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Ballast Water Risk Assessment

Port of Sepetiba
Federal Republic of Brazil

DECEMBER 2003

Final Report

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GEF UNDP IMO URS MERIDIAN

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

ANVISA	Agência Nacional de Vigilância Sanitária (National Agency for Health Surveillance)
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)
CDRJ	Companhia Docas do Rio de Janeiro (Rio de Janeiro Port Company)
CFP	Country Focal Point (of the GloBallast Programme in each Pilot Country)
CFP/A	Country Focal Point Assistant
CRIMP	Centre for Research on Introduced Marine Pests (now part of CSIRO Marine Research, Hobart, Tasmania)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DSS	Decision support system (for BW management)
DWT	Deadweight tonnage (typically reported in metric tonnes)
FEEMA	Fundação Estadual de Engenharia do Meio Ambiente (Foundation for the Study of Environmental Engineering)
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
IEAPM	Instituto de Estudos do Mar Almirante Paulo Moreira (Admiral Paulo Moreira Institute of Marine Studies)
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IUCN	The World Conservation Union
LAT	Lowest Astronomical Tide
MESA	Multivariate environmental similarity analysis
MEPC	Marine Environment Protection Committee (of the IMO)
NEMISIS	National Estuarine & Marine Invasive Species Information System (managed by SERC)
NIMPIS	National Introduced Marine Pests Information System (managed by CSIRO, Australia)
NIS	Non-indigenous species
OBO	Ore/bulk oil tankers (an rather unsuccessful vessel class now used for oil transport only)
OS	Operating System (of any personal or mainframe computer)
PCU	Programme Coordination Unit (of the GloBallast Programme based at IMO London)
PRIMER	Plymouth Routines In Marine Environmental Research
PBBS	Port Biological Baseline Survey
ROR	Relative overall risk
SAP	(Regional) Strategic Action Plan
SERC	Smithsonian Environmental Research Center (United States)
VLCC	Very large crude carrier (200,000 – 300,000 DWT)
UFRJ	Universidade Federal Rio de Janeiro (Federal University of Rio de Janeiro)
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 Sepetiba, which is the Demonstration Site for the Federal Republic of Brazil, managed by Companhia Docas do Rio de Janeiro (CDRJ). This capacity-building activity commenced in January 2002, with URS Australia Pty Ltd (URS) contracted to the Programme Coordination Unit (PCU) to provide BWRA training and software. Under the terms of reference, the consultants worked closely with their counterparts in a project team co-managed by URS and the Country Focal Point Assistant (CFPA) for completing all required tasks. These tasks required two in-country visits by the consultants (in April and August-September 2002) to install the BWRA software and provide 'hands-on' instruction and guidance. Most of the data collation tasks were undertaken before, between and during these visits, with gap-filling work undertaken by the consultants prior to a short 'project wrap-up' visit in 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 Sepetiba port offices. These records also helped identify which next ports of call may have been a destination port for any BW taken up at Sepetiba.

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 Activity was to identify 'high-risk' species that may be transferred to and/or from the Demonstration Site. The customised BWRA database provided by URS therefore contained tables and interfaces for storing and managing the names, distribution and other information on risk species. 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 Rio de Janeiro's State Foundation of Environmental Engineering (Fundação Estadual de Engenharia do Meio Ambiente - FEEMA) 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 BWRF 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, which was designed by the consultants 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 Sepetiba and its source and destination ports.

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

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

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

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

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

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

Of the 919 vessel visits and 1540 associated ballast tank discharges added to the database by the end of the second consultants visit, half originated from BWRFs submitted between January 2001 and June 2002, the rest being expanded from spreadsheet data provided by the CFP-A from 1998-2000 port shipping records. The total number of BW source ports identified from the tank discharge records was 148. The source port 'supplying' the highest frequency of BW discharges at Sepetiba was Rotterdam (9%), followed by Santos (Brazil; 4.4%), Ijmuiden (Netherlands; 4.2%) and Praia Mole (Brazil; 4.1%). The top 16 source ports provided 50% of all source-identified discharges, while only 38 of all source ports (26%) accounted for 75% of the total number of source-identified discharges at Sepetiba.

The total volume of BW discharged at Sepetiba from the identified source ports was 11,652,829 tonnes. The source port rankings for discharged volume were similar to those for discharge frequency. Source ports providing the largest volume of discharged BW were Rotterdam (13.4%), Santos (Brazil; 7.2%) and Salvador (Brazil; 5.6%). The top 11 of identified source ports provided 50% of the total discharged volume, while only 33 (22%) of all identified source ports accounted for 75% of the source-identified volume discharged at Sepetiba. Of the top 20 ports, five were in Brazil, three in both the Netherlands and United States, two in both France and United Kingdom, and one each in Australia, Belgium, Gibraltar, Portugal and Spain.

Of the 104 potential BW destination ports (i.e. reported Next Ports of Call where BW uplifted at Sepetiba could be discharged), only 44 of them accounted for >80% of reported Next Ports of Call. The nearby port of Santos was by far the most frequently reported destination port (over 10%, and which serves Brazil's largest industrial city of Sao Paulo). Of the 17 ports accounting for the destinations of >50% of vessel departures from Sepetiba, five were in Brazil, four in Argentina, two each in France and China, and one each in Bulgaria, Colombia, Mexico and Taiwan Province.

Of the various BW source and potential destination ports, sufficient environmental data were obtained to include 58% of the former and 56% of the latter in the multivariate similarity analysis by PRIMER. These ports accounted for 80% of all tank discharges and 67% of all vessel departures respectively. To allow all identified BW source ports and next ports of call to be part of the 'first-pass' risk assessment, ports not included in the multivariate analysis were provided with environment matching coefficient estimates. The most environmentally similar port to Sepetiba was Rio de Janeiro (0.86 matching coefficient), while 22 other Brazilian ports had either calculated or estimated coefficients in the 0.7 - 0.8 range. The nearest similar ports beyond Brazil were the west African port of Abidjan (0.70), Singapore (0.63) and several Mediterranean ports (>0.6). The most environmentally dissimilar ports trading with Sepetiba in 1998-2002 were riverine, highly brackish and/or cool water ports in North America, southern Argentina and north-west Europe (matching coefficients in the 0.2 -0.3 range).

The relative overall risk (ROR) posed by each of Sepetiba's identified BW source ports was calculated as proportions of the total threat due its contemporary (1998-2002) trading pattern. The project standard ROR calculations identified 20 of Septiba's148 identified source ports as representing the highest risk group, in terms of their BW discharge frequency, volume, environmental similarity and assigned risk species threat. However it was noted that the risk species threat component calculated for each source port (which varied according to the number of introduced and native species in its bioregion, and their categorization as either unlikely, suspected or known harmful species) did not provide a globally reliable list owing to regional biases in aquatic sampling effort and taxonomic knowledge.

From the 919 visit records, the project standard calculation indicated that Brazilian ports provided the top 20% of the total ROR (values in the 0.20-0.29). The highest risk ports were led by Santos (ROR 0.290) and Rio de Janeiro (0.285), closely followed by Rio Grande and Praia Mole (0.248). The first non-Brazilian ports were Montevideo (Uruguay) and Rotterdam (Netherlands), which were grouped as 'High Risk' ports and ranked 22nd and 23rd overall (RORs close to 0.20). The highest risk ports beyond the Atlantic were the Mediterranean ports of Taranto, Italy (0.201) and the Adiratic port of Koper, Slovenia (0.199). The highest risk port beyond the Atlanto-Mediterranean area was the Pacific coast Mexican port of Lazaro Cardenas (ranked 42nd with a ROR value of 0.183). Seventy five of Sepetibas's BW source ports were ranked in the low (31) and lowest (44) risk categories. These had a wide distibution and were warm or cool water ports plus riverine/brackish ports. The source port with the lowest ROR (0.05) was the cool temperate port of Puerto Madryn in southern Argentina.

Based on Sepetiba's pattern of shipping trade in 1998-2002, the ROR results indicated that BW from vessels arriving from ports in temperate to cool temperate pose far less of threat than those from Brazil's coast and southern Europe, with the exception of Rotterdam and Lazaro Cardenas in Mexico. In the case of the Brazilian ports, their relatively close environmental similarities and regular BW sources made them dominate the highest risk group. The project standard results therefore indicated a much higher threat of BW-mediated introductions is posed by vessels arriving in ballast from Brazilian and southern European ports, and this was logical given Sepetiba's biogeographic location and trading pattern. The project standard results also indicated that the 'first-pass' treatment of the risk coefficients provides a reasonable benchmark for any investigative manipulations of the risk formula or database management.

While the tropical and subtropical coastline of Brazil does not appear to be experiencing the level of harmful invasive species recently reported for the cooler Uruguayan and Argentinean waters, it was clear that Sepetiba Bay is not immune to the spread of harmful marine species such as introduced/cryptogenic toxic dinoflagellates that can increase the severity and impacts of red tides. For a largely tropical country with a high number of brackish and estuarine ports, the issue of water-borne tropical pathogens such as cholera, typhus and yellow fever and parasites was also recognized.

The BWRA results confirmed that Sepetiba 'exports' considerable volumes of BW, much of which appeared to be destined for other Brazilian ports (especially via bulk carriers departing the coal and alumina berths and some of the ships leaving the Tecon wharf). However, reliable identification of the BW destination ports was confounded by the lack specific questions on the IMO-standard BWRFs, and the uncertainty of knowing if a recorded 'Next of Port Call' is where BW is actually discharged. The most important BW destination port appeared to be Santos, and this port also had one of the closest environmental matching values to Sepetiba. The results therefore indicated that any unwanted species which establishes in Sepetiba Bay has a more than reasonable chance of 'port-hopping' to both Santos or Rio de Janeiro via BW-mediated transfers. In the case of more distant ports, the French Atlantic port of Quimper was a relatively frequent next port of call with a moderate environmental similarity (0.5). In the case of the risk species currently assigned to Sepetiba's bioregion, noxious phytoplanktonic species that can make cysts, survive ballast tank conditions and produce suffocating or toxic red tides in eutrophic inshore waters, represented species deemed likely to cause the highest potential impacts if introduced to new areas.

The top 20 ports identified in the highest risk category by the project-standard method were all Brazilian ports. This outcome was to a large part determined by the size of their environmental matching coefficients, together with the relatively short voyage durations. An investigation of the project standard's default weightings confirmed that the environmental coefficient was powerful, and that altering these can lead to unexpected outcomes and create the potential trap of merely playing 'numbers games', particularly if the objective and rationale for altering the project standard calculation and default input factors are not clearly established. It was recognized there is a good argument for allowing environmental matching to remain the most influential component of a BWRA formula when there is any doubt as to the completeness or reliability about the particular risk species threat. It was therefore concluded that, when evaluating any BWRA results, each risk component of the calculation should be examined to understand its contribution to the overall outcome, whichever method is used.

Of the various BWRA objectives and tasks that were undertaken during the activity, reliable identification of destination ports that may receive BW from the Demonstration Site was confounded by the lack of specific questions on the IMO-standard BWRFs, and the uncertainty of knowing if the 'Next Port of Call' recorded on a BWRF is where ballast water is actually discharged. Thus presently there is no mechanism enabling a 'reverse BWRA' to be undertaken reliably. In the case of Sepetiba, several visiting vessels types do not uniformly discharge or uptake their full capacity of BW, with many of their previous and next ports of call involving part cargo discharge and loading. If more reliable and 'forward-looking' BWRAs are to be undertaken to identify destination ports in the future, supplementary questions will need to be added to the present IMO-standard BWRF, including the names of the three last ports of call as well as the port where discharges from each partially or completely ballasted tank are predicted.

The main objectives of the BWRA Activity were successfully completed during the 15 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 Brazil. Project outputs included a trained in-country risk assessment team, and an operational BWRA system and *User Guide* for use as a demonstration tool in the region. This places Brazil in a good position to provide assistance, technical advice, guidance and encouragement to other port States in South America.

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.

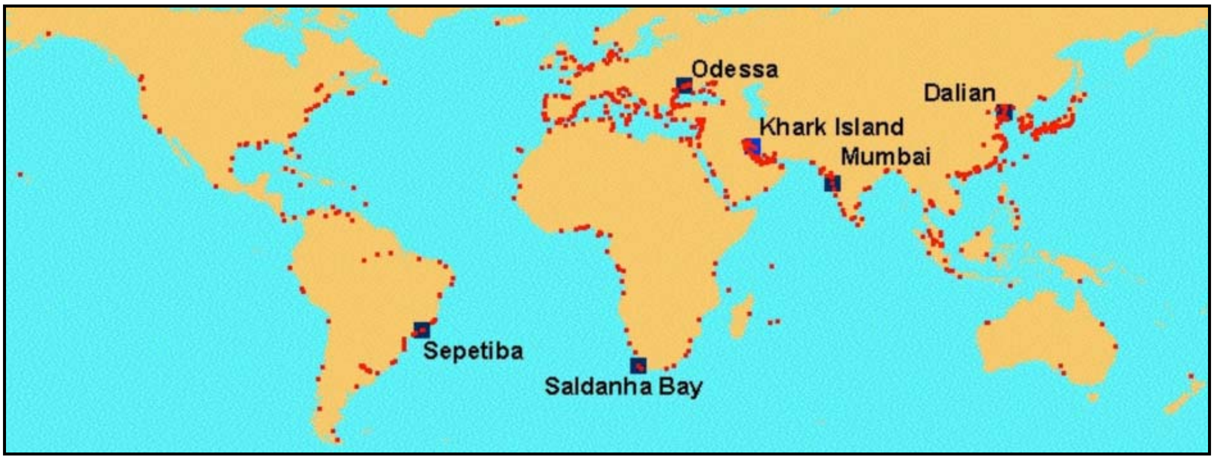

Figure 1. *Locations of the six GloBallast Demonstration Sites and their various ballast water source and destination ports.*

This report describes and presents the results of the first Ballast Water Risk Assessment (BWRA) carried out for the Port of Sepetiba (Brazil) during 2002. This GloBallast Demonstration Site is a relatively modern bulk commodity and general cargo handling port which was expanded during the late 1990s to relieve pressure on the crowded facilities inside Rio de Janeiro harbour, which lies some 60 km to the east (Figure 2).

Figure 2. *Location of Sepetiba and other ports of Brazil*

2 Aims and Objectives

The aims of the GloBallast BWRA for the Port of Sepetiba were set by the GloBallast Programme Coordination Unit (PCU), in accordance with Terms of Reference developed by the PCU Technical Adviser (Appendix 7) 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 Sepetiba 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 Sepetiba.
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 Sepetiba 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 Sepetiba via standard IMO BWRFs.
6. Characterise as far as possible from existing data, the physical, chemical and biological environments for both Sepetiba and each of its source and destination ports.
7. Develop environmental similarity matrices and indices to compare the Port of Sepetiba 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 Sepetiba, 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 Sepetiba was conducted by URS Australia Pty Ltd (URS) under contract to the GloBallast PCU, in accordance with the Terms of Reference (Appendix 7). The consultants worked alongside their Pilot Country counterparts during the country visits to provide training and skills-transfer as part of the capacity building objectives of the programme. Structure and membership of the joint project team is shown in Appendix 2.

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.

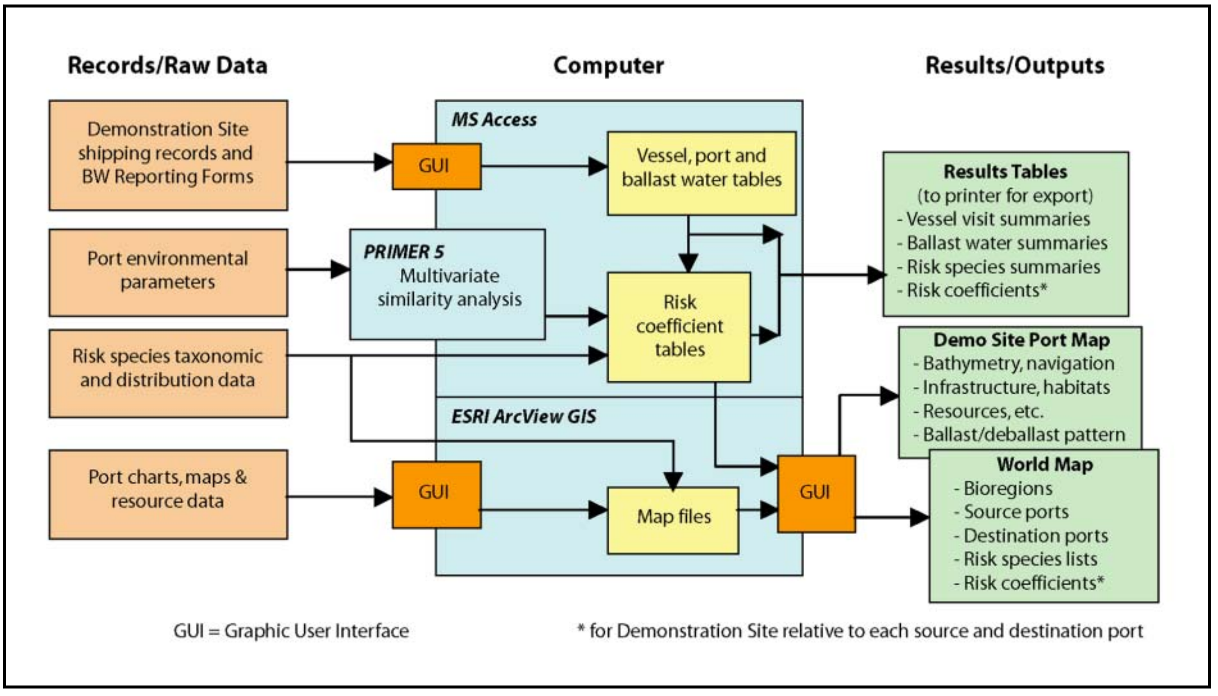

Figure 3. *Schematic of the GloBallast BWRA system*

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 Sepetiba were completed during two in-country visits by the consultants (14-19 April and 22 August-06 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 12-14 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 office space provided in the FEEMA building at Rio de Janeiro.
- 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.
- Visit Sepetiba to tour the port facilities, obtain information on the ballasting practises of visiting ships and gain an understanding of the coastal habitats and local marine resources.
- Review available BWRFs and port shipping records to identify trading patterns, vessel types, key BW source ports and likely destination ports.
- Check available port environmental data and identify potential in-country and regional sources of same.
- Commence listing risk species and identifying potential in-country or regional sources of same.
- Identify critical information gaps and the data assembly work required before the second visit.

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

During the third visit in 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 corrections to some of the vessel visit records and environmental matching assignments (made by the CFP-A in consultation with URS), 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). This database was used to identify source and destination ports, and was designed for ongoing input and management of future BWRFs.

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

[2] Several port States (e.g. Australia) and Demonstration Sites (e.g. Dalian, Odessa) have produced their own BWRFs, using translated formats to permit improved BWRF understanding and completion by local shipping. Such BWRFs need to include <u>all</u> 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 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 Sepetiba 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), the Australian Centre for Research on Introduced Marine Pests (CRIMP; now CSIRO Marine Research), the Baltic Regional Marine Invasions Database and the Global Invasive Species Programme (GISP) (Appendix 5). The species taxonomic information and bioregional distributions were also added to the Access database. The combined BW discharge, environmental matching and risk species coefficients provided the basis of the semi-quantitative risk assessment.

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

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

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 Sepetiba port map extends from the open seaway at the mouth of Sepetiba Bay, and along the port's approaches past the anchorages to its terminals and berths located at Madeira Island. The map also extends further

[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.

eastward to encompass the edges of the bay and landward to show the port hinterland and watershed drainages.

Approximately 305 km^2 of Sepetiba bay and its hinterland were already in a ArchInfo digital map format owing to a detailed watershed study undertaken for the Rio de Janeiro's Secretary of State of Environment in 1997. However there was no subtidal or navigational information, and vector-based electronic nautical charts were not available for the Sepetiba region. Counterparts from the Fundação Estadual de Engenharia do Meio Ambiente (Foundation for the Study of Environmental Engineering) (FEEMA) generated the bathymetry and navigation layers using their digitising table to capture salient details of port infrastructure, shipping channels and anchorages from the 1:20,000 *Baia de Sepetiba* Brazilian nautical chart. Point and pattern symbols were based on the international IHO/IALA system for nautical charts.

Infrastructure and social cultural information was captured by importing and re-registering FEEMA ArchInfo files showing transportation lines and land uses, plus digital data extracted from other files showing local drainage and river systems, terrestrial contours, habitats and reserves. Some intertidal habitat were also available in digital format from the 1997 study, and these were supplemented by subtidal habitat information 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. Additional layers were provided to incorporate various FEEMA coastal zone data, including a colour Landsat image of Sepetiba bay. Two GIF files showing projected movements of discharged BW from tide-only and by two tide/wind regimes were provided by the CFP-A and these were linked to the port map.

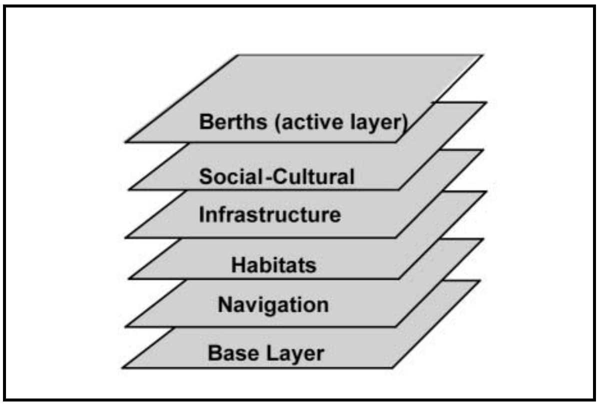

Figure 4. *Thematic layers used for the Port Map GIS*

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 Sepetiba comprised:

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

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

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

Habitat Layer: This layer 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 FEEMA, with some of the natural and artificial habitat boundaries based on notes and map annotations made by BWRA team members during the port tour, and sediment information provided by the CFP-A from the Sepetiba PBBS. The port tour was undertaken by vehicle and foot on 15 April 2002. Delineation of some intertidal and subtidal habitat boundaries was supplemented from seafloor and coastal features displayed on the *Baia de Sepetiba* nautical chart. These included the intertidal mud flats, sand beaches and rocky shorelines, plus symbols denoting the presence of sand, mud or rocky substrate.

Infrastructure Layer: This layer shows the urban and developed land surrounding the port, including 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 mariculture sites and recognised recreational fishing areas and sardine grounds in Sepetiba Bay. There is no dedicated fishing port in Sepetiba Bay, with the nearest ramps and a small jetty used by recreational and artesanal fishing boats located at the head of a shallow embayment 4 km north of the port.

Berth Layer: An 'active' berth layer was added to show the principal berthing and anchoring areas at the Port of Sepetiba. Their names and numbering system were supplied by the Port of Sepetiba engineer. 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 Sepetiba were discussed during the port visit (15 April 2002) where a meeting was held at the port manager's office to confirm the types of port trade, pilotage rules and draft requirements, current anchorage areas and deballasting/ballasting practises and locations. Copies of port shipping records covering 1998-2001 had been previously supplied to the CFP-A for a previous project.

Further information was obtained from the shipping records of Sepetiba's port authority (Companhia Docas do Rio Janeiro - CDRJ) for periods where BWRFs were unavailable or incomplete[4]. It was relatively simple to determine where and which arriving ships discharged or uplifted BW by identifying their berthing location and vessel type, because the port has dedicated bulk import and export terminals plus a new multipurpose terminal capable of handling vehicles, containers, break-bulk and general cargo. However many ships arriving at the latter only part discharged and/or part loaded cargo and it was often unclear if and how much ballast water was being discharged or taken up, particularly by ro-ro vessels and container ships.

4 These records listed the vessel name, arrival and departure dates, berth, last port of call, and cargo details.

3.4 Identification of source ports

To provide confidence as to which ports were the predominant sources of BW discharged at Sepetiba, visit records from a spreadsheet containing information extracted from Sepetiba's port shipping records for the 1998-2000 were added to the Access database. Source ports were therefore identified from BWRFs (January 2001 - June 2002) and from shipping record information previously obtained from the Sepetiba port office.

BWRFs had been collected from arriving ships by the Agência Nacional de Vigilância Sanitária, (National Agency for Health Surveillance) (ANVISA); Brazil's federal agency for border health and quarantine control), at Sepetiba since June 2000 on a voluntarily basis. Completion and submission of this form became mandatory after January 2001 due to Resolution 17, a national regulation established by ANVISA to all vessels that claim Free Pratique (as reviewed in November 2001 as Resolution 217). BWRFs collected from 1 January 2001 were entered into the database. Before a new port was added to the database, the port and country name spelling, its location coordinates, bioregion and unique UN Port Code number were checked using the Lloyds *Fairplay World Ports Guide* and world bioregion list in the database (port data input is detailed in the GloBallast *BWRA User Guide*).

Whenever possible, BWRFs were cross-referenced with port shipping records since many of the former were partly or incorrectly completed. For vessels arriving before BWRFs were collected, or which submitted incomplete or no forms, gap-filling details were obtained from the port's shipping records. However these records show only the *Last Port of Call*, which may not be the BW source. To identify which last ports of call were probable BW sources, cross-checks were made of source ports and last ports of call reported in other BWRFs by the same or similar types of vessel. The Lloyds *Fairplay Port Guide* and *Lloyds Ship Register*[5] were also used to confirm source port trade and the vessel's IMO identification number, vessel type and DWT of arriving ships respectively.

Many gaps in the BWRFs and port shipping records could therefore be filled by checking, for any arrival, the vessel name, type and DWT, its previous visit history, last port/s of call and apparent charter/liner trade, and by using a customised Excel spreadsheet supplied by the consultants to estimate the amount BW discharged or taken up[6] (Figure 5). This was less easy for the vessels arriving at the multi-purpose berths, and many incomplete BWRFs could not be filled to the level allowing a database record.

Nearly all BWRFs had to be carefully checked for completeness and accuracy. In the case of unusual (or missing) BW values, these were checked using the same Excel spreadsheet to determine likely volumes based on vessel type, DWT, last port/source port and loading record. This BWRF checking and gap-filling exercise was undertaken by Group A and B team members during the second in-country visit, with the database of almost 920 vessel visits constructed by:

- entering visit details from the spreadsheet of port shipping records for the pre-BWRF period (1998-2000) on the Excel spreadsheet, and using the *Fairplay Port Guide* and *Lloyds Ship Register* to add or correct port details, vessel names, IMO ship numbers, types, DWTs, voyage durations; and
- cross-checking incomplete or unusual BWRFs with port shipping records, using the *Lloyds Ship Register*, *Fairplay Port Guide* and the Excel spreadsheet to correct errors or add missing data.

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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*.

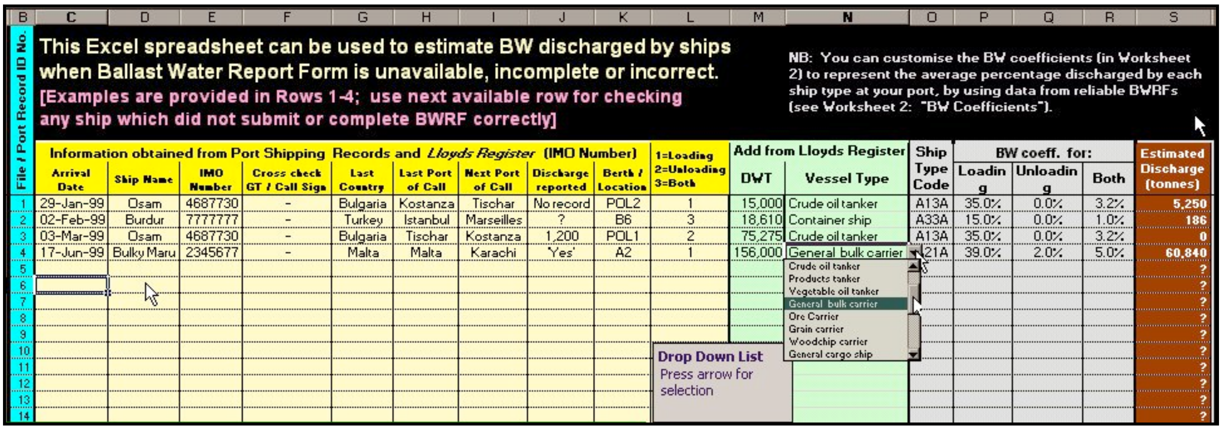

Figure 5. *Working page of the Excel spreadsheet used to estimate BW discharges*

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).

The BWRFs for Sepetiba list the *Next Port of Call* of all arriving 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. many container ships, vehicle carriers, Ro-Ro ships and LNG carriers, as well as some crude oil tankers, products tankers and large bulk carriers). However for other ship types (and occasionally the former) ship officers cannot reliably anticipate where BW discharges will be necessary. For example, for general cargo ships, bulk carriers and tankers engaged in spot charter work (or when completing a charter period), these vessels may often depart in ballast having received a general sailing order to proceed towards a strategic location until further instructions.

In the case of the Port of Sepetiba, there is considerable importation of bulk coal and alumina requiring the visiting bulk carriers 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). Another item requiring frequent look-up was the vessel's deadweight tonnage (DWT) since the BWRF requests only the gross tonnage (GT). As noted in Section 3.4, adding the DWT (present in the *Lloyds Ship Register*) enables convenient checks of reported volumes and gap-filling of missing values (see below).

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

- Vessel identification - a unique 7 digit IMO number that remains the same for the life of the ship, irrespective of any name changes;
- Arrival date; 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 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 time-consuming, and it is far more efficient and reliable for port officers to ensure the BWRF has been filled in correctly and completely at the time of submission (Section 4.10).

The database contains reference tables 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).

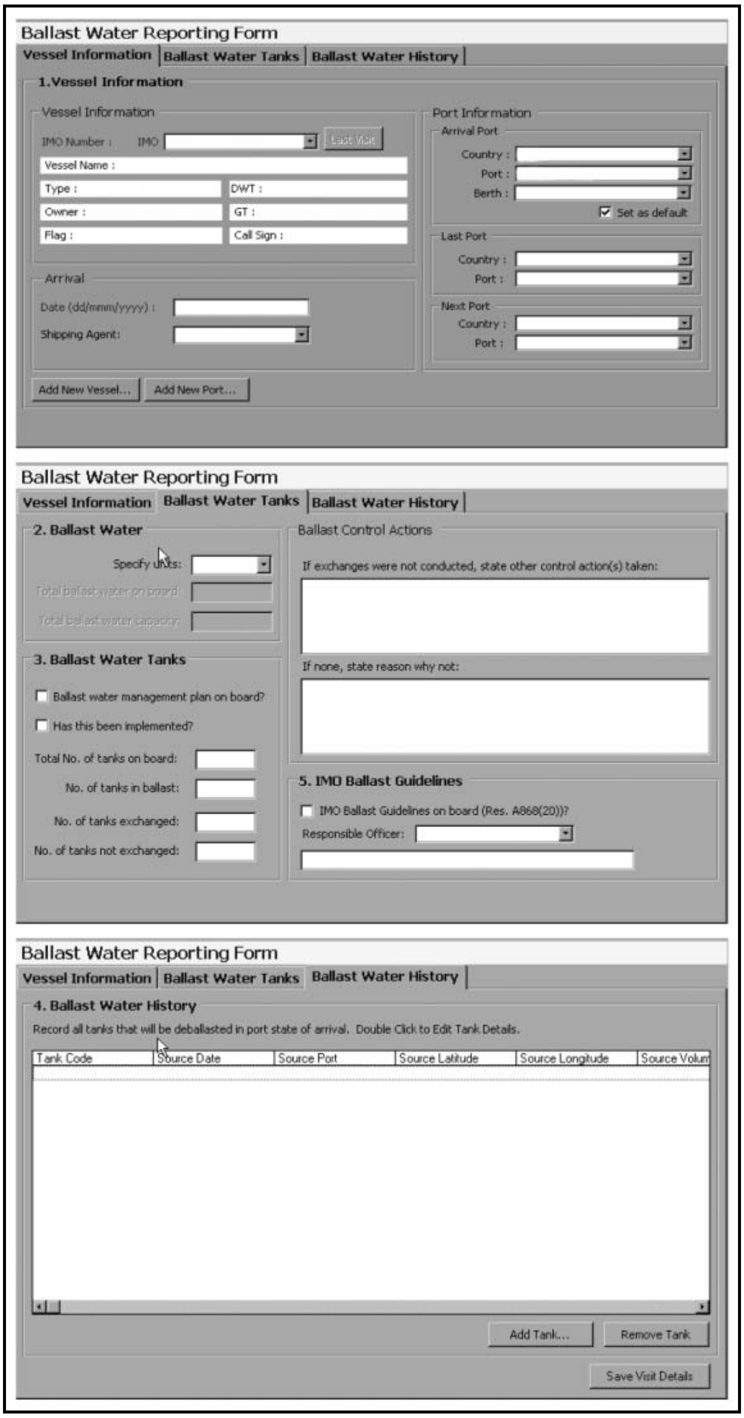

Figure 6. *The three tabs of the GUI used for entering the BWRF data*

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 (^{o}C)	Scalable
3.	Maximum water temperature at warmest time of year (^{o}C)	“
4.	Mean water temperature during coolest season (^{o}C)	“
5.	Minimum water temperature at coolest time of year (^{o}C)	“
6.	Mean day-time air temperature recorded in warmest season (^{o}C)	“
7.	Maximum day-time air temperature recorded in warmest season (^{o}C)	“
8.	Mean night-time air temperature recorded in coolest season(^{o}C)	“
9.	Minimum night-time air temperature recorded in coolest season (^{o}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)	“
<u>Logarithmic distance categories (0-5)</u>: 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,

[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.

port and scientific publications, internet web sites, port survey reports and sampling records, SST and salinity charts, climate databases, atlases, national tide-tables, nautical charts, coastal sensitivity and oil spill habitat maps, oil spill contingency plans, aerial photographs, national habitat databases and local expert advice (Appendix 4). The most difficult to find were reliable water temperature and salinity data, particularly for identifying the averages, maxima and minima for ports in or near estuaries (Section 3.12).

A preliminary list of frequently recorded BW source ports and destination ports for the Port of Sepetiba was made at the end of the first in-country visit in April 2002 (the complete list did not become available until near the end of the second in-country visit; Section 3.1). It was agreed that the environmental parameters for these ports should be sought between the first and second consultants' visits, with the Brazilian Group C members focussing on important ports in Brazil, 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 40% of all ports identified as trading with the Port of Sepetiba, with estimates provided for ports where unobtained/incomplete data prevented their inclusion in the multivariate similarity analysis (Section 4.6). The percentage of ports with calculated environmental coefficients was subsequently expanded by a gap-filling exercise undertaken by the consultants between 22 December 2002 and 31 January 2003. These were added to the updated BWRA provided at the third meeting in 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).

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

The environmental distances between the Port of Sepetiba and its source and destination ports were determined using a multivariate method in the PRIMER package. Of the various distance measures available in PRIMER, the normalised Euclidean distance is the most appropriate. Normalisation of the various input parameters removes the problem of scale differences, and the method can manage a mix of scalable, integer and even categorical values, provided the latter reflect a logical sequence of intensity or distance/location steps. Individual variables cannot be weighted but the predominance of temperature variables (8) and salinity/salinity-related parameters (also 8; see Table 1) ensured 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 Brazil. The modifications

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.

included adding new bioregions for several large river systems to accommodate some important river ports that trade with one or more of the Demonstration Sites. In the case of Brazilian coast, bioregion SA-II which extended southward from Cabo de São Tomé (21° 54' S, 40° 59' W) to the large La Plata river mouth was divided into SA-IIA and SA-IIB at Cabo Santa Marta Grande (28^{o} 36'S, 48^{o} 49'W) (Figure 7). The SA-IIA / SA-IIB boundary was set at this Cape to accommodate the southern limit of mangrove occurrence in South America, plus the marked changes in the coastal circulation pattern and phytoplankton community composition (particularly among the types of harmful toxic species), all of which occur close to Cape Santa Marta Grande.

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 preliminary lists of organisms found by the recent GloBallast PBBS of Sepetiba (which became available during the second consultants visit). Brazilian and URS members of Group C also investigated the possible existence of introduced species lists held by marine biologists in agencies and universities in the South American region, and one was found for the temperate and cool-temperate coastal bioregions of Uruguay-Argentina-Patagonia (Orensanz *et al*. 2002).

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

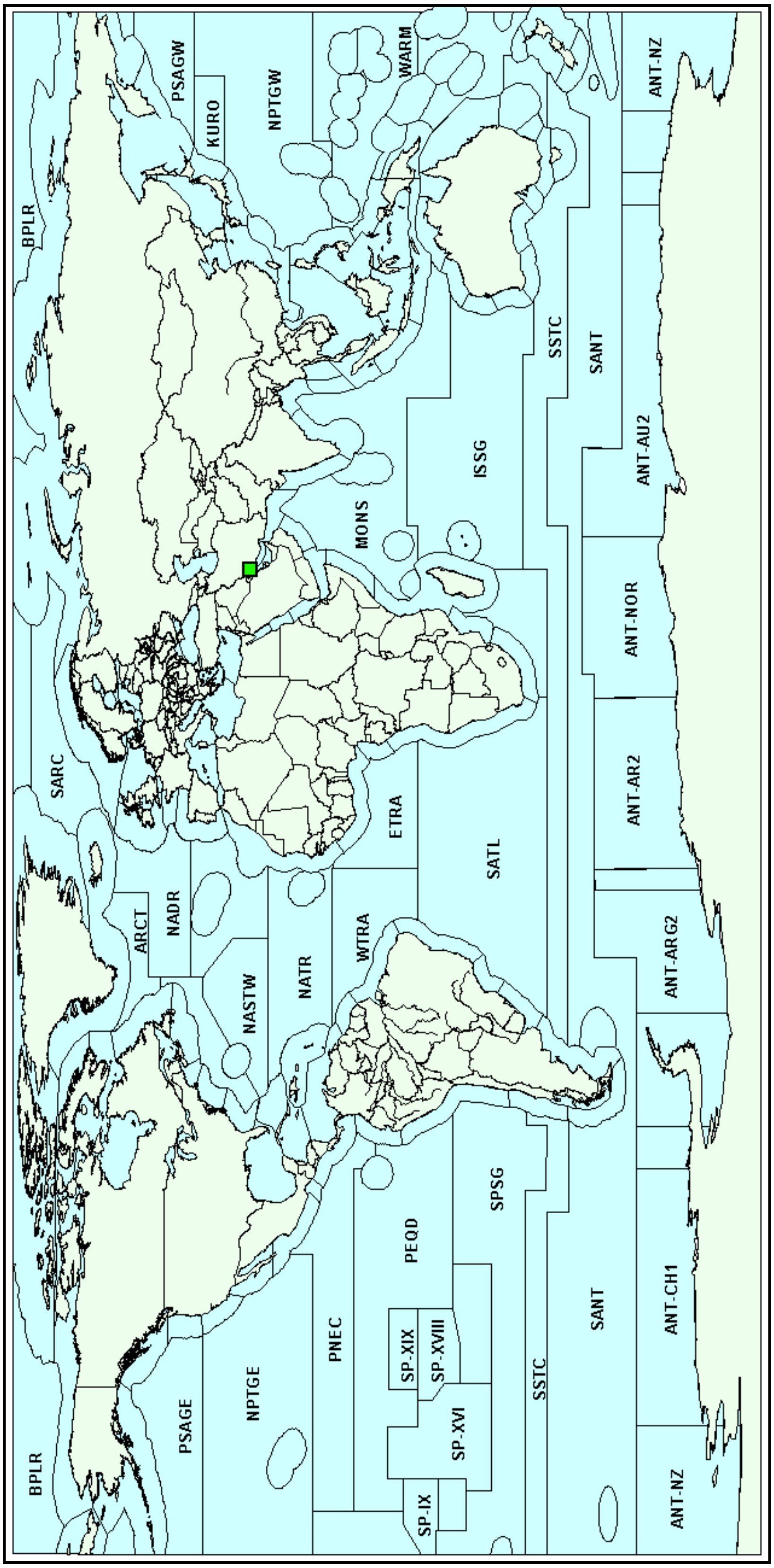

Figure 8. *Complete GIS world map showing the marine bioregions [to improve clarity, not all bioregion codes are shown in this example]*

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

The database calculated the coefficient of 'risk species threat' posed by each source port, with each port value representing a proportion of the total risk species threat. The latter was the sum of all weighted risk species assigned to the bioregion of all source ports that export BW to the Demonstration Site. Species assigned to more than one bioregion are summed only once, and the algorhythm automatically discounted any species that was <u>native</u> 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 BW and/or hull fouling or possibly aquaculture in the project standard BWRA database. For future BWRAs a 'vector status' value could be assigned to each species in the database, so that risk assessments could be focussed on specific shipping-mediated vectors.

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 Australian/New Zealand).
- Gaps and constraints in the taxonomy and reliable identifications for many aquatic species groups.

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

3.10 Risk assessment

Approach

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

The semi-quantitative method aims to identify the riskiest tank discharges with respect to a Demonstration Site's present pattern of trade. Unlike a fully quantitative approach, it does not attempt to predict the specific risk posed by each intended tank discharge of individual vessels, nor the level of confidence attached to such predictions. However, by helping a Demonstration Site to determine its riskiest trading routes, exploring the semi-quantitative BWRA provides a coherent method for

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

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.

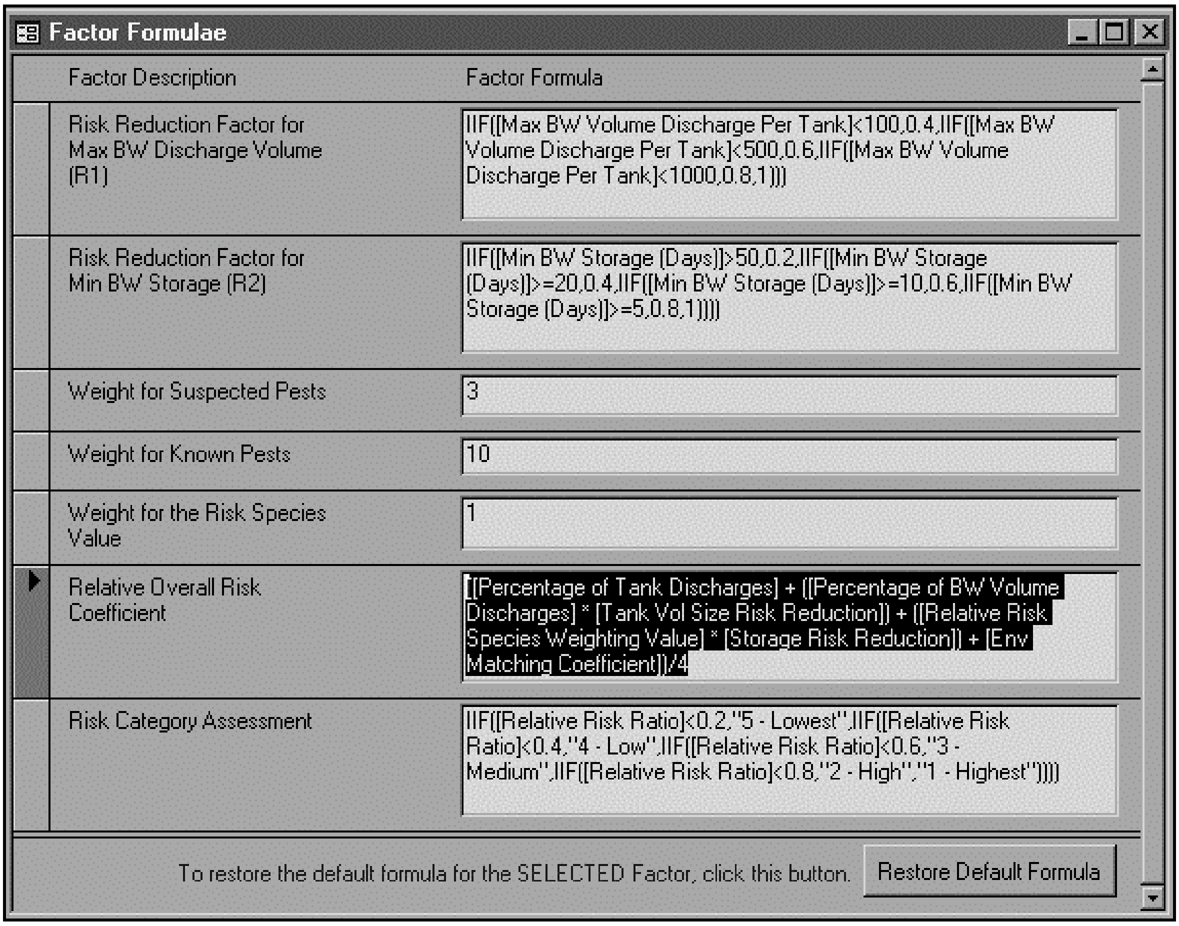

Figure 9. *Database GUI used for manipulating the BWRA calculation and weightings*

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 on a voluntary basis before 2001, with no formal mechanism compelling all vessels to submit fully completed forms at Sepetiba;
- 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.

[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.

BWRA calculation

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

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

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

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

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

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

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

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

(*when C1 and C2 are less than 50%)	Relative Overall Risk **ROR**	Proportion of discharge Frequency **C1**	Proportion of discharge Volume **C2**	Enviro-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

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 Brazilian 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 days]	Introductory half-day seminar Install and check computer software Commence training and capacity building Begin GIS mapping of port and resources Port familiarisation tour Review BWRFs and Port Shipping Records Commence BWRF database development & training Review port environmental data and identify sources Seminar & tutorials on multivariate similarity analysis Identify data collation/input tasks before 2nd visit	D Blumberg J Polglaze R Hilliard	FEEMA offices, Rio de Janeiro Group A counterparts Group B counterparts Group C counterparts
2nd Country Visit August-September 2002 [12 days]	Update Database GUIs, add-ins & make ODBC links Continue training and capacity building Complete GIS mapping of port and resources Complete BWRF database development and training Complete port environmental data assembly/training Complete environmental similarity analysis training Generate environmental matching coefficients Add risk species data to database, refine bioregions Complete BWRA training and undertake first analysis Hold seminar to review and discuss results Discuss pilot country needs for future BWRA	C Clarke J Polglaze R Hilliard	FEEMA offices, Rio de Janeiro. Group A counterparts Group B counterparts Group C counterparts
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	DPC office, Rio de Janeiro. Group A leader Group B leader Group C leader

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

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

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

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

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

During the first consultant's visit, Mr Daniel Menucci and Mrs Catia Ferreira (initially assigned to Group B) arranged a demonstration of a prototype electronic BWRF, as developed by ANVISA to become a user-friendly component of its web-based *Free Pratique* form system. This also used an Access application to provide a sophisticated database and BWRF screen images (in Portuguese) to facilitate the import and management of BWRF data, with particular reference to the management of water borne pathogens and parasites.

However it was not possible for the consultant and Brazilian counterparts of Group B to conduct a collaborative evaluation of the ANVISA prototype, which had been designed to allow convenient internet transmittal of electronic BWRFs from any of ANVISA's 45 port offices to its database centre in Brasilia.

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 Sepetiba is located in the north-east part of Sepetiba Bay at 22^o 56' S 43^o 50' W, and is approximately 80 km west of Rio de Janeiro (Figures 2, 11, 13). The port is located on Madeira Island, which was formerly separated from the mainland by narrow deltaic estuarine channels and mangrove areas (see Section 4.2 for coastal habitat details). After entering Sepetiba Bay, ships follow a well marked shipping channel, the majority of which follows naturally deep (un-dredged) areas >20 m below chart datum (LAT).

The port was initially developed with a single pier to provide a bulk import terminal for coal and alumina (in use since 1982). To help alleviate pressure on crowded container and break-bulk facilities in Rio de Janeiro harbour, a multi-use container, vehicles and general cargo wharf was subsequently developed by a substantial dredging and land reclamation exercise during the 1990s. This new wharf and port land has been in use since 1998 for the import and export various cargos, including rolled steel, vehicles, containers and sulphur. A dedicated conveyor-fed T-jetty and ship-loader was also installed on the east side of the original import pier to allow iron ore exports, and this has been in use since 1999.

Climate and weather

The warm subtropical-to-tropical climate of the Sepetiba region comprises hot, humid summers with variable sea breezes, and cooler but equally moist winters dominated by southerly fronts. Mean day-time temperatures regularly exceed 26^{o}C during summer (maxima to +38^{o}C), while night-time temperatures typically fall below 22^{o}C in winter (minima to 11^{o}C). Annual rainfall is moderately high (1500 mm) and evenly divided between both these seasons. An annual wind rose showing the dominance of easterly and south-westerly components of the prevailing winds in the area is shown in Figure 10.

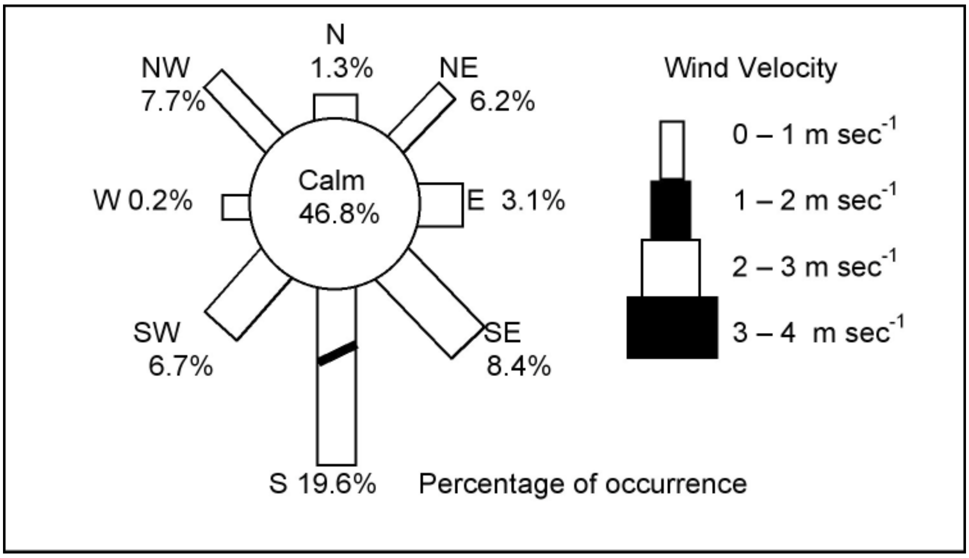

Figure 10. *Annual wind rose typical of Sepetiba Bay region (Angra dos Reis; 23o 0.5' S 44o 19.0' W; for 30 years)*

Hydrodynamic conditions

Tidal currents in the open areas of Sepetiba Bay are not particularly strong owing to the relatively small tidal range, which is close to 1.4 m during springs and 0.7 m during neaps. Strongest tidal flows near the port are generally to the east and west during the spring flood and ebb tide respectively. A hydrodynamic study previously undertaken for the Port of Sepetiba generated BW plume dispersal plots as animated GIF files. These files were obtained by the CFP-A and the consultants wrote a small piece of code to link them to the GIS port map to enable convenient launch. The animations had been generated by numerical hydrodynamic modelling at the Laboratório de Modelagem de Processos Marinhos e Atmosféricos (Universidade Federal de Rio de Janeiro; UFRJ), using a 2-dimensional model and a bay-wide uniform 250 m grid.

The GIFs show the direction and dilution of dispersing ballast water throughout several tidal cycles during a south-westerly wind regime, calm conditions and a north-easterly wind regime. The GIF frames in Figure 11 show the effect of SW winds (a) and calm conditions (b) on BW plume dispersal, while those in Figure 12 show the effect of NE winds. Figure 11 shows how the near-surface components of the BW plume are held close against the eastern shore of Sepetiba Bay during south-westerly breezes (a), whereas under calm conditions the plume spreads slowly into Sepetiba Bay under the action of the tidal cycle (b).

In Figure 12, the synergistic effect of the tidal cycle and NE winds is very clear, with the plume rapidly spreading into the bay within 40 hours (a) and continuing to disperse across much of the bay over the next 40 hours (b).

The modelling summarised in Figures 11 and 12 indicates that the BW plumes discharged at the port have the capacity to carry any associated organisms to most types of marine and coastal habitats within the bay by the main prevailing local hydrological forces.

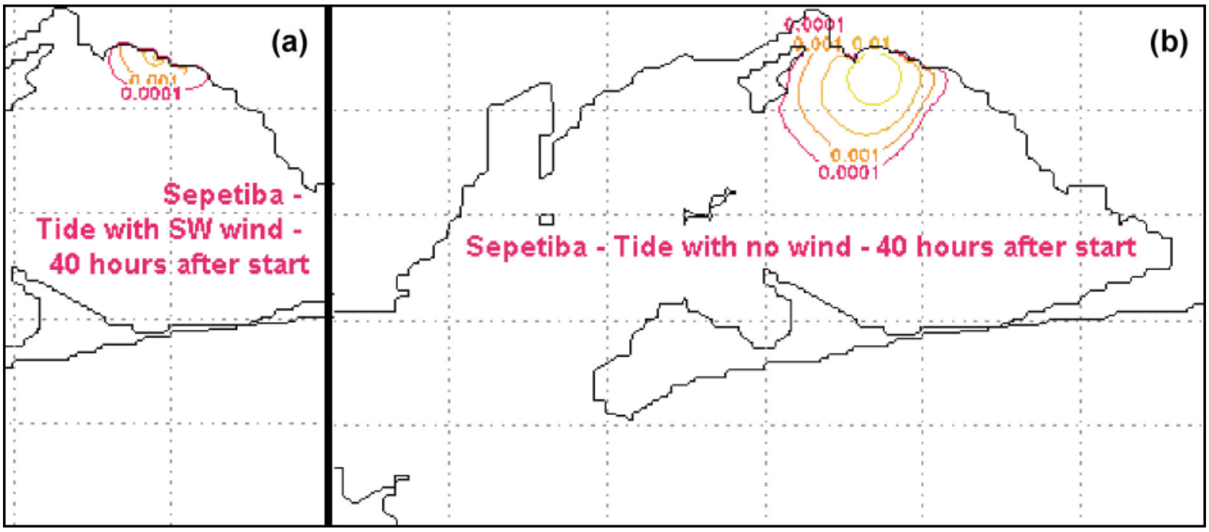

Figure 11. *GIF frame of modelled ballast water plume dispersing from Sepetiba, at the 40 hour mark for tide and SW winds (a) and tide plus calm conditions (b)*

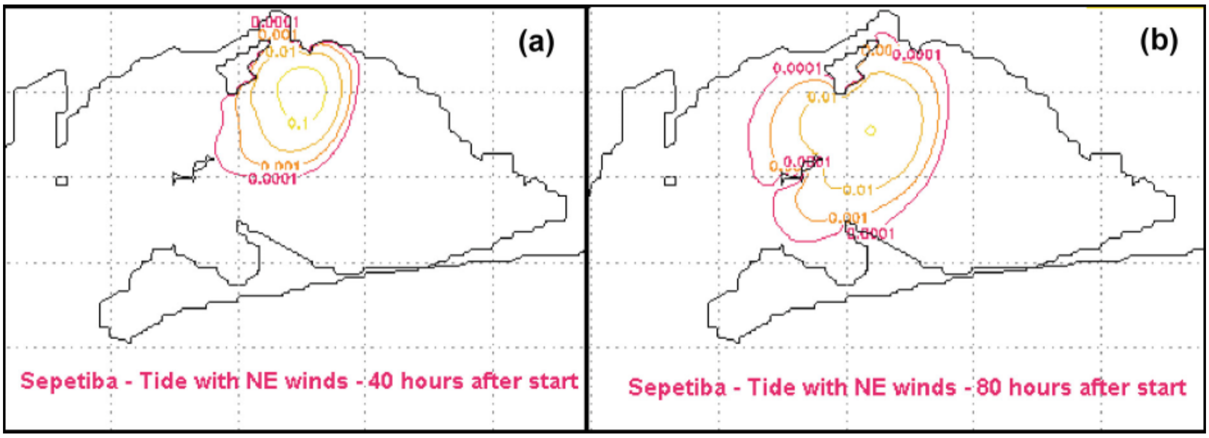

Figure 12. *GIF frame of modelled ballast water plume dispersing from Sepetiba by the action of tide and NE winds at the 40 hour (a) and 80 hour (b) marks*

Port facilities and maintenance

Since 1999 the Port of Sepetiba has been operating four main berthing areas. These are shown in Figure 13 and described below.

- **Carvao (coal) import terminal (berths 101, 102)**: these are located on the outer (south) side of 798 m long 'L'-shape import pier, which provides room for two colliers (either one up to 90,000 DWT and another of 50,000 DWT, or two of approximately 65,000 DWT or less). Water depth is 15.0 m and there are two mooring dolphins to facilitate berthing. Of the seven conveyor .
- **Alumina import terminal (berths 201, 202)**: these are located on the inner (south) side of the pier belts on the 540 m long and 40 m wide stem of the import pier, three are dedicated to coal import, and can accommodate two bulk carriers or chemical/products tankers up to 45,000 DWT for both dry and liquid bulk cargoes (alumina, caustic soda, etc). Water depth is 12.0 m.
- **Tecon wharf (berths 301, 302)**: The two berths on the face of this multi-use wharf have design depths of 14.5 m and are backed by a total hardstand area of 400,000 m^2 used for handling containers, vehicles, rolled steel and other cargos.
- **Ferteco (iron ore) export jetty (berth 401)**: This terminal commenced operating in 1999, and has conveyors and a single ship-loader dedicated to iron ore export. Water depth in the single berth pocket exceeds 17 m during all tides.

Tugs, line boats, port launches and other small vessels generally use the western end of the Tecon wharf. The port has no commercial fish processing or reception facilities.

Because of the naturally deep waters within many parts of Sepetiba Bay, no significant capital dredging was required to provide the initial (western) approach channel to the original bulk import pier. In the case of the Tecon multi-use wharf, a major developmental dredging programme was undertaken during the 1990s to deepen the inshore area lying behind the import pier, an operation also providing much of the landfill for developing the large reclaimed hardstand area that services the two berths. Some extensive deepening was also undertaken to the south and south-west of the new Ferteco export jetty to provide an alternative and more direct, safer approach and departure and a wider swing area for large bulk carriers. Dredging to maintain the achieved design depths (21.5 m below LAT) has not yet been required.

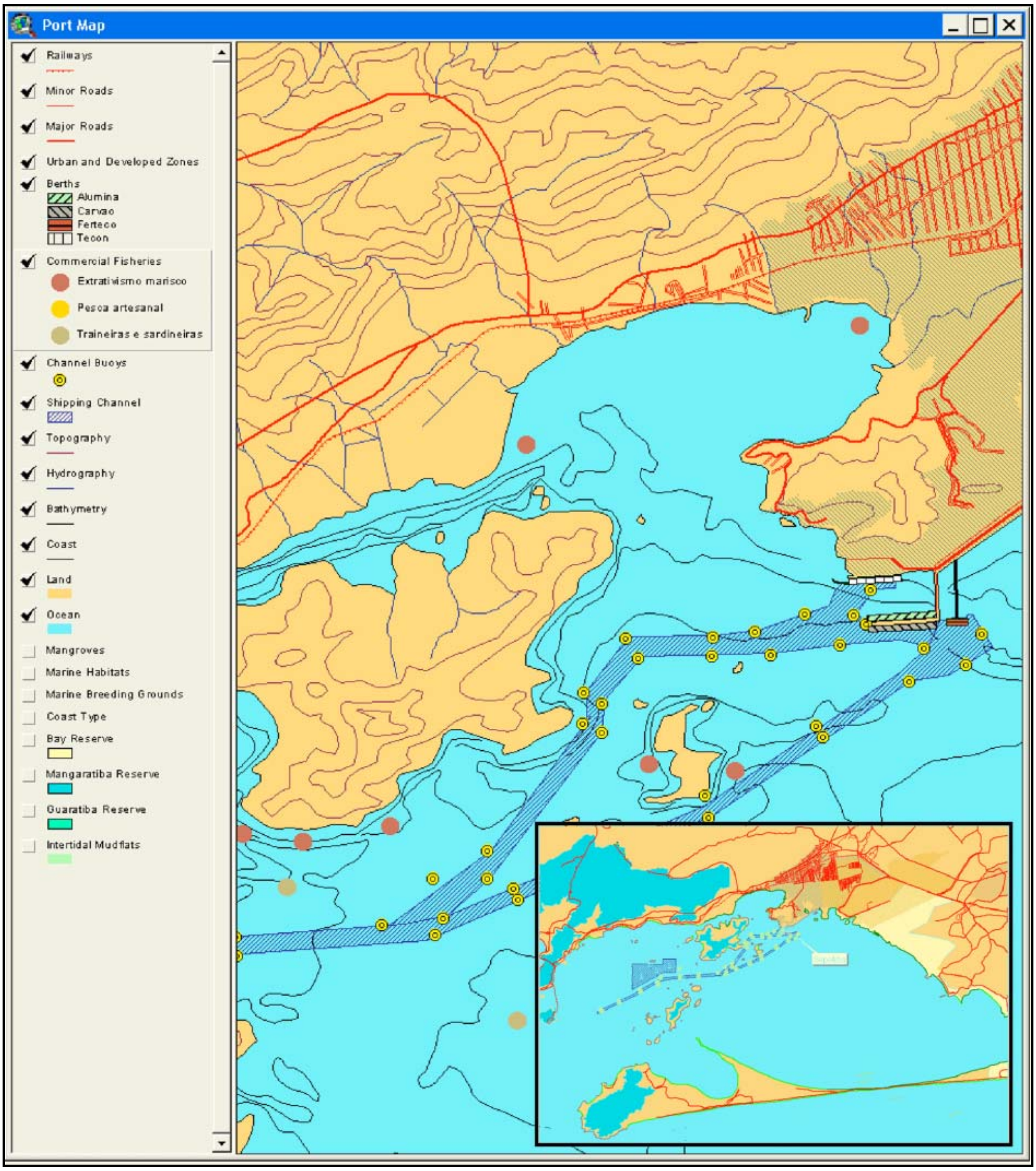

Figure 13. *Part of the GIS Port Map showing the navigation, infrastructure and active berth layers for Sepetiba (inset shows approach channels and anchorage)*

4.2 Resource mapping

The subtidal seafloor habitats in Sepetiba Bay are dominated by soft muddy and harder sandy sediments, and these are shown on the GIS Port Map (Figure 14). It is likely there are some significant areas of seagrass and/or seaweed beds (e.g. *Dictyotis*) within Sepetiba Bay, but no information could be found to help delineate where these might be best developed. There are no coral reefs in this region of Brazil. The intertidal habitats of Sepetiba Bay comprise the following:

- Artificial rocky walls along the reclaimed, heightened and stabilised shorelines in and near the port;

- Narrow rocky shores;
- Lower intertidal mud flats (best developed in the shallow bay to the north of the Madeira Island);
- Mid-to-high tidal mangrove forests (relatively intact and degraded mangrove forest areas have been identified by FEEMA and these are shown accordingly in Figure 14);
- Linear sand beaches (most developed on the south side of the bay along the large sand spit that separates the bay from the ocean).

There are no high tidal salt flats or salt marshes (salinas) at or near the port owing to the topography of the hinterland, the large areas of developed land and the relatively high rainfall. Thus the mangrove forests often terminate abruptly with the commencement of terrestrial woodland and shrub or a revetment.

There are several gazetted reserves and wildlife breeding areas, as well as recreational, artesanal and sardine fishing areas, as identified around the bay by FEEMA during a 1997 study of the Sepetiba region (the latter features are shown in Figure 13 to improve clarity and avoid blending with the marine habitats).

The GIS port map does not yet show the locations of the PBBS sampling sites, but these can be readily added when the coordinates of the survey sampling sites become available. The port map does depict all of the drainage lines, deltaic channels and streams (Figure 14), plus the main navigational and urban/developed features near the port, including the railway and road system (Figure 13). Significant hilltops including the one behind the port on Madeira Island are clearly identified by the topographic contours (Figure 13). Because of the scale of the map and the extent of the urbanised and other developed areas on the north-east side of the bay (Figure 13), features such as post offices, churches and radio masts were not added. No historical wreck-sites of archaeological significance or cultural-heritage value were identified in the area covered by the GIS port map.

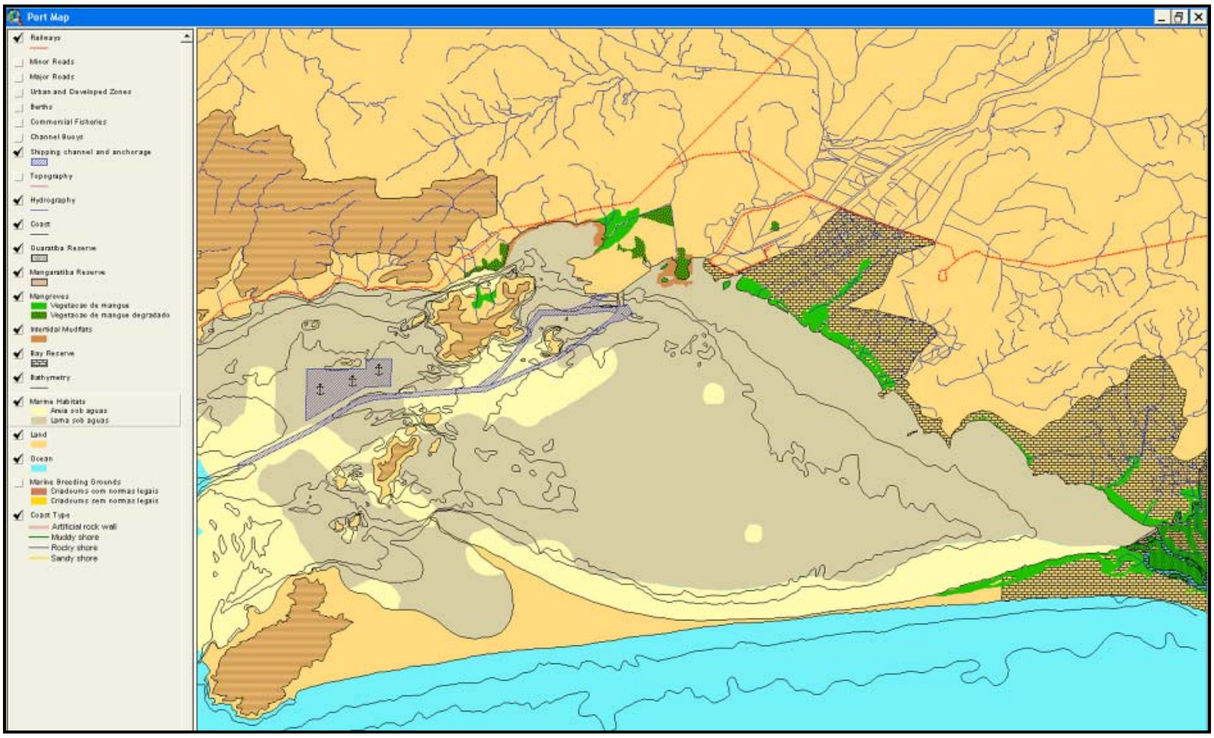

Figure 14. *Part of the GIS Port Map showing the marine habitats and reserve layers*

4.3 De-ballasting/ballasting pattern

During the port meeting in April 2002, the navigational rules and deballasting and ballasting practises of arriving vessels were discussed. Pilotage is compulsory, with boarding occurring beyond the mouth of Sepetiba Bay. As in other ports, 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 is typically more significant in the winter months due to the exposed aspect of the port's terminals to the south-westerly winds (Figure 10).

It was not difficult to establish the main deballasting/ballasting pattern for the Port of Sepetiba because it contains two side-by-side bulk import terminals ('Carvao' and 'Alumina'), and one dedicated export jetty ('Ferteco') nearby at the end of a lengthy approach across the bay (Figure 13). For example, by the time (cargo) empty (ballasted) vessels destined for the Ferteco terminal reach their final approach and berthing phase, they typically contain a normal quantity of ballast for sheltered coastal waters (i.e. 80-95% of standard capacity), even if they had spent time at the anchorage 8 miles to the west (Figure 13). By contrast, bulk carriers approaching the Carvao or Alumina berths are either fully or sufficiently loaded with cargo to have negligible ballast on board. These vessels have no requirement to uplift any ballast water until well after they have berthed and started discharging their cargo.

While it was straightforward to identify which bulk carriers arriving at these terminals must have taken up or discharged BW, this was not case for vessels berthing at the multi-use Tecon wharf. Many of the general cargo ships, smaller bulk carriers, container vessels and ro-ro vessels visiting this terminal appeared to be part-loaded with cargo, some or all of which was destined for either:

- unloading cargo (i.e. possible ballast water uptake),
- loading additional cargo (i.e. requiring no or relatively small releases of BW), or
- both (an operation that can require some vessels to discharge ballast water to maintain trim during part of the cargo unloading/loading cycle).

Thus unless these vessels submit a reasonably complete BWRF, it is not possible to estimate what ballast may have been taken up or released owing to the lack of information concerning the amount of cargo already on board. Since parts of many BWRFs handed to port officials were often incomplete and/or contained illogical information, it was also very time consuming and often impossible to interpret from either these forms or the port shipping records how much ballast water had been taken up or discharged.

Thus of the total of 919 vessel visits that had been added to the database by the end of the second consultants visit, only half of these originated from BWRFs submitted between January 2001 and June 2002, the rest being expanded from the CFP-A's spreadsheet that summarised other visits in the 1998-2000 port shipping records. The following statistics were obtained from the Access database of 919 visit records:

- For the 208 visits entered for the Ferteco export terminal, these comprised bulk carriers visiting between 27 August 1999 (when it opened) and 25 April 2002, and included the largest vessel to visit the port (*Amy N*; 322,457 DWT).
- For the 323 visits relating to the Carvao import terminal, these comprised bulk carriers spanning the period between 5 January 1998 and 24 May 2002.
- For the 54 visits entered for the Alumina import terminal, these spanned the period from 16 January 1998 to 4 April 2002 and comprised bulk carriers, a few general cargo ships plus eleven chemical and product tankers delivering caustic soda and other bulk liquids. Since these berths are supplied with watering but no bunker oil or export lines, some relatively small BW discharges estimated for vessels visiting this terminal during the pre-BWRF period (46 tank records, mean 718 tonnes) may not have actually occurred.

- For the 197 vessel visits entered for the Tecon terminal, these spanned the period from 28 June 1998 to 1 June 2002 and involved four main types of vessel (i.e. 70 general cargo ships, 29 container ships, 13 ro-ro vessels and 10 vehicle carriers, some of which visited more than once), plus one reefer (refrigerated cargo ship), four passenger ships and 5 miscellaneous types classed as ‘Other’ to enable their entry into the BWRA database.
- The remainder comprised 132 visit records entered from incomplete BWRFs submitted between 23 January 2001 and 2 June 2002. These could not be readily reconciled with port shipping records to identify their correct berthing terminal and required further attention.

The database stores the amounts and sources of BW discharged from these arrivals (i.e. Ferteco and Tecon terminals), as entered from the BWRFs and/or supplemented or wholly derived from the port shipping records (1998-2001). Connection of the active berth layer of the GIS Port Map to the database allowed tables summarising the BW discharge statistics to be conveniently displayed for each terminal. Examples of these table displayed by the GIS Port Map are shown for the Ferteco, Tecon and Alumina terminals in Figures 15, 16 and 17 respectively.

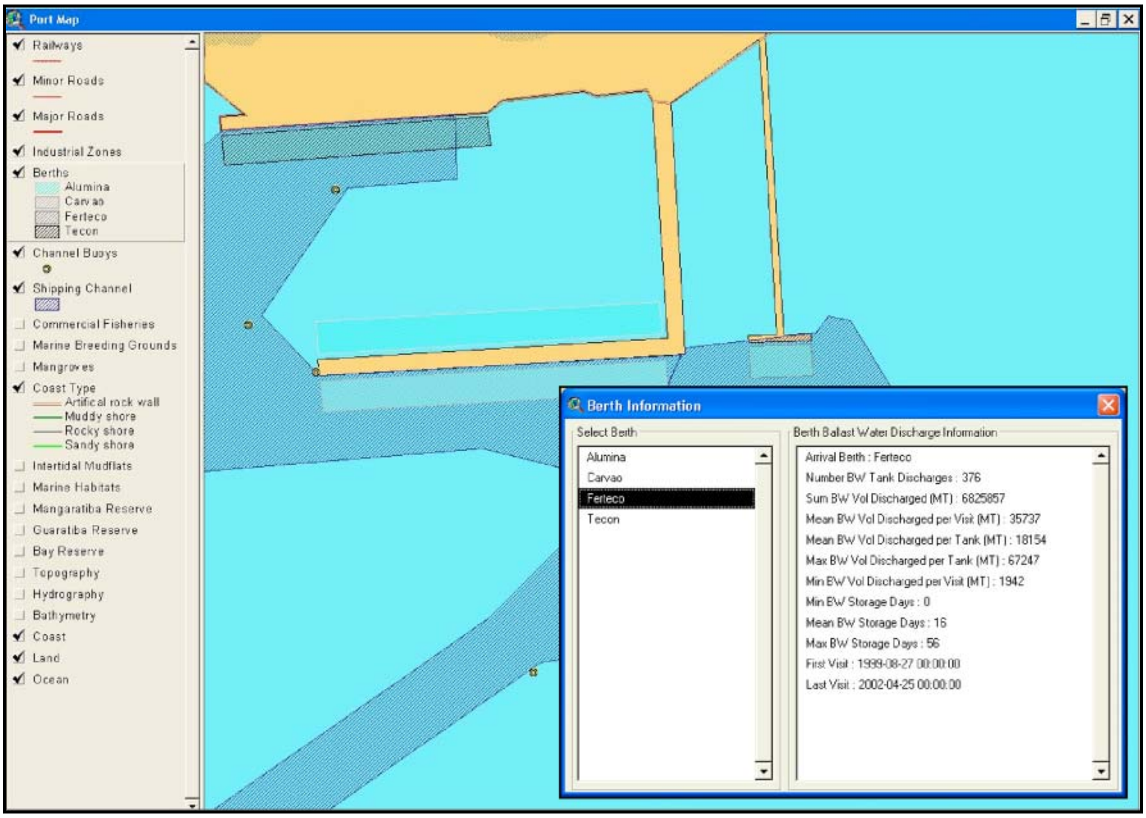

Figure 15. *BW discharge statistics displayed by GIS Port Map for the Ferteco (iron ore) export terminal*

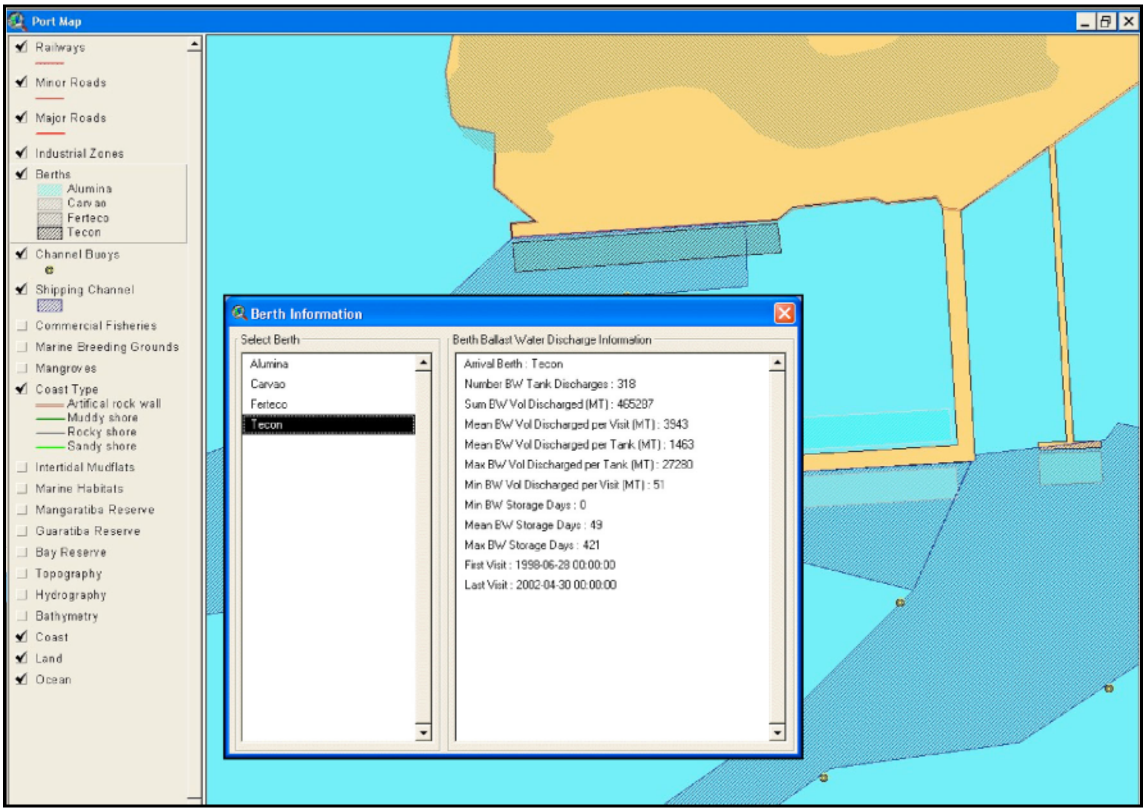

Figure 16. *BW discharge statistics displayed by GIS Port Map for the multi-use Tecon terminal*

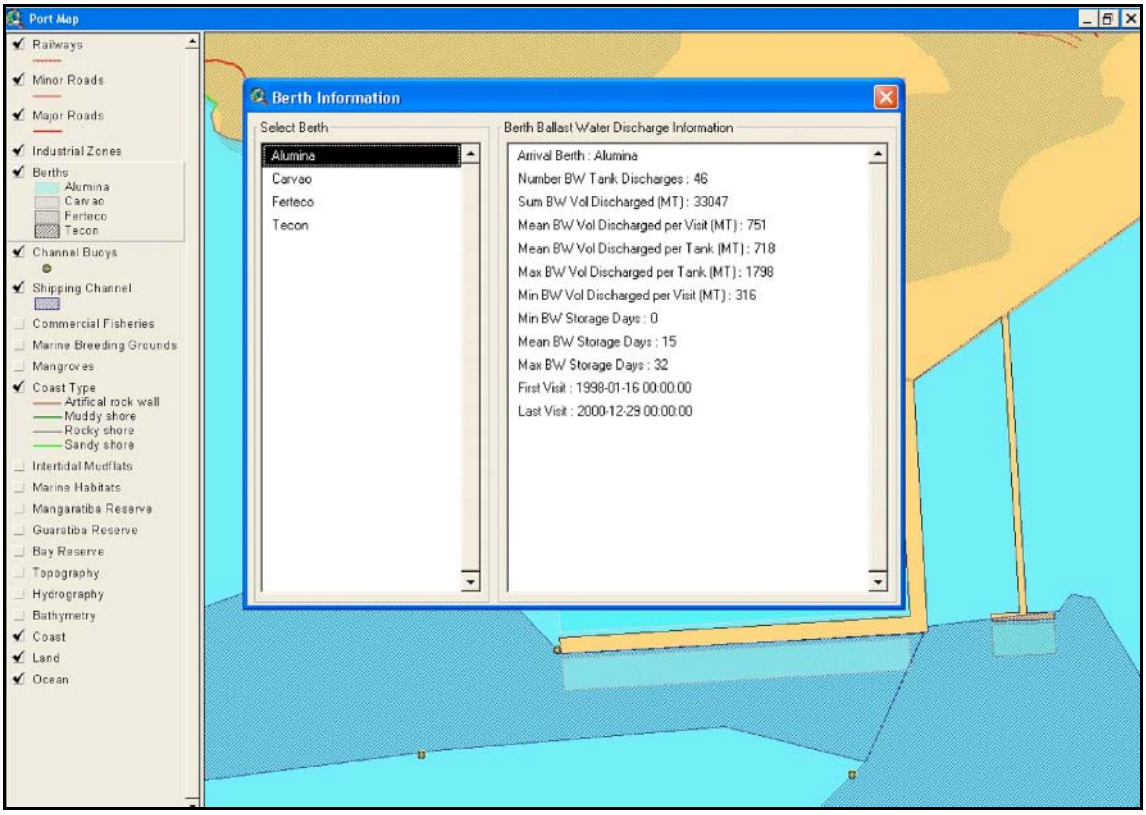

Figure 17. *BW discharge statistics displayed by GIS Port Map for the Alumina dry and liquid bulk terminal*

4.4 Identification of source ports

From the 919 vessel visit records and 1540 associated tank discharges in the Sepetiba database, the total number of identified BW source ports was 148 (Table 3). Figure 18 shows output from the GIS world bioregion map depicting the location and relative importance of these source ports with respect to C1 (BW discharge frequency). As with all GIS outputs, the map is 'zoomable' to allow all ports and symbols to be clearly delineated at smaller scales.

The frequency values for the 148 identified source ports listed in Table 3 are the C1 coefficients used to calculate the relative overall risk (Section 3.10). The source port 'supplying' the highest frequency of BW discharges at Sepetiba was Rotterdam (9%). This was followed by Santos (Brazil; 4.4%), Ijmuiden (Netherlands; 4.2%), Praia Mole (Brazil; 4.1%), Salvador (Brazil; 3.4%) and Brest (France; 2.8%).

Of the 148 identified source ports, the top 16 provided 50% of the source-identified discharges at Sepetiba, while the next 22 ports contributed a further 25%, i.e. only 38 of all source ports (26%) accounted for 75% of the total number of source-identified BW discharges (Table 3).

As noted earlier, the low number of individual tank discharges (1540) compared to the visits (919), is due to (a) the need to include port shipping records prior to the regular use of BWRFs (all tanks combined), and (b) many vessels submitted a single, total discharge volume covering all their tanks on the BWRF.

The total volume of BW discharged from identified source ports of the 919 vessel visits was 11,652,829 tonnes. The various discharge volume percentages shown for each source port in Table 3 and Figure 19 provide the C2 (BW discharge volume) values used in the risk calculation (Section 3.10).

The port rankings for C2 were close but not exactly the same as those for C1 (as ranked in Table 3). The source ports providing the largest volume of BW discharged at Sepetiba were Rotterdam (13.4%), Santos (Brazil; 7.2%) and Salvador (Brazil; 5.6%; Table 3). These were followed by Dunkerque (France; 4.9%), Ijmuiden (Netherlands; 4.0%), Praia Mole (Brazil; 3.6%) and Fos sur Mer (France; 2.8%). The first non-Atlantic port in the C2 ranking was the Port of Hay Point (Australia; 2.0%) which was ranked 11th.

The top 11 of identified source ports provided 50% of the total discharged volume, and the next 22 ports a further 25%. Thus only 33 (22%) of all identified source ports accounted for 75% of the source-identified BW discharged at Sepetiba. Of the top 20 ports in terms of total discharge volume (63% of C2), five were in Brazil, three in both the Netherlands and United States, two in both France and United Kingdom, and one in Australia, Belgium, Gibraltar, Portugal and Spain.

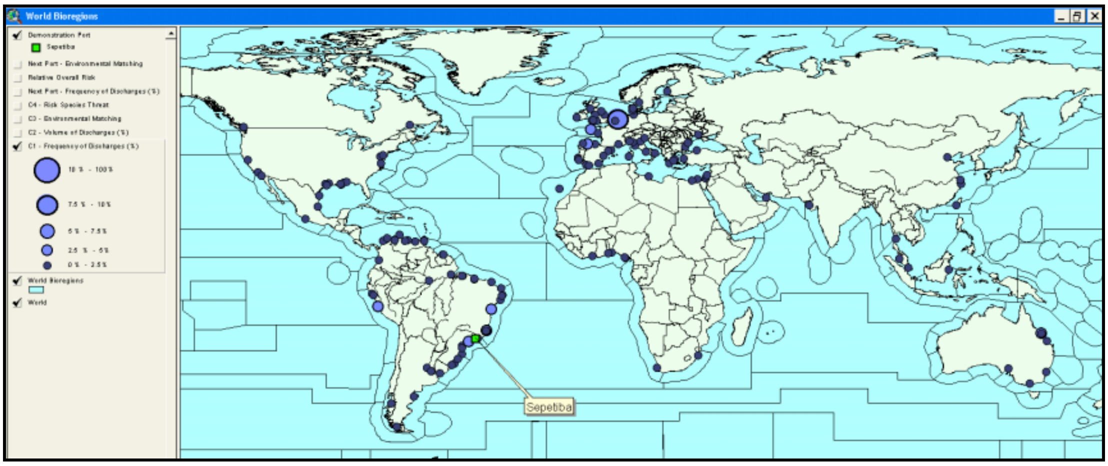

Figure 18. *GIS output showing the location and relative importance of BW source ports with respect to frequency of tank discharges (C1) at Port of Sepetiba*

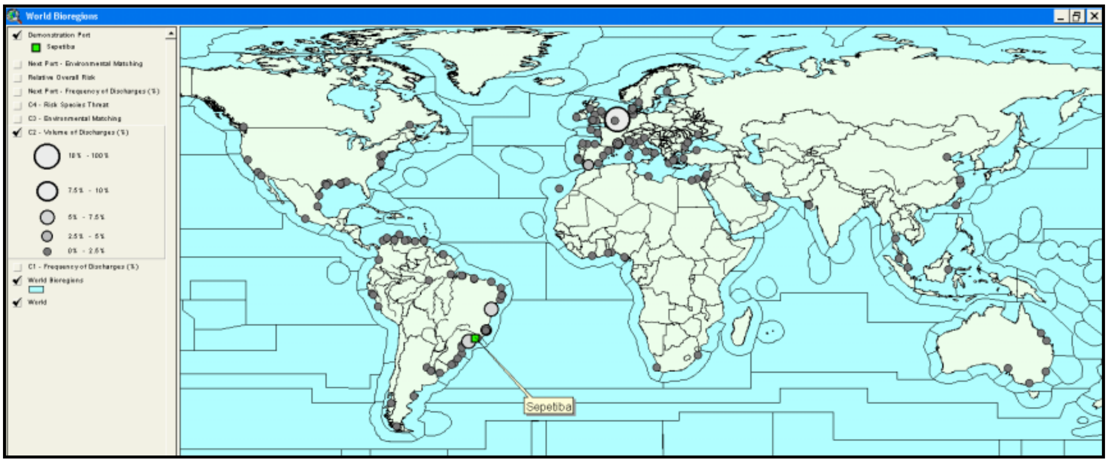

Figure 19. *GIS output showing location and relative importance of the source ports with respect to the volume of tank discharges (C2) at Port of Sepetiba*

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

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
1	NLRTM	Rotterdam	Netherlands	8.989%	1,557,061	13.362%
2	BRSSZ	Santos	Brazil	4.401%	834,151	7.158%
3	NLIJM	IJmuiden	Netherlands	4.213%	470,699	4.039%
4	BRPRM	Praia Mole	Brazil	4.120%	421,160	3.614%
5	BRSSA	Salvador	Brazil	3.371%	655,153	5.622%
6	FRBES	Brest	France	2.809%	22,602	0.194%
7	PECLL	Callao	Peru	2.809%	119,334	1.024%
8	AUHPT	Hay Point	Australia	2.528%	236,949	2.033%
9	ESGIJ	Gijon	Spain	2.528%	264,404	2.269%
10	FRFOS	Fos sur Mer	France	2.154%	327,835	2.813%
11	CNTXG	Tianjinxingang (Xingang) Tianjin	China	2.060%	117,704	1.010%
12	FRDKK	Dunkerque	France	2.060%	572,420	4.912%
13	GIGIB	Gibraltar	Gibraltar	1.966%	285,379	2.449%
14	NLAMS	Amsterdam	Netherlands	1.966%	145,534	1.249%
15	BRVDC	Vila Do Conde	Brazil	1.873%	95,632	0.821%
16	GBIMM	Immingham	United Kingdom	1.873%	171,242	1.470%
17	PTSIE	Sines	Portugal	1.779%	184,050	1.579%
18	ZARCB	Richards Bay	South Africa	1.498%	50,660	0.435%
19	BRALU	Alumar	Brazil	1.404%	53,037	0.455%
20	IEMOT	Moneypoint	Ireland	1.404%	126,292	1.084%
21	USMOB	Mobile Alabama	United States	1.404%	145,623	1.250%
22	GRMIL	Milaki	Greece	1.311%	93,414	0.802%
23	CIABJ	Abidjan	Ivory Coast	1.217%	27,819	0.239%
24	IDTBA	Tanjung Bara Coal Terminal	Indonesia	1.217%	99,492	0.854%
25	ITTAR	Taranto	Italy	1.217%	99,725	0.856%
26	BEANR	Antwerpen	Belgium	1.124%	161,879	1.389%
27	CAVAN	Vancouver British Columbia	Canada	1.124%	108,405	0.930%
28	NGPHC	Port Harcourt	Nigeria	1.124%	8,196	0.070%
29	USPHF	Hampton Roads	United States	1.124%	46,308	0.397%
30	DEHAM	Hamburg	Germany Federal Republic	1.030%	98,176	0.843%
31	USBPT	Beaumont	United States	1.030%	36,570	0.314%
32	ITGOA	Genoa	Italy	0.936%	33,846	0.290%
33	USLGB	Long Beach California	United States	0.936%	161,820	1.389%
34	USTXT	Texas City Texas	United States	0.936%	160,020	1.373%
35	AUGLT	Gladstone	Australia	0.843%	72,896	0.626%
36	BRVIX	Vitoria	Brazil	0.843%	256,393	2.200%
37	GB001	Burry Port	United Kingdom	0.843%	88,570	0.760%
38	ROCND	Constanta	Romania	0.843%	99,902	0.857%
39	USNEN	Norfolk-Newport News Virginia	United States	0.843%	89,177	0.765%
40	BRRIO	Rio de Janeiro	Brazil	0.749%	33,195	0.285%
41	AUPDT	Dalrymple Bay	Australia	0.562%	88,126	0.756%
42	BRFOR	Fortaleza	Brazil	0.562%	113,845	0.977%
43	ESALG	Algeciras	Spain	0.562%	136,844	1.174%
44	ESCAD	Cadiz	Spain	0.562%	24,816	0.213%
45	GBBRS	Bristol	United Kingdom	0.562%	81,427	0.699%
46	GBHST	Hunterston	United Kingdom	0.562%	151,275	1.298%
47	SIKOP	Koper	Slovenia	0.562%	49,176	0.422%
48	AWSNL	San Nicolas	Aruba	0.468%	93,373	0.801%
49	CARBK	Roberts Bank	Canada	0.468%	67,346	0.578%
50	FRMTX	Montoir	France	0.468%	22,790	0.196%
51	GBRER	Redcar	United Kingdom	0.468%	47,209	0.405%
52	ILHAD	Hadera	Israel	0.468%	49,976	0.429%
53	INBED	Bedi	India	0.468%	31,170	0.267%
54	ITSVN	Savona	Italy	0.468%	19,940	0.171%
55	NGONN	Onne	Nigeria	0.468%	9,653	0.083%
56	PESVY	Salaverry	Peru	0.468%	57,001	0.489%

*C1 = proportion of all discharges (% of 1540 charges);   C2 = proportion of total discharge volume (%)

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

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
57	TRERE	Eregli	Turkey	0.468%	56,268	0.483%
58	TTCHA	Chaguaramas	Trinidad and Tobago	0.468%	8,145	0.070%
59	USBAL	Baltimore Maryland	United States	0.468%	57,626	0.495%
60	USSAN	San Diego California	United States	0.468%	23,754	0.204%
61	ARZAE	Zarate	Argentina	0.375%	79,279	0.680%
62	BRNAT	Natal	Brazil	0.375%	144,384	1.239%
63	ESCRS	Carboneras	Spain	0.375%	115,620	0.992%
64	ESSCI	San Ciprian	Spain	0.375%	21,455	0.184%
65	USDVT	Davant	United States	0.375%	101,859	0.874%
66	VEGUT	Guanta	Venezuela	0.375%	65,075	0.558%
67	BGBOJ	Bourgas	Bulgaria	0.281%	5,263	0.045%
68	BRMGU	Munguba	Brazil	0.281%	61,821	0.531%
69	BRPNG	Paranagua	Brazil	0.281%	5,061	0.043%
70	COBAQ	Barranquilla	Colombia	0.281%	30,059	0.258%
71	ESTAR	Tarragona	Spain	0.281%	19,932	0.171%
72	GRPIR	Piraeus	Greece	0.281%	36,236	0.311%
73	ITPVE	Porto Vesme (Portoscuso)	Italy	0.281%	2,826	0.024%
74	ITSPE	La Spezia	Italy	0.281%	9,181	0.079%
75	TTPTS	Point Lisas	Trinidad and Tobago	0.281%	33,798	0.290%
76	USGFT	Gulfport	United States	0.281%	7,267	0.062%
77	USILG	Wilmington Delaware	United States	0.281%	3,552	0.030%
78	USMSY	New Orleans	United States	0.281%	32,965	0.283%
79	BEGNE	Ghent/Gent	Belgium	0.187%	3,267	0.028%
80	BJCOO	Cotonou	Benin	0.187%	14,088	0.121%
81	BRBEL	Belem	Brazil	0.187%	67,645	0.581%
82	BRSFS	Sao Francisco do Sul	Brazil	0.187%	88,684	0.761%
83	BRTUB	Tubarao	Brazil	0.187%	53,620	0.460%
84	COSMR	Santa Marta	Colombia	0.187%	2,066	0.018%
85	EGDAM	Damietta	Egypt	0.187%	27,252	0.234%
86	ESBIO	Bilbao	Spain	0.187%	2,401	0.021%
87	GBLIV	Liverpool	United Kingdom	0.187%	65,112	0.559%
88	NLVLI	Flushing (Vlissingen)	Netherlands	0.187%	1,310	0.011%
89	PTSET	Setubal	Portugal	0.187%	33,918	0.291%
90	TRIZM	Izmir (Smyrna)	Turkey	0.187%	53,489	0.459%
91	UYMVD	Montevideo	Uruguay	0.187%	57,741	0.496%
92	VELAG	La Guaira	Venezuela	0.187%	31,369	0.269%
93	AEDXB	Dubai	United Arab Emirates	0.094%	11,156	0.096%
94	ARCMP	Campana	Argentina	0.094%	4,663	0.040%
95	ARPMY	Puerto Madryn	Argentina	0.094%	1,475	0.013%
96	ARROS	Rosario	Argentina	0.094%	1,416	0.012%
97	AUPKL	Port Kembla	Australia	0.094%	376	0.003%
98	AUPPI	Port Pirie	Australia	0.094%	1,385	0.012%
99	BRARB	Aratu	Brazil	0.094%	1,559	0.013%
100	BRIBB	Imbituba	Brazil	0.094%	1,597	0.014%
101	BRMAO	Manaus	Brazil	0.094%	27,060	0.232%
102	BRPOA	Porto Alegre	Brazil	0.094%	544	0.005%
103	BRREC	Recife	Brazil	0.094%	27,664	0.237%
104	BRRIG	Rio Grande	Brazil	0.094%	31,169	0.267%
105	BRSLZ	São Luis	Brazil	0.094%	3,450	0.030%
106	BRSSO	São Sebastiao	Brazil	0.094%	26,984	0.232%
107	BRTRM	Tramandai	Brazil	0.094%	30,120	0.258%
108	CASEI	Sept Iles (Seven Is.) Quebec (Pointe Noire)	Canada	0.094%	26,722	0.229%
109	CLCHA	Chacabuco	Chile	0.094%	649	0.006%
110	CNNBO	Beilun	China	0.094%	1,776	0.015%
111	CNSHA	Shanghai (Shihu) Shanghai	China	0.094%	1,510	0.013%
112	COBUN	Buenaventura	Colombia	0.094%	906	0.008%
113	COCTG	Cartagena	Colombia	0.094%	946	0.008%
114	DKENS	Enstedvaerkets Havn	Denmark	0.094%	61,349	0.526%
115	DKFRC	Fredericia	Denmark	0.094%	29,586	0.254%
116	EGEDK	El Dekheila	Egypt	0.094%	31,161	0.267%
117	ESLPA	Las Palmas	Spain	0.094%	55	0.000%
118	FIPOR	Pori	Finland	0.094%	16,971	0.146%
119	FRMRS	Caronte (Marseilles)	France	0.094%	1,600	0.014%
120	GBPTB	Port Talbot	United Kingdom	0.094%	29,446	0.253%
121	GBTEE	Teesport (Middlesbrough)	United Kingdom	0.094%	1,629	0.014%
122	GREEU	Eleusis	Greece	0.094%	140	0.001%
123	GRKLX	Kalamata	Greece	0.094%	18,035	0.155%
124	ILASH	Ashdod	Israel	0.094%	2,756	0.024%
125	ILHFA	Haifa	Israel	0.094%	40,424	0.347%
126	ITNAP	Napoli	Italy	0.094%	1,006	0.009%
127	ITPIO	Piombino	Italy	0.094%	762	0.007%
128	ITRAN	Ravenna	Italy	0.094%	33,823	0.290%
129	ITTRS	Trieste	Italy	0.094%	630	0.005%
130	LYMRA	Misurata	Lybian Arab Jamahiriya	0.094%	29,357	0.252%
131	MXLZC	Lazaro Cardenas	Mexico	0.094%	596	0.005%
132	MXTAM	Tampico	Mexico	0.094%	1,605	0.014%
133	MYLUM	Lumut	Malaysia	0.094%	627	0.005%
134	PEPCH	Puerto Chicama	Peru	0.094%	1,629	0.014%
135	PTLIS	Lisboa	Portugal	0.094%	526	0.005%
136	ROMAG	Mangalia	Romania	0.094%	19,457	0.167%
137	SEGOT	Gothenburg (Göteborg)	Sweden	0.094%	852	0.007%
138	SGSIN	Singapore	Singapore	0.094%	1,502	0.013%
139	SRPBM	Paramaribo	Suriname	0.094%	1,573	0.013%
140	SRPRM	Paranam	Suriname	0.094%	1,630	0.014%
141	TH001	Bang Saphan	Thailand	0.094%	11,628	0.100%
142	TWKHH	Kaohsiung	Taiwan Province of China	0.094%	852	0.007%
143	UADNB	Dnepro-Bugsky	Ukraine	0.094%	1,573	0.013%
144	USBRO	Brownsville Texas	United States	0.094%	1,629	0.014%
145	USPHG	Pittsburg	United States	0.094%	1,766	0.015%
146	VEMAR	Maracaibo	Venezuela	0.094%	1,349	0.012%
147	VEPBL	Puerto Cabello	Venezuela	0.094%	1,483	0.013%
148	ZASDB	Saldanha Bay	South Africa	0.094%	615	0.005%

*C1 = proportion of all discharges (% of 1540 charges); 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 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 Sepetiba, since the large majority of bulk carriers departing the Carvao and Alumina import terminals must have been carrying ballast water uplifted alongside these berths.

Of the 104 assumed BW destination ports (i.e. Next Ports of Call) in the 1998-2002 database, their location and proportional frequency are shown Figure 20 and listed in Table 4. The latter lists the top 44 destination ports that accounted for >80% of the reported Next Ports of Call by all 919 vessel departures. Figure 20 and Table 4 also show that the nearby port of Santos stood out as the most frequent destination port, with over 10% of Next Ports of Call attributed to this one port which serves Brazil's largest industrial city of Sao Paulo.

Table 4 shows that, of the 17 ports accounting for the destinations of >50% of the vessel departures from Sepetiba, five were in Brazil, four were in Argentina, two each in France and China, and one each in Bulgaria, Colombia, Mexico and Taiwan Province.

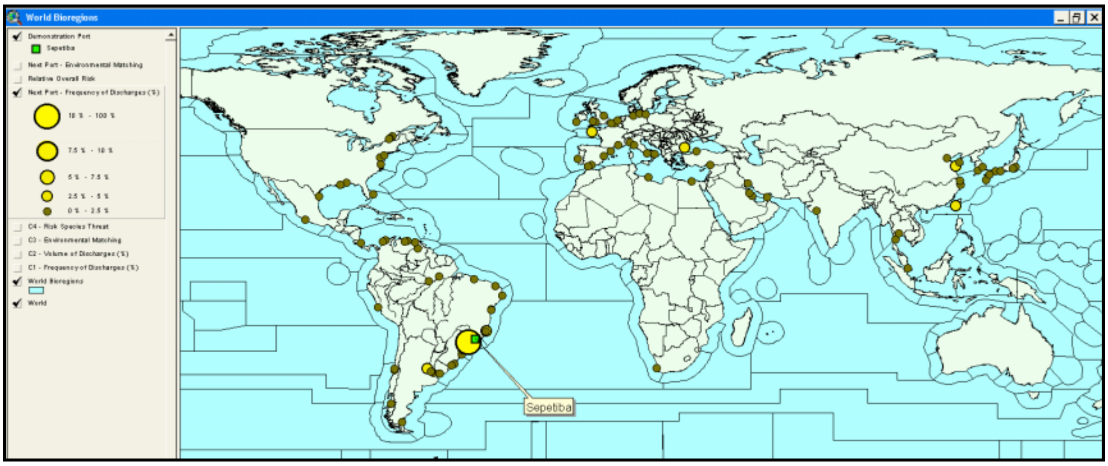

Figure 20. *GIS output showing the location and frequency of destination ports, recorded as the Next Port of Call in the Port of Sepetiba BWRFs and shipping records*

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

No.	UN Port Code	Destination Port (Next Port of Call)	Country	Proportion of Departures (%)	Cumulative Percentage
1	BRSSZ	Santos	Brazil	10.23	10.23
2	TWKHH	Kaohsiung	Taiwan Province of China	4.05	14.28
3	ARVCN	Villa Constitucion (Puerto Acevedo)	Argentina	3.84	18.12
4	BRTUB	Tubarao	Brazil	3.20	21.32
5	BGBOJ	Bourgas	Bulgaria	2.56	23.88
6	BRSPB	Sepetiba	Brazil	2.56	26.44
7	CNTAO	Qingdao (Longgang) Shandong	China	2.56	29.00
8	FRUIP	Quimper	France	2.56	31.56
9	ARBUE	Buenos Aires	Argentina	2.35	33.91
10	ARSLO	San Lorenzo-San Martin	Argentina	2.35	36.26
11	BRSSA	Salvador	Brazil	2.35	38.61
12	FRDKK	Dunkerque	France	2.35	40.96
13	ARSNS	San Nicolas	Argentina	2.13	43.09
14	BRPNG	Paranagua	Brazil	1.92	45.01
15	CNNBO	Beilun	China	1.92	46.93
16	COBAQ	Barranquilla	Colombia	1.92	48.85
17	MXLZC	Lazaro Cardenas	Mexico	1.92	50.77
18	PLSWI	Swinoujscie	Poland	1.71	52.48
19	BRMAO	Manaus	Brazil	1.49	53.97
20	BRRIG	Rio Grande	Brazil	1.49	55.46
21	BRRIO	Rio de Janeiro	Brazil	1.49	56.95
22	BRSSO	São Sebastiao	Brazil	1.49	58.44
23	JPOIT	Oita Oita	Japan	1.49	59.93
24	BEGNE	Ghent/Gent	Belgium	1.28	61.21
25	BRITJ	Itajai	Brazil	1.28	62.49
26	DEHAM	Hamburg	Germany Federal Republic of	1.28	63.77
27	FRFOS	Fos sur Mer	France	1.28	65.05
28	KRKPO	Pohang	Korea	1.28	66.33
29	NLRTM	Rotterdam	Netherlands	1.28	67.61
30	BRVIX	Vitoria	Brazil	1.07	68.68
31	DERSK	Rostock	Germany Federal Republic of	1.07	69.75
32	SAJUB	Jubail	Saudi Arabia	1.07	70.82
33	USBAL	Baltimore Maryland	United States	1.07	71.89
34	BRPRM	Praia Mole	Brazil	0.85	72.74
35	GBPTB	Port Talbot	United Kingdom	0.85	73.59
36	KRKAN	Kwangyang	Korea	0.85	74.44
37	PTLIS	Lisboa	Portugal	0.85	75.29
38	UYMVD	Montevideo	Uruguay	0.85	76.14
39	VEPBL	Puerto Cabello	Venezuela	0.85	76.99
40	AEQIW	Umm Al Qiwain	United Arab Emirates	0.64	77.63
41	ARCMP	Campana	Argentina	0.64	78.27
42	ARZAE	Zarate	Argentina	0.64	78.91
43	BHMAN	Manama	Bahrain	0.64	79.55
44	BRSFS	Sao Francisco do Sul	Brazil	0.64	80.19

4.6 Environmental similarity analysis

Of the identified 148 source ports and 104 destination ports, sufficient port environmental data were obtained to include 58% of the former and 56% of the latter in the multivariate similarity analysis by PRIMER. These ports accounted for 79.5% of all recorded tank discharges and 67% of all recorded departures respectively (Tables 5-6). Details of the 357 ports included in the multivariate analysis carried out for Sepetiba 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 Sepetiba 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 Sepetiba 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 Sepetiba source and destination ports are in Figures 21 and 22 respectively. These plots and Tables 5-6 show that Sepetiba has a relatively high environmental similarity to a large number of its trading ports (i.e. C3s in the 0.6 - 0.8 range). This can be related to its borderline subtropical-tropical location, providing a wide seasonality to its temperature regimes, plus an annual pattern of rainfall that constrains any seasonal development of salinity extrema.

It is not surprising that the most environmentally similar port to Sepetiba was Rio de Janeiro (C3 = 0.86) with 22 other Brazilian ports having either calculated or estimated C3 matching coefficients in the 0.7-0.8 range (Table 5). The nearest similar source ports beyond Brazil were the west African port of Abidjan (C3 of 0.70), Singapore (0.63), several Mediterranean ports and the port of Port Kembla on the east coast of Australia, all of which were in the 0.6-0.63 range (Table 5). The most environmentally dissimilar ports that were trading with Sepetiba in 1998-2002 were various riverine, highly brackish and/or cool water ports in North America, southern Argentina and north-west Europe (0.2 - 0.3; Tables 5-6; Figures 21,22).

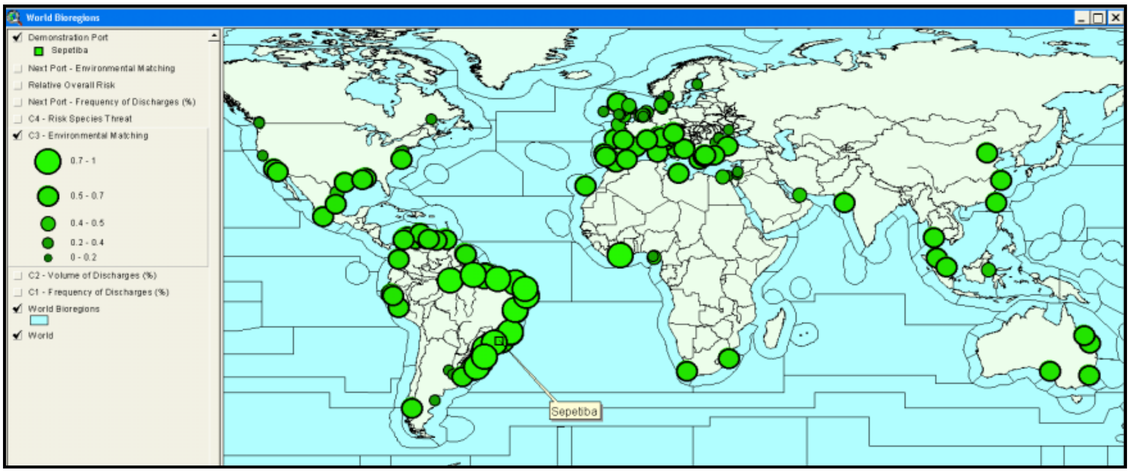

Figure 21. *GIS output showing the location and environmental matching coefficients (C3) of BW source ports identified for the Port of Sepetiba*

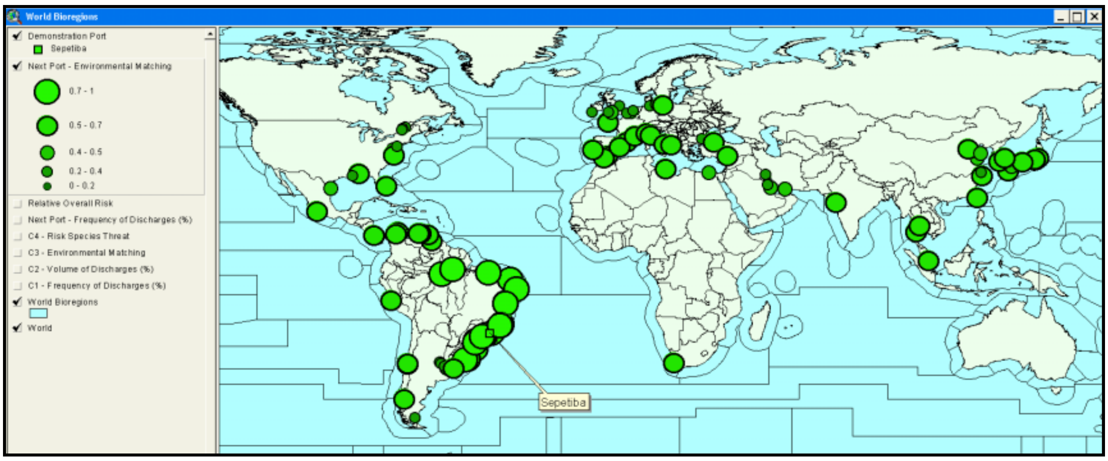

Figure 22. *GIS output showing the location and environmental matching coefficients (C3) of the destination ports identified for the Port of Sepetiba*

***Table 5.** Source ports identified for Port of Sepetiba, 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
BRRIO	Rio de Janeiro	Brazil	0.75%	0.86	
BRPRM	Praia Mole	Brazil	4.12%	0.80	
BRTUB	Tubarao	Brazil	0.19%	0.79	
BRSSZ	Santos	Brazil	4.40%	0.78	
BRVIX	Vitoria	Brazil	0.84%	0.74	
BRSSA	Salvador	Brazil	3.37%	0.72	
BRPNG	Paranagua	Brazil	0.28%	0.72	
BRALU	Alumar	Brazil	1.40%	0.70	Estimated
BRARB	Aratu	Brazil	0.09%	0.70	Estimated
BRBEL	Belem	Brazil	0.19%	0.70	Estimated
BRFOR	Fortaleza	Brazil	0.56%	0.70	Estimated
BRIBB	Imbituba	Brazil	0.09%	0.70	Estimated
BRMAO	Manaus	Brazil	0.09%	0.70	Estimated
BRMGU	Munguba	Brazil	0.28%	0.70	Estimated
BRNAT	Natal	Brazil	0.37%	0.70	Estimated
BRPOA	Porto Alegre	Brazil	0.09%	0.70	Estimated
BRREC	Recife	Brazil	0.09%	0.70	Estimated
BRRIG	Rio Grande	Brazil	0.09%	0.70	Estimated
BRSFS	Sao Francisco do Sul	Brazil	0.19%	0.70	Estimated
BRSLZ	São Luis	Brazil	0.09%	0.70	Estimated
BRSSO	São Sebastiao	Brazil	0.09%	0.70	Estimated
BRTRM	Tramandai	Brazil	0.09%	0.70	Estimated
BRVDC	Vila Do Conde	Brazil	1.87%	0.70	Estimated
CIABJ	Abidjan	Ivory Coast	1.22%	0.70	Estimated
SGSIN	Singapore	Singapore	0.09%	0.63	
ITTRS	Trieste	Italy	0.09%	0.62	
SIKOP	Koper	Slovenia	0.56%	0.62	
AUPKL	Port Kembla	Australia	0.09%	0.61	
ITTAR	Taranto	Italy	1.22%	0.60	
BJCOO	Cotonou	Benin	0.19%	0.60	Estimated
CLCHA	Chacabuco	Chile	0.09%	0.60	Estimated
ITSPE	La Spezia	Italy	0.28%	0.60	Estimated
ITSVN	Savona	Italy	0.47%	0.60	Estimated
LYMRA	Misurata	Lybian Arab Jamahiriya	0.09%	0.60	Estimated
MXLZC	Lazaro Cardenas	Mexico	0.09%	0.60	Estimated
MXTAM	Tampico	Mexico	0.09%	0.60	Estimated
PEPCH	Puerto Chicama	Peru	0.09%	0.60	Estimated
PESVY	Salaverry	Peru	0.47%	0.60	Estimated
TH001	Bang Saphan	Thailand	0.09%	0.60	Estimated
TTCHA	Chaguaramas	Trinidad and Tobago	0.47%	0.60	Estimated
TTPTS	Point Lisas	Trinidad and Tobago	0.28%	0.60	Estimated
USNEN	Norfolk-Newport News Virginia	United States	0.84%	0.60	
ITRAN	Ravenna	Italy	0.09%	0.60	
USTXT	Texas City Texas	United States	0.94%	0.59	
ZARCB	Richards Bay	South Africa	1.50%	0.59	
USPHF	Hampton Roads	United States	1.12%	0.59	
ZASDB	Saldanha Bay	South Africa	0.09%	0.58	
CNNBO	Beilun	China	0.09%	0.58	
GREEU	Eleusis	Greece	0.09%	0.57	
ESTAR	Tarragona	Spain	0.28%	0.57	
AUPPI	Port Pirie	Australia	0.09%	0.57	
ESBIO	Bilbao	Spain	0.19%	0.56	
PECLL	Callao	Peru	2.81%	0.56	
GIGIB	Gibraltar	Gibraltar	1.97%	0.56	
GRMIL	Milaki	Greece	1.31%	0.55	Estimated
ESGIJ	Gijon	Spain	2.53%	0.55	
COBAQ	Barranquilla	Colombia	0.28%	0.55	Estimated
COSMR	Santa Marta	Colombia	0.19%	0.55	Estimated
ESCAD	Cadiz	Spain	0.56%	0.55	Estimated
ESSCI	San Ciprian	Spain	0.37%	0.55	Estimated
GRKLX	Kalamata	Greece	0.09%	0.55	Estimated
INBED	Bedi	India	0.47%	0.55	Estimated
PTSET	Setubal	Portugal	0.19%	0.55	Estimated
USSAN	San Diego California	United States	0.47%	0.55	
GRPIR	Piraeus	Greece	0.28%	0.55	
AWSNL	San Nicolas	Aruba	0.47%	0.54	Estimated
ESCRS	Carboneras	Spain	0.37%	0.54	Estimated
AUGLT	Gladstone	Australia	0.84%	0.54	
COCTG	Cartagena	Colombia	0.09%	0.54	
MYLUM	Lumut	Malaysia	0.09%	0.54	
TRERE	Eregli	Turkey	0.47%	0.53	
AUHPT	Hay Point	Australia	2.53%	0.53	
AUPDT	Dalrymple Bay	Australia	0.56%	0.53	

Table 5 (cont'd). *Source ports identified for Port of Sepetiba, 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
FRMRS	Caronte (Marseilles)	France	0.09%	0.53	
USLGB	Long Beach California	United States	0.94%	0.52	
PTSIE	Sines	Portugal	1.78%	0.52	
TWKHH	Kaohsiung	Taiwan Province of China	0.09%	0.52	
COBUN	Buenaventura	Colombia	0.09%	0.52	Estimated
FRFOS	Fos sur Mer	France	2.15%	0.52	
ESLPA	Las Palmas	Spain	0.09%	0.52	
PTLIS	Lisboa	Portugal	0.09%	0.52	
ESALG	Algeciras	Spain	0.56%	0.51	
UYMVD	Montevideo	Uruguay	0.19%	0.51	
TRIZM	Izmir (Smyrna)	Turkey	0.19%	0.51	
USMOB	Mobile Alabama	United States	1.40%	0.50	
ITGOA	Genoa	Italy	0.94%	0.50	
GBHST	Hunterston	United Kingdom	0.56%	0.50	
CNTXG	Tianjinxingang (Xingang) Tianjin	China	2.06%	0.50	Estimated
FRMTX	Montoir	France	0.47%	0.50	Estimated
ITNAP	Napoli	Italy	0.09%	0.50	Estimated
ITPIO	Piombino	Italy	0.09%	0.50	Estimated
ITPVE	Porto Vesme (Portoscuso)	Italy	0.28%	0.50	Estimated
SRPBM	Paramaribo	Suriname	0.09%	0.50	Estimated
SRPRM	Paranam	Suriname	0.09%	0.50	Estimated
USGFT	Gulfport	United States	0.28%	0.50	Estimated
VEGUT	Guanta	Venezuela	0.37%	0.50	Estimated
VELAG	La Guaira	Venezuela	0.19%	0.50	Estimated
VEMAR	Maracaibo	Venezuela	0.09%	0.50	Estimated
VEPBL	Puerto Cabello	Venezuela	0.09%	0.50	Estimated
IDTBA	Tanjung Bara Coal Terminal	Indonesia	1.22%	0.48	
EGEDK	El Dekheila	Egypt	0.09%	0.47	
NGONN	Onne	Nigeria	0.47%	0.46	
GBBRS	Bristol	United Kingdom	0.56%	0.45	Estimated
GBLIV	Liverpool	United Kingdom	0.19%	0.45	Estimated
USBRO	Brownsville Texas	United States	0.09%	0.45	Estimated
NLIJM	IJmuiden	Netherlands	4.21%	0.45	
FRBES	Brest	France	2.81%	0.44	
DKFRC	Fredericia	Denmark	0.09%	0.42	
DKENS	Enstedvaerkets Havn	Denmark	0.09%	0.41	
NLVLI	Flushing (Vlissingen)	Netherlands	0.19%	0.41	
GBRER	Redcar	United Kingdom	0.47%	0.41	
GBTEE	Teesport (Middlesbrough)	United Kingdom	0.09%	0.41	
AEDXB	Dubai	United Arab Emirates	0.09%	0.41	
NGPHC	Port Harcourt	Nigeria	1.12%	0.39	
ROCND	Constanta	Romania	0.84%	0.38	
ROMAG	Mangalia	Romania	0.09%	0.38	
FRDKK	Dunkerque	France	2.06%	0.37	
IEMOT	Moneypoint	Ireland	1.40%	0.37	
USBPT	Beaumont	United States	1.03%	0.36	
NLRTM	Rotterdam	Netherlands	8.99%	0.35	
CARBK	Roberts Bank	Canada	0.47%	0.35	
BGBOJ	Bourgas	Bulgaria	0.28%	0.35	
CAVAN	Vancouver British Columbia	Canada	1.12%	0.34	
GBPTB	Port Talbot	United Kingdom	0.09%	0.32	
USBAL	Baltimore Maryland	United States	0.47%	0.31	
GB001	Burry Port	United Kingdom	0.84%	0.31	
EGDAM	Damietta	Egypt	0.19%	0.30	
FIPOR	Pori	Finland	0.09%	0.30	Estimated
ILHAD	Hadera	Israel	0.47%	0.30	Estimated
ILHFA	Haifa	Israel	0.09%	0.30	Estimated
SEGOT	Gothenburg (Göteborg)	Sweden	0.09%	0.30	Estimated
GBIMM	Immingham	United Kingdom	1.87%	0.30	
USILG	Wilmington Delaware	United States	0.28%	0.30	
DEHAM	Hamburg	Germany Federal Republic	1.03%	0.29	
USDVT	Davant	United States	0.37%	0.29	
UADNB	Dnepro-Bugsky	Ukraine	0.09%	0.29	
CASEI	Sept Iles (Seven Is.) Quebec (Pointe Noire)	Canada	0.09%	0.27	
ILASH	Ashdod	Israel	0.09%	0.26	
NLAMS	Amsterdam	Netherlands	1.97%	0.25	
BEGNE	Ghent/Gent	Belgium	0.19%	0.25	
CNSHA	Shanghai (Shihu) Shanghai	China	0.09%	0.24	
BEANR	Antwerpen	Belgium	1.12%	0.24	
ARCMP	Campana	Argentina	0.09%	0.21	
USMSY	New Orleans	United States	0.28%	0.20	
ARPMY	Puerto Madryn	Argentina	0.09%	0.20	Estimated
ARROS	Rosario	Argentina	0.09%	0.20	Estimated
ARZAE	Zarate	Argentina	0.37%	0.20	Estimated
USPHG	Pittsburg	United States	0.09%	0.20	Estimated

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

UN Port Code	Destination Port (Next Port of Call)	Country	Proportion of Departures (%)	Environmental Matching (C3)	Coefficient Calculated
BRRIO	Rio de Janeiro	Brazil	149.00%	0.86	
BRPRM	Praia Mole	Brazil	85.00%	0.80	
BRTUB	Tubarao	Brazil	320.00%	0.79	
BRSSZ	Santos	Brazil	1023.00%	0.78	
BRVIX	Vitoria	Brazil	107.00%	0.74	
BRSSA	Salvador	Brazil	235.00%	0.72	
BRPNG	Paranagua	Brazil	192.00%	0.72	
BRARB	Aratu	Brazil	21.00%	0.70	Estimated
BRARE	Areia Branca	Brazil	21.00%	0.70	Estimated
BRIBB	Imbituba	Brazil	21.00%	0.70	Estimated
BRMAO	Manaus	Brazil	149.00%	0.70	Estimated
BRPCL	Portocel	Brazil	21.00%	0.70	Estimated
BRPOA	Porto Alegre	Brazil	21.00%	0.70	Estimated
BRREC	Recife	Brazil	21.00%	0.70	Estimated
BRRIG	Rio Grande	Brazil	149.00%	0.70	Estimated
BRSFS	Sao Francisco do Sul	Brazil	64.00%	0.70	Estimated
BRSLZ	São Luis	Brazil	21.00%	0.70	Estimated
BRSSO	São Sebastiao	Brazil	149.00%	0.70	Estimated
BRTMT	Trombetas	Brazil	21.00%	0.70	Estimated
SGSIN	Singapore	Singapore	43.00%	0.63	
JPKMT	Kimitsu Chiba	Japan	21.00%	0.62	
JPCHB	Chiba Chiba	Japan	21.00%	0.62	
JPKWS	Kawasaki Kanagawa	Japan	64.00%	0.61	
ITTAR	Taranto	Italy	43.00%	0.60	
BSFPO	Freeport Grand Bahama	Bahamas	21.00%	0.60	Estimated
CLCHA	Chacabuco	Chile	21.00%	0.60	Estimated
CLSAI	San Antonio	Chile	21.00%	0.60	Estimated
CLVAP	Valparaiso	Chile	21.00%	0.60	Estimated
LYMRA	Misurata	Lybian Arab Jamahiriya	64.00%	0.60	Estimated
MXLZC	Lazaro Cardenas	Mexico	192.00%	0.60	Estimated
PLSWI	Swinoujscie	Poland	171.00%	0.60	Estimated
TH001	Bang Saphan	Thailand	64.00%	0.60	Estimated
THKSI	Koh Sichang	Thailand	21.00%	0.60	Estimated
USNEN	Norfolk-Newport News Virginia	United States	21.00%	0.60	
JPKOJ	Kagoshima Kagoshima	Japan	21.00%	0.58	
ZASDB	Saldanha Bay	South Africa	43.00%	0.58	
CNNBO	Beilun	China	192.00%	0.58	
JPKSM	Kashima Ibaraki	Japan	43.00%	0.57	
ESBCN	Barcelona	Spain	21.00%	0.56	
PECLL	Callao	Peru	21.00%	0.56	
JPOSA	Osaka Osaka	Japan	21.00%	0.56	
COBAQ	Barranquilla	Colombia	192.00%	0.55	Estimated
CRLIO	Puerto Limon	Costa Rica	21.00%	0.55	Estimated
ESSAG	Sagunto	Spain	21.00%	0.55	Estimated
KRKPO	Pohang	Korea	128.00%	0.54	
KRKAN	Kwangyang	Korea	85.00%	0.54	
COCTG	Cartagena	Colombia	43.00%	0.54	
TRERE	Eregli	Turkey	43.00%	0.53	
BRPOU	Ponta do Ubu	Brazil	43.00%	0.53	
TWKHH	Kaohsiung	Taiwan Province of China	405.00%	0.52	
ITLIV	Livorno	Italy	43.00%	0.52	
FRFOS	Fos sur Mer	France	128.00%	0.52	
PTLIS	Lisboa	Portugal	85.00%	0.52	
ESALG	Algeciras	Spain	21.00%	0.51	
UYMVD	Montevideo	Uruguay	85.00%	0.51	
TRISD	Isdemir	Turkey	21.00%	0.51	
FRUIP	Quimper	France	256.00%	0.51	Estimated
USMOB	Mobile Alabama	United States	43.00%	0.50	
ITGOA	Genoa	Italy	64.00%	0.50	
VECBL	Ciudad Bolivar	Venezuela	21.00%	0.50	Estimated
CNTXG	Tianjinxingang (Xingang) Tianjin	China	64.00%	0.50	Estimated
ESAGP	Malaga	Spain	21.00%	0.50	Estimated
INHAZ	Hazira	India	21.00%	0.50	Estimated
ITSAL	Salerno	Italy	43.00%	0.50	Estimated
VEGUT	Guanta	Venezuela	21.00%	0.50	Estimated
VELAG	La Guaira	Venezuela	64.00%	0.50	Estimated
VEPBL	Puerto Cabello	Venezuela	85.00%	0.50	Estimated
CNTAO	Qingdao (Longgang) Shandong	China	256.00%	0.50	
JPMIZ	Mizushima Okayama	Japan	21.00%	0.49	
CNYNT	Yantai (Muping) Shandong	China	43.00%	0.49	
BRITJ	Itajai	Brazil	128.00%	0.48	
EGEDK	El Dekheila	Egypt	43.00%	0.47	
JPOIT	Oita Oita	Japan	149.00%	0.47	

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

UN Port Code	Destination Port (Next Port of Call)	Country	Proportion of Departures (%)	Environmental Matching (C3)	Coefficient Calculated
ARBUE	Buenos Aires	Argentina	2.3	0.453	
GBNPT	Newport	United Kingdom	0.2	0.450	Estimated
USBRO	Brownsville Texas	United States	0.6	0.450	Estimated
BHMAN	Manama	Bahrain	0.6	0.411	
AEQIW	Umm Al Qiwain	United Arab Emirates	0.6	0.408	
DERSK	Rostock	Germany Federal Republic of	1.1	0.386	Estimated
FRDKK	Dunkerque	France	2.3	0.374	
IEBTM	Baltimore (Rep. of Ireland)	Ireland	0.2	0.368	Estimated
NLRTM	Rotterdam	Netherlands	1.3	0.351	
BGBOJ	Bourgas	Bulgaria	2.6	0.348	
GBPTB	Port Talbot	United Kingdom	0.9	0.325	
CABEC	Becancour Quebec	Canada	0.2	0.324	Estimated
CAMTR	Montreal Quebec	Canada	0.2	0.311	Estimated
USBAL	Baltimore Maryland	United States	1.1	0.309	
GBIMM	Immingham	United Kingdom	0.6	0.299	
DEHAM	Hamburg	Germany Federal Republic of	1.3	0.295	
SAJUB	Jubail	Saudi Arabia	1.1	0.293	
CACOC	Contrecoeur	Canada	0.2	0.276	Estimated
USPHL	Philadelphia Pennsylvania	United States	0.2	0.272	
BEGNE	Ghent/Gent	Belgium	1.3	0.245	
CNSHA	Shanghai (Shihu) Shanghai	China	0.4	0.243	
IRBKM	Bandar Khomeini	I.R. Iran	0.6	0.223	
ARCMP	Campana	Argentina	0.6	0.205	
USMSY	New Orleans	United States	0.4	0.204	
ARRGL	Rio Gallegos	Argentina	0.4	0.200	Estimated
ARROS	Rosario	Argentina	0.2	0.200	Estimated
ARSLO	San Lorenzo-San Martin	Argentina	2.3	0.200	Estimated
ARSNS	San Nicolas	Argentina	2.1	0.200	Estimated
ARVCN	Villa Constitucion (Puerto Acevedo)	Argentina	3.8	0.200	Estimated
ARZAE	Zarate	Argentina	0.6	0.200	Estimated

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 that was identified for Sepetiba are shown in Figure 23 and listed in Table 7. Table 7 also lists the scores for the introduced, suspected and known harmful species of the source port bioregions, as had been added and assigned to the database's species tables by March 2003.

As noted in Section 3.9, these tables and their associated Excel species reference file do not give a complete global list, but provide a working resource enabling convenient update and improvement for each bioregion. Similarly, the 204 bioregions on the GIS world map should not be considered unalterable. Regional resolution of species-presence records is steadily improving in several areas, and this will allow many bioregions to become divided into increasingly smaller units (ultimately approaching the scale of local port waters).

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

The species in Table 8 include preliminary identifications from the Sepetiba PBBS, plus those listed in published and unpublished reports collated by Group C members (Appendix 5).

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 remembered when comparing C4 values between different bioregions, and is a further reason why the independent treatment of C3 for calculating the ROR values is a safer approach (Section 3.10).

Because of the different historical vectors (hull fouling, 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 Sepetiba). 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 Sepetiba (which is located near the centre of bioregion SAII-B; Figure 7, Table 8).

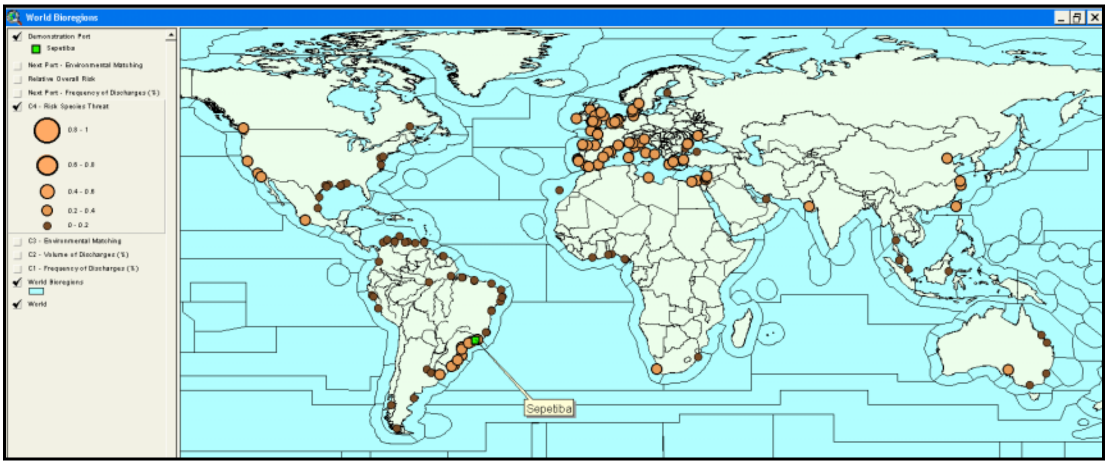

Figure 23. *GIS output showing the location and risk species threat coefficients (C4) of the BW source ports identified for the Port of Sepetiba*

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

Port Code	Source Port	Country	Bio-Region	No. of Introduced Species	Suspected Harmful Species	Knwn Harmful Species	Total Threat Value	Relative Risk Species Threat (C4)
CARBK	Roberts Bank	Canada	NEP-III	66	9	10	193	**0.383**
USPHG	Pittsburg	United States	NEP-V	66	9	10	193	**0.383**
CAVAN	Vancouver British Columbia	Canada	NEP-III	66	9	10	193	**0.383**
AUPPI	Port Pirie	Australia	AUS-VII	39	4	14	191	**0.379**
CNNBO	Beilun	China	NWP-3a	15	11	12	168	**0.333**
CNSHA	Shanghai (Shihu) Shanghai	China	NWP-3a	15	11	12	168	**0.333**
CNTXG	Tianjinxingang (Xingang) Tianjin	China	NWP-4a	11	11	12	164	**0.325**
TWKHH	Kaohsiung	Taiwan Province of China	NWP-2	11	10	12	161	**0.319**
ESTAR	Tarragona	Spain	MED-II	18	5	12	153	**0.304**
FRMRS	Caronte (Marseilles)	France	MED-II	18	5	12	153	**0.304**
FRFOS	Fos sur Mer	France	MED-II	18	5	12	153	**0.304**
GRKLX	Kalamata	Greece	MED-IV	18	5	12	153	**0.304**
LYMRA	Misurata	Lybian Arab Jamahiriya	MED-IV	18	5	12	153	**0.304**
ITGOA	Genoa	Italy	MED-II	18	5	12	153	**0.304**
ITSPE	La Spezia	Italy	MED-II	18	5	12	153	**0.304**
ITSVN	Savona	Italy	MED-II	18	5	12	153	**0.304**
ESCRS	Carboneras	Spain	MED-II	18	5	12	153	**0.304**
ITTAR	Taranto	Italy	MED-IV	18	5	12	153	**0.304**
ITPVE	Porto Vesme (Portoscuso)	Italy	MED-II	18	5	12	153	**0.304**
ITNAP	Napoli	Italy	MED-III	17	5	12	152	**0.302**
ITPIO	Piombino	Italy	MED-III	17	5	12	152	**0.302**
FRMTX	Montoir	France	NEA-IV	21	9	10	148	**0.294**
ESCAD	Cadiz	Spain	NEA-V	20	9	10	147	**0.292**
PTLIS	Lisboa	Portugal	NEA-V	20	9	10	147	**0.292**
ESGIJ	Gijon	Spain	NEA-V	20	9	10	147	**0.292**
ESSCI	San Ciprian	Spain	NEA-V	20	9	10	147	**0.292**
ESBIO	Bilbao	Spain	NEA-V	20	9	10	147	**0.292**
PTSET	Setubal	Portugal	NEA-V	20	9	10	147	**0.292**
PTSIE	Sines	Portugal	NEA-V	20	9	10	147	**0.292**
BEGNE	Ghent/Gent	Belgium	NEA-II	22	8	10	146	**0.290**
GBBRS	Bristol	United Kingdom	NEA-III	19	9	10	146	**0.290**
GBLIV	Liverpool	United Kingdom	NEA-II	22	8	10	146	**0.290**
GBPTB	Port Talbot	United Kingdom	NEA-III	19	9	10	146	**0.290**
UYMVD	Montevideo	Uruguay	SA-IIA	28	6	10	146	**0.290**
NLRTM	Rotterdam	Netherlands	NEA-II	22	8	10	146	**0.290**
NLIJM	IJmuiden	Netherlands	NEA-II	22	8	10	146	**0.290**
NLAMS	Amsterdam	Netherlands	NEA-II	22	8	10	146	**0.290**
GBIMM	Immingham	United Kingdom	NEA-II	22	8	10	146	**0.290**
NLVLI	Flushing (Vlissingen)	Netherlands	NEA-II	22	8	10	146	**0.290**
FRBES	Brest	France	NEA-III	19	9	10	146	**0.290**
BRRIG	Rio Grande	Brazil	SA-IIA	28	6	10	146	**0.290**
GBTEE	Teesport (Middlesbrough)	United Kingdom	NEA-II	22	8	10	146	**0.290**
DEHAM	Hamburg	Germany Federal Republic	NEA-II	22	8	10	146	**0.290**
IEMOT	Moneypoint	Ireland	NEA-III	19	9	10	146	**0.290**
GB001	Burry Port	United Kingdom	NEA-III	19	9	10	146	**0.290**
FRDKK	Dunkerque	France	NEA-II	22	8	10	146	**0.290**
BEANR	Antwerpen	Belgium	NEA-II	22	8	10	146	**0.290**
SEGOT	Gothenburg (Göteborg)	Sweden	B-II	22	8	10	146	**0.290**
GBHST	Hunterston	United Kingdom	NEA-II	22	8	10	146	**0.290**
BRPOA	Porto Alegre	Brazil	SA-IIA	28	6	10	146	**0.290**
GBRER	Redcar	United Kingdom	NEA-II	22	8	10	146	**0.290**
DKFRC	Fredericia	Denmark	B-III	21	8	10	145	**0.288**
DKENS	Enstedvaerkets Havn	Denmark	B-III	21	8	10	145	**0.288**
EGEDK	El Dekheila	Egypt	MED-V	18	5	11	143	**0.284**
EGDAM	Damietta	Egypt	MED-V	18	5	11	143	**0.284**
ILHFA	Haifa	Israel	MED-V	18	5	11	143	**0.284**
ILHAD	Hadera	Israel	MED-V	18	5	11	143	**0.284**
ILASH	Ashdod	Israel	MED-V	18	5	11	143	**0.284**
ITRAN	Ravenna	Italy	MED-VII	17	5	11	142	**0.282**
ITTRS	Trieste	Italy	MED-VII	17	5	11	142	**0.282**
SIKOP	Koper	Slovenia	MED-VII	17	5	11	142	**0.282**
TRIZM	Izmir (Smyrna)	Turkey	MED-VI	17	5	11	142	**0.282**
GRMIL	Milaki	Greece	MED-VI	17	5	11	142	**0.282**
GREEU	Eleusis	Greece	MED-VI	17	5	11	142	**0.282**
GIGIB	Gibraltar	Gibraltar	MED-I	17	5	11	142	**0.282**
GRPIR	Piraeus	Greece	MED-VI	17	5	11	142	**0.282**
ESALG	Algeciras	Spain	MED-I	17	5	11	142	**0.282**
BRIBB	Imbituba	Brazil	SA-IIB	21	5	10	136	**0.270**
BRSSO	São Sebastiao	Brazil	SA-IIB	21	5	10	136	**0.270**
BRSSZ	Santos	Brazil	SA-IIB	21	5	10	136	**0.270**
BRSFS	Sao Francisco do Sul	Brazil	SA-IIB	21	5	10	136	**0.270**
BRTRM	Tramandai	Brazil	SA-IIB	21	5	10	136	**0.270**
BRPNG	Paranagua	Brazil	SA-IIB	21	5	10	136	**0.270**

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

Port Code	Source Port	Country	Bio-Region	No. of Introduced Species	Suspected Harmful Species	Knwn Harmful Species	Total Threat Value	Relative Risk Species Threat (C4)
BRRIO	Rio de Janeiro	Brazil	SA-IIB	21	5	10	136	**0.270**
ROMAG	Mangalia	Romania	MED-IXB	15	5	9	120	**0.238**
UADNB	Dnepro-Bugsky	Ukraine	MED-IXB	15	5	9	120	**0.238**
ROCND	Constanta	Romania	MED-IXB	15	5	9	120	**0.238**
ZASDB	Saldanha Bay	South Africa	WA-IV	14	3	9	113	**0.224**
USLGB	Long Beach California	United States	NEP-VI	35	5	6	110	**0.218**
INBED	Bedi	India	CIO-I	8	14	6	110	**0.218**
MXLZC	Lazaro Cardenas	Mexico	NEP-VIII	35	5	6	110	**0.218**
USSAN	San Diego California	United States	NEP-VI	35	5	6	110	**0.218**
TRERE	Eregli	Turkey	MED-IXA	14	5	7	99	**0.196**
BGBOJ	Bourgas	Bulgaria	MED-IXA	14	5	7	99	**0.196**
ZARCB	Richards Bay	South Africa	WA-V	13	3	7	92	**0.183**
TH001	Bang Saphan	Thailand	EAS-I	6	6	6	84	**0.167**
MYLUM	Lumut	Malaysia	EAS-VI	6	6	6	84	**0.167**
SGSIN	Singapore	Singapore	EAS-VI	6	6	6	84	**0.167**
BRBEL	Belem	Brazil	SA-IV	8	4	6	80	**0.159**
BRALU	Alumar	Brazil	SA-IV	8	4	6	80	**0.159**
BRSLZ	São Luis	Brazil	SA-IV	8	4	6	80	**0.159**
BRFOR	Fortaleza	Brazil	SA-IV	8	4	6	80	**0.159**
BRMGU	Munguba	Brazil	SA-IV	8	4	6	80	**0.159**
BRNAT	Natal	Brazil	SA-IV	8	4	6	80	**0.159**
BRVDC	Vila Do Conde	Brazil	SA-IV	8	4	6	80	**0.159**
USNEN	Norfolk-Newport News Virginia	United States	NA-ET3	10	3	6	79	**0.157**
USBAL	Baltimore Maryland	United States	NA-ET3	10	3	6	79	**0.157**
USILG	Wilmington Delaware	United States	NA-ET3	10	3	6	79	**0.157**
USPHF	Hampton Roads	United States	NA-ET3	10	3	6	79	**0.157**
AWSNL	San Nicolas	Aruba	CAR-III	8	3	6	77	**0.153**
COSMR	Santa Marta	Colombia	CAR-III	8	3	6	77	**0.153**
VEMAR	Maracaibo	Venezuela	CAR-III	8	3	6	77	**0.153**
COBAQ	Barranquilla	Colombia	CAR-III	8	3	6	77	**0.153**
SRPBM	Paramaribo	Suriname	CAR-VI	8	3	6	77	**0.153**
COCTG	Cartagena	Colombia	CAR-III	8	3	6	77	**0.153**
SRPRM	Paranam	Suriname	CAR-VI	8	3	6	77	**0.153**
TTCHA	Chaguaramas	Trinidad and Tobago	CAR-III	8	3	6	77	**0.153**
VELAG	La Guaira	Venezuela	CAR-III	8	3	6	77	**0.153**
TTPTS	Point Lisas	Trinidad and Tobago	CAR-III	8	3	6	77	**0.153**
VEGUT	Guanta	Venezuela	CAR-III	8	3	6	77	**0.153**
VEPBL	Puerto Cabello	Venezuela	CAR-III	8	3	6	77	**0.153**
BRARB	Aratu	Brazil	SA-III	7	4	4	59	**0.117**
AEDXB	Dubai	United Arab Emirates	AG-5	1	6	4	59	**0.117**
BRVIX	Vitoria	Brazil	SA-III	7	4	4	59	**0.117**
BRTUB	Tubarao	Brazil	SA-III	7	4	4	59	**0.117**
BRPRM	Praia Mole	Brazil	SA-III	7	4	4	59	**0.117**
BRSSA	Salvador	Brazil	SA-III	7	4	4	59	**0.117**
BRREC	Recife	Brazil	SA-III	7	4	4	59	**0.117**
CASEI	Sept Iles (Seven Is.) Quebec (Pointe Noire)	Canada	NA-S3	7	3	3	46	**0.091**
USGFT	Gulfport	United States	CAR-I	5	3	3	44	**0.087**
USBPT	Beaumont	United States	CAR-I	5	3	3	44	**0.087**
USTXT	Texas City Texas	United States	CAR-I	5	3	3	44	**0.087**
MXTAM	Tampico	Mexico	CAR-I	5	3	3	44	**0.087**
USMOB	Mobile Alabama	United States	CAR-I	5	3	3	44	**0.087**
USMSY	New Orleans	United States	CAR-I	5	3	3	44	**0.087**
USBRO	Brownsville Texas	United States	CAR-I	5	3	3	44	**0.087**
USDVT	Davant	United States	CAR-I	5	3	3	44	**0.087**
AUGLT	Gladstone	Australia	AUS-XII	10	1	3	43	**0.085**
AUPDT	Dalrymple Bay	Australia	AUS-XII	10	1	3	43	**0.085**
AUHPT	Hay Point	Australia	AUS-XII	10	1	3	43	**0.085**
IDTBA	Tanjung Bara Coal Terminal	Indonesia	EAS-II	2	3	1	21	**0.042**
ARCMP	Campana	Argentina	SA-IIA-RP	0	0	1	10	**0.020**
ARROS	Rosario	Argentina	SA-IIA-RP	0	0	1	10	**0.020**
ARZAE	Zarate	Argentina	SA-IIA-RP	0	0	1	10	**0.020**
PESVY	Salaverry	Peru	SEP-C	3	1	0	6	**0.012**
PEPCH	Puerto Chicama	Peru	SEP-C	3	1	0	6	**0.012**
PECLL	Callao	Peru	SEP-C	3	1	0	6	**0.012**
ARPMY	Puerto Madryn	Argentina	SA-I	0	1	0	3	**0.006**
NGPHC	Port Harcourt	Nigeria	WA-II	0	0	0	0	**0.000**
AUPKL	Port Kembla	Australia	AUS-X	0	0	0	0	**0.000**
BJCOO	Cotonou	Benin	WA-II	0	0	0	0	**0.000**
BRMAO	Manaus	Brazil	SA-IV-AR	0	0	0	0	**0.000**
FIPOR	Pori	Finland	B-XI	0	0	0	0	**0.000**
CIABJ	Abidjan	Ivory Coast	WA-II	0	0	0	0	**0.000**
ESLPA	Las Palmas	Spain	WA-I	0	0	0	0	**0.000**
CLCHA	Chacabuco	Chile	SEP-A'	0	0	0	0	**0.000**
COBUN	Buenaventura	Colombia	SEP-I	0	0	0	0	**0.000**
NGONN	Onne	Nigeria	WA-II	0	0	0	0	**0.000**

***Table 8.** Status of risk species assigned to the bioregions of Sepetiba (SAII-B)*

Group	Common Name	Species Name	Regional Status	Threat Status
Bacillariophyta	Pennate diatom	*Pseudonitzschia australis*	Cryptogenic	Known harmful species
Bacillariophyta	Pennate diatom	*Pseudonitzschia delicatissima*	Cryptogenic	Known harmful species
Bacillariophyta	Pennate diatom	*Pseudonitzschia pseudodelicatissima*	Cryptogenic	Known harmful species
Bacillarriophyta/Centricae	Centric diatom	*Coscinodiscus wailesii*	Introduced	Known harmful species
Bacillarriophyta/Centricae	Centric diatom	*Odontella sinensis*	Cryptogenic	Not suspected
Bacillarriophyta/Centricae	Centric diatom	*Thallassiosira punctigera*	Cryptogenic	Not suspected
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Ceratium furca*	Native	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Dinophysis acuminata*	Native	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gymnodinium catenatum*	Introduced	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gyrodinium aureolum*	Cryptogenic	Known harmful species
Raphidophycea	Raphidophyte	*Heterosigma akashiwo*	Introduced	Known harmful species
Platyhelminthes	Flatworm	*Turbellarid sp.*	Introduced	Not suspected
Cnidaria	Octocoral	*Stereonephythya aff. curvata*	Introduced	Not suspected
Cnidaria	Sea anemone	*Paracondylactis hertwigi*	Cryptogenic	Not suspected
Cnidaria	Organ pipe coral	*Tubastraea coccinea*	Introduced	Not suspected
Cnidaria	Organ pipe coral	*Tubastraea tagusensis*	Introduced	Not suspected
Annelida	Brazilian serpulid worm	*Hydroides sp.*	Cryptogenic	Suspected harmful species
Annelida	Sabellid fan worm	*Sabella spallanzanii*	Introduced	Known harmful species
Annelida	Spionid worm	*Streblospio benedicti*	Introduced	Not suspected
Arthropoda	Copepod	*Paracyclopina longifurca*	Cryptogenic	Not suspected
Arthropoda	Copepod	*Pseudodiaptomus tritamatus*	Cryptogenic	Not suspected
Arthropoda	Sea Lice	*Paracerceis sculpta*	Introduced	Not suspected
Arthropoda	Asian slater	*Synidotea laevidorsalis*	Introduced	Not suspected
Arthropoda	Barnacle	*Balanus venustus*	Cryptogenic	Not suspected
Arthropoda	Barnacle	*Balanus reticulatus*	Introduced	Suspected harmful species
Arthropoda	Barnacle	*Chirona amaryllis*	Cryptogenic	Suspected harmful species
Arthropoda	Barnacle	*Chthamalus proteus*	Native	Suspected harmful species
Arthropoda	Giant Barnacle	*Megabalanus coccopoma*	Introduced	Suspected harmful species
Arthropoda	Shrimp	*Metapenaeus monoceros*	Introduced	Not suspected
Arthropoda	Alpheid shrimp	*Alpheus houvieri, A. heterochaelis*	Native	Not suspected
Arthropoda	Green tanaid shrimp	*Leptochelia dubia*	Introduced	Not suspected
Arthropoda	Prawn	*Penaeus japonicus*	Introduced	Not suspected
Arthropoda	Prawn	*Penaeus monodon*	Introduced	Not suspected
Arthropoda	Burrowing xanthid crab	*Rhithropanopeus harrisii*	Introduced	Not suspected
Arthropoda	Asian grapsid crab	*Pachygrapsus gracilis*	Cryptogenic	Suspected harmful species
Arthropoda	Swimming crab	*Charybdis hellerii*	Introduced	Known harmful species
Arthropoda	Mud crab	*Scylla serrata*	Introduced	Not suspected
Ectoprocta/Ctenostomata	Sea moss (Bryozoan)	*Amathia distans*	Native	Not suspected
Ectoprocta/Ctenostomata	Sea Moss (Bryozoan)	*Bowerbankia caudata*	Cryptogenic	Not suspected
Ectoprocta/Cheilostomata	Sea Moss (Bryozoan)	*Buskia socialis*	Cryptogenic	Not suspected
Ectoprocta/Cheilostomata	Sea moss (Bryozoan)	*Watersipora cucullata*	Cryptogenic	Not suspected
Ectoprocta/Ctenostomata	Sea Moss (Bryozoan)	*Zoobotryon pellucidum*	Cryptogenic	Not suspected
Mollusca	Teredinid bivalve	*Bankia carinata*	Cryptogenic	Not suspected
Mollusca	Teredinid bivalve	*Bankia fimbriatula*	Cryptogenic	Not suspected
Mollusca	Teredinid bivalve	*Bankia gouldi*	Cryptogenic	Not suspected
Mollusca	Teredinid bivalve	*Lyrodus floridanus*	Cryptogenic	Not suspected
Mollusca	Teredinid bivalve	*Lyrodus massa*	Cryptogenic	Not suspected
Mollusca	Boring bivalve	*Nototeredo knoxi*	Cryptogenic	Not suspected
Mollusca	Mussel	*Isognomon bicolor*	Introduced	Suspected harmful species
Mollusca	Brown mussel	*Perna perna*	Introduced	Known harmful species
Mollusca	Bivalve	*Martesia striata*	Cryptogenic	Not suspected
Mollusca	Boring bivalve	*Teredo bartschi*	Cryptogenic	Not suspected
Mollusca	Boring bivalve	*Teredo furcifera*	Cryptogenic	Not suspected
Mollusca	Polycerid nudibranch	*Thecacera pennigera*	Cryptogenic	Not suspected
Mollusca	Tergepedid nudibranch	*Tenellia adspersa*	Introduced	Not suspected
Mollusca	Marine snail	*Limacina cf. inflata*	Cryptogenic	Not suspected
Urochordata	Colonial sea squirt (tunicate)	*Botrylloides nigrum*	Cryptogenic	Not suspected
Urochordata	Sea Vase (tunicate)	*Ciona intestinalis*	Introduced	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Didemnum ahu*	Cryptogenic	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Didemnum apersum*	Cryptogenic	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Didemnum granulatum*	Cryptogenic	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Herdmania momus*	Cryptogenic	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Microcosmus exasperatus*	Cryptogenic	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Polyandrocarpa zorritensis*	Cryptogenic	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Stomozoa gigantea*	Cryptogenic	Not suspected
Urochordata	Sea Squirt (Tunicate)	*Styela canopus*	Cryptogenic	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 (1998-2002).

After calculating the RORs the database generates a large output table listing the source ports and their coefficients, risk-reduction factors and ROR value. It also contains the five categories of ROR used by the GIS plot, and the standardised ROR values (S-ROR; Section 3.10). Results from the project-standard BWRA for the Port of Sepetiba are listed in Table 9, and the GIS plot of the ROR categories is shown in Figure 24.

From the 919 visit records in the database, the project standard identified 20 of the 148 source ports as representing the highest risk group (in terms of their BW source frequency, volume, environmental similarity and assigned risk species). These ports, all of which were Brazilian, provided the top 20% of the total ROR, with individual values in the 0.20-0.29 range (Table 9). The highest risk ports were led by Santos (ROR = 0.290; S-ROR = 1.0) and Rio de Janeiro (ROR = 0.285; S-ROR = 0.98), followed by Rio Grande and Praia Mole with almost the same risk values (ROR = 0.248; S-ROR 0.82).

The first non-Brazilian ports were Montevideo (Uruguay) and Rotterdam (Netherlands). These was grouped as High Risk ports and ranked 22nd and 23rd overall, both with RORs very close to 0.202 (S-ROR = 0.63; Table 9). The first highest risk ports beyond the Atlantic region were the Mediterranean ports of Taranto in Italy (ROR = 0.201; S-ROR =0.63) and Koper in Slovenia (ROR = 0.199; S-ROR = 0.62). The highest risk port beyond the Atlanto-Mediterranean area was the Pacific coast Mexican port of Lazaro Cardenas (ranked 42nd with a high risk ROR of 0.183 (S-ROR = 0.55; Table 9).

The 75 source ports in the low (31) and lowest (44) risk categories were generally a mixture of cool and very warm water ports, plus river/brackish ports with a wide distribution. The source port with the lowest ROR (0.051; S-ROR = 0) was the cool temperate port of Puerto Madryn in southern Argentina (Table 9).

Based on the current pattern of shipping trade (1998-2002), the ROR results indicate BW from vessels arriving from ports in temperate to cool temperate areas present much less of threat to Sepetiba than those from Brazil and the southern European ports, with the exception of Rotterdam (north-west Europe) and Lazaro Cardenas (Mexico; Figure 24, Table 9). In the case of the latter, their C1-C4 coefficients show that it is the relatively high BW discharge frequency and volume from Rotterdam and the relatively high environmental similarity estimated for Lazaro (C3 = 0.6), which lifts them into the High risk group. In the case of the Brazilian ports, their relatively close environmental similarities (both calculated and estimated) and in many cases regular BW sources made them dominate the highest risk group.

The risk results in Table 9 and plots in Figure 24 indicate there is a much higher threat of BW-mediated introductions posed by vessels arriving in ballast from many Brazilian and southern European ports, and this is logical given Sepetiba's biogeographic location and current pattern of trade. The results also suggest that the project standard 'first-pass' treatment of the risk coefficients provides a reasonable 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 Brazilian coastline could be readily spread by coastal shipping, and it would be very worth to obtain port environmental data for many of these ports to allow their C3 coefficient to be calculated rather than estimated for the assessment reported here.

While the tropical and subtropical coastline of Brazil does not appear to be experiencing the level of harmful invasive species recently reported for the cooler Uruguayan and Argentinean waters (Orensanz *et al*. 2002), the number of introduced and cryptogenic toxic dinoflagellates in Table 9 shows that Brazil is not immune to the spread of harmful marine species. These phytoplankton could increase the severity of red tides in or close to several of the large and gradually eutrophying coastal bays and lagoons of Brazil.

For a largely tropical country with a high number of brackish and estuarine ports, the issue of water-borne tropical pathogens such as cholera, typhus and yellow fever and parasites that are widely present in South America also needs to be remembered, and their almost virtual absence from the risk species database highlights the fragility of the C4 coefficient and the problem of performing ‘reverse’ BW risk assessments.

Figure 25 shows the frequency distribution of the standardised ROR values. The two small peaks on the right side of the plot reflects the gaps between the most highest risk ports (Santos and Rio de Janeiro, then the next eight ports), while the lower risk ports form an uninterrupted tail to the left side of the plot.

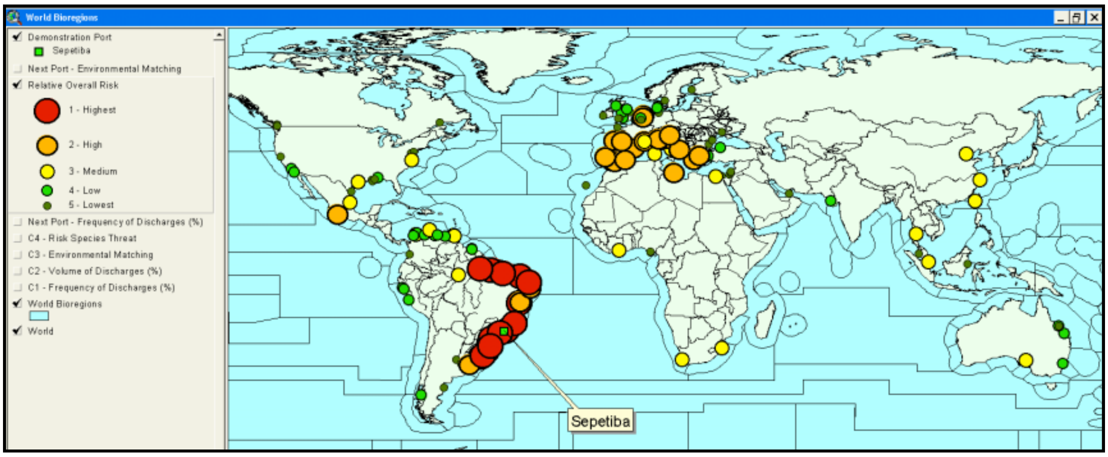

Figure 24. *GIS output showing the location and categories of relative overall risk (ROR) of source ports identified for the Port of Sepetiba*

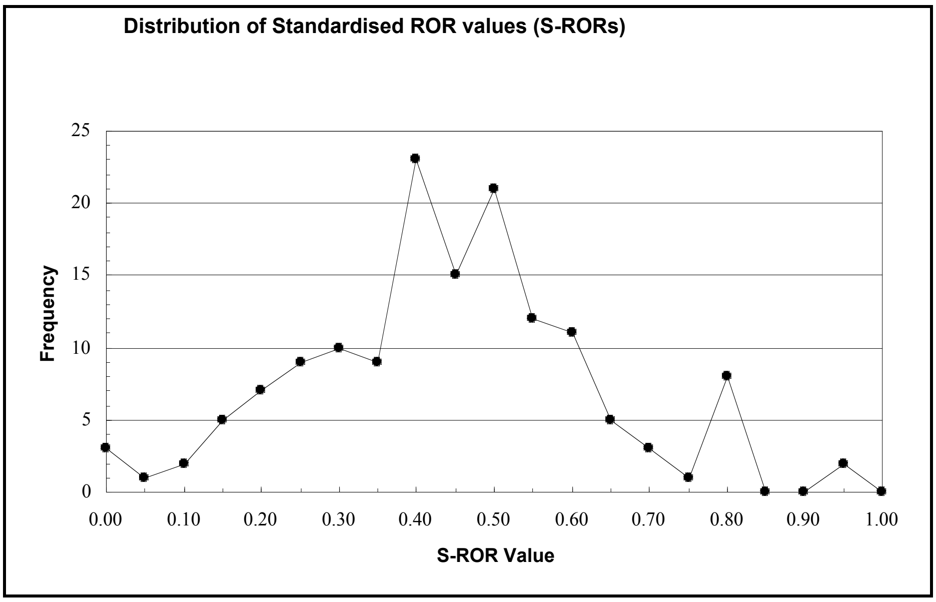

Figure 25. *Frequency distribution of the standardised ROR values*

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

Port Code	Source Port	Country	C1 BW Freq	C2 BW Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match	Estimated	C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk	Cumulative Percentage	Risk Category	Standrdisd ROR
BRSSZ	Santos	Brazil	0.0440	0.0716	65,688	1.0	2	1.0	0.776		0.270	**0.290**	1.21	1.21	Highest	1.00
BRRIO	Rio de Janeiro	Brazil	0.0075	0.0028	22,837	1.0	0	1.0	0.861		0.270	**0.285**	1.19	2.41	Highest	0.98
BRRIG	Rio Grande	Brazil	0.0009	0.0027	28,877	1.0	2	1.0	0.700	Y	0.290	**0.248**	1.04	3.44	Highest	0.82
BRPRM	Praia Mole	Brazil	0.0412	0.0361	55,175	1.0	1	1.0	0.799		0.117	**0.248**	1.04	4.48	Highest	0.82
BRPOA	Porto Alegre	Brazil	0.0009	0.0000	504	0.8	3	1.0	0.700	Y	0.290	**0.248**	1.04	5.52	Highest	0.82
BRPNG	Paranagua	Brazil	0.0028	0.0004	1,816	1.0	1	1.0	0.717		0.270	**0.248**	1.03	6.55	Highest	0.82
BRSFS	Sao Francisco do Sul	Brazil	0.0019	0.0076	53,430	1.0	1	1.0	0.700	Y	0.270	**0.245**	1.02	7.58	Highest	0.81
BRTRM	Tramandai	Brazil	0.0009	0.0026	27,904	1.0	2	1.0	0.700	Y	0.270	**0.243**	1.02	8.59	Highest	0.80
BRSSO	São Sebastiao	Brazil	0.0009	0.0023	24,999	1.0	0	1.0	0.700	Y	0.270	**0.243**	1.02	9.61	Highest	0.80
BRIBB	Imbituba	Brazil	0.0009	0.0001	1,480	1.0	2	1.0	0.700	Y	0.270	**0.243**	1.01	10.63	Highest	0.80
BRSSA	Salvador	Brazil	0.0337	0.0562	59,400	1.0	2	1.0	0.725		0.117	**0.233**	0.97	11.60	Highest	0.76
BRTUB	Tubarao	Brazil	0.0019	0.0046	48,166	1.0	1	1.0	0.791		0.117	**0.229**	0.96	12.56	Highest	0.74
BRVIX	Vitoria	Brazil	0.0084	0.0220	67,103	1.0	1	1.0	0.738		0.117	**0.221**	0.93	13.48	Highest	0.71
BRNAT	Natal	Brazil	0.0037	0.0124	47,889	1.0	4	1.0	0.700	Y	0.159	**0.219**	0.91	14.40	Highest	0.70
BRVDC	Vila Do Conde	Brazil	0.0187	0.0082	58,297	1.0	7	0.8	0.700	Y	0.159	**0.213**	0.89	15.29	Highest	0.68
BRALU	Alumar	Brazil	0.0140	0.0046	25,227	1.0	6	0.8	0.700	Y	0.159	**0.211**	0.88	16.17	Highest	0.67
BRFOR	Fortaleza	Brazil	0.0056	0.0098	54,807	1.0	5	0.8	0.700	Y	0.159	**0.211**	0.88	17.05	Highest	0.67
BRMGU	Munguba	Brazil	0.0028	0.0053	54,464	1.0	8	0.8	0.700	Y	0.159	**0.209**	0.87	17.93	Highest	0.66
BRBEL	Belem	Brazil	0.0019	0.0058	31,335	1.0	7	0.8	0.700	Y	0.159	**0.209**	0.87	18.80	Highest	0.66
BRREC	Recife	Brazil	0.0009	0.0024	25,629	1.0	3	1.0	0.700	Y	0.117	**0.205**	0.86	19.65	Highest	0.64
BRARB	Aratu	Brazil	0.0009	0.0001	1,444	1.0	2	1.0	0.700	Y	0.117	**0.205**	0.86	20.51	High	0.64
UYMVD	Montevideo	Uruguay	0.0019	0.0050	29,353	1.0	3	1.0	0.512		0.290	**0.202**	0.84	21.35	High	0.63
NLRTM	Rotterdam	Netherlands	0.0899	0.1336	107,600	1.0	6	0.8	0.351		0.290	**0.202**	0.84	22.20	High	0.63
ITTAR	Taranto	Italy	0.0122	0.0086	12,358	1.0	17	0.6	0.603		0.304	**0.201**	0.84	23.04	High	0.63
SIKOP	Koper	Slovenia	0.0056	0.0042	10,980	1.0	18	0.6	0.619		0.282	**0.199**	0.83	23.87	High	0.62
BRSLZ	São Luis	Brazil	0.0009	0.0003	3,196	1.0	10	0.6	0.700	Y	0.159	**0.199**	0.83	24.71	High	0.62
ESCRS	Carboneras	Spain	0.0037	0.0099	54,403	1.0	7	0.8	0.538	Y	0.304	**0.199**	0.83	25.54	High	0.62
ITTRS	Trieste	Italy	0.0009	0.0001	584	0.8	18	0.6	0.622		0.282	**0.198**	0.83	26.36	High	0.61
ITSVN	Savona	Italy	0.0047	0.0017	5,866	1.0	18	0.6	0.600	Y	0.304	**0.197**	0.82	27.19	High	0.61
LYMRA	Misurata	Lybian Arab Jamahiriya	0.0009	0.0025	27,197	1.0	16	0.6	0.600	Y	0.304	**0.196**	0.82	28.01	High	0.61
ESGIJ	Gijon	Spain	0.0253	0.0227	27,964	1.0	10	0.6	0.552		0.292	**0.194**	0.81	28.82	High	0.60
GIGIB	Gibraltar	Gibraltar	0.0197	0.0245	56,619	1.0	13	0.6	0.561		0.282	**0.193**	0.81	29.63	High	0.59
ITRAN	Ravenna	Italy	0.0009	0.0029	31,335	1.0	18	0.6	0.596		0.282	**0.192**	0.80	30.43	High	0.59
NLIJM	IJmuiden	Netherlands	0.0421	0.0404	52,848	1.0	8	0.8	0.447		0.290	**0.190**	0.80	31.23	High	0.58
ESTAR	Tarragona	Spain	0.0028	0.0017	8,706	1.0	15	0.6	0.567		0.304	**0.188**	0.79	32.02	High	0.57
FRFOS	Fos sur Mer	France	0.0215	0.0281	47,380	1.0	15	0.6	0.516		0.304	**0.187**	0.78	32.80	High	0.57
GRMIL	Milaki	Greece	0.0131	0.0080	11,229	1.0	18	0.6	0.554	Y	0.282	**0.186**	0.78	33.57	High	0.56
GREEU	Eleusis	Greece	0.0009	0.0000	130	0.6	17	0.6	0.570		0.282	**0.185**	0.77	34.35	High	0.56
ESBIO	Bilbao	Spain	0.0019	0.0002	1,374	1.0	15	0.6	0.562		0.292	**0.185**	0.77	35.12	High	0.56
GRKLX	Kalamata	Greece	0.0009	0.0015	16,708	1.0	17	0.6	0.550	Y	0.304	**0.184**	0.77	35.89	High	0.55
ESCAD	Cadiz	Spain	0.0056	0.0021	8,609	1.0	10	0.6	0.550	Y	0.292	**0.183**	0.77	36.65	High	0.55
MXLZC	Lazaro Cardenas	Mexico	0.0009	0.0001	552	0.8	18	0.6	0.600	Y	0.218	**0.183**	0.76	37.42	High	0.55
ESSCI	San Ciprian	Spain	0.0037	0.0018	11,335	1.0	14	0.6	0.550	Y	0.292	**0.183**	0.76	38.18	High	0.55
PTSIE	Sines	Portugal	0.0178	0.0158	19,426	1.0	10	0.6	0.521		0.292	**0.183**	0.76	38.95	High	0.55
PTSET	Setubal	Portugal	0.0019	0.0029	18,321	1.0	13	0.6	0.550	Y	0.292	**0.182**	0.76	39.71	High	0.55
ITSPE	La Spezia	Italy	0.0028	0.0008	4,574	1.0	22	0.4	0.600	Y	0.304	**0.181**	0.76	40.47	Medium	0.54
GRPIR	Piraeus	Greece	0.0028	0.0031	24,961	1.0	18	0.6	0.546		0.282	**0.180**	0.75	41.22	Medium	0.54
ZARCB	Richards Bay	South Africa	0.0150	0.0043	28,861	1.0	13	0.6	0.589		0.183	**0.180**	0.75	41.97	Medium	0.54
ZASDB	Saldanha Bay	South Africa	0.0009	0.0001	570	0.8	10	0.6	0.583		0.224	**0.180**	0.75	42.72	Medium	0.54
AUPPI	Port Pirie	Australia	0.0009	0.0001	1,283	1.0	27	0.4	0.565		0.379	**0.179**	0.75	43.47	Medium	0.54
CIABJ	Abidjan	Ivory Coast	0.0122	0.0024	12,189	1.0	9	0.8	0.700	Y	0.000	**0.179**	0.75	44.22	Medium	0.53
CNNBO	Beilun	China	0.0009	0.0002	1,645	1.0	34	0.4	0.580		0.333	**0.179**	0.75	44.96	Medium	0.53
FRMRS	Caronte (Marseilles)	France	0.0009	0.0001	1,483	1.0	15	0.6	0.527		0.304	**0.178**	0.74	45.71	Medium	0.53
USNEN	Norfolk-Newport News Virginia	United States	0.0084	0.0077	29,328	1.0	15	0.6	0.596		0.157	**0.177**	0.74	46.44	Medium	0.52
BRMAO	Manaus	Brazil	0.0009	0.0023	25,070	1.0	10	0.6	0.700	Y	0.000	**0.176**	0.74	47.18	Medium	0.52
ESALG	Algeciras	Spain	0.0056	0.0117	50,344	1.0	13	0.6	0.515		0.282	**0.175**	0.73	47.91	Medium	0.52
SGSIN	Singapore	Singapore	0.0009	0.0001	1,392	1.0	28	0.4	0.630		0.167	**0.174**	0.73	48.64	Medium	0.51
TTPTS	Point Lisas	Trinidad and Tobago	0.0028	0.0029	28,869	1.0	10	0.6	0.600	Y	0.153	**0.174**	0.73	49.37	Medium	0.51
TTCHA	Chaguaramas	Trinidad and Tobago	0.0047	0.0007	1,702	1.0	15	0.6	0.600	Y	0.153	**0.174**	0.73	50.10	Medium	0.51
USPHF	Hampton Roads	United States	0.0112	0.0040	28,763	1.0	15	0.6	0.587		0.157	**0.174**	0.73	50.83	Medium	0.51
ITGOA	Genoa	Italy	0.0094	0.0029	25,052	1.0	16	0.6	0.501		0.304	**0.174**	0.73	51.55	Medium	0.51
PTLIS	Lisboa	Portugal	0.0009	0.0000	487	0.6	13	0.6	0.515		0.292	**0.173**	0.72	52.28	Medium	0.51
ITPVE	Porto Vesme (Portoscuso)	Italy	0.0028	0.0002	1,022	1.0	15	0.6	0.500	Y	0.304	**0.171**	0.72	52.99	Medium	0.50
FRMTX	Montoir	France	0.0047	0.0020	8,468	1.0	16	0.6	0.500	Y	0.294	**0.171**	0.71	53.71	Medium	0.50
ITNAP	Napoli	Italy	0.0009	0.0001	932	0.8	18	0.6	0.500	Y	0.302	**0.170**	0.71	54.42	Medium	0.50
ITPIO	Piombino	Italy	0.0009	0.0001	706	0.8	15	0.6	0.500	Y	0.302	**0.170**	0.71	55.13	Medium	0.50
TH001	Bang Saphan	Thailand	0.0009	0.0010	10,773	1.0	30	0.4	0.600	Y	0.167	**0.167**	0.70	55.83	Medium	0.48
USTXT	Texas City Texas	United States	0.0094	0.0137	64,307	1.0	16	0.6	0.591		0.087	**0.167**	0.70	56.53	Medium	0.48
CNTXG	Tianjinxingang (Xingang) Tianjin	China	0.0206	0.0101	28,878	1.0	32	0.4	0.500	Y	0.325	**0.165**	0.69	57.22	Medium	0.48
MXTAM	Tampico	Mexico	0.0009	0.0001	1,487	1.0	16	0.6	0.600	Y	0.087	**0.163**	0.68	57.90	Medium	0.47
TWKHH	Kaohsiung	Taiwan Province of China	0.0009	0.0001	789	0.8	32	0.4	0.520		0.319	**0.162**	0.68	58.58	Medium	0.46

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

Port Code	Source Port	Country	C1 BW Freq	C2 BW Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match.	*Estimated*	C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk	Cumulative Percentage	Risk Category	Standrdisd ROR
EGEDK	El Dekheila	Egypt	0.0009	0.0027	28,869	1.0	19	0.6	0.473		0.284	**0.162**	0.68	60.61	Low	0.46
INBED	Bedi	India	0.0047	0.0027	25,121	1.0	24	0.4	0.550	*Y*	0.218	**0.161**	0.67	61.28	Low	0.46
COSMR	Santa Marta	Colombia	0.0019	0.0002	1,368	1.0	12	0.6	0.550	*Y*	0.153	**0.161**	0.67	61.95	Low	0.46
USSAN	San Diego California	United States	0.0047	0.0020	16,132	1.0	22	0.4	0.548		0.218	**0.160**	0.67	62.62	Low	0.46
GBBRS	Bristol	United Kingdom	0.0056	0.0070	37,677	1.0	19	0.6	0.450	*Y*	0.290	**0.159**	0.67	63.29	Low	0.45
GBHST	Hunterston	United Kingdom	0.0056	0.0130	27,583	1.0	23	0.4	0.500		0.290	**0.159**	0.66	63.95	Low	0.45
USLGB	Long Beach California	United States	0.0094	0.0139	55,745	1.0	22	0.4	0.524		0.218	**0.159**	0.66	64.62	Low	0.45
GBLIV	Liverpool	United Kingdom	0.0019	0.0056	58,808	1.0	16	0.6	0.450	*Y*	0.290	**0.158**	0.66	65.28	Low	0.45
TRIZM	Izmir (Smyrna)	Turkey	0.0019	0.0046	42,944	1.0	26	0.4	0.511		0.282	**0.157**	0.66	65.93	Low	0.44
COCTG	Cartagena	Colombia	0.0009	0.0001	876	0.8	13	0.6	0.537		0.153	**0.157**	0.66	66.59	Low	0.44
SRPRM	Paranam	Suriname	0.0009	0.0001	1,510	1.0	8	0.8	0.500	*Y*	0.153	**0.156**	0.65	67.24	Low	0.44
SRPBM	Paramaribo	Suriname	0.0009	0.0001	1,457	1.0	8	0.8	0.500	*Y*	0.153	**0.156**	0.65	67.89	Low	0.44
TRERE	Eregli	Turkey	0.0047	0.0048	40,118	1.0	20	0.4	0.534		0.196	**0.156**	0.65	68.54	Low	0.44
FRDKK	Dunkerque	France	0.0206	0.0491	76,687	1.0	12	0.6	0.374		0.290	**0.154**	0.65	69.19	Low	0.43
PESVY	Salaverry	Peru	0.0047	0.0049	47,971	1.0	16	0.6	0.600	*Y*	0.012	**0.154**	0.64	69.83	Low	0.43
AUPKL	Port Kembla	Australia	0.0009	0.0000	349	0.6	25	0.4	0.614		0.000	**0.154**	0.64	70.48	Low	0.43
AUHPT	Hay Point	Australia	0.0253	0.0203	51,486	1.0	25	0.4	0.529		0.085	**0.152**	0.64	71.11	Low	0.42
PEPCH	Puerto Chicama	Peru	0.0009	0.0001	1,509	1.0	15	0.6	0.600	*Y*	0.012	**0.152**	0.64	71.75	Low	0.42
PECLL	Callao	Peru	0.0281	0.0102	27,982	1.0	15	0.6	0.561		0.012	**0.152**	0.63	72.38	Low	0.42
BJCOO	Cotonou	Benin	0.0019	0.0012	7,864	1.0	11	0.6	0.600	*Y*	0.000	**0.151**	0.63	73.01	Low	0.42
VEGUT	Guanta	Venezuela	0.0037	0.0056	27,138	1.0	13	0.6	0.500	*Y*	0.153	**0.150**	0.63	73.64	Low	0.41
CLCHA	Chacabuco	Chile	0.0009	0.0001	601	0.8	9	0.8	0.600	*Y*	0.000	**0.150**	0.63	74.27	Low	0.41
DKFRC	Fredericia	Denmark	0.0009	0.0025	27,410	1.0	18	0.6	0.423		0.288	**0.150**	0.63	74.90	Low	0.41
VELAG	La Guaira	Venezuela	0.0019	0.0027	26,960	1.0	10	0.6	0.500	*Y*	0.153	**0.149**	0.62	75.52	Low	0.41
VEPBL	Puerto Cabello	Venezuela	0.0009	0.0001	1,374	1.0	11	0.6	0.500	*Y*	0.153	**0.148**	0.62	76.14	Low	0.40
VEMAR	Maracaibo	Venezuela	0.0009	0.0001	1,250	1.0	12	0.6	0.500	*Y*	0.153	**0.148**	0.62	76.76	Low	0.40
DKENS	Enstedvaerkets Havn	Denmark	0.0009	0.0053	56,837	1.0	18	0.6	0.411		0.288	**0.148**	0.62	77.37	Low	0.40
GBRER	Redcar	United Kingdom	0.0047	0.0041	11,372	1.0	18	0.6	0.407		0.290	**0.147**	0.62	77.99	Low	0.40
AUGLT	Gladstone	Australia	0.0084	0.0063	28,520	1.0	25	0.4	0.537		0.085	**0.146**	0.61	78.60	Low	0.40
NLVLI	Flushing (Vlissingen)	Netherlands	0.0019	0.0001	674	0.8	16	0.6	0.408		0.290	**0.146**	0.61	79.21	Low	0.40
USMOB	Mobile Alabama	United States	0.0140	0.0125	58,906	1.0	16	0.6	0.505		0.087	**0.146**	0.61	79.82	Low	0.40
GBTEE	Teesport (Middlesbrough)	United Kingdom	0.0009	0.0001	1,509	1.0	17	0.6	0.407		0.290	**0.145**	0.61	80.43	Lowest	0.39
FRBES	Brest	France	0.0281	0.0019	1,603	1.0	21	0.4	0.435		0.290	**0.145**	0.61	81.04	Lowest	0.39
AUPDT	Dalrymple Bay	Australia	0.0056	0.0076	66,572	1.0	25	0.4	0.529		0.085	**0.144**	0.60	81.64	Lowest	0.39
MYLUM	Lumut	Malaysia	0.0009	0.0001	581	0.8	63	0.2	0.535		0.167	**0.142**	0.60	82.24	Lowest	0.38
IEMOT	Moneypoint	Ireland	0.0140	0.0108	23,042	1.0	16	0.6	0.368		0.290	**0.142**	0.59	82.83	Lowest	0.38
USGFT	Gulfport	United States	0.0028	0.0006	3,763	1.0	16	0.6	0.500	*Y*	0.087	**0.139**	0.58	83.41	Lowest	0.37
COBUN	Buenaventura	Colombia	0.0009	0.0001	839	0.8	15	0.6	0.518	*Y*	0.000	**0.130**	0.54	83.95	Lowest	0.33
ESLPA	Las Palmas	Spain	0.0009	0.0000	51	0.4	11	0.6	0.515		0.000	**0.129**	0.54	84.49	Lowest	0.32
IDTBA	Tanjung Bara Coal Terminal	Indonesia	0.0122	0.0085	27,086	1.0	28	0.4	0.476		0.042	**0.128**	0.54	85.03	Lowest	0.32
CARBK	Roberts Bank	Canada	0.0047	0.0058	29,749	1.0	26	0.4	0.348		0.383	**0.128**	0.54	85.56	Lowest	0.32
CAVAN	Vancouver British Columbia	Canada	0.0112	0.0093	35,477	1.0	26	0.4	0.336		0.383	**0.127**	0.53	86.10	Lowest	0.32
GBIMM	Immingham	United Kingdom	0.0187	0.0147	14,952	1.0	17	0.6	0.299		0.290	**0.126**	0.53	86.63	Lowest	0.31
USBRO	Brownsville Texas	United States	0.0009	0.0001	1,509	1.0	16	0.6	0.450	*Y*	0.087	**0.126**	0.53	87.15	Lowest	0.31
GBPTB	Port Talbot	United Kingdom	0.0009	0.0025	27,280	1.0	16	0.6	0.325		0.290	**0.125**	0.52	87.68	Lowest	0.31
GB001	Burry Port	United Kingdom	0.0084	0.0076	43,965	1.0	16	0.6	0.305		0.290	**0.124**	0.52	88.19	Lowest	0.30
ROCND	Constanta	Romania	0.0084	0.0086	16,500	1.0	21	0.4	0.380		0.238	**0.123**	0.51	88.71	Lowest	0.30
DEHAM	Hamburg	Germany Federal Republic	0.0103	0.0084	23,167	1.0	15	0.6	0.295		0.290	**0.122**	0.51	89.22	Lowest	0.29
EGDAM	Damietta	Egypt	0.0019	0.0023	24,757	1.0	19	0.6	0.303		0.284	**0.119**	0.50	89.72	Lowest	0.28
SEGOT	Gothenburg (Göteborg)	Sweden	0.0009	0.0001	789	0.8	17	0.6	0.300	*Y*	0.290	**0.119**	0.50	90.21	Lowest	0.28
ILHFA	Haifa	Israel	0.0009	0.0035	37,451	1.0	19	0.6	0.300	*Y*	0.284	**0.119**	0.50	90.71	Lowest	0.28
ROMAG	Mangalia	Romania	0.0009	0.0017	18,026	1.0	21	0.4	0.376		0.238	**0.118**	0.50	91.20	Lowest	0.28
BGBOJ	Bourgas	Bulgaria	0.0028	0.0005	2,206	1.0	19	0.6	0.348		0.196	**0.117**	0.49	91.69	Lowest	0.28
NGONN	Onne	Nigeria	0.0047	0.0008	1,908	1.0	15	0.6	0.463		0.000	**0.117**	0.49	92.18	Lowest	0.28
NLAMS	Amsterdam	Netherlands	0.0197	0.0125	19,582	1.0	12	0.6	0.254		0.290	**0.115**	0.48	92.66	Lowest	0.27
AEDXB	Dubai	United Arab Emirates	0.0009	0.0010	10,335	1.0	25	0.4	0.405		0.117	**0.114**	0.47	93.14	Lowest	0.26
BEANR	Antwerpen	Belgium	0.0112	0.0139	28,869	1.0	16	0.6	0.238		0.290	**0.109**	0.46	93.60	Lowest	0.24
USBPT	Beaumont	United States	0.0103	0.0031	24,961	1.0	16	0.6	0.364		0.087	**0.107**	0.45	94.04	Lowest	0.23
ILASH	Ashdod	Israel	0.0009	0.0002	2,553	1.0	19	0.6	0.257		0.284	**0.107**	0.45	94.49	Lowest	0.23
ILHAD	Hadera	Israel	0.0047	0.0043	12,000	1.0	24	0.4	0.300	*Y*	0.284	**0.106**	0.44	94.93	Lowest	0.23
BEGNE	Ghent/Gent	Belgium	0.0019	0.0003	1,618	1.0	16	0.6	0.245		0.290	**0.105**	0.44	95.37	Lowest	0.23
USBAL	Baltimore Maryland	United States	0.0047	0.0049	48,166	1.0	15	0.6	0.309		0.157	**0.103**	0.43	95.81	Lowest	0.22
NGPHC	Port Harcourt	Nigeria	0.0112	0.0007	1,206	1.0	9	0.8	0.391		0.000	**0.101**	0.42	96.23	Lowest	0.21
UADNB	Dnepro-Bugsky	Ukraine	0.0009	0.0001	1,457	1.0	21	0.4	0.286		0.238	**0.096**	0.40	96.63	Lowest	0.18
CNSHA	Shanghai (Shihu) Shanghai	China	0.0009	0.0001	1,399	1.0	34	0.4	0.243		0.333	**0.094**	0.39	97.02	Lowest	0.18
USILG	Wilmington Delaware	United States	0.0028	0.0003	1,472	1.0	22	0.4	0.296		0.157	**0.090**	0.38	97.40	Lowest	0.16
USDVT	Davant	United States	0.0037	0.0087	67,247	1.0	16	0.6	0.291		0.087	**0.089**	0.37	97.77	Lowest	0.16
USPHG	Pittsburg	United States	0.0009	0.0002	1,636	1.0	24	0.4	0.200	*Y*	0.383	**0.089**	0.37	98.14	Lowest	0.16
CASEI	Sept Iles (Seven Is.) Quebec	Canada	0.0009	0.0023	24,757	1.0	15	0.6	0.273		0.091	**0.083**	0.35	98.49	Lowest	0.13
FIPOR	Pori	Finland	0.0009	0.0015	15,723	1.0	20	0.4	0.300	*Y*	0.000	**0.076**	0.32	98.80	Lowest	0.10
USMSY	New Orleans	United States	0.0028	0.0028	27,791	1.0	16	0.6	0.204		0.087	**0.065**	0.27	99.08	Lowest	0.06

Reverse BWRA

There is no doubt that Sepetiba 'exports' considerable volumes of ballast water, much of which appears destined for other Brazilian ports via bulk carriers departing from the coal and alumina berths, plus much smaller quantities in some of the ships that leave the Tecon wharf. The most important BW destination port appears to be Santos (Section 4.5) which, like Rio de Janeiro, has one of the closest environmental matching values to Sepetiba. This suggests any unwelcome species that can establish in Sepetiba Bay have a more than reasonable chance of 'port-hopping' to Santos or Rio de Janeiro via BW-mediated transfer. For distant ports, the French Atlantic port of Quimper is a relatively frequent next port of call (2.6% of departures) with a C3 of 0.51. This combination implies a greater chance of introductions from vessels departing in ballast from Sepetiba than for other European ports. In the case of the risk species currently assigned to Sepetiba's bioregion SA-IIB, the noxious phytoplankton species that can make cysts, survive tank conditions and produce suffocating and/or toxic red tides in eutrophic inshore waters, represent the type of species that could have most potential impact if introduced to new areas (Table 8).

Influence of coefficients and C4 weightings

The project-standard method classified 20 ports in the highest risk category, and these were all Brazilian (Section 4.8). This outcome was to a large part determined by the size of their environmental matching coefficients (C3), together with relatively short voyage durations (R2). An example of how C3 markedly influenced the ROR outcome is the port of Tubarão. This port had a relatively low C1 (83^{rd}; Table 3) and a C4 that was 40% of the highest risk species threat value (0.383; Table 7), but its ROR was ranked 13^{th} in the highest risk group (Table 9). Such outcomes were not uncommon since the project standard calculation of ROR used the simple mean of the C1-C4 coefficients (Section 3.10), and C3 was usually the largest (Table 9). This is because C3 is a direct index of port-to-port similarity that is unaffected by the number or locations of other trading ports, while C1, C2 and C4 are proportions of the total discharge frequency, volume and risk species threat posed by all 148 BW source ports (Table 9; Section 3.10).

Because C4 typically exerts less influence on the ROR result than C3, Group C counterparts altered the three default weights used in the project standard calculation of C4 ($w1$=3, $w2$=10, $w3$=1; Sections 3.9, 3.10) to evaluate their influence on the size of C4 and hence ROR outcomes. For example, the database's formula GUI was used in one of the trials firstly to decrease $w3$ to 0.2, and then increase it by two and then five times. This showed that only ports with medium-range environmental matching coefficients had ROR rankings that were sensitive to changes in C4 size. In the case of trials on $w2$ (the weight applied to a known pest), its influence on C4 was investigated by simulating three scenarios where the bioregion of interest had different numbers of Non-Indigenous Species (NIS) and the same number of Suspected (S) and Known harmful (K) species. This trial confirmed that altering $w2$ may cause C4 to increase, decrease or remain virtually unaltered, depending on the particular combination of NIS, S and K numbers.

The investigation by Group C counterparts showed that altering the default weightings can lead to unexpected outcomes and creates the potential trap of merely playing 'numbers games', particularly if the objective and rationale used for altering the project standard calculation and default input factors have not been carefully assessed. In this context, there is a good argument for allowing C3 to remain the most influential component of the BWRA formula when there is any paucity or reliability doubt about C4, and for the reverse to be arranged when C4 carries adequate survey data, and specifically unwanted species have been targeted. Group C counterparts concluded that the formula GUI of the GloBallast BRWA system provides users the choice of enhancing the environmental matching or target species approach, and to trial some hybrid approaches. It was also concluded that when evaluating results, each risk component of the calculation needs to be examined individually to understand its importance and contribution to the overall outcomes, whichever method is used.

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 Programa GloBallast office in Rio de Janeiro. This PC, plus another made available by FEEMA's GIS section 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 mapping work was conducted at FEEMA's GIS office in Rio de Janeiro, with the Group A counterparts already familiar with ESRI products and therefore requiring only minor guidance in the use of ArcView and the structure of the layers recommended for the port map. One member of Group B and two from Group C also received basic training in GIS map development and file management. There is no doubt that FEEMA is capable of producing similar resource maps for future BWRA demonstration and training activities in the region. Experienced FEEMA GIS staff such as Mr João Batista, will be able to provide very useful continuity to any future BW management projects involving GIS applications. FEEMA also provided several counterparts to Group B and C (Section 3.11; Appendix 2).

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. In the absence of available personal with this profile to input the BWRF information, two oceanographic graduate students were contracted at short notice. A combined Group A / B effort was then made during the second consultants visit to boost the number of BWRF records in the system and to check those recently entered by the students.

Much effort was focussed on removing a wide range of BWRF discrepancies and errors in the database (both ship-entry related and computer-entry related). 'Fixing' tasks included the need to fix misinterpretations and duplications of BW tank data, illogical date formats, replicated vessels and ports, and to remove ~140 records for BWRFs collated by neighbouring ports (MBR Terminal and Rio de Janeiro). Group B also worked hard to expand the CFP-A spreadsheet of the 1998-2000 visit data to include key requirements for the database (i.e. estimated BW uptake dates, berth location (by cargo type), and estimated BW discharge volumes). Group C provided help in BWRF date-checking and calculating minimum voyage durations. By 6 September 2002, over 910 ship visit records had been entered and edited within the Access database, of which 589 were from the (1998-2000) port shipping records and 330 from BWRFs.

It is unfortunate that key counterparts of the initial Group B membership were unable to attend the second visit to gain a similar understanding of the BWRF data-checking requirements, and thus improve their knowledge in using port shipping records and other databases for checking, verifying and/or gap-filling BWRFs (e.g. *Fairplay Ports Guide*, the *Lloyds Ship Register* and the consultants Excel spreadsheet for estimating BW discharge volumes). There was no time to undertake a formal analysis of the rates of different error types, and what kind of improvement had occurred after the voluntary BWRF system at Sepetiba was replaced with more a formal requirement for BWRF submissions in January 2001.

Of the three groups, Group C was the largest (Appendix 2). 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. The lead counterpart of Group B (CFP-A) also received guidance and became very adept at importing the C3 coefficients to the database. Collation of risk species information and networking with other marine scientists was undertaken by Dr Andrea Junqueira (UFRJ; lead counterpart of Group C) with assistance from Dr Luciano Fernandes (UFPR), Dr Flavio Fernandes (IEAPM) and Dr Luis Proença (UNIVALI). Much of the Brazilian port environment data was ably collated and entered into the required Excel spreadsheet format by Mrs Fátima Soares (FEEMA), Mrs Karen Larsen (IEAPM) and

Ms Maria Matos (UFRJ). Dr Junqueira worked closely with the CFP-A to review the project-standard BWRA calculations and investigate the effects on results when the various weighting coefficients are altered.

4.10 Identification of information gaps

Ballast Water Reporting Forms

The majority of BWRFs provided sufficient data to allow reasonable corrections, gap-filling and estimations. Nevertheless considerable work was still required to 'salvage' them, and many BWRFs could not be inputted (the overall rejection rate was ~40%). The number and status of the BWRFs collected under the initial voluntary scheme (from June to December 2000) showed improvement in 2001, when BWRF lodgements became an official requirement and were more readily associated with *Free Pratique* and other formalities. However BWRFs containing many empty or incorrect entries for BW source/s, uptake date/s and tank volumes intended to be discharged remained common (as was the case for other Demonstration Sites). It had been planned to conduct an error analysis of the BWRFs during the second country visit, but the unexpected need to populate and restore the database prevented this. However the following list summarises the most common omissions or mistakes in submitted BWRFs that were informally observed and also recorded by 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.
- 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%).
- different and confusing combinations of ballast tanks listed in the BW source and BW discharge columns of the BWRF (in Part 4 of the form; Appendix 1).
- BW Discharge field often ignored or partly filled, even by ships loading a full cargo and therefore discharging most of their ballast.

The above summary shows which items port officers should immediately check when collecting or receiving any BWRF. Unless guidance is provided and errors corrected, ships' officers, shipping agents and the port officers will take much longer to become familiar with and effectively use the BWRF process. Apart from lack of BWRF familiarity, the time provided for a ship's officer to complete a BWRF is another important factor influencing the number of mistakes and omissions. Linking BWRFs to the radio *Free Pratique* system (i.e. 1-2 days before arrival) is therefore valuable, since BWRFs provided to ships during their arrival/berthing phase cannot be expected to receive the same level attention as those completed prior to arrival. Unless BWRFs are completed accurately and fully by vessels visiting Sepetiba, a significant percentage of BW sources and discharge volumes will remain unclear – especially for the Tecon wharf. Even with correctly completed forms, it is often impossible to identify the ultimate destination of any BW uplifted by a port that receives and analyses BWRFs (Section 3.5). This is important given the objective of the GloBallast BWRA to identify the destinations of BW uplifted at each Demonstration Site. In fact some of the GloBallast BWRA objectives required considerable effort searching and/or deducing the following information, which is not available from the standard BWRFs:

- Destination Port/s where either BW will be discharged or cargo actually offloaded (not necessarily the Next Port of Call).
- Berth number/location at the reception port (obtained for each Demonstration Site by laborious cross-checking with port records);

- Deadweight tonnage (DWT). This is very useful for checking claimed BW discharge volumes (DWTs were eventually obtained for most ships from the *Lloyds Ship Register*, but this is a time-consuming task, particularly for ships that had entered a new name, incorrect IMO number or Call Sign on the BWRF).

It is therefore recommended that the IMO Marine Environment Protection Committee (MEPC) review the standard BWRF with a view to improving its global application under the new 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 Brazil's ports are not exceptions to this finding. In the case of species data, many national and regional data sets remain incomplete and/or unpublished, and there are none for South America except for its southernmost area (Oresanz et al 2002). Many sites for North American Caribbean, European, Asian and Australasian regions list species which were historically introduced by the aquaculture, fisheries, aquarium industry or hull fouling vectors, while 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 Brazilian counterparts, including the GIS and environmental expertise from FEEMA facilitated effective instruction and familiarisation of the BWRA system. In addition, some of the team members are hoping to repeat the exercise for the southern Brazilian port of Paranaguá.

Continuing work in ballast water management projects will enable Brazil to provide assistance, technical advice, guidance and encouragement to other South American port States. It could adopt a leading role if it could make coordinated and strategic use of its existing agencies, several of which have expertise and complimenting roles in the various maritime, technical, statistical, ecological and public health aspects of ballast water management.

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

- availability of guidelines and instructions about BWRF reporting to ship's officers, shipping agents and port officers;
- virtual lack of species surveys (PBBSs) in South America;
- relative lack of reliable port water temperature and salinity data for the major seasons
- lack of any regional web-based database for exchanging and updating species survey information.

Regional organisations, port authorities and 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 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 BWRF verification checking and analysis for part-loaded vessels visiting multi-use terminals.
- Linking BWRF submissions to electronic methods such as the radio *Free Pratique* system offers very significant labour and cost-saving benefits, as well as removing the problem of illegible writing.
- BWRFs submitted by paper or electronically are likely to contain errors and gaps. Any port officer whose duties include collecting or receiving BWRFs should check that all relevant fields have been completed, and be instructed 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 recommended, particularly during the implementation of a BWRF system at any port.

- To help interpret incomplete or suspect BWRFs, BWRF database officers should have access to up-to-date copies of the *Lloyds Ship Register*, the *Fairplay Ports Guide, Lloyd's Maritime Atlas of World Ports* or equivalent publications[18].
- Students do not make suitable BWRF data-entry people owing to the large number of possible errors and misinterpretations that can be made with the these types of form. People with a practical knowledge of port and shipping operations are far more easier and cost effective to train.

5.2 BWRA recommendations and plans by Pilot Country

- The project standard method allows the environmental similarity coefficient (C3) to be the most influential component of the BWRA formula, and the resultant 'environmental matching' approach is valid and useful when there is a paucity, bias or other doubt about the reliability about the bioregional distribution and categorisation of the various risk species that form the C4 coefficient.
- The reverse needs to be arranged (using the formula GUI of the BWRA database) when C4 carries adequate survey data and specifically unwanted species have been targeted and weighted accordingly.
- Whichever method is applied, each risk component of the calculation should be examined individually when evaluating the BWRA results in order to understand its importance and contribution to the outcome.

[18] For ports using the GloBallast BWRA system, a copy of the world bioregions map will also be needed so that the bioregion of any new port added to the database can be quickly identified. This is available in the *User Guide*.

6 Location and maintenance of the BWRA System

The GloBallast BWRA hardware and software packages in Brazil are presently maintained by the Country Focal Point Assistant at the Programa GloBallast office in the Diretoria de Portos e Costas offices in Rio de Janeiro. The following people are currently responsible for maintaining and updating the following features of the BWRA system in Brazil:

Port resource mapping and GIS display requirements:

Name:	Mr João Batista Dias
Organisation:	Fundação Estadual de Engenharia do Meio Ambiente (FEEMA)
Address:	Rua Fonseca Teles 121 – 16o Andar Rio de Janeiro – Rio de Janeiro, Brazil, 20.940-200.
Tel:	+55 21 3891 3486
Fax:	+55 21 2589 7388
Email:	depdivea@feema.rj.gov.br

Ballast water reporting form database:

Name:	Mr Alexandre de C. Leal Neto
Organization:	GloBallast - Brazil
Address:	Rua Teófilo Otoni 4, Rio de Janeiro – Rio de Janeiro, Brazil. 20.090-070.
Tel:	+55 21 3870 5674
Fax:	+55 21 3870 5674
Email:	aneto@dpc.mar.mil.br

Port environmental and risk species data:

Contact person:	Dr Andrea de O. R. Junqueira (coordination of risk species data)
Position:	Departamento de Biologia Marinha
Organization:	Instituto de Biologia, Universidade Federal do Rio de Janeiro
Address:	CCS – Bloco A – Ilha do Fundão Rio de Janeiro – Rio de Janeiro, Brazil. 21.949-900
Tel:	+55 21 2280 2394
Fax:	+55 21 2562 6306
Email:	ajunq@biologia.ufrj.br

Contact person:	Ms Fátima de F. L. Soares (environmental data for ports in Rio de Janeiro State)
Position:	Aquatic environment coordinator
Position:	Group C - Port environmental and habitat data collection
Organization:	Fundação Estadual de Engenharia do Meio Ambiente (FEEMA)
Email:	ffls@gbl.com.br

Contact person:	Dr Luciano F. Fernandes (phytoplankton risk spp., environment data in Paraná State)
Position:	Departamento de Botanica
Organization:	Setor de Ciências Biológicas, Universidade Federal do Paraná
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Tel:	+55 41 361 1759
Fax:	+55 41 266 2042
Email:	lff@ufpr.br

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

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

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

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

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

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

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

Orensanz, J.M., Schwindt, E., Pastorino, G., Bortolus, A., Casas1, G., Darrigran, G., Elías, R., López Gappa, J.J., Obenat, S., Pascual, M., Penchaszadeh, P., Piriz1, M.L., Scarabino, F., Spivak, E.D. & Vallarino, E.A. 2002. No longer the pristine confines of the world ocean: a survey of exotic marine species in the south-western Atlantic. *Biological Invasions 4*: pp. 115–143.

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 the Port of Sepetiba, Brazil

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 Alexandre de C. Leal Neto (GloBallast Country Focal Point Assistant) and Dr Rob Hilliard (URS Australia Pty Ltd).

Group A (GIS mapping)

Person: Mr João Batista Dias
Position: Group A Leader
Organization: Fundação Estadual de Engenharia do Meio Ambiente (FEEMA), Rio de Janeiro
Email: depdivea@feema.rj.gov.br

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

Person: Mr Eduardo Soares Cruz
Position: Group A – GIS cartographer
Organization: Fundação Estadual de Engenharia do Meio Ambiente (FEEMA), Rio de Janeiro
Email: educruz@rio.com.br

Group B (database BW records)

Person: Mr Alexandre de C. Leal Neto
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Organization: GloBallast Programme
Email: aneto@dpc.mar.mil.br

Person: Mr John Polglaze
Position: Group B Counterpart Trainer
Organization: URS Australia Pty Ltd
Email: john_polglaze@urscorp.com

Person: Mr Paulo César Francisco Alves
Position: Group B – Port records, port shipping data extraction, BW report forms.
Organization: Port Engineer, Companhia Docas do Rio de Janeiro, Porto de Sepetiba, Brazil.
Email: pcfa48@ig.com.br

Person: Mrs Catia Pedroso Ferreira
Position: Group B – Port records, port shipping data extraction, BW report forms.
Organization: Agência Nacional de Vigilância Sanitária, Gerência Geral de Portos e Fronteiras, Brazil.
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Group C (port environment and risk species data)

Person: Dr Andrea de Oliveira Ribeiro Junqueira
Position: Group C Leader – risk species database and port environmental similarity analysis
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Email: ajunq@biologia.ufrj.br

Person: Dr Robert Hilliard
Position: Group C Counterpart Trainer
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Email: robert_hilliard@urscorp.com.au

Person: Dr. Flavio da Costa Fernandes
Position: Group C – risk species database and port environmental similarity analysis
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Email: flaviocofe@yahoo.com

Person: Mrs Karen Tereza Sampaio Larsen
Position: Group C – port environment data collation and similarity analysis
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Person: Mrs Gisele Alves Gomara
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Person: Ms Maria Cordeiro de Farias Gouveia Matos
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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 usually bundled inside MS Office 97 (Business Edition), Office Pro; Office 2000; etc. Please check with your IT people if unsure.

MS Word, MS Excel, MS PowerPoint.

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

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

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

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

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

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

Provisional Dates for 1st Visit (5 working days)

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

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

1st Visit Activities:

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

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

Environmental Data Requirements - see next page, attached.

ATTACHMENT

TYPES OF ENVIRONMENTAL DATA FOR PORT SIMILARITY ANALYSIS

The project requires two types of port environmental data:

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

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

In the case of the quantitative parameters, these include:

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

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

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

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

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

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

APPENDIX 4
Information sources used for collating Port Environmental Data

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

Continued over…

Distance to nearest river mouth Catchment size of nearest river with significant flow	Grand Atlas of India; Atlas of Soviet States (1974); Times Atlas of World; Readers Digest Atlas of Rivers & Lakes; MS Encarta Deluxe Reference Library World Atlas [watershed layer] (2003). C-Map World for Windows 3.03 [river layer] (2001). Atlas of People's Republic of China. Atlases of Africa, Iran, Japan, Korea, South America. Grand Atlas of Japan and North Asia (1996). Heibonsha Cartographic Publishing Co. Ltd, Tokyo.	NIO, IBSS, Meridian GIS Meridian GIS Meridian GIS, MSA CSIR, PSO, FEEMA,E&E.
Distance to nearest smooth artificial wall Distance to nearest rocky artificial wall distance to nearest wood pilings/structures Distance to nearest high tide salt marsh/saline flats Distance to nearest sand beach or sand bar Distance to nearest stony/pebble/shingle beach Distance to nearest low tide mud flat Distance to nearest mangroves Distance to nearest natural rocky shore Distance to nearest subtidal firm sands Distance to nearest subtidal soft mud Distance to nearest seagrass meadow Distance to nearest subtidal rocky reef or pavement Distance to nearest coral reef (carbonate framework)	Port plans, hydrographic charts, coastal resource maps, OSCP plans. Saifullah SM, Khan SH & Ismail S, 2002. Mar Poll Bull. 44: 570-576. Danulat E, Muniz P, Garcia-Alonso J, Yannicelli B, 2002. Mar Poll Bull 44: 554-565. National coastal resource maps; Field observations noted on hydrographic charts. Probyn T, Pitcher G, Pienaar R & Nuzzi R, 2001. Mar Poll Bull 42: 405-408. Hilliard et al. (1997). EcoPorts Monograph12, Ports Corporation of Queensland, Brisbane. Unpublished data from National Hydraulic Laboratory, Colombo, Sri Lanka. Red Sea habitat information from Drs H Shalaby & T Rouphael, UNDP program, Cairo. Colour aerial photographs, Landsat thematic images, coastal resource studies (various). Interactive world coral reef distribution maps, Reefbase (UNEP/ICLARM). Interactive world mangrove distribution map, Reefbase (UNEP/ICLARM). Seagrass distribution maps (Americas, Asia, Australasia, Europe-Med). McComb, A. et al (1992). Seagrasses of the World, Academic Press, UK. Dusek ML & Kitchens WM, 2003. Vegetation of the Lower Savannah River Delta. Florida Cooperative Fish and Wildlife Unit, University of Florida. Marine habitat maps web-published by the Biodiversity Centre, Nature Conservation Bureau, Ministry of Environment, Japan.	CFP-As, CSIR, DMU, E&E, FEEMA, IBSS, IEMA, Meridian GIS, MPT-JNPT, MEPA, MSA, NIO, NPA, PSO, SA, UFP, UFRJ, Meridian GIS. http://www.reefbase.org/DataPhotos/dat_gis.asp http://www.biodic.go.jp/site_map/site.html http://www.wec.ufl.edu/coop/Annual_Reports/Marsha%27s%2520 poster.ppt+

Abbreviations: CFP-As; GloBallast Country Focal Point Assistants; CSIR: Commonwealth Science and Industry Research (Durban Office), South Africa; CSIRO-CRIMP: now CSIRO Marine Research (Hobart).
DMU: Dalian Maritime University, Dalian, PR China; E&E: Environmental & Energy Solutions Inc., Kamata, Chuo-ku, Japan; FEEMA: FundaÁ‚o Estadual de Engenharia do Meio Ambiente, Departamento de Controle Ambiental, Rio de Janeiro, Brazil; IBSS: Institute of Biology of the Southern Seas, Odessa, Ukraine; IEMA: Instituto de Estudos do Mar Almirante Paulo Moreira, Arraial do Cabo, Brazil;
JICA: Japan International Cooperation Agency (Tokyo); MEPA: Meteorological and Environment Protection Agency, Saudi Arabia; MPT-JNPT: Port Trusts of Mumbai and Jaharwal Nehru Ports;
MSA: Maritime Safety Authority, Beijing, PR China; NIO: National Institute of Oceanography, Donna Paula, Goa, India; NIOC: National Iranian Oil Company;
NPA: National Ports Authority (Saldahna Bay, Richards Bay, Johanessburg Offices), South Africa; PSO: Ports & Shipping Organisation (Bandar Abbas, BIK, Tehran), IR Iran;
SA: Saudi-Aramco, Dammam, Kingdom of Saudi Arabia; UFP: Departamento de Bot‚nica, Universidade Federal do Paran·, Brazil; UFRP: Departamento de Biologia Marinha, Universidade Federal do RdJ, Brazil.

APPENDIX 5

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

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

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

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

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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
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

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Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Redcar	*285*	*330*	*9*	-4	3,000	5	5	4	3	3	4	4	0	3	4	5	0	3	0
Batumi, Georgia	539	978	7	7	22,000	5	5	4	3	4	4	3	0	4	4	5	0	4	0
Poti, Georgia	*537*	*840*	*8*	4	13,300	5	5	4	3	4	1	3	0	2	4	5	0	1	0
Gibraltar	*690*	*146*	*5*	25	1,600	5	5	3	0	4	4	0	0	4	3	5	3	5	0
Aspropyrgos	180	278	6	4	5,600	5	5	4	0	5	4	2	0	4	5	4	2	3	0
Elefsis (Eleusis)	69	302	6	5	961	5	5	4	0	4	4	2	0	4	4	5	2	4	0
Chios	181	278	6	93	900	5	5	5	0	4	5	1	0	5	4	3	2	5	0
Pachi	69	302	6	34	855	5	4	1	0	2	2	2	0	5	4	4	2	5	0
Piraeus	69	302	6	14	320	5	5	4	0	4	3	3	0	4	5	3	3	4	0
Thessaloniki	181	278	7	6	1,800	5	5	5	0	4	4	4	0	3	4	5	3	4	0
Volos	*181*	*278*	*6*	0	64	5	5	4	0	4	4	2	0	4	4	5	3	4	0
Hong Kong Hong Kong	206	2520	5	33	1,000,000	5	5	3	1	3	3	3	3	3	3	4	3	4	3
Hong Kong Kowloon	*206*	*2520*	*5*	33	1,000,000	5	5	5	1	2	2	4	3	3	3	5	3	3	3
Omisalj	*470*	*570*	*9*	18	250	5	0	2	0	1	2	0	0	5	3	2	1	5	0
Belawan Sumatra	960	1150	9	12	550	5	0	4	0	3	0	5	5	3	4	5	3	3	2
Dumai Sumatra	985	1287	9	42	20,000	5	2	4	0	3	0	5	4	2	3	5	4	1	1
Cigading	286	899	7	5	50	5	3	5	1	1	1	1	1	1	4	4	3	2	2
Merak (inc. Anyer Terminal) Java	480	1335	7	20	700	5	4	4	0	3	1	2	2	4	5	3	3	5	4
Jakarta Java	268	1434	6	5	300	5	4	5	0	4	3	1	3	3	3	5	4	3	3
Cilacap Java	1325	2172	8	-1	900	3	2	3	1	3	2	1	1	2	5	3	4	3	3
Semarang Java	312	1390	6	2	200	5	4	4	1	3	5	1	2	5	3	5	2	5	4
Tanjung Perak (Surabaya) Java	203	1277	6	1	200	5	3	4	0	1	2	1	2	2	4	4	2	2	2
Tanjung Bara Coal Terminal Kalimantan	*1272*	*1494*	*9*	80	100,000	5	0	0	0	3	0	2	3	4	5	4	4	4	4
Balikpapan Kalimantan	1272	1494	9	100	100,000	5	4	5	0	3	0	4	4	4	4	5	3	3	3
Amamapare Irian Jaya	*1203*	*1330*	*9*	0	500	5	4	5	1	1	5	1	1	5	5	3	3	4	4
Moneypoint	*544*	*878*	*8*	-18	4,000	5	2	5	2	3	4	4	0	5	4	5	0	5	0
Ashdod	*7*	*100*	*4*	3	20	5	5	0	0	4	4	0	0	0	5	0	4	0	0
Mumbai (Ex Bombay)	287	2246	2	10	9,800	5	1	2	0	2	0	5	4	4	4	4	0	4	0
Calcutta	149	1484	4	-140	1,200,000	5	2	5	1	0	0	5	1	0	0	5	0	0	0
Cochin	498	2417	3	-3	6,170	5	5	5	0	5	0	5	5	1	2	2	0	1	0
Haldia	149	1484	4	-36	1,200,000	5	4	5	2	3	0	5	3	1	3	5	1	0	0
Mangalore (New Mangalore)	268	2739	2	15	2,500	5	4	4	0	5	3	3	3	3	4	4	0	2	0
Kandla	3	338	2	-40	150,000	5	1	4	3	2	0	5	5	2	2	5	0	2	3
Chennai (Ex Madras)	341	863	7	110	50,000	5	5	2	0	5	0	1	1	1	4	5	1	1	0
Marmugao (Marmagoa)	49	2915	4	0	2,500	5	5	4	3	4	3	4	3	5	4	5	0	4	0
Mundra	6	485	2	10	1,100	5	5	5	4	4	0	5	4	1	0	5	2	1	1
Porbandar	350	1500	3	18	1,200	5	5	4	3	3	3	2	2	4	3	5	2	4	0
Paradeep	198	1551	4	5	132,100	5	5	2	0	5	0	4	4	1	4	4	0	2	0
Salaya	*150*	*900*	*3*	*2*	*800*	5	4	4	3	3	2	5	4	3	3	5	2	4	0
Sikka	6	485	2	14	1,100	5	4	3	2	0	0	4	4	1	0	5	2	1	5
Tuticorin (New Tuticorin)	158	506	3	15	14,400	5	5	3	0	5	0	4	4	5	4	4	2	5	3
Vadinar Terminal	*150*	*900*	*3*	*2*	*800*	4	4	3	3	3	2	3	3	3	4	5	2	4	0
Visakhapatnam	*78*	*799*	*4*	15	113,000	5	5	2	0	4	0	1	1	4	3	3	0	4	4
Bandar Imam Khomeyni	2	190	3	144	500,000	5	0	5	2	0	2	5	0	0	0	5	1	0	0
Bandar Mushar (Mushahr)	2	190	3	100	500,000	5	0	5	2	0	2	5	0	0	0	5	1	0	0
Bandar Abbas (Oil Jetty)	11	172	4	30	42,000	5	5	0	3	3	1	5	2	1	5	5	2	2	2
Bushehr	5	160	4	25	12,000	5	0	3	3	4	2	5	1	0	4	5	3	0	2
Khark Island	2	154	4	31	12,000	5	5	4	2	4	4	2	2	4	5	3	4	0	5
Lavan Island	0	84	3	140	42,000	5	0	0	0	4	4	0	0	4	5	4	4	0	4
Sirri Island Oil Terminal	*0*	*84*	*3*	140	42,000	5	0	0	0	4	4	0	0	4	5	4	4	0	4
Hafnarfjordur	220	330	8	4	200	5	5	4	0	0	4	0	0	4	0	3	0	5	0
Straumsvik	*220*	*330*	*8*	1	200	5	5	4	0	0	4	0	0	4	0	3	0	5	0
Genoa	451	825	6	28	600	5	4	4	0	3	4	0	0	4	3	2	*3*	4	0
Porto Foxi (Sarroch)	294	641	7	20	400	5	3	0	2	4	3	1	0	4	3	2	*3*	4	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the...			Distance to River Mouth (km)	Size of River Catchment (km²)	Intertidal Habitats [I]									Shallow Subtidal Habitats (S)				
	Driest 6 months	Wettest 6 months	No. of months for 75%			Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Livorno	343	565	8	20	4,100	5	5	5	2	4	4	0	0	3	3	5	3	4	0
Ravenna	346	411	9	0	2,000	5	5	4	0	3	3	4	0	3	3	5	2	4	0
Taranto	132	308	7	8	550	5	4	3	2	3	2	2	0	4	3	5	3	4	0
Venezia (=Fusina)	438	604	8	-2	1,200	5	5	4	2	3	1	3	0	3	3	5	3	2	0
Trieste	469	573	9	20	3,000	5	4	4	0	3	3	3	0	3	3	5	2	3	0
Aboshi Hyogo	400	900	7	3	480	5	5	3	2	2	4	2	0	4	3	4	3	4	0
Amagasaki Hyogo	431	885	7	0	7,600	5	4	2	0	3	4	2	0	3	3	2	3	4	0
Beppu Oita	465	1176	6	10	1,500	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Chiba Chiba	580	1100	7	18	880	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Kimitsu Chiba	580	1100	7	11	880	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Fukuyama Hiroshima	342	834	7	5	649	5	3	2	1	3	2	2	0	2	3	3	2	5	0
Higashi-Harima Hyogo	390	950	6	10	1,656	5	4	3	2	3	4	3	0	4	3	4	3	4	0
Himeji Hyogo	400	900	7	10	480	5	5	4	2	2	3	2	0	3	3	5	3	4	0
Hakata Fukuoka	509	1095	7	6	280	5	3	2	1	2	3	2	0	3	3	2	2	5	0
Imabari Ehime	450	899	4	2	70	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Innoshima Hiroshima	340	850	6	15	60	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Iwakuni Yamaguchi	499	1045	7	3	260	5	4	4	2	3	3	4	0	3	4	5	3	4	0
Kochi Kochi	798	1841	4	-4	640	5	3	4	3	3	3	4	0	4	3	5	3	4	3
Kakogawa Hyogo	402	916	7	1	1,656	5	4	2	2	2	3	2	0	3	3	4	3	4	0
Kiire Kagoshima	632	1607	6	20	100	4	4	2	2	3	4	2	3	4	4	3	2	5	2
Niigata Niigata	724	1065	6	-2	1,800	5	4	4	0	3	2	3	0	5	3	5	2	4	0
Kikuma Ehime	450	899	4	1	10	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Kinwan (Ishikawa) Okinawa	818	1320	7	5	10	5	4	2	2	4	4	3	4	4	4	5	4	0	4
Kanda Fukuoka	554	1106	7	4	40	4	3	2	1	3	4	2	0	4	3	2	2	5	0
Kinuura Aichi	478	1057	7	-2	350	5	4	4	2	3	2	3	0	3	3	5	3	4	0
Kagoshima Kagoshima	632	1607	6	2	260	5	4	4	2	3	4	2	2	4	3	3	2	5	3
Kashima Ibaraki	683	983	8	32	1,800	5	4	2	1	4	3	1	0	2	5	4	2	3	0
Kudamatsu Yamaguchi	635	1210	7	1	30	5	4	3	1	3	1	3	0	5	3	5	3	5	0
Kawasaki Kanagawa	570	1100	7	4	2,200	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Maizuru Kyoto	781	1020	8	12	1,600	5	4	4	0	2	4	3	0	5	2	5	2	4	0
Mizushima Okayama	339	821	7	2	1,990	5	4	2	1	3	2	3	0	3	4	5	4	4	0
Moji (Kitakyushu) Fukuoka	554	1106	7	13	300	5	3	1	1	2	2	2	0	2	3	3	3	5	0
Muroran Hokkaido	724	1065	6	15	740	5	4	4	0	3	3	3	0	5	3	5	2	4	0
Matsuyama Ehime	450	899	4	12	270	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Naha Okinawa	818	1320	7	2	15	5	4	4	3	4	2	3	3	3	4	5	4	0	4
Negishi (Yokohama) Kanagawa	548	1021	7	3	230	5	4	4	1	4	3	3	0	3	3	5	3	4	1
Nagoya Aichi	478	1057	7	2	900	5	4	4	2	4	1	3	0	3	3	5	4	5	0
Nagasaki Nagasaki	562	1417	6	-5	480	5	3	5	0	3	4	3	0	4	3	5	3	5	1
Oita Oita	465	1176	6	3	2,150	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Okinawa Okinawa	818	1320	7	2	15	5	4	4	3	4	2	3	3	3	4	5	4	0	4
Onomichi Hiroshima	340	850	6	2	60	5	3	5	2	3	3	4	0	3	4	5	3	4	0
Osaka Osaka	430	880	7	0	16,000	5	4	3	0	3	4	2	0	3	3	5	2	3	0
Saiki Oita	465	1176	6	18	2,150	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Saganoseki Oita	465	1176	6	18	2,150	4	3	2	1	3	4	2	0	4	3	3	2	5	0
Sakai Osaka	420	850	7	1	1,600	5	4	4	0	3	4	2	0	4	4	4	3	4	0
Shibushi Kagoshima	632	1607	6	2	140	5	4	4	2	3	4	2	3	4	4	3	2	5	2
Sakaide Kagawa	358	775	7	4	120	4	4	3	0	2	2	2	0	2	4	4	2	5	0
Sakaiminato Tottori	848	1075	9	11	280	5	4	4	3	4	3	3	0	4	4	4	2	3	0
Shimotsu Wakayama	456	886	7	3	25	5	4	4	2	4	1	3	0	3	3	5	4	4	1
Shimizu Shizuoka	738	1356	7	1	900	5	4	4	1	3	4	3	0	4	4	5	3	4	0
Tamano (Uno) Okayama	339	821	7	23	1,990	5	4	2	1	3	2	3	0	3	4	5	4	5	0
Tobata (Kitakyushu) Fukuoka	554	1106	7	5	10	5	3	4	1	3	2	4	0	2	4	4	4	5	0
Tokuyama Yamaguchi	631	1213	7	1	70	5	4	3	1	3	1	4	0	5	3	5	3	5	0
Tomakomai Hokkaido	724	1065	6	0	10	5	4	4	0	3	3	3	0	5	3	5	2	4	0
Toyama Toyama	327	739	7	3	4,800	5	4	4	0	3	2	3	0	3	3	5	2	3	0

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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

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

APPENDIX 7
Consultants' Terms of Reference

Global **Ballast Water** Management Programme

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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