and growth experiments to investigate whether the phytoplankton cells are able to recover and start growing again after a treatment method.

Further details of the experiments and a summary of the results will be outlined in future issues of Ballast Water News.

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Singapore Seeks Rapid Monitoring Method

Technologies to monitor the microbiological quality of ballast water are being developed at Nanyang Technological University in Singapore. The project aims to develop simple and rapid methods of detecting, counting and identifying microbes in ships' ballast water.

Flow-cytometry analysis

Conventional methods of water quality monitoring are not appropriate for the shipping industry because the analysis has to be performed by skilled technicians in specialized laboratories and takes several days to complete. Simpler, more rapid techniques are required.

Flow-cytometry is a useful tool for assessing many parameters of micro-organisms including enumeration (counting), viability and species identification. Flow cytometry is based on the principle that cells in suspension flow in single-file past a laser where they scatter light and emit fluorescence that is collected, filtered and converted

into digital values. The scatter of light from cells is representative of their size and shape. The fluorescence emitted from cells may be due to bioluminescence, or a result of fluorescent dyes or fluorescent labels that have been attached to them for a specific purpose. Flow cytometry has been traditionally used in clinical laboratories for the analysis of lymphocytes. Its applications are however continually broadening. The fluorescent dyes commonly used in flow-cytometry to stain and highlight nucleic acids are usually mutagenic. Practical enumeration of bacterial cells is impaired by the addition of mutagenic substances. Enumeration based on light scatter with reference cell cultures as standards is safer and quicker. The enumeration of cells can be performed by a comparison of the number of forward scatter events of the cell population and a known concentration of beads.

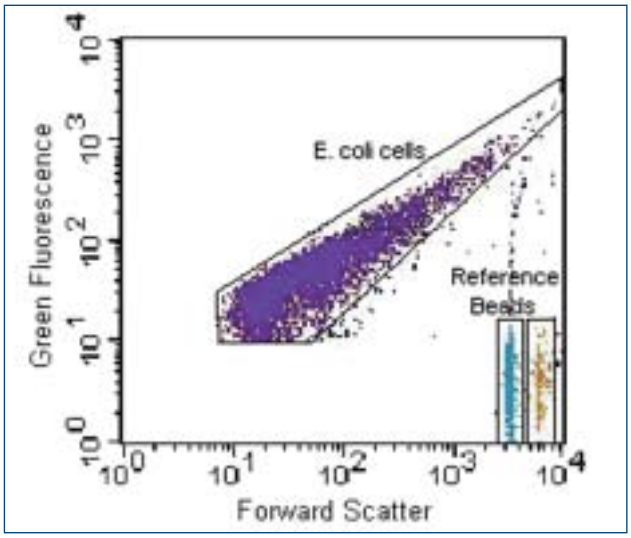
Comparisons were made between 'ambient' seawater and ballast samples using flow-cytometry and two conventional techniques of cell enumeration – spread plate counting and fluorescence microscopy. Compared to spread plate counting[1], the non-cultivation techniques of fluorescence microscopy[2] and flow-cytometry were considered to be more reliable. Previous reports have discussed the difficulties with successfully culturing organisms from the marine environment.[3]

Speed of analysis is another important aspect. Spread plating is a prolonged and tedious procedure, which introduces large margins of error. Although fluorescence microscopy is a simple and relatively quick staining protocol, it relies on the judgement and accuracy of the investigator, which is prone to error. On the other hand, flow-cytometry is rapid, fully automated and completely free of observer error.

Although there were large differences between the methods, they each found that the concentration of cells in the ballast samples were much smaller than that in ordinary seawater samples. The conditions in the ballast tank (higher temperature and low oxygen) were assumed to be the cause of this. However, further analysis revealed that in some cases there was a much higher proportion of facultative anaerobic microorganisms compared to the seawater samples (in one case there was 50% in the ballast sample compared to 7% in the seawater samples). This is of importance as facultative anaerobes are much more likely to be pathogenic. Therefore it seemed that in some instances the conditions inside ships' ballast tanks might promote or select for dangerous microorganisms.

In addition to enumerating the number of cells present in samples, fluorescence *in situ* hybridisation (FISH) methods with oligonucleotide probes (matched to the genetic sequences of particular organisms) are useful for the identification of individual microbial cells and specific species of interest. These molecular biological methods can be used to quickly detect pathogens, or indicator bacteria, in ballast water down to species level. Various specific oligonucleotide probes have been used to simultaneously identify and enumerate *E. coli* (see Figure). The addition of reference beads allows the enumeration of cells to be performed simultaneously with species identification. Another organism, which will be of interest to study in this way, is *Vibrio cholerae*, a highly dangerous pathogen that has been found in ballast water.

Eva Joachimsthal



An example of the CY3 fluorescence dot-plots of E. coli cells (purple) with the specific labelled probe Eub338.CY3 with comparison to reference beads for counting purposes (blue and orange).

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Editors Note:

Flow-cytometry and FISH methods are highly suited to laboratory-based analysis of samples from ballast water treatment R&D tests. They also show significant promise as rapid and highly accurate diagnostic techniques for ballast water sampling and monitoring.

However, despite the rapidity, accuracy and utility of flow-cytometry, the bench-top scale of current analysis equipment still requires samples to be collected from the ship and delivered to the laboratory. The R&D challenge remains to downsize the equipment into portable devices that can be carried by port inspectors; in order to sample and test ships in real-time.

Another option could be to fit the necessary probes in ballast tanks and carry the analysis equipment on-board. This could be linked to a warning when species of concern are detected in the ballast tanks, ideally at the port of uptake.

SR

Publications

Invasive Species and Biodiversity

The global scale and impacts of bio-invasions are becoming increasingly evident, as highlighted in this selection of papers from the UN Conference on Alien Species held in Trondheim, Norway in 1996, and recently published by Kluwer.

Altogether 33 contributors from around the world joined to produce this outstanding 430-page publication, entitled *Invasive Species and Biodiversity Management* and edited by Odd Terje Sandland, Peter Johan Schei and Åslaug Viken.

For the first time in one volume, this book presents ecological, biological and epidemiological aspects of invasive species, as well as the problem of disease organisms for agriculture and human health. While considering the issue of invasive species in a broad context, there is a significant focus on aquatic environments and several papers of much interest to those of us involved in ballast water and the maritime sector.

The book provided a comprehensive background to the Global Invasive Species Programme (GISP) and serves to highlight the need for ballast water and other ship-borne vectors of aquatic invasive species to be considered within a broader, integrated framework for managing invasive species in general, while recognizing that different environments, pathways and vectors require specialized management approaches.

The book is well suited for management staff in various environmental, economic and social sectors, and is essential for university and college teachers, researchers and students involved in this field.

www.wkap.nl

CIESM Atlas of Exotic Species

The International Commission for the Scientific Exploration of the Mediterranean Sea (CIESM) has just released the first volume of its Atlas of Exotic Species in the Mediterranean Sea – focussing on fishes.

Written by Daniel Golani, Lidia Orsi-Relini, Enric Massutí and Jean-Pierre Quignard and edited by Frederic Briand, this is the first of several volumes that will cover various groups (decapods, mollusks etc).

With 256 pages and 26 original colour drawings, the Atlas of Exotic Fishes presents an illustrated record of 91 species. The quasi-totality is of tropical origin: two-thirds from the Red Sea or Indo-Pacific domain, the others from tropical regions of the Atlantic. Notes on the biology and ecology of the species, distribution maps, an annotated list of species excluded for cause from the Atlas, plus a large bibliographic section complete this volume aimed at specialists and non-specialists alike.

CIESM is one of the oldest and most enduring scientific intergovernmental organisations in the world. The Commission is currently funded by 22 Member States which support the work of a large scientific network - some 500 institutes and over 2500 researchers - united by a commitment to promote marine science for the lasting protection of the Mediterranean Sea and for the well-being of its coastal populations.

The CIESM Atlas of Exotic Species makes an important contribution to the management of invasive species in the Mediterranean.

www.ciesm.org

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Progress Report

Activities Undertaken April – June 2002

- ✓ Commenced implementation of the recommendations from the review of the Information Clearing House function, including:
  - Revamp web site, directories and databases.
  - Interactive chat-room/e-forum.
- ✓ Held Train-X Workshop in Montevideo, Uruguay, 15-23 April.
- ✓ Completed first round of country visits for ballast water risk assessments for all six Demonstration Sites.
- ✓ Attended and presented at IUCN Invasive Species Workshop in Gland, Switzerland, 1-3 May.
- ✓ Attended and presented at Offshore Arabia – Clean Seas Conference in Muscat, Oman, 13-14 May.
- ✓ Held 1st Regional Conference on Ballast Water Control and Management in Tehran, Iran, 17-19 June.
- ✓ Progressed new set of awareness materials.
- ✓ Submitted sponsorship proposals to potential partners for production of TV documentary.
- ✓ Produced 9th issue of Ballast Water News.

Activities Planned July – September 2002

- PCU staff annual leave.
- Prepare for and attend World Summit on Sustainable Development, Johannesburg, 26 August – 4 September.
- Complete UNDP-GEF Project Implementation Review.
- Undertake mid-term external review of the programme.
- Commence second round of country visits for ballast water risk assessments.
- Attend and present at NordTest workshop, Copenhagen, 16 September.
- Prepare for and attend GEF International Waters Conference, Dalian, China, 26-29 September.
- Distribute new awareness materials.
- Progress sponsorship and partnership arrangements for production of TV documentary.
- Produce 10th issue of Ballast Water News.

More Information?

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