Global **Ballast Water**
Management Programme

GLOBALLAST MONOGRAPH SERIES NO.10

Ballast Water Risk Assessment
Port of Odessa
Ukraine

OCTOBER 2003

Final Report

B. Alexandrov, R. Bashtannyy,
C. Clarke, T. Hayes, R. Hilliard,
J. Polglaze, V. Rabotnyov
& S. Raaymakers

GEF UNDP IMO URS MERIDIAN

A cooperative initiative of the Global Environment Facility,
United Nations Development Programme and International Maritime Organization.

GloBallast Monograph Series No. 10

Ballast Water Risk Assessment
Port of Odessa
Ukraine

October 2003

Final Report

**Boris Alexandrov[3], Roman Bashtannyy[2],
Christopher Clarke[1], Terry Hayes[1], Robert Hilliard[1],
John Polglaze[1], Vladimir Rabotnyov[2] & Steve Raaymakers[4]**

[1] URS Australia Pty Ltd, Perth, Western Australia
[2] Information and Analytical Centre for Shipping Safety, State Department of Maritime and Inland Water Transport, Ministry of Transport of Ukraine
[3] Institute of Biology of the Southern Seas, Odessa Branch
[4] Programme Coordination Unit, GEF/UNDP/IMO Global Ballast Water Management Programme, International Maritime Organization

ISSN 1680-3078

Published in March 2004 by the
Programme Coordination Unit
Global Ballast Water Management Programme
International Maritime Organization
4 Albert Embankment, London SE1 7SR, UK
Tel +44 (0)20 7587 3251
Fax +44 (0)20 7587 3261
Email sraaymak@imo.org
Web http://globallast.imo.org

The correct citation of this report is:
Alexandrov, B, Bashtannyy, R., Clarke, C., Hayes, T., Hilliard, R., Polglaze, J., Rabotnyov, V. & Raaymakers, S. 2004. *Ballast Water Risk Assessment, Port of Odessa, Ukraine, October 2003: Final Report.* GloBallast Monograph Series No. 10. IMO London.

The Global Ballast Water Management Programme (GloBallast) is a cooperative initiative of the Global Environment Facility (GEF), United Nations Development Programme (UNDP) and International Maritime Organization (IMO) to assist developing countries to reduce the transfer of harmful organisms in ships' ballast water.

The GloBallast Monograph Series is published to disseminate information about and results from the programme, as part of the programme's global information clearing-house functions.

Acknowledgements

The Ballast Water Risk Assessment for the Port of Odessa was undertaken during 2002 and funded by the GEF/UNDP/IMO Global Ballast Water Management Programme and the Government of Ukraine. The study team (Appendix 2) thanks the following for their help and assistance:

Mr Ruslan Barskiy	Commercial Sea Port of Illichivsk, Illichivsk, Ukraine
Dr Gustaaf Hallegraeff	University of Tasmania, Hobart, Tasmania
Dr Keith Hayes	CSIRO Marine Research, Hobart, Tasmania
Dr Chad Hewitt	Biosecurity Unit, New Zealand Ministry of Fisheries, Auckland
Mr Vladimir Savusin	State Inspectorate for the Protection of the Black Sea, Ministry of Environment &Natural Resources of Ukraine, Odessa
Ms Olesya Serdyuk	Department of Energy Saving &Environment Safety, Ministry of Transport, Kiev, Ukraine
Ms Natalia Syomina	Commercial Sea Port of Yuzhny, Yuzhny, Ukraine
Dr Fred Wells	Western Australian Museum, Perth, Western Australia

The report was formatted and prepared for print by Leonard Webster.

Some of the Ukraine risk assessment team

Acronyms

BW	Ballast water
BWM	Ballast water management
BWRA	Ballast Water Risk Assessment
BWRF	Ballast Water Reporting Form (the standard IMO BWRF is shown in Appendix 1)
CFP	Country Focal Point (of the GloBallast Programme in each Pilot Country)
CFP/A	Country Focal Point Assistant
CRIMP	Centre for Research on Introduced Marine Pests (now part of CSIRO Marine Research, Hobart, Tasmania)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CSPO	Commercial Sea Port of Odessa (port authority)
DSS	Decision support system (for BW management)
DWT	Deadweight tonnage (typically reported in metric tonnes)
GIS	Geographic information system
GISP	Global Invasive Species Programme
GloBallast	GEF/UNDP/IMO Global Ballast Water Management Programme
GT	Gross tonnage (usually recorded in metric tonnes)
GUI	Graphic User Interface
IACSS	Information and Analytical Centre for Shipping Safety, State Department of Maritime and Inland Water Transport, Ministry of Transport of Ukraine.
IALA	International Association of Lighthouse Authorities
IBSS	Institute of Biology of the Southern Seas (Odessa Branch) of the Ukraine National Academy of Science
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IUCN	The World Conservation Union
LAT	Lowest Astronomical Tide
MESA	Multivariate environmental similarity analysis
MEPC	Marine Environment Protection Committee (of the IMO)
NEMISIS	National Estuarine & Marine Invasive Species Information System (managed by SERC)
NIMPIS	National Introduced Marine Pests Information System (managed by CSIRO, Australia)
NIS	Non-indigenous species
OBO	Ore/bulk oil tankers (an rather unsuccessful vessel class now used for oil transport only)
OS	Operating System (of any personal or mainframe computer)
PCU	Programme Coordination Unit (of the GloBallast Programme based at IMO London)
PRIMER	Plymouth Routines In Marine Environmental Research
PBBS	Port Biological Baseline Survey
ROR	Relative overall risk
SAP	(Regional) Strategic Action Plan
SERC	Smithsonian Environmental Research Center (Washington DC, United States)
SIPBS	State Inspection for Protection of the Black Sea
VLCC	Very large crude carrier (200,000 – 300,000 DWT)
ULCC	Ultra large crude carrier (over 300,000 DWT)

Glossary of Terms and Definitions

The following terms and definitions are summarised from various sources including Carlton (1985, 1996, 2002), Cohen & Carlton (1995), Hilliard *et al.* (1997a), Leppäkoski *et al.* (2002), Williamson *et al.* (2002) and the GloBallast *BWRA User Guide*. The latter document contains more detailed definitions with explanatory notes, plus a glossary of maritime terms.

Ballast water	Any water and associated sediment used to manipulate the trim and stability of a vessel.
Bioinvasion	A broad based term that refers to both human-assisted introductions and natural range expansions.
Border	The first entrance point into an economy's jurisdiction.
Cost benefit analysis	Analysis of the cost and benefits of a course of action to determine whether it should be undertaken.
Cryptogenic	A species that is not demonstrably native or introduced.
Disease	Clinical or non-clinical infection with an aetiological agent.
Domestic routes/shipping	Intra-national coastal voyages (between domestic ports).
Established introduction	A non-indigenous species that has produced at least one self-sustaining population in its introduced range.
Foreign routes/shipping	International voyages (between countries).
Fouling organism	Any plant or animal that attaches to natural and man-made substrates such as piers, navigation buoys or hull of ship, such as seaweed, barnacles or mussels.
Harmful marine species	A non-indigenous species that threatens human health, economic or environmental values.
Hazard	A situation that under certain conditions will cause harm. The likelihood of these conditions and the magnitude of the subsequent harm is a measure of the risk.
Indigenous/native species	A species with a long natural presence that extends into the pre-historic record.
Inoculation	Any partial or complete discharge of ballast tank water that contains organisms which are not native to the bioregion of the receiving waters (analogous to the potentially harmful introduction of disease – causing agents into a body – as the outcome depends on inoculum strength and exposure incidence).
Intentional introduction	The purposeful transfer or deliberate release of a non-indigenous species into a natural or semi-natural habitat located beyond its natural range.

Introduced species A species that has been intentionally or unintentionally transferred by human activity into a region beyond its natural range.

Invasive species An established introduced species that spreads rapidly through a range of natural or semi-natural habitats and ecosystems, mostly by its own means.

Marine pest A harmful introduced species (i.e. an introduced species that threatens human health, economic or environmental values).

Non-invasive An established introduced species that remains localised within its new environment and shows minimal ability to spread despite several decades of opportunity.

Pathogen A virus, bacteria or other agent that causes disease or illness.

Pathway (Route) The geographic route or corridor from point A to point B (see Vector).

Port Biological Baseline Survey (PBBS) A biological survey to identify the types of introduced marine species in a port.

Risk The likelihood and magnitude of a harmful event.

Risk assessment Undertaking the tasks required to determine the level of risk.

Risk analysis Evaluating a risk to determine if, and what type of, actions are worth taking to reduce the risk.

Risk management The organisational framework and activities that are directed towards identifying and reducing risks.

Risk species A species deemed likely to become a harmful species if it is introduced to a region beyond its natural range, as based on inductive evaluation of available evidence.

Translocation The transfer of an organism or its propagules into a location outside its natural range by a human activity.

Unintentional introduction An unwitting (and typically unknowing) introduction resulting from a human activity unrelated to the introduced species involved (e.g. via water used for ballasting a ship or for transferring an aquaculture species).

Vector The physical means or agent by which a species is transferred from one place to another (e.g. BW, a ship's hull, or inside a shipment of commercial oysters)

Lead Agencies

Lead Agency for General BW Issues in Ukraine:

Contact person:	Mr Vladimir Rabotnyov
Position:	Head, Information and Analytical Centre for Shipping Safety
Organization:	State Department of Maritime and Inland Water Transport, Ministry of Transport.
Address:	Post Box 44, Post Office 58, 65058 Odessa, Ukraine
Tel:	+38 (0482) 219 488
Fax:	+38 (0482) 219 483
Email:	rabotn@te.net.ua
Web:	www.globallast.od.ua

Primary contact for BW Risk Assessments in Ukraine:

Contact person:	Mr Roman Bashtannyy
Position:	Scientist, Information and Analytical Centre for Shipping Safety
Organization:	State Department of Maritime and Inland Water Transport, Ministry of Transport.
Address:	Post Box 44, Post Office 58, 65058 Odessa, Ukraine
Tel:	+38 (0482) 219 488
Fax:	+38 (0482) 219 483
Email:	rabotn@te.net.ua
Web:	www.globallast.od.ua

Executive Summary

The introduction of harmful aquatic organisms and pathogens to new environments via ships' ballast water (BW) and other vectors has been identified as one of the four greatest threats to the world's oceans. The International Maritime Organization (IMO) is working to address the BW vector through various initiatives. One initiative has been the provision of technical assistance to developing countries through the GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast).

Core activities of the GloBallast Programme are being undertaken at Demonstration Sites in six Pilot Countries. These sites are the ports at Sepetiba (Brazil), Dalian (China), Mumbai (India), Khark Island (Iran), Odessa (Ukraine) and Saldanha Bay (South Africa). One of these activities (Activity 3.1) has been to trial a standardised method of BW risk assessment (BWRA) at each of the six Demonstration Sites. Risk assessment is a fundamental starting point for any country contemplating implementing a formal system to manage the transfer and introduction of harmful aquatic organisms and pathogens in ships' BW, whether under existing IMO Ballast Water Guidelines (A.868(20)) or a new international Convention..

To maximise certainty while seeking cost-effectiveness and a relatively simple, widely applicable system, a semi-quantitative approach was followed, using widely-supported computer software. The semi-quantitative method aims to minimise subjectivity by using as much quantitative data as possible, to identify the riskiest ballast tank discharges with respect to a Demonstration Site's current pattern of trade. Unlike a fully quantitative approach, it does not attempt to predict the specific risk posed by each intended tank discharge of individual vessels, nor the level of certainty attached to such predictions. However, by helping a Demonstration Site to determine its riskiest trading routes, exploring the semi-quantitative BWRA provides a coherent method for identifying which BW sources deserve more vessel monitoring and management efforts than others.

This report describes the BWRA activity undertaken for the Port of Odessa, which is the Demonstration Site managed by the Commercial Sea Port of Odessa (CSPO). This capacity-building activity commenced in January 2002, with URS Australia Pty Ltd (URS) contracted to the Programme Coordination Unit (PCU) to provide BWRA training and software. Under the terms of reference, the consultants worked closely with their counterparts in a project team co-managed by URS and the Country Focal Point Assistant (CFPA) for completing all required tasks. These tasks required two in-country visits by the consultants (in April and August-September 2002) to install the BWRA software and provide 'hands-on' instruction and guidance. Most of the data collation tasks were undertaken before, between and during these visits, with gap-filling work undertaken by the consultants prior to a short 'project wrap-up' visit in February 2003.

The first step was to collate and computerise data from IMO Ballast Water Reporting Forms (BWRFs) to identify the source ports from which BW is imported to the Demonstration Site. For periods or vessel arrivals where BWRFs were not collected or were incomplete, gap-filling data were extracted from the port shipping records held at the Odessa port offices. These records also helped identify which next ports of call may have been a destination port for any BW taken up at Odessa.

A multivariate procedure was then use to determine the relative environmental similarity between the Demonstration Site and each of its BW source and destination ports. Comparing port-to-port environmental similarities provides a relative measure of the risk of organism survival, establishment and potential spread. This is the basis of the 'environmental matching' method adopted by the project, which facilitates estimating the risk of BW introductions when the range and types of potentially harmful species that could be introduced from a particular source port are poorly known.

Another objective of the BWRA Activity was to identify 'high-risk' species that may be transferred to and/or from the Demonstration Site. The customised BWRA database provided by URS therefore contained tables and interfaces for storing and managing the names, distribution and other information on risk species. Thus the taxonomic details, bioregional distribution, native/introduced status and level

of threat assigned to a species were stored in the database for display, review and update as well as for the BWRA analysis. For the purposes of the BWRA and its 'first-pass' risk assessment, a risk species was considered to be any introduced, cryptogenic or native species that might pose a threat to marine ecological, social and/or commercial resources and values if successfully transferred to or from a Demonstration Site.

During each visit the consultants worked alongside their Pilot Country counterparts to provide skills-transfer as part of the capacity building objectives of the programme, with the project team divided into three groups. Group A mapped the port and its resources using ArcView GIS. This group included counterparts from the Institute of Biology of the Southern Seas (IBSS, Odessa Branch) and the Port of Odessa, who helped collate and compile much of the required GIS data. Group B was responsible for managing the customised Access database supplied by the consultants, and for entering, checking and managing the BW discharge data, as recorded on the BWRFs voluntarily submitted by arriving ships and/or derived from the port's shipping records. Group B used the database to identify BW source and destination ports, and it is designed for ongoing input and management of BWRFs. Group C undertook the environmental matching and risk species components of the Activity, using the PRIMER package to perform the multivariate analyses for determining the environmental distances between Odessa and its source and destination ports.

The various BW discharge, environmental matching and risk species data described above were then processed by the database with other risk factors, including voyage duration and tank size, to provide preliminary indication of:

(a) the relative overall risk posed by each BW source port, and

(b) which destination ports appeared most at risk from any BW uplifted at the Demonstration Site.

This was achieved using a project standard approach, although the database also facilitates instant modifications of the calculations for exploratory and demonstration purposes. The GloBallast BWRA also adopted a 'whole-of-port' approach to compare the subject port (Demonstration Site) with all of its BW source and destination ports. The project has therefore established in Odessa an integrated database and geographic information system (GIS) that manages and displays:

- ballast water data obtained from arriving ship BWRFs and port shipping records;
- information on the Demonstration Site's navigational, physical and environmental conditions and aquatic resources,
- port-to-port environmental matching data,
- risk species data, and
- risk coefficients and graphical categories of risk for ballast discharges.

The results, which were graphically displayed on user-friendly GIS port and world maps as well as in ranked output tables, help determine the types of management responses.

From the 2297 vessel visit and 3387 associated ballast tank records in the 1999-2002 Odessa database, the total number of identified BW source ports was 122. The source port supplying the highest frequency of BW discharges at Odessa was the Bulgarian Black Sea port of Bourgas (14.4%). This was followed by the Italian Adriatic port of Trieste (7.7%), the Romanian Black Sea port of Constanta (5.6%), the Greek port of Piraeus (4.9%), the French Atlantic port of Fos sur Mer (4.1%) and the Croatian Adriatic port of Omisalj (3.6%). The highest-ranked source port in terms of BW discharge frequency from beyond the Euro-Mediterranean region was the east Russian port of Nakhodka (Sea of Japan), which at 0.73% was ranked 32nd. The top 10 of the 122 identified source ports provided >50% of the recorded discharges at Odessa, with the top 29 (24%) accounting for >75%.

Of the 2297 visits, 933 record BW tank discharges at Odessa that total 12,439,796 tonnes. Source port ranking on the basis of discharged volumes was very similar but not exactly the same as that based on discharge frequency. Source ports providing the largest volumes of discharged BW were Bourgas (17.3%), Trieste (9%), Constanta (7.5%) and Piraeus (6.7%). Only 21 of the 122 ports (17%) accounted for 75% of the source-identified total BW volume discharged at Odessa. Of the top 20 ports, seven were in the Black Sea, seven in the Adriatic Sea, two in the Aegean Sea, three in the Eastern Mediterranean and one on the Atlantic French coast. There were no recorded discharges from transhipment ports in the Azov Sea and Don River which facilitate trade with the Caspian Sea region via the Volga-Don canal.

Of the identified 122 BW source ports and 145 potential destination ports, sufficient port environmental data were obtained to include 53% of the former and 50% of the latter in the multivariate similarity analysis by PRIMER. These accounted for 75% of all recorded BW discharges and 82% of all recorded vessel departures respectively. To allow all identified source and potential destination ports to be part of the risk assessment, those which could not be included in the multivariate analysis were provided with environment matching coefficient estimates. These were based on their port type and geographic location with respect to the nearest comparable port for which the coefficient had been calculated. The calculated coefficients showed that Odessa has a relatively high environmental similarity to the majority of its regular trading ports. This was related to their regional proximity plus the relatively wide seasonal temperature and salinity ranges experienced at Odessa.

It was therefore not surprising that the most environmentally similar port was the nearby port of Illyichevsk (0.82), while 21 other Black Sea and Adriatic Sea ports had matching coefficients above 0.6. The most environmentally similar ports beyond the Mediterranean region were Nakhodka in the Sea of Japan (0.65), Boston on the north-east American seaboard (0.59), Fos sur Mer and Lavera on the French Atlantic coast (0.59) and Rotterdam (0.58). The most environmentally dissimilar ports trading with Odessa were two wet tropics Malaysian ports (Port Kelang and Kuala Baram) and the hot, high salinity Gulf port of Dubai (all below 0.3).

From the tank discharge records in the Odessa database, the project standard calculation identified 19 of the 122 source ports (15.6%) as representing the highest risk group (in terms of their BW source frequency, volume, environmental similarity and assigned risk species). The highest risk ports were led by Nakhodka followed by Bourgas in the Black Sea and Trieste in the northern Adriatic. Eight of the 19 highest risk ports were in Black Sea, nine were in the Adriatic and Eastern Mediterranean and two were beyond this region (including Nakhodka). The other was the French Atlantic port of Fos sur Mer. The vast majority of source ports in the lowest risk category were subtropical or tropical, with four exceptions comprising the ports of Bremen (Germany), Rijeka Bakar (Croatia) and Piombino and Ancone (Italy). The lowest risk source port (0.36% of total risk) was the Mauritanian port of Nouakchott on the West African coast.

Based on the current pattern of shipping trade (1999-2002), the results imply that BW from vessels arriving from the temperate to warm temperate ports of southern Europe provide the highest risk, together with the eastern Russian port of Nakhodka located on the Sea of Japan. These results are logical given Odessa's biogeographic location and current pattern of trade. The recent history of invasions to and from the NE American seaboard and the Black Sea, most via Western European stepping stones, also match these results, since they indicate that Odessa has not been the key entry or exit point for these introductions (Boston was the only NE American port to trade with Odessa in 1999-2002, but the frequency of visits and BW volume discharged was low). The picture was uncertain for Odessa being a source of introductions into the Caspian Sea, although the results show Odessa does trade with ports in and beside the Azov Sea and Don River mouth (which leads to the Volga-Don canal). The results of the 'first pass' project standard BWRA do imply that any species which establishes in a Black Sea or northern Mediterranean port can be readily spread to Odessa, Illyichivesk or other ports in their NW Black Sea bioregion via the current pattern of shipping trade.

Identification of destination ports for BW taken up at a Demonstration Site is confounded by the lack specific questions on the standard IMO BWRF, and the uncertainty of knowing if the Next Port of Call recorded on a BWRF (or in a shipping record) is where BW is actually discharged. Thus there is no reporting mechanism enabling a 'reverse BWRA' to be undertaken reliably. This posed a significant constraint on objective 4 for Odessa (Section 2), since a significant portion of general cargo ships and some bulk carriers departing the dry bulk/general cargo terminal had probably uplifted at least some BW when alongside these berths (e.g. for trimming purposes when unloading then loading cargo).

Of the 145 potential BW destination ports in the 1999-2002 database (i.e. Next Ports of Call), their location and proportional frequency are shown in Figure 20. Table 4 lists the top 62 'BW destination' ports that accounted for 90% of all reported the Next Ports of Call. This shows that the Romanian Black Sea port of Constanta stood out as the most frequent destination port, with 16% of Next Ports of Call attributed to this one port, which was a frequent destination for ships departing the container and oil terminals, and some from the dry bulk/general cargo terminal.

Constanta was followed by a group of ports in the 6-10% range, namely the nearby Ukrainian port of Ilyichevsk (9.3%), which is deeper and often visited for top-up cargos, followed by the Bulgarian Black Sea port of Bourgas (8.9%; much of this traffic comprising a shuttle export service involving three Bulgarian flagged crude oil tankers *Osam, Khan Asparukh* and *Mesta* plus a few product tankers), the roadstead off Odessa (7.0%; used for cargo top-ups and transhipments with small vessels trading from river ports in the Denpr and Yuzhny-Bug systems) and then Istanbul (6.6%). Istanbul may also not represent an important BW destination port since it was found that some bulk carriers and tankers departing Odessa had sailing instructions to proceed to Istanbul only for the purpose of entering the Turkish Straits (Bosphorus then Dardanelles) to visit a unknown Mediterranean port.

It was not clear how much BW is 'exported' from Odessa. The largest volumes of exported BW were identified to occur in the ships departing the dry bulk/general cargo terminal, and some from the container terminal. Of the top 20 Next Port of Calls which accounted for the potential BW destination of 72% of all vessel departures from Odessa, nine were located in the Black Sea, six were in the Eastern Mediterranean, four in the Eastern Mediterranean and two were in the Adriatic. The highest ranked possible destination port beyond the Mediterranean was Singapore (ranked 24th with 0.68% of all departures). None of the small general cargo ships reported they were sailing direct to a Caspian Sea port, but six of these reported staging ports in the Azov Sea (i.e. where transhipments can also be made to vessels using the Volga-Don canal).

While the three most important Next Ports of Call were Bourgas, Constanta and Illyichevsk, these may not be important BW destinations since much of the trade to these ports are ships departing fully-loaded with oil or other liquid bulk cargo, or were sailing for top-up cargos. These ports are 'down-current' from Odessa with respect to the surface water circulation in the Black Sea. Any harmful species that establishes in Odessa therefore has a chance to spread south-westward by the prevailing current regime, provided its dispersive and adult stages can tolerate the increased salinity beyond the north-west gulf of the Black Sea. In the case of the risk species currently assigned to Odessa's bioregion, several have achieved extensive populations in this direction, while some of these plus other species have spread to the Caspian Sea. As noted above, the database suggested Odessa could not be ruled out as a potentially significant source of shipping-mediated introductions to the Azov Sea, Volga-Don system and Caspian region.

Of the various BWRA objectives and tasks, reliable identification of destination ports that may receive BW from the Demonstration Site was the least successful, as it was confounded by the lack of specific questions on the IMO-standard BWRFs, and the uncertainty of knowing if the Next port of Call recorded on a BWRF is where BW is actually discharged. Thus there is presently no mechanism enabling a 'reverse BWRA' to be undertaken reliably. In the case of Odessa, many visiting vessels types do not uniformly discharge or uptake their full capacity of ballast water (especially general cargo ships, container vessels and some of the bulk carriers visiting the dry bulk/general cargo terminal). If more reliable forward-looking BWRAs are to be undertaken to identify destination ports, supplementary questions will need to be added to the present BWRF, including the names of the three last ports of call as well as the port where discharges from each partially or completely ballasted tank are predicted.

The main objectives of the BWRA Activity were successfully completed during the 14 month course of the project, with the various tasks and exploratory/demonstration software providing a foundation enabling the regional promulgation of further BW management activities by Ukraine. Project outputs included a trained in-country risk assessment team, and an operational BWRA system and *User Guide* for use as a demonstration tool in the region. A series of valuable ideas and recommendations also emerged from the process and are contained in this report. Successful completion of the BWRA project places Ukraine in a strong position to provide assistance, technical advice, guidance and encouragement to other port States in the region of the Black Sea, Caspian Sea and Eastern Mediterranean.

Table of Contents

1 Introduction and Background

The introduction of harmful aquatic organisms and pathogens to new environments via ships' ballast water (BW) and other vectors, has been identified as one of the four greatest threats to the world's oceans. The International Maritime Organization (IMO) is working to address the BW vector through a number of initiatives, including:

- adoption of the *IMO Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens* (A.868(20));
- developing a new international legal instrument (*Draft International Convention for the Control and Management of Ships' Ballast Water and Sediments*, as currently scheduled to be considered for adoption by an IMO Diplomatic Conference in February 2004); and
- providing technical assistance to developing countries through the GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast).

Core activities of the GloBallast Programme are being undertaken at Demonstration Sites in six Pilot Countries. These sites are the ports at Sepetiba (Brazil), Dalian (China), Mumbai (India), Khark Island (Iran), Odessa (Ukraine) and Saldanha Bay (South Africa). Activities carried out at the Demonstration Sites will be replicated at additional sites in each region as the programme progresses (further information at http://globallast.imo.org).

One of GloBallast's core activities (Activity 3.1) has been to trial a standardised method of BW risk assessment (BWRA) at each of the six Demonstration Sites. Risk assessment is a fundamental starting point for any country contemplating implementing a formal system to manage the transfer and introduction of harmful aquatic organisms and pathogens in ships' BW, whether under the existing IMO Ballast Water Guidelines (A.868(20)) or the forthcoming Convention.

A port State may wish to apply its BW management regime uniformly to all vessels that call at its ports, or it may wish to assess the relative risk of these vessels to its coastal marine resources and apply its regime selectively. Uniform application or the 'blanket' approach offers the advantages of simplified administration and no requirement for 'judgement calls' to be made. This approach also requires substantially less information management effort. If applied strictly, the uniform approach offers greater protection from unanticipated bio-invaders, as it does not depend on the reliability of a decision support system that may not be complete. However, the key disadvantage of the strict blanket approach are the BW management costs imposed on vessels which otherwise might not be forced to take action. It also requires a substantial vessel monitoring and crew education effort to ensure all foreign and domestic flagged ships are properly complying with the required BW management actions.

A few nations have started to develop and test systems that allow more selective application of BW management requirements, based on voyage-specific risk assessments. This 'selective' approach offers to reduce the numbers of vessels subject to BW controls and monitoring, and is amenable to nations that wish to reduce the introduction, and/or domestic spread, of 'targeted' marine species only. More rigorous measures can be justified on ships deemed to be of high risk if fewer restrictions are placed on low risk vessels.

For countries/ports that choose the selective approach, it is essential to establish an organized means of evaluating the potential risk posed by each arriving vessel, through a 'Decision Support System' (DSS). However, this approach places commensurate information technology and management burdens on the port State, and its effectiveness depends on the quality of the information and database systems that support it. A selective approach that is based on a group of targeted species may also leave the country/port vulnerable to unknown risks from non-targeted species.

Before a port State decides on whether to adopt the blanket or the selective approach, it needs to carry out some form of risk assessment for each port under consideration. Ballast water risk assessments (BWRAs) can be grouped into three categories[1]:

- **Qualitative Risk Identification**: this is the simplest approach, and is based on subjective parameters drawn from previous experience, established principals and relationships and expert opinion, resulting in simple allocations of 'low', 'medium' and 'high' risk. However it is often the case that subjective assessments tend to overestimate low probability/high consequence events and underestimate higher probability/lower consequence events (e.g. Haugom *et al*, in Leppäkoski *et al*. 2002).

- **Semi-Quantitative Ranking of Risk**: this 'middle' approach seeks to increase objectivity and minimise the need for subjective opinions by using quantitative data and ranking of proportional results wherever possible. The aim is to improve clarity of process and results, thereby avoiding the subjective risk-perception issues that can arise in qualitative approaches.

- **Quantitative Risk Assessment**: this is the most comprehensive approach which aims to achieve a full probablistic analysis of the risk of BW introductions, including measures of confidence. It requires significant collation and analysis of physico-chemical, biological and voyage-specific data, including key lifecycle and tolerance data for every pre-designated species of risk ('target species'), port environmental conditions, ship/voyage characteristics, the BW management measures applied, and input and evaluation of all uncertainties. The approach requires a high level of resourcing, computer networking and sophisticated techniques that are still being developed[1].

The purpose of GloBallast Activity 3.1 has been to conduct initial, first-pass BWRAs for each Demonstration Site. To maximise certainty while seeking cost-effectiveness and a relatively simple, widely applicable system, the middle (semi-quantitative) approach was selected.

The first step of the GloBallast method is to collate data from IMO Ballast Water Reporting Forms (BWRFs) (as contained in Resolution A.868(20); see Appendix 1) to identify the source ports from which BW is imported to the demonstration port. For periods or vessel arrivals where BWRFs were not collected or are incomplete, gap-filling data can be extracted from port shipping records.

Source port/discharge port environmental comparisons are then carried out and combined with other risk factors, including voyage duration and risk species profiles, to give a preliminary indication of overall risk posed by each source port. The results help determine the types of management responses required, while the BWRA process provides a foundation block enabling application of more sophisticated BW management DSSs by Pilot Countries.

The GloBallast approach is not the only one available but is considered to combine the best elements of the semi-quantitative method to provide useful results within the available budget (US$250,000 spread across the six pilot countries). It has also taken a 'whole-of-port' approach which compares the subject port (Demonstration Site) with all of its BW source and destination ports. The outputs include published reports, trained in-country risk assessment teams and an operational BWRA system for use as demonstration tools in each of the six main developing regions of the world, plus a platform and database to facilitate further DSS development. The GloBallast BWRA activity has therefore established an integrated database and information system to manage and display:

- ballast water data from arriving ship BWRFs and port shipping records;
- data on the demonstration port's physical and environmental conditions and aquatic resources,
- port-to-port environmental matching data,

[1] for further details see the GloBallast *BWRA User Guide.*

- risk species data, and
- ballast water discharge risk coefficients.

The results provide a knowledge base that will help the Pilot Countries and other port States to evaluate the risks currently posed by BW introductions, identify high priority areas for action, and decide whether to apply a blanket or selective BW management regime. If a selective regime is adopted, vessel and voyage-specific risk assessments can then be applied using systems such as those being developed and trialled by the Australian Quarantine & Inspection Service (AQIS Decision Support System), Det Norsk Veritas in Norway (EMBLA system) and the Cawthron Institute in New Zealand (SHIPPING EXPLORER), and/or by further development of the GloBallast system. If a uniform approach is adopted, the results help identify which routes and vessel types warrant the most vigilance in terms of BW management compliance checking and verification monitoring, including ship inspections and ballast tank sampling.

The geographical spread and broad representativeness of the six Demonstration Sites also means that the results help plug a very large gap in the existing global knowledge base. Figure 1 indicates the broad global spread of the GloBallast risk assessment activity. As a result of this activity, comprehensive data are now available on source port and destination port linkages, environmental parameters, environmental matching coefficients, risk species and relative overall risk of BW transfers for the six GloBallast Demonstration Sites and a total of 723 ports around the world. Project outcomes will therefore place governments, scientists, the shipping industry and the general public in a stronger, more enlightened position to deal with the BW problem.

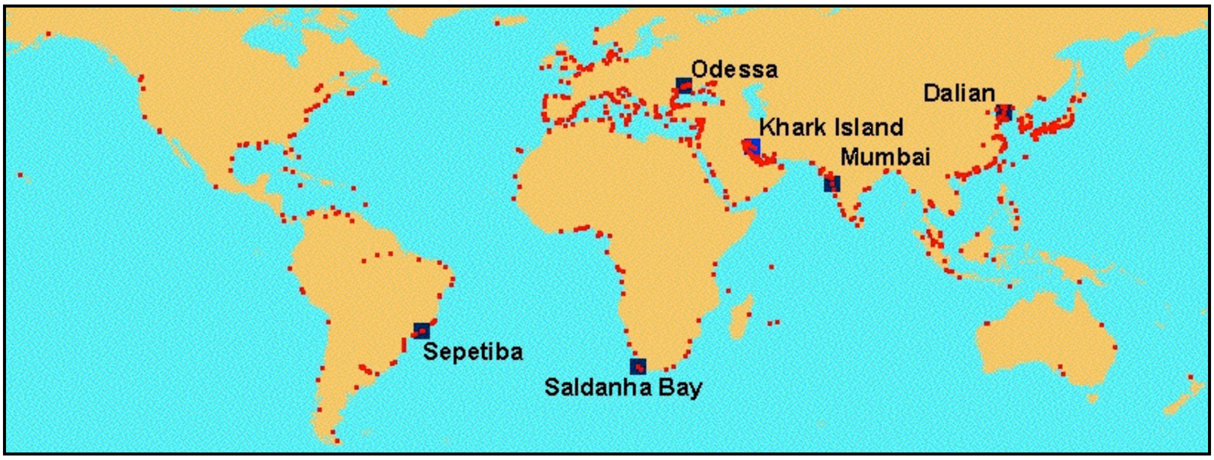

Figure 1. *Locations of the six GloBallast Demonstration Sites and their various ballast water source and destination ports.*

This report describes and presents the results of the first Ballast Water Risk Assessment (BWRA) carried out for the Port of Odessa (Ukraine) during 2002. This GloBallast Demonstrate Site is one of the busiest ports in the Black Sea (Figure 2), being equipped with liquid and dry bulk terminals, a variety of break bulk and general cargo berths, a modern container terminal, a passenger terminal and a ship repair yard.

Figure 2. *Location of Odessa and other ports in the Black Sea region*

2 Aims and Objectives

The aims and objectives of the GloBallast BWRA were set by the GloBallast Programme Coordination Unit (PCU), in accordance with Terms of Reference developed by the PCU Technical Adviser (Appendix 7).

The aims of the GloBallast BWRA for the Port of Odessa were to:

1. Assess and describe as far as possible from available data, the risk profile of invasive aquatic species being both introduced to and exported from Odessa in ships' BW, and to identify the source ports and destination ports posing the highest risk for such introductions.
2. Help determine the types of management responses that are required, and provide the foundation blocks for implementing a more sophisticated BW management system for the Port of Odessa.
3. Provide training and capacity building to in-country personnel, resulting in a fully trained risk assessment team and operational risk assessment system, for ongoing use by the Pilot Country, replication at additional ports and use as a demonstration tool in the region.

The specific objectives of the BWRA for the Port of Odessa were to:

1. Identify, describe and map on a Geographic Information System (GIS) all coastal and marine resources (biological, social/cultural and commercial) in and around the port that might be impacted by introduced marine species.
2. Characterise, describe and map (on GIS) de-ballasting and ballasting patterns in and around the port including locations, times, frequencies and volumes of BW discharges and uptakes.
3. Identify all ports/locations from which BW is imported (source ports).
4. Identify all ports/locations to which BW is exported (destination ports).
5. Establish a database at the nominated in-country agency for the efficient ongoing collection, management and analysis of the data collected at the Port of Odessa via standard IMO BWRFs.
6. Characterise as far as possible from existing data, the physical, chemical and biological environments for both Odessa and each of its source and destination ports.
7. Develop environmental similarity matrices and indices to compare the Port of Odessa with each of its source ports and destination ports, as a key basis of the risk assessment.
8. Identify as far as possible from existing data, any high-risk species present at the source ports that might pose a threat of introduction to the Port of Odessa, and any high-risk species present at this port that might be exported to a destination port.
9. Identify any information gaps that limit the ability to undertake the aims and objectives and recommend management actions to address these gaps.

3 Methods

3.1 Overview and work schedule

The BWRA for the Port of Odessa was conducted by URS Australia Pty Ltd (URS) under contract to the GloBallast PCU, in accordance with the Terms of Reference (Appendix 7). The consultants worked alongside their Pilot Country counterparts during the country visits to provide training and skills-transfer as part of the capacity building objectives of the programme. Structure and membership of the joint project team is shown in Appendix 2.

To achieve the Terms of Reference, the consultants adopted an innovative, modular approach that integrated three widely used computer software packages to provide a user-friendly tool for conducting, exploring and demonstrating semi-quantitative BWRAs. As shown in Figure 3, the key software comprised:

- Microsoft Access - for the main database;
- PRIMER 5 [*Plymouth Routines In Marine Environmental Research*] - a versatile multivariate analysis package from the United Kingdom enabling convenient multivariate analysis of the port environmental data; and
- ESRI ArcView 3.2 Geographic Information System (GIS) - to graphically display the results in a convenient, readily interpretable format using port and world maps.

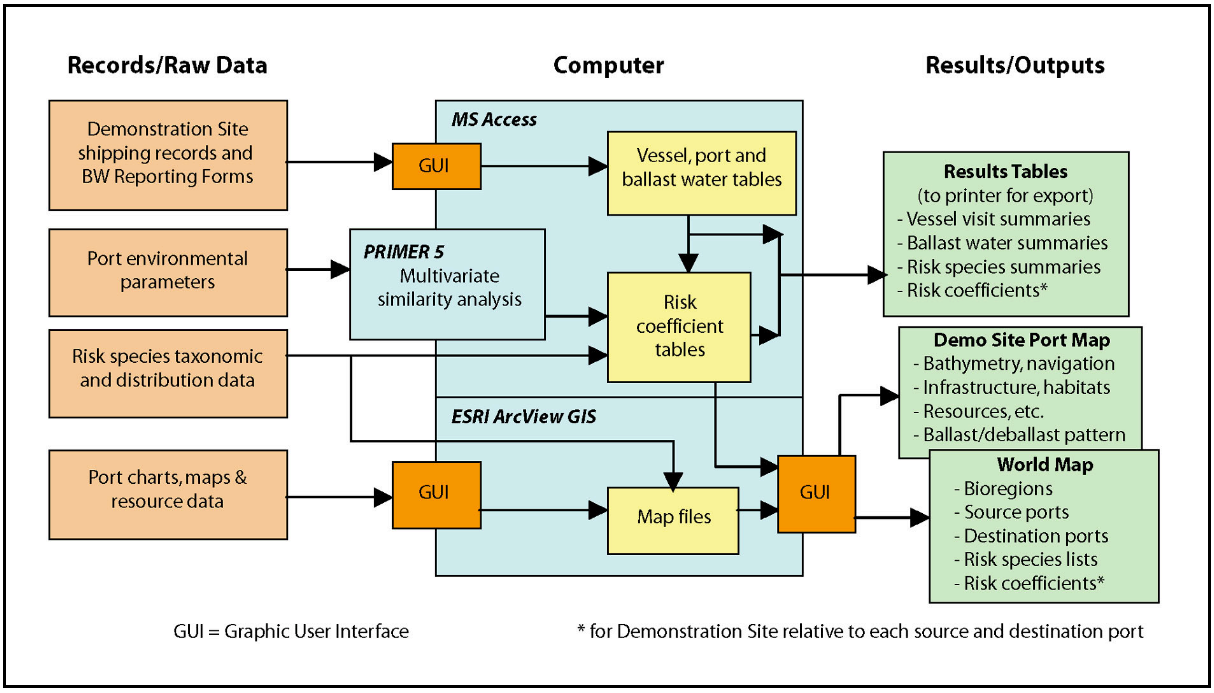

Figure 3. *Schematic of the GloBallast BWRA system*

The work schedule started with project briefing meetings with personnel from all six Demonstration Sites to arrange logistics and resource needs, during the third meeting of the GloBallast Programme's Global Task Force, held in Goa (India) on 16-18 January 2002 (Appendix 3). The majority of tasks subsequently undertaken for the Port of Odessa were completed during two in-country visits by the consultants (25 February – 1 March and 23 November – 5 December 2002), with information searches and data collation undertaken by both consultant and pilot country team members between and after these visits. A 'project wrap-up' visit was subsequently made by one of the consultants on 24-26 February 2003.

The specific tasks of the week-long first visit were to:

- Install and test the Access, ArcView and PRIMER software and the functionality of the computer system that was located in office space provided by the Commercial Sea Port of Odessa (CSPO).
- Familiarise the project team with the GloBallast BWRA method by seminar and work-shopping.
- Commence GIS guidance and developing the port map for the Demonstration Site.
- Commence training on the use of the various Graphic User Interfaces (GUI) of the Access Database for inputting and editing BW discharge data.
- Make a tour of the port facilities, obtain information on the ballasting practises of visiting ships and gain an understanding of the coastal habitats and local marine resources.
- Review available BWRFs and port shipping records to identify trading patterns, vessel types, key BW source ports and likely destination ports.
- Check available port environmental data and identify potential in-country and regional sources of same.
- Commence listing risk species and identifying potential in-country or regional sources of same.
- Identify critical information gaps and the data assembly work required before the second visit.

During the longer second visit by the consultants, the environmental and risk species data were added to the database, more vessel arrival, BW and voyage data were entered and checked, the first BWRA was undertaken, and a workshop was held to review the initial results and identify future actions.

During the third visit in February 2003, the consultants supplied the Information and Analytical Centre for Shipping Safety (in State Department of Maritime and Inland Water Transport, Ministry of Transport of Ukraine) with updated versions of the database and *BWRA User Guide* on CD-ROM, which included additional source port environment and risk species data (as obtained from the BWRA Activities conducted at the other five Demonstration Sites). The results of the February 2003 version, plus subsequent corrections to some of the vessel visit records and port-to-port environmental matching assignments, are reported here.

Throughout the schedule, the joint project team was divided into three groups to facilitate training and progress (Appendix 2). Group A was responsible for developing the port map and graphically displaying results via the GIS. All coastal and marine resources (biological, social/cultural and commercial) in and near the port that could be impacted by aquatic bio-invasions were mapped using the ArcView GIS, using specific layers to show the bathymetry, navigation aids, port infrastructure and tables of the port's de-ballasting/ballasting patterns (including frequencies and volumes of discharges and uptakes for the berth locations), as well as the marine habitat types.

Group B was responsible for managing the customised Access database supplied by the consultants, and for entering, checking and managing the BW data, as collated from the BWRFs submitted by arriving ships (and/or derived from port shipping records for periods or arrivals when BWRFs were not obtained or incomplete). This database was used to identify source and destination ports, and was designed for ongoing input and management of future BWRFs.

The requirement for arriving ships to submit to the relevant port State authority a completed form that complies with the IMO BWRF (Appendix 1) is a fundamental and essential first basic step for any port State wishing to commence a BW management programme[2].

Group C was responsible for collating the port environmental and risk species data, undertaking port-to-port environmental similarity analyses and performing the BWRA. Thirty four environmental variables were collated for the Demonstration Site and the majority of its source and destination ports[3], including sea water and air temperatures, salinities, seasonal rainfall, tidal regimes and proximity to a standardised set of intertidal and subtidal habitats. Where water temperature data or salinity data could not be found for a source or destination port, values were derived for the riverine, estuarine or coastal location of the port with respect to the temperature and salinity data ranges of its IUCN marine bioregion, plus ocean maps depicting sea surface temperature/salinity contours at quarter degree and degree scales (as obtained from CRIMP [now CSIRO Marine Research], URS and other sources; Appendix 4).

The multivariate analysis of the port environmental data was undertaken using the *PRIMER* package, with the similarity values between the Port of Odessa and its source and destination ports converted into environmental matching coefficients then added to the database. Species in or near source ports that were deemed to pose a threat if introduced to the Demonstration Site, together with species at the Demonstration Site that might be exported to a destination port, were identified from all available sources found by the project team. These sources included lists of introduced species compiled for the Aegean, Marmara, Black, Azov and Caspian Seas by IBSS (Zaitsev & Öztürk, 2001) and preliminary results from the Port Biological Baseline Surveys (PBBS; as recently completed at each Demonstration Site by another GloBallast Activity). Searches were also made of 'on-line' databases such as those under ongoing development by the Smithsonian Environmental Research Center (SERC), the Australian Centre for Research on Introduced Marine Pests (CRIMP; now CSIRO Marine Research), the Baltic Regional Marine Invasions Database and the Global Invasive Species Programme (GISP) (Appendix 5). The species taxonomic information and bioregional distributions were also added to the Access database. The combined BW discharge, environmental matching and risk species coefficients provided the basis of the semi-quantitative risk assessment.

Graphic User Interfaces (GUIs) customised by the consultants for the Access database and ArcView GIS were used to generate results tables and graphical outputs that were displayed on interactive maps of the Demonstration Site and World bioregions. The various BWRA outputs can be printed, exported to other software, or viewed interactively to enhance the user-friendliness and management utility of the system.

The methods used to attain each objective of the BWRA Activity are summarised in the following sections, with technical details of the risk assessment procedures provided in the GloBallast *BWRA User Guide*. This manual was developed by the consultants to facilitate BWRA training and demonstrations for all six GloBallast Pilot Countries. The *BWRA User Guide* comprises a separate document that accompanies this report, and is available from the GloBallast PCU (http://globallast.imo.org).

---

2 Several port States (e.g. Australia) and some of the Demonstration Sites, including Odessa, have produced their own BWRFs, the latter using translated formats to permit improved BWRF understanding and completion by local shipping. Such BWRFs need to include all questions of the IMO standard form.

3 The complete set of source and destination ports identified for the six Demonstration Sites (723) remained unknown until the end of the BWRF/port record data collation, database entry and checking phases (i.e. end of the second round of in-country visits; 22 December 2002). A gap-filling effort was made by the consultants to obtain the environmental parameters during January 2003, but this had to focus on the most frequently recorded of these ports, since there was insufficient time or resources to order charts and search for the environmental data for all of them (the majority of which were associated with few or only single vessel arrivals). For these ports, their environmental matching values were provided by a comparison method described in Section 4.6.

3.2 Resource mapping of the demonstration port

The port resources were mapped using ArcView GIS to display the bathymetric, navigational and infrastructure features, including habitats and social-cultural features. The scope of the Odessa port map includes the offshore coastal waters south of the port, the port's approaches and anchorages, and the various terminals and berths located behind its breakwaters. Lower resolution portions of the port map show the Black Sea and the deltas of the four major river systems that enter the Black Sea after traversing the south-west region of Ukraine (i.e. from the Romanian border to the Crimean Peninsula; Figure 2). These sections of the port map were obtained by scanning and geographically correcting regional maps provided by the Institute of Biology of the Southern Seas (IBSS) and CSPO.

There were no vector-based electronic nautical charts available for the Odessa region. Group A members therefore generated the baseline layer containing the coastline, bathymetry and navigation data from geo-referenced high resolution scan images of existing nautical charts provided by CSPO. This layer contains details of the port infrastructure, the approach channel and anchorages. Point and pattern symbols for the navigational features were based on the international IHO/IALA system for nautical charts.

Infrastructure and social cultural information was taken from the Odessa port chart and an urban map, while some existing digital data showing habitat types was obtained from IBSS in Mapinfo format and converted to ArcView to help construct the habitat layer. This layer also contained subtidal habitat information provided by Group C members from review of the PBBS field results and results of previous marine benthic surveys undertaken by IBSS. For clarity and convenience of data management and display, each 'theme' of information was added as a separate layer that followed the scheme shown in Figure 4.

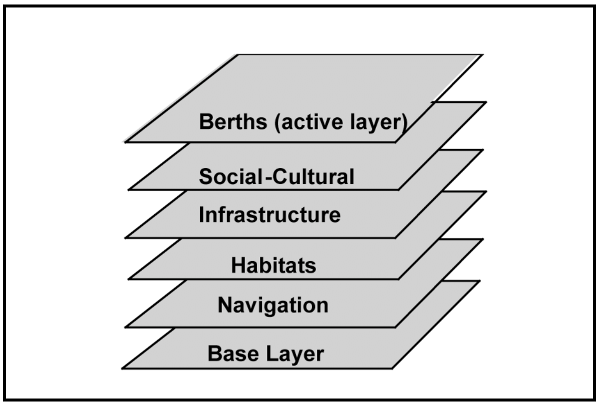

Figure 4. *Thematic layers used for the Port Map GIS*

The protocol for the five main layers are described in the *BWRA User Guide* and summarised below:

Base Layer: The base layer includes important planimetric features such as depth contours, jetties, important channels and other permanent or at least semi-permanent 'reference' features that are unlikely to change or move. The key features of the base layer for the Port of Odessa comprised:

- Coastlines of the mainland and various islands within Odessa Bay (as depicted by the high tide mark on the nautical charts).
- The low tide mark (i.e. the 0 metre bathymetric contour of hydrographic charts).
- 5 metre isobath (often the first continuous contour below the low tide mark).
- 10 metre, 20 metre and 30 metre isobaths.
- Edges of the main shipping channels (often blue or purple lines showing the boundary of depths maintained by port dredging).

The colour scheme of the base layer follows that of standard nautical charts to maintain the familiar land/sea depth effect.

Navigational Layer: The standard navigational symbols of the IHO/IALA system were followed as closely as possible. ArcView's symbol libraries do not contain these international navigation symbols, and convenient third-party symbology could not be found despite extensive searches of public domain web resources. Closest-match point and pattern symbols were therefore developed for this purpose, using the UK Hydrographic Office Chart No. 5011 (= IHO INT 1) as the source.

Habitat Layer: This layer displays the coastal habitat information compiled by Group C in a standardised, logical colour scheme to facilitate recognition of the main intertidal and subtidal habitat types in and near the port. Delineation of some of the boundaries between natural and artificial intertidal habitats were based on notes and map annotations of harbour and shoreline features made by BWRA team members during two tours of the port area by launch and inspections along the coast as far as Yuzhny (~35 km south of Odessa) by vehicle. Beyond the harbour walls, shorelines in the Odessa region are predominantly narrow stony beaches backed eroding cliffs, with sand dunes and beaches occurring both to the east and more than 10 km to the south of Odessa.

Infrastructure Layer: This layer shows the urban and developed land surrounding the port, including roads and railway lines.

Social-Cultural Layer: This layer facilitates the addition of significant social-cultural features at the port. There are no commercial fish processing facilities, fishing harbour or aquaculture operations in the port, and recreational fishing from wharfs, breakwaters or privates boats is prohibited in accordance with the 1997 Odessa Sea Port Obligatory Regulations (as amended 2000).

Berth Layer: An 'active' berth layer was added to show the principal berthing and anchorage areas at the Port of Odessa. Their names and numbering system were supplied by CSPO members of Group B. The same nomenclature was used for the berthing information stored in the Access database, to allow display of statistical summaries of the BW source and discharge data on the correct locations of the GIS port map (the GloBallast *BWRA User Guide* shows how the database-GIS link is established).

3.3 De-ballasting/ballasting patterns

The deballasting/ballasting patterns at Odessa were discussed with CSPO personnel during the first tour of the port's terminals, berthing areas and shipyards, and at a subsequent meeting with the Harbour Master on 22 February 2002. During this meeting the various pilotage rules, draft requirements and State environmental regulations pertaining to BW discharges and uptake in and near the port were canvassed.

A copy of a paper record listing the total deballasted volume from each vessel which made a licensed BW discharge at the port from 19 November 1999 to 31 December 2000 was obtained from CSPO during the first visit for data entry and evaluation. Further information was obtained from the IMO-style BWRFs (translated into Russian) that CSPO had phased in during early 2001, while access to the port's general shipping records (*Harbour Master Log)* provided a source of gap-filling information for last and next ports of call and vessel identification details[4]. BWRF submission rates were high owing to Order No 62 of the State Department of Maritime and Inland Water Transport (11 March 2001) requiring Harbour Masters to collect IMO BWRFs, plus a mandatory licensing requirement for BW discharges, as managed under the environmental regulations of Ukraine's *State Inspection for Protection of the Black Sea* (SIPBS). Records held at the Odessa office of SIPBS contained the same vessel visit information as in the port shipping records, plus the results of tested BW (sampled mostly from the tanks of oil tankers and other vessels suspected to contain oily BW).

4 These records list vessel name, IMO number, GT, arrival/departure dates, berth, last and next ports of call, and cargo details.

The ballasting/deballasting picture for Odessa was therefore assembled from CSPO's 1999-2000 paper record and the Russian-translated BWRFs collected between January 2001 and July 2002, plus record cross-checking and gap-filling using the Harbour Master's port shipping records[5] (both for the paper record and where incomplete or doubtful BWRF entries were found during database entry).

The Port of Odessa has dedicated liquid and dry bulk import/export terminals, rail and road-served general cargo wharfs, a ship repair yard and a modern container terminal. The multi-purpose wharfs handle a wide variety of break-bulk, palleted and dry bulk cargos. Determining where and which arriving ships were discharging or uplifting BW was therefore based on their BWRFs, identifying the vessel type and berthing location, plus cross-checks of cargo loading/unloading details in the Harbour Master's records.

3.4 Identification of source ports

To provide confidence as to which ports were the predominant sources of BW discharged at Odessa, the ship name, arrival date, source port and volume of discharged BW listed in CSPO's 1999-2000 paper record were first entered into a customised Excel spreadsheet supplied to Group B members by the consultants. Vessel ID information and port location details required by the database were then added to this spreadsheet in a format enabling convenient copy/pasting into the relational Visit, Vessel, Tank and Port tables of the Access database. Before any new port was added to the database, its correct port name and country spelling, unique UN Port Code number, location coordinates and bioregion were checked using Lloyds' *Fairplay World Ports Guide* and the world bioregion list in the Access database (full details on entering the required port data are given in the GloBallast *BWRA User Guide*).

BWRFs collected between January 2001 and July 2002 by CSPO's Ecology Department officers were entered to the database, an operation started by Group B members during the consultants first visit and completed during their second visit. Collection of the Russian-translated BWRFs became virtually mandatory for any ship deemed likely to discharge significant quantities of BW after entering the Port of Odessa in March 2001, so there had been a high return rate of these forms from this month forward. These BWRFs were initially sorted by source port, country and date, translated to English, entered into the database, then gap-filled and double-checked as and where necessary.

For vessels arriving before BWRFs were regularly collected, or which submitted incomplete forms and/or doubtful data, checking and gap-filling details were obtained by cross-referencing with CSPO's paper record and the Harbour Master's port shipping records. However the latter showed only the *Last Port of Call*, which may not be the BW source. To identify which last ports of call were probable BW sources, cross-checks were made of source ports and last ports of call reported in other BWRFs by the same or similar types of vessel. The Lloyds *Fairplay Port Guide* and *Lloyds Ship Register*[6] were also used to confirm source port trade and the vessel's IMO identification number, vessel type and DWT of arriving ships respectively.

Many gaps or doubtful values in the BWRFs and CSPO's paper record could therefore be filled by checking, for any arrival, the vessel name, type and DWT, its previous visit history, last port/s of call and apparent charter/liner trade, and by using the Excel spreadsheet supplied by the consultants to estimate the amount BW discharged or taken up[7] (Figure 5). This was less easy for vessels arriving at the general cargo and container berths, for which some incomplete BWRFs could not be gap-filled to

[5] The *Harbour Master Log* was used in preference to SIPBS's BW testing and licensing records owing to the former's convenient location at the port offices, its port-oriented filing order and the lack of access and confidentiality issues with respect to SIPBS evidence used for past and potential court rulings.

[6] A CD-ROM version of the 2001 *Lloyds Ship Register* was supplied to each Demonstration Site by PCU. These are much faster to use than the large 'directory style' hard-copy volumes.

[7] This spreadsheet contained coefficients of the BW taken up or discharged (as percentages of DWT for each vessel type when loading and/or discharging cargo), based on BW capacity and discharge data obtained from other studies, BWRFs and *Lloyds Ship Register*.

the level allowing inclusion by the automatic calculation of BW tank discharge frequency and volume for every identified source port.

Most BWRFs required careful checking for completeness and accuracy. In the case of unusual (or missing) BW discharge values, these were checked using the Excel spreadsheet to determine likely volumes based on vessel type, DWT, last port/source port and loading record.

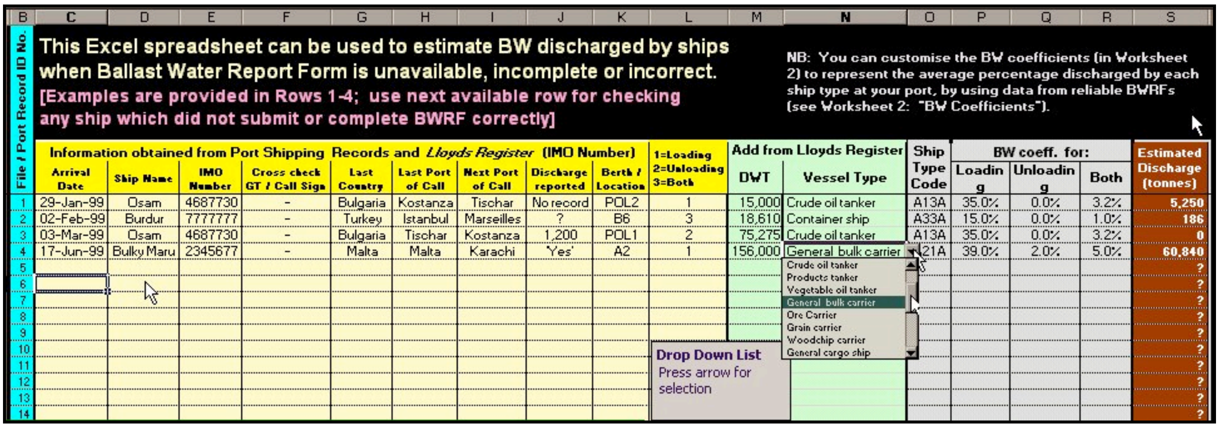

Figure 5. *Working page of the Excel spreadsheet used to estimate BW discharges*

The database filling, checking and gap-filling exercise was undertaken by Group B members before and during the consultants' second visit, with the database of 2297 vessel visits compiled by:

- entering visit details to the Excel spreadsheet from the CSPO paper record and Harbour Master's shipping records for the pre-BWRF and BWRF phase-in periods (19 November 1999 - 28 February 2001), then using the *Fairplay Port Guide* and *Lloyds Ship Register* to add or correct the port details, vessel names, IMO numbers, vessel types, DWTs and BW volumes; and
- entering the BWRFs (1 March 2001 – 4 July 2002) then cross-checking and gap-filling incomplete, unusual or missing forms using the Harbour Master shipping records, the *Lloyds Ship Register*, *Fairplay Port Guide* and/or Excel spreadsheet.

3.5 Identification of destination ports

Since 'prevention is better than cure', it is usually most effective to address environmental problems as close to their source as possible. In the case of ballast-mediated aquatic bio-invasions, actions helping prevent ships taking up harmful organisms from ballasting areas may be more effective than trying to treat the organisms once they are inside the tanks, or trying to manage the problem at the discharge port. To date, however, the majority of actions addressing ballast-mediated introductions have been driven and undertaken by ports and port States that receive BW, with little activity occurring at the locations of BW uptake. The GloBallast programme has therefore been attempting to shift some of the focus from shipboard/point-of-discharge measures towards reducing the uptake of organisms in the first place**.**

Knowing the destinations where departing vessels will discharge BW is an important step in helping port States to reduce the spread of unwanted and potentially harmful species (either introduced or native to their own ports) to their trading partners. It is also critical for preventing unwanted species translocations between a State's domestic ports and/or its neighbouring foreign ports. Determining the destinations of BW exported from the Demonstration Site was therefore an objective of the GloBallast BWRA (Section 2).

Both the BWRFs and port shipping records for Odessa list the *Next Port of Call* of all departing vessels, and these were added to the database for analysis. However the next port of call may not be where BW carried by a ship is discharged, either fully or partly. For example, it may be a nearby port where some minor cargo is unloaded/loaded, a strategic destination port that was received in the initial sailing instructions (e.g. Istanbul, Suez, Gibraltar), and/or a convenient 'hub' port where ships anchor and wait for new sailing instructions.

To overcome this problem, a supplementary question needs to be added to the present IMO BWRF, i.e. requesting the name of the port where discharge from each ballast tank is predicted. These ports can be predicted by ships engaged on a regular liner service (e.g. many container ships, vehicle carriers, Ro-Ro ships and LNG carriers, as well as some crude oil tankers, products tankers and large bulk carriers). However for other ship types (and occasionally the former) ship officers cannot reliably anticipate where BW discharges will be necessary. For example, for general cargo ships, bulk carriers and tankers engaged in spot charter work (or when completing a charter period), these vessels may often depart in ballast having a received a general sailing order to proceed towards a strategic location until further instructions.

The next ports of call were therefore added to the vessel visit data and examined, so that the Pilot Country team could gain experience in the problem of identifying ballast water destinations. Adding the next port of call also improves the trading history for each vessel, and these can be useful when trouble-shooting missing or incorrect BWRF data. As with the source ports, any new next port of call added to the database was provided with its country name, UN Port Code, world bioregion and location coordinates to enable its frequency of use by departing vessels to be displayed on the GIS world map (port input details are in the GloBallast *BWRA User Guide*).

3.6 BWRF database

The Access database developed by the consultants manages all items on the IMO standard BWRF. Entry, editing and management of the BWRF records are undertaken using a series of GUIs, as described in Section 2 of the *BWRA User Guide*. The three 'tab' pages of the GUI used for general BWRF data and the individual ballast tank inputs are shown in Figure 6.

Items not listed on the BWRF but required by the database to run the risk analysis and display the results on the GIS include the geographic coordinates, bioregion and UN code (a unique five letter identifier) of every source and destination port, plus the berthing location and DWT of every arrival at the Demonstration Site.

Many berthing locations had to be identified from the port shipping records because the BWRA objectives include identifying the locations *within* a Demonstration Site where deballasting/ballasting occurs (Section 2). After the consultants first in-country visit (February 2002), CPSO Ecology Department officers ensured the berthing location was annotated to submitted BWRFs to help reduce the data-entry workload. Another item requiring frequent look-up was the vessel's deadweight tonnage (DWT) since the BWRF requests only the gross tonnage (GT). As noted in Section 3.4, adding the DWT (present in the *Lloyds Ship Register*) enables convenient checks of reported volumes and gap-filling of missing values (see below).

Not all of the BWRF question fields need to be completed by a ship's officer to provide a visit record that can be saved to the database and later included in the risk analysis. A basic visit record can be established if three key items are entered. These are outlined in red on the input GUIs (Figure 6) and are:

- Vessel identification - a unique 7 digit IMO number that remains the same for the life of the ship, irrespective of any name changes;.
- Arrival date.
- A ballast tank code (which appears on the 'Add Tank' sheet and provides an 'All Tanks' option for BWRFs that were submitted without individual tank details).

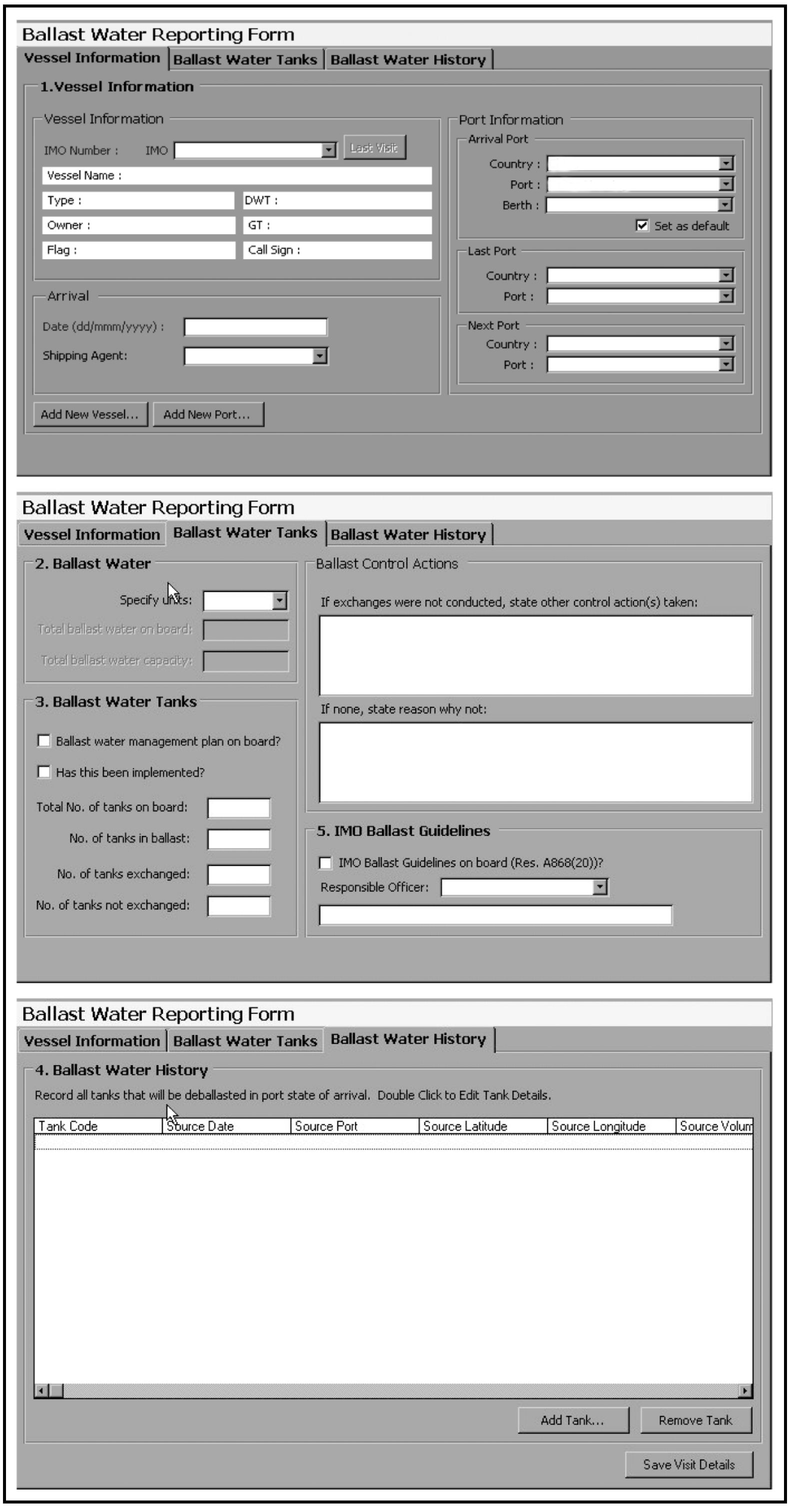

Figure 6. *The three tabs of the GUI used for entering the BWRF data*

Without these items the database cannot save a visit / tank record or any other associated information. Whether or not a saved record is included by the database for its risk analysis calculations depends on which other BWRF fields were completed or gap-filled. Key items are the source port, source date, volume and discharge date for each (or all) ballast tanks discharged, and the berthing location. As described in Sections 3.4 and 3.5, important BWRF information that is missing or incorrect can usually be substituted or corrected by cross-checking with port shipping records, the *Lloyd's Ship Register* and a comprehensive port directory such as the *Fairplay* guide. However this is time-consuming, and it is far more efficient and reliable for port officers to ensure the BWRF has been filled in correctly and completely at the time of submission (Section 4.10).

The database contains reference tables which hold the checked details of every vessel and port previously added. A new visit record is therefore made by entering the arrival date then using a series of drop-down lists to select the vessel, source port, last port, next port, destination port and tank details (Figure 6). This avoids the need to re-enter the same information over and over again, as well as the risk of generating false, ‘replicate’ vessel, port or tank names due to spelling mistakes on the BWRF.

Spelling mistakes on BWRFs are common. All data-entry and database managers therefore need to understand how to avoid transcribing such errors by carefully checking all names and ID numbers using the database drop-down lists and, where necessary, by referring to a reliable ship registry or port directory when entering the details of a new vessel or port respectively.

The most easily-trained and efficient database operators are those with previous port and maritime experience since they (a) bring knowledge of the local shipping trade, (b) are familiar with the problems of checking and searching for vessel names (e.g. *Tokyo Maru 2*, *Tokyo Maru II*, *Tokyo Maru No. 11* etc), and (c) are aware that the official name of many ports in Europe, Africa and South America may be quite different from the English name (e.g. Vlissingen versus Flushing).

3.7 Environmental parameters

During the briefing meetings in January 2002, the consultants provided a preliminary list of environmental parameters that would be used to generate the environmental matching coefficients between the Demonstration Sites and their main BW source ports and destination ports (Appendix 3). The provisional list was based on review of previous port-to-port environmental analyses undertaken for twelve trading ports in northeast Australia (Hilliard *et al.* 1997b). The final list of 34 parameters used for the six Pilot Countries (Table 1) was selected in February 2002, during a joint review of the provisional list by the consultants and scientists of IBSS in Odessa who were members of Group C. IBSS recommended that distance categories from the berthing area/s to the nearest rocky artificial wall, smooth artificial wall and wooden artificial substrates should be added to the list of parameters, since these surfaces offer different types of hard port habitat which become colonised by different types of native and introduced biota. Group C biologists at the other the Demonstration Sites were informed of the IBSS recommendation, which was accepted unanimously.

The 34 parameters were steadily collated during course of BWRA activities for all Demonstration Sites. They were taken or derived from data and information culled from a wide range of government, port and scientific publications, internet web sites, port survey reports and sampling records, SST and salinity charts, climate databases, atlases, national tide-tables, nautical charts, coastal sensitivity and oil spill habitat maps, oil spill contingency plans, aerial photographs, national habitat databases and local expert advice (Appendix 4). The most difficult to find were reliable water temperature and salinity data, particularly for identifying the averages, maxima and minima for ports in or near estuaries (Section 3.12).

A preliminary list of frequently recorded BW source ports and destination ports for the Port of Odessa was made at the end of the first in-country visit in April 2002 (the complete list did not become available until near the end of the second in-country visit; Section 3.1). It was agreed that the environmental parameters for these ports should be sought between the first and second consultants’ visits, with the Odessa Group C members focussing on important ports in the Black Sea and the consultants focussing on more distant ports in western Europe, the Middle East, Asia etc. To facilitate this task the consultants provided a customised Excel spreadsheet for collating the environmental data, which included guidance and reminder notes plus a format enabling direct export to PRIMER (Section 3.8).

Near the end of the second in-country visit, sufficient port environmental data had been collated to generate environmental matching coefficients for approximately 40% of all ports identified as trading with the Port of Odessa, with estimates provided for ports where unobtained/incomplete data prevented their inclusion in the multivariate similarity analysis (Section 4.6). The percentage of ports with calculated environmental coefficients was subsequently expanded by a gap-filling exercise undertaken by the consultants between 22 December 2002 and 31 January 2003. These were added to the updated BWRA provided at the third meeting in February 2003 (Section 3.1) and reported here.

Table 1. *Port environmental parameters used by the Environmental Similarity Analysis*

	Name	Variable Type
1.	Port type[8]	Categorical (1-6)
2.	Mean water temperature during warmest season (°C)	Scalable
3.	Maximum water temperature at warmest time of year (°C)	"
4.	Mean water temperature during coolest season (°C)	"
5.	Minimum water temperature at coolest time of year (°C)	"
6.	Mean day-time air temperature recorded in warmest season (°C)	"
7.	Maximum day-time air temperature recorded in warmest season (°C)	"
8.	Mean night-time air temperature recorded in coolest season(°C)	"
9.	Minimum night-time air temperature recorded in coolest season (°C)	"
10.	Mean water salinity during wettest period of the year (ppt)	"
11.	Lowest water salinity at wettest time of the year (ppt)	"
12.	Mean water salinity during driest period of year (ppt).	"
13.	Maximum water salinity at driest time of year (ppt).	"
14.	Mean spring tidal range (metres)	"
15.	Mean neap tidal Range (metres)	"
16.	Total rainfall during driest 6 months (millimetres)	"
17.	Total rainfall during wettest 6 months (millimetres)	"
18.	Fewest months accounting for 75% of total annual rainfall	Integer
19.	Distance to nearest river mouth (kilometres; negative value if upstream)	Scalable
20.	Catchment size of nearest river with significant flow (square kilometres)	"
Logarithmic distance categories (0-5): From the closest BW discharge location to nearest:		
21.	Smooth artificial wall	Categorical
22.	Rocky artificial wall	"
23.	Wooden pilings	"
24.	High tide salt marsh/lagoon, saline flats or sabkah	"
25.	Sand beach	"
26.	Shingle, stony or cobble beach	"
27.	Low tide mud flat	"
28.	Mangrove fringe/mangrove forest	"
29.	Natural rocky shore or cliff	"
30.	Subtidal firm sandy sediments	"
31.	Subtidal soft muddy sediments	"
32.	Seagrass meadow[9]	"
33.	Rocky reef or pavement	"
34.	Coral reef (with carbonate framework)	"

3.8 Environmental similarity analysis

The more a BW receival port is environmentally similar to a BW source port, the greater the chance that organisms discharged with the imported BW can tolerate their new environment and maintain sufficient numbers to grow, reproduce and develop a viable population. Comparing port-to-port environmental similarities therefore provides a relative measure of the risk of organism survival, establishment and potential spread. This is the basis of the 'environmental matching' method, and it

[8] Offshore terminal or mooring / Natural bay / Breakwater harbour / Tidal creek / Estuary / River port.
[9] Kelp forest/macroalgae bank was not included but should be considered for future analysis.

facilitates estimating the risk of BW introductions when the range and types of potentially harmful species that could be introduced from a particular source port or its bioregion are poorly known.

A limitation of the environmental matching approach is that several harmful species appear capable of tolerating relatively wide temperature and salinity regimes[10]. As discussed, other risk factors include the frequency of ship visits/BW discharges, the volume of BW discharged, voyage times and ballast tank size and any management measures applied during the voyage. While environmental matching alone does not provide a complete measure of risk, an analysis of 'real world' invasions indicates that if any one factor is to be used alone, environmental matching is probably the best single indicator of risk.

Classic examples include the two-way transfer and relatively rapid spread of harmful and other unwanted species between the Ponto-Caspian and North American watersheds (some via stepping stones in western Europe), and *northern* Australian ports that have extremely high risk factors in terms of frequency and volumes of BW discharges (the very large bulk export ports of Port Headland, Dampier and Hay Point and smaller bulk export ports like Weipa and Abbot Point), but which have not experienced any significant harmful invasions (due to a low environmental matching with their source ports). Conversely, in southern Australia and in particular Tasmania, ports which have relatively low risk factors in terms of frequency and volumes of BW discharges, have been the entry points of the most harmful aquatic bio-invasions (due to a high environmental matching with their source ports).

The environmental distances between the Port of Odessa and its source and destination ports were determined using a multivariate method in the PRIMER package. Of the various distance measures available in PRIMER, the normalised Euclidean distance is the most appropriate. Normalisation of the various input parameters removes the problem of scale differences, and the method can manage a mix of scalable, integer and even categorical values, provided the latter reflect a logical sequence of intensity or distance/location steps. Individual variables cannot be weighted but the predominance of temperature variables (8) and salinity/salinity-related parameters (also 8; see Table 1) ensured these exerted a strong influence on the results. Air temperature extrema, rainfall and tidal parameters were included owing to their influence on the survivorship of intertidal and shallow subtidal organisms[11]. The similarity values produced by PRIMER were examined using its clustering and ordination modules, then exported back to the Excel file for conversion into environmental matching coefficients before insertion into the database[12].

To provide consistent and comparable results, the similarity analysis was conducted on a wide geographical range of ports; i.e. from cold water ports in high latitude areas to warm water ports in tropical regions, as well as from up-river terminals to those located in relatively exposed offshore waters. This avoids the possibility of generating spurious patterns among a set of ports located in neighbouring and/or relatively similar regions. Collating the environmental parameters for the frequent source and destination ports of all six Demonstration Sites into a single Excel spreadsheet achieved this, as well as permitting direct comparisons between the results from these sites[13].

---

10 For example, the Asian date mussel (*Musculista senhousia*) has been reported from Vladivostok to Singapore.

11 While ecosystem disturbance, pollution, eutrophication and other impacts on habitats and water quality can increase the 'invasibility' of port environments (particularly for *r*-selected species), this information was not collated for the environmental similarity analysis owing to the problem of obtaining reliable measures of their spatial extent and temporal nature at each port. This topic is discussed further in Sections 4.8 and 5.

12 As described in the *BWRA User Guide*, a simple proportional conversion of the similarity values was made so that each matching coefficient lay between 1 (a perfect environmental match) and 0.01 (least matching), since it is unsafe to assume a port environment can be totally hostile no matter how distant.

13 The total number of ports with a complete set of environmental parameters obtained by the end of the data collation phase was 357. These were provided to all Demonstration Sites during the third consultant's visit in February-March 2003 and used for this report.

The Excel file used for collating the port environmental data also contains linked spreadsheets used for their export to PRIMER, as well as for re-importing the results and converting them into environmental matching coefficients. In fact the database can import any type of environment matching value obtained by any method, provided the values are placed in an Excel spreadsheet in the format expected by the database's import feature. Details on the treatment of the environmental variables and the production, checking, conversion and import of the similarity measures are given in the *BWRA User Guide.*

3.9 Risk species

One of the BWRA objectives was to identify 'high-risk' species that may be transferred to and/or from the Demonstration Sites (Section 2). The Access database was therefore provided with tables for storing the names, distribution and other information on risk species. For the purposes of the BWRA and its 'first-pass' risk assessment, a risk species was considered to be any introduced, cryptogenic or native species that might pose a threat if transferred from a source port to a Demonstration Site. The taxonomic details, bioregion distribution, native/introduced status and level of threat assigned to a species are also stored in the database and can be displayed for review, edit and update.

The database manages the bioregional locations and status of each entered species using the same bioregions displayed on the GIS world map (Figures 7, 8). This map is used as a backdrop for displaying the source and destination ports and associated BWRA results, and was compiled from a bioregion map provided by CRIMP (now CSIRO Marine Research). The boundaries of some bioregions were subsequently modified according to advice provided by Group C marine scientists in five of the Demonstration Sites, including Odessa. The modifications included adding new bioregions for large river systems to accommodate some important river ports that trade with one or more of the Demonstration Sites. In the case of Odessa, the Black Sea bioregion MED-IX was divided into two regions (MED-IXA and MED-IXB) owing to the distinctive salinity boundary that separates the shallow north-west gulf of the Black Sea from the central basin (Figure 7), and four new bioregions were added for the following river systems which contain ports and barge terminals that trade to Odessa and other Black Sea ports:

MED-IXA-RDA	=	Danube River system and Delta
MED-IXA-RDT	=	Dniestr River system
MED-IXA-RYB	=	Yuzhny-Bug River system
MED-IXA-RDP	=	Dnepr River system

The world map displays 204 discrete bioregions which are coded in similar fashion as those in the IUCN scheme of marine bioregions from which they were derived (Figure 8; Kelleher *et al*. 1995; see Appendix 3 of the GloBallast *BWRA User Guide*). Bioregions serve multiple purposes and are required for several reasons. For example, many marine regions of the world remain poorly surveyed and have a limited marine taxonomy literature. This causes a patchy and essentially artificial distribution of recorded marine species distributions. Few marine species surveys have been undertaken in port environments and there are very few bioregions which contain more than one port that has undertaken a PBBS.

Bioregions represent environmentally similar geographic areas. Thus if a species is found established in one part of a bioregion, there is a good chance it can spread via natural or human-mediated processes to other sites in the same bioregion. A conservative approach was therefore adopted for the GloBallast BWRA, whereby a risk species, if recorded in at least one location of a bioregion, is assumed potentially present at all source ports within the same bioregion. This type of approach will remain necessary until a lot more PBBSs are conducted and published. Because taxonomic analyses of the PBBS samples of the Demonstration Sites had not been completed by the consultants second visits, the reverse stance was adopted for these ports (i.e. it was assumed they did *not* contain any risk species recorded at other location/s in their bioregion).

The corresponding set of bioregions stored in the database has particular sets of risk species assigned to them. The species and associated data added to the database over the course of the Activity were collated from a range of sources. These included the book of introduced species in the Aegean, Marmara, Black Azov and Caspian Seas (AMBACS) published by Group C member Professor Yuvenaly Zaitsev (Zaitsev & Öztürk, 2001) and a preliminary list of organisms found by the recent GloBallast PBBS of Odessa (which became available during the consultants' second visit).

Other sources used for developing the risk species database are listed in Appendix 5. These comprised a range of literature plus international and regional internet databases, including those being developed by the Smithsonian Environmental Research Center's (SERC) National Estuarine & Marine Invasive Species Information System (NEMISIS), CSIRO's National Introduced Marine Pests Information System (NIMPIS), the Global Invasive Species Programme's (GISP) Global Invasive Species Database, and the Baltic, Nordic and Gulf of Mexico web sites. The database used for the 'first-pass' risk assessments and provided to the Demonstration Sites during the consultants third visit contained 421 species but these do not represent a complete or definitive global list. Thus the database tables and their associated Excel reference file represent a working source and convenient utility of risk species information that can be readily updated and improved.

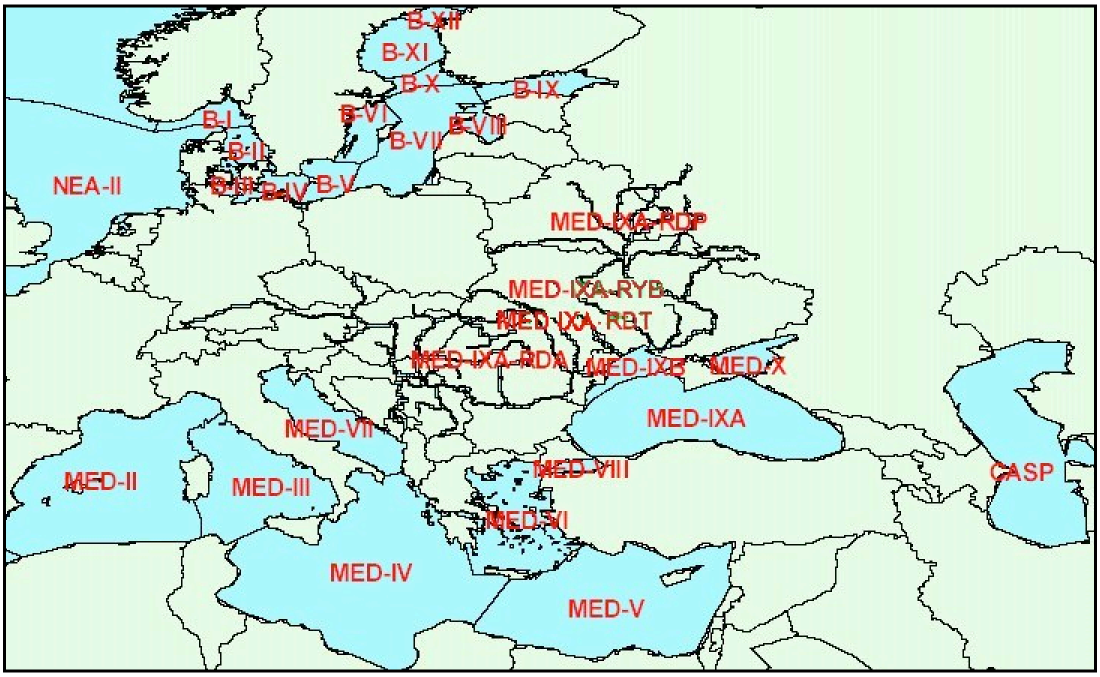

Figure 7. *Part of the GIS world map of marine bioregions, showing the code names of those in the Black Sea region*

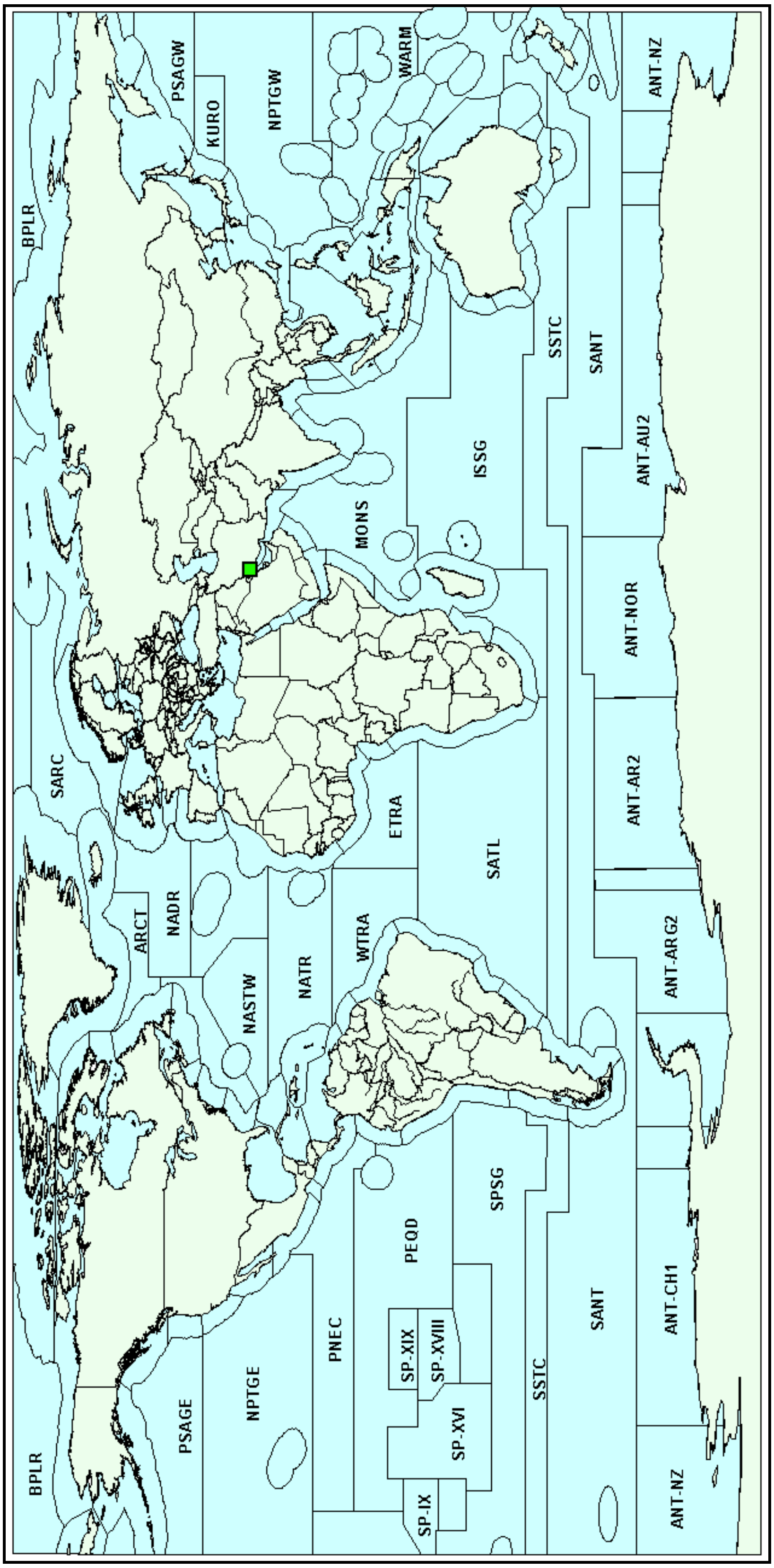

Figure 8. *Complete GIS world map showing the marine bioregions [to improve clarity, not all bioregion codes are shown in this example]*

To provide a measure of the risk species threat posed by each source port, the database analyses the status of each species assigned to each bioregion and generates a set of coefficients that are added to the project-standard calculation of relative overall risk (Section 3.10). The following description is summarised from Section 6 of the GloBallast *BWRA User Guide*, which describes how the species data are managed and used by the BWRA system.

The database allows each species to be assigned to one of three levels of threat, with each level weighted in log rhythmic fashion as follows:

- **Lowest threat level:** This is assigned to species with no special status other than their reported or strongly suspected introduction by BW and/or hull fouling[14] in at least one bioregion (i.e. population/s with demonstrated genetic ability to survive transfer and establish in regions beyond their native range). A fixed weighting (1) is applied to each of these species when present in bioregions outside their native range. This was also the default level assigned to any new species when first added to the database.
- **Intermediate threat level:** This level is assigned to any species suspected to be a harmful species or invasive pest. Risk species assigned to this level receive a default weighting value of 3 in both their native and introduced bioregions.
- **Highest threat level:** This level is assigned to known harmful invasive species, as reported in institutional or government lists of aquatic nuisance species and pests, and/or in peer-reviewed scientific journals. The default weighting value applied to these species is 10.

The database allows users to change the threat status level assigned to each species, as well as the size of the second and third level default weighting values. Another risk species weighting option was also provided in the database, which could be used to proportionally increase the weight of all source port threat coefficients by increasing its default value of 1. The default values of the four weightings (1, 3, 10 and 1) provided the 'project standard' result to permit unbiased comparisons between the 'first-pass' BWRA results for each Demonstration Site.

The database calculated the coefficient of 'risk species threat' posed by each source port, with each port value representing a proportion of the total risk species threat. The latter was the sum of all weighted risk species assigned to the bioregion of all source ports that export BW to the Demonstration Site. Species assigned to more than one bioregion are summed only once, and the algorhythm automatically discounted any species that was native in the Demonstration Site's bioregion. It included any introduced species assigned to the bioregion of the Demonstration Site since, as discussed above, the Demonstration Site was assumed to be free of risk species. This was the default position of the project-standard BWRA[15].

The risk species coefficient for each source port is therefore calculated by firstly summing the number of non-indigenous species (NIS) in that port's bioregion which have no suspected or known harmful status. This provides a measure of the low level 'weedy' and sometimes cosmopolitan species which, although having no acknowledged harmful status, have proven transfer credentials that could enable their establishment in another port with probably low but nevertheless unpredictable biological or economic consequences. This number is then added to the sums of suspected and known harmful

---

14 At the outset of the project, species capable of transfer only by ballast water were planned to be added to the database. However many species may be introduced by hull fouling as well as BW, with the principal vector for many of these remaining unclear. Group C scientists in all Pilot Countries were unanimous in their preference for including all species introduced by BW and/or hull fouling or possibly aquaculture in the project standard BWRA database. For future BWRAs a 'vector status' value could be assigned to each species in the database, so that risk assessments could be focussed on specific shipping-mediated vectors.

15 When the taxonomic identifications of the recent port biological baseline surveys are completed, risk species confirmed as already present at a Demonstration Site may be identified for the BWRA database maintained for that site. Their deletion would reduce the size of the risk species coefficients obtained by the 'first-pass' BWRA such as reported here for Odessa, but the revised database should not be copied to develop other port BWRAs.

species in the same bioregion (these include any native species identified as such by Group C local scientists). The default calculation for the risk species coefficient for each source port (C) is thus:

$$C_{\text{Source Port}} = (\text{NIS} + [\text{Suspected Harmfuls x 3}] + [\text{Known Harmfuls x 10}]) / \text{Total Sum}_{\text{All Source Ports}}$$

The C values lie between 0-1 and represent an objective measure of the relative total species threat, since the only subjective components within the project standard BWRA database were the 'universal' assignments of species to particular levels of threat, plus the weightings attached to these levels. Note that the C values for source ports inside the same bioregion will be the same, and that the Total Sum divisor does not represent all species in the database, but only those assigned to bioregions containing source port/s that actually trade with the Demonstration Site. It should also be noted there are several limitations from incorporating a risk species coefficient into the default calculation of the 'first-pass' BWRAs. These included:

- Use of an incomplete list of species that were assigned to one of the three levels of threat (introductions, suspected harmful species, known invaders).
- Significant knowledge gaps on the global distribution of many native, cryptogenic and introduced species (as a consequence of the limited number of species surveys that remain geographically biased to parts of North America, Europe and Australian/New Zealand).
- Gaps and constraints in the taxonomy and reliable identifications for many aquatic species groups.

Such limitations must be taken into account when considering the weighting of the risk species coefficient relative to the other risk factors such as environmental matching.

3.10 Risk assessment

Approach

The database employed the BW discharge, port environmental matching and bioregion species distribution/threat data to calculate, as objectively as possible, the relative risk of a harmful species introduction to a Demonstration Site, as posed by discharges of BW and associated organisms that had been ballasted at each of its identified source ports. A GUI enabling convenient alteration of the risk calculations and weighting values (Figure 9), plus use of ArcView to geographically the display results, improves the system's value as an exploratory utility and demonstration tool.

The semi-quantitative method aims to identify the riskiest tank discharges with respect to a Demonstration Site's present pattern of trade. Unlike a fully quantitative approach, it does not attempt to predict the specific risk posed by each intended tank discharge of individual vessels, nor the level of confidence attached to such predictions. However, by helping a Demonstration Site to determine its riskiest trading routes, exploring the semi-quantitative BWRA provides a coherent method for identifying which BW sources deserve more vessel monitoring and management efforts than others, plus the significance of local, regional and distant trading routes and associated vessel types.

Risk coefficients and risk reduction factors

For each source port, the database used four coefficients of risk (C1-C4) and two risk reduction factors (R1, R2) to produce a relative overall measure of the risk of a harmful species introduction at the Demonstration Site. The database GUI shown in Figure 9 can be used to remove one or more of these components, or alter the way they are treated, from the default 'project-standard' formula which was used for the first-pass BWRA. The four risk coefficients calculated for each source port were:

C1 – proportion of the total number of ballast tank discharges made at the Demonstration Site,
C2 – proportion of the total volume of BW discharged at the Demonstration Site,
C3 – port-to-port environmental similarity, as expressed by the matching coefficient,
C4 – source port's contribution to the total risk species threat to the Demonstration Site, as posed by the contemporary pattern of trade (1999-2002).

In biological terms, C1 and C2 represent the frequency and size of organism 'inoculations' respectively. C3 provides a measure of the likely survivability of these inoculated organisms, and C4 the relative threat posed by the organisms within each inoculation. Each coefficient has values between 0-1 except C3, where the lowest value was set to 0.01 (it is unsafe to assume a port environment can be sufficiently hostile to prevent survival/establishment of every transferred introduced species; Section 3.8).

The two risk reduction factors calculated by the database were R1 (effect of ballast tank size on C2) and R2 (effect of tank storage time on C4). R1 represents the effect of tank size on the number and viability of organisms that survive the voyage, since water quality typically deteriorates more rapidly in small tanks than large tanks (owing to the volume/tank wall ratio and other effects such as more rapid temperature change, with mortality rates generally higher in small tanks). As described below, no risk reduction was applied to any source port dispatching vessels with tank volumes greater than 1000 tonnes.

R2 represents the effect of tank storage time on the range and viability of discharged organisms. Survival of most phytoplankton and aerobic biota inside any tank decreases with time, with relatively high survival rates reported for voyages less than 5 days (as shown below, this was adopted as the cut-off point for any risk reduction due to in-tank mortality). If the focus is only on long-lived anaerobes, dinoflagellate cysts or pathogens (all of which have long tank survival rates), then R2 can be deleted from the BWRA calculation, using the GUI shown in Figure 9 (details are in the GloBallast *BWRA User Guide*).

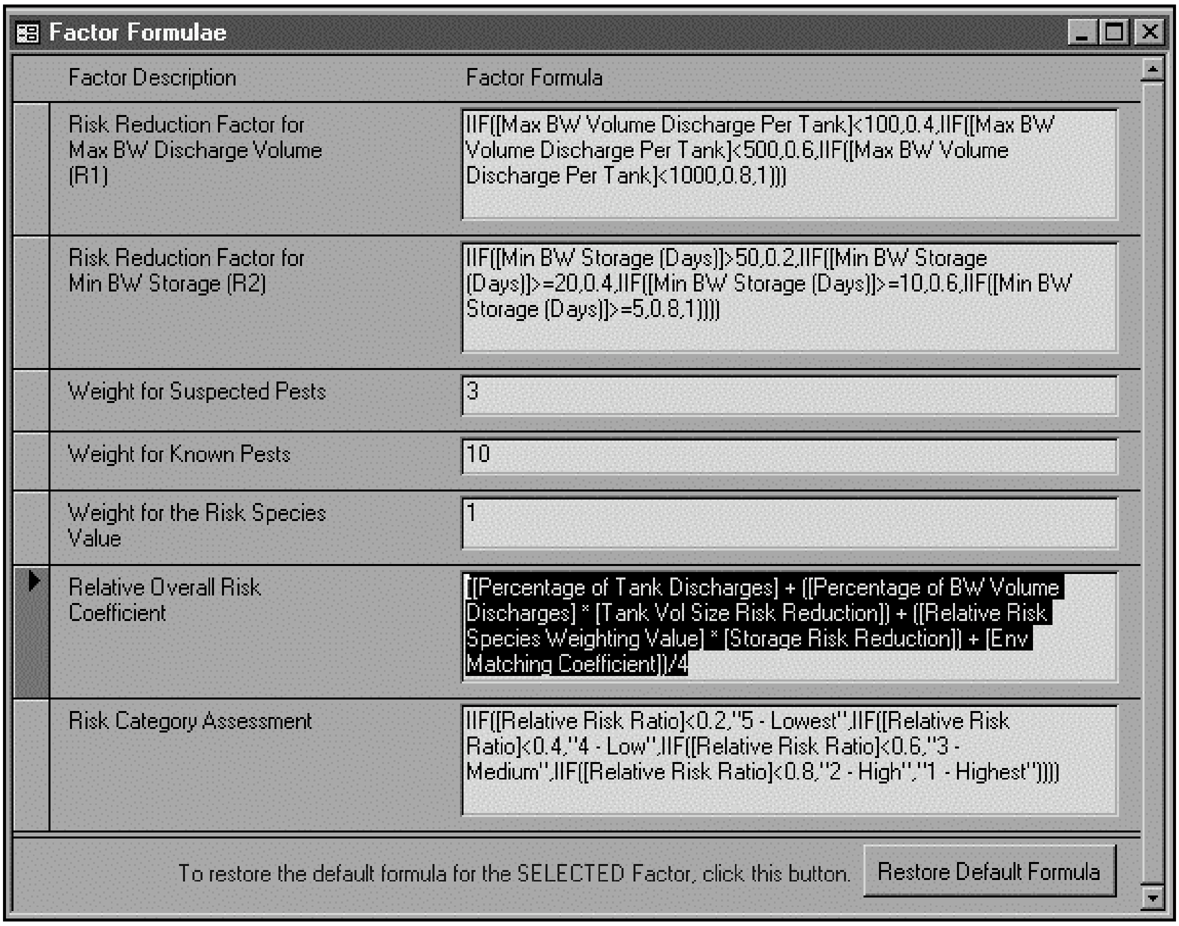

Figure 9. *Database GUI used for manipulating the BWRA calculation and weightings*

The database calculates the tank storage time by subtracting the reported tank discharge date from the ballast uptake date. For incomplete BWRFs with missing discharge or uptake dates, the vessel arrival date plus a standard voyage duration at 14 knots[16] were used to estimate the BW uptake date for adding to the database. The database automatically provides values for R1 and R2 using a log rhythmic approach[17], with the project-standard BWRAs applying the following default (but adjustable) R1 and R2 risk-reduction weightings to C2 and C4 respectively:

R1	Maximum tank volume discharged (tonnes) in the database record for each source port	<100	100-500	500-1000	>1000
W4	Default risk-reduction weighting applied to C2	0.4	0.6	0.8	1

R2	Minimum tank storage time (days) in the database record for each source port	<5	5-10	10-20	20-50	>50
W5	Default risk-reduction weighting applied to C4	1	0.8	0.6	0.4	0.2

Although all information reported in the ballast tank exchange section of the BWRFs was entered into the database, the 'first-pass' BWRA did not use these data to apply a risk reduction factor for each source port route for the following reasons:

- implementation of the BWRFs at the Demonstration Sites was relatively recent, and the tank exchange did not provide a sufficiently consistent or reliable sample of ballast importation (Section 3.4);
- although BWRFs were introduced at Odessa in early 2001 under an order of the State Department of Marine and Inland Water Transport to implement IMO Resolution A.868(20), there was no formal mechanism compelling all vessels to submit fully completed forms;
- insufficient vessel log inspections and tank monitoring data were available for checking claimed exchanges and reported locations;
- discounting whether or not effective BW exchange/s were taking place (a) removed the need to predict the size of the risk reduction, and (b) was precautionary with respect to the ability of exchanges to remove all organisms taken up at the time of ballasting.

BWRA calculation

As shown in Figure 9 and described in the GloBallast *BWRA User Guide*, the database GUI allows the six components of the BWRA calculation and the five weighting factors to be altered from the default, 'project-standard' setting. The GUI can therefore be used to explore how particular risk components and their treatment influence the final result, and also improves the demonstration value of the system. One example is the way the environmental matching coefficient (C3) is treated by the BWRA calculation. For scientists who consider that C3 should be treated as an independent coefficient of risk (see below), then the formula for calculating the relative overall risk (ROR) posed by a source port is:

(1) $ROR = (C1 + [C2 \times R1_{W4}] + C3 + [C4 \times R2_{W5}]) / 4$

Equation (1) is the default setting used for the project-standard BWRA for each Demonstration Site. In this case, ROR is the combined measure of the proportional 'inoculation' frequency (C1) and size (C2), the relative similarity of the source port/Demonstration Site environmental conditions (C3), and the relative level threat posed by the status of species assigned to the source port's bioregion (C4). The division by 4 keeps the result in the 0-1 range to allow the convenient expression of the ROR as a ratio or percentage of the total risk posed by all the source ports.

---

16 The voyage duration between ports for particular vessel speeds are tabled in many maritime guides and atlases, such as the Lloyds *Maritime Atlas of World Ports and Shipping Places* and the 2001 *Fairplay Port Directory.*

17 As with the risk species threat level weightings, a log rhythmic approach is appropriate for risk reduction factors in biological risk assessments.

For those who consider the proportional risk species threat (C4) should provide the focal point of the risk calculation, they may prefer to treat C3 as a risk reduction factor for influencing the size of C4, rather than using it as an independent 'surrogate' coefficient to help cover unidentified or unknown species. The GUI allows the formula to be changed to reflect this approach, in which case C3 would be applied as follows:

(2) $ROR = (C1 + [C2 \times R1_{W4}] + [C3 \times C4 \times R2_{W5}]) / 3$
[*divisor is now 3 because of the reduced number of summed coefficients*].

For a source port in a bioregion with a large number of risk species (eg. a relatively high C4 of 0.2) but with an environment very dissimilar to the Demonstration Site (e.g. C3 = 0.2), then Equation (2) would reduce C4 to 0.04 (i.e. an 80% reduction). If the minimum tank storage time was relatively long (e.g. R2 was between 10-20 days for the quickest voyages, so W5 = 0.6), then C4 would be further reduced to 0.024 (i.e. an 88% reduction to its initial value).

Equation (2) is logical provided the database contains an accurate distribution of appropriately weighted risk species in the various source port bioregions (including native species considered potentially harmful if they established in other areas). However Equation (2) is less conservative than Equation (1), particularly if there are doubts that C4 provides a true picture of potential risk species threat. As shown in Table 2, Equation (1) produces higher ROR values, unless a single source port accounts for over 50% of the frequency (C1) and volume (C2) of the total discharges at a Demonstration Site (this is highly unlikely). The database also allows users to increase the influence of C4 on the ROR by increasing the default value of the overall W3 weighting factor from 1 (but see the caution in Section 3.10). Increasing the size of C4 has more affect in Equation (1) because C3 has no direct influence on the size of C4.

Table 2. *Examples showing how Equation (1) provides more conservative outcomes than (2) for typical situations**

(*when C1 and C2 are less than 50%)	Relative Overall Risk	Proportion of discharge Frequency	Proportion of discharge Volume	Enviro-mental matching	Relative Risk species threat
	ROR	**C1**	**C2**	**C3**	**C4**
ROR = [C1 + C2 + C3 + C4] / 4 Equation (1)	**0.150**	0.1	0.1	0.2	0.2
ROR = [C1 + C2 + (C3 x C4)] / 3 Equation (2)	**0.080**	0.1	0.1	0.2	0.2
ROR = [C1 + C2 + C3 + C4] / 4 Equation (1)	**0.200**	0.2	0.2	0.2	0.2
ROR = [C1 + C2 + (C3 x C4)] / 3 Equation (2)	**0.147**	0.2	0.2	0.2	0.2
ROR = [C1 + C2 + C3 + C4] / 4 Equation (1)	**0.350**	0.5	0.5	0.2	0.2
ROR = [C1 + C2 + (C3 x C4)] / 3 Equation (2)	**0.347**	0.5	0.5	0.2	0.2
ROR = [C1 + C2 + C3 + C4] / 4 Equation (1)	**0.400**	0.6	0.6	0.2	0.2
ROR = [C1 + C2 + (C3 x C4)] / 3 Equation (2)	**0.413**	0.6	0.6	0.2	0.2
ROR = [C1 + C2 + C3 + C4] / 4 Equation (1)	**0.450**	0.7	0.7	0.2	0.2
ROR = [C1 + C2 + (C3 x C4)] / 3 Equation (2)	**0.480**	0.7	0.7	0.2	0.2
ROR = [C1 + C2 + C3 + C4] / 4 Equation (1)	**0.550**	0.9	0.9	0.2	0.2
ROR = [C1 + C2 + (C3 x C4)] / 3 Equation (2)	**0.613**	0.9	0.9	0.2	0.2

Managing and displaying the results

When the database is requested to calculate the BWRA, it generates a large output table that lists all sources of tank discharges recorded at the Demonstration Site, as entered from the BWRFs and/or derived from the port's shipping records. The table shows the ROR values plus their component coefficients and reduction factors. Because the Demonstration Sites have a large number of source ports (80-160), trends are difficult to see within long columns of tabled values.

The ROR results are therefore further manipulated by the database to provide additional columns showing:

- the risk category of each source port, as placed in one of five levels of risk for displaying on the GIS world map;
- a standardised distribution of the ROR results, i.e. from 1 (highest ROR value) to 0 (lowest value).

The five risk categories are labelled 'highest', 'high', 'moderate', 'low' or 'lowest', with their boundaries set at equal linear intervals along the 0-100% scale of cumulative percentage risk (i.e. at 80%, 60%, 40% and 20% intervals). This is the default setting used for the project-standard BWRAs. The database GUI (Figure 9) allows users to shift one or more of these boundaries to any point on the scale. For example, a log–based distribution of the five risk categories may be preferred and is easy to produce using the GUI.

In the case of the standardisation, the database applies the following simple manipulation to expand the distribution of ROR values to occupy the 0-1 range, where 1 represents the maximum ROR value and 0 the minimum value:

$$ROR_{STANDARDISED} = (ROR - ROR_{MINIMUM}) \times 1/(ROR_{MAXIMUM} - ROR_{MINIMUM})$$

This facilitates comparisons between BWRA results from other sites, as well as from different treatments of the ROR formula and/or the weightings. As with the ArcView GIS, the database was designed to optimise the user-friendliness, flexibility and management utility of the system.

Rationale for undertaking 'Project Standard' BWRAs

The flexibility provided by the database allows users to investigate and demonstrate various permutations and avenues without requiring specialised knowledge in database construction and editing. However it was important to apply a consistent, straightforward approach to the 'first-pass' BWRA for each Demonstration Site, so their outcomes could be compared and contrasted to help (a) evaluate the system and approach, and (b) identify areas where changes could improve future use.

Each Demonstration Site has a particular trade profile and associated pattern of deballasting/ballasting. Their divergent geographic locations further contributes to their possession of unique sets of BW source ports which have relatively limited overlap. Thus if results from any two or more Demonstration Sites are to be compared, all of their shared and non-shared source ports and bioregions need to be combined for calculating the environmental matching and risk species threat coefficients.

It was therefore decided that, because the six sites effectively span the globe, the 'project-standard' BWRAs undertaken for each site should use the same global set of source port environment and risk species data. This ensures the port-to-port similarities and risk species threats were based on the widest possible range of port conditions and species distributions, thereby reducing the potential for spurious results resulting from overly narrow regional approaches (Section 3.8).

3.11 Training and capacity building

Members of the consultants team worked with their Odessa counterparts to provide BWRA guidance, training, software and associated materials on the following occasions:

Occasion/ Date [working days]	BWA Activity Tasks	Consultants	Location and Counterparts*
Activity Kick-Off January 2002 [1.5 days]	Presentation, briefing and logistics meetings to: Identify equipment and counterpart requirements Develop provisional pilot country visit schedule	R Hilliard	NIO Offices in Goa. CFP:/CFPAs from all Pilot Countries
1st Country Visit February 2002 [5 days]	Introductory half-day seminar Install and check computer software Commence training and capacity building Begin GIS mapping of port and resources Port familiarisation tour Review BWRFs and Port Shipping Records Commence BWRF database development & training Review port environmental data and identify sources Seminar & tutorials on multivariate similarity analysis Identify data collation/input tasks before 2nd visit	R Healy T Hayes R Hilliard	CSPO offices, Odessa Group A counterparts Group B counterparts Group C counterparts
2nd Country Visit Nov-Dec 2002 [12 days]	Update Database GUIs, add-ins & make ODBC links Continue training and capacity building Complete GIS mapping of port and resources Complete BWRF database development and training Complete port environmental data assembly/training Complete environmental similarity analysis training Generate environmental matching coefficients Add risk species data to database, refine bioregions Complete BWRA training and undertake first analysis Hold seminar to review and discuss results Discuss pilot country needs for future BWRA	C Clarke J Polglaze R Hilliard	CSPO offices, Odessa. Group A counterparts Group B counterparts Group C counterparts
3rd 'Wrap-up' Visit February 2003 [2.5 days]	Provide Database containing all port environmental and risk species data obtained for the six sites Provide updated *BWRA User Guide* and final training on BWRA system operation Review and discuss updated BWRA results	C. Clarke	IACSS, Odessa. Group A leader Group B leader+ CFP & CFP-A.

* refer Appendix 2 for project team structure and counterpart details.

At the kick-off meeting in January 2001, CFP/CFPAs were briefed on the nature, objectives and requirements of the activity. An introductory PowerPoint presentation describing the BWRA system proposed for achieving the BWRF objectives was made, and logistics meetings with individual Pilot Countries subsequently held. A project check-list and briefing document were distributed listing the computer hardware and peripherals required at each Demonstration Site plus the proposed structure of the joint Pilot Country-consultants project team (see Appendices 2 and 3). Appropriate experience of Pilot Country counterparts for the three groups forming the team was emphasised during the kick-off meetings.

During the subsequent in-country visits by the consultants, the main BWRA training and capacity-building components provided were as follows:

- Supply of software licences and User Guide and installation of ESRI ArcView 3.2 and PRIMER 5.
- Guidance and 'hands-on' training and in GIS mapping of marine resources.
- Supply of 2001 CD-ROM edition of the *Lloyds Ship Register*, and customised Excel spreadsheet file for convenient collation of vessel identification and DWT data and reliable estimation of BW discharges from port shipping records, for the pre-BWRF period and BWRF checking.
- Guidance, 'hands-on' training and assistance with the Access database and BWRF management;
- Guidance, 'hands-on' training and glossaries of terminology on the collation, checking, gap-filling and computerisation of BWRFs and principles of database management.
- Guidance and assistance on (a) search, collation and computer entry of environmental data for important BW source and destination ports, and (b) the terminology, networking, data collation and management requirements for species information used for the risk species threat coefficient.
- Tutorial, 'hands-on' training and assistance on theory, requirements and mechanics of multivariate similarity analyses of port and coastal environmental data.
- Tutorial, guidance, 'hands-on' training, seminars and PowerPoint material on BWRA approaches, methods and results evaluation.
- Supply of electronic *BWRA User Guide* with glossaries and technical appendices.

To promote collaboration, understanding and continuity among the three groups, the consultants arranged for group counterparts to provide presentations and guidance to other group members during the 2nd visit.

3.12 Identification of information gaps

This was a critical part of the activities undertaken during the first in-country visit by the consultants, with attention focussed on locating and checking the following BWRA information input components:

- Completeness of BWRFs submitted by vessels arriving at the Demonstration Site.
- Gaps, legibility and authenticity of information reported in the returned BWRFs.
- Sources and availability of shipping records for BWRF gap-filling.
- Existence of electronic and paper charts, topographic and coastal resource maps, atlases, aerial photographs and publications for GIS port map.
- Sources, reliability and extent of port environmental data and coastal resource information for Demonstration Site and its trading ports in the Pilot Country and region.
- Sources and extent of marine species records, information and researchers on introduced species in and near the Pilot Country.

At the end of the first country visit, the status of the above were reviewed and a list of gap-filling tasks, as allocated to the Pilot Country groups or consultants and to be undertaken by the second visit, were agreed upon and minuted. Follow-up gap-filling tasks were also conducted during and after the second visit.

4 Results

4.1 Description of port

General features

The port is located in Odessa Bay (Odesskiy Zaliv; Odes'ka Zatoka) near the north-west corner of the Black Sea at 46^o 32'N 30^o 54'E (Figures 2,11). The first harbour was developed during the late 1790's to provide merchant and military berths close to the fortress of Hajibey (Khadjibey). The port was heavily damaged during World War II and was steadily rebuilt during the 1950s-1970s to become a fully commercial port by 1980. The container terminal was subsequently developed on port land reclaimed during the 1980s. Trade reached an annual peak of 11 million tonnes of dry cargo and 20 million tonnes of oil products in 1989, but was subsequently halved following the end of the Soviet Union. By 1994 the port management structure had been changed and joint-activity companies had been developed to accelerate port and cargo-handling modernisation. Odessa steadily rebuilt its trade during the 1990s to remain the largest port in Ukraine, with oil and petroleum products, metals, grain and fertilizer forming the most important components of its trade. In 2001 its trade in liquid (18.9 million tonnes) and dry cargos (10.1 million tonnes) reached 29 million tonnes, increasing further in 2002 to 32.6 million tonnes, which is approximately one third of Ukraine's total port trade. After entering the relatively shallow coastal waters more than 40 km south-east of the port, ships approach the port along a marked channel where depths gradually shoal from ~20 m until the final 3 km approach, where dredging is required to maintain navigable depths of 12.5 m below chart datum.

Climate and weather

The temperate climate of the southern Ukraine region is characterised by mild to warm summers with variable sea breezes and cold, dry winters dominated by northerly winds. Mean day-time temperatures regularly exceed 20^{o}C during summer (maxima to ~37^{o}C), while winter night-time temperatures usually fall below 0^{o}C (minima to -27^{o}C). Coastal sea ice typically develops in late December/early January and may extend for 4-8 weeks depending on the severity of the winter. Annual rainfall is low (390 mm) and occurs mostly between spring and autumn. A wind rose showing the predominance of the seasonal northerly winds and summer sea breezes is shown in Figure 10.

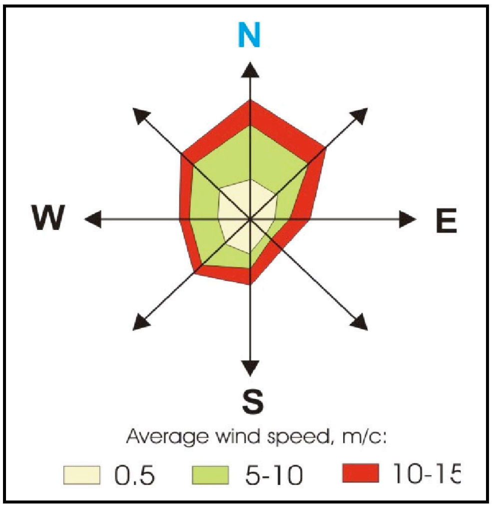

Figure 10. *Wind rose typical of the Odessa Bay region*

Hydrodynamic conditions

Tidal currents are virtually non-existent owing to the relatively small astronomical tidal range, which is only 0.1 m during springs and virtually 0 m during neaps. Water levels and currents in and near the port are generated by local surface winds, which generate sea level changes in the order of 0.6 m (maximum 1 m between seasons). The general pattern of water circulation in this region of the Black Sea is shown in Figure 11. Because of the lack of tides and river mouth at Odessa, there are no tidal water movement plots. However there is a weak but relatively persistent south-westerly long-shore drift across Odessa Bay. Figure 11 shows how the circulation in the relatively shallow north-west corner of the Black Sea is slow but influenced by the western gyre plus freshwater discharges from the four major rivers systems (particularly the large the Dnepr system east of Odessa during spring and summer). Relatively weak water exchange inside the port's main breakwaters indicates that BW plumes are not rapidly dispersed out of the harbour, which often contains very brackish water in spring and summer (5-14‰) owing to the river discharges near Odessa, particularly the 51.2 m^3 of freshwater released annually by the Dnepr[18].

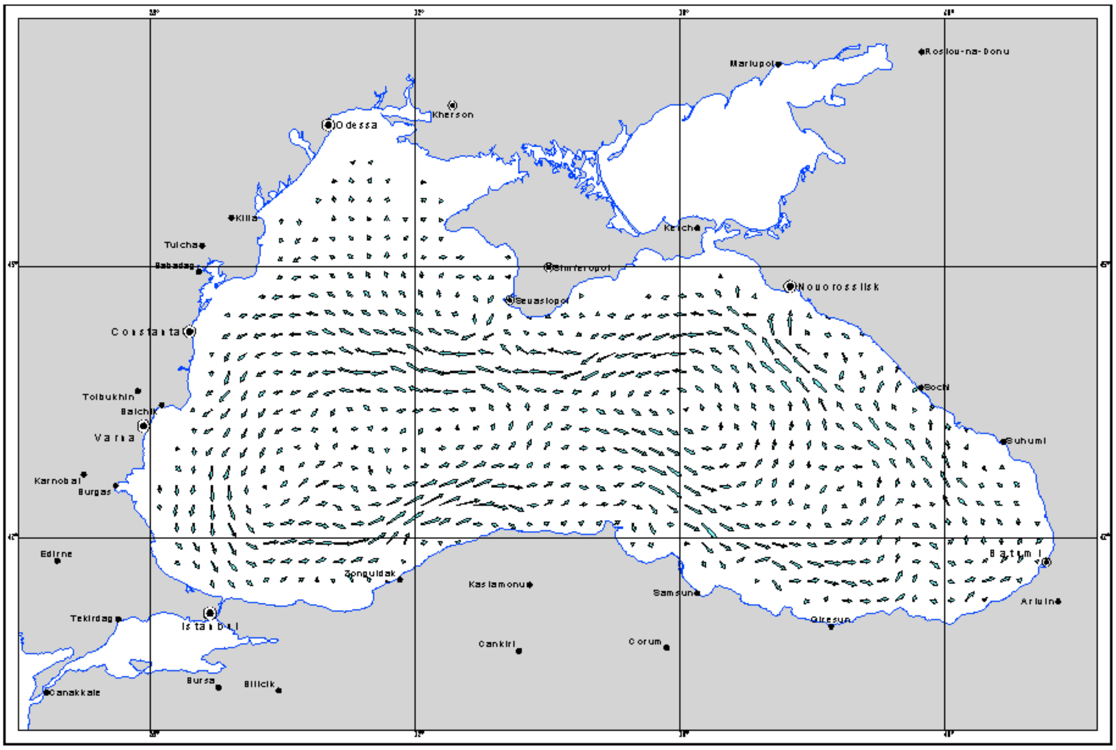

Figure 11. *Regional surface water circulation in the Black Sea*

[18] The Dnepr rises in the Valdai Hills southwest of Moscow and is Europe's third longest river (2,285 km). It is navigable throughout its course and ice-free for eight months of the year, making it an important shipping artery from Ukraine to Russia and Belarus, particularly for grain, timber and metals. The total catchment of the Dnepr, Yuzhny-Bug, Dniestr, Danube and other smaller rivers draining into the north-west gulf near Odessa is six times larger than the 415,000 km^2 Black Sea. The Danube Delta (Europe's largest) forms 5,650 km^2 of marshland while the 14 estuaries between this delta and the mouth of the Dnepr River occupy a further ~2000 km^2.

Port development and maintenance

The harbour is sheltered by three detached breakwaters and covers an area of 2.8 km^2 with an average depth of 9.5 m. Mean annual temperature and salinity of the 0.03 km^3 of water occupying the harbour basin is 11.0º_ and 14.4‰ respectively. Since the completion of the new container terminal in 1989 on land reclaimed by dredging and back-fill, CPSO has been operating six main terminal areas plus the ship repair yard and a small vessel harbour. These are shown in the GIS Port Map (Figure 12) and described from north to south as follows:

- **Oil terminal:** This terminal is located on the north side of the harbour and contains six berths, the deepest (12.5 m) on its T-jetty and capable of receiving up to 250 m long crude oil and products tankers for oil, fuel and chemical products from the nearby oil storage tanks and refinery (which receives crude by pipeline). The gas tanker berth is on the south-facing wharf west of the T-jetty.

- **Grain terminal:** Two jetties south of the oil terminal provide berths for general bulk carriers and are equipped for the export and import of cereals and other grain, with the port's silos providing temporary storage for 60,000 tonnes.

- **Ship repair yard:** This area is located between the grain terminal and the small vessel harbour and contains several slipways, floating cranes and heavy lift gantries. It is owned by the City of Odessa and not managed by CPSO.

- **Passenger terminal and small boat harbour:** The passenger terminal jetty is located in the centre of the harbour and is closest to the city centre. It has five berths and can accommodate passenger ferries and cruise liners up to 240 m long and 11 m draft. The small boat harbour contains marina facilities as well as servicing line boats and other work vessels.

- **Dry bulk/general cargo terminal:** This terminal provides 17 berths located north and south of the passenger terminal, which are serviced by road and rail spurs and backed by 215,000 m^2 of open yardage and 78,000 m^2 of warehouse space. A wide variety of bulk, break-bulk, pallet, boxed, bagged and Ro-Ro cargos are handled at these berths, including scrap iron, rolled steel, non-ferrous metals, raw sugar, vegetable oil, paper, fertilizer, machinery, packed cereals, fruits and other foodstuffs.

- **Refrigerated cargo terminal:** Following the opening of the container terminal, reefer trade has been declining following the increased use of refrigerated containers for storing and transporting fruit, vegetables and other perishables. While 23 reefers continued to visit the port during 2001-2002 (the majority Ukraine flagged), most of the refrigerated warehouses which once provided up to 13,500 tonnes of chilled or frozen storage capacity near the two reefer berths had been mothballed by 2001.

- **Container terminal:** Two berths equipped with container gantries and stackers in 1989-91 can service ships up to 240 m long and 12 m draft, and have a capacity to handle 100,000 TEU per year.

Beyond the harbour, the roadstead to the north-east of the main entrance channel provides a safe anchorage where some cargo transhipments occur from general cargo ships and bulk carriers into river vessels and barges, most frequently between spring and autumn. No BWRFs were collected from vessels anchoring in this area, as these ships are either unloading cargo and/or receiving small cargo top-ups following departure from the harbour.

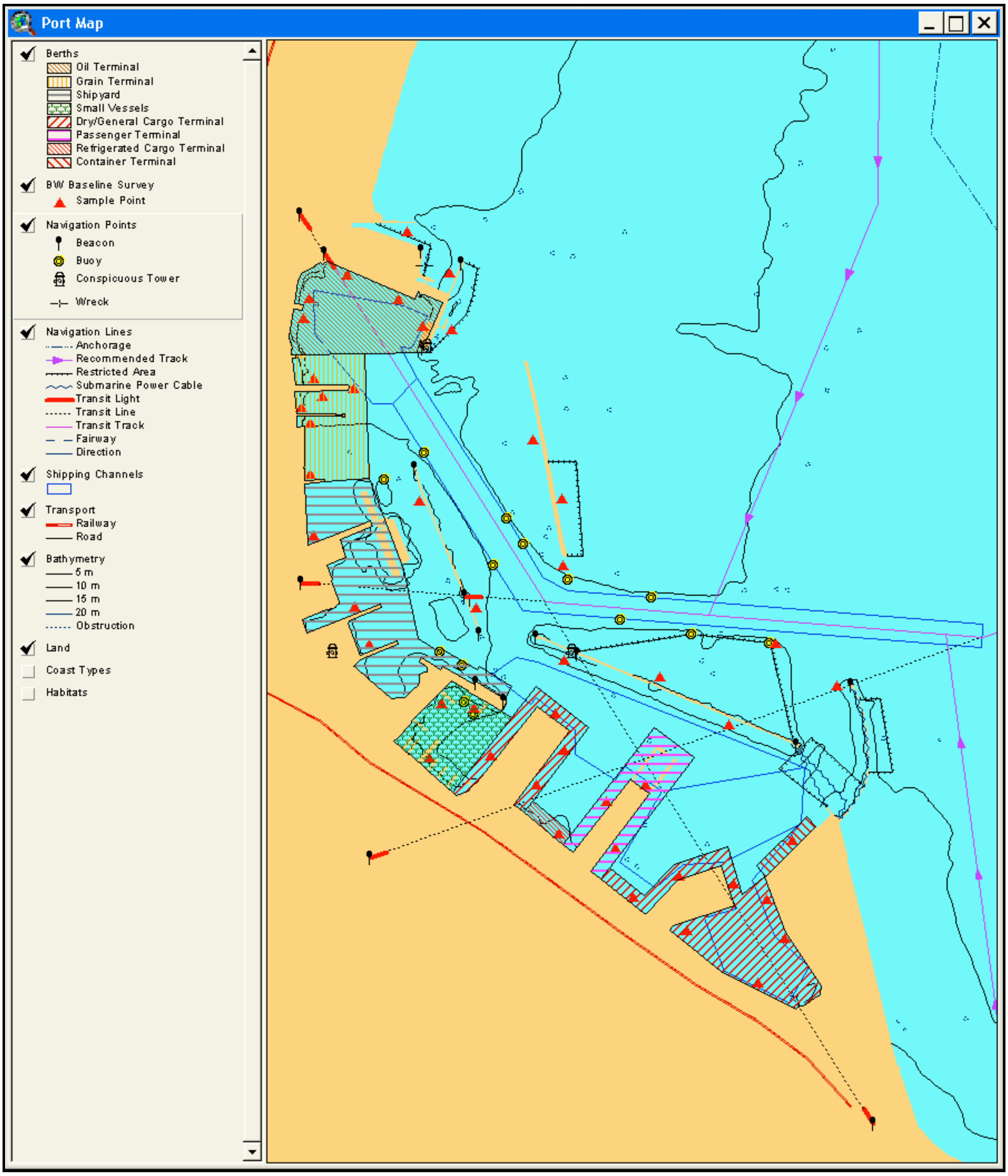

Figure 12. *Part of the GIS Port Map showing the navigation and active berth layers.*

4.2 Resource mapping

The habitat layer of the GIS port map shows how the subtidal seafloor habitats in and beyond Odessa Bay are dominated by soft muddy sediments (Figure 13). Subtidal sand banks are located east of Odessa and near the wide entrance to the Dnepr River estuary (Figure 13).

Seagrass beds in the Odessa region are restricted to a sheltered sublittoral area containing *Zostera marina* and *Zostera noltii* south of the port and close to the narrow stony beach which extends southward until the sand dunes and beaches near Illichivsk (Figure 13). There is also a small area of *Phyllophora* brown algae in the eastern part of Karkinitsky Bay. The closest sand beaches extend northward from the harbour around the bay (Figure 14). The stony beaches are backed by erosive breccia and soil low cliffs and there is only one natural rocky headland near Odess which delineates the north-east boundary of the bay (Figure 14). Prior to the appearance of eutrophication events in Odessa Bay, the low intertidal and subtidal rocky areas were dominated by the brown macroalgae *Cystoseira barbata*. During the late 1960s-early 1970s, the rocky shore communities became colonised by filamentous and turfing green algae, blue mussels (*Mytilus galloprovincalis*) and the NW Europe bay barnacle (*Balanus improvisus*; first introduced in the Black Sea during the middle and late 19th Century via hull fouling; Zaitsev & Öztürk 2001). The port breakwaters and berths provide over 15 km of artificial intertidal and subtidal hard substrate that are dominated by rocky walls (Figure 13), followed by smooth walls and partially submerged wooden fender work and pilings.

The GIS port map also shows the location of the Odessa PBBS sampling sites on a separate layer (Figure 13), so that the final results from each sampling station can be readily added from the final PBBS report. Because of the scale of the map and the extent of the urbanised area surrounding the port, features such as post offices, churches and radio masts were not added. No historical wreck-sites of archaeological significance or cultural-heritage value were identified in the area covered by the GIS port map.

The GIS Port Map does not portray the major ecological changes that have occurred in Odessa Bay and other parts of the north-west gulf over the past 40 years as a result of a significant decline in flushing riverine discharges due to increased industry and irrigation extractions, plus an associated rapid increase in nutrient inputs and eutrophication. This has led to the regular development of major phytoplankton blooms which collapse over summer and decompose to cause major hypoxic zones and mass mortalities to benthic invertebrates and fish stocks.

The first of these shallow water deoxygenation events was discovered in August 1973 occupying 3,500 km^2 of the north-west gulf. These hypoxic events became regular summer phenomena that caused an estimated total biomass loss of 60 million tonnes between 1973-1990, including 5 million tonnes of commercial and non-commercial fish species (Zaitsev & Öztürk 2001). Typical summer average density of surface water phytoplankton in the north-west gulf is now 2,500 mg/m^3 versus 150 mg/m^3 for the central Black Sea.

Over the same period, increased commercial fishing pressure across the Black Sea led to a collapse of native fish stocks (from 26 in the 1950s to five by the early 1980s). Stock augmentation by deliberate introduction of *Mugil soiuy* from Japan helped maintain large commercial catches until their 1985 peak of ~700,000 tonnes. This was followed by a rapid crash exacerbated by the inadvertent BW-mediated introduction of the comb jellyfish *Mnemiopsis leidyi* from the NE American seaboard. By the late 1990s, accidental but fortuitous introduction of two further comb jellyfish which predate on *Mnemiopsis* (*Beroe cucumis* and *B. ovata*) have decreased the abundance of the latter population and appear to be facilitating a limited recovery of some fish catches. However the future of much of the Black Sea's native biodiversity, ecological processes and fish stocks remains uncertain, particularly in the eutrophic and hypoxia-prone north-west gulf region.

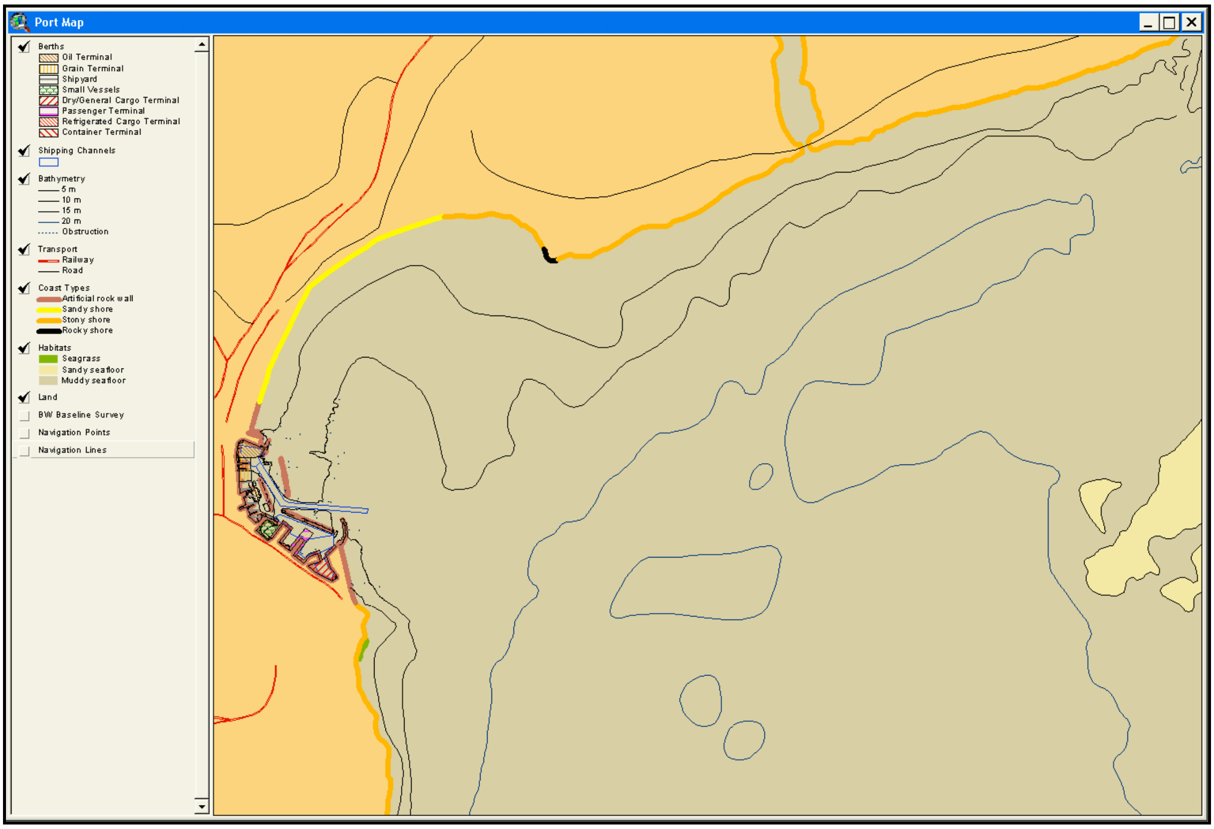

Figure 13. *Part of the GIS Port Map showing the marine habitat layer.*

4.3 De-ballasting/ballasting pattern

During meetings with the Harbour Master and SPSIP officials in February and November 2002, the port navigational rules and State licensing requirements that influence deballasting and ballasting practises at Odessa were discussed. Pilotage is compulsory, with boarding occurring some 5 km outside the harbour. Because of the lack of swells, vessels in ballast approaching the port are often containing approximately 75-85% of their normal ballast, and are encouraged to undertake offshore BW exchanges, which under SIPBS regulations are required to be completed before they enter the 12 nautical mile territorial limits (i.e. more than 20 km off the coast). As in other ports, the port and pilotage rules require all empty ships to retain sufficient ballast on board to maintain adequate propulsion and steerage control, and to minimise windage until berthing is completed. Windage becomes a significant feature of the port during autumnal gales and spells of strong northerly winds in winter and early spring.

It was straightforward to identify which dry bulk carriers and tankers arriving at the oil and grain terminals were discharging BW, and this was also true for general cargo vessels and container ships berthing at the Dry bulk/general cargo berths and container terminal (i.e. from the 2001-2002 submitted BWRFs and CPSO's paper record for 1999-2000). However many ships using at the general purpose and container berths were either fully or part discharging cargo, and it was not clear which vessels had departed with BW taken up at the port. In fact many of the general cargo ships, bulk carriers, ro-ro vessels and container ships which visit the port are either:

- completely or part unloading (i.e. possible ballast water uptake);
- retaining cargo on board (i.e. taking a top-up cargo and requiring no BW uptake or discharge); or
- both (i.e. operations requiring some vessels to uptake/discharge BW to maintain trim during their cargo unloading/loading cycle).

Owing to the lack of information concerning the amount of cargo already on board, it was not possible to estimate what BW may have been taken up, even for vessels which submitted reasonably complete BWRFs. For incomplete BWRFs, it was very time consuming and sometimes impossible to interpret from these or the port shipping records how much BW was probably discharged, let alone ascertain how much was taken up for trimming purposes. It also became apparent that many ships had not reported exactly how much BW was discharged, particularly those which had not undertaken an exchange and were thus liable to the polluted water discharge penalty, as negotiated with SIPBS (Section 3.3).

Of the total of 2297 vessel visits that had been added to the database by the end of the second consultants visit, approximately 80% of these originated from BWRFs submitted between January 2001 and July 2002, the rest being expanded from the 1999-2000 BW discharge records collated by CSPO. The database stores the amounts and sources of BW discharged from the arrivals at each terminal. Connection of the database to the active berth layer of the GIS Port Map allowed tables summarising the BW discharge statistics to be conveniently displayed for each terminal. Examples of these tables displayed by the GIS Port Map are shown in Figures 14-17 for the four terminals where reported BW discharges were made.

The following vessel discharge statistics for the six terminals were extracted from the database as follows:

- For the 1003 visits entered for the oil terminal for the period 19 November 1999 – 4 July 2002, these included 234 visits by crude oil tankers, 247 visits by products tankers, 31 by ore/bulk oil tankers (OBOs), 48 by gas tankers and 12 by chemical tankers. The database records a total of 10,842,360 tonnes of BW discharged at Odessa by these ships, including one of the largest vessels to visit the port (the crude oil tanker *Genmar Macedon* of 155,547 DWT, which reported a discharge of 39,900 tonnes during its part-loading of crude oil in November 2001). Large tankers cannot fully load at Odessa owing to the depth restrictions at the berth and approach channel.
- For the 21 visits involving cereal exports from the grain terminal over the same period, these comprised 19 bulk carriers and 2 general cargo ships up to 60,158 DWT, which discharged a total of 179,691 tonnes of BW (Figure 15).
- For the ferries and cruise liners which visited the passenger terminal during 2001 and 2002, BWRFs were received for 11 of them, and none reported any BW discharge. The largest cruise ship visiting in this period was the *Rotterdam* (59,652 GT; 6,932 DWT), operated by the Holland America Line.
- For the 17 berths forming CPSO's dry bulk/general cargo terminal, details were entered into the database for 637 visits involving 509 general cargo ships (55,501-693 DWT), 89 bulk carriers (75,681-14,030 DWT) and four ro-ro cargo ships (5,536-1,377 DWT) arriving between 19 November 1999 and 4 July 2002. These ships accounted for a total of 135 discharges amounting to 1,019,006 tonnes of BW, the major proportion being reported by bulk carriers arriving in ballast to load scrap metal, steel and non-ferrous metals (917,000 MT). None of the ro-ro vessels reported a need to discharge BW during their visits.
- Between November 1999 and June 2002, 23 refrigerated vessels (9,970-844 DWT) made 48 visits to the reefer berths, most arriving between spring and autumn to part unload tropical and sub-tropical fruits from Caribbean and southern Mediterranean ports, and to load local fruits and vegetables for transportation to other ports in the Black Sea. Only one arrival reported a need to discharge BW (152 tonnes) to maintain trim whilst alongside the reefer terminal. This was added to the dry bulk/cargo berth statistics as the reefer berths are close to the centre of this area (Figure 12).
- Of the 397 arrivals to the container terminal berths which submitted BWRFs between early 2001 and July 2002, the vast majority were dedicated (railed) container ships (241) and general cargo ships (131) capable of handling containers with their own gear. Of all arrivals,

only 14 reported a need to make BW discharge to maintain vessel trim during container unloading/loading, with an average discharge of 1,124 tonnes. However the container terminal statistics are distorted by the reception of the 42,035 DWT bulk carrier *You Mei* in May 2001, which discharged 7,121 tonnes sourced from Ancona (Italy) whilst loading a cargo believed to comprise disassembled gantry work, old containers, vehicles, machinery and scrap steel.

Because the database must accept and manage individual tank discharges as discrete units (as recorded in IMO-standard BWRFs; Appendix 1), the need to treat each BW tank as a single entity for all vessels arriving prior to BWRF use (or which submitted incomplete BWRFs; Section 3.6) markedly reduces the number of individual tank discharges actually made between November 1999 and July 2002, whilst inflating the mean and maximum tank discharge volumes. Thus the latter typically reflect the total ballast water capacity of the largest vessels visiting the terminals at Odessa (Figures 14-17), and this causes a more conservative outcome in terms of the BWRA results. It is therefore worth emphasising that a database containing individual tank data collated from, say, a 12 month set of fully completed BWRFs, will generate far more precise BW source port values for the C1, C2 and R1 components (Section 3.10).

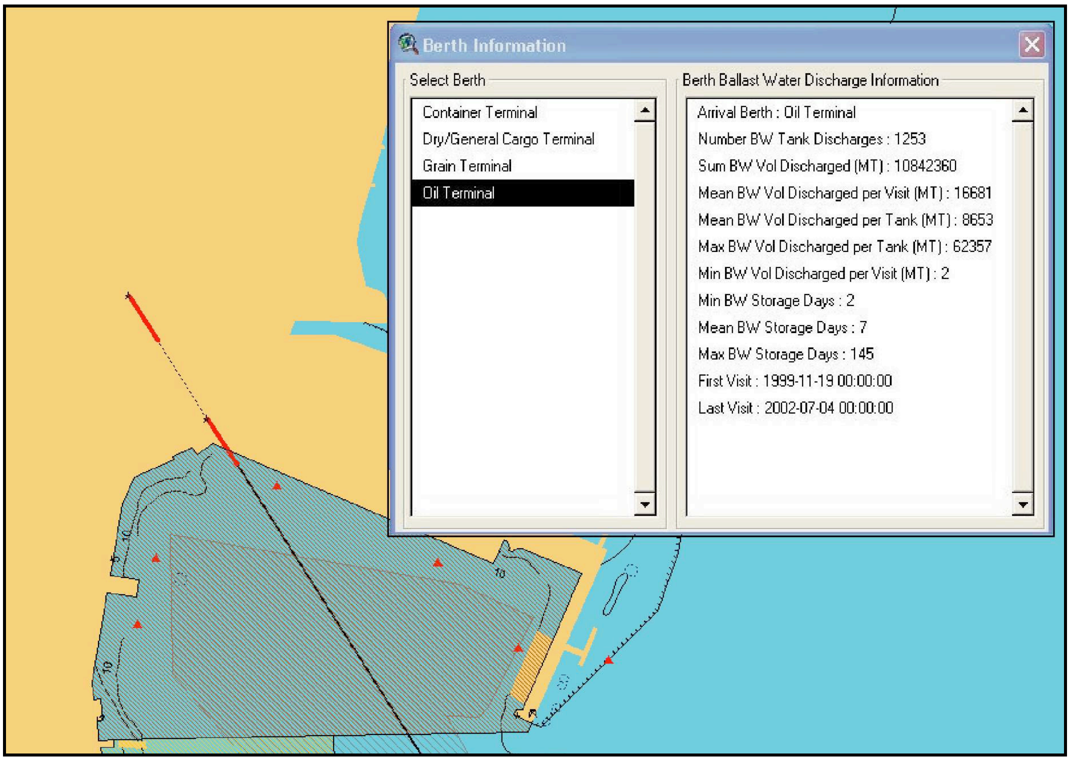

Figure 14. *BW discharge statistics displayed by GIS Port Map for the oil terminal.*

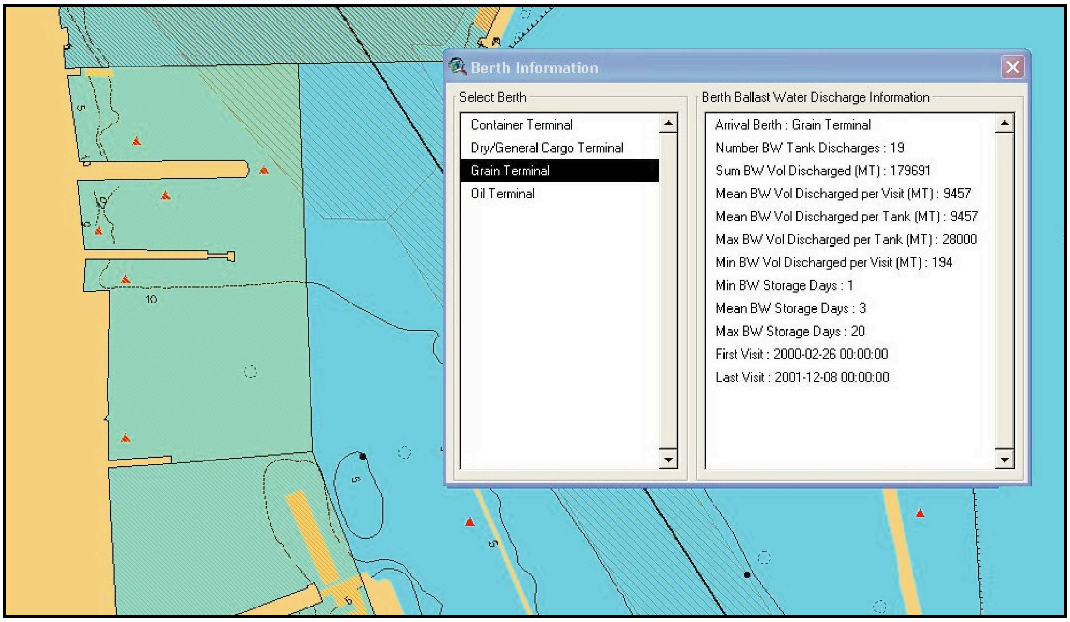

Figure 15. *BW discharge statistics displayed by GIS Port Map for the grain terminal*

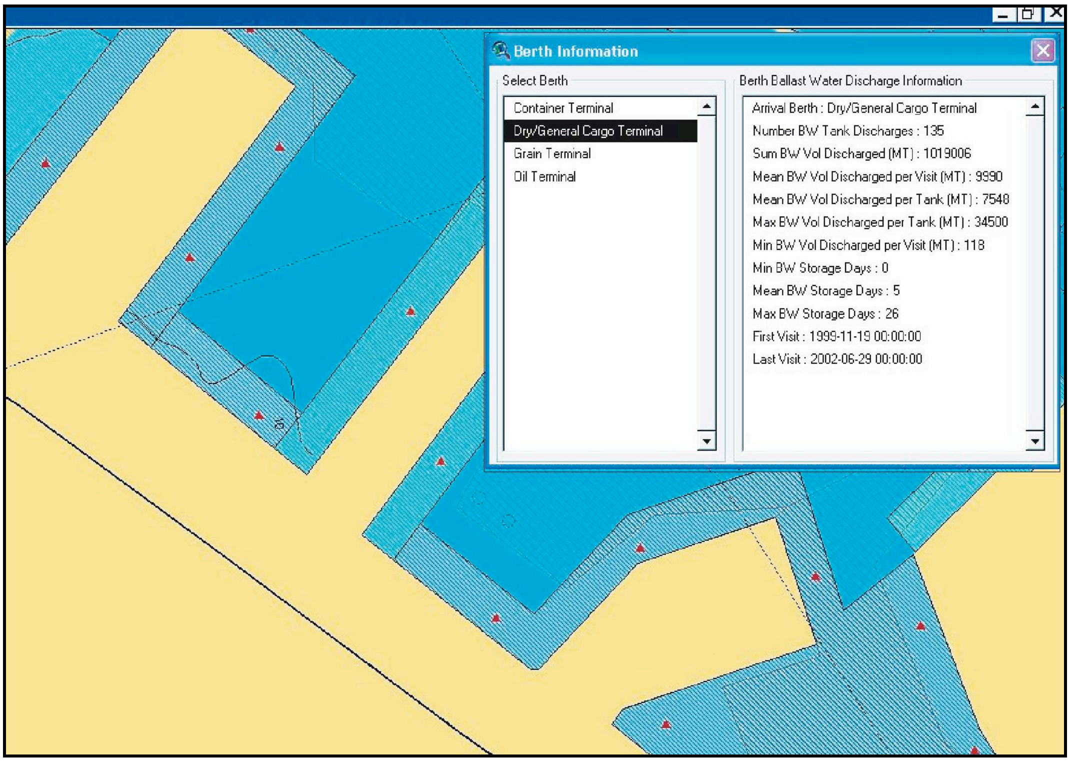

Figure 16. *BW discharge statistics displayed for the dry bulk/general cargo terminal*

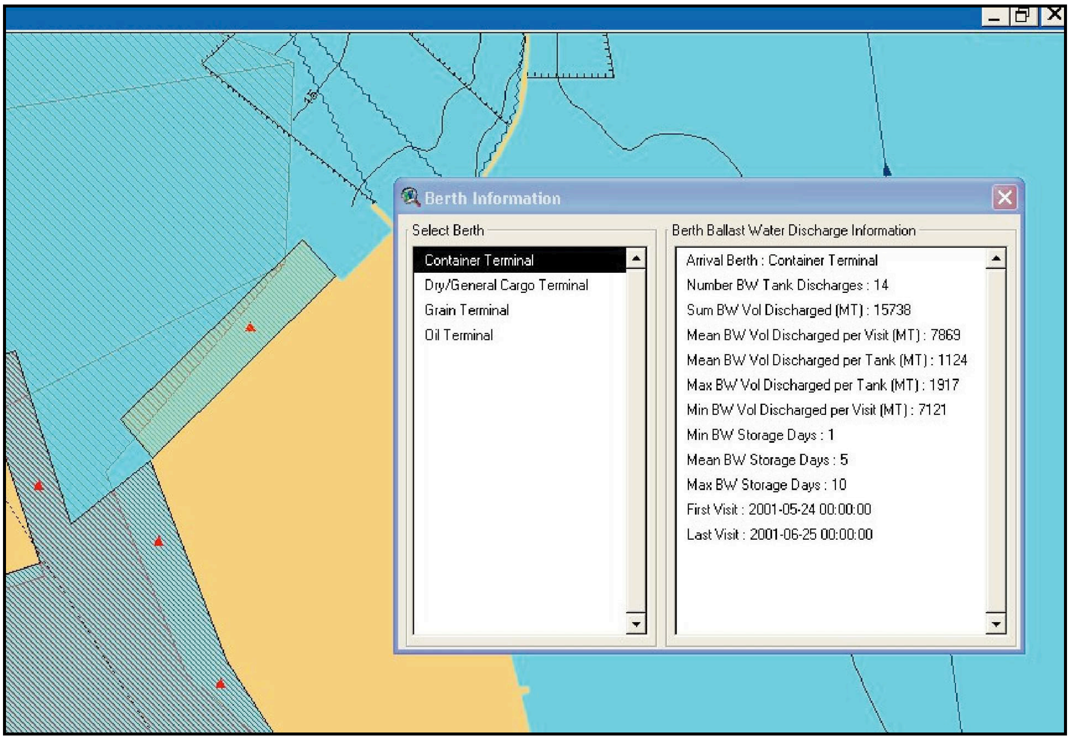

Figure 17. *BW discharge statistics displayed by the GIS Port Map for the container terminal*

4.4 Identification of source ports

From the 2297 vessel visit and 3387 associated ballast tank records in the Odessa database, the total number of identified BW source ports was 122 (Table 3). Figure 18 shows output from the GIS world bioregion map depicting the location and relative importance of these source ports with respect to C1 (BW discharge frequency). As with all GIS outputs, the map is 'zoomable' to allow all ports and symbols to be clearly delineated at smaller scales.

The discharge frequency values listed for the identified source ports in Table 3 are the C1 coefficients used to calculate the relative overall risk (Section 3.10). The source port 'supplying' the highest frequency of BW discharges at Odessa was the Bulgarian Black Sea port of Bourgas (14.4%). This was followed by the Italian Adriatic port of Trieste (7.7%), then the Black Sea port of Constanta (Romania; 5.6%), the East Mediterranean port of Piraeus (Greece; 4.9%), the north-west Atlantic port of Fos sur Mer (France; 4.1%) and the Adriatic port of Omisalj (Croatia; 3.6%) (Table 3).

The first port in the C1 ranking beyond the Euro-Mediterranean region was the east Russian port of Nakhodka (Sea of Japan), which at 0.73% was ranked 32nd. Of the 122 identified source ports, the top 10 provided >50% of the recorded discharges at Odessa, while the next 19 ports contributed a further 25%, i.e. only 29 of the 122 source ports (24%) accounted for >75% of all source-identified BW discharges (Table 3). The last 38 source ports in the C1 list each accounted for only one arrival that made a recorded BW discharge in the 1999-2002 database. As noted earlier, there is a relatively low number of individual tank records (3387) compared to vessel visits (2297) and this is due to (a) the need to include port shipping records prior to the regular use of BWRFs (all tanks combined), (b) some vessels submitting a single discharge volume on the BWRF covering all discharged tanks, many vessels submitting a BWRF showing that no BW was either on board or intended for discharge.

Of the 2297 visit records, 933 of these contained 1396 tank records showing a total of 12,439,796 tonnes of BW discharged at Odessa, with source ports identified for all but 156 tanks that contributed 5.5% of the volume. The various discharged volume percentages for each source port shown in Table 3 and Figure 19 provide the C2 values used in the risk calculation (Section 3.10). The source port rankings for C2 (proportion of total volume) were very similar but not exactly same as those for C1 (i.e. the discharge frequency, as ranked in Table 3). Thus the source ports providing the largest volume of BW discharged at Odessa were also Bourgas (17.3%), Trieste (9%), Constanta (7.5%) and Piraeus (6.7%), but then followed by the Italian port of Ravenna (3.4%) before Fos sur Mer (3.1%; Table 3). The highest non-European port in the C2 ranking was Hanoi in Vietnam (0.26%), ranked 87th on the C2 scale.

Seven identified source ports provided >50% of the total discharged volume, and another 14 ports a further 25%. Thus only 21 of the 122 ports (17%) accounted for 75% of the source-identified total volume discharged at Odessa. Of the top 20 ports in terms of BW discharge volume, seven were in the Black Sea, seven in the Adriatic Sea, two in the Aegean Sea, three in the Eastern Mediterranean and one on the NW Atlantic Coast of France. There were no recorded tank discharges sourced from the Caspian Sea or from the transhipment ports in the Azov Sea or Don River which facilitate this trade via the Volga-Don canal.

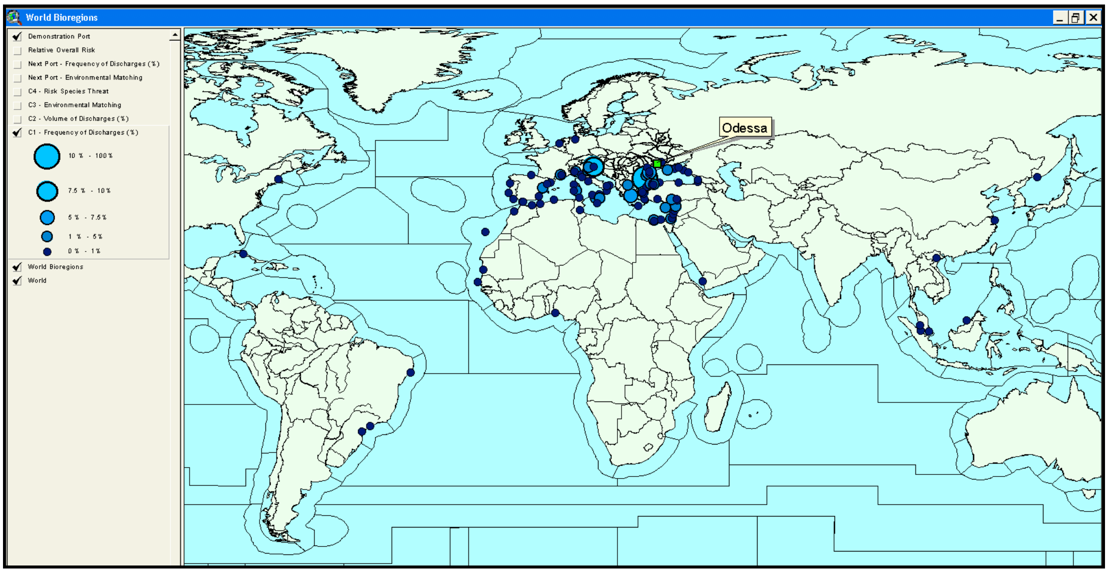

Figure 18. *GIS output showing the location and relative importance of BW source ports with respect to frequency of tank discharges (C1) at the Port of Odessa.*

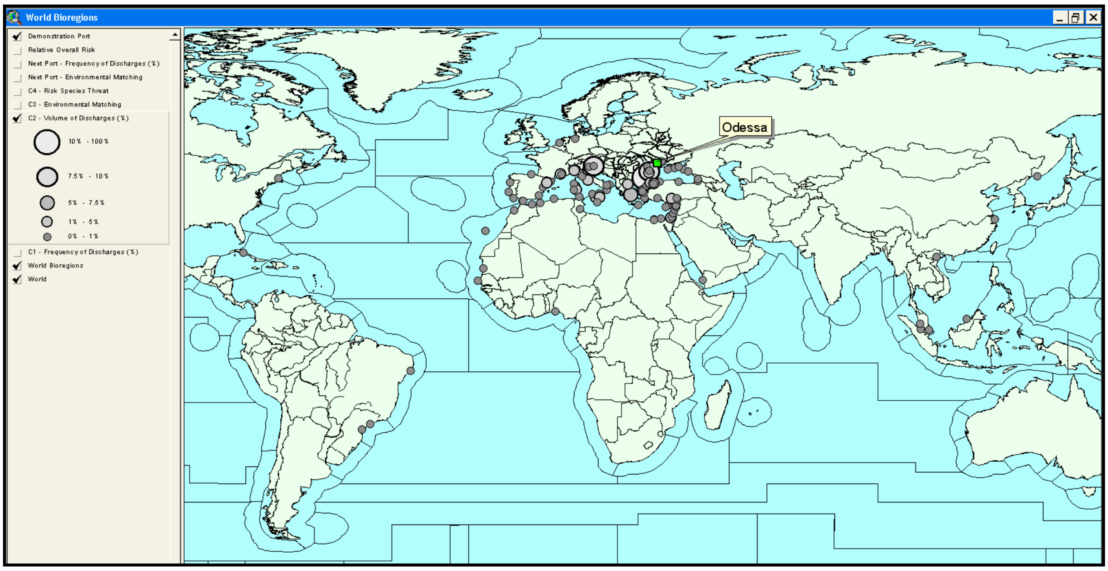

Figure 19. *GIS output showing location and relative importance of the source ports with respect to the volume of tank discharges (C2) at the Port of Odessa.*

Table 3. *List of identified source ports in the Port of Odessa database, showing proportions of recorded ballast tank discharges (C1*) and volumes (C2*)*

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
1	BGBOJ	Bourgas	Bulgaria	14.42%	2,149,733	17.28%
2	ITTRS	Trieste	Italy	7.70%	1,112,922	8.95%
3	ROCND	Constanta	Romania	5.59%	930,851	7.48%
4	GRPIR	Piraeus	Greece	4.86%	826,964	6.65%
5	FRFOS	Fos sur Mer	France	4.05%	382,255	3.07%
6	HROMI	Omisalj	Croatia	3.57%	258,000	2.07%
7	GREEU	Eleusis	Greece	3.32%	342,459	2.75%
8	ITRAN	Ravenna	Italy	2.76%	425,643	3.42%
9	TRALI	Aliaga	Turkey	2.59%	318,340	2.56%
10	TRIZT	Izmit	Turkey	2.59%	210,103	1.69%
11	BGVAR	Varna	Bulgaria	2.51%	249,049	2.00%
12	TRIST	Istanbul	Turkey	1.94%	167,976	1.35%
13	CYLMS	Limassol	Cyprus	1.94%	92,630	0.74%
14	ILAKL	Ashkelon	Israel	1.62%	245,202	1.97%
15	GRSKG	Thessaloniki	Greece	1.62%	242,278	1.95%
16	ITSPA	Santa Panagia	Italy	1.46%	191,114	1.54%
17	ITGOA	Genoa	Italy	1.38%	362,276	2.91%
18	ITGEA	Gela	Italy	1.22%	155,879	1.25%
19	UASVP	Sevastopol	Ukraine	1.13%	22,548	0.18%
20	PTLEI	Leixoes	Portugal	1.05%	68,370	0.55%
21	SYTTS	Tartous	Syrian Arab Republic	1.05%	36,965	0.30%
22	TRMER	Mersin	Turkey	0.97%	221,897	1.78%
23	ITPFX	Porto Foxi (Sarroch)	Italy	0.97%	178,091	1.43%
24	ITVCE	Venezia (=Fusina)	Italy	0.97%	81,302	0.65%
25	EGALY	Alexandria (El Iskandariya)	Egypt	0.97%	79,779	0.64%
26	ESCAS	Castellon de la Plana	Spain	0.97%	43,918	0.35%
27	ITPIO	Piombino	Italy	0.81%	23,277	0.19%
28	ESTAR	Tarragona	Spain	0.73%	204,196	1.64%
29	ROMAG	Mangalia	Romania	0.73%	201,864	1.62%
30	ITMLZ	Milazzo	Italy	0.73%	99,195	0.80%
31	ITPVE	Porto Vesme (Portoscuso)	Italy	0.73%	39,730	0.32%
32	RUNJK	Nakhodka	Russian Federation	0.73%	20,138	0.16%
33	TRSSX	Samsun	Turkey	0.73%	1,179	0.01%
34	GRAGT	Agioi Theodoroi	Greece	0.65%	183,288	1.47%
35	ITFAL	Falconara	Italy	0.65%	115,886	0.93%
36	MANDR	Nador	Morocco	0.65%	33,650	0.27%
37	ITPMA	Porto Marghera	Italy	0.65%	13,006	0.10%
38	ITAUG	Augusta/Priolo	Italy	0.57%	156,860	1.26%
39	ITSVN	Savona	Italy	0.57%	143,348	1.15%
40	RUNVS	Novorossiysk	Russian Federation	0.57%	57,298	0.46%
41	TRNEM	Nemrut Bay	Turkey	0.57%	38,394	0.31%
42	ILASH	Ashdod	Israel	0.57%	36,558	0.29%
43	ESLPA	Las Palmas	Spain	0.57%	24,271	0.20%
44	SYBAN	Baniyas	Syrian Arab Republic	0.57%	12,377	0.10%
45	ITFCO	Fiumicino	Italy	0.49%	118,263	0.95%
46	TNBIZ	Bizerte	Tunisia	0.49%	32,764	0.26%
47	TRAYT	Antalya	Turkey	0.49%	11,433	0.09%
48	ITAOI	Ancona	Italy	0.49%	7,588	0.06%
49	UAILK	Ilyichevsk	Ukraine	0.41%	68,520	0.55%
50	TRIZM	Izmir (Smyrna)	Turkey	0.41%	66,435	0.53%
51	TRISK	Iskenderun	Turkey	0.41%	46,355	0.37%
52	GRASS	Aspropyrgos	Greece	0.41%	20,370	0.16%
53	SNDKR	Dakar	Senegal	0.41%	10,030	0.08%
54	GEPTI	Poti	Georgia	0.41%	9,964	0.08%
55	ITCRV	Crotone	Italy	0.41%	7,529	0.06%
56	ILHFA	Haifa	Israel	0.32%	69,469	0.56%
57	ESCAR	Cartagena	Spain	0.32%	63,467	0.51%
58	GIGIB	Gibraltar	Gibraltar	0.32%	63,405	0.51%
59	ITLIV	Livorno	Italy	0.32%	59,462	0.48%
60	CYLCA	Larnaca	Cyprus	0.32%	42,794	0.34%
61	HRRJK	Rijeka Bakar	Croatia	0.32%	32,555	0.26%

*C1 = proportion of all discharges (% of 3387 records); C2 = proportion of total BW discharged (% of reported discharge volume)

Table 3 (cont'd). *List of identified source ports in the Port of Odessa database, showing proportions of recorded ballast tank discharges (C1*) and volumes (C2)*

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
62	TRCEY	Botas-Ceyhan	Turkey	0.32%	20,886	0.17%
63	LBBEY	Beirut	Lebanon	0.32%	17,246	0.14%
64	NGLOS	Lagos	Nigeria	0.32%	12,780	0.10%
65	MTMAR	Marsaxlokk	Malta	0.32%	11,746	0.09%
66	YEHOD	Hodeidah	Yemen	0.32%	7,033	0.06%
67	GRLAV	Lavrion (Laurium)	Greece	0.32%	2,815	0.02%
68	TRERE	Eregli	Turkey	0.24%	28,026	0.23%
69	ITSIR	Siracusa	Italy	0.24%	27,658	0.22%
70	UADNB	Dnepro-Bugsky	Ukraine	0.24%	24,533	0.20%
71	MTMLA	Malta (Valetta)	Malta	0.24%	24,190	0.19%
72	TNGAE	Gabes	Tunisia	0.24%	18,265	0.15%
73	ITPTO	Porto Torres	Italy	0.24%	9,725	0.08%
74	TRAMB	Ambali/Kumport	Turkey	0.24%	369	0.00%
75	NLRTM	Rotterdam	Netherlands	0.16%	58,610	0.47%
76	ESALG	Algeciras	Spain	0.16%	40,447	0.33%
77	ITPMO	Palermo	Italy	0.16%	29,411	0.24%
78	GEBUS	Batumi	Georgia	0.16%	26,481	0.21%
79	DZALG	Alger	Algeria	0.16%	15,984	0.13%
80	MACAS	Casablanca	Morocco	0.16%	13,320	0.11%
81	SYLTK	Latakia	Syrian Arab Republic	0.16%	10,955	0.09%
82	UAFEO	Feodosiya	Ukraine	0.16%	3,907	0.03%
83	SIKOP	Koper	Slovenia	0.16%	3,463	0.03%
84	ITBDS	Brindisi	Italy	0.08%	37,459	0.30%
85	PTFAO	Faro	Portugal	0.08%	34,100	0.27%
86	TRTUT	Tutuncifilik	Turkey	0.08%	34,100	0.27%
87	VNHAN	Hanoi	Viet Nam	0.08%	31,969	0.26%
88	PTLIS	Lisboa	Portugal	0.08%	30,370	0.24%
89	ITTAR	Taranto	Italy	0.08%	29,305	0.24%
90	BRSSZ	Santos	Brazil	0.08%	26,641	0.21%
91	SGSIN	Singapore	Singapore	0.08%	22,378	0.18%
92	ROMID	Midia	Romania	0.08%	21,435	0.17%
93	USBOS	Boston Massachusetts	United States	0.08%	17,050	0.14%
94	LBKYE	Tripoli	Lebanon	0.08%	15,984	0.13%
95	EGEDK	El Dekheila	Egypt	0.08%	15,665	0.13%
96	EGDAM	Damietta	Egypt	0.08%	14,556	0.12%
97	TRDYL	Dortyol Oil Terminal	Turkey	0.08%	12,468	0.10%
98	BRMCZ	Maceio	Brazil	0.08%	12,042	0.10%
99	RUTUA	Tuapse	Russian Federation	0.08%	11,722	0.09%
100	DZORN	Oran	Algeria	0.08%	11,162	0.09%
101	CNSHA	Shanghai (Shihu) Shanghai	China	0.08%	10,656	0.09%
102	TRTOR	Toros	Turkey	0.08%	10,635	0.09%
103	FRLAV	Lavera	France	0.08%	9,644	0.08%
104	GRKGS	Kos	Greece	0.08%	9,591	0.08%
105	MYKBA	Kuala Baram	Malaysia	0.08%	9,591	0.08%
106	BRPNG	Paranagua	Brazil	0.08%	8,589	0.07%
107	DEBRE	Bremen	Germany	0.08%	8,525	0.07%
108	GRMGR	Megara Oil Terminal (Agia Trias)	Greece	0.08%	8,525	0.07%
109	MRNKC	Nouakchott	Mauritania	0.08%	8,388	0.07%
110	ESBCN	Barcelona	Spain	0.08%	6,394	0.05%
111	UAKEH	Kerch	Ukraine	0.08%	6,394	0.05%
112	GRNPL	Nauplia (Nafplion)	Greece	0.08%	4,369	0.04%
113	ESBIO	Bilbao	Spain	0.08%	4,263	0.03%
114	GRANI	Aghios Nikolaos	Greece	0.08%	4,263	0.03%
115	ITMNF	Monfalcone	Italy	0.08%	4,263	0.03%
116	MYPKG	Port Kelang	Malaysia	0.08%	3,517	0.03%
117	TRTUZ	Tuzla	Turkey	0.08%	1,598	0.01%
118	UANIK	Nikolayev	Ukraine	0.08%	1,279	0.01%
119	IDDUM	Dumai Sumatra	Indonesia	0.08%	853	0.01%
120	TRYAR	Yarimca	Turkey	0.08%	320	0.003%
121	ROGAZ	Galatz	Romania	0.08%	213	0.002%
122	TRBDM	Bandirma	Turkey	0.08%	213	0.002%

*C1 = proportion of all discharges (% of 3387 records); C2 = proportion of total BW discharged (% of reported discharge volume)

4.5 Identification of destination ports

As discussed in Section 3.5, identification of destination ports for BW taken up at a Demonstration Site is confounded by the lack specific questions on the BWRF, and the uncertainty of knowing if the Next port of Call recorded on a BWRF (or in a shipping record) is where BW is actually discharged. Thus there is no reporting mechanism enabling a 'reverse BWRA' to be undertaken reliably. This posed a significant constraint on objective 4 for Odessa (Section 2), since a significant portion of general cargo ships and some bulk carriers departing the dry bulk/general cargo terminal had probably uplifted at least some BW when alongside these berths (e.g. for trimming purposes when unloading then loading cargo).

Of the 145 potential BW destination ports in the 1999-2002 database (i.e. Next Ports of Call), their location and proportional frequency are shown in Figure 20. Table 4 lists the top 62 'BW destination' ports that accounted for 90% of all reported the Next Ports of Call. This shows that the Romanian Black Sea port of Constanta stood out as the most frequent destination port, with 16% of Next Ports of Call attributed to this one port, which was a frequent destination for ships departing the container and oil terminals, and some from the dry bulk/general cargo terminal.

Constanta was followed a group of ports in the 6-10% range, namely the nearby Ukrainian port of Ilyichevsk (9.3%), which is deeper and often visited for top-up cargos, followed by the Bulgarian Black Sea port of Bourgas (8.9%; much of this traffic comprising a shuttle export service involving three Bulgarian flagged crude oil tankers *Osam, Khan Asparukh* and *Mesta* plus a few product tankers), the roadstead off Odessa (7.0%; used for cargo top-ups and transhipments with small vessels trading from river ports in the Denpr and Yuzhny-Bug systems) and then Istanbul (6.6%). Istanbul may also not represent an important BW destination port since it was found that some bulk carriers and tankers departing Odessa had sailing instructions to proceed to Istanbul only for the purpose of entering the Turkish Straits (Bosphorus then Dardanelles) to visit a unknown Mediterranean port.

Table 4 shows that, of the top 20 ports which accounted for the destinations of 72% of the vessel departures from Odessa, nine were located in the Black Sea, six were in the Eastern Mediterranean, four in the Marmara and Aegean Seas and two in the Adriatic Sea. The highest ranked destination port lying beyond the Black Sea-Mediterranean was Singapore, ranked 24th as the destination of 0.68% of all departures. No vessel reported it was sailing to a Caspian Sea port, and only a few reported to be bound for Azov Sea staging ports (where transhipments can also be made to vessels using the Volga-Don canal). These comprised small general cargo ships departing for the Ukrainian port of Kerch (1 departure) and the Russian ports of Azov (1), Taganrog (1) and Rostov-on-Don (3 departures) (Figures 2, 20; Table 4).

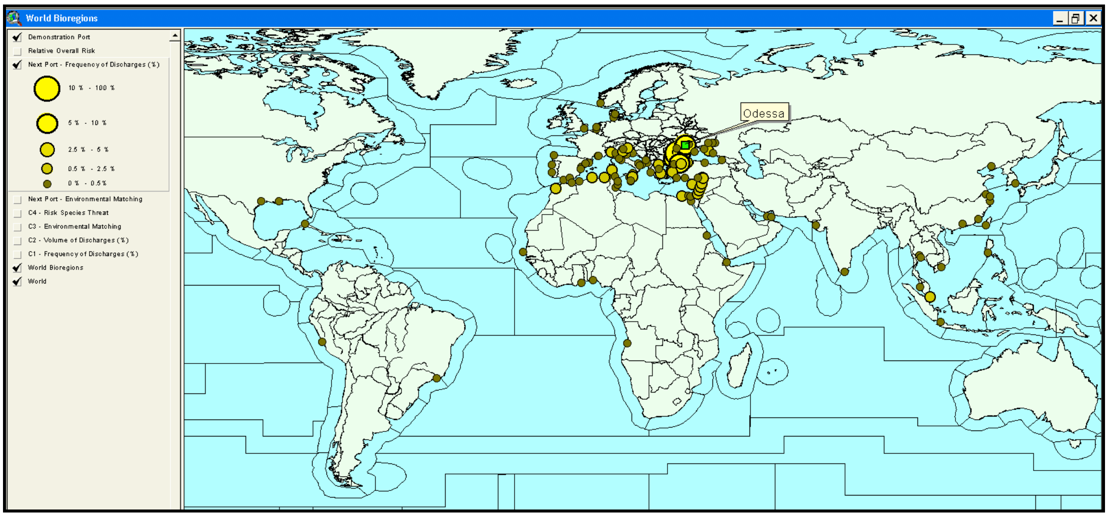

Figure 20. *GIS output showing the location and frequency of destination ports, recorded as the Next Port of Call in the Port of Odessa BWRFs and shipping records.*

Table 4. *Destination ports accounting for 90% of all vessel departures during November 1999-July 2002 (recorded as Next Ports of Call).*

	UN Port Code	Destination Port (Next Port of Call)	Country	% Proportion of Departures	Cumulative %
1	ROCND	Constanta	Romania	16.08	16.1
2	UAILK	Ilyichevsk	Ukraine	9.26	25.3
3	BGBOJ	Bourgas	Bulgaria	8.87	34.2
4	UAODS	Odessa	Ukraine	7.02	41.2
5	TRIST	Istanbul	Turkey	6.63	47.9
6	BGVAR	Varna	Bulgaria	4.39	52.3
7	ROMID	Midia	Romania	2.34	54.6
8	ILASH	Ashdod	Israel	2.24	56.8
9	RUNVS	Novorossiysk	Russian Federation	1.95	58.8
10	EGALY	Alexandria (El Iskandariya)	Egypt	1.85	60.6
11	GREEU	Eleusis	Greece	1.75	62.4
12	ITRAN	Ravenna	Italy	1.66	64.0
13	ITTRS	Trieste	Italy	1.36	65.4
14	GRPIR	Piraeus	Greece	1.07	66.5
15	TRYAR	Yarimca	Turkey	1.07	67.5
16	ILHFA	Haifa	Israel	0.97	68.5
17	CYLMS	Limassol	Cyprus	0.88	69.4
18	SYTTS	Tartous	Syrian Arab Republic	0.88	70.3
19	TRALI	Aliaga	Turkey	0.88	71.2
20	TRDYL	Dortyol Oil Terminal	Turkey	0.78	71.9
21	TRIZM	Izmir (Smyrna)	Turkey	0.78	72.7
22	DZALG	Alger	Algeria	0.68	73.4
23	LBBEY	Beirut	Lebanon	0.68	74.1
24	SGSIN	Singapore	Singapore	0.68	74.8
25	TRAMB	Ambali/Kumport	Turkey	0.68	75.4
26	DZSKI	Skikda/Phillippeville	Algeria	0.58	76.0
27	GRSKG	Thessaloniki	Greece	0.58	76.6
28	ITAUG	Augusta/Priolo	Italy	0.58	77.2
29	ITGOA	Genoa	Italy	0.58	77.8
30	ITPFX	Porto Foxi (Sarroch)	Italy	0.58	78.3
31	ITSPA	Santa Panagia	Italy	0.58	78.9
32	MACAS	Casablanca	Morocco	0.58	79.5
33	TRERE	Eregli	Turkey	0.58	80.1
34	TRISK	Iskenderun	Turkey	0.58	80.6
35	ALDRZ	Durres	Albania	0.49	81.1
36	HROMI	Omisalj	Croatia	0.49	81.6
37	IDJKT	Jakarta Java	Indonesia	0.49	82.1
38	THBKK	Bangkok	Thailand	0.49	82.6
39	TNSUS	Sousse	Tunisia	0.49	83.1
40	TRMER	Mersin	Turkey	0.49	83.6
41	FRFOS	Fos sur Mer	France	0.39	84.0
42	ESALG	Algeciras	Spain	0.39	84.4
43	TRSSX	Samsun	Turkey	0.39	84.8
44	UAKHE	Kherson	Ukraine	0.39	85.1
45	DZORN	Oran	Algeria	0.29	85.4
46	CNHUA	Huangpu (Xinzao) Guangdong	China	0.29	85.7
47	FRLAV	Lavera	France	0.29	86.0
48	ITFAL	Falconara	Italy	0.29	86.3
49	ITMLZ	Milazzo	Italy	0.29	86.6
50	ITPMA	Porto Marghera	Italy	0.29	86.9
51	ITVCE	Venezia (=Fusina)	Italy	0.29	87.2
52	RUROS	Rostov-on-Don	Russian Federation	0.29	87.5
53	TNSFA	Sfax	Tunisia	0.29	87.8
54	TRIZT	Izmit	Turkey	0.29	88.0
55	TRMRM	Marmaris	Turkey	0.29	88.3
56	UAIZM	Izmail	Ukraine	0.29	88.6
57	USHOU	Houston Texas	United States	0.29	88.9
58	YUBAR	Bar	Yugoslavia (Fed Rep Of)	0.29	89.2
59	DJJIB	Djibouti	Djibouti	0.19	89.4
60	GRASS	Aspropyrgos	Greece	0.19	89.6
61	GRJKH	Chios	Greece	0.19	89.8
62	INMUN	Mundra	India	0.19	90.0

4.6 Environmental similarity analysis

Of the identified 122 BW source ports and 145 potential destination ports, sufficient port environmental data were obtained to include 53% of the former and 50% of the latter in the multivariate similarity analysis by PRIMER. These ports accounted for 75% of all recorded tank discharges and 82% of all recorded departures respectively (Tables 5, 6). Details of the 357 ports included in the multivariate analysis carried out for Odessa and the other Demonstration Site BWRAs are listed in Appendix 6 (this list is ordered alphabetically using the UN port identification code, in which the first two letters represent the country).

To allow all identified BW source and next ports of Odessa to be part of the 'first-pass' risk assessment, those ports not included in the multivariate analysis were provided with environment matching coefficient estimates, and are noted as such in the database. The C3 estimates were based on their port type (Section 3.7) and geographic location with respect to the nearest comparable ports for which C3 had been calculated. A precautionary approach was adopted (i.e. the estimated values were higher than the calculated C3s of the comparable ports). Providing C3 estimates allowed the database to include all of Odessa source ports and next ports when calculating the ROR values and displaying the BWRA results.

The GIS world map outputs displaying the C3 values of the Odessa source and destination ports are shown in Figures 21 and 22 respectively. These figures and Tables 5-6 reveal that Odessa has a relatively high environmental similarity to the majority of its regular trading ports (i.e. source and destination ports with C3s greater than 0.6 accounted for >40% of all BW discharges and >50% of all vessel departures respectively). This can be related to the regional proximity of Odessa's most regular trading ports plus its relatively wide seasonal temperature/salinity ranges.

It is not surprising that the most environmentally similar port to Odessa was Illyichevsk (C3 = 0.819) with 21 other BW source ports in the Black Sea and Adriatic Sea having calculated or estimated C3 values above 0.6 (Table 5). The most environmentally similar source ports beyond the Black Sea-Mediterranean region were Nakhodka in the Sea of Japan (C3 estimated at 0.65 based on the calculated values for comparable Japanese and Korean ports), followed by Boston on the NE American seaboard (calculated C3 of 0.592), Fos sur Mer and Lavera on France's NW Atlantic coast (0.588; 0.585) and Rotterdam (0.582; Table 5). The most environmentally dissimilar ports trading with Odessa in the 1999-2002 database (i.e. C3s below 0.3) were the two wet tropics Malaysian ports of Port Kelang and Kuala Baram plus the warm water/high salinity port of Dubai in the arid Gulf (Tables 5-6; Figures 21, 22).

As discussed in Section 4.5 and shown in Table 4 and Figure 20, the most frequent potential BW destination port was Constanta (i.e. the Next Port of Call for 16% of all departures). This port also has a relatively high calculated environmental matching of 0.797 (Table 6), and is located down-current of Odessa owing to the direction of the western surface water gyre in the Black Sea. While Illyichivesk had the highest match (0.819), it is not a frequent BW source port (0.41% of reported discharges; Table 3) but the second-most common destination port (9.6% of departures; Table 4). How many of these departures may have been carrying at least some BW uplifted from Odessa and required to be discharged in this port could not be ascertained. However, since voyage durations and BW storage times of ships trading between Odessa and all other Black Sea ports are relatively short (<5 days and potentially less than 24 hours for Illyichevsk), any sessile benthic species introduced to Odessa from beyond the Black Sea may have many opportunities to be spread faster and wider via BW-mediated 'port-hopping' than by its natural dispersal means. The latter will be limited by the longevity and salinity tolerances of its dispersal stages and the speed and direction of prevailing currents extending south-west from Odessa (Figure 11).

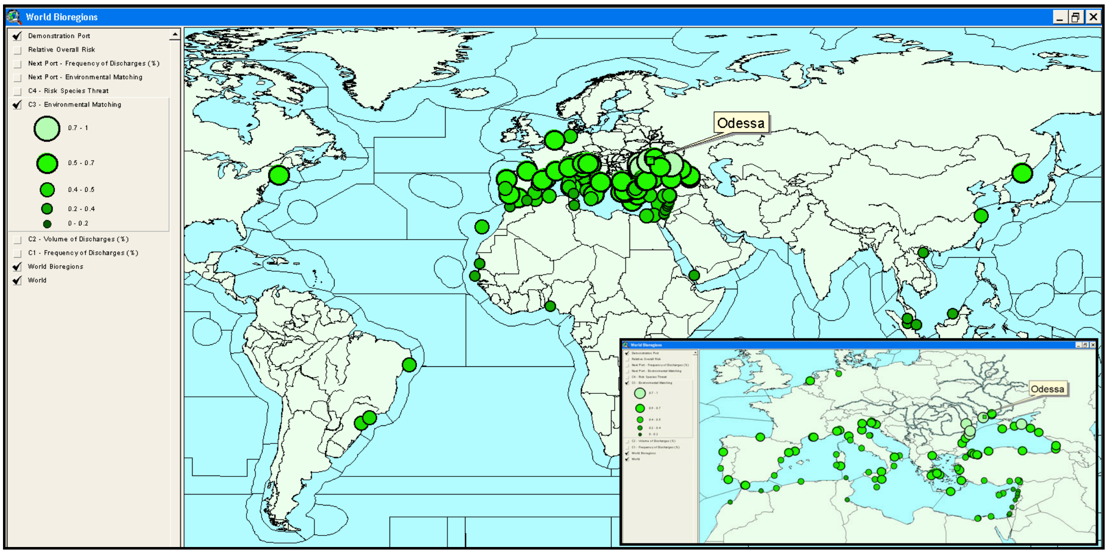

Figure 21. *GIS output showing the location and environmental matching coefficients (C3) of BW source ports identified for the Port of Odessa.*

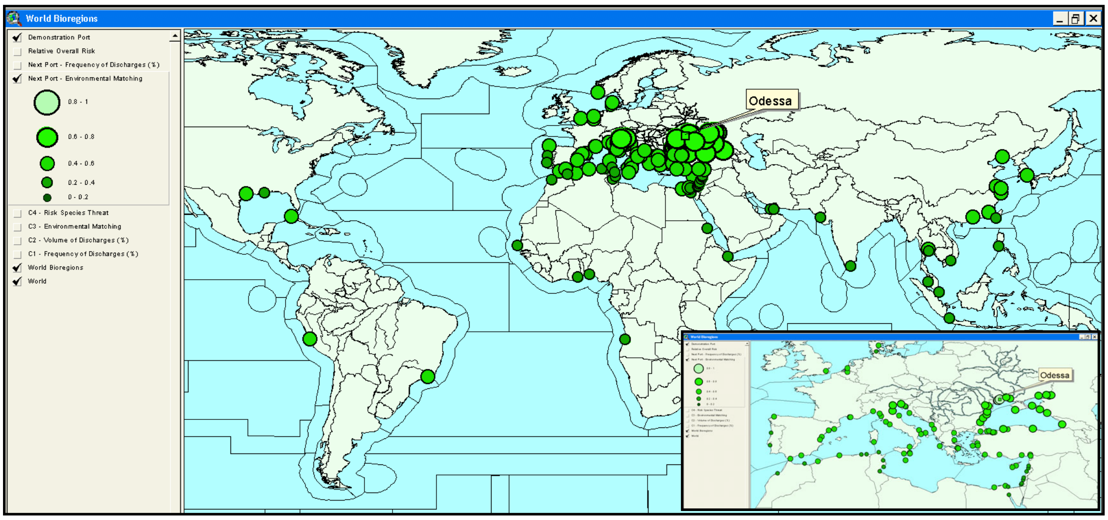

Figure 22. *GIS output showing the location and environmental matching coefficients (C3) of the destination ports identified for the Port of Odessa.*

Table 5. *Source ports identified for Port of Odessa, as ranked according to size of their environmental matching coefficient (C3)*

UN Port Code	Port Name	Country	Proportion of BW discharged	Environmental Matching (C3)	C3 Estimated
UAILK	Ilyichevsk	Ukraine	0.41%	**0.8193**	
UAKEH	Kerch	Ukraine	0.08%	**0.7500**	Y
ROMID	Midia	Romania	0.08%	**0.7386**	
ROCND	Constanta	Romania	5.73%	**0.7375**	
ROMAG	Mangalia	Romania	0.75%	**0.7286**	
ROGAZ	Galatz	Romania	0.08%	**0.7000**	Y
TRERE	Eregli	Turkey	0.25%	**0.6895**	
BGVAR	Varna	Bulgaria	2.57%	**0.6866**	
TRSSX	Samsun	Turkey	0.75%	**0.6805**	
RUNVS	Novorossiysk	Russian Federation	0.58%	**0.6731**	
RUTUA	Tuapse	Russian Federation	0.08%	**0.6716**	
GEBUS	Batumi	Georgia	0.17%	**0.6644**	
RUNJK	Nakhodka	Russian Federation	0.75%	**0.6500**	Y
GEPTI	Poti	Georgia	0.00%	**0.6452**	
UASVP	Sevastopol	Ukraine	1.16%	**0.6446**	
BGBOJ	Bourgas	Bulgaria	14.77%	**0.6382**	
UADNB	Dnepro-Bugsky	Ukraine	0.25%	**0.6298**	
SIKOP	Koper	Slovenia	0.17%	**0.6273**	
ITVCE	Venezia (=Fusina)	Italy	1.00%	**0.6242**	
ITTRS	Trieste	Italy	7.88%	**0.6219**	
ITRAN	Ravenna	Italy	2.82%	**0.6130**	
UAFEO	Feodosiya	Ukraine	0.17%	**0.6000**	Y
USBOS	Boston Massachusetts	United States	0.08%	**0.5924**	
FRFOS	Fos sur Mer	France	4.15%	**0.5880**	
FRLAV	Lavera	France	0.08%	**0.5853**	
NLRTM	Rotterdam	Netherlands	0.17%	**0.5816**	
ITLIV	Livorno	Italy	0.33%	**0.5775**	
GRSKG	Thessaloniki	Greece	1.66%	**0.5641**	
TRIST	Istanbul	Turkey	1.99%	**0.5632**	
UANIK	Nikolayev	Ukraine	0.08%	**0.5572**	
ITTAR	Taranto	Italy	0.08%	**0.5547**	
TRTUT	Tutuncifilik	Turkey	0.08%	**0.5500**	Y
TRTUZ	Tuzla	Turkey	0.08%	**0.5500**	Y
GREEU	Eleusis	Greece	3.40%	**0.5339**	
TRYAR	Yarimca	Turkey	0.08%	**0.5334**	
ESTAR	Tarragona	Spain	0.75%	**0.5320**	
PTFAO	Faro	Portugal	0.08%	**0.5297**	
GIGIB	Gibraltar	Gibraltar	0.33%	**0.5287**	
ESBCN	Barcelona	Spain	0.08%	**0.5242**	
ITGOA	Genoa	Italy	1.41%	**0.5211**	
ESBIO	Bilbao	Spain	0.08%	**0.5207**	
ESALG	Algeciras	Spain	0.17%	**0.5200**	
GRASS	Aspropyrgos	Greece	0.41%	**0.5145**	
ITPFX	Porto Foxi (Sarroch)	Italy	1.00%	**0.5104**	
TRIZM	Izmir (Smyrna)	Turkey	0.41%	**0.5070**	
GRPIR	Piraeus	Greece	4.98%	**0.5053**	
GRAGT	Agioi Theodoroi	Greece	0.66%	**0.5000**	Y
GRANI	Aghios Nikolaos	Greece	0.08%	**0.5000**	Y
GRKGS	Kos	Greece	0.08%	**0.5000**	Y
GRLAV	Lavrion (Laurium)	Greece	0.33%	**0.5000**	Y
GRMGR	Megara Oil Terminal (Agia Trias)	Greece	0.08%	**0.5000**	Y
GRNPL	Nauplia (Nafplion)	Greece	0.08%	**0.5000**	Y
HRRJK	Rijeka Bakar	Croatia	0.33%	**0.5000**	Y
ITMLZ	Milazzo	Italy	0.75%	**0.5000**	Y
ITSIR	Siracusa	Italy	0.25%	**0.5000**	Y
ITSPA	Santa Panagia	Italy	1.49%	**0.5000**	Y
ITSVN	Savona	Italy	0.58%	**0.5000**	Y
TRMER	Mersin	Turkey	1.00%	**0.4858**	
EGEDK	El Dekheila	Egypt	0.08%	**0.4796**	
EGALY	Alexandria (El Iskandariya)	Egypt	1.00%	**0.4789**	

Table 5 (cont'd). *Source ports identified for Port of Odessa, ranked according to the size of their environmental matching coefficient (C3)*

UN Port Code	Port Name	Country	Proportion of BW discharged	Environmental Matching (C3)	C3 Estimated
TRIZT	Izmit	Turkey	2.66%	**0.4771**	
PTLIS	Lisboa	Portugal	0.08%	**0.4729**	
ESLPA	Las Palmas	Spain	0.58%	**0.4602**	
CYLCA	Larnaca	Cyprus	0.33%	**0.4550**	
CNSHA	Shanghai (Shihu) Shanghai	China	0.08%	**0.4536**	
ESCAR	Cartagena	Spain	0.33%	**0.4500**	Y
ESCAS	Castellon de la Plana	Spain	1.00%	**0.4500**	Y
ITAOI	Ancona	Italy	0.50%	**0.4500**	Y
ITAUG	Augusta/Priolo	Italy	0.58%	**0.4500**	Y
ITBDS	Brindisi	Italy	0.08%	**0.4500**	Y
ITCRV	Crotone	Italy	0.41%	**0.4500**	Y
ITFAL	Falconara	Italy	0.66%	**0.4500**	Y
ITFCO	Fiumicino	Italy	0.50%	**0.4500**	Y
ITGEA	Gela	Italy	1.24%	**0.4500**	Y
ITMNF	Monfalcone	Italy	0.08%	**0.4500**	Y
ITPIO	Piombino	Italy	0.83%	**0.4500**	Y
ITPMA	Porto Marghera	Italy	0.66%	**0.4500**	Y
ITPTO	Porto Torres	Italy	0.25%	**0.4500**	Y
ITPVE	Porto Vesme (Portoscuso)	Italy	0.75%	**0.4500**	Y
DEBRE	Bremen	Germany	0.08%	**0.4464**	
HROMI	Omisalj	Croatia	3.65%	**0.4462**	
CYLMS	Limassol	Cyprus	1.99%	**0.4438**	
TRDYL	Dortyol Oil Terminal	Turkey	0.08%	**0.4420**	
BRPNG	Paranagua	Brazil	0.08%	**0.4418**	
EGDAM	Damietta	Egypt	0.08%	**0.4268**	
BRSSZ	Santos	Brazil	0.08%	**0.4097**	
MTMLA	Malta (Valletta)	Malta	0.25%	**0.4066**	
BRMCZ	Maceio	Brazil	0.08%	**0.4000**	Y
DZALG	Alger	Algeria	0.17%	**0.4000**	Y
DZORN	Oran	Algeria	0.08%	**0.4000**	Y
ITPMO	Palermo	Italy	0.17%	**0.4000**	Y
TRALI	Aliaga	Turkey	2.66%	**0.4000**	Y
TRAMB	Ambali/Kumport	Turkey	0.25%	**0.4000**	Y
TRAYT	Antalya	Turkey	0.50%	**0.4000**	Y
TRBDM	Bandirma	Turkey	0.08%	**0.4000**	Y
TRCEY	Botas-Ceyhan	Turkey	0.33%	**0.4000**	Y
TRISK	Iskenderun	Turkey	0.41%	**0.4000**	Y
TRNEM	Nemrut Bay	Turkey	0.58%	**0.4000**	Y
TRTOR	Toros	Turkey	0.08%	**0.4000**	Y
YEHOD	Hodeidah	Yemen	0.33%	**0.3940**	
NGLOS	Lagos	Nigeria	0.33%	**0.3770**	
ILASH	Ashdod	Israel	0.58%	**0.3761**	
SNDKR	Dakar	Senegal	0.00%	**0.3697**	
LBBEY	Beirut	Lebanon	0.33%	**0.3500**	Y
LBKYE	Tripoli	Lebanon	0.08%	**0.3500**	Y
MACAS	Casablanca	Morocco	0.17%	**0.3500**	Y
MANDR	Nador	Morocco	0.66%	**0.3500**	Y
MRNKC	Nouakchott	Mauritania	0.08%	**0.3500**	Y
MTMAR	Marsaxlokk	Malta	0.33%	**0.3500**	Y
SYBAN	Baniyas	Syrian Arab Republic	0.58%	**0.3500**	Y
SYLTK	Latakia	Syrian Arab Republic	0.17%	**0.3500**	Y
SYTTS	Tartous	Syrian Arab Republic	1.08%	**0.3500**	Y
TNGAE	Gabes	Tunisia	0.25%	**0.3500**	Y
SGSIN	Singapore	Singapore	0.08%	**0.3387**	
IDDUM	Dumai Sumatra	Indonesia	0.08%	**0.3054**	
ILAKL	Ashkelon	Israel	1.66%	**0.3000**	Y
ILHFA	Haifa	Israel	0.33%	**0.3000**	Y
VNHAN	Hanoi	Viet Nam	0.08%	**0.3000**	Y
MYPKG	Port Kelang	Malaysia	0.08%	**0.2763**	
MYKBA	Kuala Baram	Malaysia	0.08%	**0.2500**	Y

Table 6. *Destination ports identified for Port of Odessa, ranked according to the size of their environmental matching coefficient (C3)**

UN Port Code	Port Name	Country	Proportion of Departures	Environmental Matching (C3)	C3 Estimated
UAILK	Ilyichevsk	Ukraine	9.26	**0.819**	
UAKHE	Kherson	Ukraine	0.39	**0.750**	*Y*
UAIZM	Izmail	Ukraine	0.29	**0.750**	*Y*
UAOKT	Oktyabrsky	Ukraine	0.19	**0.750**	*Y*
UAKEH	Kerch	Ukraine	0.10	**0.750**	*Y*
UAMPW	Mariupol (=Azovstal/Zhdanov)	Ukraine	0.10	**0.750**	*Y*
UARNI	Reni	Ukraine	0.19	**0.740**	
ROMID	Midia	Romania	2.34	**0.739**	
ROCND	Constanta	Romania	16.08	**0.737**	
ROMAG	Mangalia	Romania	0.10	**0.729**	
TRERE	Eregli	Turkey	0.58	**0.690**	
BGVAR	Varna	Bulgaria	4.39	**0.687**	
TRSSX	Samsun	Turkey	0.39	**0.680**	
RUNVS	Novorossiysk	Russian Federation	1.95	**0.673**	
RUTUA	Tuapse	Russian Federation	0.10	**0.672**	
RUROS	Rostov-on-Don	Russian Federation	0.29	**0.650**	*Y*
RUAZO	Azov	Russian Federation	0.10	**0.650**	*Y*
RUTAG	Taganrog	Russian Federation	0.10	**0.650**	*Y*
GEPTI	Poti	Georgia	0.10	**0.645**	
UASVP	Sevastopol	Ukraine	0.19	**0.645**	
BGBOJ	Bourgas	Bulgaria	8.87	**0.638**	
ITVCE	Venezia (=Fusina)	Italy	0.29	**0.624**	
ITTRS	Trieste	Italy	1.36	**0.622**	
ITRAN	Ravenna	Italy	1.66	**0.613**	
UABGD	Belgorod-Dnestrovskiy	Ukraine	0.10	**0.600**	*Y*
FRFOS	Fos sur Mer	France	0.39	**0.588**	
FRLAV	Lavera	France	0.29	**0.585**	
NLRTM	Rotterdam	Netherlands	0.10	**0.582**	
ITLIV	Livorno	Italy	0.10	**0.578**	
CNNGB	Ningbo Zhejiang	China	0.10	**0.565**	
GRSKG	Thessaloniki	Greece	0.58	**0.564**	
TRIST	Istanbul	Turkey	6.63	**0.563**	
GRVOL	Volos	Greece	0.10	**0.559**	
UANIK	Nikolayev	Ukraine	0.19	**0.557**	
ITTAR	Taranto	Italy	0.10	**0.555**	
YUBAR	Bar	Yugoslavia (Fed Rep Of)	0.29	**0.550**	*Y*
NOSVG	Stavanger	Norway	0.10	**0.550**	*Y*
ESVLC	Valencia	Spain	0.10	**0.545**	
GREEU	Eleusis	Greece	1.75	**0.534**	
TRYAR	Yarimca	Turkey	1.07	**0.533**	
ESTAR	Tarragona	Spain	0.10	**0.532**	
ESBCN	Barcelona	Spain	0.19	**0.524**	
ITGOA	Genoa	Italy	0.58	**0.521**	
ESALG	Algeciras	Spain	0.39	**0.520**	
KRPUS	Pusan	Korea Republic of	0.10	**0.516**	
GRASS	Aspropyrgos	Greece	0.19	**0.515**	
USHOU	Houston Texas	United States	0.29	**0.511**	
ITPFX	Porto Foxi (Sarroch)	Italy	0.58	**0.510**	
TRIZM	Izmir (Smyrna)	Turkey	0.78	**0.507**	
GRPIR	Piraeus	Greece	1.07	**0.505**	
GRJKH	Chios	Greece	0.19	**0.504**	
ITSPA	Santa Panagia	Italy	0.58	**0.500**	*Y*
ALDRZ	Durres	Albania	0.49	**0.500**	*Y*
ITMLZ	Milazzo	Italy	0.29	**0.500**	*Y*
GBQUB	Queenborough	United Kingdom	0.19	**0.500**	*Y*
CNBAY	Bayuquan Liaoning	China	0.10	**0.500**	*Y*
DKHOR	Horsens	Denmark	0.10	**0.500**	*Y*
GRSTA	Stavros/Vathi	Greece	0.10	**0.500**	*Y*
HRRJK	Rijeka Bakar	Croatia	0.10	**0.500**	*Y*
HRZAD	Zadar	Croatia	0.10	**0.500**	*Y*
ITMDC	Marina di Carrara	Italy	0.10	**0.500**	*Y*
ITSIR	Siracusa	Italy	0.10	**0.500**	*Y*
ITTAL	Talamone	Italy	0.10	**0.500**	*Y*

Table 6 (cont'd). *Destination ports identified for Port of Odessa, ranked according to the size of their environmental matching coefficient (C3)*

UN Port Code	Port Name	Country	Proportion of Departures	Environmental Matching (C3)	C3 Estimated
BEANR	Antwerpen	Belgium	0.10	**0.499**	
PECLL	Callao	Peru	0.10	**0.493**	
TRMER	Mersin	Turkey	0.49	**0.486**	
EGALY	Alexandria (El Iskandariya)	Egypt	1.85	**0.479**	
TRIZT	Izmit	Turkey	0.29	**0.477**	
CYLCA	Larnaca	Cyprus	0.10	**0.455**	
CNSHA	Shanghai (Shihu) Shanghai	China	0.10	**0.454**	
ITAUG	Augusta/Priolo	Italy	0.58	**0.450**	*Y*
ESCAS	Castellon de la Plana	Spain	0.10	**0.450**	*Y*
ESFER	Ferrol/Laxe	Spain	0.10	**0.450**	*Y*
ESMOT	Motril	Spain	0.10	**0.450**	*Y*
ITBDS	Brindisi	Italy	0.10	**0.450**	*Y*
ITBRI	Bari	Italy	0.10	**0.450**	*Y*
ITCVV	Civitavecchia	Italy	0.10	**0.450**	*Y*
HROMI	Omisalj	Croatia	0.49	**0.446**	
CYLMS	Limassol	Cyprus	0.88	**0.444**	
TRDYL	Dortyol Oil Terminal	Turkey	0.78	**0.442**	
BRRIO	Rio de Janeiro	Brazil	0.10	**0.429**	
EGDAM	Damietta	Egypt	0.10	**0.427**	
CNHUA	Huangpu (Xinzao) Guangdong	China	0.29	**0.414**	
THBKK	Bangkok	Thailand	0.49	**0.414**	
MTMLA	Malta (Valetta)	Malta	0.10	**0.407**	
TRALI	Aliaga	Turkey	0.88	**0.400**	*Y*
DZALG	Alger	Algeria	0.68	**0.400**	*Y*
TRAMB	Ambali/Kumport	Turkey	0.68	**0.400**	*Y*
TRISK	Iskenderun	Turkey	0.58	**0.400**	*Y*
DZORN	Oran	Algeria	0.29	**0.400**	*Y*
TRMRM	Marmaris	Turkey	0.29	**0.400**	*Y*
TRGEB	Gebze	Turkey	0.19	**0.400**	*Y*
CNJIA	Jiangyin Jiangsu	China	0.10	**0.400**	*Y*
CNXMN	Xiamen (Weitou) Fujian	China	0.10	**0.400**	*Y*
CUHAV	Habana	Cuba	0.10	**0.400**	*Y*
TRTEK	Tekirdag	Turkey	0.10	**0.400**	*Y*
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	0.19	**0.396**	
TWKHH	Kaohsiung	Taiwan Province of China	0.19	**0.388**	
IDJKT	Jakarta Java	Indonesia	0.49	**0.386**	
NGTIN	Tin Can Island	Nigeria	0.19	**0.383**	
NGLOS	Lagos	Nigeria	0.10	**0.377**	
ILASH	Ashdod	Israel	2.24	**0.376**	
EGPSD	Port Said	Egypt	0.10	**0.375**	
SNDKR	Dakar	Senegal	0.10	**0.370**	
DJJIB	Djibouti	Djibouti	0.19	**0.361**	
USMSY	New Orleans	United States	0.10	**0.361**	
DEFLF	Flensburg	Germany Federal Republic Of	0.10	**0.360**	*Y*
SDPZU	Port Sudan	Sudan	0.10	**0.354**	
SYTTS	Tartous	Syrian Arab Republic	0.88	**0.350**	*Y*
LBBEY	Beirut	Lebanon	0.68	**0.350**	*Y*
DZSKI	Skikda/Phillippeville	Algeria	0.58	**0.350**	*Y*
MACAS	Casablanca	Morocco	0.58	**0.350**	*Y*
LBKYE	Tripoli	Lebanon	0.10	**0.350**	*Y*
MANDR	Nador	Morocco	0.10	**0.350**	*Y*
PTAVE	Aveiro	Portugal	0.10	**0.350**	*Y*
PTSET	Setubal	Portugal	0.10	**0.350**	*Y*
TNBIZ	Bizerte	Tunisia	0.10	**0.350**	*Y*
PHMNL	Manila	Philippines	0.19	**0.349**	
SGSIN	Singapore	Singapore	0.68	**0.339**	
MYLUM	Lumut	Malaysia	0.10	**0.332**	
INMUN	Mundra	India	0.19	**0.331**	
INTUT	Tuticorin (New Tuticorin)	India	0.10	**0.330**	
ILHFA	Haifa	Israel	0.97	**0.300**	*Y*
ILAKL	Ashkelon	Israel	0.19	**0.300**	*Y*
THKSI	Koh Sichang	Thailand	0.19	**0.300**	*Y*
AOLOB	Lobito	Angola	0.10	**0.300**	*Y*
GHTEM	Tema	Ghana	0.10	**0.300**	*Y*
ILHAD	Hadera	Israel	0.10	**0.300**	*Y*
VNVUT	Vung Tau	Viet Nam	0.10	**0.300**	*Y*
AEDXB	Dubai	United Arab Emirates	0.10	**0.268**	

4.7 Risk species

The risk species threat from a source port depends on the number of introduced and native species in its bioregion, and their categorisations as unlikely, suspected or known harmful species (Section 3.9).

The risk species threat coefficient (C4) of the BW source ports identified for Odessa are shown in Figure 23 and listed in Table 7. Table 7 also lists the scores for the introduced, suspected and known harmful species of the source port bioregions, as had been added and assigned to the database's species tables by March 2003. As noted in Section 3.9, these tables and their associated Excel species reference file do not give a complete global list, but provide a working resource enabling convenient update and improvement for each bioregion. Similarly, the 204 bioregions on the GIS world map should not be considered unalterable. Regional resolution of species-presence records is steadily improving in several areas, and this will allow many bioregions to become divided into increasingly smaller units (ultimately approaching the scale of local port waters).

It should also be recognised that the distribution of risk species in the database also contains a regional bias due to the level of aquatic sampling and taxonomic effort in the Black Sea and other parts of Europe, plus Australia/New Zealand and North America.

The species in Table 8 include preliminary from the Odessa PBBS, plus those listed in published and unpublished reports collated by Group C members (Section 3.9 and Appendix 5). It also lists recent final identifications (i.e. not included in the C4 calculation).

Many of the species listed for the bioregions with source ports trading with Odessa can be related to their history of transfer via aquaculture, hull fouling on sailing vessels and the canal/river-link invasions of the east Mediterranean (Suez Canal, 1899), east Europe (Ponto-Caspian rivers and Volga-Don canal that opened in 1952) and the Great Lakes (St Lawrence River seaway). The regional and often patchy sampling bias needs to be remembered when comparing C4 values between different bioregions, and is a further reason why the independent treatment of C3 for calculating the ROR values is a safer approach (Section 3.10).

Because of the different historical vectors (hull fouling, canal links, aquaculture, dry ballast, water ballast, etc), a future version of the BWRA system could provide more accurate C4 values for BW-mediated introduction threats if vector weightings are added to the database for the C4 calculation.

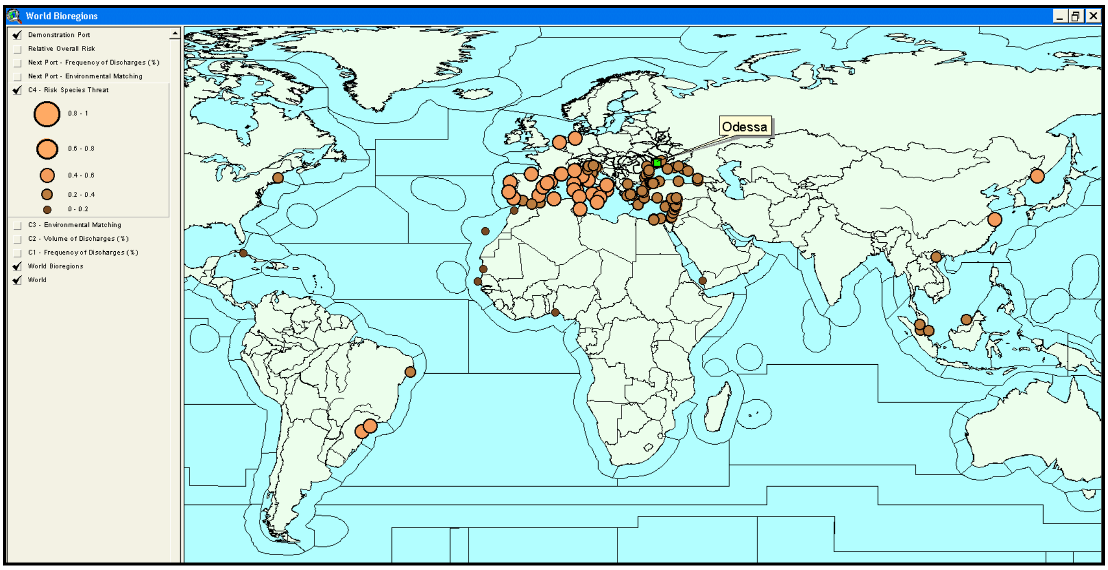

Figure 23. *GIS output showing the location and risk species threat coefficients (C4) of the BW source ports identified for the Port of Odessa*

***Table 7.** Ranking of BW source ports identified for Port of Odessa, according to the size of their risk species threat (C4).*

Port Code	Source Port	Country	Bio-Region	No. of Introduced Species	Suspected Harmful Species	Knwn Harmful Species	Total Threat Value	Relative Risk Species Threat (C4)
CNSHA	Shanghai (Shihu) Shanghai	China	NWP-3a	11	10	11	151	**0.572**
BRPNG	Paranagua	Brazil	SA-IIB	20	6	11	148	**0.561**
BRSSZ	Santos	Brazil	SA-IIB	20	6	11	148	**0.561**
RUNJK	Nakhodka	Russian Federation	NWP-4a	8	10	11	148	**0.561**
ESBIO	Bilbao	Spain	NEA-V	20	8	8	124	**0.470**
PTFAO	Faro	Portugal	NEA-V	20	8	8	124	**0.470**
PTLEI	Leixoes	Portugal	NEA-V	20	8	8	124	**0.470**
PTLIS	Lisboa	Portugal	NEA-V	20	8	8	124	**0.470**
DEBRE	Bremen	Germany	NEA-II	22	7	8	123	**0.466**
NLRTM	Rotterdam	Netherlands	NEA-II	22	7	8	123	**0.466**
DZALG	Alger	Algeria	MED-II	18	3	8	107	**0.405**
ESBCN	Barcelona	Spain	MED-II	18	3	8	107	**0.405**
ESCAR	Cartagena	Spain	MED-II	18	3	8	107	**0.405**
ESCAS	Castellon de la Plana	Spain	MED-II	18	3	8	107	**0.405**
ESTAR	Tarragona	Spain	MED-II	18	3	8	107	**0.405**
FRFOS	Fos sur Mer	France	MED-II	18	3	8	107	**0.405**
FRLAV	Lavera	France	MED-II	18	3	8	107	**0.405**
ITBDS	Brindisi	Italy	MED-VII	18	3	8	107	**0.405**
ITFAL	Falconara	Italy	MED-VII	18	3	8	107	**0.405**
ITGOA	Genoa	Italy	MED-II	18	3	8	107	**0.405**
ITLIV	Livorno	Italy	MED-II	18	3	8	107	**0.405**
ITMLZ	Milazzo	Italy	MED-III	18	3	8	107	**0.405**
ITPIO	Piombino	Italy	MED-III	18	3	8	107	**0.405**
ITPVE	Porto Vesme (Portoscuso)	Italy	MED-II	18	3	8	107	**0.405**
ITRAN	Ravenna	Italy	MED-VII	18	3	8	107	**0.405**
ITSIR	Siracusa	Italy	MED-IV	18	3	8	107	**0.405**
ITSPA	Santa Panagia	Italy	MED-IV	18	3	8	107	**0.405**
ITSVN	Savona	Italy	MED-II	18	3	8	107	**0.405**
ITTAR	Taranto	Italy	MED-IV	18	3	8	107	**0.405**
MTMAR	Marsaxlokk	Malta	MED-IV	18	3	8	107	**0.405**
MTMLA	Malta (Valetta)	Malta	MED-IV	18	3	8	107	**0.405**
TNGAE	Gabes	Tunisia	MED-IV	18	3	8	107	**0.405**
ITGEA	Gela	Italy	MED-IV	17	3	8	106	**0.402**
ITMNF	Monfalcone	Italy	MED-VII	17	3	8	106	**0.402**
ITPMA	Porto Marghera	Italy	MED-VII	17	3	8	106	**0.402**
ITPTO	Porto Torres	Italy	MED-II	17	3	8	106	**0.402**
TNBIZ	Bizerte	Tunisia	MED-III	17	3	8	106	**0.402**
CYLCA	Larnaca	Cyprus	MED-V	18	3	7	97	**0.367**
CYLMS	Limassol	Cyprus	MED-V	18	3	7	97	**0.367**
EGALY	Alexandria (El Iskandariya)	Egypt	MED-V	18	3	7	97	**0.367**
EGDAM	Damietta	Egypt	MED-V	18	3	7	97	**0.367**
EGEDK	El Dekheila	Egypt	MED-V	18	3	7	97	**0.367**
ILASH	Ashdod	Israel	MED-V	18	3	7	97	**0.367**
ILHFA	Haifa	Israel	MED-V	18	3	7	97	**0.367**
ITAOI	Ancona	Italy	MED-VII	18	3	7	97	**0.367**
LBBEY	Beirut	Lebanon	MED-V	18	3	7	97	**0.367**
LBKYE	Tripoli	Lebanon	MED-V	18	3	7	97	**0.367**
SYBAN	Baniyas	Syrian Arab Republic	MED-V	18	3	7	97	**0.367**
SYLTK	Latakia	Syrian Arab Republic	MED-V	18	3	7	97	**0.367**
SYTTS	Tartous	Syrian Arab Republic	MED-V	18	3	7	97	**0.367**
TRAYT	Antalya	Turkey	MED-V	18	3	7	97	**0.367**
TRCEY	Botas-Ceyhan	Turkey	MED-V	18	3	7	97	**0.367**
TRDYL	Dortyol Oil Terminal	Turkey	MED-V	18	3	7	97	**0.367**
TRISK	Iskenderun	Turkey	MED-V	18	3	7	97	**0.367**
TRMER	Mersin	Turkey	MED-V	18	3	7	97	**0.367**
TRTOR	Toros	Turkey	MED-V	18	3	7	97	**0.367**
DZORN	Oran	Algeria	MED-I	17	3	7	96	**0.364**
ESALG	Algeciras	Spain	MED-I	17	3	7	96	**0.364**
GIGIB	Gibraltar	Gibraltar	MED-I	17	3	7	96	**0.364**
GRAGT	Agioi Theodoroi	Greece	MED-VI	17	3	7	96	**0.364**
GRANI	Aghios Nikolaos	Greece	MED-VI	17	3	7	96	**0.364**

Table 7 (cont'd). *Ranking of BW source ports identified for Port of Odessa, according to the size of their risk species threat (C4).*

Port Code	Source Port	Country	Bio-Region	No. of Introduced Species	Suspected Harmful Species	Knwn Harmful Species	Total Threat Value	Relative Risk Species Threat (C4)
GRASS	Aspropyrgos	Greece	MED-VI	17	3	7	96	**0.364**
GREEU	Eleusis	Greece	MED-VI	17	3	7	96	**0.364**
GRKGS	Kos	Greece	MED-VI	17	3	7	96	**0.364**
GRLAV	Lavrion (Laurium)	Greece	MED-VI	17	3	7	96	**0.364**
GRMGR	Megara Oil Terminal	Greece	MED-VI	17	3	7	96	**0.364**
GRNPL	Nauplia (Nafplion)	Greece	MED-VI	17	3	7	96	**0.364**
GRPIR	Piraeus	Greece	MED-VI	17	3	7	96	**0.364**
GRSKG	Thessaloniki	Greece	MED-VI	17	3	7	96	**0.364**
HROMI	Omisalj	Croatia	MED-VII	17	3	7	96	**0.364**
HRRJK	Rijeka Bakar	Croatia	MED-VII	17	3	7	96	**0.364**
ITAUG	Augusta/Priolo	Italy	MED-IV	17	3	7	96	**0.364**
ITCRV	Crotone	Italy	MED-IV	17	3	7	96	**0.364**
ITFCO	Fiumicino	Italy	MED-III	17	3	7	96	**0.364**
ITPFX	Porto Foxi (Sarroch)	Italy	MED-II	17	3	7	96	**0.364**
ITPMO	Palermo	Italy	MED-III	17	3	7	96	**0.364**
ILAKL	Ashkelon	Israel	MED-V	17	3	7	96	**0.364**
ITTRS	Trieste	Italy	MED-VII	17	3	7	96	**0.364**
ITVCE	Venezia (=Fusina)	Italy	MED-VII	17	3	7	96	**0.364**
MANDR	Nador	Morocco	MED-I	17	3	7	96	**0.364**
SIKOP	Koper	Slovenia	MED-VII	17	3	7	96	**0.364**
TRALI	Aliaga	Turkey	MED-VI	17	3	7	96	**0.364**
TRAMB	Ambali/Kumport	Turkey	MED-VIII	17	3	7	96	**0.364**
TRBDM	Bandirma	Turkey	MED-VIII	17	3	7	96	**0.364**
TRIST	Istanbul	Turkey	MED-VIII	17	3	7	96	**0.364**
TRIZM	Izmir (Smyrna)	Turkey	MED-VI	17	3	7	96	**0.364**
TRIZT	Izmit	Turkey	MED-VIII	17	3	7	96	**0.364**
TRNEM	Nemrut Bay	Turkey	MED-VI	17	3	7	96	**0.364**
TRTUT	Tutuncifilik	Turkey	MED-VIII	17	3	7	96	**0.364**
TRTUZ	Tuzla	Turkey	MED-VIII	17	3	7	96	**0.364**
TRYAR	Yarimca	Turkey	MED-VIII	17	3	7	96	**0.364**
USBOS	Boston Massachusetts	United States	NA-ET2	9	2	6	75	**0.284**
ROCND	Constanta	Romania	MED-IXB	15	3	5	74	**0.280**
ROGAZ	Galatz	Romania	MED-IXB	15	3	5	74	**0.280**
ROMAG	Mangalia	Romania	MED-IXB	15	3	5	74	**0.280**
ROMID	Midia	Romania	MED-IXB	15	3	5	74	**0.280**
UADNB	Dnepro-Bugsky	Ukraine	MED-IXB	15	3	5	74	**0.280**
UAILK	Ilyichevsk	Ukraine	MED-IXB	15	3	5	74	**0.280**
UANIK	Nikolayev	Ukraine	MED-IXB	15	3	5	74	**0.280**
IDDUM	Dumai Sumatra	Indonesia	EAS-VI	5	6	5	73	**0.277**
MYKBA	Kuala Baram	Malaysia	EAS-I	5	6	5	73	**0.277**
MYPKG	Port Kelang	Malaysia	EAS-VI	5	6	5	73	**0.277**
SGSIN	Singapore	Singapore	EAS-VI	5	6	5	73	**0.277**
VNHAN	Hanoi	Viet Nam	EAS-I	5	6	5	73	**0.277**
BGBOJ	Bourgas	Bulgaria	MED-IXA	14	3	4	63	**0.239**
BGVAR	Varna	Bulgaria	MED-IXA	14	3	4	63	**0.239**
GEBUS	Batumi	Georgia	MED-IXA	14	3	4	63	**0.239**
GEPTI	Poti	Georgia	MED-IXA	14	3	4	63	**0.239**
RUNVS	Novorossiysk	Russian Federation	MED-IXA	14	3	4	63	**0.239**
RUTUA	Tuapse	Russian Federation	MED-IXA	14	3	4	63	**0.239**
TRERE	Eregli	Turkey	MED-IXA	14	3	4	63	**0.239**
TRSSX	Samsun	Turkey	MED-IXA	14	3	4	63	**0.239**
UAFEO	Feodosiya	Ukraine	MED-IXA	14	3	4	63	**0.239**
UASVP	Sevastopol	Ukraine	MED-IXA	14	3	4	63	**0.239**
BRMCZ	Maceio	Brazil	SA-III	6	5	4	61	**0.231**
UAKEH	Kerch	Ukraine	MED-X	11	1	4	54	**0.205**
YEHOD	Hodeidah	Yemen	RS-1	4	2	1	20	**0.076**
ESLPA	Las Palmas	Spain	WA-I	0	0	0	0	**0.000**
MACAS	Casablanca	Morocco	WA-I	0	0	0	0	**0.000**
MRNKC	Nouakchott	Mauritania	WA-I	0	0	0	0	**0.000**
NGLOS	Lagos	Nigeria	WA-II	0	0	0	0	**0.000**
SNDKR	Dakar	Senegal	WA-I	0	0	0	0	**0.000**

Finally, it is worth noting the database cannot produce 'reverse' C4 values for BW destination ports (i.e. measures of relative threat posed by BW exported from Odessa). This requires knowing the sources of all the other BW discharged at each destination port. What can be extracted from the database to assist a 'reverse' BWRA is the list of species assigned to the bioregion of Odessa (MED-IXB; Figure 7, Table 8).

Table 8. *Status of risk species assigned to the bioregion of Odessa (MED-IXB)*

Group	Common Name	Species Name	Regional Status	Threat Status
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium tamarense**	Introduced	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium affine**	Introduced	Suspected harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium catenella**	Introduced	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium pseudogonyaulax**	Introduced	Suspected harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Cochlodinium polykrikoides**	Introduced	Suspected harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gyrodinium cf. aureolum**	Introduced	Suspected harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gymnodinium catenatum*	Introduced	Known harmful species
Pyrrophyta/Dinophycae	Freshwater dinoflagellate	*Gymondinium uberrimum*	Introduced	Suspected harmful species
Pyrrophyta/Dinophycae	Dinoflagellate	*Spatulodinium pseudonoctiluca**	Introduced	Not suspected
Pyrrophyta/Dinophycae	Dinoflagellate	*Pyramimonas longicauda**	Introduced	Not suspected
Bacillariophyta/Centricae	Centric diatom	*Thalassiotrix mediterraneae**	Introduced	Not suspected
Bacillariophyta/Centricae	Centric diatom	*Rhizosolenia calcar-avis*	Introduced	Suspected harmful species
Phaeophyta	Soft sour weed	*Desmarestia viridis (Fucus viridis)*	Introduced	Suspected harmful species
Phaeophyta	Brown alga	*Striaria attenuata*	Native	Not suspected
Hyphomyceta	Marine fungi	*Savoryella lignicola**	Cryptogenic	Not suspected
Hyphomyceta	Marine fungi	*Cirrenalia basiminuta**	Cryptogenic	Not suspected
Cnidaria, Scyphomedusae	Moon Jellyfish	*Aurelia aurita*	Native	Suspected harmful species
Ctenophora, Lobata	Beroe comb jellyfish	*Beroe ovata*	Introduced	Not suspected
Ctenophora, Lobata	Comb jellyfish	*Mnemiopsis leidyi*	Introduced	Known harmful species
Annelida, Polychaeta	Hesionid errant bristle worm	*Hesionides arenarius*	Introduced	Not suspected
Annelida, Polychaeta	Reef-building serpulid tube worm*	*Ficopomatous enigmaticus (syn. Mercierella enigmatica)**	Introduced	Suspected harmful species
Annelida, Polychaeta	Tube worm	*Tubificoides benedii**	Introduced	Not suspected
Annelida, Polychaeta	Sedentary spionid worm	*Polydora ciliata limicola*	Native	Not suspected
Crustacea, Copepoda	Black Sea copepod	*Acartia clausi*	Native	Suspected harmful species
Crustacea, Cirripedia	Ivory barnacle	*Balanus eburneus*	Introduced	Not suspected
	Stripoed barnacle	*Balanus amphitrite**	Introduced	Not suspected
Crustacea, Cirripedia	Bay barnacle	*Balanus improvisus*	Introduced	Not suspected
Crustacea, Amphipoda	Sea flea	*Corophium acherusicum*	Native	Not suspected
Crustacea, Amphipoda	Sea flea	*Corophium volutator*	Native	Not suspected
Crustacea, Isopoda	Sea Lice	*Dynamene bidentata*	Native	Not suspected
Crustacea, Isopoda	Sea Lice	*Sphaeroma serratum*	Native	Not suspected
Crustacea, Decapoda	Chinese mitten crab	*Eriocheir sinensis*	Introduced	Known harmful species
Crustacea, Decapoda	Burrowing xanthid crab	*Rithropanopaeus harrisii tridentatus*	Introduced	Not suspected
Mollusca, Gastropoda	New Zealand periwinkle	*Potamopyrgus jenkinsi*	Introduced	Not suspected
Mollusca, Thaididae	Veined rapa whelk	*Rapana venosa (= R. thomasiana)*	Introduced	Suspected harmful species
Mollusc, Arcidae	Ark shell	*Anadara inaequivalis*	Introduced	Suspected harmful species
Mollusca, Cardiidae	European Cockle	*Hypanis colorata*	Native	Not suspected
Mollusca, Mytilidae	Mediterranean blue mussel	*Mytilus galloprovincialis*	Native	Known harmful species
Mollusca, Mytilidae	NW European blue mussel	*Mytilus edulis**	Introduced	Not suspected
Mollusca, Mytilidae	Baltic sea blue mussel	*Mytilus trossulus**	Introduced	Not suspected
Mollusca, Myidae	Soft-shell clam	*Mya arenaria*	Introduced	Suspected harmful species
Mollusca, Teridiidae	Ship worm	*Teredo navalis*	Introduced	Known harmful species
Mollusca, Ophistobranchia	Nudibranch	*Ercolania funerea**	Introduced	Not suspected
Mollusca, Ophistobranchia	Dorid nudibranch	*Doridella obscura**	Introduced	Not suspected
Entoprocta	Kamptozoan nodding heads	*Barentsia benedeni*	Native	Not suspected
Ectoprocta/Ctenostomata	Marine sea moss (Bryozoan)	*Bowerbankia imbricata*	Native	Not suspected
Ectoprocta/Cheilostomata	Marine sea moss (Bryozoan)	*Conopeum seurati*	Native	Not suspected
Ectoprocta/Cheilostomata	Marine sea moss (Bryozoan)	*Cryptosula pallasiana*	Native	Suspected harmful species
Ectoprocta/Cheilostomata	Nth American FW sea moss	*Urnatella gracilis*	Introduced	Not suspected
Urochordata	Colonial sea squirt (tunicate)	*Botryllus schlosseri*	Native	Not suspected
Pisces, Mugilidae	Amur sea mullet	*Mugil soiuy*	Introduced	Not suspected
Pisces, Perciformes	N American pumpkin-seed fish	*Lepomis gibbosus*	Introduced	Known harmful species

*species identified from the Odessa PBBS after February 2003 (not included by C4 calculation)

Spatial patterns of introduced species found inside port of Odessa harbour

Recent research work by Group C counterparts at IBSS has used results from the PBBS survey and BWRA database to investigate the numbers of both recently-discovered and all introduced species sampled from harbour substrates within each terminal, and to see if higher numbers are associated with the harbour areas that receive most BW discharge. Recently-discovered species are those believed to have arrived in the past 15-25 years as a result of increasing port trade (Section 4.1). The aim was to see if there was any link between the volumes and sources of BW discharged within the different terminals at Odessa, and the abundance of these species on nearby wharf piles, harbour walls and seafloor substrates.

The results are shown in Figure 24. The plots indicate there is no strong relationship between volumes of BW discharged and the number of recently-discovered and all introduced species. However, numbers of the recently-discovered species were almost twice as high at the two terminals which receive the largest individual BW tank discharges (i.e. from large oil tankers and bulk carriers visiting the oil and grain terminals respectively).

Analysis of the BWRA database to determine which regions were the most common source of BW at Odessa showed that Italian source ports (most on the Adriatic coast) contributed the largest proportion of the total discharged volumes, as shown in Figure 25.

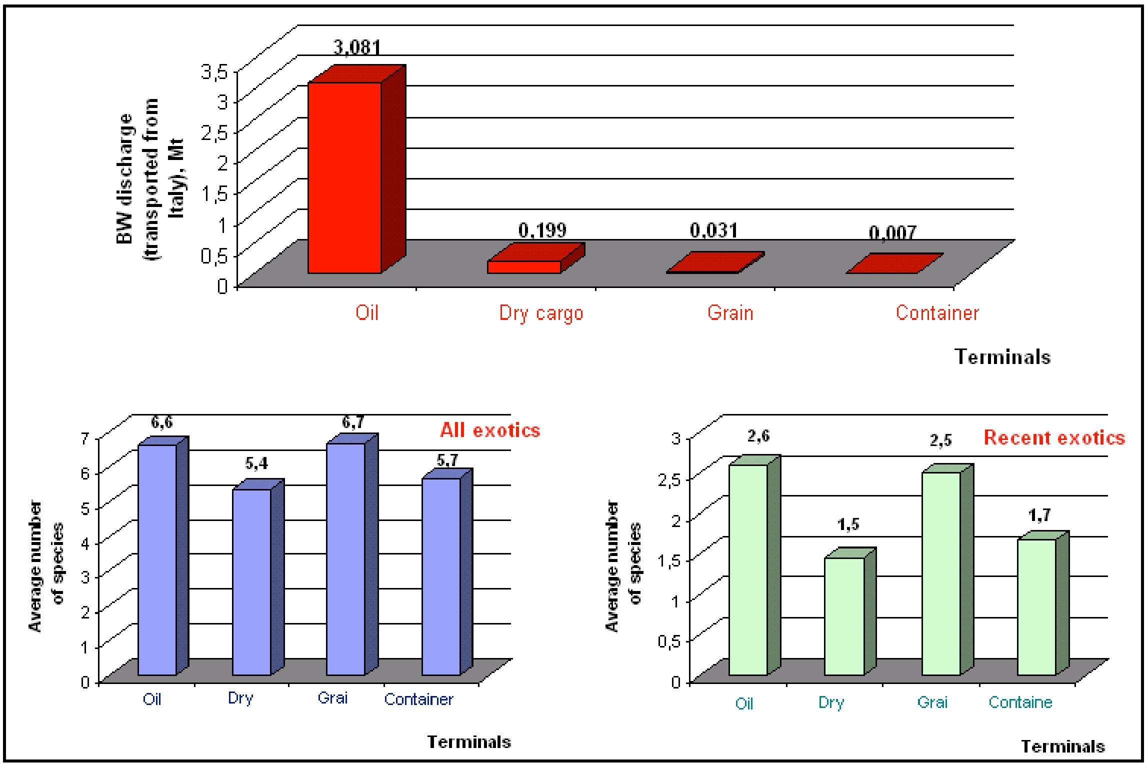

Figure 24. *Plots showing numbers of all and recently-introduced species in the four terminal areas that receive almost all BW discharged in the Port of Odessa.*

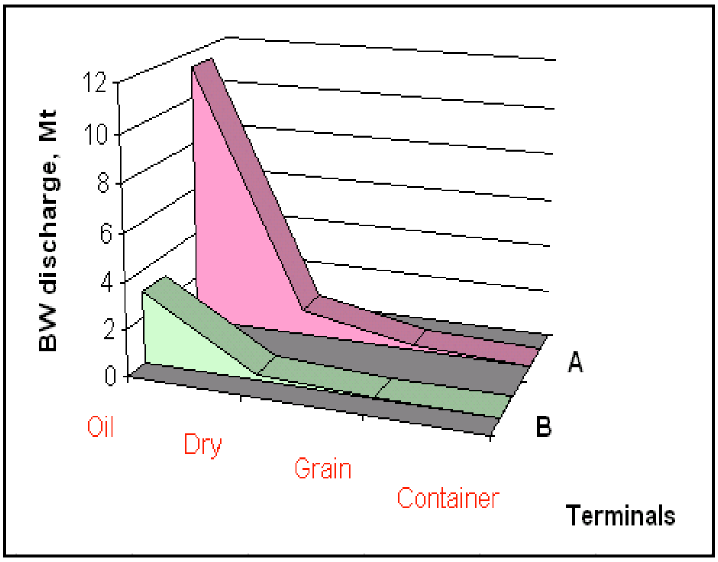

Figure 25. *Comparison of BW volumes discharged at the Odessa terminals from all source ports (A) and from the Italian source ports (B).*

Value of specific production and trophic status as predictors of risk species threat

IBSS scientists in Group C have also been investigating the effect of the widespread eutrophication of the NW shelf of the Black Sea with respect to the functional activity of the most dominant introductions. Severe eutrophication of the coastal water in the Odessa region occurred in the 1960s-1980s as a result of widespread increased use of mineral fertilisers in the river catchments, plus reduced flushing owing to the decreased freshwater inputs due to major river damming projects (e.g. Alexandrov & Zaitsev 1998, Zaitsev Yu P & V Mamaev (1997).

Eutrophication led to a major increase in both pelagic and benthic zone primary production (the former also becoming >200 times that of the latter). Marked changes to the predominant planktonic and benthic species led to major modifications of community composition, with the new dominant taxa showing a doubling of functional activity (Table 9). Introduced species characterized by maximal values of specific production were at the forefront of these mass-predominant taxa[19]. The increased trophic conditions also caused a marked decline in biodiversity, which in turn led to ecosystem instability and created niches now occupied by highly productive species more adapted to the new conditions. Thus the increased BW transportation into the Black Sea over the same period (1970s-present; both volume and frequency) had enhanced the number of successful introductions, with the most invasive being highly-productive and hence ‘pre-adapted’taxa which could acclimatize and expand rapidly in the recently-formed niches.

If the coastal waters of the Black Sea maintain their elevated trophic status, then it seems possible to predict the invasiveness (and hence threat) of newly-discovered or potential introductions using the criteria in Table 9 (as summarised from Appendix 7). Thus the calculation of C4 could be improved if specific production coefficients can be added to reflect the functional activity of the predominant pelagic and benthic native species inhabiting the receival port’s bioregion. These coefficients would behave and could be treated as a ‘species similarity’ index for BW source ports. Similarly, C3 could be improved by adding appropriate parameter/s reflecting the trophic status of the ports. Such parameters could be selected from those used in the OECD or TRIX trophic classification methods,

[19] Specific production is the ratio of a species productivity (P; biomass increase per unit of time) and its standing biomass (B; same mass unit), and is useful for measuring and comparing a species functional activity. The specific production ratio (P/B) is based on different time intervals for different groups of organisms. Accepted units of measurements for phytoplankton, seaweeds (macrophytes) and macrobenthic animals are day-1, month-1 and year-1 respectively (refer Appendix 7 for the P/B calculation methods of the major groups).

i.e. chlorophyll *a* (yearly average and peak), O_2 saturation, dissolved inorganic N (DIN), total P, Secci transparency.

Table 9. *Increase in the average specific production (d^{-1}) of predominant taxa (by biomass) in the Black Sea*.*

Group	Past (pre-eutrophication)	Present (post-eutrophication)	Criteria for predicting invasion success
Phytoplankton	1.828	2.967	>2.4
Zooplankton	0.484	1.042	>1.2
Seaweeds	0.008	0.017	>0.012
Macrobenthic animals	0.011	0.017	>0.022#

*averaged from tables of native and introduced taxa listed in Appendix 7. # = less certain.

4.8 Risk assessment results

The database calculates the relative overall risk (ROR) of a potentially harmful introduction for all source ports that have C1-C4 coefficients and R1-R2 factors. The ROR value for each source port represents a proportion of the threat posed to the Demonstration Site as result of its contemporary trading pattern (1999-2002).

After calculating the RORs the database generates a large output table listing the source ports and their coefficients, risk-reduction factors and ROR value, plus the five ROR categories used for the GIS plot and the standardised ROR values (S-ROR; Section 3.10). Results from the project-standard BWRA for the Port of Odessa are listed in Table 9, and GIS plots of the ROR categories are shown in Figure 26.

From the tank discharge records in the Odessa database, the project standard calculation identified 19 of the 122 source ports (15.6%) as representing the highest risk group (in terms of their BW source frequency, volume, environmental similarity and assigned risk species). These ports provided the top 20% of the total ROR, with individual values in the 0.24 – 0.31 range (i.e. 1 - 1.25% of the total relative risk; Table 9). The highest risk ports were led by Nakhodka in the Sea of Japan, followed by the Bulgarian Black Sea port of Bourgas then the Italian Adriatic port of Trieste (Table 9). Of the 19 highest risk ports, 8 were in Black Sea, 9 were in the Adriatic and Eastern Mediterranean and two were beyond this region. Thus after Nakhodka, the other non-Mediterranean/Black Sea port in the highest risk group was the French Atlantic port of Fos sur Mer (ranked 12th; Table 9).

The number of BW source ports in the medium, low and lowest risk categories were 23 (19%), 25 (21%) and 34 (28%) respectively (Table 9). The vast majority of ports in the lowest risk category were subtropical or tropical, with four exceptions being the ports of Bremen (Germany), Rijeka Bakar (Croatia) and Piombino and Ancone (Italy). The source port with the lowest ROR (0.087; 0.36% of total risk) was the Mauritanian port of Nouakchott on the West African coast (Table 9).

Based on the current pattern of shipping trade (1999-2002), the plot of the ROR results in Figure 26 implies that BW from vessels arriving from the temperate to warm temperate ports of southern Europe provide the highest risk, together with the eastern Russian port of Nakhodka which is located beside the Sea of Japan. These results are logical given Odessa's biogeographic location and current pattern of trade. The results also suggest that the project standard 'first-pass' treatment of the risk coefficients provides a useful benchmark for any investigative manipulations of the risk formula or database management.

The recent history of invasions to and from the NE American seaboard and the Black Sea, both directly and via Western Europe stepping stones, also match the first-pass C1-C4 and ROR results, which indicate that Odessa has not been the key entry or exit point for these introductions. The picture is less certain for introductions into the Caspian Sea, since Odessa does trade with ports in and beside the Azov Sea and Don River mouth, which leads to the Volga-Don canal (Section 4.5).

The project standard results also imply that any species which establishes in a Black Sea or northern Mediterranean port can be readily spread to Odessa, Illyichivesk or other ports in the MED-IXB bioregion via the current pattern of shipping trade. It therefore would be worth obtaining further port environmental data to increase the proportion of calculated C3 coefficients for ports in the Adriatic, Aegean, Marmara and Black Sea regions.

Figure 27 shows the frequency distribution of the standardised ROR values. This plot shows that five BW source ports form a small 'highest-risk' group (i.e. Nakhodka, Bourgas, Trieste, Constanta and Ilyichevsk). These are followed by a relatively steep grade of highest, high and medium risk source ports, which in turn lead into a long tail of low and lowest risk ports on the left side of the plot.

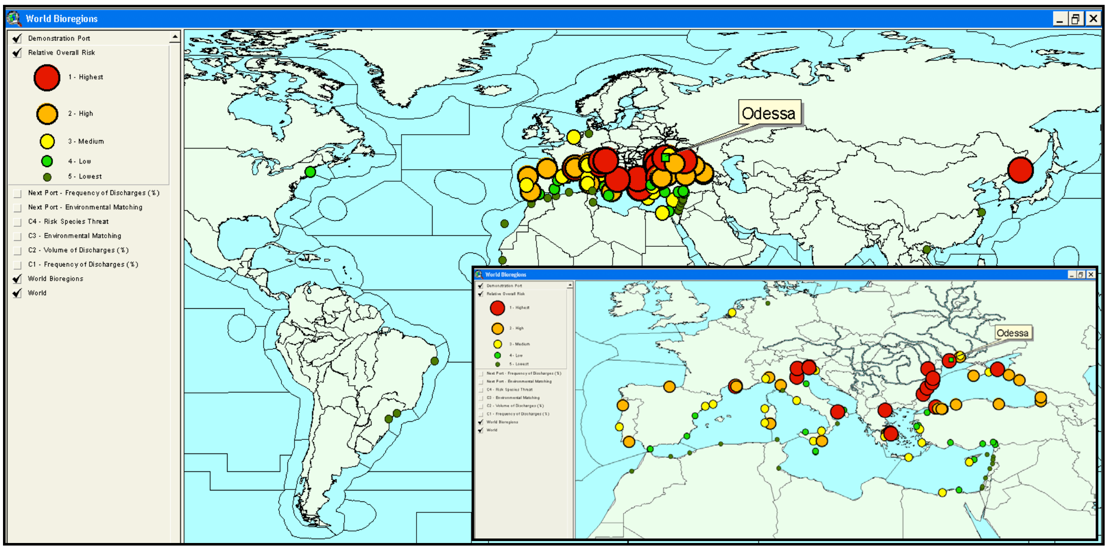

Figure 26. *GIS world map outputs (two scales) showing the location and categories of relative overall risk (ROR) of the BW source ports identified for Odessa.*

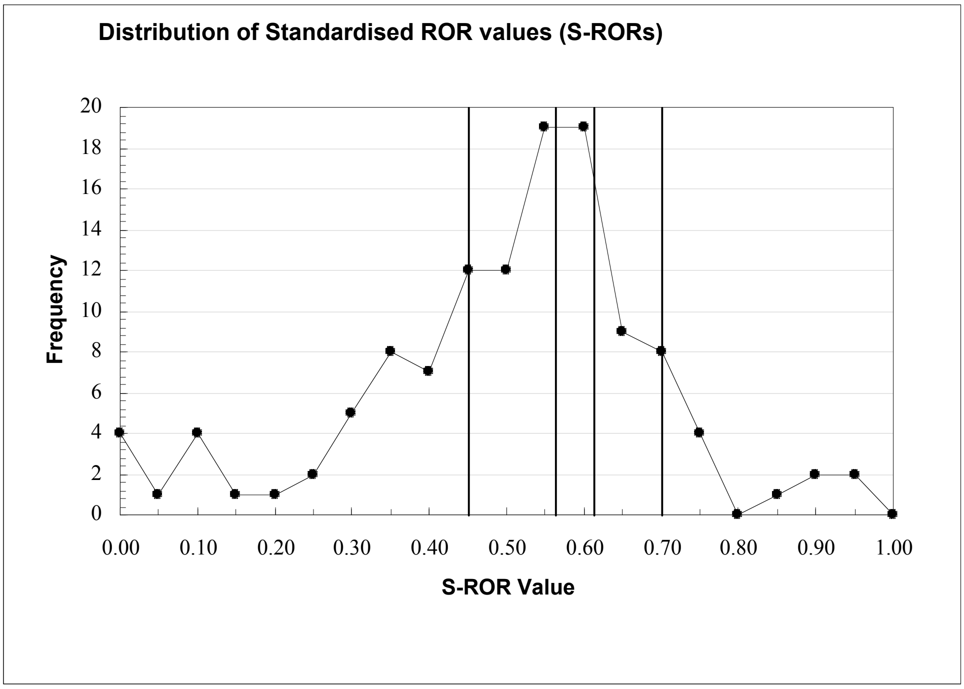

Figure 27. *Frequency distribution of the standardised ROR values*

Table 9. *BW source ports reported for the Port of Odessa, ranked according to their Relative Overall Risk (ROR)*

Port Code	Source Port	Country	C1 BW Freq	C2 BW Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match	*Estimated*	C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk	Cumulative Percentage	Risk Category	Standrdisd ROR
RUNJK	Nakhodka	Russian Federation	0.73%	0.16%	4,384	1.0	3	1.0	0.650	*Y*	0.561	**0.305**	1.24	1.24	Highest	1.00
BGBOJ	Bourgas	Bulgaria	14.42%	17.28%	37,000	1.0	0	1.0	0.638		0.239	**0.298**	1.22	2.46	Highest	0.97
ITTRS	Trieste	Italy	7.70%	8.95%	45,000	1.0	0	1.0	0.622		0.364	**0.288**	1.17	3.63	Highest	0.92
ROCND	Constanta	Romania	5.59%	7.48%	36,000	1.0	1	1.0	0.737		0.280	**0.287**	1.17	4.80	Highest	0.92
UAILK	Ilyichevsk	Ukraine	0.41%	0.55%	28,000	1.0	0	1.0	0.819		0.280	**0.277**	1.13	5.93	Highest	0.87
ITRAN	Ravenna	Italy	2.76%	3.42%	36,000	1.0	4	1.0	0.613		0.364	**0.260**	1.06	6.98	Highest	0.79
ROMAG	Mangalia	Romania	0.73%	1.62%	38,500	1.0	0	1.0	0.729		0.280	**0.258**	1.05	8.04	Highest	0.78
ROMID	Midia	Romania	0.08%	0.17%	20,115	1.0	0	1.0	0.739		0.280	**0.255**	1.04	9.07	Highest	0.77
ITVCE	Venezia (=Fusina)	Italy	0.97%	0.65%	31,000	1.0	4	1.0	0.624		0.364	**0.251**	1.02	10.10	Highest	0.75
SIKOP	Koper	Slovenia	0.16%	0.03%	2,000	1.0	4	1.0	0.627		0.364	**0.248**	1.01	11.11	Highest	0.74
GRPIR	Piraeus	Greece	4.86%	6.65%	32,500	1.0	2	1.0	0.505		0.364	**0.246**	1.00	12.11	Highest	0.73
FRFOS	Fos sur Mer	France	4.05%	3.07%	35,000	1.0	5	0.8	0.588		0.405	**0.246**	1.00	13.11	Highest	0.73
ROGAZ	Galatz	Romania	0.08%	0.00%	200	0.6	1	1.0	0.700	*Y*	0.280	**0.245**	1.00	14.11	Highest	0.73
BGVAR	Varna	Bulgaria	2.51%	2.00%	20,000	1.0	1	1.0	0.687		0.239	**0.243**	0.99	15.10	Highest	0.71
GRSKG	Thessaloniki	Greece	1.62%	1.95%	32,000	1.0	2	1.0	0.564		0.364	**0.241**	0.98	16.08	Highest	0.70
ITTAR	Taranto	Italy	0.08%	0.24%	27,500	1.0	3	1.0	0.555		0.405	**0.241**	0.98	17.06	Highest	0.70
TRIST	Istanbul	Turkey	1.94%	1.35%	33,000	1.0	0	1.0	0.563		0.364	**0.240**	0.98	18.03	Highest	0.70
GREEU	Eleusis	Greece	3.32%	2.75%	36,749	1.0	1	1.0	0.534		0.364	**0.240**	0.98	19.01	Highest	0.70
UAKEH	Kerch	Ukraine	0.08%	0.05%	6,000	1.0	1	1.0	0.750	*Y*	0.205	**0.239**	0.97	19.98	Highest	0.70
ITPFX	Porto Foxi (Sarroch)	Italy	0.97%	1.43%	37,530	1.0	4	1.0	0.510		0.405	**0.235**	0.96	20.94	High	0.68
ITSPA	Santa Panagia	Italy	1.46%	1.54%	34,500	1.0	3	1.0	0.500	*Y*	0.405	**0.234**	0.95	21.89	High	0.67
TRERE	Eregli	Turkey	0.24%	0.23%	11,800	1.0	1	1.0	0.690		0.239	**0.233**	0.95	22.84	High	0.67
PTLEI	Leixoes	Portugal	1.05%	0.55%	8,124	1.0	8	0.8	0.540	*Y*	0.470	**0.233**	0.95	23.79	High	0.67
TRSSX	Samsun	Turkey	0.73%	0.01%	146	0.6	2	1.0	0.680		0.239	**0.232**	0.94	24.73	High	0.66
RUNVS	Novorossiysk	Russian Federation	0.57%	0.46%	14,000	1.0	1	1.0	0.673		0.239	**0.231**	0.94	25.67	High	0.66
TRTUT	Tutuncifilik	Turkey	0.08%	0.27%	32,000	1.0	1	1.0	0.550	*Y*	0.364	**0.229**	0.93	26.60	High	0.65
TRTUZ	Tuzla	Turkey	0.08%	0.01%	1,500	1.0	1	1.0	0.550	*Y*	0.364	**0.229**	0.93	27.54	High	0.65
UADNB	Dnepro-Bugsky	Ukraine	0.24%	0.20%	9,000	1.0	1	1.0	0.630		0.280	**0.229**	0.93	28.47	High	0.65
RUTUA	Tuapse	Russian Federation	0.08%	0.09%	11,000	1.0	1	1.0	0.672		0.239	**0.228**	0.93	29.39	High	0.65
FRLAV	Lavera	France	0.08%	0.08%	9,050	1.0	5	0.8	0.585		0.405	**0.228**	0.93	30.32	High	0.64
ITLIV	Livorno	Italy	0.32%	0.48%	34,500	1.0	5	0.8	0.578		0.405	**0.227**	0.93	31.25	High	0.64
PTFAO	Faro	Portugal	0.08%	0.27%	32,000	1.0	7	0.8	0.530		0.470	**0.227**	0.93	32.17	High	0.64
GEBUS	Batumi	Georgia	0.16%	0.21%	24,500	1.0	2	1.0	0.664		0.239	**0.227**	0.92	33.10	High	0.64
TRYAR	Yarimca	Turkey	0.08%	0.00%	300	0.6	1	1.0	0.533		0.364	**0.224**	0.91	34.01	High	0.63
ESBIO	Bilbao	Spain	0.08%	0.03%	4,000	1.0	9	0.8	0.521		0.470	**0.224**	0.91	34.92	High	0.63
UASVP	Sevastopol	Ukraine	1.13%	0.18%	1,951	1.0	0	1.0	0.645		0.239	**0.224**	0.91	35.84	High	0.63
GEPTI	Poti	Georgia	0.41%	0.08%	2,987	1.0	4	1.0	0.645		0.239	**0.222**	0.90	36.74	High	0.62
ITGOA	Genoa	Italy	1.38%	2.91%	34,500	1.0	5	0.8	0.521		0.405	**0.222**	0.90	37.64	High	0.62
GRAGT	Agioi Theodoroi	Greece	0.65%	1.47%	33,000	1.0	3	1.0	0.500	*Y*	0.364	**0.221**	0.90	38.55	High	0.61
GRASS	Aspropyrgos	Greece	0.41%	0.16%	15,000	1.0	4	1.0	0.515		0.364	**0.221**	0.90	39.45	High	0.61
TRIZT	Izmit	Turkey	2.59%	1.69%	34,887	1.0	1	1.0	0.477		0.364	**0.221**	0.90	40.34	Medium	0.61
TRIZM	Izmir (Smyrna)	Turkey	0.41%	0.53%	24,000	1.0	1	1.0	0.507		0.364	**0.220**	0.90	41.24	Medium	0.61
ITGEA	Gela	Italy	1.22%	1.25%	24,000	1.0	4	1.0	0.450	*Y*	0.405	**0.220**	0.90	42.14	Medium	0.61
ESTAR	Tarragona	Spain	0.73%	1.64%	38,500	1.0	5	0.8	0.532		0.405	**0.220**	0.90	43.03	Medium	0.61
ITAUG	Augusta/Priolo	Italy	0.57%	1.26%	36,000	1.0	3	1.0	0.450	*Y*	0.405	**0.218**	0.89	43.92	Medium	0.60
NLRTM	Rotterdam	Netherlands	0.16%	0.47%	35,000	1.0	10	0.6	0.582		0.466	**0.217**	0.88	44.80	Medium	0.59
GRLAV	Lavrion (Laurium)	Greece	0.32%	0.02%	660	0.8	3	1.0	0.500	*Y*	0.364	**0.217**	0.88	45.69	Medium	0.59
HROMI	Omisalj	Croatia	3.57%	2.07%	35,000	1.0	4	1.0	0.446		0.364	**0.217**	0.88	46.57	Medium	0.59
ITFCO	Fiumicino	Italy	0.49%	0.95%	38,000	1.0	4	1.0	0.450	*Y*	0.402	**0.216**	0.88	47.45	Medium	0.59
ITPVE	Porto Vesme (Portoscu	Italy	0.73%	0.32%	12,500	1.0	4	1.0	0.450	*Y*	0.405	**0.216**	0.88	48.33	Medium	0.59
GRKGS	Kos	Greece	0.08%	0.08%	9,000	1.0	2	1.0	0.500	*Y*	0.364	**0.216**	0.88	49.21	Medium	0.59
GRMGR	Megara Oil Terminal (	Greece	0.08%	0.07%	8,000	1.0	2	1.0	0.500	*Y*	0.364	**0.216**	0.88	50.09	Medium	0.59
GRNPL	Nauplia (Nafplion)	Greece	0.08%	0.04%	4,100	1.0	2	1.0	0.500	*Y*	0.364	**0.216**	0.88	50.97	Medium	0.59
GRANI	Aghios Nikolaos	Greece	0.08%	0.03%	4,000	1.0	2	1.0	0.500	*Y*	0.364	**0.216**	0.88	51.85	Medium	0.59
ITPTO	Porto Torres	Italy	0.24%	0.08%	3,800	1.0	4	1.0	0.450	*Y*	0.405	**0.215**	0.87	52.73	Medium	0.58
PTLIS	Lisboa	Portugal	0.08%	0.24%	28,500	1.0	7	0.8	0.473		0.470	**0.213**	0.87	53.59	Medium	0.58
ESBCN	Barcelona	Spain	0.08%	0.05%	6,000	1.0	5	0.8	0.524		0.405	**0.212**	0.86	54.46	Medium	0.57
EGEDK	El Dekheila	Egypt	0.08%	0.13%	14,700	1.0	3	1.0	0.480		0.367	**0.212**	0.86	55.32	Medium	0.57
ITSVN	Savona	Italy	0.57%	1.15%	40,000	1.0	5	0.8	0.500	*Y*	0.405	**0.210**	0.86	56.18	Medium	0.56
UAFEO	Feodosiya	Ukraine	0.16%	0.03%	2,500	1.0	1	1.0	0.600	*Y*	0.239	**0.210**	0.86	57.03	Medium	0.56
UANIK	Nikolayev	Ukraine	0.08%	0.01%	1,200	1.0	1	1.0	0.557		0.280	**0.210**	0.85	57.89	Medium	0.56
CYLMS	Limassol	Cyprus	1.94%	0.74%	34,500	1.0	3	1.0	0.444		0.367	**0.210**	0.85	58.74	Medium	0.56
ITMLZ	Milazzo	Italy	0.73%	0.80%	19,174	1.0	9	0.8	0.500	*Y*	0.402	**0.209**	0.85	59.59	Medium	0.56

Table 9 (cont'd)

Port Code	Source Port	Country	C1 BW Freq	C2 BW Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match	*Estimated*	C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk	Cumulative Percentage	Risk Category	Standrdisd ROR
CYLCA	Larnaca	Cyprus	0.32%	0.344%	22,177	1.0	3	1.0	0.455		0.367	**0.207**	0.84	60.44	Low	0.55
ITSIR	Siracusa	Italy	0.24%	0.22%	8,743	1.0	5	0.8	0.500	*Y*	0.405	**0.207**	0.84	61.28	Low	0.55
GIGIB	Gibraltar	Gibraltar	0.32%	0.51%	25,000	1.0	6	0.8	0.529		0.364	**0.207**	0.84	62.12	Low	0.55
MTMLA	Malta (Valetta)	Malta	0.24%	0.19%	9,500	1.0	3	1.0	0.407		0.405	**0.204**	0.83	62.95	Low	0.54
ESALG	Algeciras	Spain	0.16%	0.33%	31,956	1.0	6	0.8	0.520		0.364	**0.204**	0.83	63.78	Low	0.53
TRALI	Aliaga	Turkey	2.59%	2.56%	33,000	1.0	3	1.0	0.400	*Y*	0.364	**0.204**	0.83	64.61	Low	0.53
ITMNF	Monfalcone	Italy	0.08%	0.03%	4,000	1.0	4	1.0	0.450	*Y*	0.364	**0.204**	0.83	65.44	Low	0.53
TRDYL	Dortyol Oil Terminal	Turkey	0.08%	0.10%	11,700	1.0	3	1.0	0.442		0.367	**0.203**	0.83	66.27	Low	0.53
TRMER	Mersin	Turkey	0.97%	1.78%	35,000	1.0	6	0.8	0.486		0.367	**0.202**	0.82	67.09	Low	0.53
ITPMO	Palermo	Italy	0.16%	0.24%	14,000	1.0	4	1.0	0.400	*Y*	0.402	**0.201**	0.82	67.91	Low	0.52
EGDAM	Damietta	Egypt	0.08%	0.12%	13,660	1.0	3	1.0	0.427		0.367	**0.199**	0.81	68.72	Low	0.51
EGALY	Alexandria (El Iskanda	Egypt	0.97%	0.64%	16,000	1.0	5	0.8	0.479		0.367	**0.197**	0.80	69.52	Low	0.50
ESCAS	Castellon de la Plana	Spain	0.97%	0.35%	12,200	1.0	7	0.8	0.450	*Y*	0.405	**0.197**	0.80	70.33	Low	0.50
ESCAR	Cartagena	Spain	0.32%	0.51%	38,000	1.0	8	0.8	0.450	*Y*	0.405	**0.196**	0.80	71.12	Low	0.50
TRISK	Iskenderun	Turkey	0.41%	0.37%	14,200	1.0	3	1.0	0.400	*Y*	0.367	**0.194**	0.79	71.91	Low	0.49
TRAYT	Antalya	Turkey	0.49%	0.09%	2,663	1.0	1	1.0	0.400	*Y*	0.367	**0.193**	0.79	72.70	Low	0.49
TRNEM	Nemrut Bay	Turkey	0.57%	0.31%	15,000	1.0	2	1.0	0.400	*Y*	0.364	**0.193**	0.79	73.48	Low	0.48
TRTOR	Toros	Turkey	0.08%	0.09%	9,980	1.0	4	1.0	0.400	*Y*	0.367	**0.192**	0.78	74.27	Low	0.48
TRAMB	Ambali/Kumport	Turkey	0.24%	0.00%	137	0.6	3	1.0	0.400	*Y*	0.364	**0.192**	0.78	75.05	Low	0.48
USBOS	Boston Massachusetts	United States	0.08%	0.14%	16,000	1.0	16	0.6	0.592		0.284	**0.191**	0.78	75.83	Low	0.48
TRBDM	Bandirma	Turkey	0.08%	0.00%	200	0.6	1	1.0	0.400	*Y*	0.364	**0.191**	0.78	76.60	Low	0.48
MTMAR	Marsaxlokk	Malta	0.32%	0.09%	6,000	1.0	3	1.0	0.350	*Y*	0.405	**0.190**	0.77	77.38	Low	0.47
ITFAL	Falconara	Italy	0.65%	0.93%	30,000	1.0	6	0.8	0.450	*Y*	0.364	**0.189**	0.77	78.15	Low	0.47
ITPMA	Porto Marghera	Italy	0.65%	0.10%	2,686	1.0	9	0.8	0.450	*Y*	0.364	**0.187**	0.76	78.91	Low	0.46
ITBDS	Brindisi	Italy	0.08%	0.30%	35,152	1.0	8	0.8	0.450	*Y*	0.364	**0.186**	0.76	79.67	Low	0.45
SYTTS	Tartous	Syrian Arab Republic	1.05%	0.30%	10,900	1.0	3	1.0	0.350	*Y*	0.367	**0.183**	0.74	80.41	Lowest	0.44
DEBRE	Bremen	Germany	0.08%	0.07%	8,000	1.0	11	0.6	0.446		0.466	**0.182**	0.74	81.15	Lowest	0.43
DZALG	Alger	Algeria	0.16%	0.13%	8,000	1.0	5	0.8	0.400	*Y*	0.405	**0.182**	0.74	81.89	Lowest	0.43
HRRJK	Rijeka Bakar	Croatia	0.32%	0.26%	7,776	1.0	15	0.6	0.500	*Y*	0.364	**0.181**	0.74	82.63	Lowest	0.43
SYLTK	Latakia	Syrian Arab Republic	0.16%	0.09%	9,000	1.0	3	1.0	0.350	*Y*	0.367	**0.180**	0.73	83.36	Lowest	0.42
LBKYE	Tripoli	Lebanon	0.08%	0.13%	15,000	1.0	4	1.0	0.350	*Y*	0.367	**0.180**	0.73	84.09	Lowest	0.42
ITPIO	Piombino	Italy	0.81%	0.19%	3,150	1.0	11	0.6	0.450	*Y*	0.402	**0.175**	0.71	84.81	Lowest	0.40
ITCRV	Crotone	Italy	0.41%	0.06%	1,689	1.0	19	0.6	0.450	*Y*	0.405	**0.174**	0.71	85.52	Lowest	0.40
DZORN	Oran	Algeria	0.08%	0.09%	10,475	1.0	6	0.8	0.400	*Y*	0.364	**0.173**	0.70	86.22	Lowest	0.39
CNSHA	Shanghai (Shihu) Shan	China	0.08%	0.09%	10,000	1.0	26	0.4	0.454		0.572	**0.171**	0.70	86.92	Lowest	0.38
TNBIZ	Bizerte	Tunisia	0.49%	0.26%	7,882	1.0	8	0.8	0.350	*Y*	0.402	**0.170**	0.69	87.61	Lowest	0.38
ILASH	Ashdod	Israel	0.57%	0.29%	9,000	1.0	8	0.8	0.376		0.367	**0.170**	0.69	88.30	Lowest	0.38
ILHFA	Haifa	Israel	0.32%	0.56%	20,000	1.0	4	1.0	0.300	*Y*	0.367	**0.169**	0.69	88.99	Lowest	0.37
ITAOI	Ancona	Italy	0.49%	0.06%	1,669	1.0	10	0.6	0.450	*Y*	0.364	**0.168**	0.69	89.67	Lowest	0.37
BRPNG	Paranagua	Brazil	0.08%	0.07%	8,060	1.0	20	0.4	0.442		0.561	**0.167**	0.68	90.35	Lowest	0.36
SYBAN	Baniyas	Syrian Arab Republic	0.57%	0.10%	3,019	1.0	9	0.8	0.350	*Y*	0.367	**0.163**	0.66	91.02	Lowest	0.34
LBBEY	Beirut	Lebanon	0.32%	0.14%	9,200	1.0	5	0.8	0.350	*Y*	0.367	**0.162**	0.66	91.68	Lowest	0.34
BRSSZ	Santos	Brazil	0.08%	0.21%	25,000	1.0	20	0.4	0.410		0.561	**0.159**	0.65	92.33	Lowest	0.33
ILAKL	Ashkelon	Israel	1.62%	1.97%	20,000	1.0	5	0.8	0.300	*Y*	0.367	**0.157**	0.64	92.97	Lowest	0.32
TRCEY	Botas-Ceyhan	Turkey	0.32%	0.17%	6,178	1.0	18	0.6	0.400	*Y*	0.367	**0.156**	0.64	93.60	Lowest	0.32
TNGAE	Gabes	Tunisia	0.24%	0.15%	15,000	1.0	12	0.6	0.350	*Y*	0.405	**0.149**	0.61	94.21	Lowest	0.28
MANDR	Nador	Morocco	0.65%	0.27%	10,000	1.0	13	0.6	0.350	*Y*	0.364	**0.144**	0.59	94.80	Lowest	0.26
BRMCZ	Maceio	Brazil	0.08%	0.10%	11,300	1.0	16	0.6	0.400	*Y*	0.231	**0.135**	0.55	95.35	Lowest	0.22
SGSIN	Singapore	Singapore	0.08%	0.18%	21,000	1.0	19	0.6	0.339		0.277	**0.127**	0.52	95.86	Lowest	0.18
IDDUM	Dumai Sumatra	Indonesia	0.08%	0.01%	800	0.8	19	0.6	0.305		0.277	**0.118**	0.48	96.35	Lowest	0.14
ESLPA	Las Palmas	Spain	0.57%	0.20%	3,607	1.0	12	0.6	0.460		0.000	**0.117**	0.48	96.82	Lowest	0.13
YEHOD	Hodeidah	Yemen	0.32%	0.06%	2,650	1.0	16	0.6	0.394		0.076	**0.111**	0.45	97.27	Lowest	0.11
MYPKG	Port Kelang	Malaysia	0.08%	0.03%	3,300	1.0	18	0.6	0.276		0.277	**0.111**	0.45	97.72	Lowest	0.11
VNHAN	Hanoi	Viet Nam	0.08%	0.26%	30,000	1.0	22	0.4	0.300	*Y*	0.277	**0.103**	0.42	98.15	Lowest	0.07
NGLOS	Lagos	Nigeria	0.32%	0.10%	5,400	1.0	16	0.6	0.377		0.000	**0.095**	0.39	98.53	Lowest	0.03
SNDKR	Dakar	Senegal	0.41%	0.08%	2,580	1.0	15	0.6	0.370		0.000	**0.094**	0.38	98.91	Lowest	0.03
MYKBA	Kuala Baram	Malaysia	0.08%	0.08%	9,000	1.0	21	0.4	0.250	*Y*	0.277	**0.091**	0.37	99.28	Lowest	0.01
MACAS	Casablanca	Morocco	0.16%	0.11%	8,500	1.0	7	0.8	0.350	*Y*	0.000	**0.088**	0.36	99.64	Lowest	0.001
MRNKC	Nouakchott	Mauritania	0.08%	0.07%	7,871	1.0	15	0.6	0.350	*Y*	0.000	**0.088**	0.36	100.00	Lowest	0.000

Reverse BWRA

It is not clear how much BW is 'exported' from Odessa. The largest volumes of exported BW were identified to occur in the ships departing the dry bulk/general cargo terminal, and some from the container terminal. While the three most important Next Ports of Call are Bourgas, Constanta and Illyichevsk (i.e. possible BW destination ports; Section 4.5), much of the trade to these ports are ships departing either fully-loaded with oil or other liquid bulk cargo, or are visiting for top-up cargos (both types having zero or very little BW onboard). It should also be noted these ports are in 'down-current' locations from Odessa, in terms of the western gyre and overall southward flow of surface waters in the Black Sea (Figure 11).

Any harmful species that establishes in Odessa therefore has a chance to disperse south-westward by the prevailing current regime, provided its dispersive and adult stages are sufficiently euryhaline to tolerate the increased salinity beyond the north-west Black Sea bioregion (MED-IXB).

In the case of the risk species currently assigned to Odessa's bioregion, several have achieved extensive populations in this direction (i.e. west side of bioregion MED-IXA; Figure 7), while some of these and other species have appeared in the Caspian Sea. As noted above, the current database indicates that Odessa cannot be ruled out as a potentially significant source of shipping-mediated introductions to the Azov Sea, Volga-Don system and Caspian region.

4.9 Training and capacity building

The computer hardware and software provided by the GloBallast Programme for the BWRA activity was successfully installed and is currently maintained at the Information and Analytical Centre for Shipping Safety (IACSS), which is located in the Odessa offices of the State Department of Maritime and Inland Water Transport (Ministry of Transport of Ukraine). This PC proved reliable and adequate for running the database, undertaking the similarity analyses, displaying the GIS maps and results and providing other project needs. A copy of the database is also maintained on the PC at the CPSO Ecology Department in the port offices. BWRFs are continuing to be collected and stored by Ecology Department offices, with the aim of entering these in large batches, rather than on a daily basis due to the workload of staff duties and requirements.

Three of the Group B counterparts, including two Ecology Department officers, had previous experience with PCs and Windows applications, so learned the data entry method and use of the Access database GUIs for editing the records, with little difficulty. For two Ecology Department officers it was their first experience of using a computer. The value of these officers for any data entry requirements will be boosted if a basic PC training course for staff members can be organised by CPSO (as the port is gradually adopting more computers for improved information management).

The mapping work was conducted at the port offices on the PC provided for the BWRA project. One of the counterparts (Dr Mykola Berlinskyy) had experience with Mapinfo applications and also provided some marine habitat data files for translation to Arcview for Group C. The two other Group A counterparts had no previous experience with GIS or ESRI products, so required considerable initial guidance to master basic use of ArcView. Both of them readily grasped the structure and management of the layers recommended for the port map, but were hindered in obtaining regular practise between consultants visits by their other duties and locations compared to the site and use of the project PC for database entries. Two members of Group B also received basic training in GIS map development and file management, and two members of Group A and two from Group C were provided a comparable level of advice and guidance from Group B members. This helped ensure there was adequate interchange of understanding about BWRA system operation and data management.

As noted in Section 3.6, the most easily-trained and efficient BWRF database operators are those with substantial port and maritime work experience, plus previous hands-on experience with Windows applications. Group B were moderately strong in both areas (more so in database management due to presence of Mr Viktor Khmelevskyy, plus the interest of Mr Roman Bashtannyy from Group A). It is likely that the Group A team would need at least some limited assistance from an ESRI-familiar person if they were asked to develop a port map for another Black Sea. Certainly they could provide useful guidance and continuity to any future BW or other management projects involving GIS applications (Section 3.11; Appendix 2).

Group B worked hard to expand CPSO Ecology Department's paper record of BW discharges recorded from November 1999 to December 2000, particularly the key requirements for developing a record useable by the database, including estimated BW uptake (source) dates from standard voyage times, source port data, vessel ID, vessel type, DWT and berth location (by vessel and cargo type). However much work was also focussed on gap-filling BWRFs and for fixing discrepancies and errors (most being ship-entry related than computer-entry related). Many checking and fixing tasks were undertaken at the point of data entry, including the need to replace non-standard or illogical date formats, making spelling checks of port and vessel names and identifying port UN codes, lat/longs and vessel IMO numbers. Considering the necessity to translate many Russian entries into English, considerable progress was made by Group B both between the consultants visits and during the second visit. By the 2nd visit most Group B members and one Group A member had also become proficient in using port shipping records and other databases for BWRF checking and gap-filling (e.g. *Fairplay Ports Guide,* the *Lloyds Ship Register* and the consultants Excel spreadsheet for estimating BW discharge volumes). Because of the translation requirements and lack of spare PCs, there was little time to undertake a formal error analysis of the BWRFs. However, Group B developed a record of commonly occurring errors, blanks and data-entry issues as part of the project team's information gap identifications.

Of the three groups, Group C contained the highest number of senior scientists who brought to the project team a high level of local expertise in coastal ecology and introduced species of the Black Sea region (Appendix 2). Group C members were already familiar with multivariate methods, and required little instruction to be able use the PRIMER package to conduct environmental similarity analysis, and this extended to one of the Group A members (Dr Mykola Berlinskyy) which promoted further integration of the team. All Group C counterparts contributed to the collation and assembly of port environmental data for important ports around the Black Sea, while two members (Dr Boris Alexandrov and Professor Zaitsev of IBSS) focussed on the provision of risk species distribution data for the Aegean-Black Sea-Caspian region (including a preliminary list of species arising from the Odessa PBBS), the expansion and refinement of bioregions for the Black Sea area (Section 3.9), and the delineation of natural and artificial habitats for the GIS port map (Section 3.7).

4.10 Identification of information gaps

Ballast Water Reporting Forms

Because of the compulsory nature of the BWRFs collection system, as established under a port Order via Ukrainian State regulations, return rates were high and most forms were sufficiently completed to provided a working record. Thus the number and status of the BWRFs collected at Odessa during 2001 showed a rapid rise from January to April to a relatively steady monthly plateau, with the initial period matching the March 2001 application of Order No. 62 of the State Department of Maritime and Inland Water Transport. Nevertheless considerable work was still required to 'salvage' many of the forms, particularly with respect to claimed or missing BW tank volumes intended for discharge, and the need to perform cross-checking estimations using the Excel spreadsheet. The most common key omissions in the Odessa BWRFs (in terms of key records required by the BWRA) were principally:

- '*Next Port of Call*' – often left blank by tankers and some bulk carriers, because the Next Port is frequently unknown until near or after completion of cargo loading. Since the BWRF is normally completed and submitted just after arrival, this is essentially a matter of timing although not critical to determining BW destinations since the tankers were not uplifting local BW[20];

- Failure to complete the BW Discharge column or provide realistic values for each tank (in Section 4 of the BWRF);
- Lack of entries for BW Source/s and Uptake Date/s.

The SIPBS is empowered to test all unexchanged (or suspected unexchanged) BW prior to giving written permission for discharge through the Harbour Master's Office. These samples are tested for oil, iron and sediment[21]. If the sample exceeds these limits, the ship has the option of proceeding beyond territorial limits (~20 kms offshore) to exchange and return with cleaner tank waters, or else paying a penalty licence for permission to discharge polluted water into the port. The penalty appears to be based on quantity of BW intended for discharge and its degree of non-compliance. It is very likely this pollution tax system may be discouraging ship officers to record reliable values for intended tank discharges on the BWRF, especially if the BWRF is provided prior to the ship undergoing SIPBS formalities and approval to discharge BW for the purposes of loading cargo.

The following list summarises other omissions or mistakes that are not uncommon in submitted BWRFs as informally observed at Odessa and also noted at other Demonstration Sites:

- No exchange data in the BW exchange field (Part 4 of the BWRF; Appendix 1), or no reason given for not undertaking an exchange.
- BWRFS showing BW exchange data contained empty BW source cells (it is important to enter the source port/location details because exchanges are often well below 95% effective and never 100%).
- Salinity units sometimes provided in gram/litre but often without unit clarification (e.g. pro-mil 0, 1%). The need for salinity units was clarified in Ukraine BWRFs produced and circulated after March 2002.
- Water depth provided in the universally confusing sea height field (actually means wave height), as a result of the first edition of Ukraine's translated BWRF form requesting sea depth. This was corrected in BWRFs produced and circulated after March 2002.
- Last country of call provided instead of last port of call (correctable for some cases where the same error had not occurred in the port's shipping records).
- BW Discharge field left empty or provided with a small number, even by ships loading a full cargo and therefore discharging most of their ballast.

The above lists highlight the items that port officers should immediately check when collecting or receiving any BWRF. Unless BWRF guidance is provided and errors corrected, ships' officers, shipping agents and port officers will not become familiar with and effectively use the BWRF process. Unless BWRFs are completed accurately and fully by vessels visiting Odessa, a significant percentage of BW sources and discharge volumes will remain unclear, especially for the Dry bulk/General Cargo terminal and the Container terminal.

Apart from lack of BWRF familiarity, the time provided for a ships' officer to complete a BWRF is another factor that can influence the number of mistakes and omissions. BWRFs provided to ships during their berthing or departure phases cannot be expected to receive the same level attention as forms already onboard the ship and completed prior to arrival. Thus reporting can be improved if shipping agents are requested to supply BWRF reminders (and blank forms where necessary) to ships 1-2 days prior to arrival, or to allow time for BWRF reporting after the ship has berthed and obtained

[20] Since the tankers were departing with cargo, the high omission rate actually prevented further distortion of the picture of potential (but unlikely) BW destination ports, as caused by the tankers engaged on regular shuttle runs.

[21] To check penalisable ezceedence of the following limits: Oil <0.05mg/l; Iron < 0.05mg/l; Total Suspended Solids <2mg/l.

permission to discharge. The former option will reduce the number of completed Next Port of Call entries, the latter option prevents use of the collected BWRF as an instrument to help assess BW discharge permission, and/or tank sampling and monitoring.

Even with correctly completed forms, it is often impossible to identify the ultimate destination of any BW uplifted by a port that receives and analyses BWRFs (Section 3.5). This is important given the objective of the GloBallast BWRA to identify the destinations of BW uplifted at each Demonstration Site. In fact some of the GloBallast BWRA objectives required considerable effort searching and/or deducing the following information, which is not available from the standard BWRFs:

- Destination Port/s where either BW will be discharged or cargo actually offloaded (not necessarily the Next Port of Call).
- Berth number/location at the reception port (obtained for each Demonstration Site by laborious cross-checking with port records);
- Deadweight tonnage (DWT). This is very useful for checking claimed BW discharge volumes (DWTs were eventually obtained for most ships from the *Lloyds Ship Register*, but this is a time-consuming task, particularly for ships that had entered a new name, incorrect IMO number or Call Sign on the BWRF).

It is therefore recommended that IMO Marine Environment Protection Committee (MEPC) review the standard BWRF with a view to improving its global application under the new BW convention (see Section 5).

Port environmental and risk species data

It was particularly difficult to obtain reliable environmental information for a port's waters, particularly for the seasonal water temperature and salinity averages and extrema. This was true for ports in developed regions (e.g. North America, Europe and Japan) as it was for less developed areas or where considerable marine research has been undertaken. Most of Odessa's ports are not exceptions to this finding.

In the case of risk species distribution and status data, many national and regional data sets remain incomplete and/or unpublished, the former being the case for the Black Sea – Mediterranean region (although the status of knowledge of risk species in the Black Sea is much higher than for most regions of the world). Many web sites containing list species for North American, Caribbean, European, Asian or Australasian regions do not clearly separate or identify which species are historical introductions (e.g. by the oyster aquaculture, fisheries, aquarium industry, sailing ship hulls) and which are recent (e.g. by ballast water and/or modern hull fouling vectors). Many lists not identify the most likely vector/s of their listed species.

The problem of obtaining reliable data for port environment comparisons and presence of risk species needs to remembered when considering the inclusion of more port environment parameters or risk species factors to provide more sophisticated BWRA calculations. Until regional databases are established that allow collation and exchange of reliable information, it will be difficult to optimise the use of trophic condition and specific production coefficients for enhancing the calculation of port environmental similarity and risk species threat (Section 4.7). Nevertheless, the current overall situation should not deter further investigations into the use of these parameters for future assessments, particularly in regions such as the Black Sea where a considerable amount of relevant data has already been collated.

5 Conclusions and Recommendations

The main objectives of the BWRA Activity were successfully completed during the course of this project, which took 14 months (i.e. between the initial briefing in January 2002 and the final consultants visit in February 2003). The level of maritime, marine biological and port experience brought to the project by the Ukrainian counterparts from IACSS, IBSS and members of the CPSO Ecology Department, facilitated effective instruction and familiarisation of the BWRA system. In addition, some senior members of the team are hoping the exercise can be repeated for other Ukraine ports such as Illyichvesk and Yuzhny.

If Ukraine continues to make good progress in the coordinated and strategic use of its agencies which have expertise and complimenting roles in the various maritime, port, ecological and environmental health aspects of ballast water management, there is no doubt it can maintain its present regional leading role in advancing ballast water management. Continuing such projects will enable Ukraine to provide assistance, technical advice, guidance and encouragement to other port States in the Black Sea and Ponto-Caspian region, which has become one of the most heavily impacted areas of Europe in terms of harmful aquatic species introductions, as well as a source of similarly unwelcome and economically damaging species invasions to parts of Western Europe and a large part of North America (i.e. the zebra mussel and round goby).

The Regional Strategic Action Plan (SAP) being developed by GloBallast for coordinating BW management activities in the region provides the best mechanism for replicating the collation analysis of BWRF data. Important items requiring attention for any future BWRA and BW management activity in the Black Sea region comprise:

- promotion and dissemination of guidelines and instructions about purpose, value and method of BWRF reporting to ship's officers, shipping agents and port officers;
- need for more species surveys (PBBSs);
- a lack of reliable harbour water temperature and salinity data for many ports in the region
- provision of a regional web-based database capable of exchanging and updating species and port survey information.

Apart from port State governments, regional organisations, port authorities and major national shipping companies in the region should be encouraged to support efforts in the above areas.

Recommendations

- The Ukrainian translation of the BW Reporting Form should be revised in Section 4 column 10 to read "sea height (m)" and column 14 to clarify the choice of salinity units, such as specific gravity [SG], mg/L and the Ukraine term 'pro mil' [‰]).
- To identify the locations where BW is discharged within a port, a more useful BWRF should include an entry for the berth or terminal name/number (instead of simply 'Port' and/or geographic coordinates, which is usually left blank).
- Modifying the "Last Port of Call" field to provide a "Last Three (3) Ports of Call" question would assist BWRF verification checking and analysis for part-loaded vessels visiting multi-use terminals.
- To help decipher and interpret poorly written, incomplete or suspect BWRFs, port and BW database entry officers should have access to up-to-date copies of the *Lloyds Ship Register*, the *Fairplay Ports Guide, Lloyd's Maritime Atlas of World Ports* or equivalent publications. For any port using the GloBallast BWRA system, a copy of the world bioregions map should also be provided to the data-entry officers so that the bioregion of any new port added to the database can be quickly identified.

- Any port officer whose duties include collecting or receiving BWRFs should be instructed to check that all relevant fields have been completed in legible script. A short BWRF information kit and training course provided to port officers and local shipping agents could be developed for Ukraine and other Black Sea ports, particularly during the implementation of any active BW management activity at a port.
- Owing to the large number of possible errors and misinterpretations that can be made with the existing BWRFs (both IMO and Ukrainian), it must always be remembered that people with a practical knowledge and good background in port and shipping operations will be far more easier and cost effective to train for the implementation of BW monitoring and management activities.

BWRA recommendations and plans by Pilot Country (Ukraine)

- A special BWRF database officer should be appointed by CSPO to work in the port's Ecology Department, with a specific job duty to orderly check and enter BW records data into the Access database, from BWRFs collected and collated by Ecology Department personnel. The experience of the BWRA project at Odessa shows that one officer will be sufficient for this task, provided this is the main and priority duty. Associated duties should include (a) occasional BWRF data summaries and reporting to IACSS and CSPO (including error/s analysis and advice), and (b) BWRF briefing, training and guidance to Ecology Department Officers, so that they can brief ships' officers and shipping agents with up to date instructions and guidance on the port's BW reporting requirements.
- A similar staffing position should be provided at any other Ukraine port which implements a BWRF database and reporting system.
- Because C1 and C2 rely on the accuracy of BWRFs which can be difficult to verify, Ukraine will promote the development, installation and use by ships of automatic BW monitoring systems that fix and record the time, place (coordinates) and volume of BW inputs and outputs, plus the water temperature and salinity.
- The GloBallast BWRA database should be used to help investigate and improve methods for calculating risk assessment coefficients for BW source ports, including the value and practicality of (a) obtaining reliable indicators to determine trophic status of port waters, and (b) adding 'specific production' to the risk species descriptions and status factors, as used by the database for calculating relative species threat.
- To help ensure that any BWRA system can highlight known sources of a previously introduced harmful species (i.e. a source port or bioregion already established as the definitive source of an unwanted invader), its procedure and calculations should automatically rank that port to the highest risk level, irrespective of the influence of C1 and C2.
- Ukraine will encourage and assist all countries in the Black Sea region to organize port biological baseline surveys and exchange information about introduced species and port environmental data.
- Ukraine will support the development of a regional database centre for biological invasion and port environmental and water quality data, as part of a network of centres stemming from the GloBallast programme. A key task of these centres should be the regular update of existing information on introduced species in port areas and their impacts, for improving risk assessment calculations and invasion predictions.

6 Location and maintenance of the BWRA System

The GloBallast BWRF hardware and software packages in Odessa are presently maintained at the Country Focal Point's office in IACSS, which is at the Odessa offices of the State Department of Maritime and Inland Water Transport (Ukraine Ministry of Transport). The following people are currently responsible for maintaining and updating the following features of the Odessa BWRA system in Ukraine:

Port resource mapping and GIS display requirements:

Name:	Mr Roman Bashtannyy
Organisation:	Information and Analytical Centre for Shipping Safety, State Department of Maritime and Inland Water Transport, Ministry of Transport of Ukraine
Address:	Post Box 44, Post Office 58, 65058 Odessa, Ukraine
Tel:	+38 (0482) 219 488
Fax:	+38 (0482) 219 483
Email:	rabotn@te.net.ua
Web:	www.globallast.od.ua

Ballast water reporting form database at CPSO, Odessa:

Contact person:	Mr Igor Borovskyy
Organization:	Sea Commercial Port of Odessa
Address:	1, Tamozhennaya Sq. 65026 Odessa, Ukraine
Tel:	+380 482 729 46 77
Fax:	+380 482 729 46 77

Port environmental and risk species data:

Name:	Dr Boris Aleksandrov (risk species and biological habitats)
Organisation:	Institute of Biology of Southern Seas Odessa Branch
Address:	37, Pushkinska Str. 65011 Odessa, Ukraine
Tel:	+380 482 25 09 18
Fax:	+380 482 25 09 18
Email:	alexandrov@paco.net

Name:	Dr Nikolay Pavlenko (water quality data)
Organisation:	Ukrainian Scientific Centre of Sea Ecology (USCSE)
Address:	89, Frantsuzskyy Blvd, 65009 Odessa, Ukraine.
Tel:	+380 482 63 72 04
Fax:	+380 482 63 72 00
Email:	svm47@yandex.ru

References

Alexandrov, B.G. & Zaitsev, Yu. P. 1998. Black Sea biodiversity in eutrophication conditions. In: *Conservation of the Biological Diversity as a prerequisite for Sustainable Development in the Black Sea Region*. Kluwer Academic Publ., pp.221-234.

Carlton, J.T. 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. *Oceanography and Marine Biology Annual Review 23*: 313-371.

Carlton, J.T. 1996. Biological invasions and cryptogenic species. *Ecology* 77: 1653-1655.

Carlton, J.T. 2002. Bioinvasion ecology: assessing impact and scale. In: *Invasive aquatic species of Europe: Distribution, impacts and management.* (E Leppäkoski, S Gollasch & S Olenin eds). Kluwer Academic Publishers, Dordrecht, Netherlands, pp. 7-19..

Cohen, A .& Carlton, J.T. 1995. *Non-indigenous aquatic species in a United States estuary: a case study of the biological invasions of the San Francisco Bay and delta*. Report to the US Fish & Wildlife Service (Washington) and the National Sea Grant College Program Connecticut Sea Grant, December 1995, 211 pp. (from http://nas.nfreg.gov/sfinvade.htm).

Hilliard, R.W., Hutchings, P.A. & Raaymakers, S. 1997a. Ballast water risk assessment for twelve Queensland ports:, Stage 4: Review of candidate risk biota. *Ecoports Monograph Series No. 13*. Ports Corporation of Queensland, Brisbane.

Hilliard, R.W., Walker, S., Vogt, F., Belbin, L. & Raaymakers, S. 1997b. Ballast water risk assessment for twelve Queensland ports, Stage 3B: Environmental similarity analyses. *EcoPorts Monograph Series No. 12.* Ports Corporation of Queensland, Brisbane (two volumes).

Kelleher, G., Bleakley, C. & Wells, S. 1995. *A Global representative system of marine protected areas*. The World Bank, Washington DC, USA.

Leppäkoski, E., Gollasch, S. & Olenin, S. 2002. *Invasive aquatic apecies of Europe: Distribution, impacts and management*. Kluwer Academic Publishers, Dordrecht, Netherlands. 583 pp.

Williamson, A.T., Bax, N.J., Gonzalez, E. & Geeves, W. 2002. *Development of a regional risk management framework for APEC economies for use in the control and prevention of introduced marine pests*. Final report of APEC Marine Resource Conservation Working Group (MRCWG), produced by Environment Australia, Canberra. 182 pp.

Zaitsev, Yu. P. & Öztürk, B. 2001. *Exotic Species in the Aegean, Marmara, Black, Azov and Caspian Seas*. Publication. No.8, Turkish Marine Foundation, Istanbul. Turk Deniz Arastirmalari Vakfi. Istanbul.

Zaitsev, Yu. P. & Mamaev, V. 1997. *Biological diversity in the Black Sea: A study of change and decline*. UN Publications, New York, 208 pp.

APPENDIX 1

Copy of
IMO Ballast Water Reporting Form

from Resolution A.868(20) Appendix 1
(Can be downloaded from http://globallast.imo.org/guidelines)

Appendix 1 - BALLAST WATER REPORTING FORM (TO BE PROVIDED TO PORT STATE AUTHORITY UPON REQUEST)

1. VESSEL INFORMATION **2. BALLAST WATER**

Vessel Name:	Type:	IMO Number:	Specify Units: m_, MT, LT, ST
Owner:	GT:	Call Sign:	Total Ballast Water on Board:
Flag:	Arrival Date:	Agent:	
Last Port and Country:		Arrival Port:	Total Ballast Water Capacity:
Next Port and Country:			

3. BALLAST WATER TANKS BALLAST WATER MANAGEMENT PLAN ON BOARD? YES_____ NO_____ HAS THIS BEEN IMPLEMENTED? YES_____ NO_____
TOTAL NO. OF TANKS ON BOARD_______ NO. OF TANKS IN BALLAST_______ IF NONE IN BALLAST GO TO NO. 5
NO. OF TANKS EXCHANGED_________ NO. OF TANKS NOT EXCHANGED___________

4. BALLAST WATER HISTORY: RECORD ALL TANKS THAT WILL BE DEBALLASTED IN PORT STATE OF ARRIVAL; IF NONE GO TO NO. 5

Tanks/Holds (list multiple sources/tanks separately)	BW SOURCE				BW EXCHANGE : circle one: Empty/Refill or Flow Through					BW DISCHARGE			
	DATE ddmmyy	PORT or LAT. LONG	VOLUME (units)	TEMP (units)	DATE ddmmyy	ENDPOINT LAT. LONG.	VOLUME (units)	% Exch.	SEA Hgt. (m)	DATE ddmmyy	PORT or LAT. LONG.	VOLUME (units)	SALINITY (units)

Ballast Water Tank Codes: Forepeak=FP, Aftpeak=AP, Double Bottom=DB, Wing=WT, Topside=TS, Cargo Hold=CH, O=Other

IF EXCHANGES WERE NOT CONDUCTED, STATE OTHER CONTROL ACTION(S) TAKEN: ______________________________

IF NONE, STATE REASON WHY NOT: ______________________________

5. IMO BALLAST WATER GUIDELINES ON BOARD (RES. 868(20))? YES_____ NO_____

RESPONSIBLE OFFICER'S NAME AND TITLE (PRINTED) AND SIGNATURE: ______________________________

APPENDIX 2

Risk Assessment Team for the Port of Odessa, Ukraine

The BWRA team contained three groups which undertook the GIS mapping (Group A), database development (Group B) and environmental matching/risk species (Group C) components of the Activity. The training activities and logistical requirements of the three groups were coordinated by Mr Igor Borovskyy (Head, Ecology Department, Sea Commercial Port of Odessa), Mr Vladimir Rabotnyov (Head, Information and Analytical Centre for Shipping Safety (in State Department of Maritime and Inland Water Transport) and Dr Rob Hilliard (URS Australia Pty Ltd).

Group A (GIS mapping)

Person:	Mr Roman Bashtannyy
Position:	Group A Leader – GIS files and BWRA computer system manager
Organization:	Information and Analytical Centre for Shipping Safety, State Department of Maritime and Inland Water Transport (Ministry of Transport), Odessa.
Email:	rabotn@te.net.ua

Person:	Mr Chris Clarke
Position:	Group A Counterpart Trainer
Organization:	Meridian GIS Pty Ltd
Email:	chris@meridian-gis.com.au

Person:	Dr Mykola Berlinskyy
Position:	Group A – GIS data compilation and cartographer
Organization:	Institute of Biology of Southern Seas, Odessa Branch
Email:	berlinsky@paco.net

Person:	Ms Anna Sukhodolskaya
Position:	Group A – GIS data compilation and trainee cartographer
Organization:	Institute of Biology of Southern Seas, Odessa Branch

Group B

Person:	Mr Igor Borovskyy
Position:	Group B Leader – BWRF data entry and database management
Organization:	Ecology Department, Commercial Sea Port of Odessa.

Person:	Mr Viktor Khmelevskyy
Position:	Group B Leader – BWRF data entry and database management
Organization:	Ecology Department, Commercial Sea Port of Odessa.

Person:	Mr Terry Hayes
Position:	Group B Counterpart Trainer
Organization:	URS Australia Pty Ltd
Email:	perth@urscorp.com

Person:	Mr Sergey Perfiliev
Position:	Group B – Port records, port shipping data extraction, BW report forms
Organization:	Ecology Department, Commercial Sea Port of Odessa

Person:	Mr Anatoliy Shpakov
Position:	Group B – Port records, port shipping data extraction, BW report forms.
Organization:	Ecology Department, Commercial Sea Port of Odessa

Person:	Mr Anatoliy Matushko
Position:	Group B – Port records, port shipping data extraction, BW report forms.
Organization:	Ecology Department, Commercial Sea Port of Odessa

Group C

Person: Dr Boris Aleksandrov
Position: Group C Leader (risk species data collation, regional networking and similarity analysis)
Organization: Institute of Biology of Southern Seas, Odessa Branch
Email: alexandrov@paco.net

Person: Dr Robert Hilliard
Position: Group C Counterpart Trainer
Organization: URS Australia Pty Ltd
Email: robert_hilliard@urscorp.com.au

Person: Dr Nikolay Pavlenko
Position: Group C – port environment data collation, environmental similarity analysis
Organisation: Ukrainian Marine Environment Scientific Centre, Odessa
Email: svm47@yandex.ru

Person: Dr Vladimir Sidenko
Position: Group C – planktonic risk species data collation
Organisation: Institute of Transport Medicine, Ministry of Public Health of Ukraine, Odessa
Email: med_trans@paco.net

Person: Prof Yuvenaly Zaitsev
Position: Group C – habitats description in port and adjacent areas, risk species data collection
Organisation: Institute of Biology of Southern Seas, Odessa Branch
Email: yu.zaitsev@paco.net

Project Manager

Steve Raaymakers
Programme Coordination Unit
International Maritime Organization
sraaymak@imo.org
http://globallast.imo.org

APPENDIX 3

Check-list of project requirements circulated at initial briefings in January 2001 (during 3rd GPTF meeting, Goa)

PROJECT REQUIREMENTS AND PROVISIONAL SCHEDULE

REMINDER AND CHECK LIST FOR CFP/CFP-A

---

(1) Confirm your availability of adequate PC hardware, + Windows, Access & peripherals

At least one PC with sufficient processor speed, memory, Windows software and peripherals must be dedicated to the project (plus full-time use during the two visits by the URS Team).

PC Capability:
- at least 600 MHz Processor speed
- at least 10 GB of Hard Disk capacity
- at least 128 MB RAM
- 3D Graphics Card with 16 MB of RAM
- x24 speed CD-ROM drive
- 21" 16-bit high-colour Monitor (XVGA or higher)
- a 10/100 base Network Card and 56k modem.

PC Software: OS: at least MS Windows 98 (preferably higher).

MS Access: This database program is usually bundled inside MS Office 97 (Business Edition), Office Pro; Office 2000; etc. Please check with your IT people if unsure.

MS Word, MS Excel, MS PowerPoint.

PC Peripherals: Convenient access to following peripherals for convenient data inputs and outputs:
- B/W laser printer (>8 pages per minute);
- A3 or A4 colour printer;
- CD Burner
- Flatbed scanner and digitising board
- Semi-auto or auto-archiving system, such as external Zip-Drive, Tape Drive or LAN servers. This is essential for protecting databases from accidental erasures, hard drive crashes, system failures, office fire, burglary, etc.

(2) Identify Your BWRA Project Team (10 people recommended):

Required Pilot Country Counterparts	PCU Consultants
BWRA project team leader	Consultants team leader
PC system and GIS operator (x2) MS Access database operator (x2)	GIS and database specialist
BWRF and shipping record manager (x2) Port environmental data searcher (x2)	Shipping record & port data specialist
Environmental similarity analyst (x2) Risk species networker / biologist	BWRA specialist

NB: when selecting team members, please note training will be conducted in English.

(3) Check all existing Port GIS, Coastal Resource Atlas, Electronic Charts/Digital Databases [refer to Briefing Paper - GTPF Agenda Item 4 [*BWRA Action Required*], and the consultants questionnaire provided at Goa (please complete and return a copy)

(4) Confirm Dates and Local Arrangements for first consultants visit.

Provisional Dates for 1st Visit (5 working days)

Monday 25 February- Friday 1 March 2002	Odessa, Ukraine
Saturday 2 March- Thursday 7 March 2002	Tehran/Khark Is, I.R. Iran
Monday 11 March- Friday 15 March 2002	Mumbai/Goa, India
Monday 25 March - Friday 29 March 2002	Saldahna, South Africa
Monday 1 April- Friday 5 April 2002	Sepetiba, Brazil
Tuesday 9 April- Saturday 14 April 2002	Dalian, China

Logistics: Assistance required for visa applications?
Customs clearance required for importation of computer software?
Local transport / work location / office facilities / accommodation

1st Visit Activities:

- Install and test the ArcView 3.2 GIS package, and the Primer 5 statistical package;
- Commence GIS training by digitising the port map (from any existing digital files, paper charts, maps, habitat information, articles, publications, aerial photos, etc);
- Review all data collated by Country Project Team, including existing databases. Set up the Access database for ship arrival records and the IMO BWRF. Commence training on the Graphic User Interfaces for BWRF inputs
- Collate and review pre-IMO BWRF shipping records to determine source and destination ports, vessel types and trading patterns.
- Review available port environmental data and potential sources of same (see Attachment)
- Commence assembling the risk species list (locate and commence networking with marine biologists in your country and region).
- Identify the critical information gaps.
- Identify the data collating and input work to be completed before the 2nd Visit.
- Agree on a provisional date for start of 2nd Visit (10 working days).

2nd Visits (10 work days). Complete port map digitising; install bioregional map; complete and add risk species to database; perform environmental similarity analysis; undertake risk assessment; evaluate results; review and reporting.

Environmental Data Requirements - see next page, attached.

ATTACHMENT

TYPES OF ENVIRONMENTAL DATA FOR PORT SIMILARITY ANALYSIS

The project requires two types of port environmental data:

(A) Charts and marine habitat and resources data are required for the GIS Port Map, and

(B) A range of parameters (measured in or near port) for the Environmental Similarity Analysis.

In the case of the quantitative parameters, these include:

- Mean water temperature during the summer [monsoon] season (^{o}C)
- Maximum water temperature at the hottest time of the summer [monsoon] season (^{o}C)
- Mean water temperature during the winter [dry] season (^{o}C)
- Minimum water temperature at the coldest time of the winter [dry] season (^{o}C)

- Mean day-time air temperature recorded in summer [monsoon] season (^{o}C)
- Maximum day-time air temperature recorded in summer [monsoon] season (^{o}C)
- Mean night-time air temperature recorded in winter [dry] season (^{o}C)
- Minimum night-time air temperature recorded in winter [dry] season (^{o}C)

- Mean water salinity during the wettest period of the year (grams/litre; ppt)
- Lowest water salinity at the wettest time of the year (grams/litre; ppt)
- Mean water salinity during the driest period of the year (grams/litre; ppt).
- Highest water salinity at the driest time of the year (grams/litre; ppt).

- Mean Spring Tidal range (metres)
- Mean Neap Tide range (metres)

- Total rainfall in the port's driest 6 months season (millimetres)
- Total rainfall in the port's wettest 6 months season (millimetres)
- Number of months accounting for 75% of total annual rainfall (=duration of peak discharges)
- Number of kilometres from the berths to the nearest river mouth (negative value if upstream)
- Size of this river's catchment (square kilometres)

[Categorical variables are also required, but these are easy to obtain from charts, maps, articles, etc]

APPENDIX 4

Information sources used for collating Port Environmental Data

Variable	Sources	Provided by/collated from:
Port type	Port plans; hydrographic charts; Fairplay Port Guide 8.4.2; C-Map World for Windows 3.03	Meridian, CFPAs, DMU, E&E, FEEMA, IBSS, MSA, NPA, NIO, PSO, UFP, UFRP
Mean day-time air temperature in warmest season Maximum day-time air temperature in warm season Mean night-time air temperature in coolest season Minimum night-time air temperature in coolest season	Buttle & Tuttle Ltd, 2002. World climate data centre (city/town stats). Hilliard et al (1997a) NOAA National Climatic Data Centre; Soviet Annals of Meteorological Statistics. Unpublished NIOC data & IR-Iran Port Guides; Japan Meteorological Agency Climatic Statistics. Unpublished ROPME Reports, JICA Reports, KSA-MEPA data	http://www.worldclimate.com; Meridian GIS. http://www.ncdc.noaa.gov/oa/ncdc.html; IBSS. PSO. http://www.jma.go.jp/JMA_HP/jma/indexe.html; E&E. Meridian-GIS; E&E.
Mean water temperature during warmest season Maximum water temperature at warmest time of year Mean water temperature during coolest season Minimum water temperature at coolest time of year Mean water salinity during wettest period of the year Lowest water salinity at wettest time of the year Mean water salinity during driest period of year Maximum water salinity at driest time of year	NOAA Nat Env Sat Dat & Inf Serv (NESDIS) 1984-98 monthly mean SST Regional Charts. Boyer TP & S Levitus, 1997. Quarter-degree grid objective analysis of world ocean temperature and salinity. NOAA Atlas NESDIS 11. Interactive monthly mean SST maps, World Oceans Atlases WOA98 and WOA01. IRI degree-scale weekly, mean monthly and seasonal SST maps for the Atlantic, Indian and Pacific Oceans for 2002-2003 (International Research Institute for Climate Prediction, Colombia University, Palisades, NY). IRD (Institut de Recherche de le Development, Centre ORSTOM du Brest) - WOCE monthly SSS and SST maps of the Indian Ocean and tropical Atlantic and Pacific Ocean regions. Port of San Diego Bay-Wide Water Quality Monitoring Program, 2001. Physical Oceanographic Real Time System [PORTS*] 2001-2003. Salinity and water temperatures in west side of Galveston Bay, 1982-2002. Schemel LE, Brown RL & Bell NW, 2003. Salinity and temperature in south San Francisco Bay, California: Results from the 1999-2002 and overview of previous data. USGS Water Resources Investigations Report 03-4005, 37 pp. Levitus S, Burgett R & TP Boyer, 1994. World Ocean Atlas 1994 (Vol .3) Salinity. NOAA NESDIS 3, 111 pp. Levitus S & T Boyer. World Ocean Atlas 1994 (Vol 4) Temperature. NOAA NESDIS 4, 129pp. AMBACS Black & Marmara Seas Regional SST and Salinity Maps (AMBACS CD-ROM) SST and SSS minima and maxima for IUCN Marine Biogeographical Regions. Dockside densities, Fairplay Ports Guide CD 8.4.2 (Lloyds Register Fairplay Ltd, 2001). World Ocean seasonal mean SSS charts 4.44.1 and 4.44.2 (Jan-Mar & Jul-Sep). Baltic Country Status Reports (Appendix III of Baltic Regional Workshop on BW Management, Tallin 2001 GloBallast Monograph Series 2 (PCU, IMO London). Danulat E, Muniz P, Garcia-Alonso J, Yannicelli B, 2002. Mar Poll Bull 44: 554-565. Walters S (1996). Average maxima and minima SSTand seasonal salinities of Australian ports. In: Vic-EPA Publication 494, State Government of Victoria, Melbourne. Hilliard et al. (1997b). EcoPorts Monograph Series 12, Ports Corporation of Queensland, Brisbn	http://www.osdpd.noaa.gov/PSB/EPS/SST/al_climo_mon.html; http://www.nodc.noaa.gov/OC5/readmehr.html http://www.nodc.noaa.gov/OC5/WOA01F/ssearch.html; http://www.nodc.noaa.gov/OC5/WOA98F/woaf_cd/search.html http://ingrid.ldgo.columbia.edu/SOURCES/.IGOSS/.nmc/.weekly/.sst/ http://www.brest.ird.fr/sss/climato_oi/ssd_clim1-12.html. Meridian, DMU, FEEMA, IBSS, MSA, NIO, NPA, PSO, UFP. http://www.portofsandiego.org/sandiego_environment/bay_water_sampling.asp http://co-ops.nos.noaa.gov/d_ports.html http://galveston.ssp.nmfs.gov/galv/news/p02/p02_tables.htm http://water.usgs.gov/pubs/wri/wri034005/ Meridian GIS Meridian GIS IBSS CSIRO Marine Research (Hobart); Campbell & Associates Meridian GIS Meridian GIS Meridian GIS Meridian GIS Meridian GIS Meridian GIS Meridian GIS
Mean spring tidal range (metres) Mean neap tidal Range (metres)	Admiralty Tide Tables (Vols 1-4). Hydrographer of Navy, United Kingdom, 1999. Port tidal ranges, Fairplay Ports Guide CD 8.4.2 (Lloyds Register Fairplay Ltd, 2001). Tide Level Predictions, C-Map World for Windows 3.03, C-Map Inc., Norway (2001).	Meridian GIS and PSO Meridian GIS and NPA Meridian GIS
Total rainfall during driest 6 months (millimetres) Total rainfall during wettest 6 months (millimetres) Fewest months providing 75% of total annual rainfall	Buttle & Tuttle Ltd, 2002. World Climate Data Center (city and town statistics) . Japan Oceanographic Data Center. NOAA National Climatic Data Center; Soviet Annals of Meteorological Statistics. Hilliard et al (1997b); Calculated from monthly rain fall data.	http://www.worldclimate.com; http://www.jodc.go.jp/ http://www.ncdc.noaa.gov/oa/ncdc.html; IBSS Odessa; Meridian GIS Meridian GIS

Continued over…

Distance to nearest river mouth Catchment size of nearest river with significant flow	Grand Atlas of India; Atlas of Soviet States (1974); Times Atlas of World; Readers Digest Atlas of Rivers & Lakes; MS Encarta Deluxe Reference Library World Atlas [watershed layer] (2003). C-Map World for Windows 3.03 [river layer] (2001). Atlas of People's Republic of China. Atlases of Africa, Iran, Japan, Korea, South America. Grand Atlas of Japan and North Asia (1996). Heibonsha Cartographic Publishing Co. Ltd, Tokyo.	NIO, IBSS, Meridian GIS Meridian GIS Meridian GIS, MSA CSIR, PSO, FEEMA,E&E.
Distance to nearest smooth artificial wall Distance to nearest rocky artificial wall distance to nearest wood pilings/structures Distance to nearest high tide salt marsh/saline flats Distance to nearest sand beach or sand bar Distance to nearest stony/pebble/shingle beach Distance to nearest low tide mud flat Distance to nearest mangroves Distance to nearest natural rocky shore Distance to nearest subtidal firm sands Distance to nearest subtidal soft mud Distance to nearest seagrass meadow Distance to nearest subtidal rocky reef or pavement Distance to nearest coral reef (carbonate framework)	Port plans, hydrographic charts, coastal resource maps, OSCP plans. Saifullah SM, Khan SH & Ismail S, 2002. Mar Poll Bull. 44: 570-576. Danulat E, Muniz P, Garcia-Alonso J, Yannicelli B, 2002. Mar Poll Bull 44: 554-565. National coastal resource maps; Field observations noted on hydrographic charts. Probyn T, Pitcher G, Pienaar R & Nuzzi R, 2001. Mar Poll Bull 42: 405-408. Hilliard et al. (1997). EcoPorts Monograph12, Ports Corporation of Queensland, Brisbane. Unpublished data from National Hydraulic Laboratory, Colombo, Sri Lanka. Red Sea habitat information from Drs H Shalaby & T Rouphael, UNDP program, Cairo. Colour aerial photographs, Landsat thematic images, coastal resource studies (various). Interactive world coral reef distribution maps, Reefbase (UNEP/ICLARM). Interactive world mangrove distribution map, Reefbase (UNEP/ICLARM). Seagrass distribution maps (Americas, Asia, Australasia, Europe-Med). McComb, A. et al (1992). Seagrasses of the World, Academic Press, UK. Dusek ML & Kitchens WM, 2003. Vegetation of the Lower Savannah River Delta. Florida Cooperative Fish and Wildlife Unit, University of Florida. Marine habitat maps web-published by the Biodiversity Centre, Nature Conservation Bureau, Ministry of Environment, Japan.	CFP-As, CSIR, DMU, E&E, FEEMA, IBSS, IEMA, Meridian GIS, MPT-JNPT, MEPA, MSA, NIO, NPA, PSO, SA, UFP, UFRJ, Meridian GIS. http://www.reefbase.org/DataPhotos/dat_gis.asp http://www.biodic.go.jp/site_map/site.html http://www.wec.ufl.edu/coop/Annual_Reports/Marsha%27s%2520 poster.ppt+
Abbreviations: CFP-As; GloBallast Country Focal Point Assistants; CSIR: Commonwealth Science and Industry Research (Durban Office), South Africa; CSIRO-CRIMP: now CSIRO Marine Research (Hobart). DMU: Dalian Maritime University, Dalian, PR China; E&E: Environmental & Energy Solutions Inc., Kamata, Chuo-ku, Japan; FEEMA: FundaÁ‚o Estadual de Engenharia do Meio Ambiente, Departamento de Controle Ambiental, Rio de Janeiro, Brazil; IBSS: Institute of Biology of the Southern Seas, Odessa, Ukraine; IEMA: Instituto de Estudos do Mar Almirante Paulo Moreira, Arraial do Cabo, Brazil; JICA: Japan International Cooperation Agency (Tokyo); MEPA: Meteorological and Environment Protection Agency, Saudi Arabia; MPT-JNPT: Port Trusts of Mumbai and Jaharwal Nehru Ports; MSA: Maritime Safety Authority, Beijing, PR China; NIO: National Institute of Oceanography, Donna Paula, Goa, India; NIOC: National Iranian Oil Company; NPA: National Ports Authority (Saldahna Bay, Richards Bay, Johanessburg Offices), South Africa; PSO: Ports & Shipping Organisation (Bandar Abbas, BIK, Tehran), IR Iran; SA: Saudi-Aramco, Dammam, Kingdom of Saudi Arabia; UFP: Departamento de Bot‚nica, Universidade Federal do Paran·, Brazil; UFRP: Departamento de Biologia Marinha, Universidade Federal do RdJ, Brazil.		

APPENDIX 5

Sources and references of Risk Species information

1 Furlani, D (1996). *Guide to Introduced Species*, CSIRO Marine Research, Hobart, Tasmania (folder-file format).

2 McClary DJ & Nelligan RJ, 2001. *Alternate Biosecurity Maangement Tools for Vector Threats: Technical guidelines for Acceptable Hull Cleaning Facilities*. Research Report No. ZBS 2000/03, prepared by Kingett Mitchell & Associates for New Zealand Ministry of Fisheries, September 2001. 29 pp.

2a M. Shaffelke, cited in McClary DJ & Nelligan RJ (2001). [see reference 2]

3 Cohen AN & Carlton JT (1995). *Biological study: Non-indigenous aquatic species in a united States estuary: a case study of the biological invasions of the San Francisco Bay and Delta*. US Fisheries & Wildlife National Sea Grant College Program Report PB96-168525. Springfield Virginia, USA. http://nas.er.usgs.gov/publications/sfinvade.htm

4 Pollard DA & PA Hutchings (1990a,b). A review of exotic marine organisms introduced to the Australian region. I. Fishes (a); and II. Invertebrates and Algae (b). *Asian Fisheries Science 3*: 205-222 (a) and 223-250 (b).

4a Wallaston 1968 and Wommersley 1981, cited in Pollard D & Hutchings PA (1990). [see reference 4]

4b Skinner & Womersley 1983, cited in Pollard D & Hutchings PA (1990). [see reference 4]

4c Allen (1953) - cited in Pollard D & Hutchings PA (1990). [see reference 4]

5 Australian NIS lists compiled by CSIRO-CRIMP (1997); CCIMPE (2001); SSC/SCFA (2000)[see reference 23]

6 Hutchings PM, Van Der Velde J & S Keable (1989). Baseline survey of the benthic macrofauna of Twofold Bay, NSW, with a discussion of the marine species introduced into the bay. *Proceedings of the Linnaean Society of New South Wales* 110 (4): 339-367.

6a Baker, cited by Hutchings et al (1989). [see reference 6]

7 Australian Coral Reef Society (1993). *A Coral Reef Handbook* (3rd Edition). Surrey Beatty & Sons Pty Ltd, Chipping Norton NSW, 264 pp.

8 Coles SL, DeFelice RC, Eldredge LG and JT Carlton (1997) Biodiversity of marine communities in Pearl Harbor, Oahu, Hawaii with observations on introduced exotic species. *Bernice Pauahi Bishop Museum Technical Report No. 10*: 1-76

9 Dakin WJ (1976). *Australian Seashores (Australian Natural Science Library Edition)*. Angus & Robertson, Sydney, 372 pp.

10 Carlton JT (1985). Transoceanic and Interoceanic Dispersal of Coastal Marine Organisms: The Biology of Ballast Water. *Oceanogr. Mar. Biol. Ann. Rev. 23*: 313-371.

11 Boyd S, Poore GCB & RS Wilson (1996). *Macrobenthic invertebrates of soft sediments in Port Phillip Bay: Introduced Species*. Unpubl. report to CSIRO-CRIMP by Museum of Victoria, Melbourne, 7-96. 122 pp.

12 Gosliner TM, Behrens DW & Williams GC (1996). *Coral Reef Animals of the Indo-Pacific - Animal life from Africa to Hawaii exclusive of vertebrates*. Sea Challengers, Monterey CA, 314 pp.

13 Wells FE & C Bryce (1988). *Seashells of Western Australia (Revised Edition)*. Western Australian Museum, Perth. 207 pp.

14 Tan LWH & PKL Ng (1988). *A guide to the seashore of Singapore.* Singapore Science Centre, Singapore, 159 pp.

15 Wells FE & RN Kilburn, 1986. Three temperate-water species of South African gastropods recorded for the first time in southwestern Australia. *Veliger 28(4)*: 453-456.

16 Gosliner TM (1987). *Guide to the nudibranchs (opisthobranch molluscs) of Southern Africa*. Sea Challengers and Jeff Hamann. Monterey.

17 Wasson & Shepherd (1995): cited in Cohen & Carlton (1995) [see reference 3].

18 Middleton MJ (1982). The oriental goby, *Acanthogobius flavimanus* (Temminck and Schlegel), an introducedfish in the coastal waters of New South Wales, Australia. *J. Fish Biology 21*: 513-523.

19 In: Leppäkoski E, Gollasch S. & S Olenin (eds) (2002). *Invasive aquatic apecies of Europe: Distribution, impacts and management*. Kluwer Academic Publishers, Dordrecht. 583 pp.

20 Morton, B (1981). Biology and functional morphology of *Mytilopsis sallei* (Recluz) (Bivalvia: Dreissenacea) fouling Visakhapatnam Harbour, Andra Pradesh, India. *Journal of Molluscan Studies* 47: 25-42.

21 Gollasch, S (2002). Importance of ship hull fouling as a vector of species introductions into the North Sea. *Biofouling* 18: 105-121.

22 Hass CG & DS Jones (1999). Marine introductions to western Australia, with a focus on crustaceans. In: Kesby JA, Stanley JM, McLen RF & Olive LJ (eds). *Geodiversity: Readings in Australian Geography at the close of the 20th Century*. Special Publication Series No. 6, School of Geography & Oceanography, University College, Australian Defence Force Academy, Canberra ACT. pp. 37-44.

23 Environment Australia (2000). *Joint SCC-SCFA Report of the National Taskforce on the Prevention and Management of Marine Pest Incursions* (October 2000 edition). Environment Australia, Canberra, Australia.

24 Domingues Rodrigues M & AI Brossi Garcia (1989). New records of *Pachygrapsus gracilis* (Saussure, 1858) in the Brazilian Littoral. *Ciene Cult San Paulo* 41: 63-66.

25 Dadon JR (1984). Distribution and abundance of Pteropoda: Thecostomata (Gastropoda) in the Southwestern Atlantic. *Physis (Buenos Aires)* 42: 25-38.

26 Christeffersen ML (1980). Is *Alpheus heterochaelis* Say (Crustacea, Decapoda, Alpheidae) found along the Brazilian coasts? *Review Nordestina Biology* 3: 236-237.

27 Galil B & C Golani (1990). Two new migrant decapods from the Eastern Mediterranean. *Crusteceana* 58: 229-236.

28 Hanna GD (1966). Introduced molluscs of western North America. *Occasional Papers of Californian Academy of Science* 48: 1-108.

29 Yoloye V (1976). The ecology of the West African Bloody cockle, Anadara (Senilia) senilis (L.). *Bulletin of the Institute Portdam Africique Noire* (Series A) 38: 25-56.

30 Jones DS (1992). A review of Australian fouling barnacles. *Asian Marine Biology* 9: 89-100.

31 Wang JJ & ZG Huang (1993). Fouling polychaetes of Hong Kong and adjacent waters. *Asian Marine Biology* 10: 1-12.

32 Arakawa KY (1980). On alien immigration of marine sessile invertebrates into Japanese waters. *Marine Fouling* 2: 29-33.

33 Carlton J (1999). Molluscan invasions in marine and estuarine communities. *Malacologia* 41(2): 439-454.

34 Griffiths CL, Hockey PAR, Van Erkom Shurink C & PJ Le Roux (1992). Marine invasive aliens on South Africa's shores: implications for community structure and trophic functioning. *South African Journal of Marine Science* 12: 713-722.

35 Wang C (1995). Some introduced molluscas *[sic]* in China. *Sinozoologia* 12: 181-191 (in Chinese).

36 Cranfield HJ, *et al* (1998). Adventive marine species in New Zealand. *National Institute of Water and Air Research (NIWA) Technical Report* 34, Auckland, New Zealand, 48 pp.

37 Dineen J, 2001. Exotic species reports for Indian River Lagoon, Florida. Smithsonian Fort Pierce website: http://www.serc.si.edu

38 J Mackie, 2001. Bryozoans at Port of Geraldton, with notes on taxonomy and distribution. In: *Geraldton Port Survey*. Unpublished report to Geraldton Port Authority by the Western Australian Museum, Perth, August 2001.

39 Wonham MJ, Carlton JT, Ruiz GM & LD Smith (2000). Fish and ships: relating dispersal frequency to success in biological invasions. *Marine Biology* 136: 1111-1121.

40 NIS data for Angola; supplied by Adnan Adawad (GloBallast Programme, Cape Town, South Africa: adawad@mcm.wcape.gov.za).

41 Dr Tamara Robertson, University of Cape Town (pers. comm.; August 2002).

42 Gollasch, S. & Griffiths, C (2000). *Case studies of introduced species in South African waters prepared for the GloBallast Programme*. Report prepared for Globallast Programme; available from Adnan Adawad (GloBallast Programme, Cape Town, South Africa: adawad@mcm.wcape.gov.za).

43 Draft provisional species list (9/02) from the Saldanha Bay Port Baseline Biological Survey (supplied by Adan Adawad (GloBallast Programme, Cape Town, South Africa): adawad@mcm.wcape.gov.za)

44 NIS data for Tanzania; supplied by Adnan Adawad (GloBallast Programme, Cape Town, South Africa: adawad@mcm.wcape.gov.za).

45 NIS data for Mauritius; supplied by Adnan Adawad (GloBallast Programme, Cape Town, South Africa: adawad@mcm.wcape.gov.za).

46 NIS data for Mozambique; supplied by Adnan Adawad (GloBallast Programme, Cape Town, South Africa: adawad@mcm.wcape.gov.za).

47 GloBallast Programme (2002). *List of Alien Species*. http://www.globallast.org

48 Williamson AT, Bax NJ, Gonzalez E & W Geeves (2002). *Development of a regional risk management framework for APEC economies for use in the control and prevention of introduced marine pests*. Final report of APEC Marine Resource Conservation Working Group, produced by Environment Australia, Canberra. 182 pp.

49 Walters S, 1996. Ballast water, hull fouling and exotic marine organism introductions via ships - a Victorian study. *Environment Protection Authority of Victoria, Publication 494* (May 1996).

50 Pitcher, G (1998). *Harmful algal blooms of the Benguela current*. Colour publication available from Sea Fisheries Research Institute (Private Bag X2, Rogge Bay 8012), Cape Town, Republic of South Africa (20 pp).

51 Benson AJ, Williams JD, Marelli DC, Frischer ME & Danforth JM, 2002. Establishment of the green mussel, *Perna viridis*, on the West Coast of Florida. In: *Proceedings of 11th International Conference of Aquatic Invasive species (Feb 25 to March 1, 2002, Washington DC)*. nvironment Department, US Army Engineer & Research Development Laboratory, US.

52 Platvoet D, Dick JTA & DW Kelly (2002). Comparative morphometrics of mouthparts and antennae in the invasive *Dikerogammeros villosus* and the native *Gammarus duebeni* (Crustacea, Amphipoda). In: *Proceedings of 11th International Conference of Aquatic Invasive species* (Feb 25 to March 1, 2002, Washington DC). Environment Department, US Army Engineer & Research Development Laboratory, US.

53 Strong JA (2002). Faunal and habitat comparisons from under and outside canopies of *Sargassum muticum*. In: *Proceedings of 11th International Conference of Aquatic Invasive species* (Feb 25 to March 1, 2002, Washington DC). Hosted by Environment Department, US Army Engineer & Research Development Laboratory.

54 Verween A (2002). Economic impact of biofouling control of an exotic bivalve, *Mytilopsis leucophaeta*, in the harbour of Antwerp, Belgium. In: *Proceedings of 11th International Conference of Aquatic Invasive species* (Feb 25 to March 1, 2002, Washington DC). Environment Department, US Army Engineer & Research Development Laboratory, US.

55 Perry HM, Lukens R, et al, 2002. Invasive species and implications for fisheries sustainability in the Gulf of Mexico. In: *Proceedings of 11th International Conference of Aquatic Invasive species* (Feb 25 to March 1, 2002, Washington DC). Environment Department, US Army Engineer & Research Development Laboratory, US.

56 Makarewicz, JC (2002). Distribution, fecundity, genetics and invasion routes of Cercopafis pengoi (Ostroumov) - a new exotic zooplankter in the Great Lakes Basin. In: *Proceedings of 11th International Conference of Aquatic Invasive specie*s (Feb 25 to March 1, 2002, Washington DC). Hosted by Environment Department, US Army Engineer & Research Development Laboratory.

57 Bauer CR & Lamberti GA (2002). Potential interactions between Eurasian Ruffe and Round Gobies in the Great Lakes: Prey and habitat differences. In: *Proceedings of 11th International Conference of Aquatic Invasive species* (Feb 25 to March 1, 2002, Washington DC). Environment Department, US Army Engineer & Research Development Laboratory. US.

58 Darrigran G *et al* (2002). Abundance and distribution of golden mussel (*Limnoperna fortunei*) larvae in a hydroelectric plant in South America. In: *Proceedings of 11th International Conference of Aquatic Invasive species* (Feb 25 to March 1, 2002, Washington DC). Environment Department, US Army Engineer & Research Development Laboratory, US.

59 Personal communications and manuscripts supplied by Dr Andrea Junqueira, Dr Flavio Fernandes, Dr Luciano Felicio Fernandes , Dr Luis Proenca during BWRA workshop at FEEMA, Rio de Janeiro (30 August 2002).

60 Fernandes, LF *et al* (2001). The recently established diatom *Coscinodiscus wailesii* in Brazilian waters: taxonomy and distribution. *Phycological Research* 2001.

61 Paula, A,F (2002). *Spatial abundance and distribution of invading coral Tubastraea in Ilha Grande Bay (RJ) and record of T. tagusensis and T. coccinea in Brazi*l. M.Sc thesis, State University of Rio de Janeiro, May 2002.

62 Translated material provided by Assoc Prof. (Biol.) Wang Lijun and Mr Jiang Yuewen (National Marine Environment Protection & Monitoring Centre, State Administration of Oceanography (Dalian Office), China (including preliminary lists of identified species sampled by Port Baseline Biological Survey for Dalian (GloBallast Programme); September 2002).

63 Anil AC, Venkat K, Sawant SS, Dileepkumar M, Dhargalkar VK, Ramaiah N, Harkantra SN & ZA Ansari (2002). Marine bioinvasions: Concern for ecology and shipping. *Current Science* 83(3): 214-218.

64 K Satyanarya Rao (2002). P*roceedings of 1st R&D Seminar, Global Ballast Water Management Programme.* National Institute of Oceanography, Goa, India. June 2002.

65 National Institute of Oceanography (2001). Report released to mass-media (from Dr AC Anil, NIO, Goa).

66 Xu, CY (1982). Surveys on the causal organisms of red tides in Dalian Bay. *Journal of Fisheries, China* 6(2): 173-180 (in Chinese).

67 Iizuka S (1976). Succession of red tide organisms in Omura Bay with relation to water pollution. *Bulletin of the Plankton Society of Japan* 23(1): 31-43 (in Japanese).

68 Kuriakose PS (1980). Mussels (Genus *Perna*) of the Indian coast. In: *Coastal aquaculture of mussels - Progress and Prospects*. Central Marine Research Fisheries Institute (Cochin, India).

69 Thompson MF (1994). *Recent developments in biofouling control*. Oxford & IBH Publishing Co, Pty Ltd, UK.

70 National Institute of Oceanography: *Bryozoan Identifications* (volume provided by Dr AC Anil, NIO, Goa, India)

71 Zaitsev Y & B Ozturk (2001). *Exotic Species in the Aegean, Marmara, Black, Azov and Caspian Seas*. Publication No.8, Turkish Marine Foundation, Istanbul. Turk Deniz Arastirmalari Vakfi. Istanbul.

72 CIESM Atlas of Introduced Species in Mediterranean Sea (2002). http://www.ciesm.org/atlas

73 McMinn, A (1990). Recent dinoflagellate cyst distribution in eastern Australia. *Review of Paleobotany and Palynology 65:* 305-310.

74 Karunasagar I, Gowda HSV, Subburaj M, Venugopal MN & I Karunasagar (1984). Outbreak of paralytic shellfish poisoning in Mangalore, west coast of India. *Current Science* 53(5): 247-249.

75 Yoon YH *et al* (1991). Red tide organisms in the coastal waters of Cheju Island, southern Korea. *Bulletin of Marine Research Institute, Cheju National University* 15: 1-14.

76 Pillai CSG & Jasmine S (1991). Life cycle of *Perna indica*. In: Symposium on tropical marine living resources, Cochin, Kerala (india), 12-16 January 1988. *J. Mar Biol. Association India* 33(1-2): 159-165.

77 Coles SL, DeFelice RC & LG Eldredge (1999). Nonindigenous marine species introductions in the harbors of the south and west shores of Oahu, Hawaii. *Bishop Museum Technical Report No. 15* (Bernice Pauahi Bishop Museum, Honolulu, Hawaii).

78 Coles SL, DeFelice RC, Eldredge LG & JT Carlton (1999). Historical and recent introductions of non-indigenous marine species into Pearl Harbor, Oahu, Hawaiian Islands. *Marine Biology* 135:147-158.

79 Coles SL, DeFelice RC & D Minton (2001). Marine species survey of Johnston Atoll, Central Pacific Ocean, June 2000. *Bishop Museum Technical Report No. 19* (Bernice Pauahi Bishop Museum, Honolulu, Hawaii).

80 DeFelice RC, Coles SL, Muir D & LG Eldredge (1998). Investigation of marine communities at Midway Harbor and adjacent lagoon, Midway Atoll, north western Hawaiian Islands. *Bishop Museum Hawaiian Biological Survey Contribution No. 1998-014* (Bernice Pauahi Bishop Museum, Honolulu, Hawaii).

81 Hewitt C (2002). Distribution and biodiversity of Australian tropical marine bioinvasions. *Pacific Science 56(2*): 213-222.

82 Coles SL & LG Eldredge (2002). Nonindigenous species introductions on coral reefs: a need for more information. *Pacific Science 56(2*): 191-209.

83 Hoedt FE, Choat JH, Collins J & JJ Cruz (2000). *Mourilyan Harbour and Abbot Point surveys: Port baseline surveys for introduced marine pests*. Unpubl. report to Ports Corporation of Queensland (Brisbane). School of Marine Biology & Aquaculture, James Cook University, Townsville

84 Choo PS, 1994. *A Review on Red Tide Occurrences in Malaysia*. Department of Fisheries, Ministry of Agriculture, Kuala Lumpur, Malaysia.

85 Southward AJ, Burton RS, Coles SL, Dando PR, DeFelice R, Hoover J, Newman WA, Parnel E, Yamaguchi (1998). Invasion of Hawaiian inner shores by an Atlantic barnacle. *Marine Ecology Progress Series 165*:119-126.

86 Nichols FH, Thompson JK & LE Schemel (1990). Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis*. II. Displacement of a former community. *Marine Ecology Progress Series* 66: 95-101.

87 Pyne R (1999). The black-striped mussel (*Mytilopsis sallei*) infestation in Darwin: clean-up strategy. In: *EcoPorts Monograph Series No.19 (77-83)*. Ports Corporation of Queensland, Brisbane.

88 Culver, CS (2000). Apparent eradication of a locally established introduced marine pest. *Biological Invasions 2 (3*): 245-253.

89 Fofonoff PW, Ruiz GM, Hines AH & L McCann (1999). Overview of biological invasions in the Chesapeake Bay region: summary of impacts on coonservation of biological diversity: a key to the restoration of the Chesapeake Bay and beyond. *Monograph. Maryland Department of Natural Resources, pp.168-180.*

90 Veldhuizen TC & S Stanish (1999). *Overview of the Life History, Distribution, Abundance, and Impacts of the Chinese mitten crab, Eriocheir sinensis.* Environmental Studies Office, California Department of Water Resources, Sacramento, CA 95816. March 1999.

91 NTMAG & CSIRO, 2000. *Port survey of introduced marine species., Port of Darwin*. Unpublished report provided by Dr Barry Russel, Museum & Art Gallery of the Northern Territory, Darwin, Northern Territory, Australia.

92 Faunce CH and Lorenz JJ (2000) Reproductive biology of the introduced Mayan cichlid, *Cichlasoma urophthalmus*, within an estuarine mangrove habitat of southern Florida. *Environmental Biology of Fishes 58*: 215–225.

93 Zhang F & M Dickman (1999). Mid-ocean exchange of container vessel ballast water. 1: Seasonal factors affecting the transport of harmful diatoms and dinoflagellates. *Marine Ecology Progress Series 176*:243-251.

94 Harris LG & MC Tyrell (2001). Changing Community States in the Gulf of Maine: Synergism Between Invaders, Overfishing and Climate Change. *Biological Invasions 3 (1)*: 9-21.

95 Crooks JA & CA Jolla (2001). Assessing invader roles within changing ecosystems: historical and experimental perspectives on an exotic mussel in an urbanized lagoon. *Biological Invasions 3 (1)*: 23-36.

96 In: Raaymakers S (Ed.) (2002). Baltic regional workshop on ballast water management, Tallinn, Estonia., 22-24 October 2001: Workshop report. *GloBallast Monograph Series No.2*. IMO, London.

97 Gosling EM (1992). Systematics and geographic distribution of Mytilus. In: Gosling EM (Ed.) *The Mussel Mytilus: Ecology, Physiology, Genetics and Culture*. Elsevier Press, Netherlands.

98 In: Raaymakers S & C Gregory (Eds) (2002). 1st East Asia regional workshop on ballast water control and management, Beijing, China. 31 Oct – 2 Nov 2002: Workshop report. *GloBallast Monograph Series No.6*. IMO, London.

99 Eno NC, Clark RA & Sanderson WG (Eds). Directory of non-native marine species in British waters. http://www.jncc.gov.uk/marine/dns/default.htm

100 Oderbrecht et al (2002).

101 Ports & Shipping Organisation (2002). Species tables. In: *Draft report of seasonal Port Baseline Biological Surveys for Port of Khark Island*. Unpublished manuscript provided by PSO, Tehran, I.R. Iran.

102 Introduction to non-indigenous species of the Gulf of Mexico (2002). Website: http://www.gsmfc.org/nis/nis/Perna_perna.html

103 Erkki Leppäkoski E & S Olenin (2000). Non-native species and rates of spread: Lessons from the brackish Baltic Sea. *Biological Invasions 2 (2)*:151-163.

104 Ambrogi AO (2000). Biotic invasions in a Mediterranean lagoon. *Biological Invasions 2 (2)*: 165-176

105 Galil BS (2000). A sea under siege – alien species in the Mediterranean. *Biological Invasions 2 (2)*:177-186

106 Mann, R (2000). Invasion of the North American atlantic coast by a large predatory Asian mollusc *Biological Invasions 2(1)*: 7-22

107 Lohrer AM, Whitlatch RB, Wada K & Y Fukui (2000). Home and away: comparisons of resource utilization by a marine species in native and invaded habitats. *Biological Invasions 2 (1)*:41-57

108 Wasson, K & B Von Holle (2000). Detecting invasions of marine organisms: Kamptozoan case histories. *Biological Invasions 2(1)*: 59-74.

109 Rivest BR, Coyer J, Haren AA & S Tyler (1999). The first known invasion of a free-living marine flatworm. *Biological Invasions 1(4)*: 393-394

110 Exotic species list of the Monterey Bay National Marine Sanctuary. http://bonita.mbnms.nos.noaa.gov/sitechar/spex.html

111 FAO database on aquatic species introductions: http://www.fao.org/waicent/faoinfo/fishery/statist/fisoft/dias/index.htm

112 Global Invasive Species Program (GISP): http://jasper.stanford.edu/GISP/ and GISP Database: http://www.issg.org/database/welcome/

113 Group on Aquatic Alien Species (GAAS) (Russia): http://www.zin.ru/projects/invasions/index.html

114 Gulf of Maine Ballast Water and Exotic Species Web Sites: http://www.gulfofmaine.org/library/exotic.htm

115 Gulf of Mexico Program Nonindigenous Species Information: http://pelican.gmpo.gov/nonindig.html

116 Smithsonian Environmental Research Center (SERC marine invasions lab): http://invasions.si.edu/

117 Ecological Society of Japan (Ed.) (2002). *Handbook of alien species in Japan*. (published 9/02). Chijinchokan Ltd, Tokyo (in Japanese). 390pp. http://www.chijinshokan.co.jp

118 Fine M, Zibrowius H & Y Loya (2001). Oculina patagonica: a non-lessepsian scleractinian coral invading the Mediterranean Sea. Springer-Verlag (New York):
http://linl.springer-ny.com/link/service/journals/00227/contents/01/00539/

119 Schaffelke B, Murphy N & S Uthicke (2002). Using genetic techniques to investigate the sources of the invasive alga *Caulerpa taxifolia* in three new locations in Australia. *Mar Poll Bull 44*: 204-210.

120 Washington State Sea Grant Program: Non-indigenous aquatic species:
http://www.wsg.washington.edu/outreach/mas/nis/nis.html

121 Baltic Research Network on invasions and introductions (NEMO). Website:
http://www.ku.lt/nemo/mainnemo.htm

122 US Geological Service non-indigenous aquatic species (NIAS) website:
http://nas.er.usgs.gov/

123 National aquatic nuisance species clearing house - Seagrant Program:
http://www.entryway.com/seagrant/

124 Esmaili Sari A, Khodabandeh S, Abtahi B, Sifabadi J & H Arshad (2001). *Invasive comb jelly Mnemiopsis leidyi and the future of the Caspian Sea*. Faculty of Natural Resources and Marine Sciences, University of Tarbiat Modarres. Kor, Mazandaran, IR Iran. ISBN: 964-91086-2-9. (+95 pp; non-English). Obtainable from: yavarivahid@hotmail.com ; yavari@ir-pso.com .

125 Cohen BF, Heislers S, Parry GD, Asplin MD, Werner GF & JE Restall (2002). *Exotic marine pests in the outer harbour of the Port of Adelaide*. Marine and Freshwater Resources Institute of Victoria (Report No. 40), MAFRE, Queenscliffe, Victoria, Australia. (9/02; 86pp.).

APPENDIX 6

Name, UN code, coordinates and environmental parameters of the 357 ports used for the multivariate similarity analyses for all Demonstration Sites

Port Environmental Data - input file used for PRIMER Analysis	UN Port Code	Latitude		N	Longitude		E	Port Type	Water Temperatures (°C) [WT]				Summer Air Temp°C [SART]		Winter Air Temp °C [WART]		Salinities (g/L) [SAL]				Tidal Ranges (m)	
		Deg	Min	S	Deg	Min	W		Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Mean day-time	Maximum daytime	Mean night-time	Lowest night-time	Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Abu Dhabi	AEAUH	24	32.0	N	54	23.0	E	3	30.5	35.5	21.0	16.0	36.5	45.0	19.0	8.0	38.0	38.0	39.5	42.0	1.6	0.4
Mina Zayed	AEMZD	24	32.0	N	54	23.0	E	3	30.5	35.5	21.0	16.0	36.5	45.0	19.0	8.0	38.0	38.0	39.5	42.0	1.6	0.4
Das Island	AEDAS	25	9.0	N	52	52.0	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	38.0	37.5	39.0	40.5	0.6	0.2
Port Rashid	AEPRA	25	16.0	N	55	16.0	E	3	30.5	34.6	23.0	16.0	33.0	47.0	19.0	8.0	38.5	37.0	40.0	42.0	2.1	0.3
Dubai	AEDXB	25	16.0	N	55	16.0	E	3	30.5	34.6	23.0	16.0	33.0	47.0	19.0	8.0	38.5	37.0	40.0	42.0	2.1	0.3
Fateh Oil Terminal	AEFAT	25	36.0	N	54	31.2	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	38.0	37.5	39.0	40.5	0.8	0.2
Fujairah	AEFJR	25	10.0	N	56	21.0	E	1	30.0	32.0	22.0	16.5	32.8	40.0	24.0	14.0	35.5	35.0	36.0	37.0	1.8	1.0
Jebel Ali	AEJEA	25	0.0	N	55	3.0	E	3	30.5	34.6	21.0	16.0	31.0	47.0	23.0	8.0	38.5	37.0	40.0	42.0	1.1	0.2
Jebel Dhanna	AEJED	24	12.0	N	52	40.0	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	39.0	38.0	39.5	41.0	0.8	0.2
Khor Al Fakkan	AEKLF	25	24.0	N	56	22.0	E	1	30.0	32.0	21.5	16.5	32.8	42.0	24.0	14.0	35.5	35.0	36.0	37.0	1.8	1.0
Um Al Qiwain	AEQIW	25	36.0	N	55	37.0	E	4	30.5	34.6	21.0	16.0	31.0	47.0	23.0	8.0	38.5	37.0	40.5	42.0	1.1	0.6
Ruwais Oil Terminal	AERUW	24	7.8	N	52	43.8	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	39.0	38.0	39.5	41.0	0.8	0.2
Sharjah	AESHJ	25	22.0	N	55	23.0	E	3	30.5	34.6	23.0	16.0	33.0	47.0	19.0	8.0	38.5	37.0	40.0	42.0	2.1	0.2
Zirku Island	AEZIR	24	52.2	N	53	4.2	E	1	30.0	35.2	22.5	16.9	31.0	43.0	21.5	12.0	38.0	37.5	39.0	40.5	0.8	0.2
Buenos Aires	ARBUE	34	34.0	S	58	23.0	W	5	*24.0*	*27.0*	*15.0*	*13.0*	*26.0*	*34.0*	*5.0*	*0.0*	*10.0*	*0.0*	*15.0*	*25.0*	1.3	0.6
Campana	ARCMP	34	9.0	S	58	58.2	W	6	*24.0*	*27.0*	*15.0*	*13.0*	*26.0*	*35.0*	*4.0*	*-3.0*	0.0	0.0	0.0	0.0	0.0	0.0
Dampier	AUDAM	20	39.0	S	116	43.0	E	4	26.5	31.0	23.0	19.0	36.0	45.0	14.0	7.0	34.8	34.1	35.1	35.5	5.6	2.8
Port Walcott (Cape Lambert)	AUPWL	20	37.0	S	117	11.0	E	1	26.5	31.0	23.0	20.0	*36.0*	*45.0*	*14.0*	*7.0*	34.9	33.8	35.1	35.5	6.0	2.9
Port Bonython	AUPBY	33	1.0	S	137	46.0	E	2	20.0	22.0	14.5	12.0	27.0	35.0	7.5	1.0	36.1	36.0	36.2	36.3	2.6	1.6
Whyalla	AUWYA	33	1.8	S	137	24.0	E	3	19.5	21.5	14.5	12.0	28.0	36.0	5.8	0.5	35.4	35.1	35.5	35.8	2.3	1.6
Port Pirie	AUPPI	33	10.2	S	138	1.8	S	2	20.0	21.5	14.5	12.0	*28.0*	*36.0*	*5.8*	*0.5*	36.5	35.8	37.2	38.0	2.7	1.7
Port Stanvac	AUPST	35	6.0	S	138	28.0	E	1	20.5	22.0	14.5	13.0	26.0	39.0	14.0	3.0	36.3	35.8	36.4	36.5	2.1	1.4
Western Port (now Hastings; AUHAS)	AUWEP	38	18.0	S	145	13.2	E	2	18.0	20.0	13.5	11.0	25.2	34.0	6.5	-4.0	35.3	35.0	35.4	35.5	3.3	2.2
Port Kembla	AUPKL	34	28.2	S	150	54.0	E	3	18.5	21.0	17.5	15.0	25.0	36.0	8.8	0.0	34.5	32.0	35.2	35.6	2.0	1.1
Brisbane	AUBNE	27	22.8	S	153	9.6	E	5	24.0	27.0	20.0	17.5	29.2	39.0	9.0	2.0	26.0	4.0	33.0	35.0	2.3	1.3
Bundaberg	AUBDB	24	46.0	S	152	23.0	E	5	25.7	29.2	19.8	15.7	29.0	36.6	16.0	5.1	35.1	25.0	35.4	36.0	2.4	1.2
Gladstone	AUGLT	23	51.0	S	151	15.0	E	4	26.0	28.5	22.0	20.0	31.0	38.0	14.0	8.0	34.1	31.0	35.2	35.5	4.0	1.7
Port Alma	AUPTL	23	35.0	S	150	52.0	E	5	26.8	28.7	21.1	19.5	29.0	39.1	11.0	6.0	30.0	20.0	35.0	36.0	4.0	1.9
Hay Point	AUHPT	21	16.0	S	149	19.0	E	1	27.0	30.0	21.5	19.0	29.0	36.6	14.0	6.7	34.9	33.0	35.3	36.5	4.8	2.2
Dallrymple Bay (= Hay Point Anchorage)	AUPDT	21	16.2	S	149	19.2	E	1	27.0	30.0	21.5	19.0	29.0	36.6	14.0	6.7	34.9	33.0	35.3	36.5	4.8	2.2
Mackay	AUMKY	21	6.0	S	149	20.0	E	3	26.2	31.0	19.5	18.0	30.5	36.6	14.8	6.7	35.0	31.0	35.3	36.5	4.5	2.1
Abbot Point	AUABP	19	53.0	S	147	5.0	E	1	28.4	32.4	23.4	19.3	31.0	37.4	18.0	9.4	34.7	24.3	35.3	36.5	2.0	0.8
Townsville	AUTSV	19	15.0	S	146	50.0	E	3	28.2	32.4	23.0	19.0	31.5	40.8	15.5	6.0	34.7	22.0	35.0	36.2	2.3	0.6
Lucinda	AULUC	18	31.0	S	146	19.0	E	1	28.0	31.0	24.0	21.0	31.0	37.0	18.0	14.5	34.4	20.0	35.0	37.0	2.2	0.6
Mourilyan	AUMOU	17	37.0	S	146	7.0	E	5	30.0	33.0	27.0	23.0	31.0	38.5	18.0	8.4	33.0	9.0	35.0	36.0	1.8	0.5
Cairns	AUCNS	16	55.0	S	145	47.0	E	4	27.0	31.0	23.6	18.5	32.0	38.3	17.5	9.2	34.4	5.0	35.0	35.3	1.8	0.4
Cape Flattery	AUCQP	14	59.0	S	145	21.0	E	2	28.0	30.0	24.0	21.0	31.0	38.4	22.0	11.3	33.6	32.0	35.0	35.5	1.7	0.4
Weipa	AUWEI	12	35.0	S	141	36.0	E	5	30.0	33.0	28.5	24.0	33.0	37.0	19.2	12.5	33.0	20.0	35.0	36.0	2.2	0.7
Karumba	AUKRB	17	29.0	S	140	50.0	E	6	30.0	32.0	28.0	24.0	32.0	38.0	18.5	14.2	24.0	0.0	35.0	39.0	3.3	2.5
Chittagong	BDCGP	22	13.0	N	91	48.0	E	5	29.0	32.4	25.0	19.0	30.0	33.0	19.0	13.0	2.0	0.0	7.0	12.0	4.9	2.1
Antwerpen	BEANR	51	14.0	N	4	28.0	E	6	*17.0*	*20.0*	*5.0*	*0.0*	21.5	30.0	2.2	-4.0	0.0	0.0	0.0	0.0	0.0	0.0
Ghent (Gent)	BEGNE	51	4.2	N	3	42.0	E	6	17.0	20.0	5.0	0.0	21.0	28.0	1.8	-5.0	0.0	0.0	0.0	0.0	0.0	0.0
Bourgas	BGBOJ	42	30.0	N	27	28.8	E	3	24.2	26.5	6.5	0.5	24.5	38.0	4.3	-16.0	17.0	16.4	18.1	19.5	0.1	0.0
Varna, Bulgaria	BGVAR	43	12.0	N	27	57.0	E	3	21.7	25.9	5.9	-0.5	24.0	38.0	3.5	-17.0	16.8	16.1	17.9	19.3	0.1	0.0
Sitra (Bahrain)	BHMAN	26	9.0	N	50	40.0	E	1	32.0	35.0	17.0	14.0	36.5	45.0	18.0	12.0	40.0	38.0	42.0	43.0	1.6	0.9
Mina Sulman (Al Manamah)	BHMIN	26	13.0	N	50	36.0	E	3	*32.0*	*35.0*	*17.0*	*14.0*	*36.5*	*45.0*	*18.0*	*12.0*	40.0	38.0	42.0	43.0	1.8	0.9
Itajai	BRITJ	26	54.0	S	48	39.7	W	6	26.2	28.0	19.1	17.5	23.0	30.6	17.6	1.3	3.0	0.0	4.9	15.0	1.2	0.3
Paranaguá	BRPNG	25	30.1	S	48	31.5	W	5	27.5	30.0	21.4	13.0	22.0	40.0	17.2	2.4	20.5	10.5	27.0	34.0	1.6	0.4
Santos	BRSSZ	23	55.0	S	46	20.0	W	4	26.5	30.5	21.5	17.0	23.7	39.0	19.0	6.4	28.0	24.0	28.5	33.5	1.3	0.4
Sepetiba	BRSPB	22	55.3	S	43	51.0	W	2	22.0	25.5	19.0	17.2	25.4	38.2	22.0	11.1	30.5	20.0	30.5	34.0	1.4	0.7
Rio de Janeiro	BRRIO	22	53.8	S	43	11.0	W	2	27.5	31.0	23.4	19.0	25.4	38.2	22.0	11.1	23.4	17.2	27.6	30.9	1.2	0.9
Ponta do Ubu	BRPOU	20	47.0	S	40	35.0	W	1	24.0	27.0	23.0	21.0	25.8	39.0	22.7	14.2	36.0	35.0	37.0	39.0	1.4	0.6
Vitória	BRVIX	20	19.2	S	40	19.1	W	5	25.0	28.0	22.0	20.0	25.8	39.0	22.7	14.2	20.5	12.0	27.0	34.0	1.3	0.5
Praia Mole	BRPRM	20	17.3	S	40	14.5	W	3	24.0	27.0	23.0	21.0	25.8	39.0	22.7	14.2	36.0	35.0	37.0	39.0	1.3	0.4
Tubarao	BRTUB	20	17.3	S	40	14.6	W	3	24.0	27.0	23.0	21.0	25.8	39.0	22.7	14.2	36.0	35.0	37.0	39.0	1.3	0.4

Port Environmental Data - input file used for PRIMER Analysis	UN Port Code	Latitude		N	Longitude		E	Port Type	Water Temperatures (ºC) [WT]				Summer Air TempºC [SART]		Winter Air Temp ºC [WART]		Salinities (g/L) [SAL]				Tidal Ranges (m)	
		Deg	Min	S	Deg	Min	W		Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Mean day-time	Maximum daytime	Mean night-time	Lowest night-time	Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Salvador	BRSSA	12	58.4	S	38	31.0	W	2	26.5	30.2	25.2	19.5	26.1	34.7	24.3	19.8	36.0	35.0	37.0	39.0	2.2	0.9
Come By Chance	CACBC	47	28.8	N	54	0.6	W	2	16.0	17.0	2.0	-1.0	15.0	23.0	-2.0	-12.0	31.5	31.0	32.0	32.5	2.6	1.7
Sept-Iles (Pointe Noire) Quebec	CASEI	50	11.0	N	66	23.0	W	2	11.0	13.0	-1.0	-6.0	18.0	26.0	-17.0	-30.0	26.0	24.0	28.0	30.0	3.5	1.6
Halifax Nova Scotia	CAHAL	44	39.0	N	63	34.0	W	2	14.5	16.0	2.0	-0.5	22.5	27.0	-8.0	-20.0	30.0	28.0	31.0	32.0	2.0	1.3
La Have	CALHA	44	17.0	N	64	21.0	W	5	11.0	13.0	2.0	-2.0	22.5	27.0	-8.0	-20.0	25.0	15.0	29.0	31.0	2.1	1.6
Vancouver (British Columbia)	CAVAN	49	16.8	N	123	7.2	W	5	11.0	13.0	3.0	-1.0	21.2	26.0	1.0	-4.0	10.0	2.0	24.0	28.0	4.1	3.4
Roberts Bank (British Columbia)	CARBK	49	2.0	N	123	9.0	W	5	11.0	13.0	3.0	-1.0	21.2	26.0	1.0	-4.0	10.0	2.0	24.0	28.0	4.1	3.4
Guangzhou Guangdong	CNCAN	23	6.0	N	113	14.0	E	5	23.0	28.0	19.7	16.0	28.3	38.7	13.2	2.0	3.9	0.1	19.0	21.0	3.5	1.0
Chiwan (Shenzhen) Guangdong	CNCWN	22	29.0	N	113	54.0	E	5	30.0	33.1	15.5	0.5	27.5	39.0	18.0	8.0	24.0	20.0	30.0	34.0	2.8	2.0
Dalian Liaoning	CNDLC	38	55.7	N	121	39.3	E	2	22.2	26.2	2.2	-1.9	24.1	34.4	-2.0	-15.4	28.9	26.9	30.3	32.0	3.9	2.6
Huangpu Guangdong	CNHUA	23	6.0	N	113	26.0	E	5	29.0	34.0	15.8	0.3	27.0	38.0	15.0	5.0	8.0	0.1	12.0	28.0	2.5	1.8
Beilun Zhejiang	CNNBO	29	56.0	N	121	53.0	E	5	22.5	26.1	11.0	8.0	29.4	39.5	8.5	-2.6	21.7	10.6	19.6	25.2	3.1	1.1
Ningbo (Beilun) Zhejiang	CNNGB	29	56.0	N	121	53.0	E	5	22.5	26.1	11.0	8.0	29.4	39.5	8.5	-2.6	21.7	10.6	19.6	25.2	3.1	1.1
Shanghai Shanghai	CNSHA	31	14.0	N	121	29.0	E	5	26.4	32.0	6.5	4.0	27.0	40.2	5.0	-10.0	0.8	0.1	4.9	9.0	4.2	1.2
Shanghai Baoshan	CNSHB	31	25.0	N	121	30.0	E	5	25.5	30.0	7.0	5.0	25.7	39.0	8.7	-5.0	0.5	0.1	5.0	5.8	5.5	2.8
Qinggdao Shandong	CNTAO	36	5.0	N	120	18.0	E	3	24.3	27.0	4.2	2.1	25.2	35.4	-1.1	-15.5	31.8	31.6	32.4	32.6	3.4	1.8
Tianjin Tianjin	CNTSN	39	6.0	N	117	10.0	E	5	26.5	30.5	-0.1	-1.5	28.0	40.0	2.0	-18.3	31.4	26.5	31.9	35.7	3.8	2.0
Yantai Shandong	CNYNT	37	34.0	N	121	26.0	E	3	22.5	26.3	3.0	0.0	24.0	32.0	1.0	-10.0	31.0	29.5	32.0	33.0	2.8	1.8
Cartagena	COCAR	10	21.6	N	75	32.9	W	2	30.5	32.0	31.0	30.0	27.5	32.0	28.0	24.8	26.0	25.0	28.5	33.0	0.4	0.1
Kyrenia	CYKYR	35	20.0	S	33	19.0	W	3	25.6	28.5	18.0	16.0	30.5	37.0	10.0	6.0	38.6	38.0	39.2	39.3	0.5	0.1
Larnaca	CYLCA	34	55.0	N	33	39.0	E	3	25.6	28.6	18.2	16.6	31.0	37.0	9.0	5.0	38.6	38.0	39.2	39.4	0.6	0.1
Limassol	CYLMS	34	39.0	N	33	1.2	E	3	25.6	28.5	18.2	16.6	32.0	39.0	10.0	6.0	38.6	38.0	39.2	39.4	0.6	0.1
Bremen	DEBRE	53	0.0	N	8	46.8	E	5	14.0	16.5	6.4	3.0	17.0	24.0	1.2	-4.0	18.0	11.0	28.0	30.0	4.2	3.4
Hamburg	DEHAM	53	33.0	N	9	59.0	E	5	16.0	20.0	3.0	0.0	17.3	23.2	0.5	-5.5	4.0	0.0	11.0	18.0	3.0	1.0
Wilhelmshaven	DEWVN	53	32.0	N	8	8.0	E	2	17.0	21.0	4.0	2.0	17.0	24.0	1.2	-4.0	28.0	24.0	32.0	33.0	4.1	2.8
Djibouti (Djibouti)	DJJIB	11	36.0	N	43	8.0	E	3	29.5	32.0	23.5	20.5	32.2	40.0	26.3	16.0	35.8	35.3	36.9	37.3	1.0	0.5
Enstedvaerkets Havn	DKENS	55	1.0	N	9	26.0	E	2	17.0	20.5	3.5	1.5	16.5	24.0	0.0	-8.0	14.0	12.0	18.0	20.0	0.4	0.2
Fredericia	DKFRC	55	34.2	N	9	45.0	E	2	17.5	20.5	3.5	1.5	16.5	24.0	0.0	-8.0	19.0	18.0	21.0	24.0	0.4	0.2
Ain Sukhna	EGAIS	29	34.0	N	32	24.0	E	1	29.0	32.0	20.0	17.0	28.7	42.0	16.7	6.0	41.0	40.0	42.0	43.0	2.3	1.4
Alexandria (El Iskandariya)	EGALY	31	10.8	N	29	52.2	E	3	25.0	29.7	16.0	13.5	29.0	36.0	11.0	7.0	38.0	37.5	38.0	39.0	0.5	0.2
Damietta	EGDAM	31	25.8	N	31	48.0	E	3	25.0	29.7	16.0	13.0	29.0	36.0	11.0	7.0	25.0	20.0	33.0	36.0	0.5	0.2
El Dekheila	EGEDK	31	8.0	N	29	49.0	E	3	25.0	29.7	16.0	13.2	29.0	36.0	11.0	7.0	38.0	37.5	38.0	39.0	0.4	0.2
Port Said	EGPSD	31	15.6	N	32	18.6	E	3	25.0	29.7	16.0	13.2	26.0	33.0	15.0	8.0	37.0	34.0	38.5	39.5	0.6	0.2
Suez (El Suweis)	EGSUZ	29	58.0	N	32	33.0	E	3	29.0	31.4	20.0	17.6	34.0	44.0	18.0	6.0	40.5	39.3	42.0	42.5	1.6	0.9
Gijon	ESGIJ	43	34.0	N	5	41.0	W	3	18.0	20.0	13.0	11.0	25.0	35.0	7.0	4.0	35.2	34.5	35.4	35.6	4.6	2.2
Bilbao	ESBIO	43	21.6	N	3	4.2	W	5	20.5	22.0	13.0	11.0	25.1	34.5	6.8	4.0	33.0	25.0	35.0	35.5	4.8	2.1
Vigo	ESVGO	42	13.8	N	8	43.8	W	2	18.5	19.5	14.5	12.5	24.0	33.0	8.0	4.0	35.8	35.4	35.8	36.0	4.0	1.8
Barcelona	ESBCN	41	19.8	N	2	9.6	E	3	23.0	24.5	13.0	11.5	27.5	38.4	8.0	6.0	37.0	36.5	37.5	38.0	0.8	0.1
Valencia	ESVLC	39	27.0	N	0	18.0	W	3	25.0	27.0	13.5	12.0	28.0	39.0	10.0	7.5	37.2	37.0	37.6	38.0	0.2	0.0
Algeciras	ESALG	36	8.0	N	5	26.0	W	2	22.2	23.4	16.0	14.5	27.0	35.0	12.2	7.0	36.5	36.0	36.5	37.0	0.4	0.1
Las Palmas	ESLPA	28	9.0	N	15	25.0	W	3	22.3	24.0	20.0	17.5	27.2	35.0	14.1	11.0	36.6	36.4	36.6	36.8	2.6	1.0
Tenerife (Santa Cruz de Tenerife)	ESSCT	28	27.0	N	16	14.0	W	3	22.3	24.0	20.0	17.5	27.0	35.0	14.0	11.0	36.6	36.4	36.6	36.8	2.5	0.8
Tarragona	ESTAR	41	5.0	N	1	14.0	E	3	25.5	27.0	13.5	11.5	27.5	38.4	8.0	6.0	37.0	36.5	37.5	38.0	0.7	0.1
Dunkerque	FRDKK	51	3.0	N	2	22.0	E	3	17.5	21.0	7.0	3.0	21.0	30.0	3.0	-4.0	32.5	32.0	33.0	33.5	6.1	3.2
Brest	FRBES	48	24.0	N	4	30.0	E	3	17.0	19.5	11.0	9.0	22.0	33.0	4.5	-2.0	34.8	34.4	35.2	35.6	7.5	2.7
Donges	FRDON	47	18.0	N	2	4.0	E	5	19.5	21.0	11.0	9.0	21.0	29.0	4.0	-1.0	20.0	3.0	32.5	34.0	5.5	2.6
Fos sur Mer (Oil Terminal)	FRFOS	43	24.0	N	4	53.0	E	5	22.0	24.5	14.0	12.5	24.0	31.0	4.5	2.0	33.0	31.0	35.0	36.0	0.1	0.0
Lavera	FRLAV	43	24.0	N	5	0.0	E	5	22.0	24.5	14.0	12.5	24.0	31.0	4.5	2.0	33.0	31.0	35.0	36.0	0.1	0.0
Le Havre	FRLEH	49	29.0	N	0	6.0	E	5	18.0	20.0	9.0	7.0	21.0	29.0	3.0	-2.0	32.5	30.0	34.0	34.5	8.0	3.9
Marseilles	FRMRS	43	19.0	N	5	22.0	E	3	22.0	24.5	14.0	12.5	24.0	31.0	4.5	2.0	33.0	31.0	35.0	36.0	0.1	0.0
Hunterston	GBHST	55	45.0	N	4	53.0	W	2	14.5	16.5	7.0	4.5	18.2	25.0	0.9	-1.0	30.0	27.0	33.0	34.0	3.7	1.9
Immingham	GBIMM	53	38.0	N	0	11.0	W	5	16.0	18.0	6.5	2.5	18.4	26.0	1.1	-1.0	18.0	10.0	24.0	26.0	7.6	3.1
Burry Port (Llanelly)	GB001	51	40.0	N	4	15.0	W	5	17.0	19.0	8.5	7.0	21.0	27.0	3.0	-1.0	29.0	27.0	32.0	33.5	9.1	3.4
Port Talbot	GBPTB	51	34.0	N	3	48.0	W	3	17.0	19.0	8.5	6.0	18.5	26.0	2.0	-1.0	31.0	30.0	32.0	34.0	8.9	4.0

Port Environmental Data - input file used for PRIMER Analysis	UN Port Code	Latitude Deg	Min	N/S	Longitude Deg	Min	E/W	Port Type	Water Temperatures (°C) [WT] Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Summer Air Temp°C [SART] Mean day-time	Maximum daytime	Winter Air Temp °C [WART] Mean night-time	Lowest night-time	Salinities (g/L) [SAL] Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Tidal Ranges (m) Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Redcar	GBRER	54	37.0	N	1	9.0	W	5	16.0	18.0	7.0	4.5	19.3	25.0	0.5	-2.5	20.0	5.0	31.0	33.1	5.2	1.9
Batumi, Georgia	GEBUS	41	39.0	N	41	37.8	E	3	23.8	28.6	10.3	6.8	21.6	40.0	7.9	-8.0	17.2	16.5	17.2	17.8	0.1	0.0
Poti, Georgia	GEPTI	42	7.8	N	41	39.0	E	3	24.0	28.5	9.6	6.1	21.7	41.0	6.3	-11.0	17.2	16.4	17.2	17.9	0.1	0.0
Gibraltar	GIGIB	36	8.0	N	5	21.0	W	3	22.2	23.4	16.0	14.5	27.0	36.0	12.5	7.5	36.5	36.0	36.5	37.0	0.5	0.2
Aspropyrgos	GRASS	38	2.0	N	23	35.0	E	1	23.0	27.0	17.0	15.0	26.0	36.0	12.0	1.0	38.6	38.0	39.2	39.3	0.4	0.0
Elefsis (Eleusis)	GREEU	38	2.0	N	23	33.0	E	2	23.5	26.5	17.0	15.0	27.0	37.0	12.0	1.0	38.6	38.0	39.2	39.3	0.1	0.0
Chios	GRJKH	38	23.0	N	26	9.0	E	2	24.4	25.8	15.5	13.8	26.0	34.0	9.0	2.0	38.8	37.5	39.1	39.8	0.3	0.0
Pachi	GRPAC	37	58.0	N	23	23.0	E	1	23.0	27.2	17.0	15.0	27.0	36.0	12.0	1.0	38.3	38.0	39.1	39.3	0.1	0.0
Piraeus	GRPIR	37	57.0	N	23	38.0	E	3	22.5	26.0	18.0	16.0	27.0	37.0	12.2	1.0	38.4	38.0	39.0	39.1	0.4	0.0
Thessaloniki	GRSKI	40	38.0	N	22	56.0	E	3	23.1	25.8	12.0	10.0	25.0	34.0	9.0	2.0	37.5	36.8	39.0	39.6	0.7	0.2
Volos	GRVOL	39	22.0	N	22	57.0	E	3	24.2	26.0	14.6	12.2	25.0	34.0	9.0	2.0	38.8	37.0	39.1	39.8	0.3	0.0
Hong Kong Hong Kong	HKHKG	22	17.0	N	114	10.0	E	3	26.0	28.5	19.9	18.1	27.2	34.0	20.8	15.0	18.6	10.0	32.5	34.0	0.8	0.6
Hong Kong Kowloon	HKKWN	22	17.0	N	114	10.0	E	2	26.0	28.5	19.9	18.1	27.2	34.0	20.8	15.0	18.6	10.0	32.5	34.0	0.8	0.6
Omisalj	HROMI	45	12.0	N	14	33.0	E	2	24.0	26.5	9.0	7.0	27.0	34.0	3.9	0.5	24.0	18.0	35.0	36.0	0.6	0.2
Belawan Sumatra	IDBLW	3	47.0	N	98	42.0	E	5	30.0	32.0	28.0	27.0	32.6	36.0	21.5	18.0	26.0	21.0	27.0	28.0	2.5	0.9
Dumai Sumatra	IDDUM	1	41.0	N	101	27.0	E	4	29.0	31.5	28.0	26.0	31.0	34.0	23.0	21.0	26.0	21.0	27.0	28.0	2.5	1.4
Cigading	IDCIG	6	1.0	S	105	57.0	E	2	28.4	30.5	27.0	26.0	30.5	36.0	24.0	23.0	32.0	30.0	33.0	34.5	0.7	0.2
Merak (inc. Anyer Terminal) Java	IDMRK	5	55.0	S	106	0.0	E	2	29.0	32.0	28.0	25.0	32.0	37.0	22.6	19.0	31.0	29.0	31.5	34.0	0.9	0.3
Jakarta Java	IDJKT	7	0.0	S	106	53.0	E	3	29.0	32.0	28.0	25.0	32.0	37.0	22.6	19.0	29.0	27.0	31.0	34.0	0.9	0.3
Cilacap Java	IDCXP	7	44.0	S	109	0.0	E	5	28.4	32.0	27.9	25.5	31.0	35.0	24.5	22.0	22.0	15.0	32.0	34.0	2.0	0.7
Semarang Java	IDSRG	6	57.0	S	110	25.0	E	2	28.5	30.5	27.5	25.0	30.0	36.0	24.2	23.0	30.0	25.0	33.0	34.0	1.0	0.7
Tanjung Perak (Surabaya) Java	IDSUB	7	12.0	S	112	44.0	E	2	28.6	30.4	28.0	25.0	30.5	36.0	23.1	23.4	28.0	23.0	30.0	32.0	1.5	0.2
Tanjung Bara Coal Terminal Kalimantan	IDTBA	0	32.0	S	117	39.0	E	1	29.0	32.0	28.0	26.0	31.0	35.0	23.5	20.0	29.0	28.0	30.0	31.0	2.5	0.8
Balikpapan Kalimantan	IDBPN	1	15.0	S	116	48.0	E	2	30.0	32.0	28.5	27.0	31.0	35.0	23.5	20.0	27.0	25.0	29.0	31.0	2.6	0.9
Amamapare Irian Jaya	IDAMA	4	49.0	S	136	58.0	E	5	28.5	30.0	27.5	25.0	30.5	36.0	22.0	19.0	12.5	0.0	15.8	28.0	2.4	0.7
Moneypoint	IEMOT	52	36.0	S	9	25.0	W	5	16.0	18.5	11.0	8.0	20.8	28.0	1.7	-3.0	10.0	0.0	22.0	27.0	5.9	4.3
Ashdod	ILASH	31	50.0	N	34	38.0	E	3	25.0	29.7	16.0	13.0	30.2	40.0	7.5	2.0	38.0	37.5	38.0	39.0	0.2	0.0
Mumbai (Ex Bombay)	INBOM	18	54.0	N	72	49.0	E	4	28.6	30.6	28.4	26.6	28.6	35.6	24.0	19.0	27.5	14.5	36.9	37.6	3.6	1.4
Calcutta	INCCU	22	33.0	N	88	19.0	E	6	29.0	32.4	25.0	19.0	30.0	33.0	19.0	13.0	0.0	0.0	0.0	0.0	4.2	2.1
Cochin	INCOK	9	58.0	N	78	48.0	E	5	30.0	31.9	28.0	25.0	29.0	31.3	23.5	19.0	5.0	1.1	11.4	22.0	0.6	0.2
Haldia	INHAL	22	2.0	N	88	5.0	E	5	29.0	32.0	25.0	22.0	30.0	34.0	20.0	17.0	15.0	0.0	18.0	23.0	4.9	1.6
Mangalore (New Mangalore)	INIXE	12	55.0	N	74	48.0	E	3	28.4	29.8	26.5	25.0	26.3	30.0	27.0	24.3	33.1	26.9	31.8	34.9	1.0	0.4
Kandla	INIXY	22	52.0	N	70	13.0	E	2	27.1	29.7	19.8	19.3	30.2	37.7	17.7	9.8	3.4	3.3	3.5	3.7	5.9	3.9
Chennai (Ex Madras)	INMAA	13	6.0	N	80	18.0	E	3	28.2	30.0	27.5	26.5	29.9	35.2	26.1	23.9	22.0	20.0	25.5	34.6	1.0	0.4
Marmugao (Marmagoa)	INMRM	15	25.0	N	73	47.0	E	5	27.8	30.4	27.8	26.0	29.8	31.7	22.7	20.5	28.4	22.4	32.2	33.3	1.4	0.8
Mundra	INMUN	22	54.0	N	69	42.0	E	2	27.9	30.5	22.0	20.0	29.1	40.0	22.8	7.0	26.0	21.0	32.0	33.0	5.2	2.6
Porbandar	INPBD	21	38.0	N	69	36.0	E	5	27.8	30.4	24.0	27.1	28.6	35.6	24.0	19.0	28.4	22.4	32.2	33.3	1.9	0.9
Paradeep	INPRT	20	15.0	N	85	40.0	E	3	30.8	31.4	27.2	26.6	29.6	36.2	18.4	12.9	14.9	9.0	29.3	33.2	1.9	0.7
Salaya	INSAL	22	18.0	N	69	34.8	E	2	28.0	31.0	23.0	20.0	29.0	40.0	23.0	11.0	27.0	22.0	32.0	33.0	4.1	2.8
Sikka	INSIK	22	31.0	N	69	48.0	E	2	27.9	30.5	24.0	27.3	29.1	40.0	22.8	7.0	36.0	35.5	35.0	35.0	4.8	2.6
Tuticorin (New Tuticorin)	INTUT	8	22.0	N	76	59.0	E	3	28.8	31.3	27.1	24.0	30.2	38.7	26.0	18.3	31.2	26.9	34.0	36.5	0.7	0.2
Vadinar Terminal	INVAD	22	30.0	N	69	42.0	E	1	28.0	31.0	23.0	20.0	29.0	40.0	23.0	11.0	27.0	22.0	32.0	33.0	4.2	2.8
Visakhapatnam	INVTZ	17	14.0	N	83	18.0	E	2	27.8	29.5	26.0	23.8	33.6	40.0	23.7	13.0	23.0	16.5	31.1	35.0	1.4	0.6
Bandar Imam Khomeyni	IRBKM	30	25.0	N	49	4.0	E	4	34.9	35.4	16.5	14.0	33.1	52.0	19.3	2.0	38.2	35.0	42.0	44.0	4.0	2.6
Bandar Mushar (Mushahr)	IRBMR	30	28.0	N	49	11.0	E	5	34.9	35.4	16.5	14.0	33.1	37.6	19.3	2.0	38.2	37.4	40.9	41.0	4.0	2.6
Bandar Abbas (Oil Jetty)	IRBND	27	11.0	N	56	17.0	E	1	34.5	34.9	20.0	19.0	34.2	45.6	18.5	7.2	36.6	35.0	37.0	37.5	3.1	1.4
Bushehr	IRBUZ	28	59.0	N	50	50.0	E	2	34.5	35.5	18.0	16.0	32.0	47.0	18.0	6.0	38.5	38.0	41.5	42.0	1.3	0.4
Khark Island	IRKHK	29	14.0	N	50	19.0	E	1	34.2	34.9	18.2	17.9	31.7	47.0	19.0	7.0	38.9	38.5	40.9	41.0	1.0	0.3
Lavan Island	IRLVP	26	47.0	N	53	20.0	E	1	33.0	34.0	21.0	19.0	33.0	37.0	23.8	10.0	36.0	35.0	36.0	37.0	1.1	0.2
Sirri Island Oil Terminal	IRSXI	25	57.0	N	54	32.0	E	1	33.0	34.0	21.0	19.0	33.0	37.0	23.8	10.0	36.0	35.0	36.0	37.0	1.2	0.4
Hafnarfjordur	ISHAF	61	4.0	N	21	58.0	W	2	9.5	11.5	3.0	-0.5	14.0	21.0	-5.0	-11.0	34.0	33.0	34.5	35.0	3.9	1.5
Straumsvik	ISSTR	64	3.0	N	22	3.0	W	3	9.5	11.5	3.0	-0.5	14.0	21.0	-5.0	-11.0	34.0	33.0	34.5	35.0	3.9	1.5
Genoa	ITGOA	44	24.0	N	8	55.2	E	3	23.5	24.0	14.0	12.5	26.0	34.0	6.0	2.0	37.0	36.0	37.5	38.0	0.2	0.0
Porto Foxi (Sarroch)	ITPFX	39	4.8	N	9	1.8	E	1	23.5	26.0	16.0	14.5	25.0	37.0	7.0	3.0	37.0	36.5	37.5	38.0	0.2	0.0

Port Environmental Data - input file used for PRIMER Analysis	UN Port Code	Latitude		N	Longitude		E	Port Type	Water Temperatures (°C) [WT]				Summer Air Temp°C [SART]		Winter Air Temp °C [WART]		Salinities (g/L) [SAL]				Tidal Ranges (m)	
		Deg	Min	S	Deg	Min	W		Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Mean day-time	Maximum daytime	Mean night-time	Lowest night-time	Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Livorno	ITLIV	43	33.0	N	10	18.6	E	3	24.0	26.0	15.0	13.0	27.5	37.0	5.0	0.5	37.5	37.0	38.0	38.5	0.3	0.0
Ravenna	ITRAN	44	28.8	N	12	16.8	E	3	25.5	27.0	12.0	10.0	29.0	37.0	4.0	0.5	18.0	10.0	36.0	37.0	0.5	0.2
Taranto	ITTAR	40	26.0	N	17	12.0	E	3	24.8	27.0	15.0	14.0	29.0	38.0	7.0	3.0	37.5	37.0	38.0	38.5	0.2	0.0
Venezia (=Fusina)	ITVCE	45	25.8	N	12	19.8	E	5	25.0	27.0	11.0	9.0	27.0	35.0	4.5	2.0	27.0	14.0	31.0	33.0	0.6	0.1
Trieste	ITTRS	45	39.0	N	13	45.0	E	3	24.0	26.0	10.0	8.0	27.0	34.0	3.9	0.5	27.0	22.0	35.0	36.0	0.9	0.2
Aboshi Hyogo	JPABO	34	45.0	N	134	34.0	E	3	25.5	27.0	11.0	9.0	29.0	36.0	5.0	1.0	25.0	20.0	28.0	30.0	1.6	0.3
Amagasaki Hyogo	JPAMA	34	41.0	N	135	23.0	E	5	24.0	26.0	11.5	9.0	29.0	34.0	6.0	1.0	18.0	16.0	20.0	25.0	1.5	0.5
Beppu Oita	JPBEP	33	20.0	N	131	31.0	E	2	24.0	27.5	16.0	12.0	29.0	34.0	3.0	-1.0	19.0	17.0	28.0	31.0	1.5	0.5
Chiba Chiba	JPCHB	35	35.0	N	140	6.0	E	2	23.0	26.0	12.0	8.0	27.0	35.0	7.0	-4.0	20.0	9.0	28.0	32.0	2.1	0.2
Kimitsu Chiba	JPKMT	35	23.0	N	139	50.0	E	2	23.0	26.0	12.0	8.0	27.0	35.0	7.0	-4.0	20.0	9.0	28.0	32.0	2.0	0.2
Fukuyama Hiroshima	JPFKY	34	29.0	N	133	22.0	E	3	23.0	26.0	8.0	4.0	30.0	33.0	2.0	-2.0	17.4	16.3	18.0	22.0	2.9	1.4
Higashi-Harima Hyogo	JPHHR	34	43.0	N	134	50.0	E	3	25.0	27.0	9.5	8.0	29.0	35.0	4.0	-0.8	24.0	19.0	27.0	29.0	1.3	0.2
Himeji Hyogo	JPHIM	34	46.2	N	134	37.8	E	3	25.5	27.0	11.0	9.0	29.0	36.0	5.0	1.0	25.0	20.0	28.0	30.0	1.6	0.3
Hakata Fukuoka	JPHKT	33	35.0	N	130	23.0	E	2	23.6	25.0	10.8	9.5	31.0	31.8	4.0	0.0	18.4	17.0	28.0	30.0	2.4	0.8
Imabari Ehime	JPIMB	34	4.0	N	133	1.0	E	2	25.0	27.0	12.0	8.0	30.0	34.0	3.0	-1.0	23.0	20.0	28.0	32.0	3.3	1.2
Innoshima Hiroshima	JPINS	34	16.8	N	133	10.8	E	2	24.0	27.0	10.0	6.0	30.0	34.0	3.0	-1.0	23.0	20.0	28.0	32.0	3.8	1.3
Iwakuni Yamaguchi	JPIWK	34	10.0	N	132	16.0	E	2	24.0	27.0	15.0	12.0	30.0	34.0	2.0	-1.0	18.0	14.0	21.0	24.0	2.9	1.1
Kochi Kochi	JPKCZ	33	31.0	N	133	33.0	E	5	24.0	27.0	15.0	12.0	29.0	34.0	2.0	0.0	25.0	18.0	27.0	30.0	2.3	0.7
Kakogawa Hyogo	JPKGA	34	42.0	N	134	47.0	E	3	25.0	26.5	9.5	8.0	28.0	34.0	3.5	-0.8	24.0	18.0	26.0	29.0	1.3	0.5
Kiire Kagoshima	JPKII	31	23.0	N	130	32.0	E	2	25.0	28.0	19.0	17.0	30.5	35.0	6.0	3.0	33.0	29.0	33.0	34.5	3.0	0.5
Niigata Niigata	JPKIJ	37	54.0	N	139	4.0	E	5	23.0	26.0	10.0	8.0	28.0	33.0	0.5	-6.0	31.0	28.0	32.0	33.0	0.3	0.0
Kikuma Ehime	JPKIK	34	2.0	N	132	50.0	E	2	25.0	27.0	13.0	9.0	30.0	35.0	3.0	-1.0	23.0	20.0	28.0	32.0	3.3	1.1
Kinwan (Ishikawa) Okinawa	JPKIN	26	22.0	N	127	58.0	E	2	28.0	30.0	24.0	20.0	30.0	35.0	15.0	13.0	32.0	27.0	33.0	34.5	2.5	0.5
Kanda Fukuoka	JPKND	33	48.0	N	131	0.0	E	3	23.5	25.0	8.0	7.0	31.0	30.3	4.0	0.0	16.5	12.5	18.0	20.0	3.6	1.5
Kinuura Aichi	JPKNU	34	52.0	N	136	57.0	E	5	23.0	26.0	17.0	14.0	27.5	34.0	3.0	1.0	23.5	19.5	29.8	30.5	2.2	0.9
Kagoshima Kagoshima	JPKOJ	31	35.0	N	130	33.0	E	3	24.0	27.0	18.0	16.0	30.5	35.0	4.0	2.0	31.0	26.0	33.0	34.5	2.7	0.4
Kashima Ibaraki	JPKSM	35	55.0	N	140	42.0	E	3	23.0	25.0	12.5	8.0	28.0	33.0	2.5	-3.0	31.0	29.0	32.0	34.0	1.4	0.1
Kudamatsu Yamaguchi	JPKUD	34	0.0	N	131	51.0	E	3	23.0	26.0	11.5	10.0	30.0	34.0	7.0	5.0	18.0	14.0	21.0	24.0	3.0	1.0
Kawasaki Kanagawa	JPKWS	35	32.0	N	139	42.0	E	3	22.5	25.0	12.0	9.0	27.0	34.0	6.0	0.0	20.0	7.0	29.0	31.0	2.5	0.3
Maizuru Kyoto	JPMAI	34	28.0	N	135	21.0	E	2	24.5	26.5	13.0	10.0	29.0	34.0	0.3	-4.0	32.0	28.0	34.0	35.0	0.3	0.1
Mizushima Okayama	JPMIZ	34	30.0	N	133	45.0	E	5	26.1	28.0	11.0	9.0	30.7	34.0	2.0	-3.0	15.0	11.0	15.0	17.0	3.3	1.4
Moji (Kitakyushu) Fukuoka	JPMOJ	33	57.0	N	130	58.0	E	3	23.5	25.6	7.8	6.9	30.0	34.0	5.8	3.4	16.0	12.0	18.0	20.0	3.0	1.0
Muroran Hokkaido	JPMUR	42	20.0	N	140	58.0	E	3	15.0	18.0	8.0	2.0	22.0	27.0	3.0	-5.0	28.0	23.0	30.0	32.0	1.5	0.1
Matsuyama Ehime	JPMYJ	33	52.0	N	132	42.0	E	2	25.0	27.0	13.0	9.0	30.0	35.0	3.0	-1.0	23.0	20.0	28.0	32.0	3.4	1.1
Naha Okinawa	JPNAH	26	12.0	N	127	40.0	E	2	28.0	30.0	24.0	20.0	30.0	35.0	14.0	12.0	32.0	27.0	33.0	34.5	2.6	0.4
Negishi (Yokohama) Kanagawa	JPNGI	35	24.0	N	139	37.8	E	3	21.9	24.5	12.0	10.0	26.4	35.0	5.1	-1.0	22.0	8.0	31.0	33.5	2.0	0.5
Nagoya Aichi	JPNGO	35	4.0	N	136	51.0	E	3	22.3	26.0	17.0	13.0	27.1	34.0	6.0	0.0	23.5	19.5	29.8	30.2	1.9	0.6
Nagasaki Nagasaki	JPNGS	32	45.0	N	129	52.0	E	5	25.0	28.5	18.0	14.0	28.0	34.0	3.5	-0.5	28.0	21.0	33.0	34.5	2.9	1.0
Oita Oita	JPOIT	33	16.0	N	131	40.0	E	2	24.0	27.5	16.0	12.0	29.0	34.0	3.0	-1.0	19.0	17.0	28.0	31.0	1.6	0.6
Okinawa Okinawa	JPOKA	26	13.2	N	127	40.2	E	2	28.0	30.0	24.0	20.0	30.0	35.0	14.0	12.0	32.0	27.0	33.0	34.5	2.6	0.4
Onomichi Hiroshima	JPONO	34	22.0	N	133	11.0	E	3	24.0	27.0	10.0	6.0	30.0	34.0	3.0	-2.0	23.0	20.0	28.0	32.0	3.0	1.3
Osaka Osaka	JPOSA	34	38.0	N	135	25.0	E	5	24.0	26.0	11.0	8.0	30.0	36.0	6.0	2.0	18.0	14.0	20.0	25.0	1.4	0.2
Saiki Oita	JPSAE	32	58.8	N	131	55.8	E	2	25.0	28.0	17.0	13.0	29.0	34.0	3.0	-0.5	19.0	17.0	28.0	31.0	2.1	0.7
Saganoseki Oita	JPSAG	33	14.0	N	131	52.0	E	2	24.0	27.5	16.0	12.0	29.0	34.0	3.0	-1.0	19.0	17.0	28.0	31.0	2.1	0.7
Sakai Osaka	JPSAK	34	34.0	N	135	27.0	E	5	25.0	26.0	12.0	9.0	30.0	35.0	6.0	2.0	18.0	15.0	21.0	26.0	1.5	0.2
Shibushi Kagoshima	JPSBS	31	28.0	N	131	7.0	E	3	25.0	28.0	20.0	18.0	30.5	35.0	7.0	4.0	32.0	28.0	33.0	34.5	2.2	0.2
Sakaide Kagawa	JPSKD	34	21.0	N	133	50.0	E	2	24.0	25.7	11.0	9.5	28.0	33.0	5.0	-2.0	20.0	18.0	26.0	29.0	3.0	1.2
Sakaiminato Tottori	JPSMN	35	32.0	N	133	14.0	E	2	25.0	27.0	14.0	12.0	28.7	34.0	1.5	-3.0	32.0	28.0	34.0	35.0	0.9	0.6
Shimotsu Wakayama	JPSMT	34	7.0	N	135	8.0	E	2	23.0	26.0	17.5	14.5	30.0	35.0	2.0	-1.0	23.5	19.5	29.8	30.2	1.9	0.2
Shimizu Shizuoka	JPSMZ	35	1.0	N	138	30.0	E	2	23.0	26.0	17.0	15.0	28.0	34.0	5.0	0.0	26.0	21.0	31.5	33.0	2.6	0.2
Tamano (Uno) Okayama	JPTAM	34	28.8	N	133	57.0	E	3	26.1	28.0	11.0	9.0	30.7	36.0	2.0	-3.0	20.0	18.0	26.0	29.0	2.4	0.9
Tobata (Kitakyushu) Fukuoka	JPTBT	33	55.0	N	130	51.0	E	3	23.0	25.5	12.0	11.0	31.0	34.0	4.0	0.0	19.0	17.0	28.0	31.0	2.0	1.0
Tokuyama Yamaguchi	JPTKY	34	2.0	N	131	48.0	E	3	23.0	26.0	11.0	9.5	30.0	34.0	7.0	5.0	16.0	12.0	18.0	19.0	3.1	1.0
Tomakomai Hokkaido	JPTMK	42	37.0	N	141	37.0	E	3	15.0	17.0	7.0	2.0	21.2	25.5	-3.0	-18.0	28.0	23.0	30.0	32.0	1.7	0.2
Toyama Toyama	JPTOY	36	45.0	N	137	13.0	E	3	24.0	26.0	12.0	9.0	28.5	35.0	0.5	-5.0	31.0	27.0	32.0	33.0	0.3	0.1

Port Environmental Data - input file used for PRIMER Analysis	UN Port Code	Latitude		N	Longitude		E	Port Type	Water Temperatures (°C) [WT]				Summer Air Temp°C [SART]		Winter Air Temp °C [WART]		Salinities (g/L) [SAL]				Tidal Ranges (m)	
		Deg	Min	S	Deg	Min	W		Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Mean day-time	Maximum daytime	Mean night-time	Lowest night-time	Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Tokyo Tokyo	JPTYO	35	43.0	N	139	45.0	E	5	23.0	26.0	11.0	8.0	27.5	36.0	7.0	-3.0	15.0	5.0	25.0	28.0	2.1	0.1
Ube Yamaguchi	JPUBJ	33	56.0	N	131	14.0	E	3	25.0	28.2	10.0	8.0	30.0	34.0	7.0	4.0	14.4	9.0	16.0	18.0	3.0	1.6
Kobe Hyogo	JPUKB	34	41.0	N	135	12.0	E	3	25.5	27.5	10.0	5.0	30.0	35.0	4.7	-1.2	26.0	20.0	28.0	30.0	1.7	0.5
Wakayama Wakayama	JPWAK	34	13.0	N	135	9.0	E	3	22.3	25.0	17.0	14.5	30.0	35.0	10.5	6.5	23.5	19.5	29.8	30.2	2.1	0.3
Yokkaichi Mie	JPYKK	34	57.0	N	136	38.0	E	3	22.3	26.0	17.0	14.0	27.5	34.0	3.0	-1.0	23.5	19.5	29.8	31.0	2.0	0.8
Yokohama Kanagawa	JPYOK	35	27.0	N	139	39.0	E	3	21.9	24.5	12.5	9.5	26.4	35.0	5.1	-1.0	22.0	8.0	31.0	33.5	2.0	0.5
Yokosuka Kanagawa	JPYOS	35	17.0	N	135	39.0	E	2	22.0	24.0	12.0	10.5	26.0	34.0	7.5	-0.5	26.0	18.0	31.5	33.5	1.7	0.3
Mombasa	KEMBA	4	40.0	S	39	40.0	E	2	29.0	33.0	26.0	24.0	31.0	36.0	22.5	19.0	34.2	33.0	34.6	35.4	4.0	2.5
Kwangyang	KRKAN	34	54.0	N	127	42.0	E	3	18.5	24.5	11.0	5.0	28.0	34.0	2.0	-3.0	32.0	31.0	33.5	34.0	4.2	1.7
Pohang	KRKPO	36	2.0	N	129	26.0	E	3	19.0	22.5	12.0	6.0	27.0	34.0	-2.0	-7.0	33.4	31.0	33.8	34.5	0.2	0.1
Kunsan	KRKUV	35	58.0	N	126	37.0	E	2	18.5	24.0	10.5	3.0	28.0	34.0	-2.0	-7.0	28.0	24.0	32.0	33.0	7.0	5.5
Mokpo (Mogpo)	KRMOK	34	46.0	N	126	23.0	E	5	19.5	24.0	11.0	4.0	28.0	34.0	2.0	-3.0	31.0	28.0	32.0	33.0	4.5	2.1
Onsan	KRONS	35	28.0	N	129	24.0	E	5	19.0	23.0	13.0	5.0	28.5	35.0	-2.0	-7.0	33.0	29.0	33.0	34.0	0.5	0.4
Pusan	KRPUS	35	6.0	N	129	4.0	E	3	19.0	23.0	12.0	8.0	27.0	34.0	-0.5	-5.0	33.0	30.0	33.5	34.0	1.5	0.6
Samcheon Po	KRSCP	34	55.0	N	128	4.0	E	3	19.0	24.5	11.0	7.0	28.0	34.0	2.0	-3.0	32.0	31.0	33.5	34.0	3.0	2.2
Ulsan	KRUSN	35	29.0	N	129	24.0	E	5	19.0	23.0	14.0	7.0	28.5	35.0	-2.0	-7.0	33.3	30.0	33.9	34.5	0.6	0.3
Yosu (Yeosu)	KRYOS	34	44.0	N	127	45.0	E	2	18.5	24.5	11.0	6.0	27.5	36.0	0.0	-5.0	32.0	31.0	33.5	34.0	4.2	1.6
Kuwait (Shuwaikh; KWSWK)	KWKWI	29	21.0	N	47	55.0	E	3	32.0	36.0	17.0	14.0	36.8	47.0	13.0	5.0	38.5	37.0	39.0	41.0	3.5	1.4
Mina Al Ahmadi	KWMAA	29	4.0	N	48	9.0	E	1	33.0	35.8	17.0	15.0	36.8	48.0	14.5	4.0	38.9	38.0	39.0	40.0	3.0	0.7
Mina Saud	KWMIS	28	45.0	N	48	24.0	E	1	33.0	34.9	17.0	15.0	36.8	47.0	14.0	6.0	38.5	38.0	39.0	40.0	1.9	1.0
Mina Abdulla	KWMIB	29	2.0	N	48	11.0	E	1	32.0	34.0	17.0	15.0	36.5	47.0	14.0	6.0	38.5	38.0	39.0	40.0	3.0	0.8
Shuaiba	KWSAA	29	2.0	N	48	10.0	E	3	33.0	36.5	17.5	14.0	37.0	48.0	14.0	4.0	39.0	37.0	39.0	41.0	2.2	0.8
Colombo	LKCMB	6	57.0	N	79	51.0	E	3	29.0	32.0	27.0	24.0	30.0	35.0	26.0	19.0	31.0	26.0	33.0	35.5	0.8	0.2
Malta (Valletta)	MTMLA	35	54.0	N	14	31.2	E	3	24.0	26.0	16.5	15.0	31.0	40.0	10.0	6.0	37.5	37.0	38.0	38.5	0.3	0.0
Penang (Georgetown)	MYPEN	5	22.0	N	100	22.0	E	5	28.5	31.0	27.0	24.0	31.0	35.0	25.5	23.0	12.0	6.0	14.0	19.0	2.7	0.2
Lumut	MYLUM	4	16.2	N	100	39.0	E	5	29.0	31.0	28.0	26.0	31.0	36.0	26.0	22.0	12.0	6.0	14.0	20.0	3.0	0.9
Port Kelang	MYPKG	3	2.0	N	101	21.0	E	5	30.0	31.0	29.3	26.0	32.0	35.0	26.4	23.0	14.0	4.0	16.0	20.0	5.4	0.9
Port Dickson	MYPDI	2	31.0	N	101	47.0	E	1	29.0	31.0	28.0	26.0	31.0	35.0	28.0	22.0	18.0	14.0	20.0	25.0	3.0	1.0
Kapar Coal Terminal	MYBTB	3	5.0	N	101	18.0	E	2	29.0	31.0	28.0	27.0	30.0	35.5	26.0	19.0	17.0	13.0	19.0	24.0	4.1	1.3
Pasir Gudang Johor	MYPGU	1	26.0	N	103	55.0	E	3	28.5	31.0	27.5	25.0	31.0	34.3	25.7	21.0	26.0	22.0	27.0	29.0	3.0	0.3
Bintulu Sarawak	MYBTU	3	16.0	N	113	4.0	E	3	30.0	31.0	29.0	26.0	30.5	35.0	26.0	23.0	25.0	23.0	26.0	30.0	1.9	0.3
Lagos	NGLOS	6	25.0	N	3	25.0	E	5	28.5	30.0	24.0	22.5	31.0	36.0	23.0	19.0	18.0	10.0	30.0	33.0	1.0	0.6
Tin Can Island	NGTIN	6	25.0	N	3	18.0	E	5	28.4	29.1	24.5	23.0	31.0	35.0	23.0	20.0	20.0	15.0	31.0	34.0	1.0	0.6
Port Harcourt	NGPHC	4	46.2	N	7	0.0	E	5	29.0	31.0	26.0	24.0	31.0	35.0	26.0	24.0	0.0	0.0	4.0	10.0	2.6	1.4
Onne	NGONN	4	39.0	N	7	9.0	E	5	29.0	31.0	26.0	24.0	31.0	35.0	26.0	24.0	2.0	0.0	8.0	14.0	2.4	1.0
Bonny	NGBON	4	26.0	N	7	9.0	E	5	29.0	31.0	25.0	24.0	30.0	34.0	23.5	20.5	17.0	8.0	27.0	30.0	2.8	1.4
Europoort	NLEUR	51	58.0	N	4	8.0	E	5	17.5	19.0	6.5	3.0	21.5	28.0	2.5	-4.0	31.0	29.0	32.0	34.0	2.4	1.3
Rotterdam	NLRTM	51	54.0	N	4	29.0	E	5	18.0	20.0	6.5	2.0	21.0	28.0	1.8	-5.0	3.0	0.0	10.0	15.0	1.8	1.4
Ijmuiden	NLIJM	52	27.0	N	4	35.0	E	5	17.5	19.0	6.5	3.0	21.0	28.0	1.5	-4.0	31.0	29.0	32.0	33.0	2.6	1.3
Amsterdam	NLAMS	52	22.0	N	4	53.0	E	6	18.0	20.0	6.0	1.0	21.0	29.0	1.0	-5.5	0.0	0.0	0.0	0.0	0.0	0.0
Flushing (Vlissingen)	NLVLI	51	27.0	N	3	36.0	E	5	17.5	19.0	6.5	3.0	21.5	28.0	2.0	-4.0	22.0	18.0	28.0	30.0	4.9	2.8
Auckland	NZAKL	36	51.0	S	174	48.0	E	3	18.8	22.4	13.0	10.5	17.7	32.2	12.9	0.2	33.5	28.0	35.0	36.0	2.6	1.9
Whangerei	NZWRE	35	46.0	S	174	21.0	E	5	19.0	23.0	13.0	11.0	19.5	33.0	13.0	1.0	29.8	22.0	32.0	34.0	3.1	1.5
Marsden Point	NZMAP	35	50.0	S	174	30.0	E	2	19.0	22.5	13.0	11.0	19.0	33.0	13.0	1.0	33.0	32.0	34.5	35.7	2.6	1.6
Callao (Lima)	PECLL	12	3.0	S	77	10.2	E	3	24.0	26.5	16.0	18.0	28.0	35.0	18.0	14.0	35.0	34.5	35.5	36.0	2.4	1.0
Lae	PGLAE	6	44.0	S	146	58.0	E	2	27.0	31.5	25.0	23.0	27.0	36.6	25.0	19.6	22.0	12.0	25.0	30.0	0.9	0.6
Port Moresby	PGPOM	9	26.0	S	147	6.0	E	3	28.0	32.0	26.0	24.0	31.0	36.0	24.0	20.0	33.0	31.0	33.5	34.5	2.0	0.9
Daru	PGDAU	9	4.0	S	143	12.0	E	1	28.0	31.0	26.0	24.0	32.0	36.0	26.0	21.0	30.0	24.0	32.0	33.5	3.7	1.3
Batangas (Luzon)	PHBTG	13	45.0	N	121	3.0	E	2	29.0	32.0	28.0	26.0	28.0	33.5	27.0	22.2	33.0	32.0	34.0	34.7	1.9	1.6
Bataan Mariveles	PHBTN	14	30.0	N	120	37.8	E	3	28.0	32.0	27.0	26.0	28.0	33.5	24.0	22.2	33.0	32.0	34.0	34.7	1.9	1.6
Limay	PHLIM	14	32.0	N	120	36.0	E	1	28.0	32.0	26.5	25.0	30.0	33.0	24.5	20.0	32.5	32.0	34.0	34.7	1.2	0.4
Manila	PHMNL	14	31.0	N	120	37.0	E	2	30.0	34.5	26.0	23.0	27.3	34.0	26.1	20.9	31.0	28.0	33.0	34.7	1.7	0.4
Subic Bay (Sana Clara)	PHSFS	14	35.0	N	120	58.0	E	3	29.0	33.0	28.0	26.0	27.4	30.4	24.0	22.4	33.0	32.0	34.0	34.7	1.3	0.9
Muhammad Bin Qasim	PKBQM	24	45.6	N	67	21.0	E	5	28.0	30.0	23.0	19.5	29.0	37.0	22.0	10.0	33.0	24.0	36.0	40.0	3.5	1.4

Port Environmental Data - input file used for PRIMER Analysis	UN Port Code	Latitude		N	Longitude		E	Port Type	Water Temperatures (°C) [WT]				Summer Air Temp°C [SART]		Winter Air Temp °C [WART]		Salinities (g/L) [SAL]				Tidal Ranges (m)	
		Deg	Min	S	Deg	Min	W		Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Mean day-time	Maximum daytime	Mean night-time	Lowest night-time	Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Karachi	PKKHI	24	48.0	N	66	59.0	E	4	27.5	30.0	23.0	21.0	29.0	37.0	22.3	10.0	35.0	20.0	37.0	40.0	2.8	1.1
Faro	PTFAO	37	0.0	N	7	55.2	W	4	22.0	24.0	17.5	15.5	24.7	37.0	11.0	6.0	35.5	35.0	35.5	36.0	2.5	0.8
Lisboa	PTLIS	38	42.0	N	9	6.0	W	5	25.0	34.0	15.0	13.0	24.5	36.0	9.0	5.0	32.0	15.0	35.0	36.0	4.6	2.4
Lagos (Portugal)	PTLOS	37	1.0	N	8	40.0	W	5	21.5	23.0	17.0	14.0	24.8	37.0	9.5	5.0	32.0	28.0	36.0	36.5	3.5	1.4
Sines	PTSIE	37	58.0	N	8	51.0	W	3	21.0	22.0	16.5	14.5	24.0	36.0	11.0	6.0	35.5	35.0	36.0	36.5	3.9	1.0
Doha	QADOH	25	16.8	N	51	33.0	E	3	31.0	35.0	17.0	13.0	35.0	44.0	19.0	12.0	38.5	37.0	40.0	42.0	1.5	0.2
Umm Said (Mesaieed)	QAUMS	24	54.0	N	51	34.0	E	3	31.0	35.0	17.0	13.0	35.0	43.0	20.9	12.6	39.0	39.0	40.0	41.0	2.4	0.4
Halul Island	QAHAL	25	39.0	N	52	26.0	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.0	11.0	38.0	37.5	39.0	40.5	0.8	0.1
Constanta	ROCND	44	10.0	N	28	39.0	E	3	23.3	24.0	4.9	0.5	22.2	38.0	2.4	-15.0	15.9	15.0	17.2	17.8	0.1	0.0
Mangalia	ROMAG	43	49.2	N	28	34.8	E	3	23.5	25.5	5.7	0.5	22.7	38.0	1.4	-15.0	17.0	15.4	17.6	18.0	0.1	0.0
Midia	ROMID	44	19.8	N	28	40.8	E	3	23.3	24.5	4.5	0.0	22.5	38.0	2.4	-16.0	15.0	12.0	17.0	17.5	0.1	0.0
Novorossiysk, Russia	RUNVS	44	43.2	N	37	46.8	E	3	22.1	26.2	7.9	0.5	21.8	41.0	4.3	-24.0	17.6	9.6	17.8	18.8	0.1	0.0
Tuapse, Russia	RUTUA	44	4.8	N	39	4.2	E	3	23.0	27.1	10.1	5.3	21.5	41.0	6.0	-19.0	16.6	12.7	17.3	18.6	0.1	0.0
Vladivostok	RUVVO	43	6.6	N	131	53.4	E	2	13.5	15.0	2.5	-1.0	22.0	27.0	-14.5	-25.0	32.0	30.0	33.0	34.0	1.4	0.3
Dammam	SADMN	26	30.0	N	50	12.0	E	3	32.0	35.0	17.0	14.0	36.0	48.0	19.0	10.0	41.0	39.0	43.0	45.0	2.3	0.6
Jeddah	SAJED	21	28.0	N	39	10.0	E	3	30.0	33.0	22.0	19.0	32.0	39.0	21.0	14.0	38.0	37.0	38.5	39.5	0.2	0.0
Jubail	SAJUB	27	3.0	N	49	40.0	E	3	32.0	36.2	16.0	11.6	36.0	47.0	15.0	9.0	49.0	48.0	50.0	52.0	1.2	0.7
Al Juaymah Terminal	SAJUT	26	55.2	N	50	1.0	E	1	31.0	34.0	16.8	13.0	36.0	47.0	15.0	9.0	40.0	38.0	42.0	44.0	2.4	1.5
Ras Al Khafji	SARAR	28	25.2	N	48	33.0	E	1	32.0	34.9	17.0	15.0	36.8	47.0	14.0	6.0	38.5	38.0	39.0	40.0	1.6	1.0
Ras Al Ghar	SA001	27	32.0	N	49	13.0	E	1	32.0	34.0	17.0	14.0	36.0	47.0	14.0	8.0	39.0	38.5	40.0	41.0	1.7	0.9
Ras Al Tannura	SARLT	26	39.0	N	50	10.0	E	1	31.0	33.8	16.8	13.0	36.0	47.0	21.0	9.0	40.0	38.5	40.5	42.0	2.4	1.5
Yanbu	SAYNB	24	5.0	N	38	3.0	E	3	30.0	33.0	22.0	18.0	32.0	39.0	19.0	10.0	39.0	37.5	39.5	41.0	0.8	0.3
Marsa Bashayer Oil Terminal	SDMBT	19	24.0	N	37	19.0	E	1	29.5	32.0	23.0	20.0	31.0	40.0	22.0	16.0	37.5	37.0	37.5	38.0	1.2	0.4
Port Sudan	SDPZU	19	36.0	N	37	13.0	E	3	31.0	34.0	22.0	19.0	32.0	42.0	21.0	16.0	38.0	37.0	38.5	38.5	1.2	0.4
Singapore Jurong	SGJUR	1	18.0	N	103	43.0	E	3	28.5	31.0	27.0	25.0	31.0	34.0	23.0	21.0	29.5	28.5	30.5	31.5	2.3	0.9
Singapore Keppel	SGKEP	1	16.2	N	103	52.3	E	3	28.5	31.0	27.0	25.0	31.0	34.0	23.0	21.0	29.5	28.5	30.5	31.5	2.3	0.9
Singapore Sembawang Port	SGSEM	1	16.0	N	103	50.0	E	4	29.0	31.5	28.0	25.0	31.0	34.0	23.0	21.0	26.0	21.0	27.0	28.0	2.3	0.9
Singapore Singapore	SGSIN	1	20.0	N	103	20.0	E	3	28.5	31.0	27.0	25.0	31.0	34.0	23.0	21.0	29.5	28.5	30.5	31.5	2.3	0.9
Singapore Pasir Panjan/Tanjung Pagar	SGTPG	1	15.6	N	103	51.0	E	3	28.5	31.0	27.0	25.0	31.0	34.0	23.0	21.0	29.5	28.5	30.5	31.5	2.3	0.9
Koper (Slovenia)	SIKOP	45	33.0	N	13	44.0	E	2	24.0	26.5	9.0	7.0	27.0	34.0	3.9	0.5	24.0	18.0	35.0	36.0	0.8	0.2
Dakar	SNDKR	14	40.2	N	18	38.4	W	3	26.0	27.5	23.0	20.0	33.5	39.0	21.0	16.0	34.5	34.0	35.0	35.5	2.5	1.2
Bangkok	THBKK	13	42.0	N	100	34.0	E	6	29.0	32.5	27.0	24.0	28.0	39.5	25.0	10.5	2.0	0.1	12.0	15.0	1.8	0.3
Laem Chabang	THLCH	13	4.0	N	100	50.0	E	3	27.5	30.0	26.0	24.0	28.0	36.0	25.0	14.0	32.0	30.0	33.0	34.0	1.9	1.3
Dortyol Oil Terminal	TRDYL	36	51.0	N	36	7.8	E	1	26.2	29.2	18.5	15.5	31.2	38.0	6.5	1.0	38.8	37.5	39.1	39.8	0.3	0.0
Eregli	TRERE	41	18.0	N	31	27.0	E	3	23.5	27.5	6.4	4.0	25.5	38.0	5.7	-5.0	17.5	16.9	17.5	18.2	0.2	0.0
Istanbul	TRIST	40	59.0	N	29	0.0	E	2	24.4	27.0	6.1	4.0	26.0	37.0	6.6	-11.0	17.5	16.3	17.5	18.3	0.3	0.0
Izmir (Smyrna)	TRIZM	38	25.2	N	27	4.2	E	2	24.4	25.5	14.0	11.5	32.0	38.0	6.0	0.0	38.0	37.0	38.7	39.2	0.4	0.0
Izmit (Tutuncifilik Oil Terminal)	TRIZT	40	45.0	N	29	55.0	E	2	24.0	27.0	7.0	5.0	26.0	38.0	8.0	-7.0	17.5	16.3	17.5	18.3	0.3	0.0
Mersin	TRMER	36	46.0	N	34	39.0	E	3	26.2	28.8	19.0	16.0	30.0	35.0	6.5	1.0	38.8	37.5	39.1	39.8	0.3	0.1
Samsun	TRSSX	41	21.0	N	36	34.2	E	3	24.6	28.0	7.6	6.0	25.0	38.0	7.9	-8.0	17.5	16.9	17.5	18.2	0.1	0.0
Yarimca	TRYAR	40	46.2	N	29	42.0	E	1	24.0	27.0	7.0	5.0	25.0	38.0	8.0	-7.0	17.5	16.3	17.5	18.3	0.3	0.0
Keelung (Chilung)	TWKEL	25	9.0	N	121	44.0	E	3	22.5	25.0	20.0	18.0	26.0	30.0	20.0	16.0	33.0	31.0	34.0	34.5	2.5	0.5
Kaohsiung	TWKHH	22	37.0	N	120	15.0	E	3	28.0	31.3	23.0	21.0	27.3	30.8	21.5	18.0	34.5	34.0	35.0	35.5	1.0	0.3
Taichung	TWTXG	23	17.0	N	120	30.0	E	3	27.0	30.0	18.0	16.0	26.6	30.1	18.6	15.6	26.0	17.0	33.0	34.5	4.8	3.9
Dar Es Salaam	TZDAR	7	10.0	S	39	17.0	E	2	29.0	32.0	26.0	24.0	31.0	37.0	22.0	17.0	30.0	20.0	34.0	35.5	3.8	1.5
Dnepro-Bugsky (Ochakov)	UADNB	46	45.0	N	31	55.0	E	5	21.4	26.0	1.3	-0.6	20.3	40.0	-0.6	-29.0	5.2	0.5	3.0	12.5	0.1	0.0
Ilyichevsk	UAILK	46	20.0	N	30	39.0	E	3	18.9	23.6	2.6	-0.7	22.6	38.0	0.5	-22.0	13.8	8.8	14.5	18.2	0.1	0.0
Odessa	UAODS	46	30.0	N	30	52.8	E	3	18.4	24.5	2.6	-3.1	20.2	37.0	0.3	-27.0	13.5	5.4	16.1	20.0	0.1	0.0
Nicolayev	UANIK	46	55.8	N	30	39.0	E	6	21.4	26.0	1.3	-0.6	20.4	39.0	-0.7	-30.0	0.1	0.1	0.2	0.5	0.0	0.0
Sevastopol	UASVP	44	37.2	N	33	31.8	E	2	21.5	25.9	7.8	1.7	20.5	38.0	4.3	-22.0	18.0	15.2	18.0	19.8	0.2	0.1
Boston Massachusetts	USBOS	42	21.0	N	71	4.8	W	2	14.0	17.0	0.5	-2.0	26.2	33.0	-5.0	-14.0	26.0	18.0	29.0	31.0	3.3	1.4
New York New York (New Jersey)	USNYC	40	42.0	N	74	1.0	W	5	14.0	20.0	2.0	-1.0	27.5	37.0	-3.0	-16.0	8.0	0.0	22.0	30.0	1.6	1.3
Philadeplhia Pennsylvania (Port Richmond)	USPHL	39	57.0	N	75	10.0	W	5	18.0	22.0	2.0	-1.0	28.0	36.0	-3.0	-12.0	0.0	0.0	1.0	3.0	1.9	1.6
Wilmington Delaware	USILG	39	45.0	N	75	30.0	W	5	18.0	22.0	2.0	-1.0	28.0	36.0	-3.0	-12.0	0.0	0.0	3.0	6.0	1.8	1.6

Port Environmental Data - input file used for PRIMER Analysis	UN Port Code	Latitude		N	Longitude		E	Port Type	Water Temperatures (°C) [WT]				Summer Air Temp°C [SART]		Winter Air Temp °C [WART]		Salinities (g/L) [SAL]				Tidal Ranges (m)	
		Deg	Min	S	Deg	Min	W		Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Mean day-time	Maximum daytime	Mean night-time	Lowest night-time	Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Baltimore Maryland	USBAL	39	16.8	N	76	34.8	W	5	20.0	24.0	2.5	0.0	30.5	38.0	-1.0	-10.0	0.0	0.0	4.0	8.0	0.4	0.3
Hampton Roads	USPHF	36	58.0	N	76	20.0	W	5	23.0	27.0	12.0	7.0	29.1	36.0	0.5	-5.0	21.0	15.0	26.0	31.0	1.1	0.7
Norfolk-Newport News Virginia	USNEN	36	51.0	N	76	19.0	W	5	23.0	27.0	11.0	6.0	29.1	36.0	0.5	-5.0	21.0	15.0	26.0	31.0	1.2	0.8
Savannah Georgia	USSAV	32	5.0	N	81	5.0	W	5	27.0	30.0	19.0	16.0	31.8	37.0	4.8	-2.0	18.0	10.0	28.0	33.0	3.0	2.2
Mobile Alabama	USMOB	30	40.0	N	88	1.8	W	5	27.0	31.0	16.0	9.0	32.5	38.0	5.6	2.0	8.0	0.0	30.0	35.0	1.0	0.3
Lake Charles Louisana	USLCH	30	13.2	N	93	13.2	W	5	27.0	29.0	20.0	15.0	32.0	39.0	6.0	1.0	0.0	0.0	7.0	13.0	0.5	0.0
Davant	USDVT	29	36.0	N	89	51.0	W	6	27.0	31.0	12.0	10.0	32.5	38.0	5.6	2.0	0.0	0.0	0.0	0.0	0.2	0.0
New Orleans	USMSY	29	57.0	N	90	4.0	W	6	27.0	31.0	17.5	15.0	32.0	39.0	7.0	4.0	0.0	0.0	0.0	0.0	0.0	0.0
LOOP Terminal	USLOP	28	52.8	N	90	1.2	W	1	27.0	29.0	20.0	17.0	29.0	38.0	14.0	5.5	30.0	24.0	31.0	34.0	0.4	0.2
Sabine	USSAB	29	42.0	N	93	52.0	W	2	27.0	29.0	19.5	16.5	31.0	38.0	8.0	3.0	35.5	35.0	36.0	36.5	0.5	0.3
Beaumont	USBPT	30	5.0	N	94	5.0	W	6	28.5	32.0	16.0	13.0	33.0	41.0	5.8	1.5	0.0	0.0	5.0	10.0	0.5	0.1
Galveston Texas	USGLS	29	17.0	N	94	50.0	W	2	28.5	33.0	18.0	16.0	32.0	40.5	9.5	2.0	18.0	14.0	26.0	33.0	0.5	0.1
Texas City Texas	USTXT	29	23.0	N	94	54.0	W	2	28.5	34.0	18.0	16.0	32.0	40.5	9.5	2.0	18.0	14.0	26.0	32.0	0.4	0.1
Houston Texas	USHOU	29	45.0	N	95	19.8	W	5	28.5	32.0	16.0	14.0	33.0	41.0	5.8	1.5	2.0	0.0	10.0	18.0	0.4	0.1
Anchorage Alaska	USANC	61	13.8	N	149	52.8	W	5	8.0	12.0	1.0	-1.0	17.0	24.0	-12.0	-19.0	2.0	0.0	8.0	12.0	8.8	5.0
Portland Oregon	USPDX	45	35.0	N	122	44.0	W	6	12.0	14.0	1.0	-2.0	25.5	32.0	1.5	-3.0	0.0	0.0	0.0	0.0	0.0	0.0
Vancouver Washington	USBCC	45	36.0	N	122	40.0	W	6	12.0	14.5	1.0	-2.0	25.4	32.0	1.1	-3.0	0.0	0.0	0.0	0.0	0.0	0.0
San Francisco California	USSFO	37	48.0	N	122	25.2	W	5	15.0	20.0	12.0	11.0	22.5	31.0	6.0	2.0	28.0	10.0	30.0	32.0	2.0	0.6
Oakland California	USOAK	37	49.8	N	122	18.0	W	5	15.0	20.0	12.0	11.0	22.5	31.0	6.0	2.0	15.0	5.0	27.0	30.0	2.0	0.7
Long Beach California	USLGB	33	45.0	N	118	12.0	W	3	18.0	22.0	14.0	12.0	27.0	34.0	7.6	1.0	33.0	31.0	33.2	33.8	2.0	0.6
San Diego	USSAN	32	42.0	N	117	10.2	W	2	18.0	22.0	15.0	13.0	25.1	34.0	9.8	3.0	34.0	33.5	35.0	37.0	2.2	1.4
Montevideo	UYMVD	34	54.0	S	56	13.2	W	3	25.0	26.8	15.0	12.5	26.0	34.0	5.0	0.0	5.0	1.0	10.0	30.0	0.3	0.1
Aden (Yemen)	YEADE	12	48.0	N	44	54.0	E	2	29.0	31.0	23.0	21.0	33.0	39.0	26.3	16.0	36.0	35.5	36.1	36.5	1.5	0.5
Hodeidah (Yemen)	YEHOD	14	48.0	N	42	55.0	E	2	29.5	32.0	23.5	20.5	32.0	39.0	26.3	16.0	36.0	35.2	36.5	37.5	1.2	0.2
Al Mukullah (Yemen)	YEMKX	14	31.0	N	49	9.0	E	3	29.5	32.0	23.5	20.5	32.0	39.0	26.3	16.0	36.9	37.5	36.1	36.5	1.2	0.4
Ras Isa Marine Terminal (Yemen)	YERAI	15	7.8	N	42	36.0	E	1	29.5	32.0	23.5	20.5	32.0	39.0	26.3	16.0	36.0	35.5	36.5	37.0	1.1	0.3
Cape Town	ZACPT	33	54.0	S	18	26.0	E	3	14.0	16.0	13.5	11.5	18.2	26.0	11.0	9.0	20.0	10.0	34.3	34.8	1.5	0.6
Durban	ZADUR	29	53.0	S	31	2.0	E	5	24.5	25.5	21.0	19.0	26.3	26.1	15.4	14.5	28.0	18.0	35.5	35.5	1.8	0.5
Port Elizabeth	ZAPLZ	33	58.0	S	25	38.0	E	3	20.5	25.5	16.5	12.5	23.6	25.0	10.0	8.5	35.2	34.9	34.9	35.0	1.6	0.5
Richards Bay	ZARCB	28	48.0	S	32	3.0	E	4	25.5	26.5	22.0	20.0	28.0	29.5	15.5	12.0	39.2	37.0	38.2	41.4	1.9	0.5
Saldanha Bay	ZASDB	33	2.0	S	18	0.0	E	2	18.5	22.6	14.0	9.0	26.0	35.0	10.0	4.0	34.9	34.6	34.9	35.0	1.4	0.6

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the…			Distance to River Mouth (km)	Size of River Catchment (km^2)	Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%			Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Abu Dhabi	3	92	4	8	30	5	5	4	3	4	2	4	4	4	5	2	4	4	4
Mina Zayed	3	92	4	8	30	5	5	4	3	4	2	4	4	4	5	2	4	4	4
Das Island	5	76	4	110	120	5	4	0	1	4	0	1	1	4	5	3	4	4	4
Port Rashid	2	100	4	5	25	5	4	3	4	1	2	4	4	2	5	2	2	5	4
Dubai	2	100	4	5	25	5	4	3	4	1	2	4	4	2	5	2	2	5	4
Fateh Oil Terminal	5	75	4	165	20	5	0	0	0	2	0	0	0	2	3	5	1	1	1
Fujairah	*4*	*80*	*4*	65	540	5	5	3	0	4	4	0	0	4	5	4	4	3	1
Jebel Ali	2	90	5	70	2,100	5	5	5	2	4	3	2	2	4	5	2	4	3	2
Jebel Dhanna	5	75	4	20	120	5	4	1	4	4	0	4	4	4	4	5	4	2	2
Khor Al Fakkan	*4*	*80*	*4*	42	540	5	4	2	0	3	3	0	0	4	5	4	4	3	1
Um Al Qiwain	2	90	5	22	1,000	5	4	4	4	5	4	4	4	4	5	2	4	3	3
Ruwais Oil Terminal	5	75	4	20	120	5	4	1	4	4	0	4	4	4	4	5	4	2	2
Sharjah	2	98	5	20	100	5	4	3	4	2	3	4	4	3	5	0	2	5	3
Zirku Island	5	75	4	85	120	5	4	0	1	4	0	1	1	4	5	3	4	4	4
Buenos Aires	424	581	9	-155	600,000	5	4	4	0	4	2	4	0	1	4	5	3	1	0
Campana	*424*	*581*	*9*	-250	280,000	5	4	5	0	1	4	1	0	0	5	5	0	0	0
Dampier	41	231	5	180	105,000	5	5	3	4	4	0	4	3	5	4	5	4	5	2
Port Walcott (Cape Lambert)	*41*	*231*	*5*	225	105,000	5	4	2	2	3	0	3	3	5	5	3	4	4	2
Port Bonython	161	355	7	65	550	5	4	3	2	3	0	2	3	4	5	3	4	4	0
Whyalla	119	151	9	40	990	5	4	4	2	5	0	2	3	4	5	3	4	3	0
Port Pirie	125	219	8	30	990	5	2	3	3	5	0	5	4	3	5	3	4	3	0
Port Stanvac	280	440	6	30	1,500	5	5	0	1	4	0	3	0	4	5	3	4	3	0
Western Port (now Hastings; AUHAS)	245	302	9	25	900	5	1	4	3	4	1	4	0	4	5	5	3	4	0
Port Kembla	457	913	8	12	400	5	5	4	1	3	0	2	1	4	5	5	4	5	0
Brisbane	369	779	7	-2	6,600	5	5	4	4	4	3	4	4	3	5	5	4	3	4
Bundaberg	323	820	7	-5	3,300	5	3	4	4	2	3	1	1	3	3	5	2	3	5
Gladstone	244	704	7	4	9,000	5	5	3	4	4	0	5	4	5	5	5	4	5	4
Port Alma	245	558	7	-16	143,000	5	2	4	4	2	4	1	1	4	2	5	4	4	4
Hay Point	297	1312	6	6	500	5	4	3	2	2	2	2	2	2	5	4	2	2	4
Dallrymple Bay (= Hay Point Anchorage)	297	1312	6	6	500	5	4	3	2	2	2	2	2	2	5	4	2	2	4
Mackay	297	1312	6	5	2,500	5	4	5	2	1	2	2	3	2	3	5	2	2	2
Abbot Point	158	853	6	18	2,768	5	4	2	2	2	2	3	3	2	5	4	1	2	4
Townsville	119	990	6	-1	200	5	4	5	3	2	2	2	2	2	3	5	1	2	3
Lucinda	204	742	6	6	8,814	5	3	3	3	2	3	2	3	3	5	3	2	3	4
Mourilyan	909	2643	7	-1	1,600	5	2	4	3	1	1	1	1	1	2	5	1	1	3
Cairns	279	1726	6	-7	300	5	2	5	4	3	1	1	1	1	3	5	1	4	4
Cape Flattery	224	1586	6	14	114	5	4	0	1	1	1	3	3	1	4	1	3	1	4
Weipa	58	1687	5	-5	4,107	5	3	4	4	1	2	2	1	2	2	5	2	2	3
Karumba	36	884	5	-3	121,290	5	0	5	4	2	5	1	1	5	4	5	2	5	5
Chittagong	149	1484	4	-3	1,200,000	5	2	5	0	0	0	5	3	0	2	5	3	1	0
Antwerpen	334	460	8	-75	4,300	5	5	5	0	1	1	2	0	0	2	5	0	0	0
Ghent (Gent)	334	460	8	-51	2,150	5	5	5	0	2	2	3	0	0	2	5	1	0	0
Bourgas	285	294	9	320	817,000	5	5	4	4	4	3	3	0	4	4	5	0	4	0
Varna, Bulgaria	246	282	8	250	817,000	5	5	4	3	3	3	2	0	2	4	5	0	4	0
Sitra (Bahrain)	2	72	4	90	50	5	4	3	3	4	3	3	3	4	5	3	4	3	4
Mina Sulman (Al Manamah)	*2*	*72*	*4*	90	50	5	5	3	3	4	3	3	3	4	5	3	4	3	4
Itajai	584	961	8	-3	15,500	5	4	5	4	4	0	5	5	4	4	2	0	4	0
Paranaguá	648	1288	8	-15	797	5	5	3	0	4	0	4	5	4	4	4	0	5	0
Santos	738	1343	7	-3	154	5	5	4	0	4	0	5	5	4	4	5	0	3	0
Sepetiba	750	750	7	5	2,500	5	3	3	1	4	0	4	4	4	3	5	0	4	0
Rio de Janeiro	750	750	7	1	30	5	4	4	1	4	0	4	4	3	3	5	0	5	0
Ponta do Ubu	446	829	7	65	1,400	5	5	0	2	5	0	1	1	1	5	2	0	1	0
Vitória	446	829	7	-6	1,400	5	5	5	0	3	0	5	4	4	3	5	0	5	0
Praia Mole	446	829	7	4	1,400	5	5	2	1	4	0	4	3	5	4	5	0	4	0
Tubarao	446	829	7	4	1,400	5	5	2	0	4	0	4	3	5	4	5	0	4	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the...					Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%	Distance to River Mouth (km)	Size of River Catchment (km^2)	Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Salvador	727	1384	8	4	35,000	5	5	2	0	4	0	2	2	5	4	5	0	4	0
Come By Chance	530	660	8	5	200	5	0	0	0	0	4	0	0	5	3	3	0	5	0
Sept-Iles (Pointe Noire) Quebec	510	596	9	6	6,000	5	4	3	0	3	4	1	0	5	3	4	0	5	0
Halifax Nova Scotia	603	793	8	1	400	5	4	4	0	0	4	0	0	5	3	5	0	5	0
La Have	603	793	8	-3	2,000	5	1	4	0	0	5	0	0	5	3	3	0	5	0
Vancouver (British Columbia)	300	807	6	0	85,000	5	4	4	0	2	4	3	0	4	4	5	0	5	0
Roberts Bank (British Columbia)	300	807	6	0	85,000	5	3	3	0	3	4	3	0	4	4	4	0	5	0
Guangzhou Guangdong	341	1362	6	-112	400,000	5	4	4	4	1	0	5	1	2	2	5	1	1	0
Chiwan (Shenzhen) Guangdong	320	1604	6	4	1,000,000	5	3	5	0	3	2	1	3	3	2	5	2	3	2
Dalian Liaoning	183	457	7	35	1,500	5	5	5	2	3	4	4	0	5	4	5	2	4	0
Huangpu Guangdong	326	1606	6	-95	452,600	4	3	5	4	4	2	5	1	2	3	5	1	2	1
Beilun Zhejiang	464	947	8	-3	600	5	2	5	3	4	2	5	0	4	4	5	2	4	0
Ningbo (Beilun) Zhejiang	464	947	8	-3	600	5	2	5	3	4	2	5	0	4	4	5	2	4	0
Shanghai Shanghai	480	840	8	-40	1,500,000	5	3	5	2	1	0	5	0	1	3	5	1	1	0
Shanghai Baoshan	382	742	7	-45	1,500,000	5	4	4	2	1	0	5	0	1	3	5	1	1	0
Qinggdao Shandong	192	577	6	24	8,800	5	5	4	2	2	1	3	0	4	3	5	3	4	0
Tianjin Tianjin	278	603	8	0	71,600	5	5	5	2	3	1	3	0	2	4	5	2	1	0
Yantai Shandong	190	500	7	30	1,200	5	5	4	0	3	4	4	0	5	4	5	2	4	0
Cartagena	80	863	3	15	1,400	5	4	2	3	4	0	4	4	3	3	5	4	3	3
Kyrenia	139	958	5	120	40	5	5	5	0	3	4	1	0	4	4	2	4	5	0
Larnaca	139	958	5	25	50	5	5	5	0	4	4	1	0	4	4	2	4	5	0
Limassol	41	411	4	3	60	5	5	5	0	4	4	1	0	4	4	2	4	5	0
Bremen	322	428	8	-15	6,500	5	2	5	0	1	2	5	0	2	2	5	1	2	0
Hamburg	429	325	9	-105	9,000	5	4	5	0	1	2	5	0	1	2	5	0	0	0
Wilhelmshaven	322	428	8	1	750	5	5	4	2	3	2	5	0	1	4	5	2	1	0
Djibouti (Djibouti)	14	33	6	5	900	5	5	4	2	4	3	2	2	4	5	3	3	0	4
Enstedvaerkets Havn	293	411	9	2	200	5	2	3	1	2	4	2	0	5	2	5	1	5	0
Fredericia	217	331	9	8	300	5	4	4	1	2	4	2	0	4	2	5	1	5	0
Ain Sukhna	3	29	4	3	200	5	3	0	2	4	0	2	2	4	5	4	2	0	4
Alexandria (El Iskandariya)	10	186	4	45	2,000	5	4	0	2	4	3	0	0	3	5	5	3	3	0
Damietta	7	100	4	7	3,000	5	5	0	2	4	4	2	0	0	5	0	4	0	0
El Dekheila	10	186	4	52	2,000	5	4	0	2	4	3	0	0	3	5	5	3	3	0
Port Said	6	190	4	270	2,000,000	5	5	4	4	3	1	4	0	2	4	5	3	3	0
Suez (El Suweis)	5	100	4	63	200	5	5	4	2	4	0	3	3	4	5	3	1	2	1
Gijon	425	670	9	6	40	5	5	5	1	4	3	3	0	4	5	5	2	4	0
Bilbao	436	655	9	-2	4,500	5	4	4	2	3	3	5	0	3	3	5	2	2	0
Vigo	503	1303	6	14	400	5	4	3	2	3	4	2	0	5	5	5	2	5	0
Barcelona	349	241	9	11	5,000	5	5	5	0	3	2	2	0	3	5	5	3	3	0
Valencia	150	318	6	4	550	5	5	4	2	5	3	0	0	1	4	5	4	2	0
Algeciras	690	146	5	35	1,600	5	5	5	0	5	5	0	0	4	3	5	3	5	0
Las Palmas	17	159	4	1	60	5	5	3	0	4	3	0	0	4	5	5	3	5	0
Tenerife (Santa Cruz de Tenerife)	46	396	9	2	20	5	5	3	0	2	3	0	0	4	5	5	3	5	0
Tarragona	349	241	9	75	6,000	5	5	4	1	3	3	4	0	3	5	5	3	3	0
Dunkerque	264	347	9	27	1,800	5	5	3	2	4	4	4	0	0	4	5	0	0	0
Brest	404	724	8	20	600	5	4	4	2	3	4	3	0	4	5	5	3	5	0
Donges	336	475	8	-3	1,300	5	4	4	0	4	4	4	0	3	4	5	3	3	0
Fos sur Mer (Oil Terminal)	195	387	7	0	3,000	5	4	3	2	3	3	0	0	3	4	5	3	3	0
Lavera	195	387	7	0	3,000	5	4	4	2	3	3	0	0	3	4	5	3	3	0
Le Havre	405	723	7	0	6,500	5	4	4	0	4	4	4	0	4	4	5	3	3	0
Marseilles	195	387	7	0	3,000	5	4	5	2	3	3	0	0	3	4	5	3	3	0
Hunterston	443	662	8	30	2,400	5	4	3	1	5	3	4	0	4	5	5	0	4	0
Immingham	271	330	9	-20	4,900	5	5	4	2	3	3	5	0	0	3	5	0	0	0
Burry Port (Llanelly)	309	507	9	0	180	5	5	5	4	4	5	4	0	3	4	5	0	3	0
Port Talbot	385	534	9	2	280	5	5	5	2	4	4	4	0	2	4	5	0	2	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the…			Distance to River Mouth (km)	Size of River Catchment (km^2)	Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%			Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Redcar	285	330	9	-4	3,000	5	5	4	3	3	4	4	0	3	4	5	0	3	0
Batumi, Georgia	539	978	7	7	22,000	5	5	4	3	4	4	3	0	4	4	5	0	4	0
Poti, Georgia	537	840	8	4	13,300	5	5	4	3	4	1	3	0	2	4	5	0	1	0
Gibraltar	690	146	5	25	1,600	5	5	3	0	4	4	0	0	4	3	5	3	5	0
Aspropyrgos	180	278	6	4	5,600	5	5	4	0	5	4	2	0	4	5	4	2	3	0
Elefsis (Eleusis)	69	302	6	5	961	5	5	4	0	4	4	2	0	4	4	5	2	4	0
Chios	181	278	6	93	900	5	5	5	0	4	5	1	0	5	4	3	2	5	0
Pachi	69	302	6	34	855	5	4	1	0	2	2	2	0	5	4	4	2	5	0
Piraeus	69	302	6	14	320	5	5	4	0	4	3	3	0	4	5	3	3	4	0
Thessaloniki	181	278	7	6	1,800	5	5	5	0	4	4	4	0	3	4	5	3	4	0
Volos	181	278	6	0	64	5	5	4	0	4	4	2	0	4	4	5	3	4	0
Hong Kong Hong Kong	206	2520	5	33	1,000,000	5	5	3	1	3	3	3	3	3	3	4	3	4	3
Hong Kong Kowloon	206	2520	5	33	1,000,000	5	5	5	1	2	2	4	3	3	3	5	3	3	3
Omisalj	470	570	9	18	250	5	0	2	0	1	2	0	0	5	3	2	1	5	0
Belawan Sumatra	960	1150	9	12	550	5	0	4	0	3	0	5	5	3	4	5	3	3	2
Dumai Sumatra	985	1287	9	42	20,000	5	2	4	0	3	0	5	4	2	3	5	4	1	1
Cigading	286	899	7	5	50	5	3	5	1	1	1	1	1	1	4	4	3	2	2
Merak (inc. Anyer Terminal) Java	480	1335	7	20	700	5	4	4	0	3	1	2	2	4	5	3	3	5	4
Jakarta Java	268	1434	6	5	300	5	4	5	0	4	3	1	3	3	3	5	4	3	3
Cilacap Java	1325	2172	8	-1	900	3	2	3	1	3	2	1	1	2	5	3	4	3	3
Semarang Java	312	1390	6	2	200	5	4	4	1	3	5	1	2	5	3	5	2	5	4
Tanjung Perak (Surabaya) Java	203	1277	6	1	200	5	3	4	0	1	2	1	2	2	4	4	2	2	2
Tanjung Bara Coal Terminal Kalimantan	1272	1494	9	80	100,000	5	0	0	0	3	0	2	3	4	5	4	4	4	4
Balikpapan Kalimantan	1272	1494	9	100	100,000	5	4	5	0	3	0	4	4	4	4	5	3	3	3
Amamapare Irian Jaya	1203	1330	9	0	500	5	4	5	1	1	5	1	1	5	5	3	3	4	4
Moneypoint	544	878	8	-18	4,000	5	2	5	2	3	4	4	0	5	4	5	0	5	0
Ashdod	7	100	4	3	20	5	5	0	0	4	4	0	0	0	5	0	4	0	0
Mumbai (Ex Bombay)	287	2246	2	10	9,800	5	1	2	0	2	0	5	4	4	4	4	0	4	0
Calcutta	149	1484	4	-140	1,200,000	5	2	5	1	0	0	5	1	0	0	5	0	0	0
Cochin	498	2417	3	-3	6,170	5	5	5	0	5	0	5	5	1	2	2	0	1	0
Haldia	149	1484	4	-36	1,200,000	5	4	5	2	3	0	5	3	1	3	5	1	0	0
Mangalore (New Mangalore)	268	2739	2	15	2,500	5	4	4	0	5	3	3	3	3	4	4	0	2	0
Kandla	3	338	2	-40	150,000	5	1	4	3	2	0	5	5	2	2	5	0	2	3
Chennai (Ex Madras)	341	863	7	110	50,000	5	5	2	0	5	0	1	1	1	4	5	1	1	0
Marmugao (Marmagoa)	49	2915	4	0	2,500	5	5	4	3	4	3	4	3	5	4	5	0	4	0
Mundra	6	485	2	10	1,100	5	5	5	4	4	0	5	4	1	0	5	2	1	1
Porbandar	350	1500	3	18	1,200	5	5	4	3	3	3	2	2	4	3	5	2	4	0
Paradeep	198	1551	4	5	132,100	5	5	2	0	5	0	4	4	1	4	4	0	2	0
Salaya	150	900	3	2	800	5	4	4	3	3	2	5	4	3	3	5	2	4	0
Sikka	6	485	2	14	1,100	5	4	3	2	0	0	4	4	1	0	5	2	1	5
Tuticorin (New Tuticorin)	158	506	3	15	14,400	5	5	3	0	5	0	4	4	5	4	4	2	5	3
Vadinar Terminal	150	900	3	2	800	4	4	3	3	3	2	3	3	3	4	5	2	4	0
Visakhapatnam	78	799	4	15	113,000	5	5	2	0	4	0	1	1	4	3	3	0	4	4
Bandar Imam Khomeyni	2	190	3	144	500,000	5	0	5	2	0	2	5	0	0	0	5	1	0	0
Bandar Mushar (Mushahr)	2	190	3	100	500,000	5	0	5	2	0	2	5	0	0	0	5	1	0	0
Bandar Abbas (Oil Jetty)	11	172	4	30	42,000	5	5	0	3	3	1	5	2	1	5	5	2	2	2
Bushehr	5	160	4	25	12,000	5	0	3	3	4	2	5	1	0	4	5	3	0	2
Khark Island	2	154	4	31	12,000	5	5	4	2	4	4	2	2	4	5	3	4	0	5
Lavan Island	0	84	3	140	42,000	5	0	0	0	4	4	0	0	4	5	4	4	0	4
Sirri Island Oil Terminal	0	84	3	140	42,000	5	0	0	0	4	4	0	0	4	5	4	4	0	4
Hafnarfjordur	220	330	8	4	200	5	5	4	0	0	4	0	0	4	0	3	0	5	0
Straumsvik	220	330	8	1	200	5	5	4	0	0	4	0	0	4	0	3	0	5	0
Genoa	451	825	6	28	600	5	4	4	0	3	4	0	0	4	3	2	3	4	0
Porto Foxi (Sarroch)	294	641	7	20	400	5	3	0	2	4	3	1	0	4	3	2	3	4	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the…			Distance to River Mouth (km)	Size of River Catchment (km^2)	Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%			Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Livorno	343	565	8	20	4,100	5	5	5	2	4	4	0	0	3	3	5	3	4	0
Ravenna	346	411	9	0	2,000	5	5	4	0	3	3	4	0	3	3	5	2	4	0
Taranto	132	308	7	8	550	5	4	3	2	3	2	2	0	4	3	5	3	4	0
Venezia (=Fusina)	438	604	8	-2	1,200	5	5	4	2	3	1	3	0	3	3	5	3	2	0
Trieste	469	573	9	20	3,000	5	4	4	0	3	3	3	0	3	3	5	2	3	0
Aboshi Hyogo	400	900	7	3	480	5	5	3	2	2	4	2	0	4	3	4	3	4	0
Amagasaki Hyogo	431	885	7	0	7,600	5	4	2	0	3	4	2	0	3	3	2	3	4	0
Beppu Oita	465	1176	6	10	1,500	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Chiba Chiba	580	1100	7	18	880	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Kimitsu Chiba	580	1100	7	11	880	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Fukuyama Hiroshima	342	834	7	5	649	5	3	2	1	3	2	2	0	2	3	3	2	5	0
Higashi-Harima Hyogo	390	950	6	10	1,656	5	4	3	2	3	4	3	0	4	3	4	3	4	0
Himeji Hyogo	400	900	7	10	480	5	5	4	2	2	3	2	0	3	3	5	3	4	0
Hakata Fukuoka	509	1095	7	6	280	5	3	2	1	2	3	2	0	3	3	2	2	5	0
Imabari Ehime	450	899	4	2	70	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Innoshima Hiroshima	340	850	6	15	60	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Iwakuni Yamaguchi	499	1045	7	3	260	5	4	4	2	3	3	4	0	3	4	5	3	4	0
Kochi Kochi	798	1841	4	-4	640	5	3	4	3	3	3	4	0	4	3	5	3	4	3
Kakogawa Hyogo	402	916	7	1	1,656	5	4	2	2	2	3	2	0	3	3	4	3	4	0
Kiire Kagoshima	632	1607	6	20	100	4	4	2	2	3	4	2	3	4	4	3	2	5	2
Niigata Niigata	724	1065	6	-2	1,800	5	4	4	0	3	2	3	0	5	3	5	2	4	0
Kikuma Ehime	450	899	4	1	10	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Kinwan (Ishikawa) Okinawa	818	1320	7	5	10	5	4	2	2	4	4	3	4	4	4	5	4	0	4
Kanda Fukuoka	554	1106	7	4	40	4	3	2	1	3	4	2	0	4	3	2	2	5	0
Kinuura Aichi	478	1057	7	-2	350	5	4	4	2	3	2	3	0	3	3	5	3	4	0
Kagoshima Kagoshima	632	1607	6	2	260	5	4	4	2	3	4	2	2	4	3	3	2	5	3
Kashima Ibaraki	683	983	8	32	1,800	5	4	2	1	4	3	1	0	2	5	4	2	3	0
Kudamatsu Yamaguchi	635	1210	7	1	30	5	4	3	1	3	1	3	0	5	3	5	3	5	0
Kawasaki Kanagawa	570	1100	7	4	2,200	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Maizuru Kyoto	781	1020	8	12	1,600	5	4	4	0	2	4	3	0	5	2	5	2	4	0
Mizushima Okayama	339	821	7	2	1,990	5	4	2	1	3	2	3	0	3	4	5	4	4	0
Moji (Kitakyushu) Fukuoka	554	1106	7	13	300	5	3	1	1	2	2	2	0	2	3	3	3	5	0
Muroran Hokkaido	724	1065	6	15	740	5	4	4	0	3	3	3	0	5	3	5	2	4	0
Matsuyama Ehime	450	899	4	12	270	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Naha Okinawa	818	1320	7	2	15	5	4	4	3	4	2	3	3	3	4	5	4	0	4
Negishi (Yokohama) Kanagawa	548	1021	7	3	230	5	4	4	1	4	3	3	0	3	3	5	3	4	1
Nagoya Aichi	478	1057	7	2	900	5	4	4	2	4	1	3	0	3	3	5	4	5	0
Nagasaki Nagasaki	562	1417	6	-5	480	5	3	5	0	3	4	3	0	4	3	5	3	5	1
Oita Oita	465	1176	6	3	2,150	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Okinawa Okinawa	818	1320	7	2	15	5	4	4	3	4	2	3	3	3	4	5	4	0	4
Onomichi Hiroshima	340	850	6	2	60	5	3	5	2	3	3	4	0	3	4	5	3	4	0
Osaka Osaka	430	880	7	0	16,000	5	4	3	0	3	4	2	0	3	3	5	2	3	0
Saiki Oita	465	1176	6	18	2,150	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Saganoseki Oita	465	1176	6	18	2,150	4	3	2	1	3	4	2	0	4	3	3	2	5	0
Sakai Osaka	420	850	7	1	1,600	5	4	4	0	3	4	2	0	4	4	4	3	4	0
Shibushi Kagoshima	632	1607	6	2	140	5	4	4	2	3	4	2	3	4	4	3	2	5	2
Sakaide Kagawa	358	775	7	4	120	4	4	3	0	2	2	2	0	2	4	4	2	5	0
Sakaiminato Tottori	848	1075	9	11	280	5	4	4	3	4	3	3	0	4	4	4	2	3	0
Shimotsu Wakayama	456	886	7	3	25	5	4	4	2	4	1	3	0	3	3	5	4	4	1
Shimizu Shizuoka	738	1356	7	1	900	5	4	4	1	3	4	3	0	4	4	5	3	4	0
Tamano (Uno) Okayama	339	821	7	23	1,990	5	4	2	1	3	2	3	0	3	4	5	4	5	0
Tobata (Kitakyushu) Fukuoka	554	1106	7	5	10	5	3	4	1	3	2	4	0	2	4	4	4	5	0
Tokuyama Yamaguchi	631	1213	7	1	70	5	4	3	1	3	1	4	0	5	3	5	3	5	0
Tomakomai Hokkaido	724	1065	6	0	10	5	4	4	0	3	3	3	0	5	3	5	2	4	0
Toyama Toyama	327	739	7	3	4,800	5	4	4	0	3	2	3	0	3	3	5	2	3	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the...					Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%	Distance to River Mouth (km)	Size of River Catchment (km^2)	Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Tokyo Tokyo	585	1110	7	0	3,200	5	4	5	1	2	3	3	0	2	2	5	2	3	1
Ube Yamaguchi	631	1213	7	2	85	5	4	3	0	3	2	3	0	2	4	3	4	5	0
Kobe Hyogo	295	1021	6	2	50	5	3	4	0	3	4	4	0	4	3	5	4	4	0
Wakayama Wakayama	420	850	7	2	3100	5	4	4	2	4	1	3	0	4	3	5	4	5	0
Yokkaichi Mie	505	1082	7	13	900	5	4	4	2	3	1	3	0	3	3	5	4	5	0
Yokohama Kanagawa	548	1021	7	3	230	5	4	4	1	4	3	3	0	3	3	5	3	4	1
Yokosuka Kanagawa	*550*	*1000*	*7*	20	230	5	4	4	1	4	3	2	0	4	4	5	4	5	1
Mombasa	*355*	*789*	*8*	100	9,000	5	4	5	4	4	2	4	4	4	5	5	3	3	3
Kwangyang	344	958	7	7	2,100	5	3	4	1	3	3	2	0	4	4	4	3	2	0
Pohang	284	774	7	7	2,300	5	4	2	2	3	2	3	0	2	3	5	3	1	0
Kunsan	344	931	4	0	*500*	*5*	*4*	*3*	*1*	*2*	3	2	0	4	*3*	5	*3*	4	0
Mokpo (Mogpo)	*344*	*931*	*4*	7	*1,000*	*5*	*4*	*3*	*2*	*2*	2	2	0	5	*3*	5	*2*	4	0
Onsan	308	1175	6	3	900	5	4	3	2	2	2	2	0	1	3	3	4	4	0
Pusan	356	1032	7	15	1,690,000	5	4	2	0	3	2	4	0	2	3	2	3	2	0
Samcheon Po	361	933	7	16	400	5	3	2	1	2	1	2	0	1	4	4	3	2	0
Ulsan	344	942	7	3	900	5	4	2	0	3	1	2	0	1	3	3	4	4	0
Yosu (Yeosu)	*344*	*958*	*7*	26	2,100	5	3	3	1	3	3	2	0	4	3	3	4	5	0
Kuwait (Shuwaikh; KWSWK)	8	91	5	140	500,000	5	5	1	3	4	3	3	2	3	5	5	4	3	3
Mina Al Ahmadi	5	90	4	105	500,000	5	5	1	2	2	1	2	2	3	5	2	3	3	2
Mina Saud	15	95	4	160	500,000	5	4	1	2	4	2	3	3	4	5	2	2	2	2
Mina Abdulla	7	91	5	120	500,000	5	2	1	2	2	2	1	2	2	4	5	3	3	3
Shuaiba	*5*	*90*	*4*	115	500,000	5	5	1	2	3	2	2	2	3	5	2	3	3	2
Colombo	*644*	*1597*	*7*	22	880	5	5	4	1	4	3	2	2	3	4	5	3	3	1
Malta (Valletta)	*117*	*493*	*7*	200	120	5	5	5	0	3	4	0	0	4	4	0	4	5	0
Penang (Georgetown)	770	1351	8	0	480	5	4	4	0	4	3	1	1	3	5	4	4	4	4
Lumut	*790*	*1450*	*8*	-2	*400*	5	3	5	0	3	2	5	3	3	4	5	3	4	3
Port Kelang	885	1305	8	-1	650	5	3	3	0	2	4	1	1	4	5	4	3	5	5
Port Dickson	713	1600	7	6	*400*	5	2	3	0	4	2	3	3	4	4	5	4	4	4
Kapar Coal Terminal	885	1305	8	1	140	5	2	3	0	2	3	1	1	3	5	3	3	5	5
Pasir Gudang Johor	1101	1433	8	10	2,800	5	2	4	3	4	3	1	2	3	4	4	3	4	4
Bintulu Sarawak	*1632*	*1993*	*9*	9	3,700	5	4	4	0	2	1	3	3	1	5	3	3	2	2
Lagos	405	1336	6	0	18,000	5	4	5	0	3	0	5	4	2	3	5	3	2	0
Tin Can Island	405	1336	6	16	18,000	5	4	4	0	4	0	5	4	2	3	5	3	2	0
Port Harcourt	561	1798	6	-66	120,000	5	0	5	0	1	2	5	4	2	4	5	0	1	0
Onne	*560*	*1800*	6	-40	120,000	5	4	4	0	2	3	5	4	2	4	5	0	1	1
Bonny	*605*	*1444*	*6*	0	8,000	5	0	5	0	2	0	5	4	0	2	5	3	0	0
Europoort	362	469	8	0	2,500	5	5	3	0	3	3	4	0	1	2	5	1	0	0
Rotterdam	362	469	8	-10	2,500	5	5	4	0	2	2	4	0	0	2	5	1	0	0
Ijmuiden	*475*	*365*	*9*	-1	300	5	5	4	1	4	3	4	0	1	4	5	2	0	0
Amsterdam	472	360	9	-18	5,000	5	5	5	0	2	2	5	0	0	2	5	1	0	0
Flushing (Vlissingen)	*480*	*370*	*9*	-3	600	5	5	4	2	4	3	4	0	1	4	5	1	0	0
Auckland	497	687	8	3	200	5	4	3	2	2	2	2	0	3	3	5	2	2	0
Whangerei	487	673	9	0	600	*5*	*0*	*4*	*1*	*5*	*3*	*5*	0	5	*4*	*5*	*2*	*4*	0
Marsden Point	*487*	*673*	*9*	20	600	5	0	2	1	4	3	2	0	5	5	3	2	5	0
Callao (Lima)	*6*	*14*	*6*	10	400	5	5	4	2	4	3	2	0	3	5	5	3	4	0
Lae	1760	2699	8	2	7,980	5	4	4	2	2	1	1	2	1	5	2	3	1	4
Port Moresby	236	919	6	7	85	5	5	5	2	2	1	2	2	1	5	3	1	1	1
Daru	*250*	*960*	*6*	35	55,600	5	0	5	3	4	0	4	4	4	5	5	4	4	3
Batangas (Luzon)	365	1372	6	2	500	5	3	4	4	2	4	1	1	4	5	4	3	4	4
Bataan Mariveles	216	1607	6	25	900	5	3	4	4	2	4	1	1	4	5	4	3	4	3
Limay	216	1607	6	4	900	5	4	2	3	3	2	3	3	3	5	4	4	4	3
Manila	216	1607	6	6	120	5	4	4	1	2	2	1	3	2	3	5	3	4	4
Subic Bay (Sana Clara)	*228*	*1797*	*6*	4	1,800	5	5	3	1	3	3	3	4	3	5	3	3	4	3
Muhammad Bin Qasim	*50*	*185*	*3*	-30	240,000	5	4	4	3	2	0	5	4	2	2	5	1	1	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the...			Distance to River Mouth (km)	Size of River Catchment (km^2)	Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%			Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Karachi	*41*	*156*	*3*	-4	240,000	5	4	5	4	4	0	5	4	3	2	5	2	2	0
Faro	87	434	5	80	8,250	5	4	4	3	3	2	4	0	4	3	4	3	3	0
Lisboa	164	538	6	0	11,000	5	4	5	3	2	3	5	0	4	3	5	2	3	0
Lagos (Portugal)	87	434	5	0	40	5	4	5	2	4	4	4	0	4	5	5	3	4	0
Sines	*164*	*538*	*4*	30	700	5	4	4	2	3	3	2	0	4	4	1	0	4	0
Doha	5	76	4	5	300	5	5	4	3	4	2	4	3	4	5	4	4	2	3
Umm Said (Mesaieed)	5	76	4	10	400	5	4	3	4	4	2	3	4	4	5	3	4	0	4
Halul Island	*5*	*76*	*4*	95	300	5	4	0	1	4	0	1	1	4	5	3	4	4	4
Constanta	196	224	9	115	817,000	5	5	4	3	4	4	3	0	2	4	5	0	1	0
Mangalia	191	222	9	145	817,000	5	5	4	3	4	4	3	0	2	4	5	0	1	0
Midia	*196*	*224*	*9*	95	817,000	5	5	4	2	4	4	4	0	2	4	5	0	1	0
Novorossiysk, Russia	320	488	9	270	1,410	5	5	4	2	3	3	2	0	5	4	5	1	4	0
Tuapse, Russia	609	930	7	140	1,410	5	5	4	1	3	2	1	0	4	4	4	1	4	0
Vladivostok	*90*	*631*	*5*	25	15,000	5	4	5	0	3	3	4	0	5	5	5	0	5	0
Dammam	15	80	4	3	80	5	5	4	2	4	1	4	4	3	4	5	4	3	3
Jeddah	5	60	3	20	800	5	5	4	3	4	0	3	3	4	5	4	3	3	4
Jubail	15	100	4	170	1,000	5	5	4	3	4	4	3	3	3	5	3	4	0	3
Al Juaymah Terminal	*15*	*100*	4	200	1,000	3	3	1	2	3	0	2	2	3	4	5	2	2	2
Ras Al Khafji	15	95	4	170	500,000	5	2	1	2	2	1	2	2	2	4	5	3	3	2
Ras Al Ghar	15	95	4	170	1,000	5	5	1	2	4	3	2	2	4	5	3	4	4	1
Ras Al Tannura	*15*	*100*	4	170	1,000	5	4	2	3	4	2	3	3	2	4	5	4	3	3
Yanbu	*2*	*55*	*3*	2	400	5	4	0	3	4	0	3	3	3	5	3	3	3	4
Marsa Bashayer Oil Terminal	*10*	*40*	4	30	1,000	5	3	3	2	3	0	2	2	2	4	5	3	3	4
Port Sudan	*10*	*40*	*4*	2	1,000	5	5	4	3	3	0	4	3	4	4	5	3	3	2
Singapore Jurong	927	1103	9	5	200	5	4	4	3	2	2	4	4	2	3	5	2	2	2
Singapore Keppel	927	1103	9	5	200	5	4	4	3	2	2	4	4	2	3	5	2	2	2
Singapore Sembawang Port	927	1103	9	2	2,800	5	4	4	3	4	4	1	1	4	3	5	3	4	4
Singapore Singapore	927	1103	9	5	200	5	4	4	3	2	2	4	4	2	3	5	2	2	2
Singapore Pasir Panjan/Tanjung Pagar	*927*	*1103*	*9*	5	200	5	3	5	3	1	1	3	3	1	3	5	2	2	2
Koper (Slovenia)	*470*	*570*	*9*	0	400	5	4	4	0	3	3	3	0	3	3	5	2	3	0
Dakar	*9*	*494*	*3*	170	40,000	5	5	4	2	4	0	2	2	4	5	5	3	3	2
Bangkok	190	1307	6	-25	250,000	5	2	5	0	5	5	1	4	5	1	5	4	1	1
Laem Chabang	*327*	*1000*	*6*	8	330	5	3	4	0	2	1	2	4	1	2	5	3	3	4
Dortyol Oil Terminal	102	652	5	5	400	5	2	2	2	3	4	1	0	4	4	2	3	5	0
Eregli	194	551	6	70	65,000	5	5	4	0	4	4	3	0	4	3	5	0	4	0
Istanbul	190	523	7	400	817,000	5	5	5	1	2	4	2	0	5	3	5	1	5	0
Izmir (Smyrna)	95	602	5	45	5,000	5	4	4	2	3	4	1	0	4	4	3	2	5	0
Izmit (Tutunciflik Oil Terminal)	190	523	8	450	817,000	5	3	5	1	3	4	1	0	5	4	2	0	4	0
Mersin	102	652	5	1	450	5	5	3	2	4	4	1	0	4	4	2	3	5	0
Samsun	296	482	8	60	78,200	5	5	4	0	3	3	1	0	4	3	5	0	3	0
Yarimca	*190*	*520*	*7*	440	817,000	5	4	3	1	3	4	1	0	5	3	3	1	5	0
Keelung (Chilung)	1721	2009	9	8	45	5	5	3	0	3	1	2	5	1	2	4	3	2	4
Kaohsiung	158	1593	5	10	100	5	5	3	1	3	4	1	4	3	3	4	3	3	4
Taichung	*370*	*935*	*7*	10	1,600	5	5	4	0	4	1	1	4	1	2	4	3	5	5
Dar Es Salaam	*248*	*810*	*6*	95	100,000	5	5	5	3	3	0	5	4	2	5	5	3	3	4
Dnepro-Bugsky (Ochakov)	227	237	9	0	505,810	5	2	5	0	2	2	3	0	1	2	5	0	1	0
Ilyichevsk	155	179	9	80	573,810	5	4	4	4	5	3	3	0	2	4	5	2	3	0
Odessa	148	242	8	54	573,810	5	5	3	2	5	4	2	0	3	2	5	4	3	0
Nicolayev	156	191	9	-80	68,000	5	1	5	2	2	2	1	0	1	2	5	0	2	0
Sevastopol	162	238	9	300	817,000	5	5	4	1	2	3	1	0	5	4	3	2	4	0
Boston Massachusetts	496	594	9	0	2,000	5	4	5	0	3	4	3	0	4	3	5	0	5	0
New York New York (New Jersey)	556	633	9	-5	25,000	5	5	4	0	2	4	2	0	2	4	5	0	*4*	0
Philadeplhia Pennsylvania (Port Richmond)	485	559	9	-50	8,400	5	5	5	0	0	4	3	0	4	3	5	0	*3*	0
Wilmington Delaware	485	559	9	-30	8,400	5	5	5	0	1	4	3	0	4	3	5	0	*1*	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the...			Distance to River Mouth (km)	Size of River Catchment (km^2)	Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%			Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Baltimore Maryland	518	574	9	-70	25,000	5	5	5	0	0	4	4	0	4	3	5	0	4	0
Hampton Roads	498	635	8	-10	25,000	5	5	3	2	3	2	4	0	4	5	5	0	4	0
Norfolk-Newport News Virginia	498	635	8	-10	25,000	5	4	3	2	3	2	4	0	4	5	5	0	4	0
Savannah Georgia	433	705	9	0	45,000	5	4	3	2	3	0	4	0	0	5	5	3	3	1
Mobile Alabama	758	915	9	-2	151,000	5	4	4	3	3	1	4	2	0	3	5	2	0	0
Lake Charles Louisana	630	786	7	-26	7,500	5	4	4	3	3	1	4	2	0	4	5	2	0	0
Davant	758	915	9	-60	1,000,000	5	5	3	1	4	4	4	1	1	4	5	1	1	0
New Orleans	718	946	8	-140	1,000,000	5	3	5	0	0	4	5	0	1	0	5	0	1	0
LOOP Terminal	729	944	8	60	1,000,000	5	2	1	1	1	0	1	1	0	2	5	2	0	1
Sabine	723	941	8	5	600	5	4	3	3	4	3	4	2	3	4	5	3	0	0
Beaumont	540	681	8	-70	12,500	5	5	5	2	3	3	5	2	0	4	5	1	0	0
Galveston Texas	459	609	9	0	8,000	5	5	3	3	4	2	5	4	2	4	5	4	1	0
Texas City Texas	459	609	9	-12	8,000	5	5	3	3	3	2	5	4	2	3	5	3	1	0
Houston Texas	540	681	8	-35	8,000	5	4	5	2	3	1	5	2	1	2	5	2	1	0
Anchorage Alaska	117	280	7	0	15,000	5	5	0	0	2	4	3	0	4	3	5	0	5	0
Portland Oregon	231	689	6	-195	200,000	5	4	5	0	3	5	1	0	5	5	5	0	5	0
Vancouver Washington	230	764	6	-188	200,000	5	4	5	0	3	5	1	0	5	5	5	0	5	0
San Francisco California	44	453	5	15	30,000	5	4	3	2	3	3	3	0	4	4	5	0	4	0
Oakland California	44	453	5	14	30,000	5	4	4	2	3	3	3	0	4	4	5	0	4	0
Long Beach California	11	165	2	5	2,500	5	5	3	2	3	3	3	0	2	5	5	0	3	0
San Diego	22	233	5	14	550	5	4	4	2	4	3	4	0	2	5	5	0	0	0
Montevideo	540	591	9	0	600,000	5	4	5	3	4	3	4	0	4	5	5	0	3	0
Aden (Yemen)	14	33	6	6	15,500	5	5	4	3	4	3	3	3	4	4	5	4	3	4
Hodeidah (Yemen)	14	33	6	14	8,200	5	5	4	2	4	2	2	2	3	5	5	4	3	3
Al Mukullah (Yemen)	14	33	6	70	12,000	5	5	4	0	5	3	0	0	5	5	4	1	5	1
Ras Isa Marine Terminal (Yemen)	14	33	6	55	8,200	5	2	2	1	3	2	1	1	4	5	4	4	3	3
Cape Town	197	630	6	3	217	5	4	4	2	4	4	2	0	4	4	5	2	4	0
Durban	332	758	7	3	180	5	4	4	3	4	0	3	4	4	5	4	3	2	0
Port Elizabeth	363	783	8	1	84	5	5	5	2	4	0	2	0	2	5	5	2	3	0
Richards Bay	462	757	8	2	183	5	4	4	4	4	0	5	4	2	5	5	4	3	0
Saldanha Bay	69	274	5	70	7,900	5	5	4	2	4	0	3	0	4	5	4	3	4	0

APPENDIX 7
Consultants' Terms of Reference

Consultants' Terms of Reference

Activity 3.1: Ballast Water Risk Assessments
6 Demonstration Sites

1. Introduction & Background

The International Maritime Organization (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 management (IMO Assembly Resolution A.868(20)), and to prepare for the anticipated introduction of an international legal instrument regulating ballast water management currently being developed by IMO member countries.

The 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.

2. The Need for the Risk Assessments

The development objectives of the programme are to assist countries to implement the existing IMO voluntary ballast water management guidelines and to prepare for the introduction of a new international legal instrument on ballast water.

The current IMO ballast water management guidelines offer states significant flexibility in determining the nature and extent of their national ballast water management regimes. This flexibility is warranted given that nations are still experimenting with approaches. A port state may wish to apply its regime uniformly to all vessels which visit, or it may wish to attempt to assess the relative risk of vessels to valuable resources and apply the regime selectively to those which are deemed of highest risk.

The uniform application option offers the advantages of simplified programme administration in that there are no "judgement calls" to be made or justified by the port state regarding which vessels must participate and which need not. In addition, the system requires substantially less information management demands. Finally, it offers more protection from unanticipated invaders, and overall protection is not dependent upon the quality of a decision support system which may not be complete. The primary disadvantages of this approach are: 1) additional overall cost to vessels which otherwise might not need to take action, and 2) more vessels will be involved in undertaking the measures, and therefore the port state will need to monitor compliance from a greater number of vessels.

Some nations are experimenting with systems to allow more selective applicability based upon voyage-specific risk assessments because this approach offers to reduce the numbers of vessels subject to ballast water controls and monitoring. The prospect of reducing the numbers of ships to which the program applies is especially attractive to nations that wish to eliminate introductions of target organisms such as toxic dinoflagellates. More rigorous measures can be justified on ships deemed to be of 'high risk' if fewer restrictions are placed on low risk vessels. However, this approach places commensurate information technology and management burdens on port state and its effectiveness depends on the quality of the information supporting it. The approach may also leave the country/port vulnerable to unknown risks from non-target organisms.

For countries/ports which choose the selective approach, it will be essential to establish an organized means of evaluating the potential risk posed by each vessel entering their port, through a Decision Support System (DSS). Only in this way can they take the most appropriate decision regarding any required action concerning that vessels' ballast water discharge. The DSS is a management system that provides a mechanism for assessing all available information relating to individual vessels and their individual management of ballast water so that, based upon assessed risk, the appropriate course of action can be taken.

Before a pilot country decides on whether to adopt the 'blanket' (i.e. all vessels) approach or to target specific, identified high risk vessels only, a general, first-past risk assessment needs to be carried out. This should look at shipping arrival patterns and identify the source ports from which ballast water is imported. Once these are identified, source port/discharge port environmental comparisons should be carried out to give a preliminary indication of overall risk. This will greatly assist the port state to assess which approach to take.

The GloBallast programme, under Activity 3.1; will support these initial , 'first-past' risk assessments as a consultancy on contract to the PCU. This is important for establishing the level and types of risks of introductions that each port faces, as well as the most sensitive resources and values that might be threatened. These will differ from site to site, and will determine the types of management responses that are required.

The PCU risk assessment consultants, in conducting the risk assessment in each pilot country, will work with and train country counterpart(s) and include them in the study process as part of the capacity building objectives of the programme, so as to allow each country to undertake its own risk assessments in future.

3. Scope of the Risk Assessments

A Risk Assessment will be undertaken for each of the ports of:

- Sepetiba, Brazil;
- Dalian, China;
- Mumbai, India;
- Kharg Island, Iran;
- Saldanha, South Africa and
- Odessa, Ukraine.

The Risk Assessments will apply to all ship movements into and out of these ports based on shipping data for the last 10 years (or longer if available).

4. Services Required & Tasks to be Undertaken

The GloBallast PCU requires a suitably qualified and experienced consultancy team to undertake the ballast water risk assessments. The consultancy team will undertake the following Tasks, for each demonstration site:

Task 1: Resource Mapping

Identify, describe and map on Geographic Information System (GIS) all coastal and marine resources (biological, social/cultural and commercial) in and around the demonstration site that might be impacted by introduced marine species.

Task 2: De-ballasting/Ballasting Patterns

Characterise, describe and map (on GIS) de-ballasting and ballasting patterns in and around the ports including locations, times, frequencies and volumes of ballast water discharges and uptakes.

Task 3: Identify Source Ports

Identify all ports/locations from which ballast water is imported (source ports).

Task 4: Identify Destination Ports

Identify all ports/locations to which ballast water is exported (destination ports).

Task 5: Database - IMO Ballast Water Reporting Form

Establish a database at the nominated in-country agency for the efficient ongoing collection, management and analysis of the data collected at the demonstration site according to the standard IMO Ballast Water Reporting Form, and the data referred to under Tasks 2, 3 and 4.

Task 6: Environmental Parameters

Characterise as far as possible from existing data, the physical, chemical and biological environments for both the demonstration site and each of its source and destination ports.

Task 7: Environmental Similarity Analysis

Using the data from Task 6 and an appropriate multivariate environmental similarity analysis programme, develop environmental similarity matrices and indices to compare each demonstration site with each of its source ports and destination ports, as the basis for the risk assessment.

Task 8: High Risk Species

Identify as far as possible from existing data, any high risk species present at the source ports that might pose a threat of introduction to the demonstration site, and any high risk species present at the demonstration site that might be exported to a destination port.

Task 9: Risk Assessment

For each demonstration site, assess and describe as far as possible, the risk profile for invasive marine species being both introduced from its set of source ports and exported to its set of destination ports, and identify the highest risk source and destination ports, using the outputs of Tasks 1 to 8 and based on the environmental similarity indices developed under Task 7.

Task 10: Training & Capacity Building

While undertaking the risk assessment, provide training and capacity building to the in-country risk assessment team (up to 10 people) in the risk assessment methodology, including use of database established under Task 5 and the multivariate environmental similarity analysis programme established under Task 7.

Task 11: Information Gaps

Identify any information gaps that limit the ability to undertake these Tasks and recommend management actions to address these gaps.

5. Methods to be Used

The consultants should clearly outline in their Tender how each Task will be achieved. These should comply with but are not necessarily restricted to the following:

Site Visits:

The consultants will undertake an initial one week (5 working days) visit to each demonstration site to hold discussions with the CFP, CFP-A, port authority, maritime administration, environment administration, fisheries/marine resources administration, marine science community and shipping industry, to identify and obtain information and data for the various Tasks, establish a working relationship with the in-country risk assessment team, conduct a site familiarisation to the demonstration site (port) and to identify information gaps.

The consultants will undertake second 8 to 10 working day visit to each demonstration to install the GIS, database and multivariate environmental similarity analysis programme and to provide training and capacity building in their use and the overall risk assessment methodology to the in-country risk assessment team.

Coordination:

The consultants will maintain close consultation and cooperation with the PCU Technical Adviser (TA), who will manage this consultancy, and with the Country Focal Point (CFP) and CFP Assistant (CFP-A) in each pilot country, who provide the primary contact point for all in-country activities and for accessing in-country information and data.

Tasks 1& 2:

This will be restricted existing data only, field surveys are not provided for in the budget. The CFP and/or CFP-A will compile as much existing information as possible in relation to Tasks 1 and 2 to provide to the consultants.

The consultants should identify and evaluate any existing in-country databases and GIS for use in these Tasks. The GIS should be tailored to suit the country's circumstances while ensuring user-friendliness and consistency across all sites.

Tasks 3 & 4:

This will be restricted to existing data only. The CFP and/or CFP-A will compile as much existing information as possible in relation to Tasks 3 and 4 to provide to the consultants. However, the consultants should identify potential additional sources of data for these two tasks, including records held by port authorities, shipping agents, customs agencies and similar, that may not have been identified/compiled by the CFP/CFP-A.

Task 5:

The consultants should identify and evaluate any existing in-country databases for use in this Task. The database should be tailored to suit the country's circumstances while ensuring user-friendliness, consistency with the IMO Ballast Water Record Form and consistency across all sites.

Task 6:

This will be based on existing data only. The consultants should clearly outline in their Tender what parameters will be used, and how the data for these parameters will be collected from the source and destination ports.

Task 7:

The consultants should clearly outline in their Tender what multivariate environmental similarity analysis programme will be used, and how it will be used.

Task 8:

The consultants should clearly outline in their Tender how this Task will be achieved, including how relevant national and international invasive marine species records and databases will be accessed.

Task 9:

The consultants should clearly outline in their Tender how the outputs of Tasks 1 to 8, and in particular Task 4, will be used to produce the risk profiles for each demonstration site, and what form these will take.

Task 10 & 11:

The consultants should clearly outline in their Tender how these Tasks will be achieved.

6. Time Frame, End Product and Reporting Procedure

- The risk assessments will be conducted for each of the six demonstration sites in the second half of 2001 and into the first half of 2002. A detailed workplan and timeline will be proposed by the consultant in their Tender and the precise timing for each site will be refined through consultation with each country, once the contract is awarded.

- The end product of this consultancy will be the establishment of the databases, GIS's, multivariate environmental similarity analysis programmes and risk assessment outputs at each demonstration site, including training in their use.

- There will also be a report for each demonstration site which addresses as fully as possible all of the Tasks under section 4, consistent with all parts of these Terms of Reference and the consultancy contract. Results presented should be supported by maps, figures, diagrams and tables here useful.

- Each report should be submitted to the PCU in draft form first, for review by the PCU and the demonstration site risk assessment team. The final report for each site will be submitted to the PCU within one month of the consultants receiving review comments.

- The PCU may arrange for peer review of the draft reports, to ensure scientific credibility and quality control.

- The final reports should be submitted to the PCU in both hard-copy and electronic form, including figures, images and data, ready for publication. The PCU will publish each final report in both English and the main language of the pilot country (if different).

7. Selection Criteria

- Cost effectiveness.

- Demonstrated record of *meeting deadlines* and *completing tasks within budget.*

- Extensive experience with the issue of *introduced marine species.*

- Extensive experience with the issue of *ballast water.*

- Extensive experience with *risk assessment* in relation to introduced marine species and ballast water.

- Demonstrated abilities in *literature search and review* and in identifying and obtaining reports, publications, information and data from sometimes obscure and difficult sources.

- Demonstrated skills in *information analysis and synthesis*.

- Experience in working in *developing countries*.

- Experience in training and *capacity building* in developing countries.

- Ability of the proposed *methods and workplan* to complete all Tasks satisfactorally.

8. Content of Tenders

The Tender should include the following:

- Total lump-sum price in US$D.

- Detailed cost break-down for all Tasks in US$ (NB. Total budget must not exceed US$250,000 and cost-effectiveness and competitiveness within this budget forms a primary selection criteria).

- Detailed workplan and provisional timeline for all Tasks outlined under section 4 above.

- Details of the methods proposed to achieve all Tasks, framed against each Task under section 4 above and consistent with section 5 above.

- CV's of each consultancy team member (maximum of 3 pages per person) (consultancy teams should be kept as small as possible).

- Details of the consultancy's professional indemnity and liability insurance and quality assurance procedures.

Further Information

Steve Raaymakers
Technical Adviser
Programme Coordination Unit
Tel +44 (0)20 7587 3251
Fax +44 (0)20 7587 3261
Email sraaymak@imo.org

More Information?

Programme Coordination Unit
Global Ballast Water Management Programme
International Maritime Organization
4 Albert Embankment
London SE1 7SR United Kingdom

Tel: +44 (0)20 7587 3247 or 3251
Fax: +44 (0)20 7587 3261
Web: http://globallast.imo.org