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Ballast Water Risk Assessment

Port of Dalian

People's Republic of China

NOVEMBER 2003

Final Report

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

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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.

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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)
CFPA	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)
DMU	Dalian Maritime University
DPA	Dalian 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
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)
MSA	Maritime Safety Administration
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 (United States)
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)

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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 the 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 Dalian, which is the Demonstration Site managed by the Dalian Port Authority (DPA) in close coordination with the Liaoning Maritime Safety Administration (MSA). 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 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 March 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 Dalian Port Authority's (DPA) port offices. These records also helped identify which next ports of call may have been a destination port for any BW taken up at Dalian.

A multivariate procedure was then used 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 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. 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 Liaoning MSA, 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 Dalian 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.

Liaoning MSA personnel at Dalian had started collecting BWRFs from international arrivals plus domestic bulk carriers and oil tankers in July 2000. To provide confidence as to which ports were the predominant sources of discharged BW, 3278 BWRFs collected between 1 August 2000 and 4 August 2002 were entered into the Access database during the project. The project therefore established at the Dalian offices of the Liaoning MSA an integrated database and geographic information system (GIS) that manages and displays:

- ballast water data obtained from the BWRFs of arriving ships;
- 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 BW discharges.

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

Of the 4319 ballast tank records in the Dalian BWRF database, the percentage showing there had been zero discharge was high (82.4%). Of the 759 tank records with a discharge, these provided a total of 77 identifiable BW source ports. Of these ports, the top eighteen (23.4%) accounted for 75% of the total number of source-identified tank discharges. The source port with the highest frequency of tank discharges at Dalian was Shanghai (10.6%). This was followed by Qingdao (a regional port near

Dalian; 7.4%), then Guangzhu (a major estuary port on the Pearl River in southern China; 6.6%), Ningbo (north of Shanghai; 5.5%) and another regional port (Yantai; 5.5%).

The total volume of source-identified BW discharged at Dalian was 1,632,020 tonnes, with a further 159,219 tonnes (8.8%) discharged from unrecorded sources. The source ports providing the largest recorded volume of discharged BW were the southern Guangdong Province ports of Zhuhai (8.9%) and Chiwan (8.3%), followed by Korea's capital port of Inchon (7.5%), then Shanghai (7.2%). In fact five of China's southern province ports were in the top seven that provided >50% of the total source-identified volume discharged at Dalian. Nagoya was the top Japanese port (ranked 9th with 2.6% of the total source-identified volume), while Sakai (ranked 12th at 2.5%) and five other Japanese ports were in the top 20 ports ranked by discharged volume. Of the top 20 ports, ten were in China (including Hong Kong), seven were in Japan and three in Korea, and these accounted for 83.6% of the total volume.

Of the 77 identified BW source ports, it was not surprising that the most similar ports identified by the multivariate environmental analysis were some of Dalian's geographically closest ports which share a similar coastal aspect to the Bohai and northern Yellow Seas. Thus Longkou, Wei Hai, Yantai, Shidao, Rushan, Laizhou, Qingdao and Rizhao all had environmental matching values (C3s) above 0.8. The environmentally closest foreign port (C3 of 0.78) was Mokpo in Korea, which also faces the Yellow Sea. The most environmentally dissimilar ports trading with Dalian in 2000-2002 were the river and estuary ports of the Yangste River system (0.20-0.37), plus warm water ports in south China and south-east Asia.

The risk species threat from a source port depends on the number of introduced and native species in its bioregion, and their categorizations as unlikely, suspected or known harmful species. A total of 84 native, cryptogenic and introduced risk species were collated for China's bioregions. These were not considered to form part of a definitive global database but to provide a working resource for the 'first-pass' assessment and to enable convenient updates and refinement for each bioregion as more data become available. The risk species in the Dalian bioregion included preliminary identifications from the Dalian Port Baseline Biological Survey (PBBS) plus taxa listed in published and unpublished reports collated by Group C members. Species native to the Bohai Sea/Yellow Sea bioregions with harmful or suspected reputations in other regions were also added. These provide important components for any 'reverse' BWRA since many have already gained a harmful species status in parts of Europe, the north-east Pacific and/or southern Australia (e.g. the Asian strangle weed, wakame kelp, Chinese mitten crab, Asian clam, date mussel and Northern Pacific starfish).

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. Thus the ROR value for each BW source port represents a proportion of the total marine invasive species threat posed to Dalian as result of its trading pattern in 2000-2002, as indicated by the BWRFs. From the 3278 BWRF records, the project standard method ranked 11 of the 77 source ports as representing the highest risk group in terms of their BW source frequency, volume, environmental similarity, voyage distance and assigned risk species. These ports were all regionally close to Dalian and provided the top 20% of the total ROR, with individual ROR values above 0.3. This highest risk group was led by Yantai (ROR = 0.354; S-ROR = 1.0) followed by Qingdao (ROR = 0.344; S-ROR = 0.96) and Longko (0.343; 0.95), with the Korean port of Inchon being the highest risk foreign port (ranked 10th with an ROR of 0.302 and S-ROR of 0.78).

The highest ranked port located beyond the Bohai-Yellow Sea region was Iwakuni (in Japan's inland Seto Sea). With an ROR of 0.297 (S-ROR = 0.76), Iwakuni was ranked 14th overall and 3rd in the second group (i.e. high risk ports). The highest ranked ports beyond East Asia were on the American west coast (Long Beach and San Francisco; ranked in the lowest group of risk ports with RORs of 0.215 and 0.202 (S-RORs of 0.41 and 0.35 respectively). These ports fell into the lowest risk group because of their smaller contribution to the overall threat, as represented by the BWRFs collected in 2000-2002. Thus while their environmental matching coefficients were moderately high (C3s of 0.62

and 0.65), their voyage duration factor (R2) and low incidence of recorded BW discharges resulted in the low ranking. However the percentage contribution made by Long Beach (1.13%) and San Francisco (1.06%) to Dalian's overall risk (100%) was not substantially lower than those of the highest ranked ports (contributions all in the 1.6% - 1.9% range). The source port with the lowest ROR (0.119; S-ROR = 0.0) was Los Angeles in southern California, which represented 0.62% of the total threat. The 38 source ports grouped in the low (16 ports) and lowest (22 ports) risk categories were a mixture of river, estuarine and/or warmer water ports in Asia and north America. In summary, the results generated by the project-standard 'fist-pass' method highlighted the following:

- Dalian's pattern of trade makes it one of the key regional 'hub' ports of East Asia;
- Dalian appeared to receive very little BW transferred directly from distant overseas ports in 2000-02;
- BW arriving in vessels from riverine and warm water ports presented much less threat than from open coastline ports in the Bohai and Yellow Sea region, not only because of the latter's high environmental matching but also their short voyage durations and high level of BW transfers.

This indicates that Dalian's trade makes it more prone to introductions of species which 'port-hop' after establishing in one or more of its commonly-traded regional ports in north China, Korea and Japan, rather than by introductions directly from America, Europe or other distant regions. The results appeared logical given Dalian's biogeographic location and recent pattern of trade, and will provide a very useful benchmark for any investigative manipulations of the risk formula or database management.

The results also implied that any introduced species which establishes in one of the many ports along the Bohai and Yellow Sea coastline may rapidly spread owing to the high level of coastal shipping. In this context, there is no doubt that northern China is experiencing a number of invasive species, both known and cryptogenic, some of which are contributing to the increased fouling and noxious red tide problems of the intensive mariculture operations, which form an important part of its coastal economy. These problems have been most felt in the Bohai Sea due its progressive eutrophication in recent decades, but increased fouling and red tide events are being noticed along parts of the Yellow Sea and Korea Bay coastlines. Since China's extensive coastline extends well into the tropics and supports numerous small ports serviced by a large coastal trading fleet, the issue of water-borne parasites and pathogens that can threaten commercially cultured species and/or public health was also noted.

Of the various BWRA objectives and tasks, reliable identification of destination ports that may receive BW from Dalian was confounded by the lack of specific questions on the IMO-standard BWRFs, and the uncertainty of knowing if the Next of Port Call recorded on a BWRF is where this BW is actually discharged. Thus presently there is no mechanism enabling a 'reverse BWRA' to be undertaken reliably. In the case of Dalian, several types of visiting vessels do not uniformly discharge or uptake their full capacity of ballast water (especially general cargo ships, container and Ro-Ro vessels), with many of their previous and next ports of call involving part discharge and loading of cargo.

Of the 121 assumed BW destination ports identified by the 2000-2002 database, the Bohai Sea port of Tianjin (13.1% of all departures from Dalian), the Korean port of Pusan (12.5%) and the nearby Chinese port of Qingdao (9.6%) stood out as the most frequently cited Next Ports of Call, a feature related to the large number of container and other liner services operating to these ports. Of the top 22 destination ports (accounting for >80% of all reported Next Ports of Call), 14 were in China (including Hong Kong), seven were in Japan and only one was Korean (Pusan).

Two of the three most frequent presumed BW destination ports had relatively high environmental matching coefficients (i.e. Tianjin and Qingdao with C3s of 0.71 and 0.82), while Pusan was less similar (C3 of 0.44). The most common Japanese destination ports (Kobe at 3.2% and Moji at 3.0%)

are in Japan's Seto Sea and had intermediate C3 values (0.69 and 0.57 respectively). If more reliable forward-looking BWRAs are to be undertaken to identify destination ports in the future, 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 were successfully completed during the 14 month course of this project, with the various tasks and exploratory/demonstration software providing a foundation enabling the regional promulgation of further BW management activities by China. Project outputs included a trained in-country risk assessment team, an operational BWRA system and *User Guide* for use as a demonstration tool in the region and recommendations regarding the future use of BW risk assessment in and beyond China. This places China in a good position to provide assistance, technical advice, guidance and encouragement to other port States in the East Asian region.

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 (*International Convention for the Control and Management of Ships' Ballast Water and Sediments*, as adopted 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 new 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.

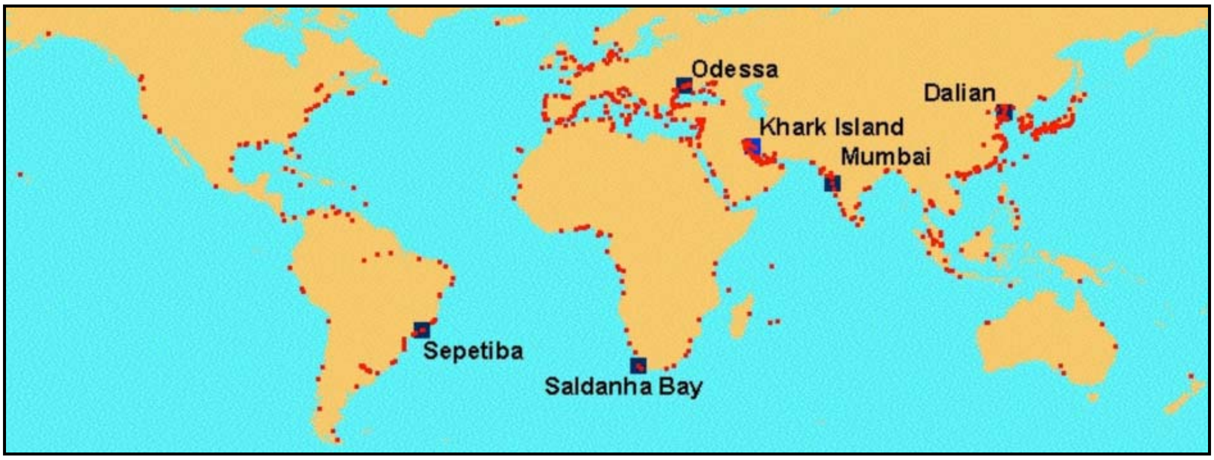

Figure 1. *Locations of the six GloBallast Demonstration Sites and their various ballast water source and destination ports.*

This report describes and presents the results of the first Ballast Water Risk Assessment (BWRA) carried out for the Port of Dalian (P.R. China) during 2002. This GloBallast Demonstrate Site is a large and rapidly modernising general cargo and bulk commodity handling port, located in north-east China on the Bohai Peninsula, which has been extended and modified many times since its opening in 1899 as one of China's first free trade ports (Figure 2).

Figure 2. *Location of Dalian and other ports in East Asia*

2 Aims and Objectives

The aims of the GloBallast BWRA for the Port of Dalian were set by the GloBallast Programme Coordination Unit (PCU), in accordance with Terms of Reference developed by the PCU Technical Adviser (Appendix 8) and 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 Dalian 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 Dalian.
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 Dalian 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 Dalian via standard IMO BWRFs.
6. Characterise as far as possible from existing data, the physical, chemical and biological environments for both Dalian and each of its source and destination ports.
7. Develop environmental similarity matrices and indices to compare the Port of Dalian 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 Dalian, 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 Activity for the Port Dalian was conducted by URS Australia Pty Ltd (URS) under contract to the GloBallast PCU, in accordance with the Terms of Reference (Appendix 8). 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.

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.

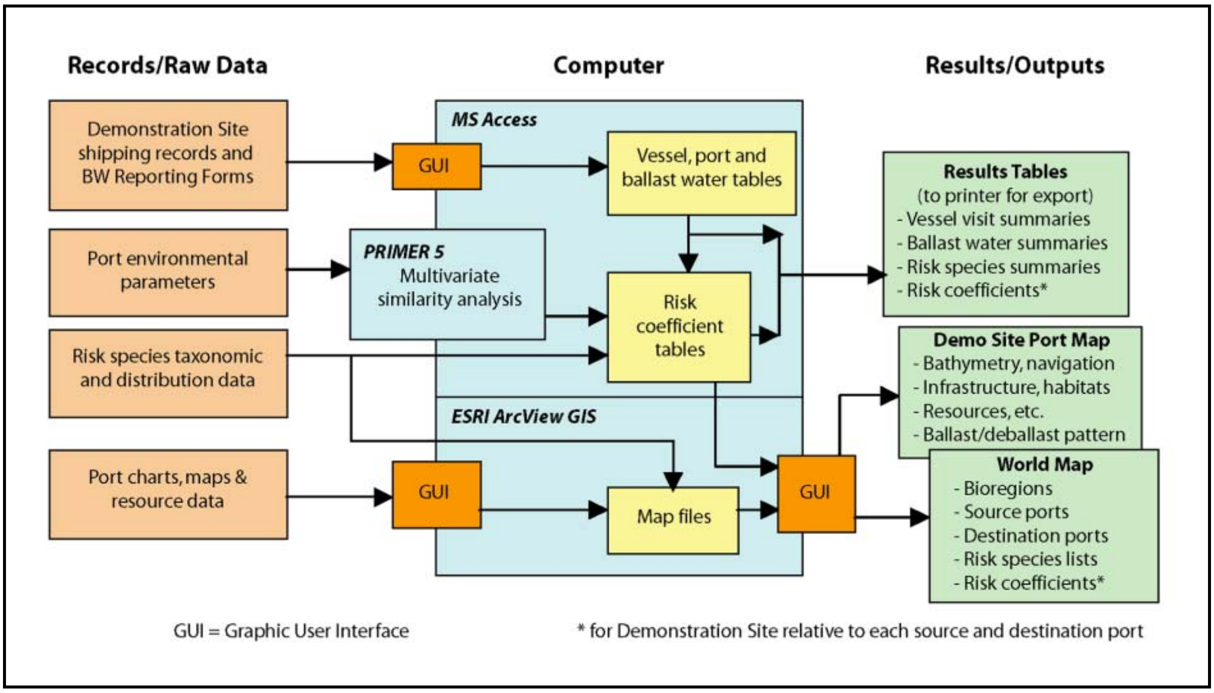

Figure 3. *Schematic of the GloBallast BWRA system*

The work schedule commenced 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 Dalian were completed during two in-country visits by the consultants (22-26 April and 9-21 September 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 17-19 March 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 function rooms arranged by Liaoning MSA in Dalian.
- 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.
- Tour the port facilities at Dalian, 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 March 2003, the consultants supplied the CFP-A 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 March 2003 version, plus subsequent minor corrections to some of the vessel visit records, 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 around the port that might 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).

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 shipping records for periods or arrivals when BWRFs were not obtained or incomplete). The Access database 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].

[2] Several port States (e.g. Australia) and Demonstration Sites (including Dalian) 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. Problems arising from voluntary submission of BWRFs are described in Section 4.10.

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 the Australian Centre for Research on Introduced Marine Pests [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 Dalian 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 preliminary results from the Port Biological Baseline Surveys (PBBS; as recently completed at each Demonstration Site by another GloBallast Activity), plus searches of 'on-line' databases such as those under ongoing development by the Smithsonian Environmental Research Center (SERC), 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).

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 Dalian port map extends beyond the wide mouth of Dalian Bay to include Dayao Bay, the outer anchorages and the neighbouring coastline. The map also extends south-west to include the edge of Dalian Bay and landward to show the port's industrial and urban hinterlands.

[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.

Parts of the western and northern Dalian Bay was available in several MapInfo GIS files at the Dalian Maritime University (DMU), and these were translated into ArcView format to help develop the base layer. However there was no subtidal or navigational information, and no vector-based electronic nautical charts were available for the region. Group A counterparts therefore generated the bathymetry and navigation layers by capturing the salient details of port bathymetry, infrastructure, shipping channels and anchorages from georeferenced, 360 dpi colour scans of the Dalian Bay nautical charts (BA 1255 and China national hydrographic chart).

Infrastructure and social/cultural information was captured by scanning and georeferencing urban maps showing transportation lines and land use areas. Point and pattern symbols were based on the international IHO/IALA system for nautical charts. Capture of the various intertidal and subtidal habitats was undertaken by digitising an annotated copy of the Dalian Port chart provided by Group C. 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.

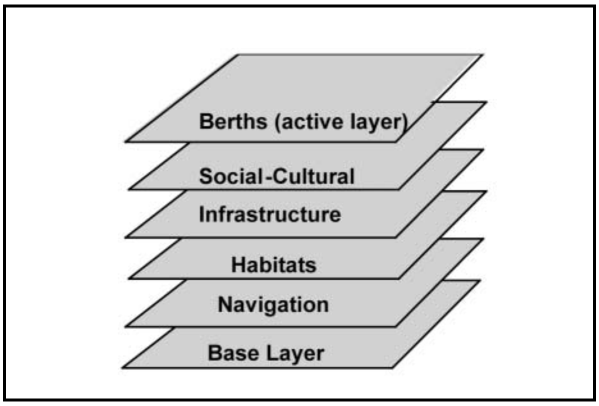

Figure 4. *Thematic layers used for the Port Map GIS*

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 Dalian comprised:

- Coastlines of the mainland and various islands within Dalian 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 programs).

The colour scheme of the base layer followed 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. The fairway boundaries and dredged approach channels, together with the anchorages designated by the Dalian

Port Authority (DPA) and the seven individual super tanker anchorage points near the Xingang oil terminal, were also included.

Habitat Layer: This layer used a standardised, logical colour scheme to facilitate recognition of the main intertidal and subtidal habitat types in and near the port. It contains coastal habitat information provided by Group C, with some of the natural and artificial habitat boundaries based on field notes and map annotations made by Group C team members during the shoreline port tour in the second consultant's visit, plus seafloor sediment information provided by a Group C member involved in the Dalian PBBS. Two port tours had been undertaken, one by port launch on 22 April 2002 (which rapidly became constrained by coastal fog reducing visibility to ~200 m) and a second more extensive tour by vehicle and on foot on 15 September 2002. Delineation of some intertidal and subtidal habitat boundaries was supplemented from seafloor and coastal features displayed on the nautical chart. These included the sand and stony beaches, natural and artificial rocky shorelines, plus seafloor symbols denoting the presence of sand, mud and rocky substrates.

Infrastructure Layer: This shows the urban and developed land areas near the port, including major and minor roads and railway lines.

Social-Cultural Layer: Social-cultural features include the three different coastal reserves near the port and two wildlife breeding grounds, plus the locations of seaweed, mussel and fish farm mariculture sites in the Dalian port region.

Berth Layer: An 'active' berth layer was added to show the nine principal terminals at the Port of Dalian, following the names and numbering system used by the DPA. The same nomenclature was also used for the berthing area 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 Dalian were discussed with representatives from the DPA, MSA and DMU during the first port tour to confirm the main types of port trade, its pilotage rules and draft requirements, use of current anchorage areas and general deballasting/ballasting practises and locations.

Further information was extracted from the BWRFs that Liaoning MSA had commenced collecting from visiting ships on a voluntary basis in July 2000, plus checks of some of the port terminal shipping records. Because Dalian has several dedicated bulk import and export terminals, for many vessel visits it was relatively simple to confirm the BWRF records as to which ships had discharged BW and where, by checking their berth location and vessel type. The situation at the general cargo and container terminals was less clear, particularly for ballasting (i.e. BW uplift during cargo unloading). Many ships arriving at the Dagang and Heizuzui terminals only part unload and/or load cargo, and it was unclear how much ballast water these vessels were discharging and/or taking up. This was particularly the case for the general cargo ships, small dry bulk carriers, reefers and ro-ro vessels visiting the Dagang terminal, from which relatively few BWRFs were collected as Liaoning MSA had focussed its BWRF collection effort on vessels and terminals identified as importing the largest quantities of BW into Dalian.

3.4 Identification of source ports

Personnel from the Liaoning MSA had started collecting BWRFs from international arrivals plus domestic bulk carriers and oil tankers during July 2000. These forms comprised facsimile copies of the IMO and translated forms. To provide confidence as to which ports were the predominant sources of BW discharged at Dalian, a total of 3,278 of the ~3,800 BWRFs collected between 1 August 2000 and 4 August 2002 were entered into the Access database. While data for previous and other ship visits were probably held in archives at individual terminal offices (more than 14 different companies) and national agencies such as Customs, obtaining and consolidating these records to produce a useful data set[4] would have been a major and very difficult task that was considered neither realistic nor achievable by Liaoning MSA staff. Source ports were therefore identified from this two year BWRF record, and no attempt was made to add additional visit information from terminal company shipping records. Another reason for not attempting to collate pre-2000 visit records had been the halt in overseas crude oil exports in 1999. This would have yielded BW sources no longer forming a contemporary component of Dalian's trade.

BWRFs were first collected by port officers at Dalian in July 2000, and by August these were being obtained from most international arrivals plus domestic bulk carrier and oil tanker arrivals, with a focus on vessels arriving to load cargo. This pattern of BWRF collection was continued for two years, with an average 140 BWRFs collected each month (range 43-213). While most ships conformed to Liaoning MSA's request for BWRF submission, checks or follow-up verification queries of submitted forms was not undertaken. The paper forms were stored in terminal batches until their entry into the Access database between April and September 2002, a laborious exercise requiring virtually full-time work by two MSA officers who received database training during the consultants first visit in April 2002 (Section 3.6). Before any new port was added to the database, its name and country spelling, location coordinates, unique UN Port Code and bioregion number were checked using Lloyds' *Fairplay World Ports Guide* and world bioregion list in the database (port data input is detailed in the GloBallast *BWRA User Guide*).

For vessels which submitted incomplete forms with no BW source, gap-filling information potentially available in terminal or Customs records would have provided only the *Last Port of Call*, which were usually already present on the BWRF but may not be actual BW sources. To help identify which last ports of call were probable sources, some cross-checking was made of the source ports and last ports of call reported in other BWRFs by the same or similar vessels visiting the same terminal. For tankers and bulk carriers arriving at export terminals with no BW source recorded on their BWRF, it was assumed these had uplifted BW at their last port of call, as many were evidently engaged in regular, shuttle-style trade. The Lloyds *Fairplay Port Guide* and *Lloyds Ship Register*[5] were also used to confirm source port trade and the vessel's IMO identification number, vessel type and DWT respectively. A customised Excel spreadsheet supplied by the consultants was also used to check claimed BW discharge volume[6] (Figure 5).

Important gaps in the BWRFs could therefore be filled or checked, including the vessel name, type and DWT, its previous visit history, last port/s of call, apparent charter/liner trade and claimed discharge. However many incomplete BWRFs could not be filled to the level allowing the database to add the record to its risk assessment calculations.

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 and cargo loading record. While this spreadsheet could also be used to provide an estimate of BW uplifted by ships unloading cargo, this was not possible for vessels arriving at the general cargo, container and multi-purpose berths owing to the difficulty of accessing cargo loading/unloading details. In summary, the laborious checking, gap-filling and data entry exercise of nearly 3,300 BWRFs required six months, with incomplete or unusual BWRFs checked and gap-filled where possible using the *Lloyds Ship Register*, *Fairplay Port Guide* and Excel spreadsheet to correct errors or add missing data, particularly for port

[4] i.e. vessel name, IMO number, type, arrival and departure dates, berth, last and next ports of call, and cargo details.

[5] 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.

[6] The BW spreadsheet contains coefficients of ballast water taken up or discharged when loading or discharging cargo (as percentages of DWT for each vessel type), based on ballast water capacity and discharge data from other studies, BWRFs and *Lloyds Ship Register*.

details, vessel name, IMO number, type, DWT and BW discharge. Vessels with no IMO number (181) received a unique 'dummy' number (Section 3.6).

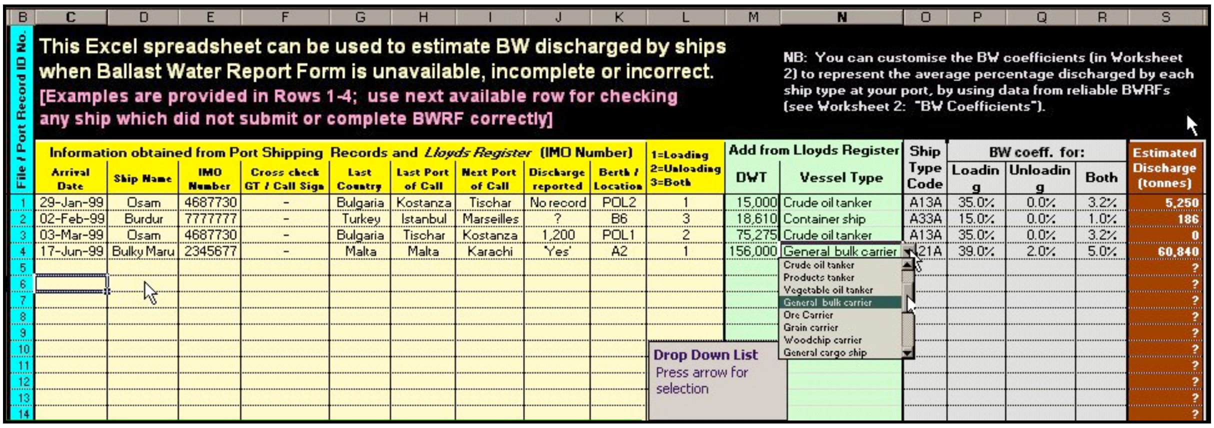

Figure 5. *Working page of the Excel spreadsheet used to estimate BW discharges*

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 Dalian 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 departing ship is discharged, either fully or partly. For example, the next port may be a bunkering, crew-change or maintenance port, a port where a 'top-up' or other minor cargo is loaded, or a convenient regional '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. most container ships, vehicle carriers, Ro-Ro ships, LNG carriers and some 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 bulk carriers, general cargo ships and tankers engaged in spot charter work (or when completing a charter period), these vessels may often depart in ballast having received a general sailing order to proceed towards a strategic location until further instructions.

In the case of the Port of Dalian, there is considerable importation of crude oil, coal, grain and other cargos requiring visiting vessels to uplift ballast water whilst unloading to maintain trim, stability and air draft (i.e. space between the hatch coamings and gantries). The next ports of call were therefore added to the vessel visit data and examined, so that the Pilot Country team could gain experience and appreciate 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 DWT and berthing location 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). This was not insurmountable at Dalian owing to the discreteness of its berthing terminals and usually the existence of a berth record for recorded BWRFs. Another item frequently requiring 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; and
- 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).

Without these items the database cannot save a vessel visit / tank record or any other associated information. Whether or not a saved record is included by the database for the risk analysis depends on which other BWRF fields were completed or gap-filled. Key items are the source port and volume 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 *Lloyds Ship Register* and a comprehensive port directory such as the *Fairplay* guide. However this is very time-consuming and, if there are no convenient 'look-up' features offered by the port's shipping record system, impractical. 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, and to annotate the berth on this form prior to its dispatch to record keepers/database entry (Section 4.10).

The Access database contains reference tables to 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 were very 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 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).

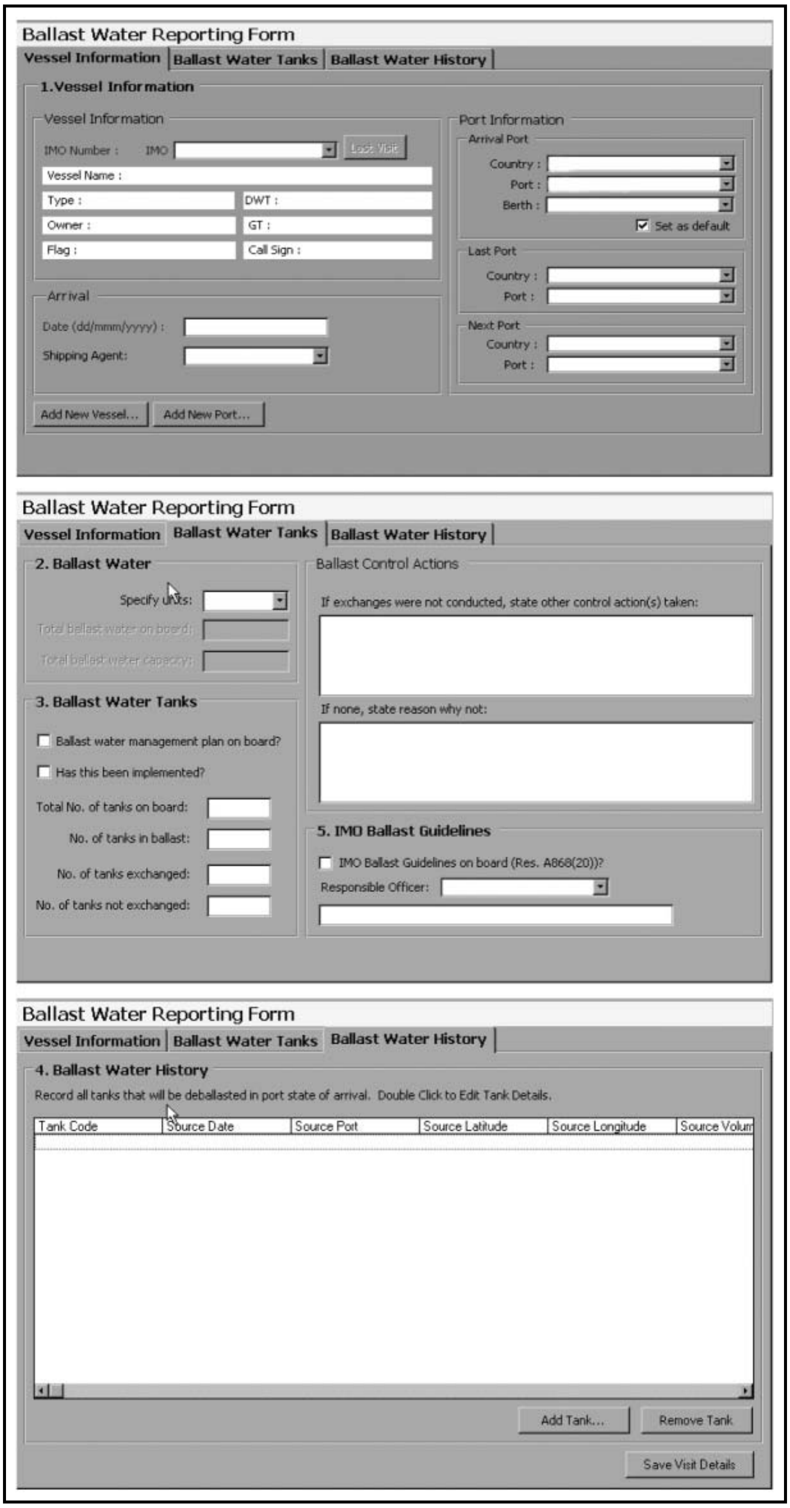

Figure 6. *The three tabs of the GUI used for entering the BWRF data*

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 the Institute of Biology of the Southern Seas (IBSS) in Odessa[7].

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)	"

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

[7] Distance categories from the berthing area/s to the nearest rocky artificial wall, smooth artificial wall and wooden artificial substrate were suggested by IBSS as they provide different types of hard port habitat.

[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.

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 Dalian 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 Dalian's Group C members focussing on important ports in China, and the consultants focussing on more distant ports in Asia, Europe, 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 25% of all ports identified as trading with Dalian, 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 two gap-filling exercises undertaken by the consultants in October 2002 (focussing on Japan and Korean ports) then between 22 December 2002 and 31 January 2003 (focussing on NW European, Mediterranean, African and American ports). These were added to the updated BWRA provided at the third meeting in March 2003 (Section 3.1) and reported here.

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 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 Dalian and its source and destination ports were determined using a multivariate method in the PRIMER package. Of the various distance measures

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

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 they exert 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].

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 the Australian Centre for Research on Introduced Marine Pests (CRIMP). The boundaries of some bioregions were subsequently modified according to advice provided by Group C marine scientists in five of the six the Pilot Countries, including Dalian. The modifications included adding new bioregions for river systems to accommodate important river ports that trade with one or more of the Demonstration Sites. In the case of Dalian, bioregions NWP-3 and NWP-4

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), these were not included owing to the problem of obtaining reliable measures of their spatial extent and temporal nature at each port.

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.

were divided into two and three portions respectively because of community composition differences in the Sea of Japan (NWP-4a) versus the Yellow Sea and Bohai Bay (NWP-3a/4c), and the Pacific coastal waters east of Japan (NWP-3b/4b; Figure 7). The Yangtse system was also added to cater for important river ports (NWP-3a-YR; Figure 7).

The map presently displays 204 discrete bioregions which are coded in similar fashion as those in the IUCN scheme of marine bioregions from which they were derived (Kelleher *et al*. 1995; see Appendix 3 of the GloBallast *BWRA User Guide* for details). Bioregions serve multiple purposes and are required for several reasons. 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 wide range of sources. These included a preliminary list of organisms found by the recent GloBallast PBBS of Dalian (which became available during the second consultants visit). Dalian and URS members of Group C also investigated the possible existence of introduced species lists held by marine biologists in agencies and universities in other parts of China. No sources were found except for the papers published by Morton and other Hong Kong-based marine researchers (Appendix 5).

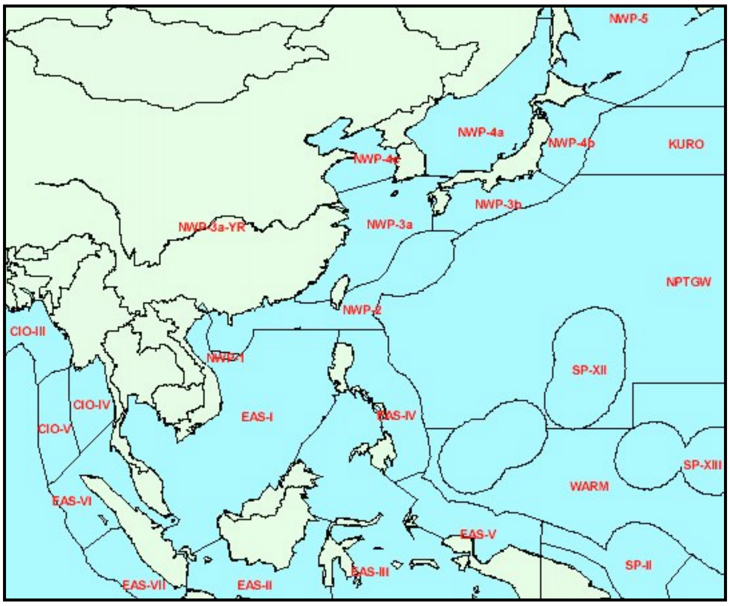

Figure 7. *Part of the GIS world map of marine bioregions, showing the code names of those in the East Asian region*

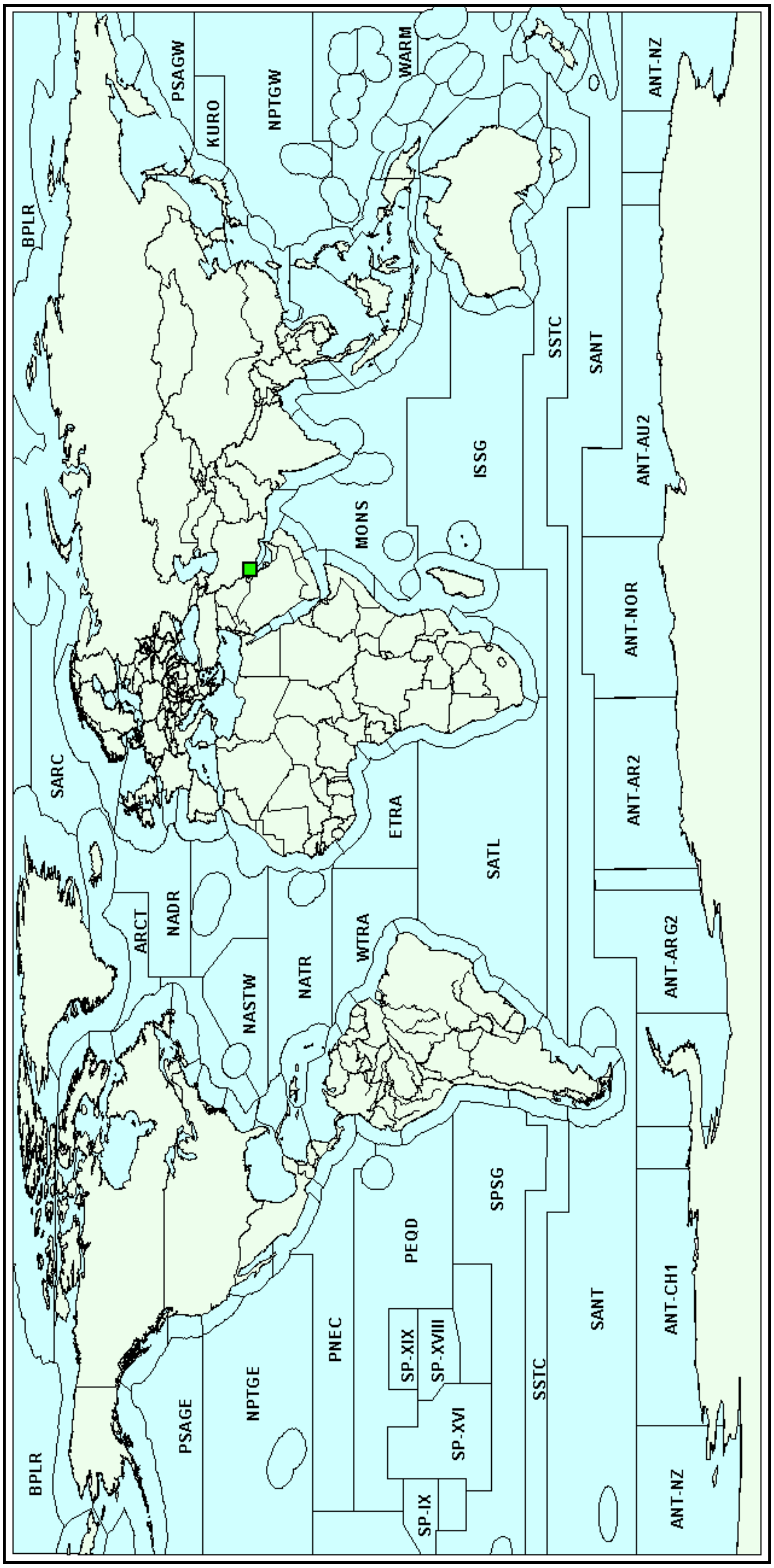

Figure 8. *Complete GIS world map showing the marine bioregions*
[to improve clarity, not all bioregion codes are shown in this example]

Sources used for developing the risk species database are listed in Appendix 5 and included 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 last visit (February 2003) contains 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.

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. A third type of risk species weighting option is also available. This can be used to proportionally increase the weight of all source port threat coefficients by increasing its default value of 1. The four default values (1, 3, 10 and 1) provided a '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

[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 ballast water and/or hull fouling 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 either or both of these shipping-mediated vectors.

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 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 Australia/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.

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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, but the revised database should not be copied for undertaking other port BWRAs.

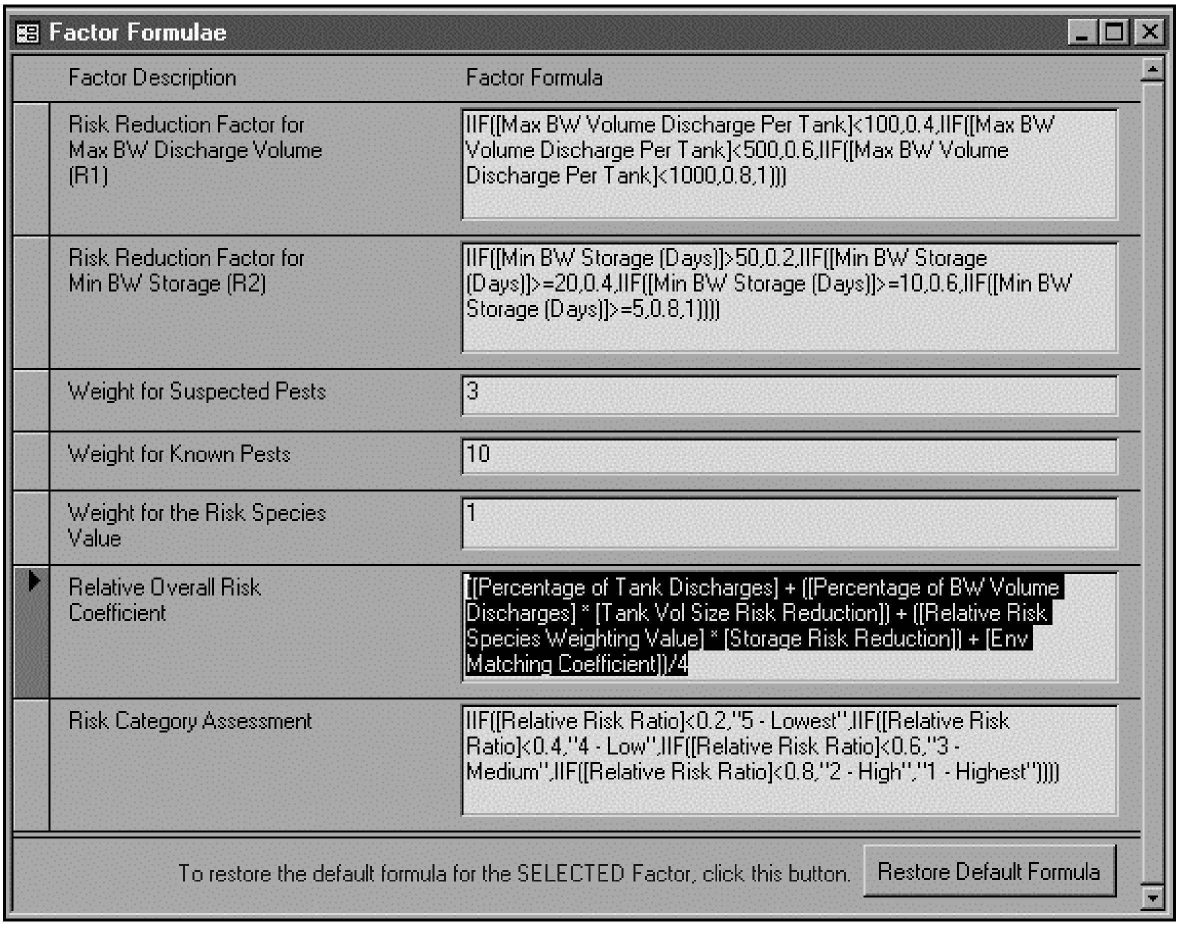

Figure 9. *Database GUI used for manipulating the BWRA calculation and weightings*

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*).

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 has been relatively recent, and the tank exchange did not provide a sufficiently consistent or reliable sample of ballast importation for most sites (Section 3.4);
- BWRF implementation was generally on a voluntary basis, with no formal mechanism compelling all vessels to submit fully completed forms at Dalian;
- insufficient vessel inspection/ tank monitoring data were available for checking claimed exchanges and their locations (often unrecorded);
- discounting whether or not effective 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,

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.

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

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.

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) $\quad ROR = (C1 + [C2 \times R1_{W4}] + [C3 \times C4 \times R2_{W5}]) / 3$

[*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).

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 **ROR**	Proportion of discharge Frequency **C1**	Proportion of discharge Volume **C2**	Environ-mental matching **C3**	Relative Risk species threat **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

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.

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 Dalian 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 April 2002 [5 work days]	Introductory half-day seminar Install and check computer software Commence training and capacity building Port familiarisation tour Begin GIS mapping of port and resources Review BWRFs collected by Liaoning MSA Commence BWRF database development & training Review port environmental data and identify sources Seminar & tutorials on multivariate similarity analysis Identify data collation and input tasks required before 2nd consultants visit	D Blumberg J Polglaze R Hilliard K. Lin	Function rooms in Dalian provided by Liaoning MSA. Group A counterparts Group B counterparts Group C counterparts Translation support
2nd Country Visit September 2002 [12 work 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 J. Zhao	Function rooms in Dalian provided by Liaoning MSA. Group A counterparts Group B counterparts Group C counterparts Translation support
3rd 'Wrap-up' Visit March 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	China MSA offices, Beijing. CFP-A Group A leader Group B leader

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

At the project kick-off meeting in January 2001, CFP/CFPAs were briefed on the nature, objectives and requirements of the activity. An introductory PowerPoint presentation was made describing the BWRA system proposed for achieving the BWRF objectives, and logistics meetings were subsequently held with individual Pilot Countries. 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 (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 improve training, guidance and capacity-building components, the consultants provided a technical English-Mandarin translator with maritime experience for the first and second country visits. 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 of Dalian is located at 38° 56’ N 121° 39’ E on the south side the Liaodong peninsula that separates the east side of the Bohai Sea (Liaodong Bay) from the Yellow Sea (Figures 2,7). Dalian is the main commercial port of north-east China and one of major eastern terminuses of the trans-Siberian railway system. This strategic port was coveted by three nations over the last century because its wide natural harbour remains silt and ice free year-round and provided access to coal. Dalian had a small fishing harbour when Russia took lease of the Liaodong peninsula under a forced agreement in 1898. Named Dalny in 1899, Russia quickly developed the port to provide coal bunkering facilities.

Following the Russo-Japanese war, control of the peninsula shifted to Japan in 1905. Japan continued developing the port which it renamed Dairen during its 1905-1945 occupation of Manchuria. From the 1950s to present Dalian has been further developed and modernised to become one of China’s leading petroleum, steel and ship-building/repair ports. The local economy has also been significantly boosted by Dalian’s popularity as a summer-autumn resort and fresh seafood centre, owing to its picturesque rocky shorelines, sand beaches, fishing and mariculture industries, while some of the city’s older architecture retains Russian and Japanese influences. Dalian also provides regular passenger and ro-ro ferry services to Tian Jin, Longkou, Wei Hai and other ports in the Bohai Sea region, as well as to Inchon near Seoul, handling over 6 million passengers each year.

Climate and weather

The temperate continental climate experienced in the Dalian region is characterised by warm, humid summers with prevailing southerly breezes followed by cold dry winters dominated by strong north and north-westerly winds. Freezing weather lasts from early January to March, although the sea ice which can develop in the bay and last for up to 60 days in certain years is always thin (5-20 mm) and does not hinder navigation. Morning fogs are common from early March to late September, with longer spells occurring mostly in June and July.

Mean day-time temperatures regularly exceed 22°C during high summer (maxima to ~35°C), while night-time temperatures often fall below -2°C in winter (minima to -15°C). Annual rainfall is relatively low with most occurring from spring to autumn. A wind rose showing the strength and alternation of the summer southerly breezes and winter northerlies of the region is shown in Figure 10.

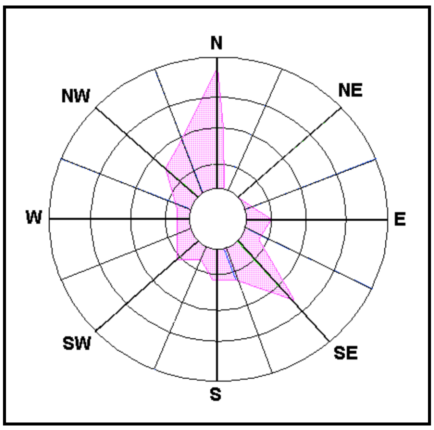

Figure 10. *Annual wind rose typical of the Dalian Bay region*

Hydrodynamic conditions

The average range of the semi-diurnal tidal regime at Dalian is 2.1 m. Tidal currents >2 knots develop around the various headlands of Dalian Bay during strong spring tides (3.9 m average; 4.6 m maximum), declining to ~1 knot during neaps (average 2.6 m; minimum 0.7 m). Flows in the fairway and shipping channels are weaker (0.5-1 knots). The direction of tidal flows in and near Dalian Bay are generally to the west and south-west during flood tides and to the east during ebb tides. Figure 11 shows a map with surface-water movement plots for Dalian Bay obtained from Dalian Maritime University.

The water currents shown in Figure 11 indicate that BW discharged at the terminals in Dalian Bay is dispersed towards and around the south-west corner of the bay (Huangbaizui Point) during flood tides and eastward along shorelines during ebb tides. Even in neaps, the tidal regime is sufficiently strong to shift and disperse BW plumes and any associated organisms to one or more of the various mariculture areas in or near Dalian Bay within two tidal cycles (Section 4.2).

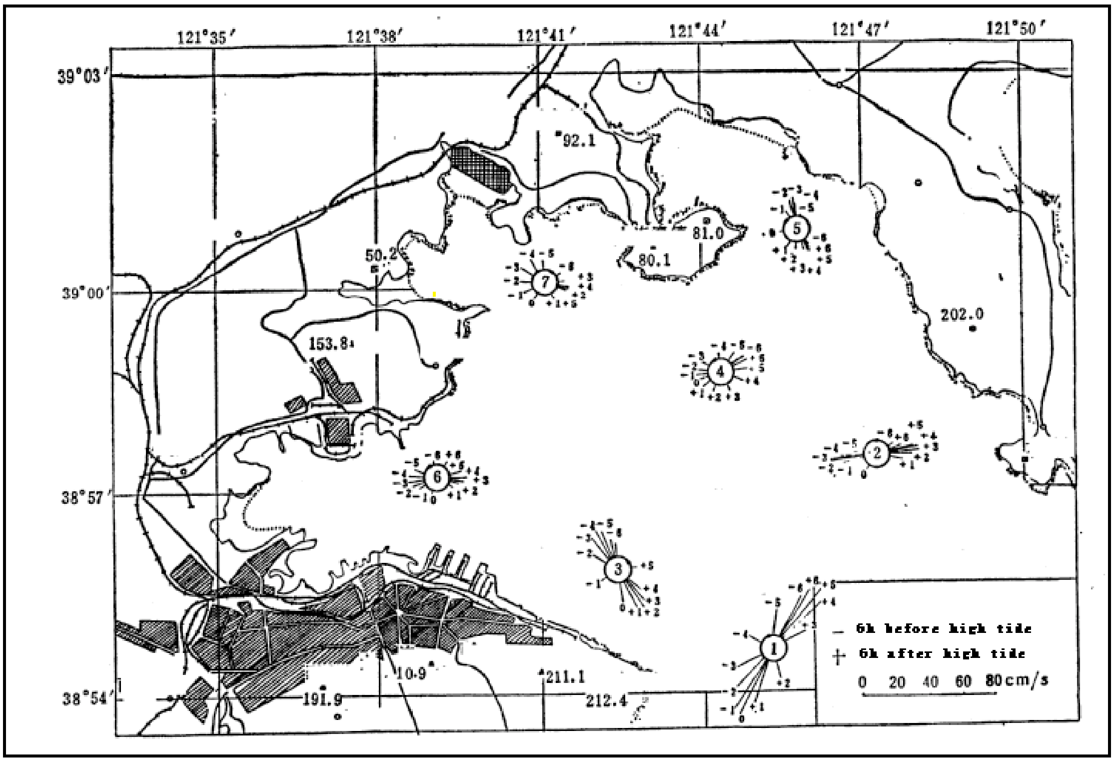

Figure 11. *Surface-water current plots in Dalian Bay*

Port facilities and maintenance

From its original town-site and coal bunkering/supply wharfs opened in 1899, Dalian has undergone a series of extensions and modernisations throughout its 104 year history to become north-east China's foremost trading port, with a diverse cargo throughput reaching almost 100 million tonnes in 2002. About 2,000 ships arrive at Dalian each year, plus a similar number of small coastal traders, fishing vessels and service vessel movements.

During the first half of the twentieth century the port was extended eastward along the south side of Dalian Bay, with the large Dagang harbour formed by installation of detached breakwaters plus dredging and backfill to develop its four piers and warehouse areas. This harbour remains protected by 7 km of rocky breakwater along its western, northern and eastern sides (Figure 12a). Other terminals were provided at Xianglujiao and Ganjingzi to service steel-making, ship building and other industries, followed by the Siergou terminal for fuel oils and liquid chemicals. The Heshangdao

(Dalianwan) terminal was developed on the north side of Dalian Bay in the l960s-70s. To achieve the navigation depths which are now in the 6-14.5 m range, all of these terminals have had their berths and approach channels dredged (Figure 12a).

While continuous or regularly-repeated maintenance dredging has not been required owing to the lack of significant riverine silt inputs, the depth requirements of crude oil tankers and the steep rise in freight containerisation during the 1980s led to the development of new terminals which take advantage of naturally deeper waters near the Dagushan peninsula on the east side of Dalian Bay. The port presently contains 72 berths distributed among nine terminals, three of which are located on Dagushan Peninsula on the east side of Dalian Bay. The latter include the busy Dayaowan container and multi-use terminal which continues to be expanded in Dayao Bay via dredging and backfill (c.f. Figures 12b, 13).

Dalian was the focal point of China's overseas crude oil exports from its Bohai Sea oil fields until 1999, when this trade ceased as a result of declining outputs plus the rapid 1990s rise in domestic consumption. Since then the main components of the port's trade have remained liquid bulk cargos (i.e. continuing crude oil imports plus petroleum product and chemical exports), dry bulk cargos (coal, mineral ores, grain, fertilizers, woodchips, cement), general and break-bulk cargos (steel, pig iron, timber, machinery, packaged goods, LPG), plus containers (now ~1 million TEU per annum), vehicles and other ro-ro freight. Eight berths in the Dagan harbour also service the passenger/ro-ro ferries. Much of the coal is imported from nearby Qinhuangdao on the north coast of the Bohai Sea (Figure 2). Dalian is also an important grain port, exporting some 60% of the national corn export which is railed from the three north-east China provinces and Inner Mongolia. Imports of wheat and other cereals also take place, but not as regularly during 2000-2002 as in previous years.

After entering Dalian Bay from the south via the Dasanshan fairway, ships follow well-marked shipping channels past the main anchorages to either the new, deeper water terminals on the Dagushan Peninsula or into the approach channels, swing basins and berthing areas of the older terminals closer to the city. The nine separately managed terminal areas in the Port of Dalian are shown in Figure 12, and are described clockwise from the Siergou terminal (on the south-east side of Dalian Bay) as follows:

- **Siergou**: This refined products and chemicals export terminal is located east of Dagang harbour on the south side of Dalian Bay, and has four 9.1-9.4 m deep berths (total length 1,363 m) which handle product/chemical tankers up to 50,000 DWT. Two smaller berths handle vessels up to 3,000 DWT which are used for bunkering services. The busy Siergou terminal is a significant BW discharge site.
- **Dagang**: This large general cargo and multi-use terminal is located close to the city on the south shore of Dalian Bay and has two districts (East and West). There are a total of 30 berths beside three quays and four wide piers providing a total frontage of 3,185 m. Four of the berths handle vessels up to 25,000 DWT, eleven to 10,000 DWT, one to 7,000 DWT, seven to 5,000 DWT, and seven to 3,000 DWT. While No. 18 berth can service liquid chemical tankers, the Dagang terminal accommodates mostly general cargo ships, small bulk carriers, reefers and various passenger/ro-ro vessels, with steel products, mineral ores, grain, soya beans, coal, break-bulk/palleted goods, containers and ro-ro freight forming the principal cargos. The majority of arrivals discharge relatively little or no BW at Dagang as its trade comprises bulk imports plus an import-export mix of general, break-bulk and palleted cargos, containers, ro-ro freight and passengers. Few BWRFs were targeted from this terminal.
- **Heizuizi**: This general cargo terminal has six relatively shallow berths providing a wharf frontage of 2,880 m which services small coastal traders in the 750-2,500 DWT range (the majority engaged on domestic voyages in the Bohai and north Yellow seas). A few BWRFs targeted by MSA indicate its arrivals occasionally discharge minor BW quantities (100-400 tonnes) uplifted from regional ports as far south as Ningbo in the southern Yellow Sea near Shanghai and eastward across Korea Bay to Inchon (Figure 2).

- **Xianglujiao**: This terminal has two piers with eight berths totalling 2,382 m in length and 6.6-9.2 m depths for accommodating ships in the 3,000-50,000 DWT range. This terminal exports mainly timber and steel products and other general cargo. The adjacent shipyards provide maintenance, repair and fit-out services, including three dry docks capable of handling vessels up to 600 DWT (length 44 m, width 14 m), 3000 DWT (length 135 m, width 16 m; depth 8.3m) and >200,000 DWT (length 365 m, width 82 m, depth 12.7 m).
- **Ganjingzi**: This terminal area contains a coal and coke import jetty equipped with four coal unloaders and two berths 200 m long, 9.5 m deep, plus a small terminal for LPG and liquid chemical exports. Since much of the coal is reported to come from Qinhuangdao in the Bohai Sea, this port may be a regular destination of BW uplifted by the colliers when alongside the Ganjingzi jetty.
- **Heshangdao (Dalianwan)**: This terminal area has a total wharf frontage of 1,500 m and six berths, the largest of which can handle colliers and general cargo vessels up to 30,000 DWT (the berths are 200-235 m long and 9.7-11.5 m deep). The main trade is coal imports (3 berths at Heshangdao plus 1at Dalianwan), plus grain and general cargo, including hazardous goods at the Heshangdao berths.
- **Beiliang**: This grain export/import terminal is located on the west side of the Dagushan Peninsula (east side of Dalian Bay), and provides two deepwater berths for handling bulk carriers to 100,000 DWT. The BWRFs added to the database from this terminal indicate few exports in 2000-2002.
- **Xingang**: This oil terminal area has three piers. The long southern pier is operated by the Dalian Xin Gang Port Company and has two berths. No. 1 is 423 m long and 17.5 m deep and can service tankers up to 120,000 DWT for crude oil export or import. No. 2 is 423 m long, 14.5 m deep and can accommodate tankers up to 50,000 DWT for crude or refined product exports. To the north there are two shorter piers at Nianyuwan operated by the New Product Oil Atlantic Co., each with a single berth for export of petroleum and chemical products. The outer berth is 346 m long and 13.5 m deep and handles tankers up to 50,000 DWT. The inner 180 m berth handles small product and chemical tankers to 10,000 DWT.
- **Dayaowan**: This new multi-purpose terminal is located north-west of Xingang at the entrance to Dayao Bay (Figure 12b), and includes two piers and silos servicing two 250 m long and 12.0 m deep multi-use berths, plus a dedicated grain import berth. The latter unloads grain from carriers up to 80,000 DWT, while the former have ship loaders for exporting corn in carriers up to 50,000 DWT. Nearby, the long wharf of the Dayaowan container terminal has five multi-use berths providing depths up to 13.5 m. These are serviced by nine gantries and backed by a 400,000 m^2 hardstand area for handling containers, vehicles and other ro-ro cargo. The busy Dayaowan terminal has maintained Dalian's status as China's leading north-east port, and it was by far the largest source of BWRFs as the majority of non-tanker international arrivals visit this terminal, particularly from Korea and Japan.

Most of the port's tugs, line boats, pilot launches and other workboats are serviced in Dagang harbour, with similar small vessel facilities at the Dalianwan and Dayaowan terminals. The Siergou oil terminal provides the port's bunkering and refuelling services, while Dalian's main commercial fish reception and market facilities are located east of the Heizuzui terminal.

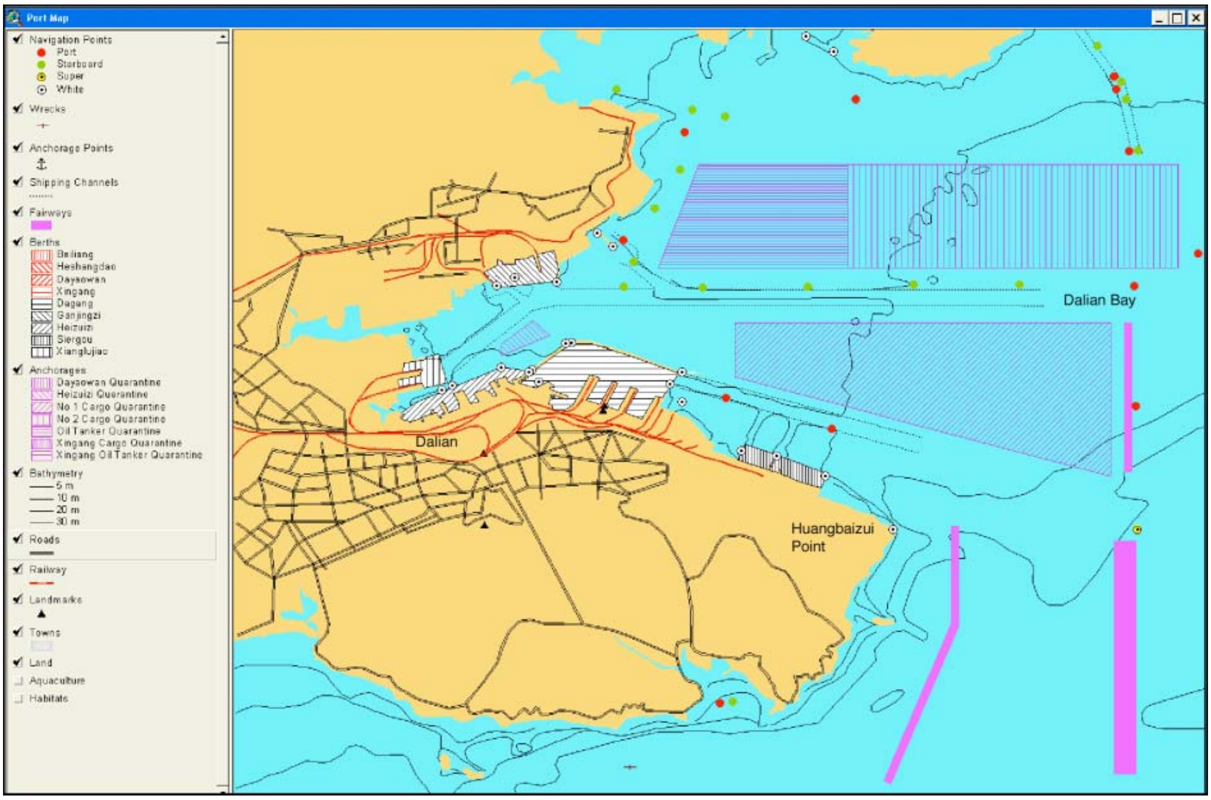

Figure 12a. *Part of the GIS Port Map showing the navigation, infrastructure and active berth layers on the west side of Dalian Bay*

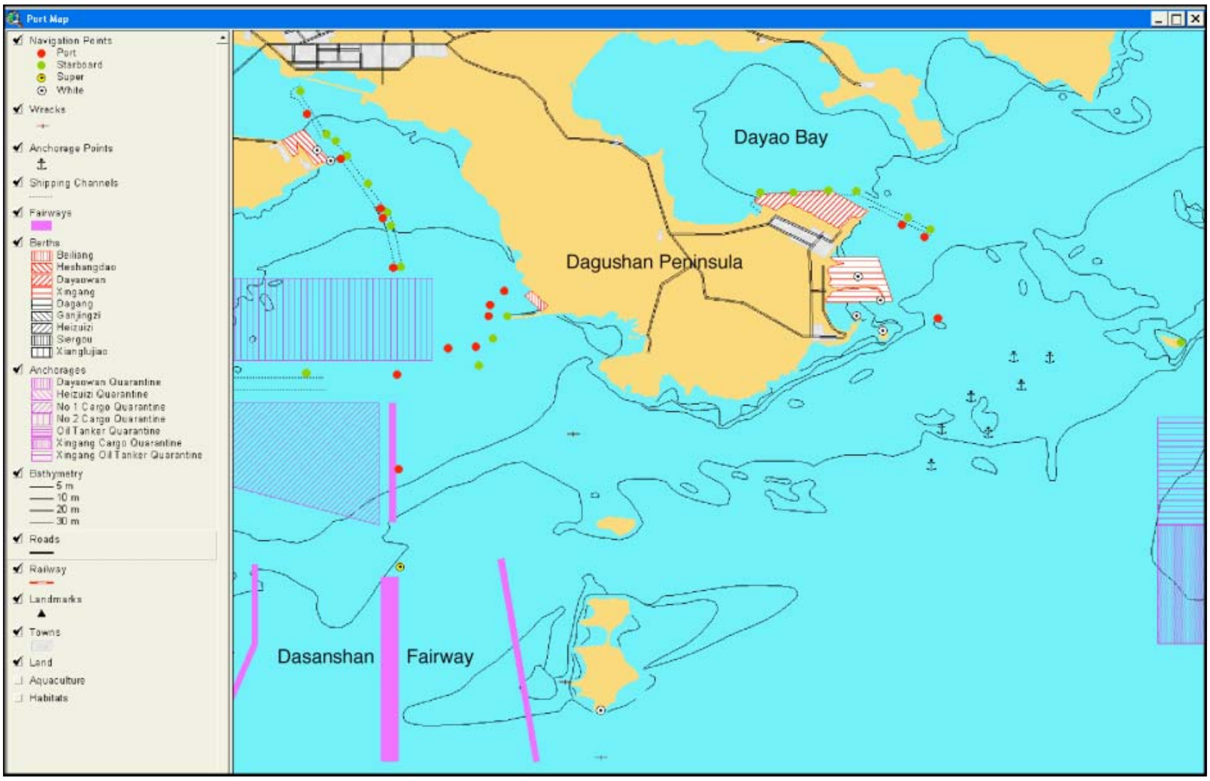

Figure 12b. *Part of the GIS Port Map showing the navigation, infrastructure and active berth layers on the east side of Dalian Bay*

4.2 Resource mapping

The subtidal seafloor habitats in Dalian Bay are dominated by soft silty sediment sheets overlying rocky substrate, the latter outcropping in many places around islands, points and reefs, as shown on the GIS Port Map (Figure 13). Seagrasses (*Zostera marinus*, *Triglochin maritimum, Phyllospadix* spp.*)* occur in patches along the shallow subtidal-lower intertidal shores and embayments in and beyond Dalian Bay, but no information could be found to delineate where these were best developed and mappable.

There are no longer any high tide salt marshes which open naturally to Dalian Bay owing to the progressive port, industrial and urban developments of the previous century. The intertidal habitats delineated by Group C and added by Group A to the GIS Port Map (Figure 13) therefore comprised:

- Artificial rocky walls along breakwaters and reclaimed shorelines;
- Smooth artificial walls inside terminals;
- Natural rocky shores;
- Sand beaches and stoney beaches;
- Partial and completed land reclamations;
- Various salt field, coal ash and land fill/waste disposal areas.

There are many local mariculture enterprises near Dalian which focus on edible algae, mussels, oysters, scallops and fish farming, and these are also delineated on the GIS port map (Figure 13). There are no gazetted marine nature reserves or wildlife breeding areas in the area. Two wreck-sites were added to the map although these have no particular historical significance, and no points of locally significant marine or cultural heritage value were identified within the area of the port map. The map does depict the main urban features and landmarks near the port, including the TV/communications tower, city railway station and Dagang passenger terminal, plus the main road and railway systems (Figure 12).

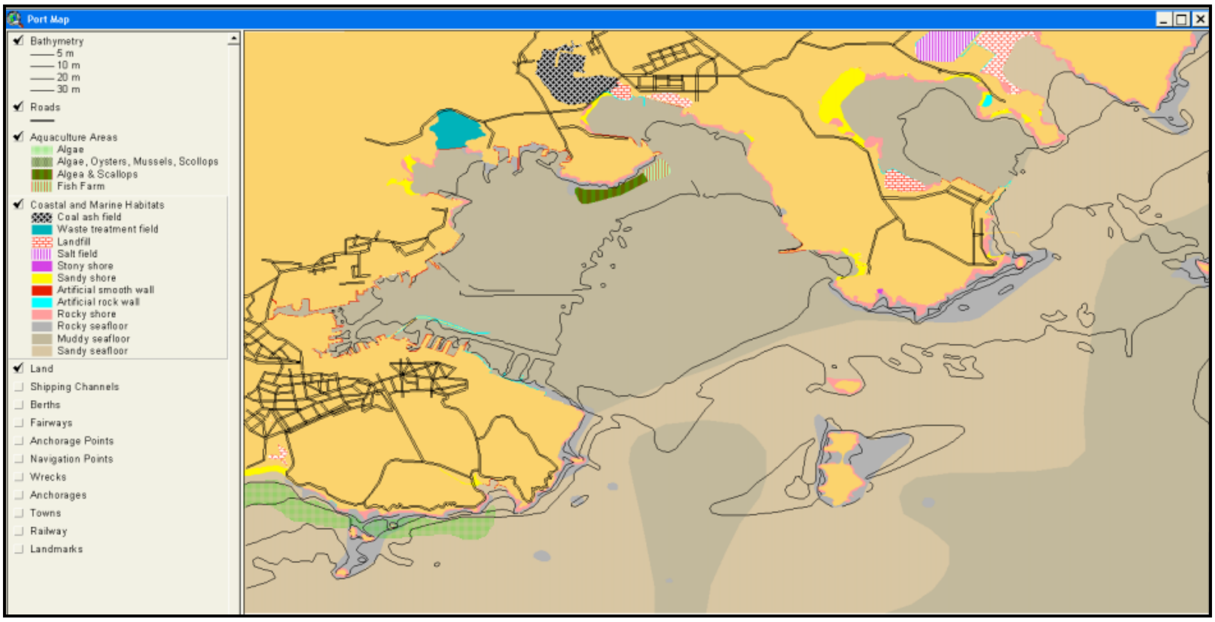

Figure 13. *GIS Port Map showing the marine habitat and mariculture layers*

4.3 De-ballasting/ballasting patterns

The navigational rules and deballasting/ballasting practises of arriving vessels were discussed during the first port tour in April 2002 (Section 3.3). Pilotage is compulsory for foreign flagged ships and is recommended for various domestic vessels, with boardings typically occurring where the fairway meets the anchorages (Figure 12a). As in other ports, the port and pilotage rules require all empty ships to retain sufficient ballast on board to maintain adequate propulsion, steerage control and forward visibility, and to minimise windage, until berthing is completed. Windage at Dalian can be significant in the winter months due to the strong northerly winds, and is least in June-July. BW discharges in port waters require permission from the local MSA office.

Because the MSA had targeted international vessels plus domestic tankers and bulk carriers arriving in ballast, the BWRF database entries mirrored local expectations as to which terminals were significant BW discharge sites[18]. It was also possible to identify which of the terminals were significant BW uptake sites because of their dedicated cargo importing infrastructure (i.e. the various grain and coal import berths, plus occasionally the southern jetty at Xingang for oil imports since 2001).

However it was not possible from the BWRFs or database to determine which of the ships that had uplifted BW when discharging grain, coal or other bulk cargo, subsequently moved to another berth (either directly or after a short lay-off at one of the anchorages) to load cargo and thus discharge this water before departing Dalian Bay. While this was unlikely for the coal carriers (because of their need to tank-wash if switching cargos), it probably occurred for some of the grain carriers and product/chemical tankers.

In the case of the various multi-use berths at Dagang, Heshangdao (Dalianwan) and Dayaowan, the Dayaowan component of the database indicated that 20% of the container ships and 12% of the general cargo ships were arriving at these berths with less than 50% of their total ballast capacity (Appendix 7), and therefore were probably unloading cargo before any loading. While there was no easy way of determining how frequent and large were any associated BW uplifts, the tank records of the Dayaowan BWRFs showed a high incidence of zero discharges (86%), with recorded BW discharges totalling 181,147 tonnes (166,132 tonnes from identified sources). This fits with the part ballasted condition of most arrivals and the part-unloading/loading nature of the container liner trade (Appendix 7).

In summary, even when vessels submit reasonably complete IMO-style BWRFs, these forms do not permit a port to identify the frequency, volume or ultimate destination of uplifted BW, particularly for any arrival at a general cargo, container or ro-ro terminal which:

- unloads all or a large part of its cargo (= at least some initial BW uptake to maintain trim, stability or air draft beneath gantries); or
- retains all or most cargo on board (=none or little BW uptake required); before
- departing with little additional cargo (= uplifted BW kept); or

[18] The large number of IMO-style BWRFs collected in 2000-2002 and entered into the Dalian database (3,278) by MSA made it unique among the Pilot Country Demonstration Sites by containing BW source and discharge values obtained solely from these forms (i.e. no visit data were drawn from shipping records). Following error checks and gap-filling, the majority of the 2185 BWRFs entered for the busy Dayaowan terminal contained sufficient information to offer a useful insight of the ballasting/deballasting patterns of a modern multi-purpose terminal where ships were being turned around within lengths of stay averaging 2.3 days. This part of the database was therefore used to investigate total BW capacities, ballasted conditions and discharges of the four main ship types using this terminal (i.e. container and general cargo ships, bulk carriers and vehicles carriers; see Appendix 7).

- loading cargo before departing (= possible discharge of the same or different BW, depending on cargo/trim needs, tank layout and ability to make internal tank transfers [many container ships]).

Dalian has large anchorages (Figure 12) but the BWRFs provided no indication of any BW discharges in these areas. Liaoning MSA and DPA staff noted that none of the anchorages have been significant discharge sites in recent years for several reasons, including:

- there is no longer any tanker queuing following the halt in crude oil exports from Dalian in 1999;
- bulk carriers arriving to load grain or other cargos have been proceeding directly to berths at the various new and old terminals because these were not being used to full capacity during 2000-2002;
- cargo transhipments within the anchorages are uncommon (there are no local river ports and associated barge traffic); and
- the various general cargo ships, bulk carriers, tankers and other vessels which do anchor are usually waiting for new cargos/sailing orders having discharged their cargo.

While the anchorages were being used mostly for vessel lay-offs, the ship repair yards at Xianglujiao were identified as a potentially significant site of discharged BW. This site was therefore provided with a summary table of BW discharge data, as estimated from dry-docking statistics obtained by the MSA (no BWRFs were collected from the yards and dry dock discharges are not archived by the yard companies).

The following statistics were extracted from the Dalian database of 3,278 visit records for the nine terminal areas, which are ranked below in terms of BW discharge importance:

- **Xingang**: Of the 191 BWRFs entered from this oil terminal, 181 provided 184 tank discharge records amounting to a total discharge volume of 794,278 tonnes (Figure 14). The discharges were reported by 19 chemical/oil product tankers, 19 gas tankers, 31 crude oil tankers and 118 product tankers (including the largest ship in the database, the 133,966 DWT oil products tanker *Nikolaos*).
- **Siergou**: For the 695 BWRF visit records entered from this liquid products terminal, most were from China Flag product tankers in the 900-30,000 DWT range. The number of BW discharges from identified sources was 598 and totalled 483,022 tonnes (Figure 15).
- **Dayaowan**: The 2185 BWRFs entered from this multi-use but predominantly container terminal, showed a very high level of liner trade, with the majority of arrivals being dedicated container ships in the 2,000-65,000 DWT range plus 2,000-16,000 DWT general cargo ships also handling containers (Appendix 7). Dry bulk carriers in the 20,000-70,000 DWT range made 47 visits, most to the Dayaowan grain berths including the 73,000 DWT *Hua Shan Hai* (the largest bulk carrier visiting Dalian in 2000-2002). Vehicle carriers in the 3,000-18,000 DWT range made 30 visits. The total number of BW discharges from identified source ports was 598 and totalled 166,332 tonnes (Figure 16).
- **Ganjingzi**: Of the 56 BWRFs entered from this terminal, 13 were from colliers importing coal and 39 from product and chemical tankers visiting the neighbouring liquid bulk berths. BWRFs from four gas tankers were also included. Total BW discharged was 132,676 tonnes (Figure 17).
- **Beiliang**: BWRFs were collected from 10 bulk carriers and five general cargo ships arriving at this terminal to load grain, with intended discharges from recorded sources totalling 99,187 tonnes.
- **Xianglujiao**: Of the 45 BWRFs entered from this terminal, these came from 10 bulk carriers, 29 general cargo ships, three ro-ro vessels and a container ship. Of the tank records with

identified sources, total BW volume discharged was 48,269 tonnes from Chinese, Korean and Japanese ports.

- **Dagang**: Of the 15 BWRF visit records entered by MSA for this terminal, two were collected from bulk carriers, two from container ships, ten from general cargo ships and one from a reefer. Of the 19 tank discharges with identified sources, total BW volume discharged was 20,135 tonnes.
- **Heizuizi**: Three BWRFs are present for this terminal, one from a small bulk carrier (4,143 DWT) and two from small coaster traders. BW discharges from these three vessels amounted to 1,273 tonnes.
- **Heshangdao (Dalianwan)**: Three BWRFs were entered for this terminal, one from a 65,000 DWT bulk carrier and two from 4,650 DWT general cargo ships. Only one the latter reported a BW discharge (544 tonnes from Haimen in the Zhejiang Province).

Connection of the active berth layer of the GIS Port Map to the database allows tables summarising the BW discharge statistics to be displayed for each terminal. Examples of the tables displayed by this map are shown for the Xingang, Siergou, Dayaowan and Ganjingzi terminals in Figures 14-17 respectively.

Finally, it is worth noting that when all of the tanks planned for discharge contain the same source water, ships' officers often submit a BWRF showing a single total discharge volume in place of individual tank values. While this is an understandable and convenient time-saving measure for both the ship and data-entry officers, such values reduce the precision of the BWRA calculations. This is because the database needs to treat individual tank discharges as discrete, fundamental units to ensure all BW sources identified on a completed IMO-style BWRF (Appendix 1) can be managed and analysed separately. Thus a large total value representing the combined discharge from an 'all tanks' discharge from the same source must also be treated as a single entity (there is no way of knowing how many and what sizes were the individual tank discharges unless these had been added to the BWRF).

Combined discharge values not only fail to reflect the actual numbers and sizes of tank discharges made at the port but also inflate the database's mean and maximum 'tank' discharge volumes, often to values approaching the total BW capacity of the largest arriving vessels; Figures 14-17). They also cause more conservative but less precise BWRA outcomes because of their negative influence on the R1 risk-reduction factors (Section 3.10), and may introduce inadvertent bias if ships submitting 'all tank' values are not evenly distributed among the receiving port's trading routes and vessel types. While such bias did not arise from the many 'all tank' values in the Dalian database, it is worth noting that a database containing individual ballast tank data from, say, a 12 month set of carefully completed BWRFs, will generate more precise C1, C2 and R1 components for each source port than a two or three year database containing a high number of 'lump-sum' total discharge values (BWRF inconvenience and reliability issues are addressed further in Sections 4.9, 4.10 and 5).

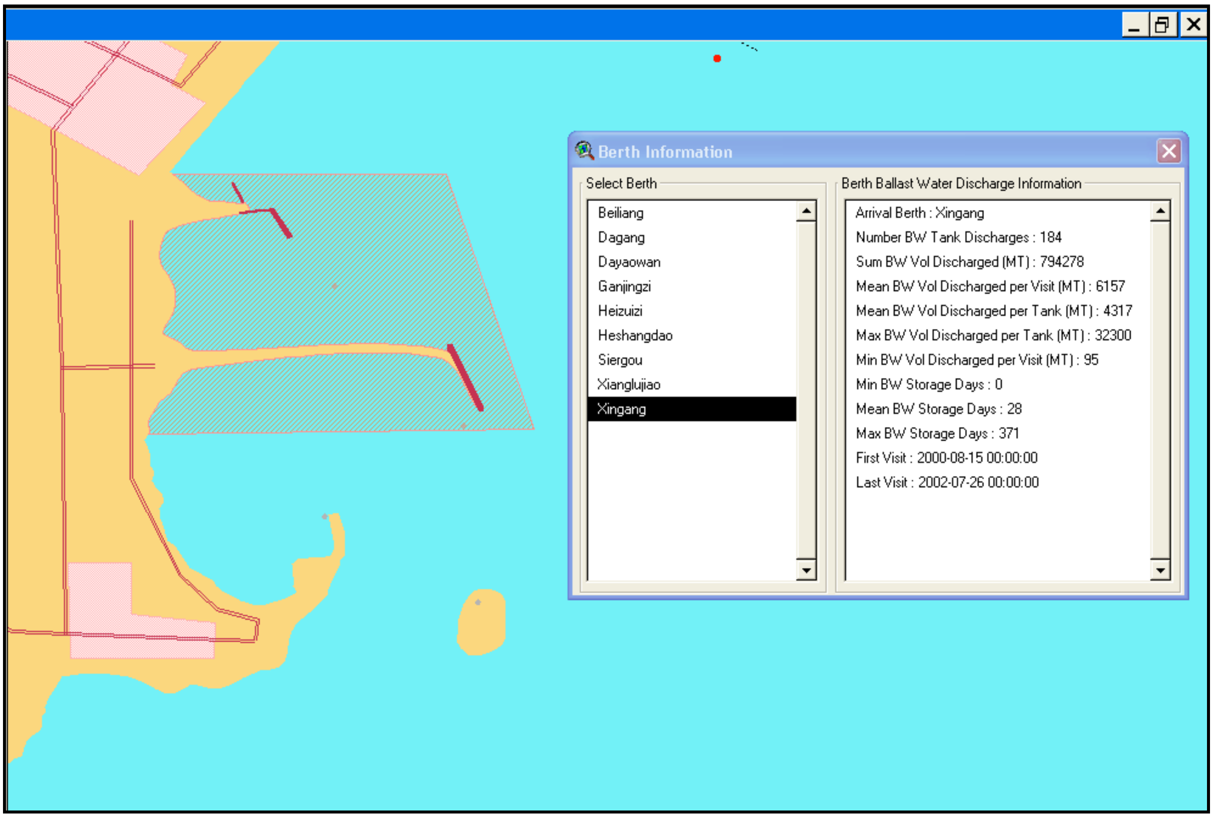

Figure 14. *BW discharge statistics displayed by GIS Port Map for the Xingang oil terminal*

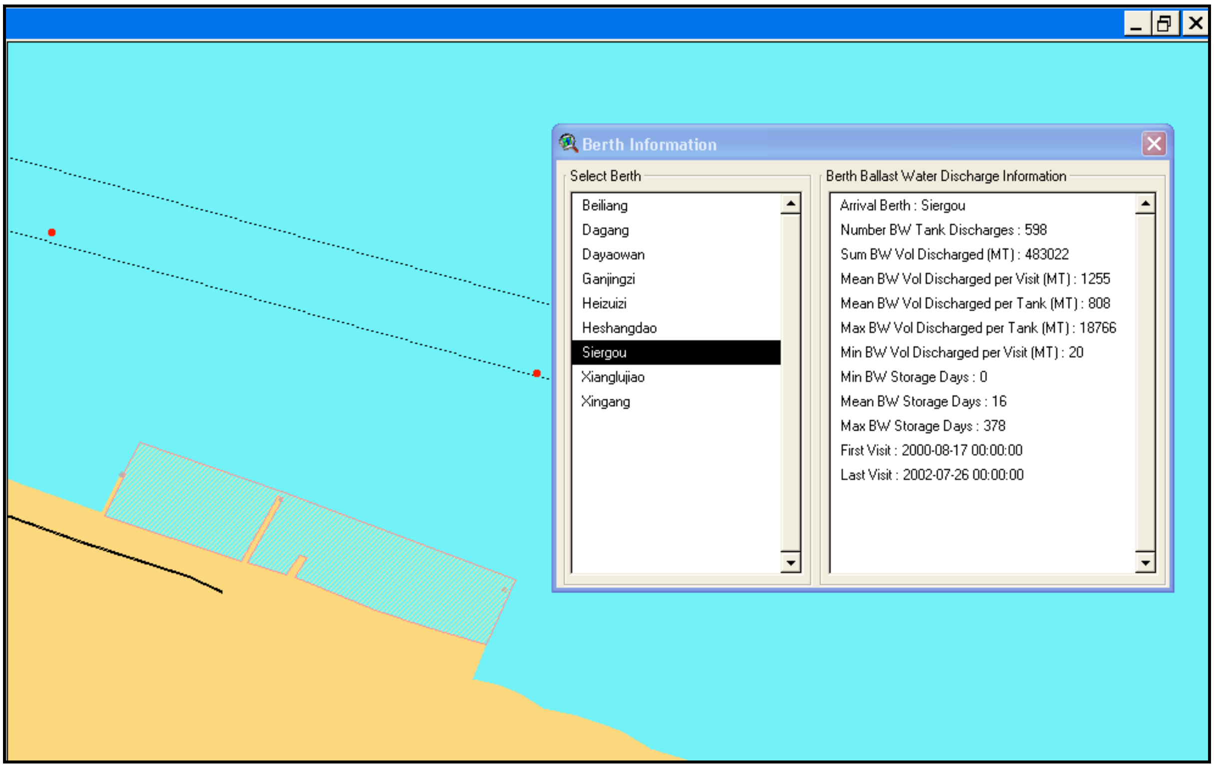

Figure 15. *BW discharge statistics displayed by GIS Port Map for the Siergou terminal*

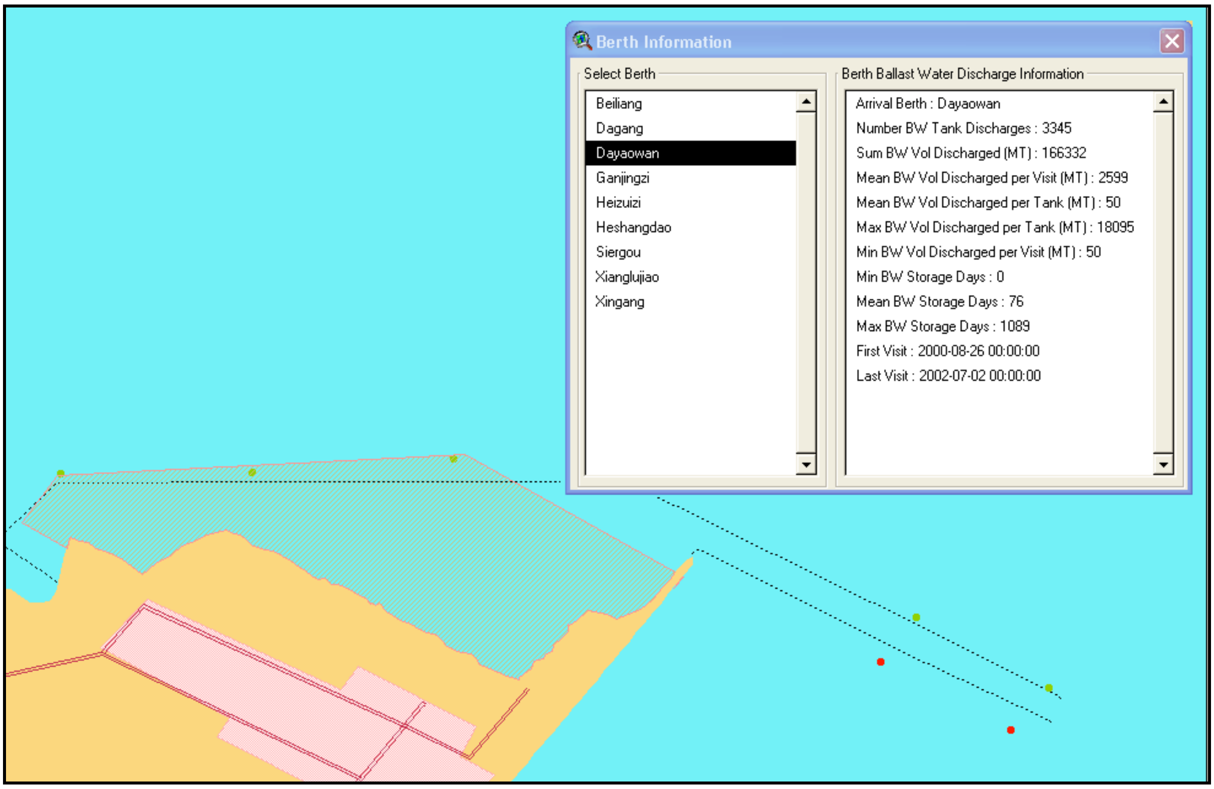

Figure 16. *BW discharge statistics displayed by GIS Port Map for the Dayaowan terminal*

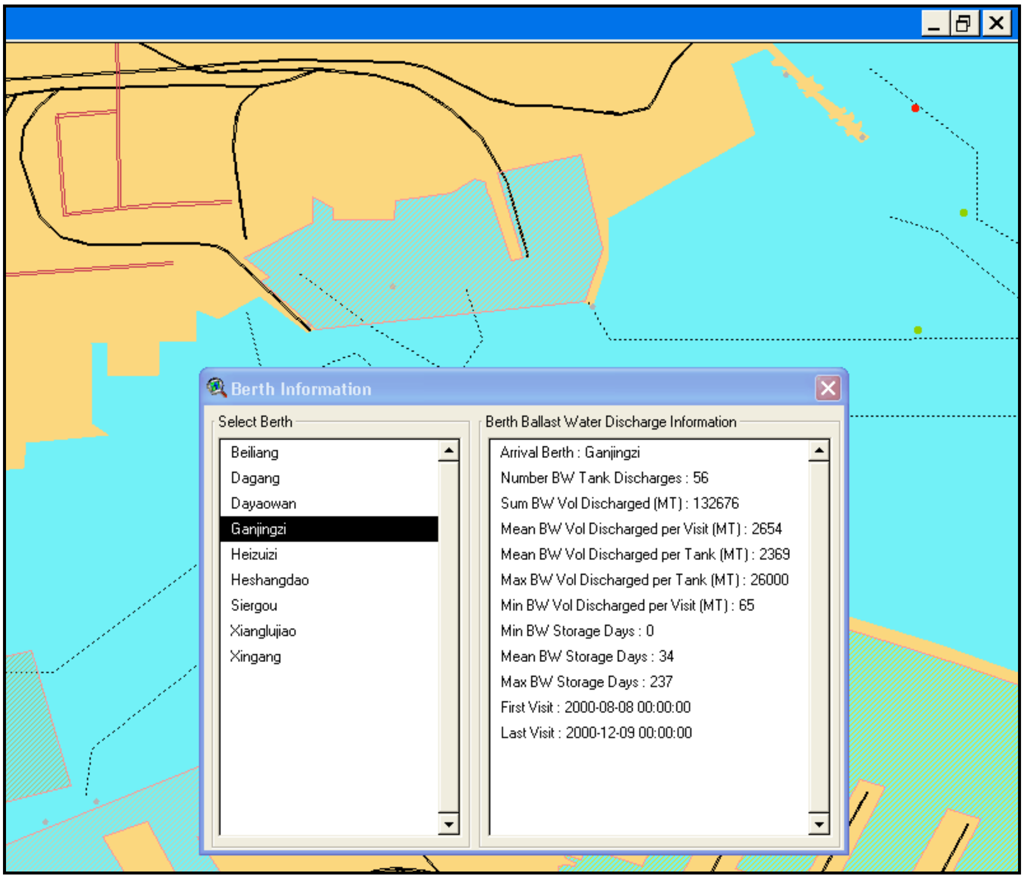

Figure 17. *BW discharge statistics displayed by GIS Port Map for the Ganjingzi terminal*

4.4 Identification of source ports

From the 3278 BWRFs and their 4319 associated ballast tank records in the Dalian database, the percentage of records showing zero discharge at Dalian was high (82.4%). Of the 759 tank records showing a discharge, 652 listed a total of 77 identifiable source ports. These are ranked in Table 3 according to their proportional contribution to the total number of identified discharges, and these provide the C1 (BW discharge frequency) coefficients used to calculate the relative overall risk (Section 3.10). Outputs from the GIS world bioregion map which show the location and relative importance of these source ports with respect to C1 are in Figure 18. As with all GIS outputs, the map is 'zoomable' to allow all ports and symbols to be clearly delineated at smaller scales (Figure 18). As shown in Table 3, the source port 'supplying' the highest frequency of identified BW discharges to Dalian in 2000-2002 was Shanghai (10.6%). This was followed by Qingdao (one of Dalian's regional ports; 7.4%), then Guangzhu (a major estuary port on the Pearl River in southern China; 6.6%), Ningbo (north of Shanghai; 5.5%) and another regional port (Yantai; 5.5%)(Table 3; see also Figure 2 for port locations).

Of the 77 identified source ports, the top 9 (11.7%) provided >50% of all source-identified discharges at Dalian, while the next 9 ports contributed a further 25%, i.e. only 18 of the source ports (23.4%) accounted for 75% of the total number of source-identified discharges (Table 3). As noted earlier, the low number of tank records (4319) compared to the visits (3278) was due to the large number of single value, 'all tank' entries in the database.

The total volume of source identified BW discharged was 1,632,020 tonnes, with a further 159,219 tonnes (8.8%) discharged from unrecorded sources. The discharge volume percentages listed for each source port in Table 3 and depicted in Figure 19 provided the C2 values used in the risk calculation (Section 3.10).

Source port rankings for C2 (BW discharge volumes) were not the same as that for C1 (discharge frequency; as ranked in Table 3). The source ports providing the largest recorded volume of BW discharged at Dalian were Zhuhai (8.9%) and Chiwan (8.3%; both in the southern Guangdong Province), followed by Korea's capital port of Inchon (7.5%), then Shanghai (7.2%). These were followed by three more Guangdong ports, i.e. Shekou (6.6%), Huangpu (5.6%) and Guangzhou (5.3%). Thus five of China's southern province ports were in the top seven that provided >50% of the total source-identified volume. Nagoya was the top Japanese port (ranked 9th with 2.6% of the total source-identified volume), while Sakai (ranked 12th at 2.5%) and five other Japanese ports were in the top 20 ports. Only 15 source ports (19.5%) provided >75% of the total source-identified discharge volume. Of the top 20 ports for C2, ten were in China (including Hong Kong), seven were in Japan and three in Korea, and these accounted for 83.6% of the total.

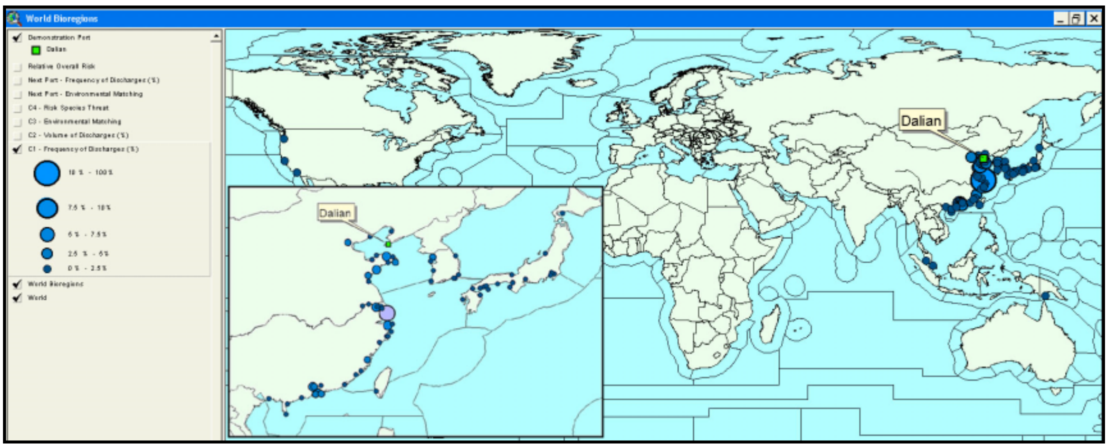

Figure 18. *GIS outputs showing the location and relative importance of BW source ports with respect to the frequency of tank discharges (C1) at the Port of Dalian.*

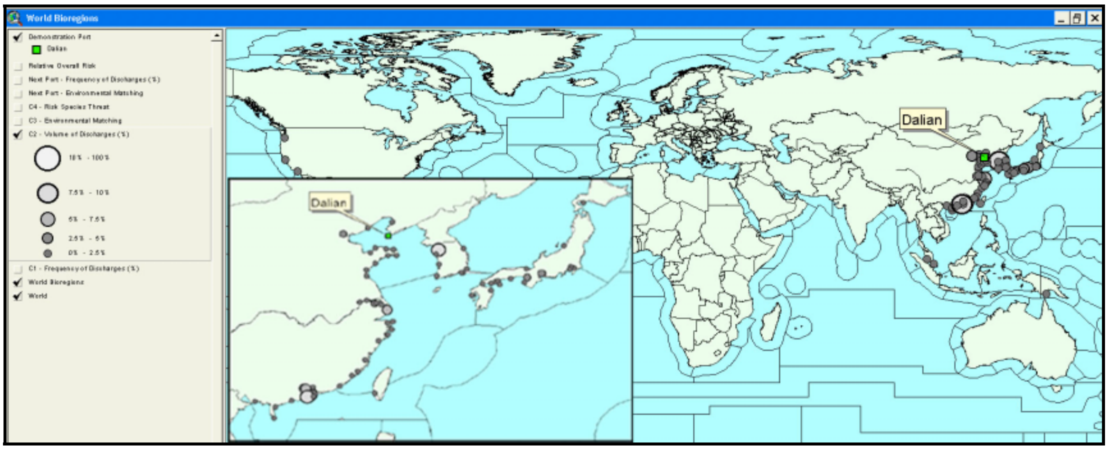

Figure 19. *GIS outputs showing location and relative importance of the source ports with respect to the volume of tank discharges (C2) at Port of Dalian*

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

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
1	CNSHA	Shanghai (Shihu) Shanghai	China	10.62%	117,256	7.185%
2	CNTAO	Qingdao (Longgang) Shandong	China	7.38%	21,547	1.320%
3	CNCAN	Guangzhou Guangdong	China	6.62%	85,870	5.262%
4	CNNGB	Ningbo Zhejiang	China	5.54%	32,910	2.017%
5	CNYNT	Yantai (Muping) Shandong	China	5.54%	10,958	0.671%
6	CNJIA	Jiangyin Jiangsu	China	5.23%	41,747	2.558%
7	HKHKG	Hong Kong	Hong Kong	4.46%	23,366	1.432%
8	CNTSN	Tianjin Tianjin	China	3.54%	50,738	3.109%
9	CNCWN	Chiwan (Shenzhen) Guangdong	China	3.23%	135,001	8.272%
10	CNHUA	Huangpu (Xinzao) Guangdong	China	3.23%	91,400	5.600%
11	KRINC	Inchon	Korea Republic of	2.77%	122,059	7.479%
12	CNRZH	Rizhao (Shijiu) Shandong	China	2.77%	16,452	1.008%
13	CNSHD	Shidao Shandong	China	2.77%	4,524	0.277%
14	CNSHK	Shekou Guangdong	China	2.62%	108,129	6.625%
15	CNFOC	Fuzhou Fujian	China	2.62%	15,456	0.947%
16	CNZUH	Zhuhai Guangdong	China	2.46%	145,032	8.887%
17	CNZOS	Zhousan (Dinghai)	China	2.31%	16,991	1.041%
18	CNNTG	Nantong Jiangsu	China	2.15%	13,970	0.856%
19	CNSWA	Shantou (Chaoyang) Guandong	China	1.69%	8,666	0.531%
20	KRPUS	Pusan	Korea Republic of	1.38%	22,759	1.395%
21	CNLKU	Longkou	China	1.38%	2,568	0.157%
22	KRONS	Onsan	Korea Republic of	1.23%	20,129	1.233%
23	CNNKG	Nanjing Jiangsu	China	1.23%	18,828	1.154%
24	CNXMN	Xiamen (Weitou) Fujian	China	1.23%	10,900	0.668%
25	CNQZJ	Quanzhou (Jinjiang) Fujian	China	1.23%	4,295	0.263%
26	CNSHP	Qinhuangdao Hebei	China	1.23%	3,495	0.214%
27	CNWEI	Wei Hai	China	1.08%	2,280	0.140%
28	CNWNZ	Wenzhou Hubei	China	0.77%	3,096	0.190%
29	JPYOK	Yokohama Kanagawa	Japan	0.62%	27,539	1.687%
30	CNLYG	Lianyungang Jiangsu	China	0.62%	19,243	1.179%

*C1 = proportion of tank discharge records from known sources (652); C2 = proportion of total discharge volume (%)

***Table 3 (cont.).** List of identified source ports in the Port of Dalian database, showing their proportion of recorded tank discharges (C1) and volumes (C2)**

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
31	JPNGO	Nagoya Aichi	Japan	0.46%	42,239	2.588%
32	CNZJG	Zhangjiagang (Changjiagang) Jiangsu	China	0.46%	3,826	0.234%
33	CNZHE	Zhenjiang Zhejiang	China	0.46%	2,850	0.175%
34	JPMOJ	Moji (Kitakyushu) Fukuoka	Japan	0.46%	2,089	0.128%
35	CNHME	Haimen Zhejiang	China	0.46%	1,744	0.107%
36	CN013	Xiangshui	China	0.46%	850	0.052%
37	JPSAK	Sakai Osaka	Japan	0.31%	40,766	2.498%
38	KRUSN	Ulsan	Korea Republic of	0.31%	35,098	2.151%
39	JPSMT	Shimotsu Wakayama	Japan	0.31%	30,722	1.882%
40	CNTGU	Tanggu Tianjin	China	0.31%	21,111	1.294%
41	KRTSN	Taesan	Korea Republic of	0.31%	20,474	1.255%
42	JPMYJ	Matsuyama Ehime	Japan	0.31%	14,512	0.889%
43	JPOSA	Osaka Osaka	Japan	0.31%	11,345	0.695%
44	USLGB	Long Beach California	United States	0.31%	2,800	0.172%
45	CNHAK	Haikou Hainan	China	0.31%	2,500	0.153%
46	JPIWK	Iwakuni Yamaguchi	Japan	0.15%	32,300	1.979%
47	JPMIZ	Mizushima Okayama	Japan	0.15%	32,085	1.966%
48	JPFKM	Fukushima Nagasaki	Japan	0.15%	25,565	1.566%
49	USSFO	San Francisco California	United States	0.15%	20,701	1.268%
50	TWKHH	Kaohsiung	Taiwan Province of China	0.15%	18,108	1.110%
51	JPCHB	Chiba Chiba	Japan	0.15%	15,047	0.922%
52	JPMUR	Muroran Hokkaido	Japan	0.15%	14,000	0.858%
53	KR001	Hadong	Korea Republic of	0.15%	11,773	0.721%
54	JPKUD	Kudamatsu Yamaguchi	Japan	0.15%	6,300	0.386%
55	KRKUV	Kunsan	Korea Republic of	0.15%	4,535	0.278%
56	CNFAN	Fangcheng (Qinzhou) Guangxi	China	0.15%	3,200	0.196%
57	CNYJI	Yangjiang Guandong	China	0.15%	3,100	0.190%
58	KRMUK	Mukho	Korea Republic of	0.15%	2,600	0.159%
59	KRMOK	Mokpo	Korea Republic of	0.15%	1,843	0.113%
60	SGSIN	Singapore	Singapore	0.15%	1,836	0.112%
61	CNZHA	Zhanjiang Guangdong	China	0.15%	1,600	0.098%
62	JPKIJ	Niigata Niigata	Japan	0.15%	1,357	0.083%
63	JPSAG	Saganoseki Oita	Japan	0.15%	873	0.053%
64	PGDAU	Daru	Papua New Guinea	0.15%	787	0.048%
65	JPKRE	Kure Hiroshima	Japan	0.15%	699	0.043%
66	CN004	Jiaojiang (Taizhou)	China	0.15%	500	0.031%
67	CN009	Shipu	China	0.15%	500	0.031%
68	CNBAY	Bayuquan Liaoning	China	0.15%	400	0.025%
69	USBCC	Vancouver Washington	United States	0.15%	380	0.023%
70	MYPKG	Port Kelang	Malaysia	0.15%	330	0.020%
71	USLAX	Los Angeles California	United States	0.15%	305	0.019%
72	CNMWN	Mawan Guangdong	China	0.15%	300	0.018%
73	CN007	Rushan	China	0.15%	213	0.013%
74	CNCGU	Changshu	China	0.15%	200	0.012%
75	JPTYO	Tokyo Tokyo	Japan	0.15%	184	0.011%
76	CN005	Laizhou	China	0.15%	140	0.009%
77	JPMAI	Maizuru Kyoto	Japan	0.15%	128	0.008%

*C1 = proportion of tank discharge records from known sources (652); C2 = proportion of total discharge volume (%)

4.5 Identification of destination ports

As discussed in Section 3.5, identification of destination ports for any 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 of Port Call recorded on a BWRF (or in a shipping record) is where the uplifted BW is actually discharged. Thus presently there is no reporting mechanism enabling a ‘reverse BWRA’ to be undertaken reliably. This posed a significant constraint for Dalian, since many vessels departing the various import berths at the Dagang, Heshangdao (Dalianwan), Beilian, Dayaowan, Ganjingzi and Xingang terminals would have been carrying BW uplifted alongside these berths.

Of the 121 assumed BW destination ports (i.e. Next Ports of Call) in the 2000-2002 database, their location and proportional frequency are shown Figure 20 and listed in Table 4. The latter lists the top 22 destination ports that accounted for 80% of the reported Next Ports of Call, as had been listed in 3051 of the 3278 BWRFs (93%). Figure 20 and Table 4 show that the regional (Bohai Sea) port of Tianjin (13.1%), the Korean port of Pusan (12.5%) and Qingdao (9.6%) stood out as the most frequent destination ports, a feature caused by the large number of container and other cargo liner services to these ports within the collected BWRFs (Appendix 7). Table 4 also shows that, of the 22 ports accounting for the destinations of 80% of the BWRF nominated vessel departures from Dalian, 14 were in China (including Hong Kong), seven were in Japan and one was in Korea (Pusan).

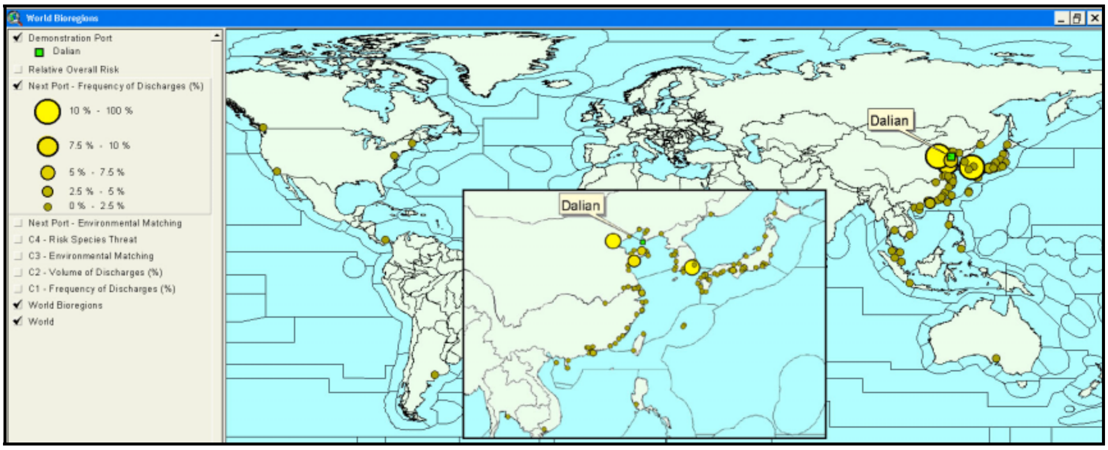

Figure 20. *GIS outputs showing the location and frequency of destination ports, recorded as the Next Port of Call in the Port of Dalian BWRFs*

Table 4. *Destination ports accounting for >80% of all vessel departures from Dalian in 1998-2002 (recorded as Next Ports of Call)*

	UN Port Code	Destination Port (Next Port of Call)	Country	% Proportion of Departures	Cumulative %
1	CNTSN	Tianjin Tianjin	China	13.14	13.1
2	KRPUS	Pusan	Korea Republic of	12.52	25.7
3	CNTAO	Qingdao (Longgang) Shandong	China	9.44	35.1
4	CNYNT	Yantai (Muping) Shandong	China	5.54	40.6
5	CNSHA	Shanghai (Shihu) Shanghai	China	4.06	44.7
6	JPUKB	Kobe Hyogo	Japan	3.24	47.9
7	JPMOJ	Moji (Kitakyushu) Fukuoka	Japan	2.98	50.9
8	HKHKG	Hong Kong	Hong Kong	2.95	53.9
9	JPNGO	Nagoya Aichi	Japan	2.56	56.4
10	JPOSA	Osaka Osaka	Japan	2.43	58.9
11	JPYOK	Yokohama Kanagawa	Japan	2.39	61.3
12	CNTGU	Tanggu Tianjin	China	2.33	63.6
13	CNJIA	Jiangyin Jiangsu	China	2.06	65.6
14	CNWEI	Wei Hai	China	2.03	67.7
15	JPHKT	Hakata Fukuoka	Japan	1.97	69.6
16	CNNGB	Ningbo Zhejiang	China	1.80	71.4
17	CNDDG	Dandong Liaoning	China	1.74	73.2
18	CNCAN	Guangzhou Guangdong	China	1.70	74.9
19	JPTYO	Tokyo Tokyo	Japan	1.47	76.4
20	CNHUA	Huangpu (Xinzao) Guangdong	China	1.28	77.6
21	CNRZH	Rizhao (Shijiu) Shandong	China	1.28	78.9
22	CNNTG	Nantong Jiangsu	China	1.08	80.0

4.6 Environmental similarity analysis

Of the 77 identified source ports and 121 destination ports, sufficient port environmental data were obtained to include 53% of both the former and latter ports in the multivariate similarity analysis by PRIMER. These ports accounted for 62% of all recorded tank discharges and 77% of all recorded departures respectively (Tables 5, 6). Details of the 357 ports included in the multivariate analysis carried out for Dalian 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 Dalian 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 made higher than the calculated C3s of the comparable ports). Providing C3 estimates allowed the database to include all of Dalian source ports and next ports when calculating the ROR values and displaying the BWRA results.

The GIS world map outputs that display the C3 values of the Port of Dalian source and destination ports are in Figures 21 and 22 respectively. These plots and Tables 5-6 show that Dalian has a relatively high environmental similarity to a large number of its trading ports (e.g. 55% of the source ports had calculated or estimated C3s above 0.6). This can be related to their relatively close regional location to Dalian and similar suite of marine habitats, the continental weather regime that provides a wide seasonality to the temperature range, and Dalian's 'middle of the road' annual rainfall pattern and salinity range that lack extrema.

It is not surprising that the most environmentally similar ports to Dalian were some of its geographically closest ports sharing a similar coastal aspect to the Bohai and north Yellow Seas. Thus Longkou, Wei Hai, Yantai, Shidao, Rushan, Laizhou, Qingdao and Rizhao all shared calculated or estimated C3s above 0.8 (Table 5). The environmentally closest foreign port was Mokpo in Korea (C3 of 0.78) which also faces the Yellow Sea. The most environmentally dissimilar ports trading with Dalian in 2000-2002 were the river and estuary ports of the Yangste River system (0.20-0.37), warm water ports in southern China and south-east Asia (Tables 5-6; Figures 21, 22).

As discussed in Section 4.6 and highlighted in Figure 20, the most frequent destination ports were Tianjin (13.1% of all departures) and Qingdao (9.6%) in the Bohai Sea, and the south-west Korean port of Pusan in the Sea of Japan (12.5%). The former had relatively high environmental matching coefficients (0.71 and 0.82) while Pusan was less similar at 0.44 (Table 6). The most common Japanese destination ports (Kobe at 3.2% and Moji at 3.0%; Table 4) are in Japan's Seto Sea and had intermediate environmental matching coefficients (i.e. 0.69 and 0.57 respectively; Table 6).

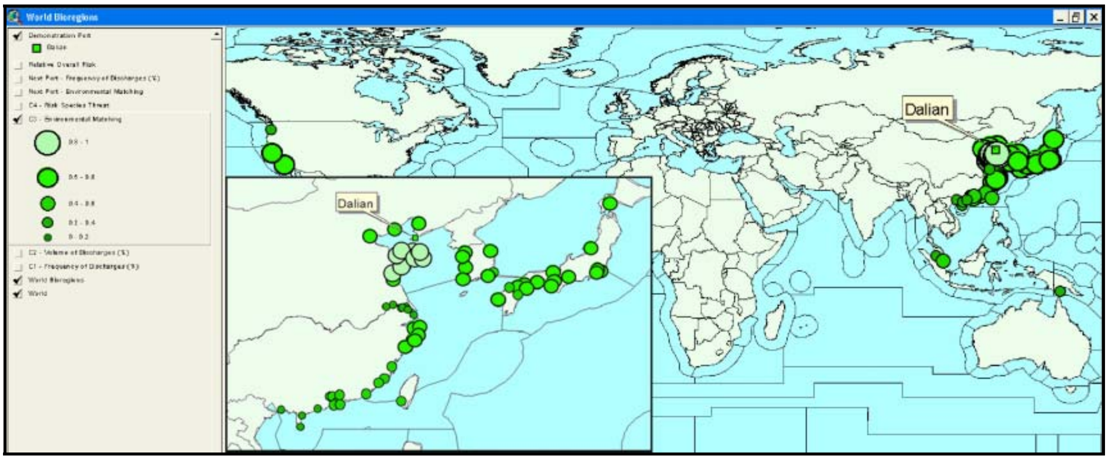

Figure 21. *GIS outputs showing the location and environmental matching coefficients (C3) of BW source ports identified for the Port of Dalian*

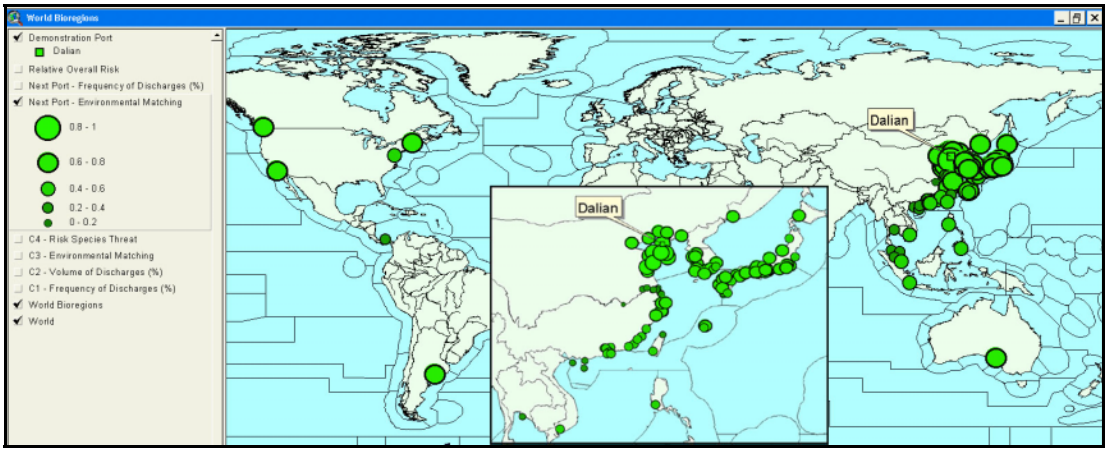

Figure 22. *GIS output showing the location and environmental matching coefficients (C3) of the destination ports identified for the Port of Dalian*

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

UN Port Code	Source Port Name	Country	Proportion of BW discharged	Environmental Matching (C3)	C3 Estimated
CNLKU	Longkou	China	1.38%	**0.890**	*E*
CNWEI	Wei Hai	China	1.08%	**0.890**	*E*
CNYNT	Yantai (Muping) Shandong	China	5.54%	**0.886**	
CNSHD	Shidao Shandong	China	2.77%	**0.850**	*E*
CN007	Rushan	China	0.15%	**0.850**	*E*
CN005	Laizhou	China	0.15%	**0.850**	
CNTAO	Qingdao (Longgang) Shandong	China	7.38%	**0.823**	
CNRZH	Rizhao (Shijiu) Shandong	China	2.77%	**0.820**	*E*
KRMOK	Mokpo	Korea Republic of	0.15%	**0.722**	
JPKRE	Kure Hiroshima	Japan	0.15%	**0.715**	
CNTSN	Tianjin Tianjin	China	3.54%	**0.714**	
JPMYJ	Matsuyama Ehime	Japan	0.31%	**0.714**	
JPIWK	Iwakuni Yamaguchi	Japan	0.15%	**0.710**	
CNZOS	Zhousan (Dinghai)	China	2.31%	**0.700**	*E*
CNSHP	Qinhuangdao Hebei	China	1.23%	**0.700**	*E*
CNLYG	Lianyungang Jiangsu	China	0.62%	**0.700**	*E*
KRTSN	Taesan	Korea Republic of	0.31%	**0.700**	*E*
KR001	Hadong	Korea Republic of	0.15%	**0.700**	*E*
KRMUK	Mukho	Korea Republic of	0.15%	**0.700**	*E*
CNBAY	Bayuquan Liaoning	China	0.15%	**0.700**	*E*
JPYOK	Yokohama Kanagawa	Japan	0.62%	**0.687**	
JPCHB	Chiba Chiba	Japan	0.15%	**0.685**	
JPFKM	Fukushima Nagasaki	Japan	0.15%	**0.684**	
JPMUR	Muroran Hokkaido	Japan	0.15%	**0.669**	
KRKUV	Kunsan	Korea Republic of	0.15%	**0.668**	
CNNGB	Ningbo Zhejiang	China	5.54%	**0.656**	
JPKUD	Kudamatsu Yamaguchi	Japan	0.15%	**0.653**	
USSFO	San Francisco California	United States	0.15%	**0.652**	
JPNGO	Nagoya Aichi	Japan	0.46%	**0.651**	
CNHME	Haimen Zhejiang	China	0.46%	**0.650**	*E*
CN004	Jiaojiang (Taizhou)	China	0.15%	**0.650**	*E*
CN009	Shipu	China	0.15%	**0.650**	*E*
JPMAI	Maizuru Kyoto	Japan	0.15%	**0.646**	
JPKIJ	Niigata Niigata	Japan	0.15%	**0.643**	
JPSAK	Sakai Osaka	Japan	0.31%	**0.638**	
KRINC	Inchon	Korea Republic of	2.77%	**0.637**	
JPSMT	Shimotsu Wakayama	Japan	0.31%	**0.637**	
JPMIZ	Mizushima Okayama	Japan	0.15%	**0.628**	
USLGB	Long Beach California	United States	0.31%	**0.623**	
JPOSA	Osaka Osaka	Japan	0.31%	**0.619**	
JPTYO	Tokyo Tokyo	Japan	0.15%	**0.609**	
CNWNZ	Wenzhou Hubei	China	0.77%	**0.600**	*E*
KRONS	Onsan	Korea Republic of	1.23%	**0.581**	
JPMOJ	Moji (Kitakyushu) Fukuoka	Japan	0.46%	**0.569**	
CNFOC	Fuzhou Fujian	China	2.62%	**0.550**	*E*
KRUSN	Ulsan	Korea Republic of	0.31%	**0.546**	
JPSAG	Saganoseki Oita	Japan	0.15%	**0.521**	
CNQZJ	Quanzhou (Jinjiang) Fujian	China	1.23%	**0.500**	*E*
CNXMN	Xiamen (Weitou) Fujian	China	1.23%	**0.500**	*E*
CNSHK	Shekou Guangdong	China	2.62%	**0.490**	*E*
CNMWN	Mawan Guangdong	China	0.15%	**0.490**	*E*
CNCWN	Chiwan (Shenzhen) Guangdong	China	3.23%	**0.490**	
CNZUH	Zhuhai Guangdong	China	2.46%	**0.450**	*E*
CNSWA	Shantou (Chaoyang) Guandong	China	1.69%	**0.450**	*E*
CN013	Xiangshui	China	0.46%	**0.450**	*E*
CNCAN	Guangzhou Guangdong	China	6.62%	**0.445**	
KRPUS	Pusan	Korea Republic of	1.38%	**0.441**	
TWKHH	Kaohsiung	Taiwan Province of China	0.15%	**0.437**	
SGSIN	Singapore	Singapore	0.15%	**0.423**	
HKHKG	Hong Kong	Hong Kong	4.46%	**0.415**	
CNHUA	Huangpu (Xinzao) Guangdong	China	3.23%	**0.414**	
CNTGU	Tanggu Tianjin	China	0.31%	**0.400**	*E*
USBCC	Vancouver Washington	United States	0.15%	**0.396**	
USLAX	Los Angeles California	United States	0.15%	**0.395**	*E*
PGDAU	Daru	Papua New Guinea	0.15%	**0.388**	
CNSHA	Shanghai (Shihu) Shanghai	China	10.62%	**0.370**	
CNHAK	Haikou Hainan	China	0.31%	**0.350**	*E*
CNCGU	Changshu	China	0.15%	**0.350**	*E*
CNYJI	Yangjiang Guandong	China	0.15%	**0.350**	*E*
CNZHA	Zhanjiang Guangdong	China	0.15%	**0.350**	*E*
CNZJG	Zhangjiagang (Changjiagang) Jiangsu	China	0.46%	**0.330**	*E*
MYPKG	Port Kelang	Malaysia	0.15%	**0.326**	
CNNKG	Nanjing Jiangsu	China	1.23%	**0.300**	*E*
CNFAN	Fangcheng (Qinzhou) Guangxi	China	0.15%	**0.300**	*E*
CNJIA	Jiangyin Jiangsu	China	5.23%	**0.200**	*E*
CNNTG	Nantong Jiangsu	China	2.15%	**0.200**	*E*
CNZHE	Zhenjiang Zhejiang	China	0.46%	**0.200**	*E*

***Table 6.** Destination ports identified for Port of Dalian, 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
CNWEI	Wei Hai	China	2.03	**0.890**	*E*
CNLKU	Longkou	China	0.59	**0.890**	*E*
CNYNT	Yantai (Muping) Shandong	China	5.54	**0.886**	
CNSHD	Shidao Shandong	China	0.43	**0.850**	*E*
CN005	Laizhou	China	0.26	**0.850**	*E*
CNTAO	Qingdao (Longgang) Shandong	China	9.44	**0.823**	
CNRZH	Rizhao (Shijiu) Shandong	China	1.28	**0.820**	*E*
JPISI	Ishikari Hokkaido	Japan	0.07	**0.761**	*E*
KRKAN	Kwangyang	Korea Republic of	0.98	**0.754**	
KRMOK	Mokpo	Korea Republic of	0.23	**0.722**	
JPISG	Ishigakijima Okinawa	Japan	0.98	**0.721**	*E*
CNDDG	Dandong Liaoning	China	1.74	**0.720**	*E*
KRYOS	Yosu	Korea Republic of	0.03	**0.718**	
CNTSN	Tianjin Tianjin	China	13.14	**0.714**	
JPKIK	Kikuma Ehime	Japan	0.03	**0.713**	
JPHHR	Higashiharima Hyogo	Japan	0.03	**0.701**	
CNZOS	Zhousan (Dinghai)	China	0.92	**0.700**	*E*
CNYIK	Yingkou Liaoning	China	0.72	**0.700**	*E*
CNLYG	Lianyungang Jiangsu	China	0.36	**0.700**	*E*
CNSHP	Qinhuangdao Hebei	China	0.36	**0.700**	*E*
CNBAY	Bayuquan Liaoning	China	0.20	**0.700**	*E*
JPAKA	Akashi Hyogo	Japan	0.16	**0.700**	*E*
KRTSN	Taesan	Korea Republic of	0.13	**0.700**	*E*
JPTSU	Tsu Mie	Japan	0.10	**0.700**	*E*
ARBHI	Bahia Blanca	Argentina	0.07	**0.700**	*E*
KRMAS	Masan	Korea Republic of	0.07	**0.700**	*E*
CN003	Huludao (near Jinzhou)	China	0.03	**0.700**	*E*
CNJNZ	Jinzhou Liaoning	China	0.03	**0.700**	*E*
KRKWJ	Kwangju	Korea Republic of	0.03	**0.700**	*E*
KRPTK	Pyeong Taek	Korea Republic of	0.03	**0.700**	*E*
JPUKB	Kobe Hyogo	Japan	3.24	**0.697**	
JPETA	Etajima Hiroshima	Japan	0.03	**0.695**	*E*
JPYOK	Yokohama Kanagawa	Japan	2.39	**0.687**	
JPCHB	Chiba Chiba	Japan	0.16	**0.685**	
JPYOS	Yokosuka Kanagawa	Japan	0.03	**0.685**	
JPFKM	Fukushima Nagasaki	Japan	0.03	**0.684**	
JPTOY	Toyama Toyama	Japan	0.07	**0.676**	
KRKUV	Kunsan	Korea Republic of	0.43	**0.668**	
RUVVO	Vladivostok	Russian Federation	0.03	**0.667**	
JPKNU	Kinuura Aichi	Japan	0.03	**0.664**	
JPYKK	Yokkaichi Mie	Japan	0.39	**0.661**	
CNNGB	Ningbo Zhejiang	China	1.80	**0.656**	
JPMIN	Minamata Kumamoto	Japan	0.03	**0.653**	*E*
JPNGO	Nagoya Aichi	Japan	2.56	**0.651**	
CNHME	Haimen Zhejiang	China	0.07	**0.650**	*E*
CN004	Jiaojiang (Taizhou)	China	0.03	**0.650**	*E*
JPTBT	Tobata (Kitakyushu) Fukuoka	Japan	0.03	**0.649**	
JPTGO	Tagonoura Shizuoka	Japan	0.10	**0.643**	*E*
JPKIJ	Niigata Niigata	Japan	0.03	**0.643**	
JPFKY	Fukuyama Hiroshima	Japan	0.03	**0.641**	
JPSAK	Sakai Osaka	Japan	0.07	**0.638**	
USPWM	Portland Maine	United States	0.13	**0.637**	*E*
KRINC	Inchon	Korea Republic of	1.02	**0.637**	
JPMIZ	Mizushima Okayama	Japan	0.07	**0.628**	
KRKPO	Pohang	Korea Republic of	0.03	**0.627**	
USLGB	Long Beach California	United States	0.10	**0.623**	
JPOSA	Osaka Osaka	Japan	2.43	**0.619**	
CAVAN	Vancouver British Columbia	Canada	0.07	**0.618**	
JPMAI	Maizuru Kyoto	Japan	0.07	**0.612**	*E*
JPTYO	Tokyo Tokyo	Japan	1.47	**0.609**	
JPHKT	Hakata Fukuoka	Japan	1.97	**0.607**	
AUWYA	Whyalla	Australia	0.03	**0.604**	
CNWNZ	Wenzhou Hubei	China	0.52	**0.600**	*E*
JPTRG	Tsuruga Fukui	Japan	0.03	**0.596**	
JPKOJ	Kagoshima Kagoshima	Japan	0.03	**0.593**	
KRONS	Onsan	Korea Republic of	0.03	**0.581**	
JPAXT	Akita Akita	Japan	0.03	**0.575**	
JPMOJ	Moji (Kitakyushu) Fukuoka	Japan	2.98	**0.569**	
JPSBS	Shibushi Kagoshima	Japan	0.26	**0.569**	
CNFOC	Fuzhou Fujian	China	0.62	**0.550**	*E*
KRUSN	Ulsan	Korea Republic of	0.23	**0.546**	
JPOIT	Oita Oita	Japan	0.13	**0.527**	
JPBPU	Beppu Oita	Japan	0.43	**0.524**	
JPKND	Kanda Fukuoka	Japan	0.03	**0.509**	
USBAL	Baltimore Maryland	United States	0.03	**0.501**	
CNXMN	Xiamen (Weitou) Fujian	China	0.56	**0.500**	*E*
CNQZJ	Quanzhou (Jinjiang) Fujian	China	0.23	**0.500**	*E*
CNDSN	Dongshan	China	0.03	**0.500**	*E*

Table 6 (cont'd). *Destination ports identified for Port of Dalian, 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
CNSHK	Shekou Guangdong	China	0.26	**0.490**	*E*
CNMWN	Mawan Guangdong	China	0.03	**0.490**	*E*
CNCWN	Chiwan (Shenzhen) Guangdong	China	0.92	**0.490**	
PHDAD	Dadiangas Mindanao	Philippines	0.03	**0.470**	*E*
JPKII	Kiire Kagoshima	Japan	0.07	**0.470**	
JPNAH	Naha Okinawa	Japan	0.03	**0.468**	
JPONA	Onahama Fukushima	Japan	0.03	**0.468**	
PHBTN	Bataan Mariveles	Philippines	0.10	**0.451**	
CNZUH	Zhuhai Guangdong	China	1.08	**0.450**	*E*
CNSWA	Shantou (Chaoyang) Guandong	China	0.59	**0.450**	*E*
CN013	Xiangshui	China	0.29	**0.450**	*E*
CNCAN	Guangzhou Guangdong	China	1.70	**0.445**	
KRPUS	Pusan	Korea Republic of	12.52	**0.441**	
TWKHH	Kaohsiung	Taiwan Province of China	0.07	**0.437**	
SGSIN	Singapore	Singapore	0.26	**0.423**	
VNSGN	Ho Chi Minh City	Viet Nam	0.07	**0.422**	*E*
HKHKG	Hong Kong	Hong Kong	2.95	**0.415**	
CNHUA	Huangpu (Xinzao) Guangdong	China	1.28	**0.414**	
IDJKT	Jakarta Java	Indonesia	0.10	**0.412**	
CNTGU	Tanggu Tianjin	China	2.33	**0.400**	*E*
USANC	Anchorage Alaska	United States	0.07	**0.399**	
USLAX	Los Angeles California	United States	0.03	**0.395**	
MYPGU	Pasir Gudang Johor	Malaysia	0.07	**0.373**	
PA001	Panama Canal	Panama	0.03	**0.371**	*E*
MYDGN	Dungun (Kuala Dungun)	Malaysia	0.03	**0.371**	*E*
CNSHA	Shanghai (Shihu) Shanghai	China	4.06	**0.370**	
QAHAL	Halul Island Terminal	Qatar	0.03	**0.365**	
MYBWH	Bagan Luar (Butterworth)	Malaysia	0.03	**0.353**	*E*
CNHAK	Haikou Hainan	China	0.07	**0.350**	*E*
CN011	Weizhou Marine Terminal	China	0.03	**0.350**	*E*
CNZHA	Zhanjiang Guangdong	China	0.03	**0.350**	*E*
CNZJG	Zhangjiagang (Changjiagang) Jiangsu	China	0.26	**0.330**	*E*
MYPKG	Port Kelang	Malaysia	0.03	**0.326**	
TWKEL	Keelung (Sha Lung & Tanshoei)	Taiwan Province of China	0.43	**0.305**	
THMAT	Mab Tapud	Thailand	0.03	**0.300**	*E*
CNNTG	Nantong Jiangsu	China	1.08	**0.300**	*E*
CNJIG	Jiading (Taicang)	China	0.13	**0.300**	*E*
CN010	Taixing	China	0.03	**0.300**	*E*
CNJIA	Jiangyin Jiangsu	China	2.06	**0.200**	*E*
CNNKG	Nanjing Jiangsu	China	0.46	**0.200**	*E*
CNZHE	Zhenjiang Zhejiang	China	0.03	**0.200**	*E*
CNJIU	Jiujiang Jiangxi	China	0.03	**0.100**	*E*

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 each BW source port identified for Dalian 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 collated and assigned to the database's species tables by March 2003.

A total of 84 native and introduced risk species were collated for the China bioregions, including species information sourced from Dalian, Hong Kong, Japan, Australia, Canada and US (Appendix 5). As noted in Section 3.9, the species tables and their associated Excel reference file do not form 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 remembered that the distribution of risk species in the database contains a regional bias due to the level of aquatic sampling and taxonomic effort in Australia/New Zealand, Europe and North America.

Many of the species listed for these areas can be related to their history of species transfers for aquaculture, plus hull fouling on sailing vessels and the canal-caused invasions of the east

Mediterranean (Suez), north-east Europe (Ponto-Caspian river canal links) and Great Lakes (St Lawrence River seaway).

The regional and often patchy sampling bias needs to be recognised 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, canals, 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.

Finally, it is worth noting the database cannot produce 'reverse' C4 values for destination ports (i.e. measures of the relative threat posed by any BW exported from Dalian). 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 Dalian (which is located in bioregion NWP-4c; Figure 7, Table 8).

The risk species listed in Table 8 include preliminary identifications from the Dalian PBBS plus taxa listed in published and unpublished reports collated by Group C members (Appendix 5). Species native to the Bohai Sea/Yellow Sea regions which have harmful or suspected reputations in other regions are also present. These provide important components to a reverse BWRA since many of them have gained harmful species credentials in Europe, the north-east Pacific and/or southern Australia (particularly the Asian strangle weed, wakame kelp, Chinese mitten crab, Asian clam, date mussel and Northern Pacific starfish).

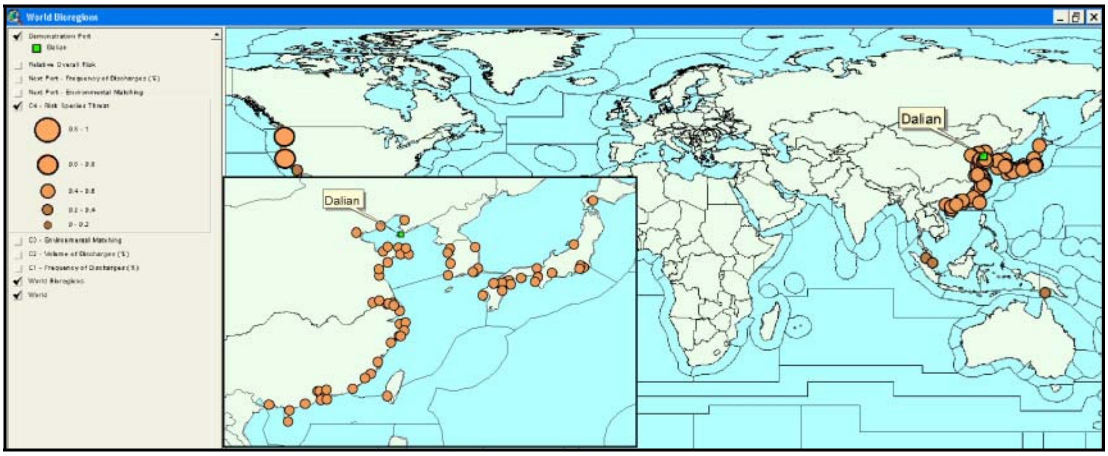

Figure 23. *GIS outputs showing the location and risk species threat coefficients (C4) of the BW source ports identified for the Port of Dalian*

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

UN 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)
USBCC	Vancouver Washington	United States	NEP-IV	41	5	7	126	**0.700**
USSFO	San Francisco California	United States	NEP-V	41	5	7	126	**0.700**
CN004	Jiaojiang (Taizhou)	China	NWP-3a	15	3	6	84	**0.467**
CN005	Laizhou	China	NWP-4c	15	3	6	84	**0.467**
CN007	Rushan	China	NWP-4c	15	3	6	84	**0.467**
CN009	Shipu	China	NWP-3a	15	3	6	84	**0.467**
CNBAY	Bayuquan Liaoning	China	NWP-4c	15	3	6	84	**0.467**
CNCGU	Changshu	China	NWP-3a	15	3	6	84	**0.467**
CNFOC	Fuzhou Fujian	China	NWP-3a	15	3	6	84	**0.467**
CNHME	Haimen Zhejiang	China	NWP-3a	15	3	6	84	**0.467**
CNJIA	Jiangyin Jiangsu	China	NWP-3a	15	3	6	84	**0.467**
CNLKU	Longkou	China	NWP-4c	15	3	6	84	**0.467**
CNLYG	Lianyungang Jiangsu	China	NWP-4c	15	3	6	84	**0.467**
CNNGB	Ningbo Zhejiang	China	NWP-3a	15	3	6	84	**0.467**
CNNKG	Nanjing Jiangsu	China	NWP-3a	15	3	6	84	**0.467**
CNNTG	Nantong Jiangsu	China	NWP-3a	15	3	6	84	**0.467**
CNQZJ	Quanzhou (Jinjiang) Fujian	China	NWP-3a	15	3	6	84	**0.467**
CNRZH	Rizhao (Shijiu) Shandong	China	NWP-4c	15	3	6	84	**0.467**
CNSHA	Shanghai (Shihu) Shanghai	China	NWP-3a	15	3	6	84	**0.467**
CNSHD	Shidao Shandong	China	NWP-4c	15	3	6	84	**0.467**
CNSHP	Qinhuangdao Hebei	China	NWP-4c	15	3	6	84	**0.467**
CNSWA	Shantou (Chaoyang) Guandong	China	NWP-3a	15	3	6	84	**0.467**
CNTAO	Qingdao (Longgang) Shandong	China	NWP-4c	15	3	6	84	**0.467**
CNTGU	Tanggu Tianjin	China	NWP-4c	15	3	6	84	**0.467**
CNTSN	Tianjin Tianjin	China	NWP-4c	15	3	6	84	**0.467**
CNWEI	Wei Hai	China	NWP-4c	15	3	6	84	**0.467**
CNWNZ	Wenzhou Hubei	China	NWP-3a	15	3	6	84	**0.467**
CNXMN	Xiamen (Weitou) Fujian	China	NWP-3a	15	3	6	84	**0.467**
CNYNT	Yantai (Muping) Shandong	China	NWP-4c	15	3	6	84	**0.467**
CNZHE	Zhenjiang Zhejiang	China	NWP-3a	15	3	6	84	**0.467**
CNZJG	Zhangjiagang (Changjiagang)	China	NWP-3a	15	3	6	84	**0.467**
CNZOS	Zhousan (Dinghai)	China	NWP-3a	15	3	6	84	**0.467**
JPFKM	Fukushima Nagasaki	Japan	NWP-3a	15	3	6	84	**0.467**
JPMOJ	Moji (Kitakyushu) Fukuoka	Japan	NWP-3a	15	3	6	84	**0.467**
KR001	Hadong	Korea Republic of	NWP-3a	15	3	6	84	**0.467**
KRINC	Inchon	Korea Republic of	NWP-4c	15	3	6	84	**0.467**
KRKUV	Kunsan	Korea Republic of	NWP-4c	15	3	6	84	**0.467**
KRMOK	Mokpo	Korea Republic of	NWP-3a	15	3	6	84	**0.467**
KRPUS	Pusan	Korea Republic of	NWP-3a	15	3	6	84	**0.467**
KRTSN	Taesan	Korea Republic of	NWP-4c	15	3	6	84	**0.467**
JPCHB	Chiba Chiba	Japan	NWP-3b	13	3	6	82	**0.456**
JPIWK	Iwakuni Yamaguchi	Japan	NWP-3b	13	3	6	82	**0.456**
JPKRE	Kure Hiroshima	Japan	NWP-3b	13	3	6	82	**0.456**
JPKUD	Kudamatsu Yamaguchi	Japan	NWP-3b	13	3	6	82	**0.456**
JPMIZ	Mizushima Okayama	Japan	NWP-3b	13	3	6	82	**0.456**
JPMYJ	Matsuyama Ehime	Japan	NWP-3b	13	3	6	82	**0.456**
JPNGO	Nagoya Aichi	Japan	NWP-3b	13	3	6	82	**0.456**
JPOSA	Osaka Osaka	Japan	NWP-3b	13	3	6	82	**0.456**
JPSAG	Saganoseki Oita	Japan	NWP-3b	13	3	6	82	**0.456**
JPSAK	Sakai Osaka	Japan	NWP-3b	13	3	6	82	**0.456**
JPSMT	Shimotsu Wakayama	Japan	NWP-3b	13	3	6	82	**0.456**
JPTYO	Tokyo Tokyo	Japan	NWP-3b	13	3	6	82	**0.456**
JPYOK	Yokohama Kanagawa	Japan	NWP-3b	13	3	6	82	**0.456**
JPKIJ	Niigata Niigata	Japan	NWP-4a	11	3	6	80	**0.444**
JPMAI	Maizuru Kyoto	Japan	NWP-4a	11	3	6	80	**0.444**
KRMUK	Mukho	Korea Republic of	NWP-4a	11	3	6	80	**0.444**
KRONS	Onsan	Korea Republic of	NWP-4a	11	3	6	80	**0.444**
KRUSN	Ulsan	Korea Republic of	NWP-4a	11	3	6	80	**0.444**
CN013	Xiangshui	China	NWP-2	11	2	6	77	**0.428**
CNCAN	Guangzhou Guangdong	China	NWP-2	11	2	6	77	**0.428**
CNCWN	Chiwan (Shenzhen) Guangdong	China	NWP-2	11	2	6	77	**0.428**
CNFAN	Fangcheng (Qinzhou) Guangxi	China	NWP-2	11	2	6	77	**0.428**
CNHAK	Haikou Hainan	China	NWP-2	11	2	6	77	**0.428**
CNHUA	Huangpu (Xinzao) Guangdong	China	NWP-2	11	2	6	77	**0.428**
CNMWN	Mawan Guangdong	China	NWP-2	11	2	6	77	**0.428**
CNSHK	Shekou Guangdong	China	NWP-2	11	2	6	77	**0.428**
CNYJI	Yangjiang Guandong	China	NWP-2	11	2	6	77	**0.428**
CNZHA	Zhanjiang Guangdong	China	NWP-2	11	2	6	77	**0.428**
CNZUH	Zhuhai Guangdong	China	NWP-2	11	2	6	77	**0.428**
HKHKG	Hong Kong	Hong Kong	NWP-2	11	2	6	77	**0.428**
JPMUR	Muroran Hokkaido	Japan	NWP-4b	11	2	6	77	**0.428**
TWKHH	Kaohsiung	Taiwan Province of China	NWP-2	11	2	6	77	**0.428**
USLAX	Los Angeles California	United States	NEP-VI	21	3	4	70	**0.389**
USLGB	Long Beach California	United States	NEP-VI	21	3	4	70	**0.389**
MYPKG	Port Kelang	Malaysia	EAS-VI	5	4	5	67	**0.372**
SGSIN	Singapore	Singapore	EAS-VI	5	4	5	67	**0.372**
PGDAU	Daru	Papua New Guinea	SP-I	8	1	3	41	**0.228**

Table 8. *Status of risk species assigned to the bioregion of Dalian (NWP-4c)*

Group	Common Name	Species Name	Regional Status	Threat Status
Toxic dinoflagellate	Pyrrophyta/Dinophycae	*Gymnodinium catenatum*	Cryptogenic	Known harmful species
Toxic dinoflagellate	Pyrrophyta/Dinophycae	*Gymnodinium cf. mikimotoi*	Cryptogenic	Known harmful species
Broccoli weed	Chlorophyta	*Codium fragile spp. tomentosoides*	Native	Known harmful species
Filamentous red alga	Rhodophyta	*Polysiphonia brodiaei*	Introduced	Not suspected
Red seaweed	Rhodophyta	*Eucheuma debticulatum*	Native	Not suspected
Red seaweed	Rhodophyta	*Eucheuma striatu*	Native	Not suspected
Red seaweed	Rhodophyta	*Kappaphycus alvareii*	Native	Not suspected
Red seaweed	Rhodophyta	*Kappaphycus cottonii*	Native	Not suspected
Asian strangle weed	Phaeophyta	*Sargassum muticum*	Native	Suspected harmful species
Asian kelp/Wakame/Qundaicai	Phaeophyta	*Undaria pinnatifida*	Native	Known harmful species
Hydroid	Cnidaria, Hydrozoa	*Ectopleura crocea*	Introduced	Not suspected
Sea anemone	Cnidaria, Anthazoa	*Diadumene lineata (=Haliplanella luciae)*	Native	Suspected harmful species
Colonial burrowing worm	Annelida, Polychaeta	*Boccardia proboscidea*	Native	Not suspected
Estuarine rag worm	Annelida, Polychaeta	*Perinereis vancaurica tetradentata*	Native	Not suspected
Serpulid tube worm	Annelida, Polychaeta	*Ficopomatous enigmaticus*	Cryptogenic	Not suspected
Serpulid tube worm	Annelida, Polychaeta	*Hydroides cf. ezoensis*	Cryptogenic	Not suspected
Serpulid tube worm	Annelida, Polychaeta	*Hydroides elegans*	Introduced	Known harmful species
Serpulid tube worm	Annelida, Polychaeta	*Hydroides norvegica*	Introduced	Suspected harmful species
Serpulid tube worm	Annelida, Polychaeta	*Pomatoleios kraussii*	Native	Not suspected
Sedentary spionid worm	Annelida, Polychaeta	*Pseudopolydora paucibranchiata*	Native	Not suspected
Copepod	Arthropoda, Copepoda	*Acartiella sinensis*	Native	Not suspected
Parasitic oyster copepod	Arthropoda, Copepoda	*Mytilicola orientalis*	Native	Suspected harmful species
Copepod	Arthropoda, Copepoda	*Oithona davisae*	Native	Not suspected
Copepod	Arthropoda, Copepoda	*Pseudodiaptomus marinus*	Native	Not suspected
Bay barnacle	Arthropoda, Cirrepedia	*Balanus improvisus*	Introduced	Not suspected
Acorn barnacle	Arthropoda, Cirrepedia	*Balanus variegatus*	Native	Not suspected
Pink giant barnacle	Arthropoda, Cirrepedia	*Megabalanus rosa*	Native	Not suspected
Giant barnacle	Arthropoda, Cirrepedia	*Megabalanus tintinnabulum*	Introduced	Known harmful species
Zebra barnacle	Arthropoda, Cirrepedia	*Megabalanus zebra*	Cryptogenic	Not suspected
Sea flea	Arthropoda, Amphipoda	*Jassa marmorata*	Introduced	Not suspected
Skeleton shrimp	Arthropoda, Caprellidae	*Caprella acanthogaster (cf. C. mutica)*	Native	Not suspected
Asian slater	Arthropoda, Isopoda	*Synidotea laevidorsalis*	Native	Not suspected
Japanese opossum shrimp	Arthropoda, Mysdiacea	*Neomysis japonica*	Native	Suspected harmful species
Oriental shrimp	Arthropoda, Palaemonidae	*Palaemon macrodactylus*	Native	Not suspected
European green shore crab	Arthropoda, Brachyura	*Carcinus maenas*	Introduced	Known harmful species
Asian paddle crab	Arthropoda, Brachyura	*Charybdis cf. japonica*	Native	Suspected harmful species
Dromiid crab	Arthropoda, Brachyura	*Dromia wilsoni*	Introduced	Not suspected
Chinese mitten crab	Arthropoda, Brachyura	*Eriocheir sinensis*	Native	Known harmful species
Asian grapsid crab	Arthropoda, Brachyura	*Hemigrapsus penicillatus*	Native	Suspected harmful species
Atlantic scallop	Mollusca, Bivalvia	*Argopecten irradians*	Introduced	Not suspected
Pacific oyster	Mollusca, Bivalvia	*Crassostrea gigas*	Native	Suspected harmful species
Mud clam	Mollusca, Bivalvia	*Macira discors*	Native	Not suspected
Asian date mussel	Mollusca, Bivalvia	*Musculista senhousia*	Native	Known harmful species
Mediteranean blue mussel	Mollusca, Bivalvia	*Mytilus galloprovincialis*	Introduced	Known harmful species
Varnish clam	Mollusca, Bivalvia	*Nuttallia obscurata*	Native	Not suspected
Asian clam	Mollusca, Bivalvia	*Potamocorbula amurensis*	Native	Known harmful species
Periwinkle	Mollusca, Gastropoda	*Litorina saxatilis*	Introduced	Suspected harmful species
Mactrid whelk	Mollusca, Gastropoda	*Raeta (Raetellops) pulchella*	Native	Not suspected
Veined rapa whelk	Mollusca, Gastropoda	*Rapana venosa (= R. thomasiana)*	Native	Suspected harmful species
White-tentacled aeolis	Mollusca, Gastropoda	*Sakuraeolis enosimensis*	Native	Not suspected
Anemone-feeding nudibranch	Mollusca, Ophistobranchia	*Aeolidiella indica (=Carolaria indica)*	Native	Not suspected
Tergepedid nudibranch	Mollusca, Ophistobranchia	*Cuthona alpha, C beta*	Native	Not suspected
Flat okenid nudibranch	Mollusca, Ophistobranchia	*Okenia plana*	Native	Not suspected
Northern Pacific seastar	Echinodermata, Asteroidea	*Asterias amurensis*	Native	Known harmful species
Sea moss (Bryozoan)	Ectoprocta/Cheilostomata	*Bugula stolonifera*	Introduced	Not suspected
Sea moss (Bryozoan)	Ectoprocta/Cheilostomata	*Cryptosula pallasiana*	Introduced	Suspected harmful species
Sea moss (Bryozoan)	Ectoprocta/Cheilostomata	*Schizoporella 'unicornis' spp.*	Native	Not suspected
Sea moss (Bryozoan)	Ectoprocta/Cheilostomata	*Tricellaria occidentalis (=T. inopinata)*	Native	Not suspected
Colonial sea squirt (tunicate)	Urochordata, Ascidiacea	*Botryllus aurantius (cf. B. violaceus)*	Native	Not suspected
Colonial sea squirt (tunicate)	Urochordata, Ascidiacea	*Botryllus schlosseri*	Introduced	Not suspected
Sea eggplant (tunicate)	Urochordata, Ascidiacea	*Styela clava*	Native	Not suspected
Oriental Yellowfin Goby	Pisces, Gobiidae	*Acanthogobius flavimanus*	Native	Not suspected
Japanese Goby	Pisces, Gobiidae	*Tridentiger barbatus*	Native	Not suspected
Japanese Goby	Pisces, Gobiidae	*Tridentiger trigonocephalus*	Native	Not suspected

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 Dalian are listed in Table 9, and the GIS plot of the ROR categories is shown in Figure 24.

From the 3278 BWRF records in the Dalian database, the project standard method ranked 11 of the 77 source ports as representing the highest risk group in terms of their BW source frequency, volume, environmental similarity and assigned risk species. These ports were all regionally close to Dalian and provided the top 20% of the total ROR, with individual ROR values above 0.3 (Table 9). The highest risk group was led by Yantai (ROR = 0.354; S-ROR = 1.0), Qingdao (ROR = 0.344; S-ROR = 0.96) and Longko (0.343; 0.95), with the Korean Port of Inchon being the highest risk foreign port (ranked 10th with an ROR of 0.302 and S-ROR of 0.78; Table 9).

The first port in the ranking that lies beyond the Bohai-Yellow Sea region was Iwakuni in Japan's Seto Sea, which was ranked 14th overall and 3rd in the second (high risk) group of ports with an ROR of 0.297 (S-ROR = 0.76; Table 9). The highest risk ports beyond East Asia were the American west coast ports of Long Beach and San Francisco (ranked in the lowest group of risk ports in Table 9, with ROR values of 0.215 (S-ROR = 0.41) and 0.202 (S-ROR = 0.35) respectively. These ports fell into the lowest risk group because of their relative contribution to the overall threat of harmful species transfers as a result of Dalian's shipping trade in 2000-2002, as represented by the BWRFs collected for this period. Thus while their environmental matching coefficients were moderately high (C3s of 0.62 and 0.65; Table 4), their voyage duration factor (R2) and very low incidence of recorded BW discharge resulted in the low ranking. However it should be noted from Table 9 that the percentage contribution made to Dalian's overall risk by Long Beach (1.13%) and San Francisco (1.06%) was not substantially different from the highest risk ports (all in the 1.6% - 1.9% range).

The 38 source ports grouped in the low (16) and lowest (22) risk categories were a mixture of river, estuarine and/or warmer water ports in Asia and north America. The source port with the lowest ROR (0.119; S-ROR = 0.0) was Los Angeles in southern California (Table 9). This port had been provided an estimated C3 value based on that calculated for nearby San Diego (Appendix 6), and contributed 0.62% of the total threat (Table 9).

Figure 25 shows the frequency distribution of the standardised risk values (S-RORs) listed in Table 9, with the vertical bars showing the boundaries separating the five categories of risk. This figure shows that the highest and high risk groups each form discrete peaks (on the right side of the plot), which indicates a natural grouping occurred (i.e. not an artificial splitting of a uniform grade). While the moderate risk group also forms a central peak, it is not surprising that the low and lowest risk groups grade into each other. The small peak between S-RORs 0.15 – 0.35 indicates some grouping among the ports of the lowest risk category.

Based on Dalian's current pattern of shipping trade (as represented by the BWRFs collected in 2000-2002), the C1-C4 and ROR results generated by the project-standard method highlight the following:

- Dalian's pattern of trade makes it one of the key regional 'hub' ports of East Asia;
- Dalian appears to receive very little BW transferred directly from distant overseas ports;
- BW arriving in vessels from riverine and warm water ports present much less threat than from open coastline ports in the Bohai and Yellow Sea region, not only because of the latter's high environmental matching but also their shorter voyage durations and higher level of BW transfers.

Thus the take-home message from the project's 'first-pass' risk assessment is that Dalian's trade makes it more prone to introductions of species which 'port-hop' after establishing in one or more of its commonly-traded regional ports in north China, Korea and Japan, rather than by introductions directly from America, Europe or other distant regions. The risk results in Table 9 and Figures 24, 25 appear logical given Dalian's biogeographic location and recent pattern of trade, and therefore indicate that the project standard 'first-pass' treatment of the risk coefficients will provide a very useful benchmark for any investigative manipulations of the risk formula or database management.

The project standard results also imply that any introduced species which establishes in one of the many small and large ports along the Bohai and Yellow Sea coastline could be readily spread by coastal shipping. Thus it would be very worthwhile to obtain port environmental data for many of these ports, so as to allow their C3 coefficients to be calculated rather than estimated for the assessment reported here.

In this context, there is no doubt that northern China is experiencing a number of invasive species, both known and cryptogenic, some of which are contributing to the increased fouling and noxious red tide problems of the intensive mariculture operations which form an important part of its coastal economy. While these problems have so far been most felt in the Bohai Sea due its progressive eutrophication in recent decades, increased fouling and red tide events are being noticed along parts of the Yellow Sea and Korea Bay coastlines (Assoc. Prof. Wang Lijun, pers. comm.) Since China's extensive coastline extends well into the tropics and supports numerous small ports serviced by a large coastal trading fleet, the issue of water-borne parasites and pathogens that threaten commercially cultured species and/or public health also needs to be remembered (their virtual absence from the current risk species database highlights the fragility of the C4 coefficient as well as the difficulty of performing 'reverse' BW risk assessments).

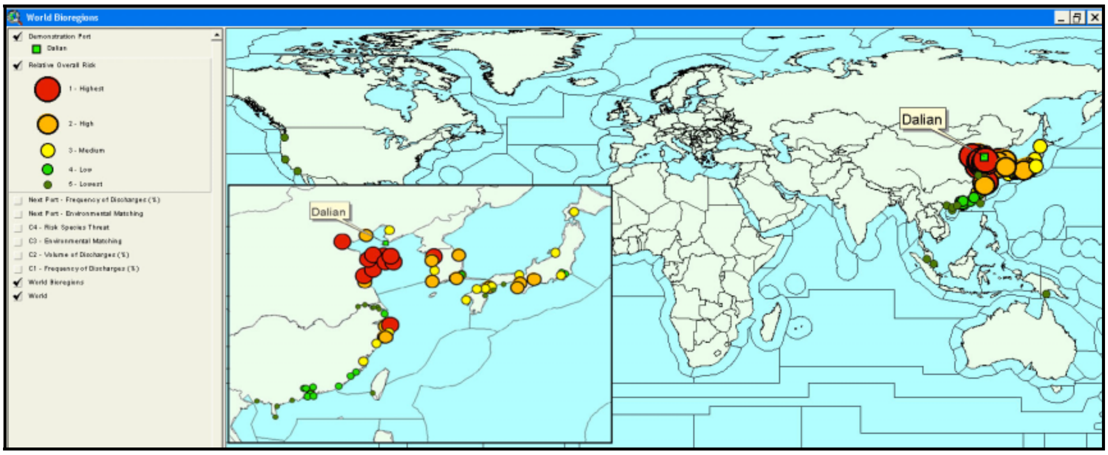

Figure 24. *GIS outputs showing the location and categories of relative overall risk (ROR) of source ports identified for the Port of Dalian*

Table 9. *BW source ports reported for the Port of Dalian, 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.		C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk			
CNYNT	Yantai (Muping) Shandong	China	0.055	0.007	1,000	1.0	0	1.0	0.886		0.467	**0.354**	1.85	1.9	Highest	1.00
CNTAO	Qingdao (Longgang) Shandong	China	0.074	0.013	1,300	1.0	0	1.0	0.823		0.467	**0.344**	1.80	3.7	Highest	0.96
CNLKU	Longkou	China	0.014	0.002	900	0.8	0	1.0	0.890	*E*	0.467	**0.343**	1.80	5.5	Highest	0.95
CNWEI	Wei Hai	China	0.011	0.001	670	0.8	0	1.0	0.890	*E*	0.467	**0.342**	1.79	7.3	Highest	0.95
CNSHD	Shidao Shandong	China	0.028	0.003	533	0.8	0	1.0	0.850	*E*	0.467	**0.337**	1.77	9.0	Highest	0.93
CNRZH	Rizhao (Shijiu) Shandong	China	0.028	0.010	4,000	1.0	0	1.0	0.820	*E*	0.467	**0.331**	1.74	10.8	Highest	0.90
CN005	Laizhou	China	0.002	0.000	140	0.6	0	1.0	0.850		0.467	**0.330**	1.73	12.5	Highest	0.90
CNTSN	Tianjin Tianjin	China	0.035	0.031	15,840	1.0	0	1.0	0.714		0.467	**0.312**	1.64	14.1	Highest	0.82
CN007	Rushan	China	0.002	0.000	213	0.6	9	0.8	0.850	*E*	0.467	**0.306**	1.61	15.7	Highest	0.80
KRINC	Inchon	Korea Republic of	0.028	0.075	26,000	1.0	0	1.0	0.637		0.467	**0.302**	1.58	17.3	Highest	0.78
CNZOS	Zhousan (Dinghai)	China	0.023	0.010	9,587	1.0	1	1.0	0.700	*E*	0.467	**0.300**	1.57	18.9	Highest	0.77
CNNGB	Ningbo Zhejiang	China	0.055	0.020	6,077	1.0	0	1.0	0.656		0.467	**0.299**	1.57	20.4	High	0.77
KRMOK	Mokpo	Korea Republic of	0.002	0.001	1,843	1.0	3	1.0	0.722		0.467	**0.298**	1.56	22.0	High	0.76
JPIWK	Iwakuni Yamaguchi	Japan	0.002	0.020	32,300	1.0	3	1.0	0.710		0.456	**0.297**	1.56	23.6	High	0.76
CNLYG	Lianyungang Jiangsu	China	0.006	0.012	10,568	1.0	2	1.0	0.700	*E*	0.467	**0.296**	1.55	25.1	High	0.76
KRTSN	Taesan	Korea Republic of	0.003	0.013	16,974	1.0	2	1.0	0.700	*E*	0.467	**0.296**	1.55	26.7	High	0.75
CNSHP	Qinhuangdao Hebei	China	0.012	0.002	915	0.8	1	1.0	0.700	*E*	0.467	**0.295**	1.55	28.2	High	0.75
KR001	Hadong	Korea Republic of	0.002	0.007	11,773	1.0	4	1.0	0.700	*E*	0.467	**0.294**	1.54	29.8	High	0.75
KRMUK	Mukho	Korea Republic of	0.002	0.002	2,600	1.0	4	1.0	0.700	*E*	0.444	**0.287**	1.50	31.3	High	0.72
JPNGO	Nagoya Aichi	Japan	0.005	0.026	22,000	1.0	4	1.0	0.651		0.456	**0.284**	1.49	32.8	High	0.70
CNHME	Haimen Zhejiang	China	0.005	0.001	800	0.8	3	1.0	0.650	*E*	0.467	**0.281**	1.47	34.2	High	0.69
JPSAK	Sakai Osaka	Japan	0.003	0.025	22,000	1.0	4	1.0	0.638		0.456	**0.280**	1.47	35.7	High	0.69
CN004	Jiaojiang (Taizhou)	China	0.002	0.000	500	0.8	4	1.0	0.650	*E*	0.467	**0.280**	1.47	37.2	High	0.68
JPSMT	Shimotsu Wakayama	Japan	0.003	0.019	15,550	1.0	4	1.0	0.637		0.456	**0.279**	1.46	38.6	High	0.68
JPKUD	Kudamatsu Yamaguchi	Japan	0.002	0.004	6,300	1.0	4	1.0	0.653		0.456	**0.278**	1.46	40.1	Medium	0.68
JPMAI	Maizuru Kyoto	Japan	0.002	0.000	128	0.6	0	1.0	0.646		0.444	**0.273**	1.43	41.5	Medium	0.66
JPKIJ	Niigata Niigata	Japan	0.002	0.001	1,357	1.0	4	1.0	0.643		0.444	**0.272**	1.43	42.9	Medium	0.65
JPKRE	Kure Hiroshima	Japan	0.002	0.000	699	0.8	6	0.8	0.715		0.456	**0.270**	1.42	44.4	Medium	0.65
CNWNZ	Wenzhou Hubei	China	0.008	0.002	1,100	1.0	3	1.0	0.600	*E*	0.467	**0.269**	1.41	45.8	Medium	0.64
CNBAY	Bayuquan Liaoning	China	0.002	0.000	400	0.6	6	0.8	0.700	*E*	0.467	**0.269**	1.41	47.2	Medium	0.64
JPYOK	Yokohama Kanagawa	Japan	0.006	0.017	25,000	1.0	9	0.8	0.687		0.456	**0.269**	1.41	48.6	Medium	0.64
JPFKM	Fukushima Nagasaki	Japan	0.002	0.016	25,565	1.0	5	0.8	0.684		0.467	**0.269**	1.41	50.0	Medium	0.64
CNFOC	Fuzhou Fujian	China	0.026	0.009	2,100	1.0	3	1.0	0.550	*E*	0.467	**0.263**	1.38	51.4	Medium	0.61
KRONS	Onsan	Korea Republic of	0.012	0.012	6,050	1.0	3	1.0	0.581		0.444	**0.263**	1.38	52.8	Medium	0.61
KRKUV	Kunsan	Korea Republic of	0.002	0.003	4,535	1.0	5	0.8	0.668		0.467	**0.261**	1.37	54.1	Medium	0.61
JPMOJ	Moji (Kitakyushu) Fukuoka	Japan	0.005	0.001	1,044	1.0	0	1.0	0.569		0.467	**0.260**	1.37	55.5	Medium	0.60
CNCWN	Chiwan (Shenzhen) Guangdong	China	0.032	0.083	17,600	1.0	0	1.0	0.490		0.428	**0.258**	1.35	56.8	Medium	0.59
CN009	Shipu	China	0.002	0.000	500	0.8	6	0.8	0.650	*E*	0.467	**0.256**	1.34	58.2	Medium	0.59
JPMUR	Muroran Hokkaido	Japan	0.002	0.009	14,000	1.0	6	0.8	0.669		0.428	**0.255**	1.34	59.5	Medium	0.58
KRUSN	Ulsan	Korea Republic of	0.003	0.022	19,120	1.0	3	1.0	0.546		0.444	**0.254**	1.33	60.9	Low	0.57
CNSHA	Shanghai (Shihu) Shanghai	China	0.106	0.072	13,025	1.0	1	1.0	0.370		0.467	**0.254**	1.33	62.2	Low	0.57
CNSHK	Shekou Guangdong	China	0.026	0.066	21,517	1.0	0	1.0	0.490	*E*	0.428	**0.253**	1.32	63.5	Low	0.57
CNCAN	Guangzhou Guangdong	China	0.066	0.053	24,000	1.0	0	1.0	0.445		0.428	**0.248**	1.30	64.8	Low	0.55
CNZUH	Zhuhai Guangdong	China	0.025	0.089	17,750	1.0	4	1.0	0.450	*E*	0.428	**0.248**	1.30	66.1	Low	0.55
CNQZJ	Quanzhou (Jinjiang) Fujian	China	0.012	0.003	1,700	1.0	4	1.0	0.500	*E*	0.467	**0.245**	1.29	67.4	Low	0.54
JPTYO	Tokyo Tokyo	Japan	0.002	0.000	184	0.6	7	0.8	0.609		0.456	**0.244**	1.28	68.7	Low	0.53
JPCHB	Chiba Chiba	Japan	0.002	0.009	15,047	1.0	14	0.6	0.685		0.456	**0.242**	1.27	69.9	Low	0.53
CNSWA	Shantou (Chaoyang) Guandong	China	0.017	0.005	1,700	1.0	0	1.0	0.450	*E*	0.467	**0.235**	1.23	71.2	Low	0.49
KRPUS	Pusan	Korea Republic of	0.014	0.014	16,596	1.0	1	1.0	0.441		0.467	**0.234**	1.23	72.4	Low	0.49
CNHUA	Huangpu (Xinzao) Guangdong	China	0.032	0.056	24,000	1.0	3	1.0	0.414		0.428	**0.232**	1.22	73.6	Low	0.48
CNMWN	Mawan Guangdong	China	0.002	0.000	300	0.6	0	1.0	0.490	*E*	0.428	**0.230**	1.21	74.8	Low	0.47
JPOSA	Osaka Osaka	Japan	0.003	0.007	11,171	1.0	12	0.6	0.619		0.456	**0.226**	1.18	76.0	Low	0.46
HKHKG	Hong Kong	Hong Kong	0.045	0.014	3,800	1.0	0	1.0	0.415		0.428	**0.225**	1.18	77.2	Low	0.45
CNXMN	Xiamen (Weitou) Fujian	China	0.012	0.007	2,200	1.0	5	0.8	0.500	*E*	0.467	**0.223**	1.17	78.4	Low	0.44
CN013	Xiangshui	China	0.005	0.001	500	0.8	2	1.0	0.450	*E*	0.428	**0.221**	1.16	79.5	Low	0.43
CNTGU	Tanggu Tianjin	China	0.003	0.013	20,433	1.0	1	1.0	0.400	*E*	0.467	**0.221**	1.16	80.7	Lowest	0.43
TWKHH	Kaohsiung	Taiwan Province of China	0.002	0.011	18,108	1.0	2	1.0	0.437		0.428	**0.219**	1.15	81.8	Lowest	0.43
USLGB	Long Beach California	United States	0.003	0.002	2,200	1.0	19	0.6	0.623		0.389	**0.215**	1.13	83.0	Lowest	0.41
JPMYJ	Matsuyama Ehime	Japan	0.003	0.009	7,485	1.0	153	0.2	0.714		0.456	**0.204**	1.07	84.0	Lowest	0.36
USSFO	San Francisco California	United States	0.002	0.013	20,701	1.0	386	0.2	0.652		0.700	**0.202**	1.06	85.1	Lowest	0.35
CNZJG	Zhangjiagang Jiangsu	China	0.005	0.002	2,626	1.0	2	1.0	0.330	*E*	0.467	**0.201**	1.05	86.1	Lowest	0.35
JPSAG	Saganoseki Oita	Japan	0.002	0.001	873	0.8	15	0.6	0.521		0.456	**0.199**	1.04	87.2	Lowest	0.34
CNNKG	Nanjing Jiangsu	China	0.012	0.012	5,000	1.0	2	1.0	0.300	*E*	0.467	**0.198**	1.04	88.2	Lowest	0.34
CNJIA	Jiangyin Jiangsu	China	0.052	0.026	6,446	1.0	0	1.0	0.200	*E*	0.467	**0.186**	0.98	89.2	Lowest	0.29
JPMIZ	Mizushima Okayama	Japan	0.002	0.020	32,085	1.0	369	0.2	0.628		0.456	**0.185**	0.97	90.2	Lowest	0.28
CNCGU	Changshu	China	0.002	0.000	200	0.6	5	0.8	0.350	*E*	0.467	**0.181**	0.95	91.1	Lowest	0.27
SGSIN	Singapore	Singapore	0.002	0.001	1,836	1.0	6	0.8	0.423		0.372	**0.181**	0.95	92.1	Lowest	0.26
CNHAK	Haikou Hainan	China	0.003	0.002	2,000	1.0	9	0.8	0.350	*E*	0.428	**0.174**	0.91	93.0	Lowest	0.24
CNNTG	Nantong Jiangsu	China	0.022	0.009	2,000	1.0	2	1.0	0.200	*E*	0.467	**0.174**	0.91	93.9	Lowest	0.24
CNYJI	Yangjiang Guandong	China	0.002	0.002	3,100	1.0	6	0.8	0.350	*E*	0.428	**0.174**	0.91	94.8	Lowest	0.24
CNZHA	Zhanjiang Guangdong	China	0.002	0.001	1,600	1.0	5	0.8	0.350	*E*	0.428	**0.174**	0.91	95.7	Lowest	0.23
CNFAN	Fangcheng (Qinzhou) Guangxi	China	0.002	0.002	3,200	1.0	7	0.8	0.300	*E*	0.428	**0.161**	0.85	96.6	Lowest	0.18
CNZHE	Zhenjiang Zhejiang	China	0.005	0.002	1,700	1.0	5	0.8	0.200	*E*	0.467	**0.145**	0.76	97.3	Lowest	0.11
MYPKG	Port Kelang	Malaysia	0.002	0.000	330	0.6	11	0.6	0.326		0.372	**0.138**	0.72	98.0	Lowest	0.08
USBCC	Vancouver Washington	United States	0.002	0.000	380	0.6	151	0.2	0.396		0.700	**0.134**	0.71	98.7	Lowest	0.07
PGDAU	Daru	Papua New Guinea	0.002	0.000	787	0.8	30	0.4	0.388		0.228	**0.120**	0.63	99.4	Lowest	0.01
USLAX	Los Angeles California	United States	0.002	0.000	305	0.6	146	0.2	0.395	*E*	0.389	**0.119**	0.62	100.0	Lowest	0.00

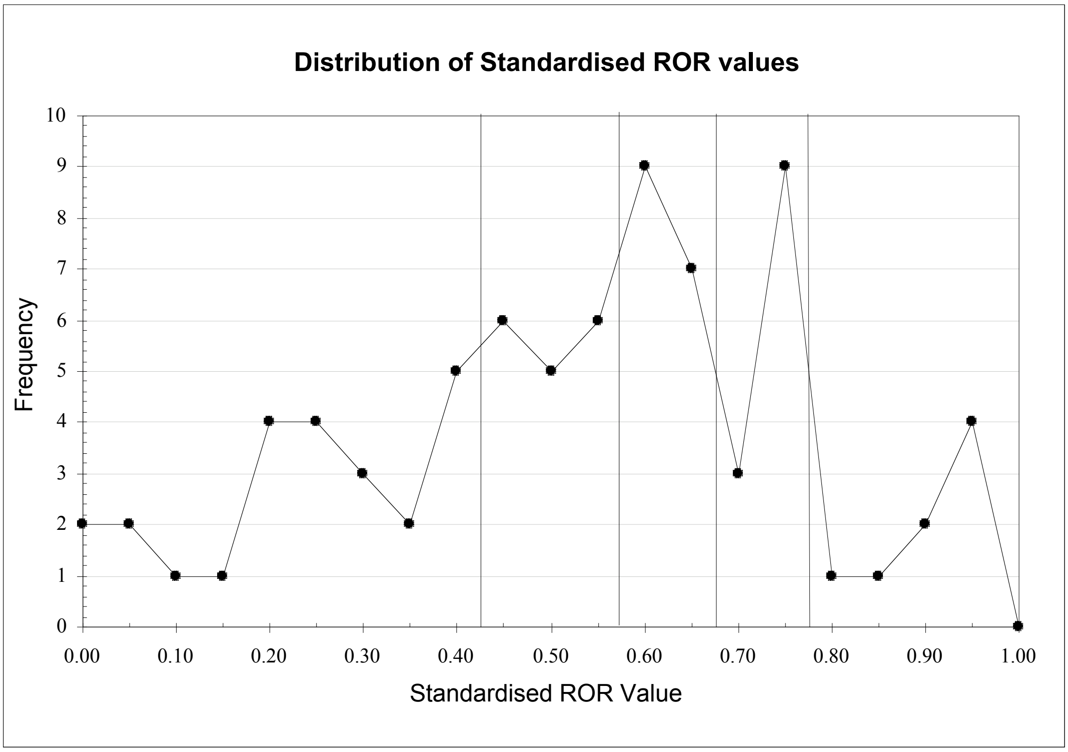

Figure 25. *Frequency distribution of the standardised ROR values*

Reverse BWRA

There is no doubt that Dalian 'exports' significant volumes of ballast water, much of which appears destined for regional ports via bulk carriers departing from the various grain, coal and oil import berths, plus smaller quantities in many of the ships that depart from the container and ro-ro berths at Dagang, Heshangdao (Dalianwan) and Dayaowan terminals (Appendix 7). The most important BW destination ports appear to be Tianjin in the north Bohai Sea and both Qingdao and Inchon which face the Yellow Sea coastline (Figure 2; also Section 4.5). These ports also have relatively high environmental matching values with Dalian, all of which were calculated (0.64-0.82; Table 5). This suggests any harmful species that establishes a viable population in Dalian has a more than reasonable chance of 'port-hopping' to these and ports via BW-mediated transfers. In the case of the risk species assigned to the Dalian bioregion the vast majority are already widely distributed in East Asia. However any new suspected harmful phytoplankton or fouling species that appears in Dalian may represent the type of species likely to exert the most potential impact if translocated to ports in the Bohai Sea, Yellow Sea and Sea of Japan (i.e. bioregions NWP-3a, NWP-4a, NWP-4c; Figure 7), particularly owing to the high level of fouling-growth sensitive mariculture and industrial infrastructure in these regions.

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 Liaoning MSA office in Dalian. This PC, plus others made available from MSA for port map development and group demonstrations, proved reliable and adequate for running the database, undertaking the similarity analyses, displaying the GIS maps and results and providing other project needs.

Most counterparts had had sufficient experience in the routine use of MS Windows applications to pick up the use of the Access database with difficulty. The GIS mapping work was new to the MSA counterparts of Group A (Appendix 2), but sufficient guidance and assistance was provided by the

DMU and URS counterparts in this Group for them to become familiar with the use of ArcView, digitising and geo-referencing new data, the types of theme layers recommended for the port map and how to housekeep the various metafiles. It is therefore considered that the close relationship between the Liaoning MSA and DMU provides a strong capacity-base for China to produce similar port resource maps for future BWRA, PBBS and/or other BW management activities and demonstrations in the region.

MSA counterparts of Group B quickly mastered the use of the Database and undertook the onerous task of entering nearly 3,200 BWRFs, a total far exceeding that of the other Pilot Country demonstration sites. As noted in Section 3.6, the most easily-trained and efficient database operators are those with port and maritime work experience, plus previous hands-on experience with Windows applications, and this was the case at Dalian. This is not to say that Group B did not encounter the same types of BWRF data entry problems experienced at the other Demonstration Sites (Section 4.11). For example, the decision by Group B counterparts to use five separate databases to allow simultaneous BWRF entries for different terminal areas led to the same problem experienced at the Mumbai Demonstration Site, namely the time wasted in duplicating ship and port details and the technically challenging difficulties of merging complex Access databases[19].

Group B also encountered but eventually overcame some technical data-entry and database calculation problems unique to Dalian. These stemmed from the wide mix of Chinese (yy-mm-dd), English (dd-mmm-yy) and US (mm-dd-yy) date formats in the BWRFs, which caused erroneous database calculations and Access/Windows-OS problems despite warnings and advice provided by the consultants during and after the first country visit. Another issue was the difficulty in relocating original BWRFs to double-check dates actually recorded by the ships' officer. The date format problem was eventually overcome by a multi-step approach led by the consultants during their second visit, and the database provided in the third visit was further modified to only accept date entries with a complete "dd-mmm-yyyy" format, to ensure no further potential for any confusion and Access/Windows conflicts. Random checks of 50 BWRFs also confirmed that, apart from the date format confusion, there had been a high level of data-entry accuracy for the other data fields.

Group C received instruction in the approach and methods of the environmental similarity analysis using the PRIMER package during the in-country visits by the consultants, with intensive 'hands-on' training provided in the second visit. Group C lead counterpart Mr Zhang Jiu Xin mastered the use of the Excel spreadsheets and PRIMER package for undertaking the multivariate environmental similarity analysis, checking the results and then generating the environmental matching coefficients for Group B to insert into the database. Other Group C members focussed on the way to add/edit risk species data, and the calculations used for the project-standard risk assessment. All Group C counterparts contributed to the collation of the port environmental data required for Dalian and six other Chinese ports. The risk species information was collated by Group C counterpart Mr Wang Lijun, who was also a senior member of the Dalian PBBS team, plus URS (Section 4.7).

Near the end of the consultants second visit the Dalian counterparts presented a very successful demonstration and briefing of the total BWRA system and its initial risk results to the Deputy Director General of the Liaoning MSA, three representatives from the Marine Environment Monitoring Centre of the State Oceanic Administration, Professor Zhang from Dalian Maritime University plus nine other representatives from DMU and interested agencies. The good ability of the key team members to demonstrate and explain the system in Mandarin was confirmed by this detailed presentation which lasted more than 3 hours. A productive 'lessons-learned' session was subsequently held by the project team and consultants on the final day.

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[19] Merging the five separate databases took over three days to complete during the consultants second visit, because of the need to remove duplicated vessel, port and country data, and to completely re-organise the unique identifiers and then check all tables for linking errors. While BWRF entries should only be made into one database for a port, a single database can be loaded onto a network server to allow convenient multi-user access.

4.10 Identification of information gaps

Ballast Water Reporting Forms

As noted in Section 4.9, inattentive or hasty completion of the IMO-style BWRFs in busy East Asian ports such as Dalian can lead to date confusions because of the differing formats, and not all fields in the BWRF provide a date format guide (Appendix 1). It was also clear that many ship's did not complete BWRFs correctly or logically, particularly with respect to tank source, exchange and discharge data. While many of these errors were spotted and fixed, this demanded considerable time and effort. Such waste of resources will re-occur unless more importance is attached to explaining to ships what is required, and for port or MSA officials to scrutinise forms at the point of collection and refuse to accept them if they have illogical or missing data in the key fields. It also became apparent that not all product tankers visiting the Siergou Terminal to load refined products were reporting all BW discharges made at the berths or just after their departure, a feature picked up and noted by the MSA counterparts.

In general, the Dalian database indicates that BWRFs containing many empty or incorrect entries for BW source/s, uptake date/s and tank volumes intended to be discharged were not as common as those collected at other Demonstration Sites where BWRFs had been submitted on a more voluntary basis. It had been planned to conduct an error analysis of the Dalian BWRFs during the second country visit, but the need to merge five complex databases and resolve the mixture of date formats (Section 4.9) prevented this. However the following list summarises common omissions or mistakes in submitted BWRFs that were noted, many of which also encountered at the other Demonstration Sites:

- BW uptake date, source port/location and/or discharge volume provided for none, one, or only a few of the total number of tanks considered most likely to have been discharged (especially at the Siergou Terminal).
- Illogical dates and confusing mixes of date formats, some easy to resolve quickly but other impossible to fix with surety (e.g. 01-03-02).
- 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%).

The above summary shows which items are immediately worth checking by MSA officers whenever collecting or receiving BWRFs. Unless guidance is provided and errors corrected, ships' officers, shipping agents and port officers will not become familiar with and effectively use the BWRF process.

Apart from lack of BWRF familiarity, the time provided for a ships' officer to complete a form is another factor influencing 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. For example, the level of reporting could be improved if the MSA or shipping agents can arrange to send reminders, a guidance sheet and blank forms (where necessary) to ships 1-2 days prior to arrival. Unless BWRFs are completed accurately and fully by vessels visiting Dalian, a significant percentage of BW sources and discharge volumes will remain unclear for future BWRA studies. For example, in the case of the Dalian study the volume of unidentified BW discharges was 11%, which was larger than the 8.9% of the leading source port (Table 3).

Even with correctly completed forms, it is very difficult and often impossible to identify with any useful certainty the ultimate destination of BW uplifted by a port that relies only on BWRF collection and analysis (Section 3.5). This is important since one of the objectives of the GloBallast BWRA was to identify the destinations of BW uplifted at each Demonstration Site, which is a fundamental requirement for any 'reverse' risk assessment. In fact several of the GloBallast BWRA objectives required considerable effort in checking and fixing BWRF errors, plus searching and/or deducing the following information which is not available from a standard BWRF:

- 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).
- Destination Port/s where either BW will be discharged or cargo actually offloaded (not necessarily the Next Port of Call).

It is therefore recommended that the 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 very developed regions (e.g. North America, Europe and Japan) as it was for less developed areas. Most of China's ports are not exceptions to this finding. In fact Group C counterparts frequently commented on the difficulty in locating reliable sources for the basic seasonal water temperature and salinity data needed for major and nearby ports such as Yantai in the neighbouring province of Shandong.

Dalian's Group C counterparts also confirmed there is very limited knowledge of aquatic risk species (both introduced and native) among marine academics and research agencies along China's coastline. This appears to have been caused by:

- historical lack of networking, coordination and cooperation between marine institutions and universities;
- very few natural history museums with marine curators (none present in Liaoning Province);
- very few comprehensive marine species surveys undertaken along China's coast; and
- the relatively few number of Chinese marine biologists who have gained specialist marine taxonomic knowledge, including good experience with the international binomial (Linnean) system of species classification.

In the case of aquatic risk species data beyond China, many national and regional data sets remain incomplete and/or unpublished, while many sites covering locations in North America, the Caribbean, Europea, Asia and Australasia list species which were historically introduced by the aquaculture, fisheries or aquarium industries or hull fouling vector. Many do not identify the likely vector/s of their listed species.

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 March 2003). The level of port and maritime experience brought to the project by the various Dalian counterparts, including the GIS and environmental expertise from DMU and NMEPMC, considerably facilitated effective instruction and familiarisation of the BWRA system. In addition, some of the team members are hoping to repeat the exercise for another port in the north China region.

Continuing work in ballast water management projects will enable China to provide assistance, technical advice, guidance and encouragement to other port States in East Asia, and allow it to maintain a leading and coordinative role. A key task will for China to expand its base of marine scientists who can become more familiar with coastal species surveys and obtain valuable marine taxonomic expertise if provided funds and encouragement to undertake more field survey work and international networking.

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 and analysis of BWRF data. Items requiring critical attention for future BWRA and/or associated BW management activities in the East Asian region should include:

- availability and promulgation of guidelines and instructions about BWRF reporting to ship's officers, shipping agents and port officers;
- the need for BWRF checking /verification procedures;
- the potential reliability and cost-saving benefits from implementing electronic BWRF reporting systems in place of laborious and error prone paper-based BWRF collation methods
- the value of developing and testing more sophisticated systems involving automatic electronic/GPS/satellite linked BW discharge transmissions;
- virtual lack of comprehensive port species surveys (PBBSs) in China, Korea and Russia (and surprisingly few in Japan);
- lack of reliable port water temperature and salinity data for the major seasons, even for major ports;
- lack of a regional web-based database for exchanging and updating species survey information.

Regional organisations, port authorities and major national shipping companies in the region should be encouraged to support efforts in the above areas.

5.1 Recommendations

- To identify the locations where BW is discharged within a port, a more useful paper or electronic BWRF should include an entry for the berth or terminal name/number (instead of simply 'Port' and/or geographic coordinates, which was usually left blank).
- Modifying the "Last Port of Call" field to provide a "Last Three (3) Ports of Call" question would assist paper/electronic BWRF verification checking and analysis for part-loaded vessels visiting multi-use terminals.
- 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, and to decline any Ballast Water Management Plan offered by the vessel in lieu of a BWRF. A short BWRF information

kit and training course provided to port officers and local shipping agents is strongly recommended, particularly during the implementation of the BWRF system at any port.

- To help decipher and interpret incomplete or suspect BWRFs, BW database entry and management officers should always have access to up-to-date copies of the *Lloyds Ship Register*, *Fairplay Ports Guide, Lloyd's Maritime Atlas of World Ports* or equivalent publications. For ports using the GloBallast BWRA system, a copy of the world bioregions map should also be provided so that the bioregion of any new port added to the database can be quickly identified.
- To ensure cost-effective training in BW reporting and management requirements, people with a sound knowledge and practical experience of port and shipping operations should always be selected in preference to newcomers, with latter more acceptable for carefully supervised apprentice roles.

5.2 BWRA recommendations and plans by Pilot Country

- **Continuation of BWRF collecting, database updating and capacity-building of relevant personnel**. Collection of BWRFs at Dalian has continued following completion of the BWRA project, with some of the newly collected BWRFs already added to the database. To facilitate future work and expected implementation of IMO's new BW Convention, collecting BWRFs from ships and database updating will be continued. Because existing Group B members are officers of the Liaoning MSA who are also responsible for other ship control activities, more people (especially newcomers) are planned to be trained for maintaining and operating the database, GIS and related software at Dalian.
- **Expansion of the IMO BWRFs and database establishment at other major ports**. Some ports in China have already expressed their intention to use IMO BWRFs for their ballast water reporting needs, and the reporting form currently used by the Chinese Quarantine Authority can include all of the information requested by the IMO BWRF through small modifications. By the end of 2002, about 3,500 BWRFs had been collected in the Port of Qinhuangdao (another major port in the Bohai Sea), so it is possible to establish a similar BW database at that port. A proposal has therefore been made to the China MSA (Beijing), that BWRFs be collected in the major ports with databases progressively established to accommodate this information, and that the Liaoning MSA members of the Group B BWRA project team can provide assistance in this regard.
- **Inclusion of BW reporting, information collecting and training into the National Regulations now under consideration for implementing the IMO BW Guidelines and expected new Convention**. The Ministry of Communications is considering formulating Provisional Regulations for the Management and Control of Ship's BW and Sediments at the ministerial level. The proposed Regulations include a requirement for ships' BW reporting and training of onboard personnel, BW information collecting, preventive measures, control procedures and a ship-specific BW management plan.
- **Replication of BWRA in other ports**. The China MSA will consider replicating the BWRA in some selected major ports. The Port of Qinhuangdao may be the first for this activity because it has already collected sufficient BWRFs.

6 Location and maintenance of the BWRA System

The GloBallast BWRF hardware and software packages in China are presently maintained by Liaoning MSA staff at their offices in Dalian. The following people are currently responsible for maintaining and updating the following features of the BWRA system in China:

Port resource mapping and GIS display requirements:

Name:	Ms Xu Xiaoman
Organisation:	Liaoning Maritime Safety Administration
Address:	Dalian, Changjiang Road 25# Liaining Province, P.R. China 116001
Tel:	
Fax:	
Email:	Xu_xiaoman@hotmail.com

Ballast water reporting form database:

Name:	Mr Liu Yan (Rock)
Organisation:	Liaoning Maritime Safety Administration
Address:	Dalian, Changjiang Road 25# Liaining Province, P.R. China 116001
Tel:	
Fax:	
Email:	rock_liuy123456@hotmail.com

Port environmental and risk species data:

Name:	Mr Zhanj Jiu Xin
Organisation:	Liaoning Maritime Safety Administration
Address:	Dalian
Tel:	
Fax:	
Email:	wffwk_lndl@sina.com

Name:	Assoc Prof Wang Lijun
Organisation:	National Marine Environment Protection & Monitoring Centre
Address:	State Administration of Oceanography, Dalian
Tel:	
Fax:	
Email:	ljwang@nmemc.gov.cn

References

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

Carlton, J.T. 1996. Biological invasions and cryptogenic species. *Ecology* 77: pp. 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.

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?
TOTAL NO. OF TANKS ON BOARD_______ NO. OF TANKS IN BALLAST_______ IF NONE IN BALLAST GO TO NO. 5 YES_____ NO_____
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 Port of Dalian, P R China

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 activities of the three groups were coordinated by Mr Zhao Dianrong (China Maritime Safety Administration, Beijing), Mr Zhao Dexiang (Liaoning Maritime Safety Administration, Dalian) and Dr Rob Hilliard (URS Australia Pty Ltd).

Group A (GIS mapping)

Person: Ms Xu Xiaoman
Position: Group A Leader
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Email: Xu_xiaoman@hotmail.com

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

Person: Professor Xiong Deqi
Position Group A – provision of GIS file data
Organization: Department of Geography, Dalian Maritime University, Dalian
Email: xiongdq@dlmu.edu.cn

Person: Ms Jin Xiumei
Position: Group A – GIS cartography trainee
Organization: Liaoning Maritime Safety Administration, Dalian

Person: Mr Ji Shan
Position: Group A – GIS cartography trainee
Organization: Liaoning Maritime Safety Administration, Dalian

Group B (Database BW records)

Person: Mr Liu Yan
Position: Group B Leader – Database management
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Person: Mr John Polglaze
Position: Group B Counterpart trainer
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Email: john_polglaze@urscorp.com

Person: Ms Li Xia
Position: Group B – BW report form data entries
Organization: Liaoning Maritime Safety Administration, Dalian

Person: Mr Zhang Chunlong
Position: Group B – BW report form data entries.
Organization: Liaoning Maritime Safety Administration, Dalian

Group C (port environment and risk species data)

Person: Mr Zhanj Jiuxin
Position: Group C Coordinator and environmental similarity analysis
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Email: wffwk_lndl@sina.com

Person: Dr Robert Hilliard
Position: Group C Counterpart trainer
Organization: URS Australia Pty Ltd
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Person: Assoc. Prof. (Biol.) Wang Lijun
Position: Group C – collation of risk species data and environmental similarity analysis
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Person: Mr Jiang Yuewen
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Email: yjiang@nmemc.gov.cn

Person: Professor Zhang Shuohui
Position: Group C – port environment data and environmental similarity analysis
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Team translators

Person: Dr Lin Kaiyu
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Person: Mr Zhao Ji
Position: Technical translation assistance – 2nd consultants visit
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Project Manager

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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

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(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 <u>usually</u> 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 <u>essential</u> 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)	Shipping record & port data specialist
Port environmental data searcher (x2)	
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 (°C)
- Maximum water temperature at the hottest time of the summer [monsoon] season (°C)
- Mean water temperature during the winter [dry] season (°C)
- Minimum water temperature at the coldest time of the winter [dry] season (°C)

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

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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 (°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
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		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
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 Deg	Latitude Min	N/S	Longitude Deg	Longitude Min	E/W	Port Type	Water Temperatures (°C) [WT] Mean Summer	Water Temperatures (°C) [WT] Maximum Summer	Water Temperatures (°C) [WT] Mean Winter	Water Temperatures (°C) [WT] Lowest Winter	Summer Air Temp°C [SART] Mean day-time	Summer Air Temp°C [SART] Maximum daytime	Winter Air Temp °C [WART] Mean night-time	Winter Air Temp °C [WART] Lowest night-time	Salinities (g/L) [SAL] Mean in Wet period	Salinities (g/L) [SAL] Lowest in Wet period	Salinities (g/L) [SAL] Mean in Dry period	Salinities (g/L) [SAL] Max in Dry period	Tidal Ranges (m) Mean Springs	Tidal Ranges (m) 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)	Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	Intertidal Habitats [I]						Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%						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… Driest 6 months	Wettest 6 months	No. of months for 75%	Distance to River Mouth (km)	Size of River Catchment (km^2)	Intertidal Habitats [I] 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	Shallow Subtidal Habitats (S) 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

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	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

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	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
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 (Tutuncifilik 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... Driest 6 months	Wettest 6 months	No. of months for 75%	Distance to River Mouth (km)	Size of River Catchment (km^2)	Intertidal Habitats [I] 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	Shallow Subtidal Habitats (S) 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

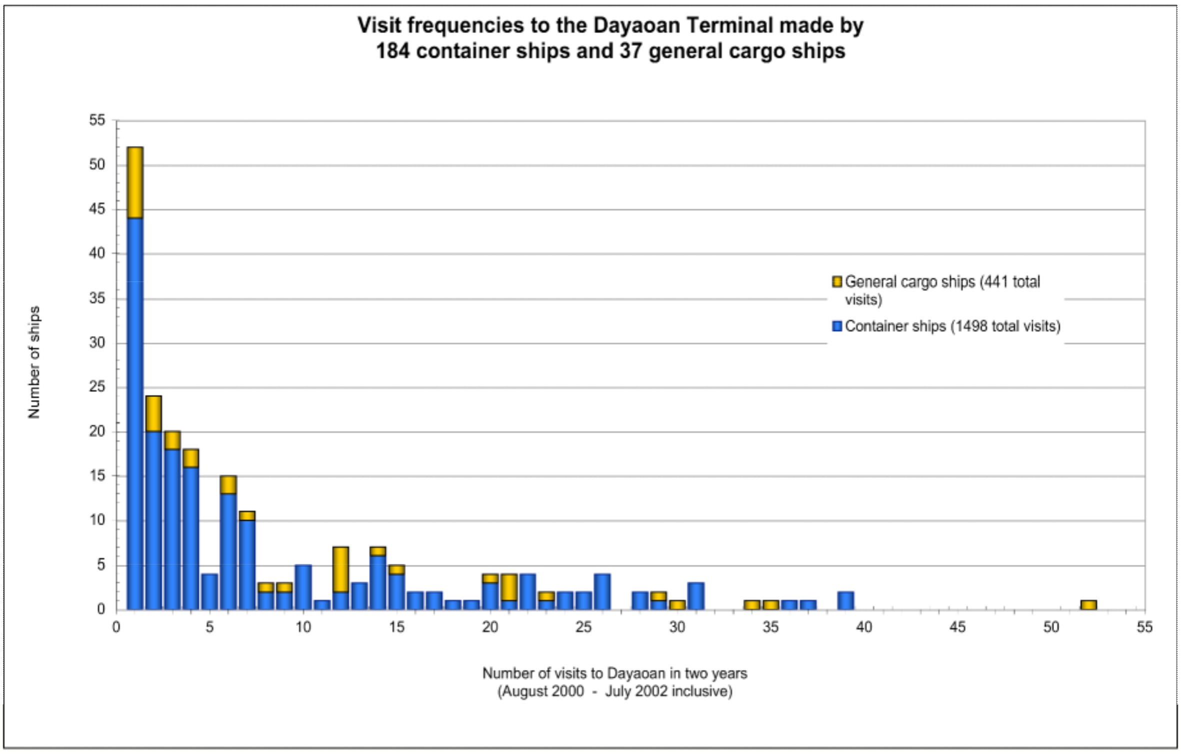
APPENDIX 7

Ships, trade and ballasting statistics for the multi-use Dayaowan terminal at Dalian

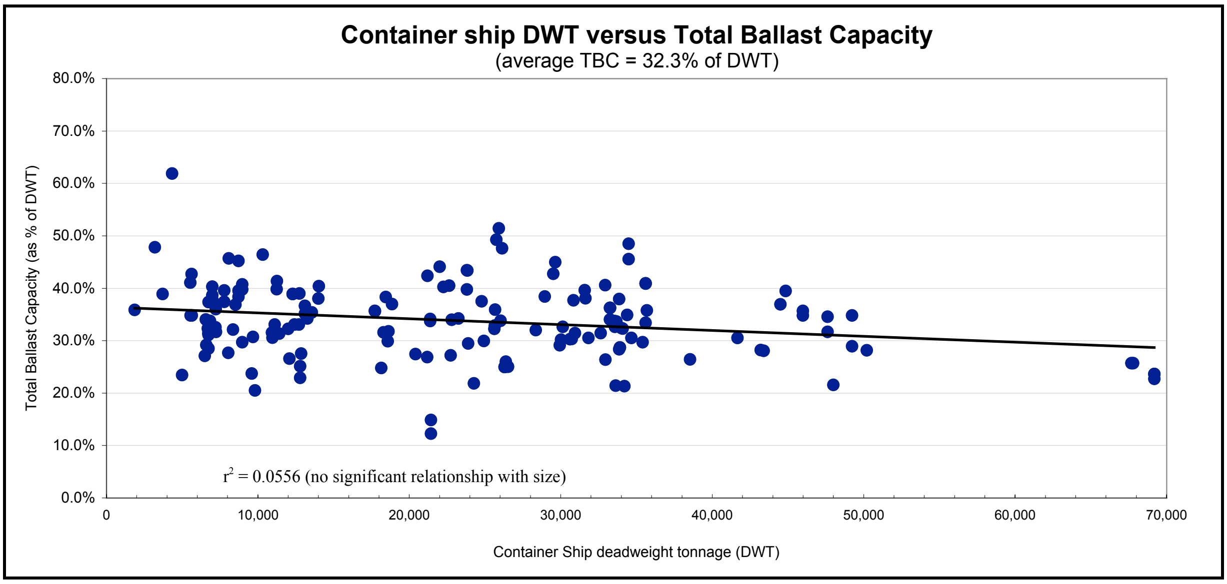
This Appendix presents summary statistics on the visit frequencies and ballast data of the three main ships types visiting the Dayaowan multi-purpose terminal at Dalian between August 2000 and July 2002.

	Type	Number of BWRF records	No. of ships
Main types	Container Ship	1498*	184
	General Cargo Ship	441*	37
	Bulk carrier	47*	38
Minor types	Vehicles carrier/Ro-Ro	30	16
	Reefer	1	1
	Product/chemical tanker	3	3
	Total	2020	279

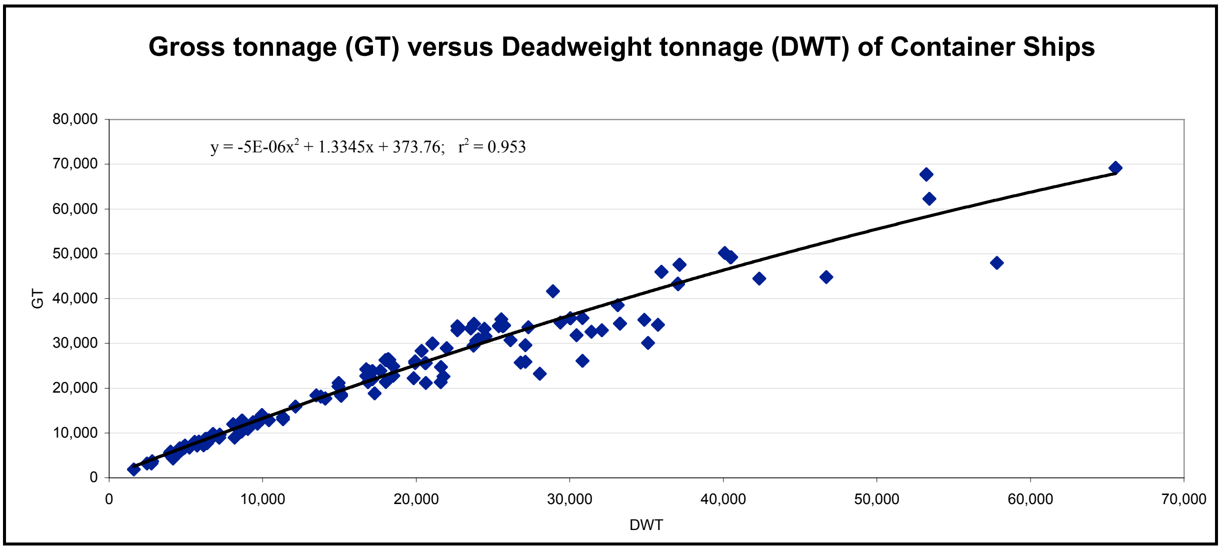
The visit frequency plot shows that the majority of container and general cargo ships made return visits to Dayaowan, with only 52 of 221 (23%) of these vessels making a single visit during the two period. The majority of visits are associated with regular services (liner trade) to/from ports in Korea, Japan and China.



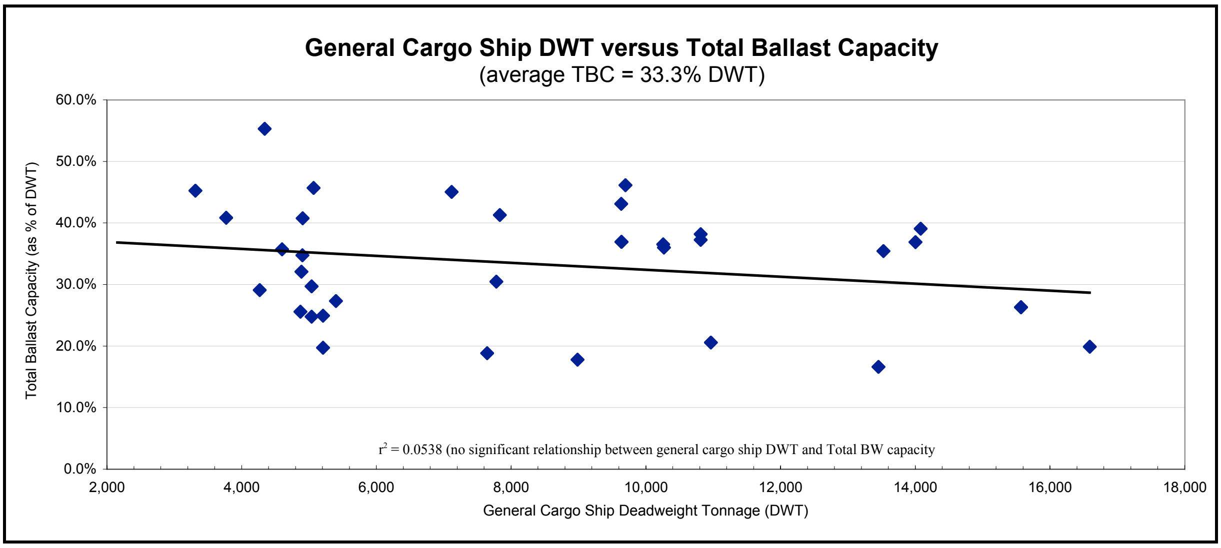
The following plots show range of ballasted condition of arriving container and general cargo ships, and relationships between Deadweight Tonnage (DWT) and Total Ballast Capacity (as % of DWT), and Gross Tonnage (GT).



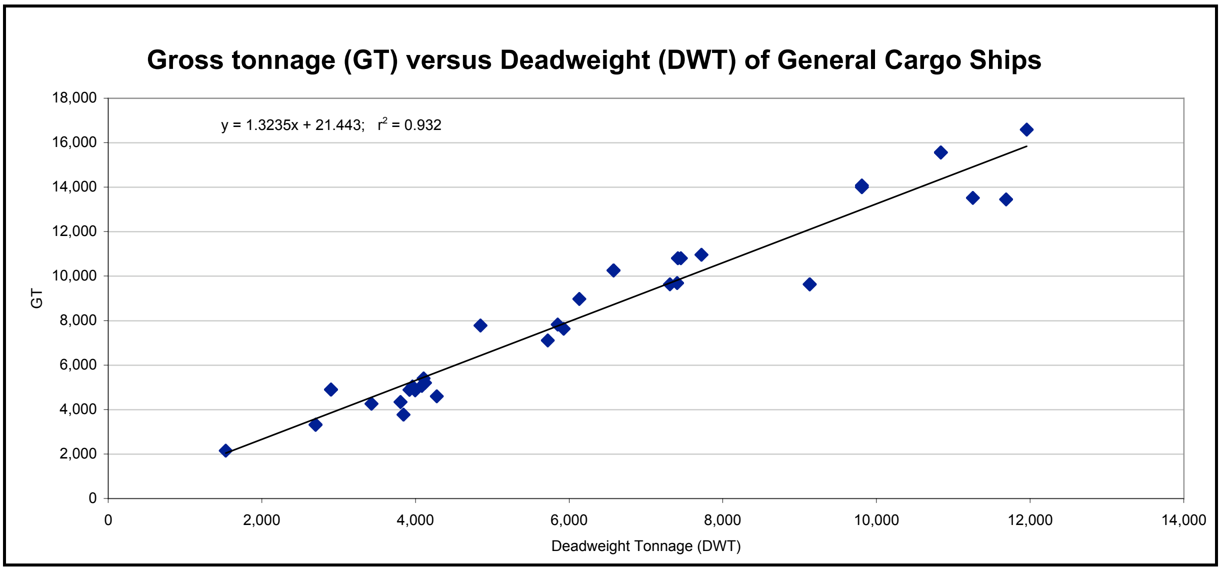
Container ship DWT versus Total Ballast Capacity
(average TBC = 32.3% of DWT)
Total Ballast Capacity (as % of DWT)
r² = 0.0556 (no significant relationship with size)
Container Ship deadweight tonnage (DWT)

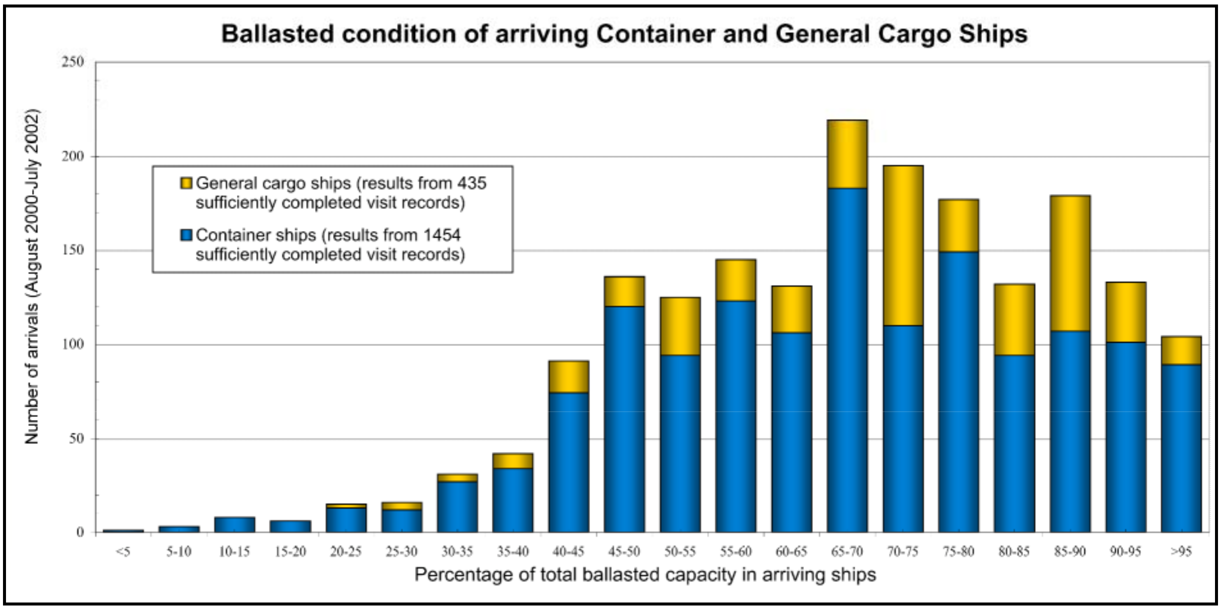


Gross tonnage (GT) versus Deadweight tonnage (DWT) of Container Ships
y = -5E-06x² + 1.3345x + 373.76; r² = 0.953
GT
DWT

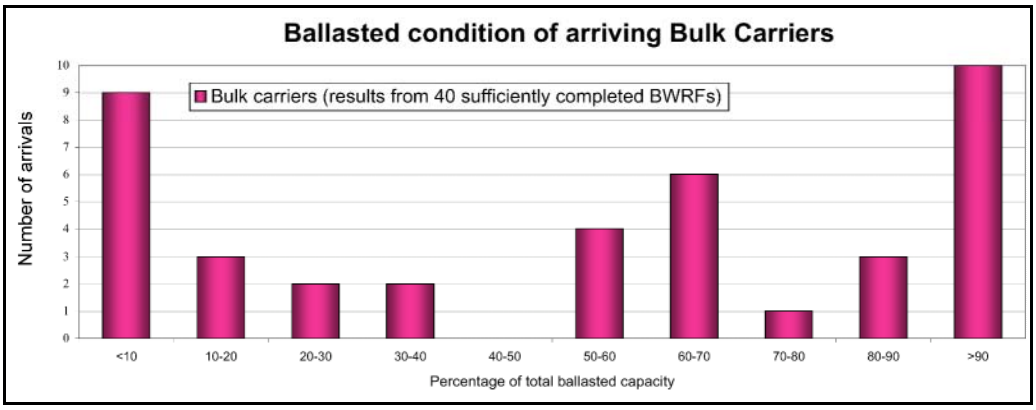


General Cargo Ship DWT versus Total Ballast Capacity
(average TBC = 33.3% DWT)
Total Ballast Capacity (as % of DWT)
r² = 0.0538 (no significant relationship between general cargo ship DWT and Total BW capacity
General Cargo Ship Deadweight Tonnage (DWT)





No of container ships less than 50% ballasted = 298	(20.5%)	No. of general cargo ships less than 50% ballasted = 51	(11.7%)
No of container ships less than 60% ballasted = 515	(35.4%)	General cargo ships less than 60% ballasted = 104	(23.9%)
No of container ships over 80% ballasted = 391	(26.9%)	No. of general cargo ships over 80% ballasted = 157	(36.1%)



APPENDIX 8
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 satisfactorily.

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

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