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Ballast Water Risk Assessment

Port of Saldanha Bay
Republic of South Africa

NOVEMBER 2003

Final Report

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GEF UNDP IMO URS MERIDIAN National Ports Authority of South Africa

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

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

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Some of the GloBallast - South Africa risk assessment team in action

Acronyms

BW	Ballast water
BWM	Ballast water management
BWRA	Ballast Water Risk Assessment
BWRF	Ballast Water Reporting Form (the standard IMO BWRF is shown in Appendix 1)
CFP	Country Focal Point (of the GloBallast Programme in each Pilot Country)
CFP/A	Country Focal Point Assistant
CRIMP	Centre for Research on Introduced Marine Pests (now part of CSIRO Marine Research, Hobart, Tasmania)
CSIR	Centre for Scientific and Industrial Research (South Africa)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DEAT	Department of Environmental Affairs and Tourism (South Africa)
DSS	Decision support system (for BW management)
DWT	Deadweight tonnage (typically reported in metric tonnes)
GIS	Geographic information system
GISP	Global Invasive Species Programme
GloBallast	GEF/UNDP/IMO Global Ballast Water Management Programme
GT	Gross tonnage (usually recorded in metric tonnes)
GUI	Graphic User Interface
IALA	International Association of Lighthouse Authorities
IBSS	Institute of Biology of the Southern Seas (Odessa Branch) of the Ukraine National Academy of Science
IHO	International Hydrographic Organization
IMO	International Maritime Organization
IUCN	The World Conservation Union
LAT	Lowest Astronomical Tide
MESA	Multivariate environmental similarity analysis
MEPC	Marine Environment Protection Committee (of the IMO)
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
NPA	National Ports Authority (of South Africa)
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
SAMSA	South African Maritime Safety Authority
SAP	(Regional) Strategic Action Plan
SERC	Smithsonian Environmental Research Center (United States)
VLCC	Very large crude carrier (200,000 – 300,000 DWT)
ULCC	Ultra large crude carrier (over 300,000 DWT)

Glossary of Terms and Definitions

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

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

Introduced species	A species that has been intentionally or unintentionally transferred by human activity into a region beyond its natural range.
Invasive species	An established introduced species that spreads rapidly through a range of natural or semi-natural habitats and ecosystems, mostly by its own means.
Marine pest	A harmful introduced species (i.e. an introduced species that threatens human health, economic or environmental values).
Non-invasive	An established introduced species that remains localised within its new environment and shows minimal ability to spread despite several decades of opportunity.
Pathogen	A virus, bacteria or other agent that causes disease or illness.
Pathway (Route)	The geographic route or corridor from point A to point B (see Vector).
Port Biological Baseline Survey (PBBS)	A biological survey to identify the types of introduced marine species in a port.
Risk	The likelihood and magnitude of a harmful event.
Risk assessment	Undertaking the tasks required to determine the level of risk.
Risk analysis	Evaluating a risk to determine if, and what type of, actions are worth taking to reduce the risk.
Risk management	The organisational framework and activities that are directed towards identifying and reducing risks.
Risk species	A species deemed likely to become a harmful species if it is introduced to a region beyond its natural range, as based on inductive evaluation of available evidence.
Translocation	The transfer of an organism or its propagules into a location outside its natural range by a human activity.
Unintentional introduction	An unwitting (and typically unknowing) introduction resulting from a human activity unrelated to the introduced species involved (e.g. via water used for ballasting a ship or for transferring an aquaculture species).
Vector	The physical means or agent by which a species is transferred from one place to another (e.g. BW, a ship's hull, or inside a shipment of commercial oysters)

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Executive Summary

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

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

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

This report describes the BWRA activity undertaken for the Port of Saldanha Bay, which is the Demonstration Site for the Republic of South Africa and managed by its National Ports Authority (NPA). 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 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 Saldanha port offices. These records also helped identify which next ports of call may have been a destination port for any BW taken up at Saldanha Bay.

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

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

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

During each visit the consultants worked alongside their Pilot Country counterparts to provide skills-transfer as part of the capacity building objectives of the programme, with the project team divided into three groups. Group A mapped the port and its resources using ArcView GIS. This group included counterparts from the Department of Environmental Affairs and Tourism (DEAT) and NPA, who helped collate and compile much of the required GIS data. Group B included counterparts from NPA and was responsible for managing the customised Access database supplied by the consultants, and for entering, checking and managing the BW discharge data obtained from records held by NPA personnel at Saldanha Bay and from BWRFs voluntarily submitted by arriving ships. Group B used the database to identify BW source and destination ports, and it is designed for ongoing input and management of BWRFs. Group C contained counterparts from NPA and the Centre for Scientific and Industrial Research's (CSIR) coastal program (Durban), and 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 Saldanha Bay 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 Cape Town (DEAT) and Johannesburg (NPA) 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.

A total of 1315 vessel visits were entered into the Saldanha Bay database during the activity, the large majority being extracted and expanded from BW records collated by the port's pollution control officer between January 1999 and June 2002. This database contained 82 vessel visits to the oil terminal berth (most laden VLCCs arriving at rates of 1-4 per month from the Gulf and Nigerian oil export terminals). Reported BW discharges for the oil terminal totalled 1,269,137 tonnes (most occurring during a period of crude oil re-exports from South Africa's strategic reserve which ceased in October 1999). The database also contained 593 visits to the iron ore export terminal (most Cape Class bulk carriers) which reported BW discharges totalling 26,802,325 tonnes, plus a further 607 visits by bulk carriers and general cargo ships to the nearby multi-purpose terminal. BW discharges reported for the latter totalled 1,576,292 tonnes. On the southwest side of Saldanha Bay, 33 visits were also made to the Sea Harvest/Cold Store terminal by small reefers (<4,200 DWT), with only one of these reporting a discharge (200 tonnes of ballasted trim water).

BW source ports identified from the 1307 BW discharge records in the Saldanha database totalled 131. Those 'supplying' the highest frequency of BW discharges to Saldanha Bay were Durban (9.2%) closely followed by Richards Bay (another South African port; 9.1%), then Rotterdam (5.1%) and Port Talbot (in the United Kingdom; 4.1%). The top thirteen BW source ports provided 50% of all source-identified discharges, while the next 23 ports contributed a further 25%. Thus 36 of the source ports (27.3%) accounted for 75% of the total number of source-identified discharges. The total volume of source-identified discharged BW at Saldanha Bay between January 1999 and June 2002 was 29,647,954 tonnes. The source ports providing the largest volume were Rotterdam (7.3% of the total volume), Port Talbot (6.5%), Singapore (5.0%) and Immingham (4.2%). Only 30 of all identified source ports (22.7%) accounted for 75% of the total volume of source-identified BW discharged at Saldanha Bay.

Many of the most frequent BW source ports were also frequent 'Next Ports of Call' (i.e. potential destination ports for BW uplifted at Saldanha Bay), with Durban, Beilun, Singapore, Rotterdam and Richards Bay accounting for >33% of those reported by departing vessels. Of the 183 next ports of call that were recorded, the top 33 were recorded by 75% of the 1315 vessel departures.

Of the identified source and destination ports, sufficient port environmental data were obtained to include 71% of the former and 51% of the latter in the multivariate similarity analysis by PRIMER. These ports accounted for 90% of all recorded BW discharges and 84.5% of all recorded departures respectively. The most environmentally similar port to Saldanha Bay was Piraeus in Greece (its matching coefficient was 0.78), with 11 other widely distributed ports also having matching coefficients above 0.7. Another widely dispersed group of ports (37) had relatively high matching coefficients in the 0.6-0.7 range. The most environmentally dissimilar ports trading with Saldanha Bay in 1999-2002 were a mixture of cool water and brackish ports, Gulf ports and ports in the humid tropics. The most frequent recorded next ports of call (Durban and Beilun) had relatively high (0.64) and moderate (0.58) environmental matching coefficients respectively.

The project standard calculation of the relative overall risk (ROR) identified that 19 of the 131 source ports (14.5%) provided 20% of the total ROR to Saldanha Bay, and therefore formed the highest risk group (in terms of their BW source frequency, volume, environmental similarity and risk species threat). The risk species threat posed by each source port varied according to the number of introduced and native species in its bioregion and the categorisation of these species as either unlikely, suspected or known harmful species. The highest risk group were predominantly Mediterranean, South African and North Asian ports, led by Piraeus in Greece (ROR = 0.250), Taranto in Italy (0.247) and Gijon in Spain (0.245). The group of source ports accounting for the next 20% of the ROR (i.e. 'high risk' ports) was 22, and these were predominantly north Asian, Brazilian and European ports. The number of BW source ports in the low risk (28) and lowest risk (38) categories were a mixture of cool, warm and/or brackish water ports and comprised 50% of the total. The wet tropics port of Onne on the Nigerian coast had the lowest ROR value (0.07). The ROR results were considered logical given Saldanha's biogeographic location, current pattern of trade and port type (a natural bay port). They also fitted with the origins of the introduced species already present in Saldanha Bay (i.e. European and Asian species). The results therefore indicated that the project standard 'first-pass' treatment of the risk coefficients provides a useful benchmark for any investigative manipulation of the risk calculations and database.

Of the various BWRA objectives and tasks, 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 of Port 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 Saldanha Bay, this posed an issue for some of the vessels departing the oil and multipurpose terminals. If more reliable forward-looking BWRAs are to be undertaken to identify destination ports in the future, supplementary questions will need to be added to the present BWRF, including the names of the three last ports of call as well as the port where discharges from each partially or completely ballasted tank are predicted.

The main objectives of the BWRA were successfully completed during the 14 month course of this project, with the various tasks and exploratory/demonstration software providing a foundation enabling the regional promulgation of further BW management activities by South Africa. 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 South Africa in a good position to provide assistance, technical advice, guidance and encouragement to other African port States.

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.

This report describes and presents the results of the first Ballast Water Risk Assessment (BWRA) carried out for the Port of Saldanha Bay (South Africa) during 2002. This GloBallast Demonstrate Site is a modern, deepwater bulk and general cargo port which was developed between 1975 and 1990 to provide iron ore export, crude oil import and multi-purpose cargo facilities near Cape Town, which lies approximately 95 km to the south-east (Figure 2).

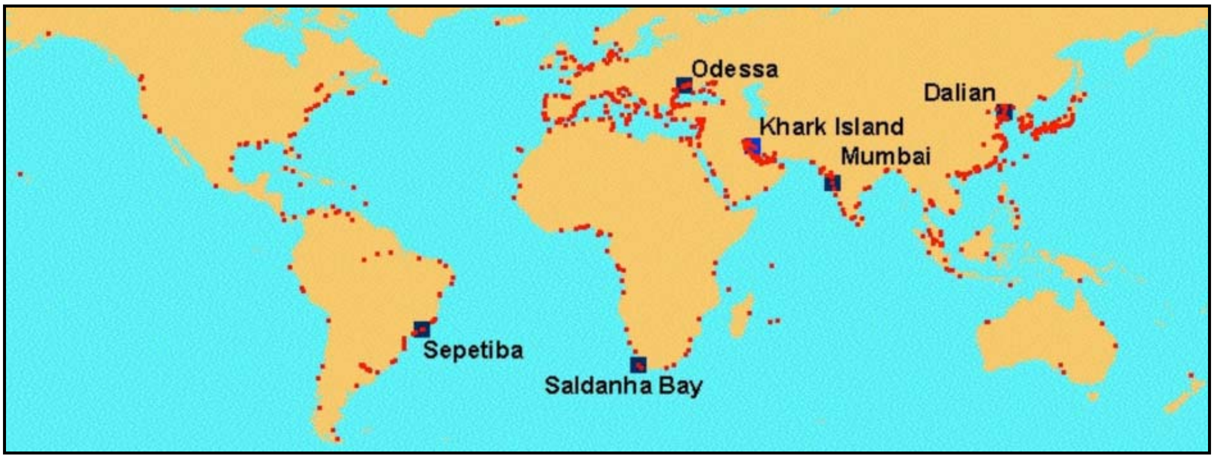

***Figure 1.** Locations of the six GloBallast Demonstration Sites and their various ballast water source and destination ports.*

Figure 2. *Location of Saldanha Bay and other ports in the southern African region*

2 Aims and Objectives

The aims of the GloBallast BWRA for the Port of Saldanha Bay 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 Saldanha Bay 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 Saldanha Bay.
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 Saldanha Bay 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 Saldanha Bay via standard IMO BWRFs.
6. Characterise as far as possible from existing data, the physical, chemical and biological environments for both Saldanha Bay and each of its source and destination ports.
7. Develop environmental similarity matrices and indices to compare the Port of Saldanha Bay 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 Saldanha Bay, 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 Saldanha Bay 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.

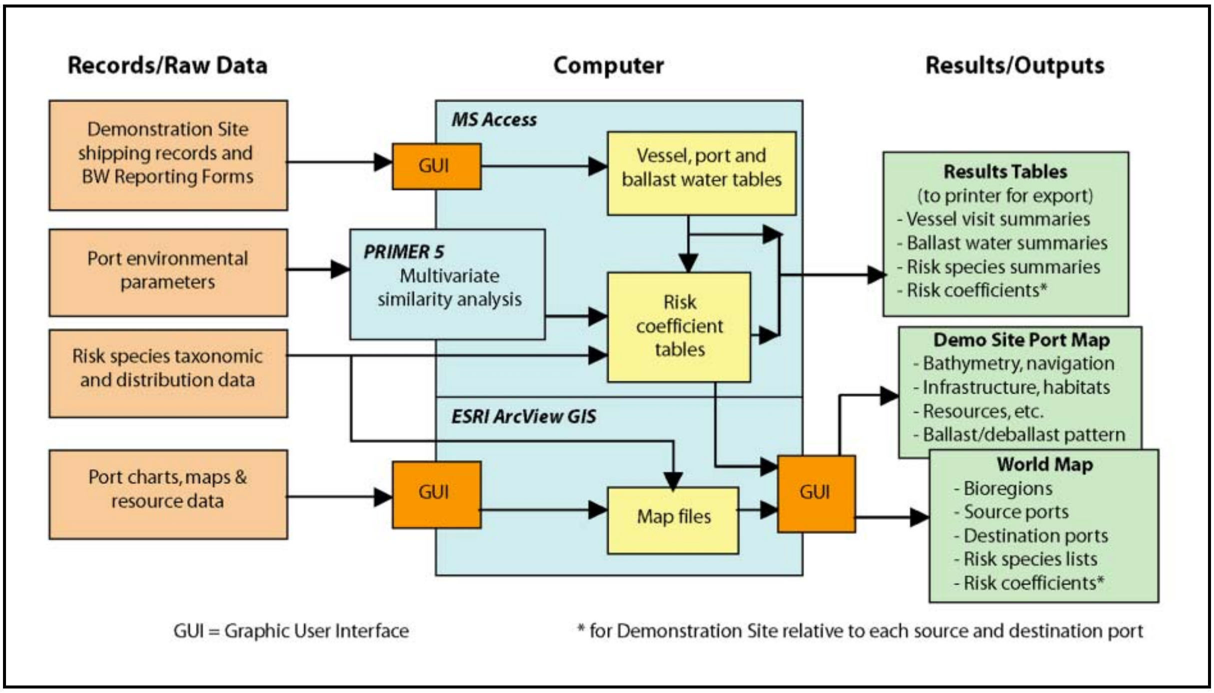

Figure 3. *Schematic of the GloBallast BWRA system*

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 Saldanha Bay were completed during two in-country visits by the consultants (7-12 April and 9-23 August 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 9-11 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 project computer system, which had been supplied by the GloBallast Programme and temporarily transferred from the Marine & Coastal Division offices of the Department of Environmental Affairs and Tourism (DEAT) at Cape Town to a function centre hired at Saldanha Bay to provide the BWRA team with convenient access to the port and its personnel.
- 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.
- Undertake a guided tour of the port facilities, obtain information on the ballasting practises of visiting ships and gain an understanding of the coastal habitats and local marine resources.
- Review available port shipping records and BWRFs 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 (9-23 August), project work was undertaken at Johannesburg, Saldanha Bay and Cape Town, with more vessel arrival, voyage data and BW discharge checking and entries to the database, and addition of the environmental and risk species data. At the end of the second visit the first BWRA was undertaken and a workshop was held at DEAT (Cape Town) to present and review the initial results and discuss future country requirements and actions.

During the third visit in March 2003, the consultants supplied the BWRA project leader and CFP-A with updated versions of the database and *BWRA User Guide* on CD-ROM, the former containing additional port environment and risk species data (as obtained from the BWRA Activities conducted at the other five Demonstration Sites). The results of the March 2003 version, plus subsequent minor corrections to some of the vessel visit records and environmental matching assignments (made by URS in consultation with the project leader and CFP-A) 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].

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 Saldanha Bay 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), recent reviews of marine species introduced to South African waters and 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).

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[2] Several port States (e.g. Australia) and Demonstration Sites (e.g. Dalian, Odessa, Sepetiba) have produced their own BWRFs, the latter using translated formats to permit improved BWRF understanding and completion by local shipping. Such BWRFs need to include all questions of the IMO standard form. Problems arising from voluntary submission of BWRFs are described in Section 4.10.

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

3.2 Resource mapping of the demonstration port

The port resources were mapped using ArcView GIS to display the bathymetric, navigational and infrastructure features, including habitats and social-cultural features. The scope of the Saldanha Bay port map extends from the coastal waters beyond its mouth to the top of the 15 km long Langebaan Lagoon which enters the south side of Saldanha Bay. The map also extends north-westward to encompass all edges of the bay, the town of Saldanha and nearby rocky headlands.

Vector-based electronic nautical charts were not available for Saldanha Bay or the Langebaan Lagoon, so Group B counterparts generated the coastline/bathymetry and navigation layers by capturing salient details from 600 dpi scanned colour images of nautical hydrographic charts covering the Saldanha Bay and Langabaan Lagoon area (i.e. charts SAN-C2, SAN-C2052, and SAN-1011). Chart SAN-C2 covered 90% of the required area and its scan was used by Group A for the initial digital registering, capture and ArcView training during the consultants first visit.

Shipping channels, anchorage areas and other navigational features were added using point and pattern symbols based on the international IHO/IALA system (details below). Infrastructure and social cultural information was also captured from these charts, with other items and reserve boundaries added from maps, tourist guides and mariculture site data obtained during the port tours which made during both the first and second consultants visits. Group C assisted Group A to assemble the marine habitat layer during the second visit, using PBBS field survey results supplied by the CFP-A and information from DEAT marine biologists at Cape Town. Gap-filling required for some of the subtidal habitat boundaries was achieved via interpretation of the seafloor substrate symbols and bathymetric contours of the three nautical charts. For clarity and convenience of GIS data management and display, each 'theme' of information was added as a separate layer that followed the scheme shown in Figure 4. An animated GIF.AVI file showing the pulsed upwelling movements into Saldanha Bay was provided by the CFP-A and linked to the port map.

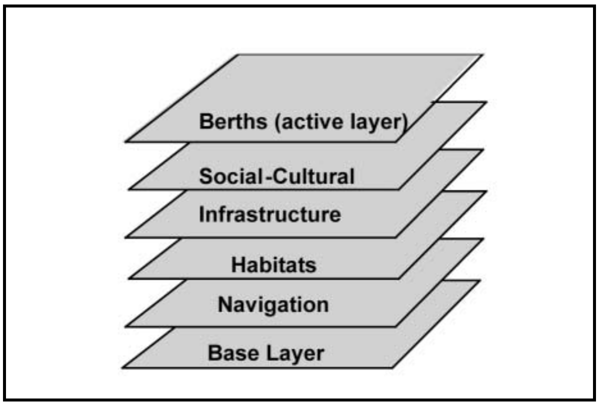

Figure 4. *Thematic layers used for the Port Map GIS*

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 Saldanha Bay comprised:

- Coastlines of the mainland and various islands within and beyond Saldanha Bay and the Langebaan Lagoon (as depicted by the high tide mark on the nautical charts).
- The low tide mark (i.e. the 0 metre bathymetric contour of hydrographic charts).
- 5 metre isobath (often the first continuous contour below the low tide mark).

- 10 metre, 20 metre and 30 metre isobaths.
- Edges of the main shipping channels (often blue or purple lines showing the boundary of depths maintained by port dredging programs).

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

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

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. These included the intertidal mud flats, sand beaches, rocky shorelines and artificial walls, plus subtidal sand, mud and rocky seafloor areas, as obtained from DEAT and the PBBS subtidal seafloor information. Some of the natural and artificial habitat boundaries were based on the notes and chart annotations made by BWRA team members during their inspection tours of the port facilities and Langebaan Lagoon, as undertaken by vehicle on 10 April and 15 August 2002.

Infrastructure Layer: This shows the urban and developed land areas around the bay, plus the major and minor roads, railway lines, power lines and airstrips. The urbanised residential areas at Diazville, Langebaan and Saldanha are also shown, as is the main fishing jetty and vessel repair and maintenance wharf beside the town.

Social-Cultural Layer: Social-cultural features include the boundaries of the three designated mariculture areas in Saldanha Bay, prohibited fishing areas and those of the West Coast National Park that encapsulates the Langebaan Lagoon.

Berth Layer: An 'active' berth layer was added to show the principal berthing and anchorage areas at the Port of Saldanha Bay. Their names and numbers were supplied by the NPA officer at Saldanha Bay (Mr Jim Norman). This 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 Saldanha Bay were discussed with the local NPA officer and then during the port tour's visit to the control tower on 15 April 2002, where the team met the acting harbour master and discussed recent and current port trade, pilotage rules and draft requirements, use of the two anchorages and the main deballasting/ballasting practises and locations. Excel files of port shipping records that summarised BW discharges reported by vessels visiting from 1991 to early 2002, as collated and maintained by the NPA pollution control officer Mr Jimmy Norman[4], were supplied to the CFP-A.

These were examined during the consultants first visit, and it was agreed that records from 1999 onward were more complete and would be suitable for entry if gap-filling was undertaken to increase the vessel, port and voyage details. 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 oil import and ore export terminals. Further BW discharge information was entered into the

[4] This record listed the vessel name, its arrival and departure dates, berthing area, last and next ports of call, and the total volume and reported source of BW discharged.

database prior to the consultant's second visit, as entered on IMO-style BWRFs that NPA port officers commenced distributing and collecting on a voluntary but very much encouraged basis in April 2002. However not all of the general cargo ships and small bulk carriers arriving at its multipurpose terminal were either fully loading or unloading cargo, and it was often unclear if and how much BW was being taken up.

3.4 Identification of source ports

To provide confidence as to which ports were the predominant sources of BW discharged at Saldanha Bay, the 1999-2002 records for vessel visits and BW discharges maintained by the NPA officer at Saldanha Bay were added to the Access database, plus the 101 IMO-style BWRFs collected by NPA officers between 1 April - 30 June 2002.. Due to the encouragement and information supplied by NPA port officers regarding the purpose of the BWRFs, the number of ships voluntarily submitting these forms was 34 per month (i.e. above the overall 1999-2002 average of 31.3 visit records/month and virtually 100% of arrival). Nevertheless the majority of source ports were identified from the much larger former set of records. Data from the BWRFs were entered into the database by a student at NPA's Johannesburg office prior to the consultants second visit in August 2002. While this generated two types of data-entry errors in the database, these were tracked down and fixed by the original Group B counterparts during the consultants second visit (Section 3.6).

For visit records showing a curious *Last Port of Call* or only a country as the source of discharged BW (i.e. no source port or location coordinates provided), cross-checks were made of records for the same and/or similar types of vessel using the same terminal. The Lloyds *Fairplay Port Guide* and *Lloyds Ship Register*[5] were also used by Group B counterparts to confirm source port trade and the IMO identification number, vessel type and DWT of arriving ships respectively. Before any new port was added to the database by Group B, its name and country name spelling, location coordinates, bioregion and unique UN Port Code number were checked using the Lloyds *Fairplay World Ports Guide* and the world bioregion list in the database (port data input is detailed in the GloBallast *BWRA User Guide*).

Some of the gaps in the NPA ship visit record and BWRFs could therefore be filled by checking the vessel name, ID, type and DWT, its previous visit history, last port/s of call and apparent charter/liner trade. Missing or peculiar BW discharge values were checked using a customised Excel spreadsheet supplied by the consultants to estimate the amount BW probably discharged or taken up[6] (Figure 5). This was less easy for the vessels arriving at the multi-purpose berths where cargos may be part loaded and/or unloaded during a visit, but the majority of the 1999-2002 records and most BWRFs were completed to the level allowing a database visit entry and a record of likely BW discharge volume and source.

In fact most of the BWRFs collected in April-June 2002 did not require extensive gap-filling or reliability checking, as most were checked individually by the NPA Pollution Control Officer. In the case of unusual 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. The main checking and gap-filling exercise of the 1999-2002 NPA vessel visit records and the BWRF entries was therefore undertaken by Group B members during the second in-country visit, with the database of 1315 vessel visits compiled from:

- the vessel visit and total BW discharge details from NPA-supplied Excel files for January 1999- March 2002, with the *Fairplay Port Guide*, *Lloyds Ship Register* and port shipping records used to identify, add or correct port details, vessel names, IMO numbers, types

[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*.

DWTs, and voyage duration (to provide minimum storage times since the BW source dates had not been recorded);

- using the BWRFs and above manuals to correct the many database errors arising from student entry of these forms (Section 3.6); and
- cross-checking unusual BWRFs with previous records, the *Lloyds Ship Register*, *Fairplay Port Guide* and Excel spreadsheet to correct obvious errors and/or add missing data.

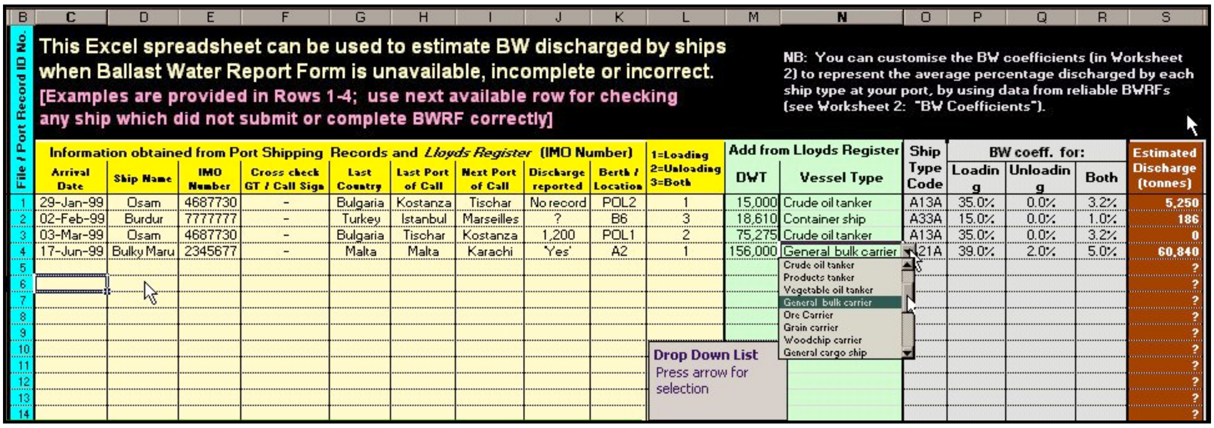

Figure 5. *Working page of the Excel spreadsheet used to estimate BW discharges*

3.5 Identification of destination ports

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

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

Both the BWRFs and port shipping records for Saldanha Bay list the *Next Port of Call* of all departing vessels, and these were added to the database for analysis. However the next port of call may not be where BW carried by a departing ship is discharged, either fully or partly. For example, the next port may be a bunkering, crew-change or maintenance port, a port where a 'top-up' or other minor cargo is loaded, or a convenient 'hub' port where ships anchor and wait for new sailing instructions.

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

In the case of the Port of Saldanha Bay, there is a regular import of crude oil requiring the visiting tankers to uplift ballast water whilst unloading to maintain trim, stability and sufficient draft for their safe departure into the South Atlantic. The next ports of call of these and the other vessel visits 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. For other Demonstration Sites many berthing locations had to be identified from the port shipping records because the BWRA objectives include identifying the locations <u>within</u> a Demonstration Site where deballasting/ballasting occurs (Section 2). In the case of Saldanha Bay, however, this was not a major problem owing to the dedicated nature of two of the terminals and supplementary information obtained from NPA's senior port officer. During the consultants first visit it was recommended that port officers collecting the IMO-BWRFs should remember to annotate the berthing location on the submitted forms, thereby avoiding unnecessary workload during data-entry. One 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 (below).

Not all of the BWRF question fields need to be completed to provide a visit record that can be saved to the database and used for 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 port records or BWRFs that do not contain individual tank details).

Without these three items the database cannot save a visit or tank record or any other associated information. Whether or not a visit 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, the berthing location and the BW source and discharge dates. 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. In the case of missing BW source dates from the 1999-2002 records, these had to be estimated from the durations of standard 14 knot voyages (typically available in port guides and maritime atlases) then added to the BW discharge records in the database.

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

This was the main problem arising from the student entries of the BWRFs prior to the second visit (Section 3.4), with over 80 replicate ports and numerous replicate vessels (many with incorrect spellings and/or identifier codes) needing to be tracked, checked with original BWRFs, and deleted or corrected to allow the database to operate properly.

Spelling mistakes on BWRFs and port shipping records are common. All data-entry and database managers therefore need to understand how to avoid transcribing such errors by carefully checking all names and ID numbers using the database drop-down lists and, where necessary, by referring to a reliable ship registry or port directory when entering the details of a new vessel or port respectively. As confirmed by NPA's experience (as well as Brazil's for the Sepetiba Demonstration Site), hire of students as casual labour to accelerate BWRF data entries is not cost-effective.

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

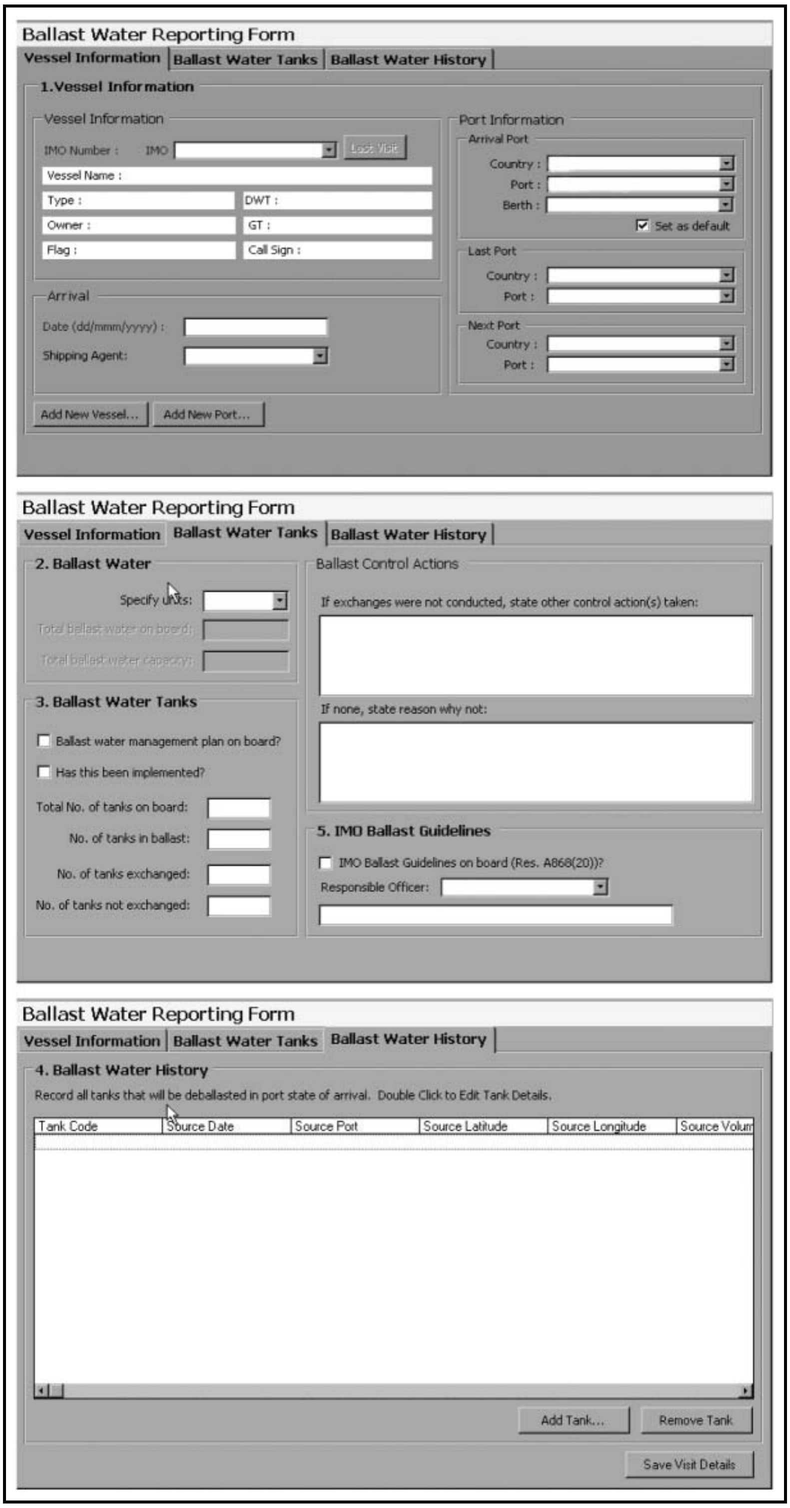

Figure 6. *The three tabs of the GUI used for entering the BWRF data*

3.7 Environmental parameters

During the briefing meetings in January 2002, the consultants provided a preliminary list of environmental parameters that would be used to generate the environmental matching coefficients between the Demonstration Sites and their main BW source ports and destination ports (Appendix 3).

The provisional list was based on review of previous port-to-port environmental analyses undertaken for twelve trading ports in northeast Australia (Hilliard *et al*. 1997b). The final list of 34 parameters used for the six Pilot Countries (Table 1) was selected in February 2002, during a joint review of the provisional list by the consultants and scientists of the Institute of Biology of the Southern Seas (IBSS) in Odessa[7].

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

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

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

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

[8] Offshore terminal or mooring / Natural bay / Breakwater harbour / Tidal creek / Estuary / River port.

[9] Kelp forest/macroalgae bank was not included but should be considered for future analysis.

salinity data, particularly for identifying the averages, maxima and minima for ports in or near estuaries (Section 3.12).

A preliminary list of frequently recorded BW source ports and destination ports for the Port of Saldanha Bay 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 Group C members focussing on important ports in South Africa, and the consultants focussing on more distant ports in Europe, South America, Asia and Australia. 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 Saldanha Bay, 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).

The environmental distances between the Port of Saldanha Bay 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

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

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. The modifications 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. No change was required for the Saldanha Bay bioregion (WA-IV; Figure 7).

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[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.

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 Saldanha Bay (which became available during the second consultants visit), plus two literature reviews of introduced species in southern Africa (Awad & Jackson 2001, Gollasch & Griffiths 2001). South African 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 African region but none were located.

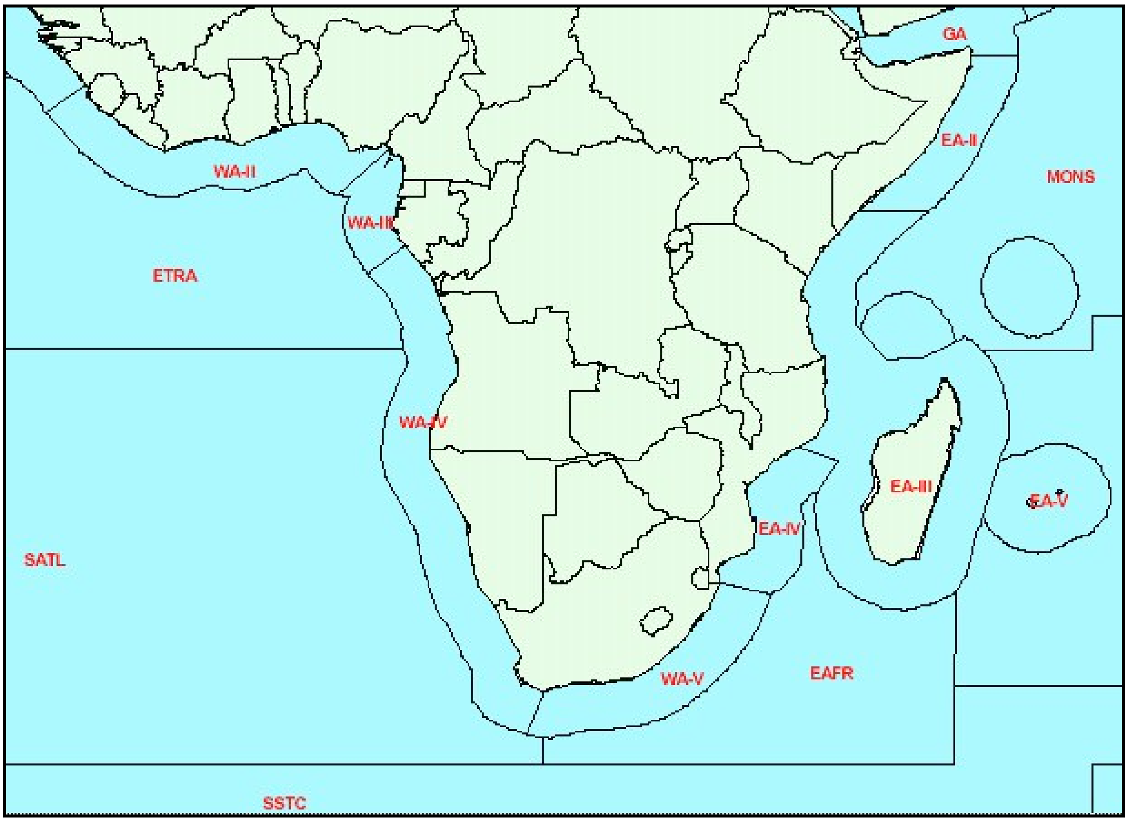

Figure 7. *Part of the GIS world map of marine bioregions, showing the code names of those in the southern African region*

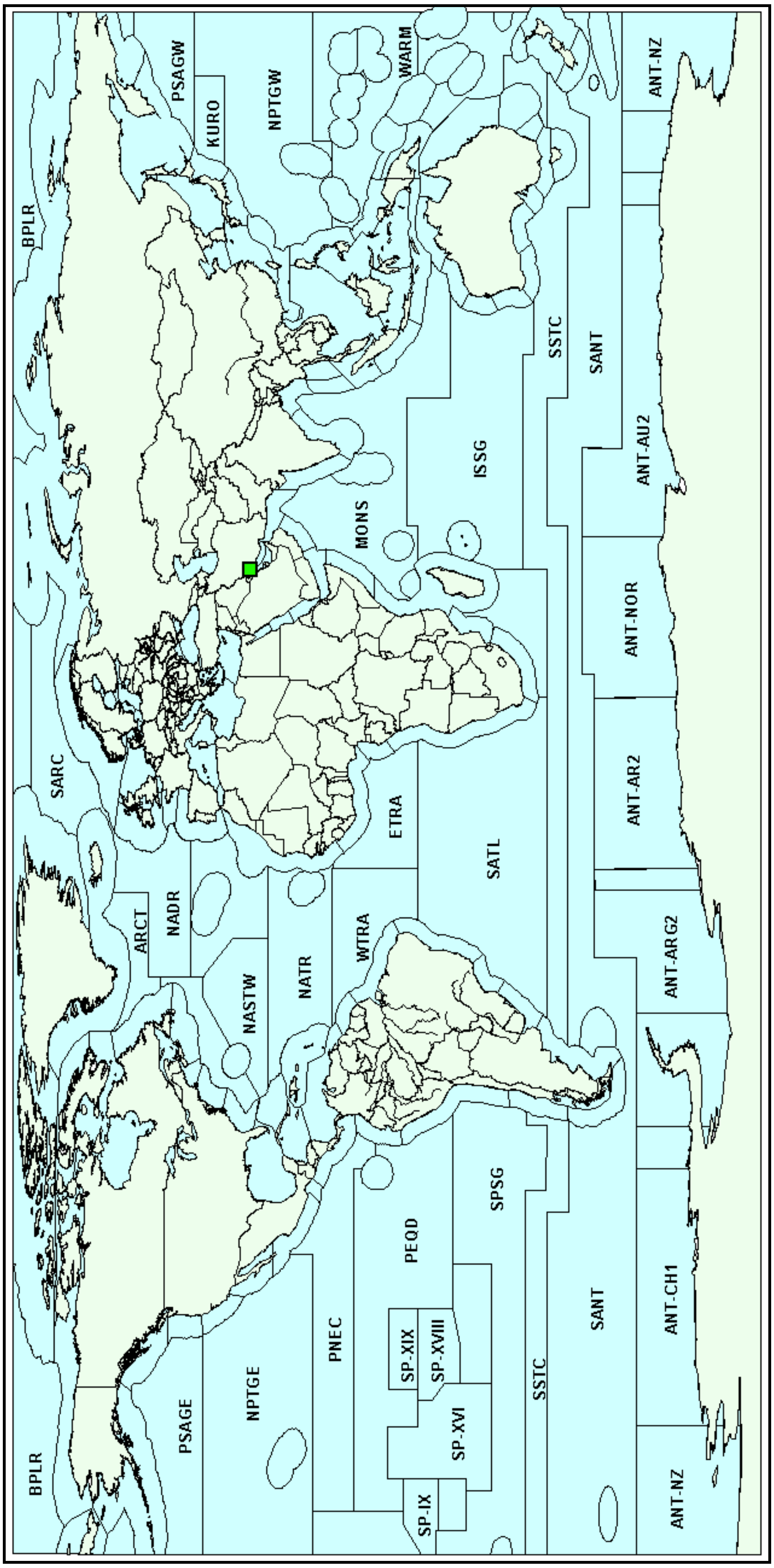

Figure 8. *Complete GIS world map showing the marine bioregions [to improve clarity, not all bioregion codes are shown in this example]*

Sources used for developing the risk species database also 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 (see list in Appendix 5). 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. A third type of risk species weighting option is also available. This can be used to proportionally increase the weight of all source port threat coefficients by increasing its default value of 1. The four default values (1, 3, 10 and 1) provided a 'project standard' result to permit unbiased comparisons between the 'first-pass' BWRA results for each Demonstration Site.

The database calculated the coefficient of 'risk species threat' posed by each source port, with each port value representing a proportion of the total risk species threat. The latter was the sum of all weighted risk species assigned to the bioregion of all source ports that export BW to the Demonstration Site. Species assigned to more than one bioregion are summed only once, and the algorhythm automatically discounted any species that was native in the Demonstration Site's bioregion. It included any introduced species assigned to the bioregion of the Demonstration Site

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

since, as discussed above, the Demonstration Site was assumed to be free of risk species. This was the default position of the project-standard BWRA[15].

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

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

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

- Use of an incomplete list of species that were assigned to one of the three levels of threat (introductions, suspected harmful species, known invaders).
- Significant knowledge gaps on the global distribution of many native, cryptogenic and introduced species (as a consequence of the limited number of species surveys that remain geographically biased to parts of North America, Europe and 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 Saldanha Bay, 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.

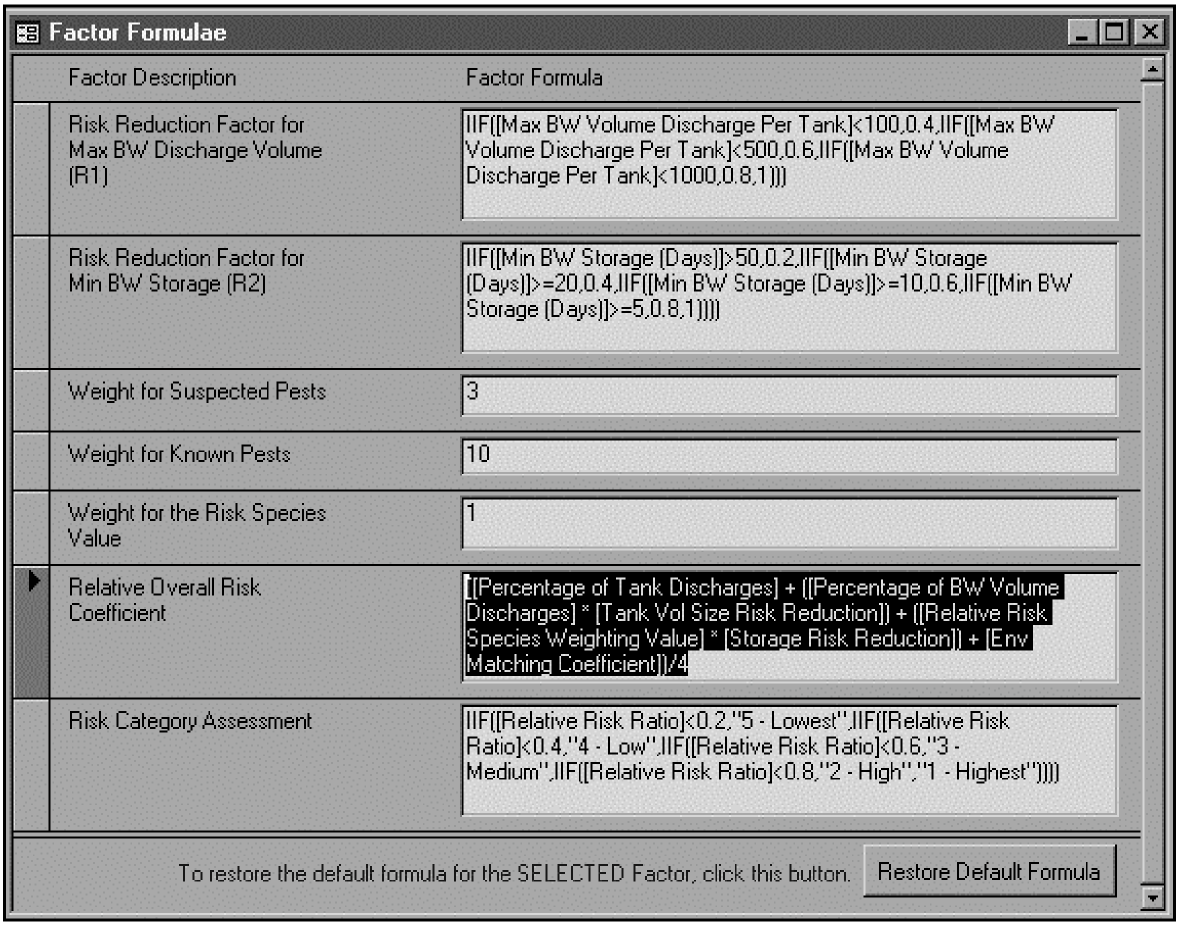

Figure 9. *Database GUI used for manipulating the BWRA calculation and weightings*

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 generally on a voluntary basis, with no formal mechanism compelling all vessels to submit fully completed forms at Mumbai-JNP;
- 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).

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

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

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

Managing and displaying the results

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

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

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

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

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

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

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

Rationale for undertaking 'Project Standard' BWRAs

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

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

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

3.11 Training and capacity building

Members of the consultants team worked with their South African 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. 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 8-12 April 2002 [5 work 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	DEAT office, Cape Town and Blue Bay function room at Saldanha Bay. Group A counterparts Group B counterparts Group C counterparts
2nd Country Visit 8-23 August 2002 [10 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	DEAT office, Cape Town and Blue Bay function room at Saldanha Bay. Group A counterparts Group B counterparts Group C counterparts
3rd 'Wrap-up' Visit 6-9 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	DEAT office, Cape Town BWRA project leader and CFP-A

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

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

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

- Supply of software licences and User Guide and installation of ESRI ArcView 3.2 and PRIMER 5.
- Guidance and 'hands-on' training and in GIS mapping of marine resources.
- Supply of 2001 CD-ROM edition of the *Lloyds Ship Register*, and customised Excel spreadsheet file for convenient collation of vessel identification and DWT data and reliable estimation of BW discharges from port shipping records, for gap-filling pre-BWRF records 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 1st and 2nd visits.

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 port shipping records for BWRF gap-filling.
- Existence of electronic and paper charts, topographic and coastal resource maps, atlases, aerial photographs, water current studies and other relevant publications useful for the 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

Saldanha Bay is a deep and well-protected natural harbour in the Western Cape Province of South Africa, and has been used by ships to provide safe shelter since its discovery and mistaken naming by Juris van Spilbergen in 1601. This Dutch captain thought he was close to Cape Town (then called Agoada de Saldanha) but the bay is actually located some 95 km to the north-west at 33^o 02’ S 17^{o}58’ E (Figures 2, 12). Although Saldanha Bay has been frequently used by ships for shelter and safety since the 17th century, plus a garrison, whaling station (1909-1930 and 1948-1967) and important convoy assembly point (1940s), its lack of freshwater and distance from Cape Town precluded any commercial port development until the 1970s.

The south-east part of Saldanha Bay connects with the 14 km long and 2-3 km wide Langebaan Lagoon, which is a very popular fishing and boating area as well as an important wildlife conservation area. Since the early 1980s increasing coastal industrial development, residential, recreational, tourism and mariculture activities at Saldanha Bay have exerted considerable anthropogenic pressure on its water quality, aquatic habitats and communities (Morant & Quinn 1999). In response to these pressures, an integrated coastal management plan was developed during the 1990s by the Department of Environmental Affairs and Tourism (DEAT). The Langebaan Lagoon was declared a National Park in 1988, is a protected wetland under the Ramsar Convention for the conservation of waders and other water birds, and was recently recommended by the South African Government to UNESCO for World Heritage listing.

Climate and weather

The temperate coastal waters of the Western Cape Province are heavily influenced by the cold water Benguela current and its coastal upwelling system, which also influence its weather and rainfall pattern. Thus the province’s subtropical climate experiences long and relatively warm summers dominated by SE winds, followed by cool and moist winters dominated by south-westerly gales and cold fronts. Mean day-time temperatures regularly exceed 26^{o}C during high summer (maxima to ~35^{o}C), while night-time temperatures often fall below 10^{o}C in mid-winter (minima to 4^{o}C). Annual rainfall is low (343 mm) with most rainfall during May-September. Seasonal and annual wind roses showing the direction and strength of the prevailing winds are shown in Figure 10. Seas are typically calmest during the summer months, although the prevailing south to south-westerly winds can reach gale force (Figure 10). While the strongest winds are from this direction and occur in all four seasons, the passage of winter storms fronts is marked by strong north to north-westerly winds (Figure 10). Berthing and sailing movements can be hampered by driving rain and/or high swells in winter, and by morning fogs between spring and summer.

Hydrodynamic conditions

Saldanha Bay and its connecting Langebaan Lagoon form an unusual embayment system along the >1,000 km of mostly exposed rocky coastline of the Western Province, which faces a high energy wave regime and has few sheltered areas. Tidal currents in the open areas of Saldanha Bay are not particularly strong owing to the relatively small tidal range, which is close to 1.5 m for average springs (extreme range is 2.2 m) and 0.6 m during neaps. The strongest tidal flows occur during ebb spring tides at narrow locations such as the entrance near Marcus Island, and in the channel connecting the bay to the Langebaan Lagoon. The "Wasserfall Bank", located between Jutten and Malgas Islands at the entrance to the outer bay, is the most significant tidal feature of the bay.

There are no significant river inputs into Saldanha Bay or nearby lagoon, with their waters originating from the Benguela shelf upwellings that occur at roughly 8 day cycles from spring to autumn. In fact Saldanha Bay is driven by these upwellings, with its water quality characteristics altering according to seasonal and smaller-scale changes to the upwelling pulses. These pulses maintain open coastal water characteristics inside the bay, with water temperature rangings between 9-23°C and salinities rarely departing from a narrow oceanic range of 34-36°/₀₀ throughout most of the system (CSIR 2000). As a result of the annual dynamics of the Benguela upwellings, which typically develop in August and persist until near the end of May, the water temperature, salinity, oxygen and stratification regime of Saldanha Bay can be divided into the following three seasonal phases (Monteiro *et al*. 1998):

- Phase 1: Early spring and early summer (August-December)
- Phase 2: High summer and early autumn (January-April)
- Phase 3: Late autumn and winter (May-July)

From August-December, the springtime rise in solar warming warms the surface water temperature in the bay reflect while the increasing strength of the SE winds intensify the force and duration of the upwelling inflows into the bay, in turn *decreasing* the near-bottom temperatures. These cold, nutrient rich inflows stimulate both natural and farmed shellfish growth and reproduction within the bay.

The regular and mostly 8-day upwelling cycles which are established by early summer can subsequently be disrupted by unusually calm mid-summer periods where no upwelling forces occurs. For example, the almost persistent calms experienced in 9-28 December 1999 stopped the nutrient-rich inflows, in turn causing a warming of the bottom layer, a major change to phytoplankton regime, and a precipitous decline in the post-spawning mussel recovery and growth that threatened the economic viability of Sea Harvest Fishing Co., the major mariculture producer in the bay (CSIR 2000). Such periods are more typical of the late summer period and increase the chances of causing harmful algal blooms, and these have tended to appear firstly in the coastal waters beyond the mouth of the bay (Monteiro & Largier, 1999).

From late April to July, the fall in solar heating reduces surface water temperatures as well as the strength and persistence of the SE winds, with the concomitant weakening of the upwelling cycles causing a gradual *increase* to the bottom layer temperatures. Thus the late summer (March-April) surface water temperatures of 18-20^{o}C and near-bottom water inflow temperature of ~10^{o}C steadily converge to the 13-14^{o}C range. This lasts for the short June-July winter, the main period when there is no naturally induced vertical stratification and the presence of a well-mixed water column until August.

Each upwelling cycle that occurs from August to May causes dissolved oxygen concentrations to oscillate between upper values that characterise the near-surface layer (~3 ml/L) and minima which characterise the near-bottom inflow of cold, dense upwelled shelfal water. While the newly upwelled water has oxygen concentrations in the 3-4 ml/L range, these become lowered from the bottom layer oxygen demand by the time it enters the bay, particularly during summer. This demand stems from the build-up of phytoplankton detritus in both the coastal sediments and near bottom layer. Thus oxygen concentrations in the bay typically fall from spring maxima of 4 ml/L to late summer minima of <0.5 ml/L (CSIR 2000). While 'in-bay' oxygen demand does not exert such a large overall effect, local hot-spot areas have been listed, such as the yacht club basin beside Saldanha and beneath intense mussel farm areas (CSIR 2000). The bay is therefore vulnerable to internal increases in oxygen demand from any organic loading of sediments, particularly in late summer when its near-bottom oxygen concentrations have already become marginal as a result of oxygen-depleted natural inflow. Microbiological monitoring undertaken by CSIR (2000) shows that coliform counts can regularly exceed recommended limits in Small Bay (near the Saldanha township) and other places where summer tourism can cause excessive sewage influx. The results indicated that mussel farms are at risk from shell-meat contamination and require careful monitoring, particularly from late spring to early autumn.

A CSIR study commissioned by NPA and depicting 8 day pulses of cool upwellings into Saldanha Bay was demonstrated to Group A by the CFP-A. The colour animations show the direction and bay-wide spread and eventual dispersal of the upwelled cold water over a typical cycle, and had been generated by temperature profiles and simple numerical modelling. The cool dense water rapidly occupies the outer pier and anchorage area in the initial phase, owing to their proximity to the entrance. To enable convenient launch via the GIS Port Map this file can be linked to ArcView files by a piece of code added by the consultants. The cool temperature and density of this water (compared to the warmer and much less dense BW likely to be discharged from visiting ships as a result of solar and ship-induced tank heating), indicates that from late August to early May (i.e. 8-9 months of the year), the planktonic stages of benthic organisms released in BW discharges have limited opportunity to reach the bottom substrates of the bay, and must wait until they are carried via surface currents into shallow shoreline areas, i.e. where the thermocline and stratification breaks down in waters <5-6 m deep.

Figure 11 shows median surface water current velocities measured in summer and winter in the vicinity of the berthing areas. The plots indicate that current speeds are relatively weak throughout the area (<0.5 km h^{-1}), and fastest near the entrance and edges of the inner bay in both seasons (0.06 - >0.12 m/s; Figure 11). The slowest surface currents occur in the centre of the bay beside the multi-purpose terminal (<0.06 m/s; Figure 11), implying relatively slow dilution and dispersal of discharged BW and associated organisms.

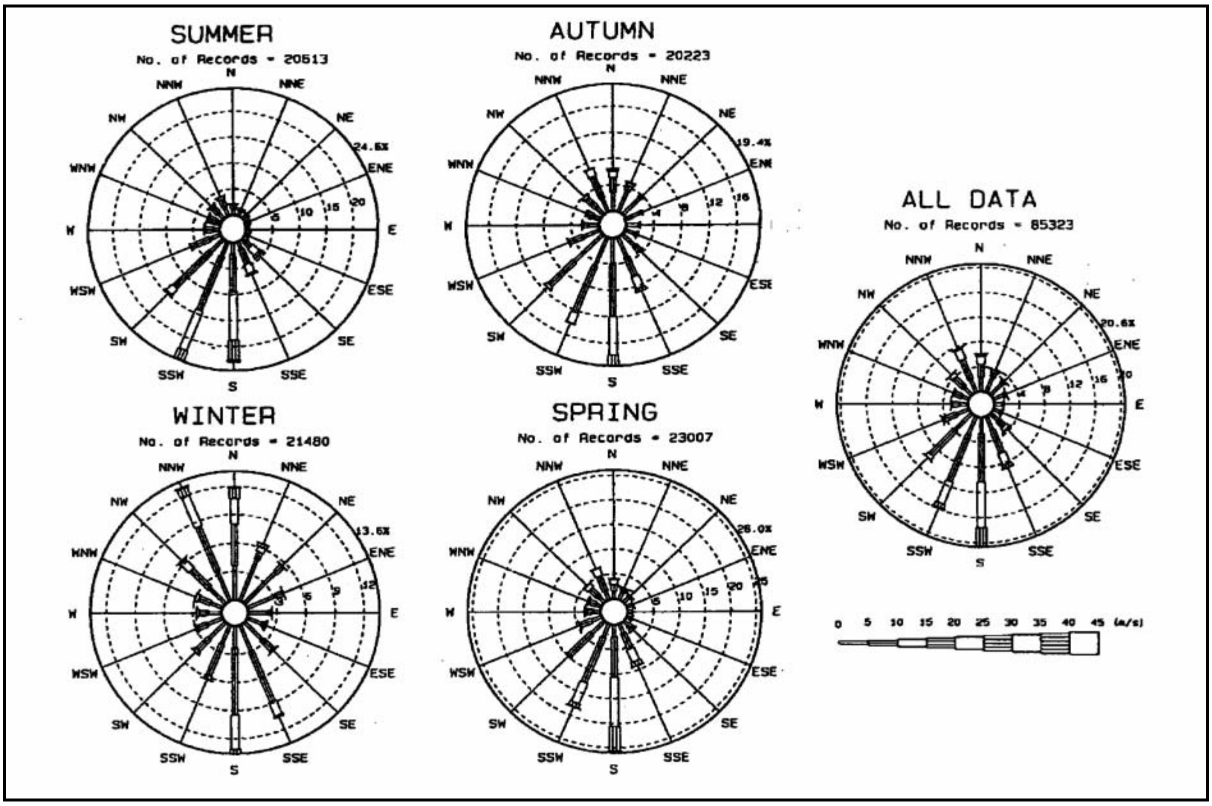

Figure 10. *Seasonal and annual wind roses for Saldanha Bay based on 1995-1998 data (from a CSIR Environmental study commissioned by NPA)*

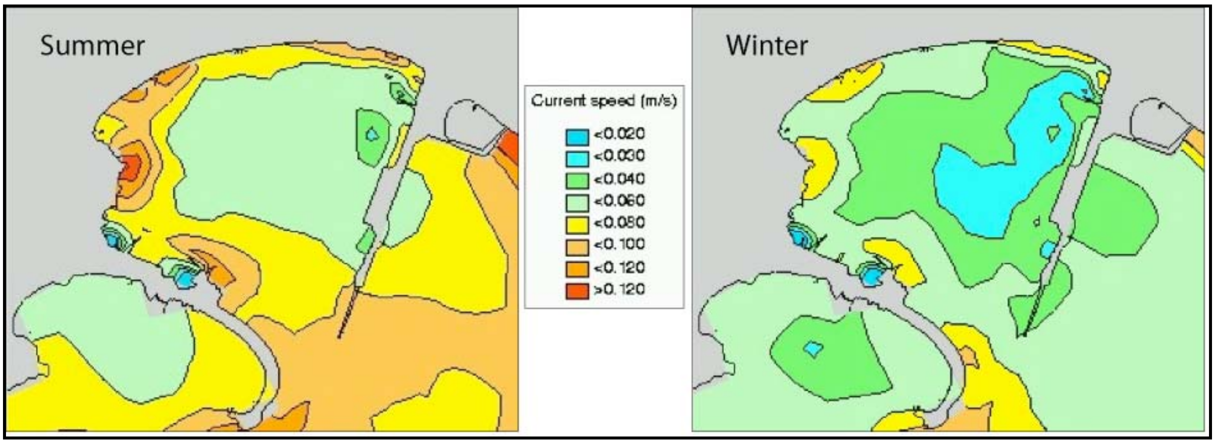

Figure 11. *Plots provided by NPA showing median current speeds in the surface depth layer in Saldanha Bay during summer and winter*

Port facilities and maintenance

As noted in Section 4.1, the first commercial port facilities in Saldanha Bay were not developed until 1974-75, and these provided a deep-water export terminal for iron ore which has been in use since 1976. An improved crude oil import facility for supplying the nation's 2 million barrel strategic oil reserve was also completed. The oil reserve is located approximately 3 km inland of the bay, with feeder pipelines to the refinery at Cape Town. During the 1980s a multi-purpose terminal was subsequently developed on land reclaimed from dredging alongside the inshore portion of the iron ore jetty, to provide berths for ships handling general cargo, lead and copper concentrates, plus rolled steel and other products produced by the nearby Saldanha steelworks that was opened in 1996. The port's three main berthing areas are therefore all located along the single, 2 km long pier that projects into the deep, central part of bay from the north side and on the west side of the deep-water anchorage (Figure 12).

The port's present-day entrance from the South Atlantic is bordered by Marcus Island and its artificial sand-spit causeway on the west side, and the natural Rietbaai Peninsula on the east side (Figure 12). After entering the bay between the small Malgas and Jutten Islands, ships follow a short and naturally deep (>22 m) shipping channel to swinging areas alongside the long pier (only the swinging area of the multi-purpose terminal is dredged; Figure 12). The pier, together with the causeway leading to Marcus Island, has divided Saldanha Bay into three water bodies, i.e. the outer bay (which is very much open coastal in character), 'Big Bay' on the east side and 'Small Bay' on the west side. The latter comprises the most enclosed water body due to the gap between the pier and Marcus Island Causeway (Figure 12).

Apart from the pier and its nearby anchorage, there is a shallow anchorage, jetty and wharf facilities beside the small town of Saldanha in the south-west corner of Small Bay. These are used for fish processing and exports, as well as providing lay-up and maintenance points for tugs, workboats, fishing and recreational vessels (Figure 12).

Because of the naturally deep waters in Saldanha Bay, the only significant capital dredging was that undertaken in the 1980s to develop the multi-purpose terminal and adjacent turning area. Repeat dredging to maintain the design depths of the inshore berths and adjacent swinging area (up to 13 m below LAT) has not yet been required, although some further development dredging was undertaken in association with the 1996-1997 extension of the multi-purpose quay. Since completion of the multipurpose terminal, the Port of Saldanha Bay has been operating four main berthing areas which are shown in Figure 12 and described as follows:

- **Iron export terminal (berths OBS, OBL)**: these 525 m long berths are located on either side of the outer section of the long pier, and provide room for two Cape-Class bulk carriers. Water depth is 21.5 m and there are two mooring dolphins to facilitate berthing. Of the seven conveyor belts on the 540 m long and 40 m wide stem of the import pier, three are dedicated to coal import.
- **Oil terminal (berth TB)**: this single berth is located on the outermost south-east side of the pier, and can accommodate one laden VLCC (100,000 - 300,000 DWT) with a maximal arrival draft of 20.5 m for the import of crude oil, mostly from the Persian Gulf, Nigeria or Venezuela.
- **Multi-purpose terminal (berths 201-204)**: This contains general cargo berths along a 624 m quay that accommodates vessels up to 200 m LOA and 13 m maximum draft, with a dredged 285m diameter turning basin situated next to the quay that is connected to deep water by a dredged approach channel that runs parallel to the pier. This berth is served by 2 x 15 tonne wharf cranes and typically handles geared bulk carriers, general cargo ships and ro-ro vessels, plus casualties from winter gales. Most trade comprises the export of lead, copper and zinc concentrates, zircon, rutile and titanium mineral sands and slag, rolled steel and other products. Importations are mainly break-bulk and bulk cargos for the local steel works and industry requirements.
- **Sea Harvest/Cold Store terminal**: This accommodates 6.5 m draft vessels loading frozen fish which are berthed opposite the Sea Harvest Corporation cold store.

Small vessel facilities are located beside the Sea Harvest terminal. These comprise the 360 m long Government jetty used mostly by fishing vessels (maximum draft 6.5m), plus a slipway jetty that can accommodate vessels up to 1,200 tonne, 70 m LOA and 5 m draft and equipped with one 10 tonne crane. The adjacent Portnet small boat harbour (225 m, draft 5.5 m) is used mainly for the berthing and maintenance of Portnet workboats and tugs. The Mossgas quay can accept vessels with drafts up to 6 m. The port provides limited bunkering and waste reception services. Heavy fuel oil is not available, while gas and diesel delivered to the ore berths are supplied from drums and road tankers based in Cape Town. Private refuelling lines are used at the Sea Harvest quay and government jetty.

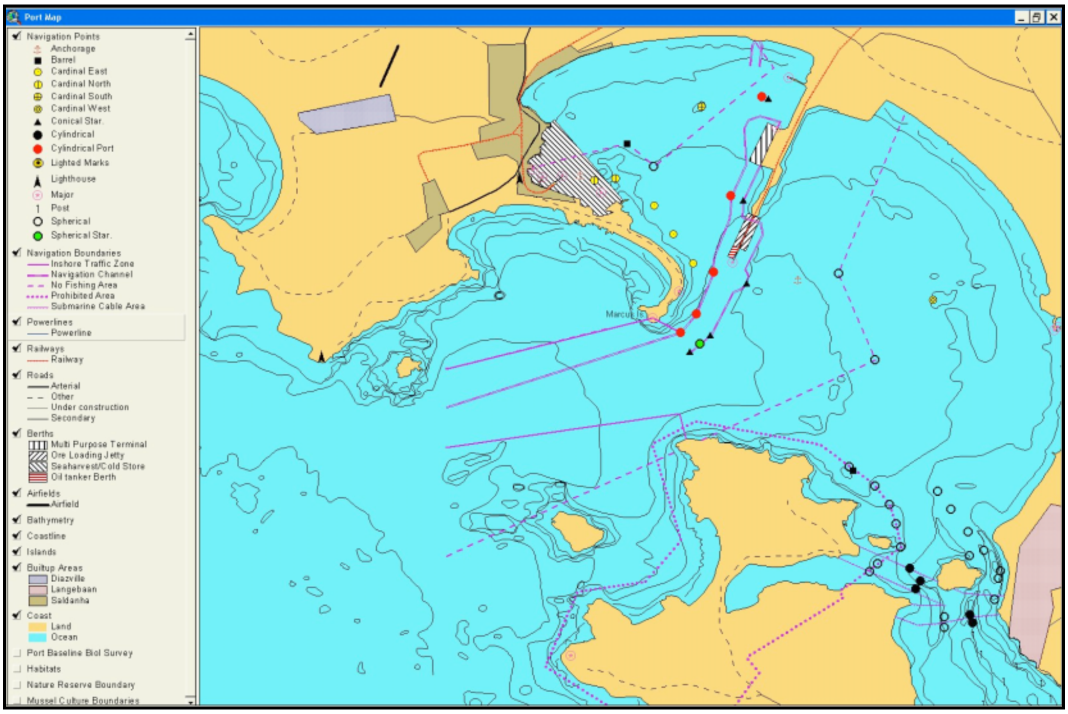

Figure 12. *Part of the GIS Port Map of Saldanha Bay showing the navigation, infrastructure and active berth layers.*

4.2 Resource mapping

As shown by the habitat layer of the GIS port map (Figure 13), the subtidal seafloor habitats in Saldanha Bay are dominated by sand sheets and rocky substrates which are covered in macroalgae that develop rapidly each spring. The connecting Langebaan Lagoon is shallow (6-7 m maximum depth) and completely sheltered from wave action, and it contains sand beaches and salt marshes without significant freshwater inflows, plus well developed seagrass meadows near its mouth (Figure 13). It is likely there are some significant areas of seagrass in parts of Saldanha Bay, but no information could be found to delineate where these are most extensive. The intertidal habitats of Saldanha Bay are shown in Figure 13 and comprise the following:

- Narrow natural rocky shores and cliffs;
- Sand beaches along the Marcus Island causeway, around the bay and in the Langebaan Lagoon; and
- High tidal marshes and low intertidal mud flats in the Langebaan Lagoon.

Artificial smooth and rocky wall substrates are restricted to the main pier and the Sea Harvest/Cold Store wharf and government jetty facilities beside the town of Saldanha. There are no coral reefs or mangroves in this temperate region of Africa (the nearest are located to the north-east near Durban, and under the influence of the warm southward flowing Agulhas Current). There are three designated mariculture areas in Saldanha Bay, while the boundaries of the West Coast National Park encapsulate most of the Langebaan Lagoon and part of the open coastline south of the entrance to Saldanha Bay (Figure 13).

The GIS port map also shows the locations of the 39 PBBS sampling sites (Figure 13). These were provided so that the results of the final PBBS report can be linked to port map for convenient display. Because of the scale of the map and the extent of the urban and other developed areas, individual features such as post offices, churches and radio masts were not added. No historical wrecks of archaeological or cultural-heritage value could be precisely located in the area covered by the GIS port map.

Saldanha Bay's protection and close link to the highly productive Benguela upwelling system provides optimal habitats, nutrients and temperatures for mussel farming and other aquaculture ventures (Pitcher *et al*. 1999). This fledgling but potentially large and lucrative shellfish farming industry has to conform to tight water quality constraints imposed by export markets. However the marked increase in human activities, including the physiographic imposition of the large pier, have altered the water quality, sediment and ecological characteristics of the system.

Changes since the 1970s include eutrophication problems from increased part-treated sewage discharge and other outfalls, leading to phytoplankton blooms, increased hypoxic events (oxygen depletion), organic sediment enrichment, sulphide formation, and a rise in sediment metal accumulations and other pollutants originating from the various industrial, urban residential, port and shipping discharges and run-off. Close coexistence of port, industrial, mariculture, recreational, tourism and wildlife conservation requirements and activities in Saldanha Bay have provided a challenge that is continuing to be met by the Saldanha Bay Water Quality Forum, established to provide for orderly consultations among and between the various stakeholders, authorities and government agencies.

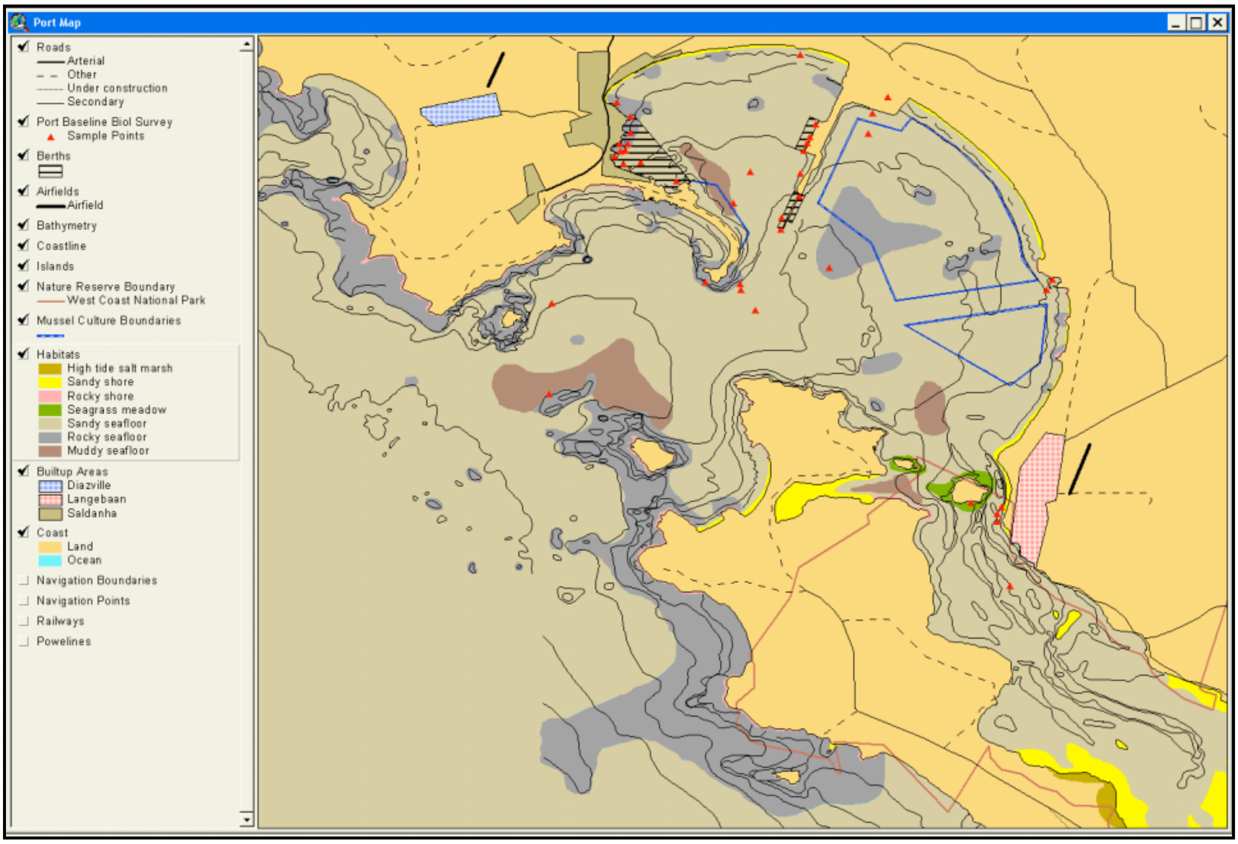

Figure 13. *Part of the GIS Port Map showing the marine habitats and reserve layers*

4.3 De-ballasting/ballasting patterns

The port's navigational rules and requirements and local metocean conditions which influence the deballasting/ballasting practises of arriving vessels were discussed during the port meeting in April 2002. The port limits extend 3 nautical miles (nM) seaward from the north and south sides of the entrance. Pilotage is compulsory for all vessels, with pilots boarding laden and partly laden vessels 3 nM off North Head, while vessels in light or ballasted conditions are usually boarded 2 nM off. Laden oil tankers must remain 6 nM off the coast until the confirmed pilot boarding time and location. Tugs usually meet incoming vessels approx 1 nM seaward of the entrance channel (four tugs are used for laden arriving oil tankers and three for laden departing iron ore carriers).

The depth of the approach channel immediately seaward of the pier is 23 m, reaching 24 m at the start of the entrance channel, which has a width of 400 m at its narrowest point. The port is periodically affected by heavy swells, particularly in the winter months (swells in the entrance channel can exceed 7.0 m during spring high tides) and its anchorage is very poor. The NPA does not recommend anchoring other than at the much safer anchorage in St Helena Bay (located 4 hours steaming north-east of Saldanha Bay). Large winter swells can also affect ships on the pier, causing them to damage fenders and break lines. In extreme cases ships have had to be taken off their berth and stood out to sea. The NPA therefore requires visiting ships not to immobilise their engines without written permission from the Port Captain, and a sufficient crew must always be kept on board.

Once inside the bay, vessels which arrive in ballast during heavy swell periods (e.g. from a winter storm front), begin to release any heavy weather ballast they had taken up in the open ocean to improve stability. As in other ports, the port and pilotage rules require all (cargo) empty ships to retain sufficient ballast on board to maintain adequate propulsion and steerage control, and to minimise windage until berthing is completed. Windage can be significant in both summer and winter months due to the strength of the SE and NNE winds and occasional SW fronts.

The database record demonstrated a relatively consistent and slightly increasing trade of 25-35 ships per month for the 1999-2002 period (Figure 14). It was not difficult to establish the main deballasting/ballasting pattern for these arrivals because of the short entrance channel to Saldanha Bay, the exposed nature of its deepwater anchorage, and the location of its iron ore export berths, crude oil import berths (no crude has been exported from the reserve since October 1999), and generally export-oriented multipurpose terminal (which mostly trades export steel and metalliferous products; see below).

Thus most BW is discharged at or close to the main pier. Ships which do temporarily anchor in the bay (typically for 24-36 hours) generally retain between 80-95% of their normal ballast due to local windage and the potential need to move quickly seaward if swells increase. By contrast, the oil tankers are either fully or sufficiently loaded with cargo to have negligible BW 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 the ballasting/deballasting locations of the iron ore carriers and tankers, this was not case for all vessels berthing at the multi-purpose terminal. A significant percentage of the general cargo ships, bulk carriers and the occasional Ro-Ro vessel visiting this terminal were part-loaded with cargo, some or all of which was destined for either :

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

Thus unless these vessels submit reasonably complete BWRFs, 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 and BW already on board. Since BWRFs were obtained only for the last three months, and since these do not contain information on ballast water uptakes, the ballasting/deballasting picture for this terminal remained imprecise, alhough it was clear that, overall, BW discharges exceed BW uptakes by a substantial margin.

Of the total of 1315 vessel visits entered into the database by the end of the second consultants visit, the majority were based on the Excel spreadsheet records for 1999-2002. The following statistics were obtained from the Access database:

- For the 82 visits at the oil terminal in January 1999 - June 2002 database, the majority were laden VLCCs arriving at rates of 1-4 per month from the Gulf and Nigerian oil export terminals, including the largest which were the *Napa* (285,640 DWT) from the Gulf oil terminal Ras Tanura, and the *Crown Unity* (300,482 DWT) from an unknown terminal. The total reported BW discharged in the fading period of crude oil exports (i.e. January - October 1999) was 1,269,137 tonnes.
- For the 593 visits to the iron ore export terminal, the vast majority were Cape Class bulk carriers in the 130,000 – 200,000 DWT range (the largest being the *Arcturus* at 251,19 DWT). The total reported BW discharged in the January 1999 – June 2002 period was 26,802,325 tonnes.
- For the 607 visits entered for the multi-purpose terminal, the vast majority were 17,000 - 50,000 DWT dry bulk carriers (338), and 11,000 – 40,000 DWT general cargo ships (241). Total recorded BW discharges amounted to 1,576,292 tonnes.

- For the 33 visits to the Sea Harvest/Cold Store terminal, these were small reefers in the 1,000 - 4,200 DWT range, only one of which reported a total of 200 tonnes of discharged BW trim water.

The database stores the amounts and sources of BW discharged from these arrivals, as entered from the NPA records (1999-2002) and April-June 2002 BWRFs. 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 tables displayed by the GIS Port Map are shown for the iron ore, multi-purpose and oil terminals in Figures 14, 15 and 16 respectively.

Because the database must accept and manage individual tank discharges as discrete units (as recorded in IMO-standard BWRFs; Appendix 1), the need to treat all BW tanks as a single entity for all vessels arriving prior to BWRF use (or which submitted incomplete BWRFs; Section 3.6) reduces the number of individual tank discharges actually made in January 1999-June 2002, and inflates the mean and maximum tank discharge volumes. Thus the latter can reflect the total BW capacity of the largest visiting vessels (Figures 15-17), which causes a more conservative outcome in terms of the BWRA results. It is worth emphasising that a database containing individual tank data collated from, say, a 12 month set of fully completed BWRFs, will generate far more precise BW source port values for the C1, C2 and R1 components (Section 3.10).

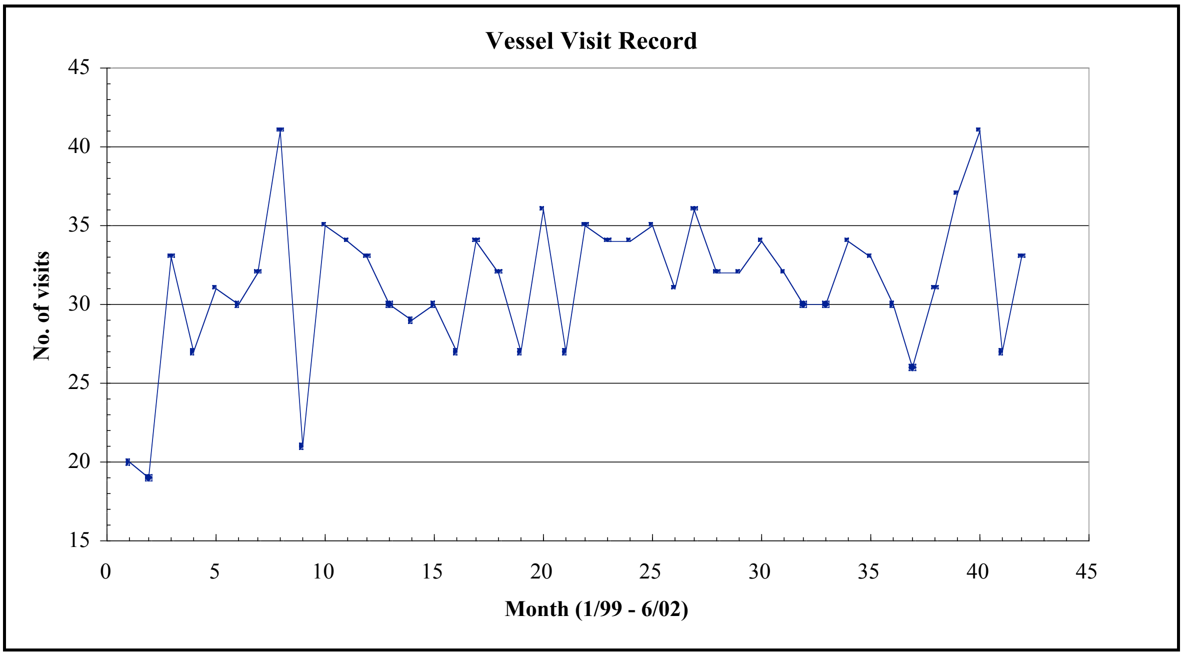

Figure 14. *Rate of monthly vessel visits in the Saldanha Bay database*

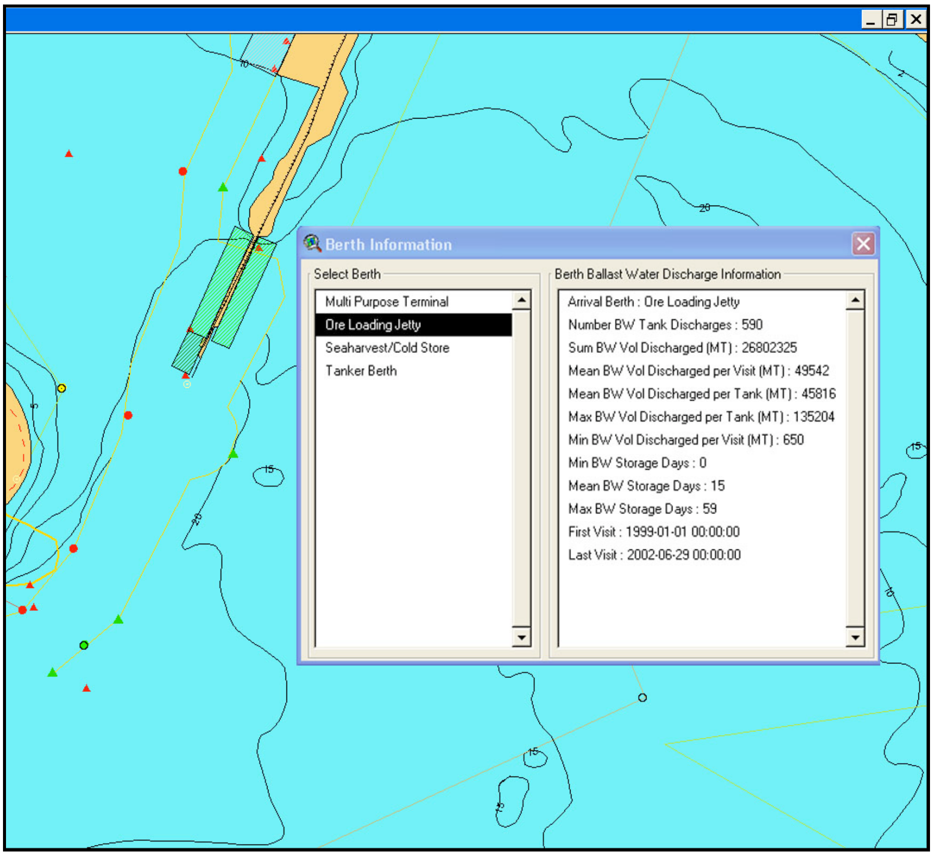

Figure 15. *BW discharge statistics displayed by GIS Port Map for the ore export terminal.*

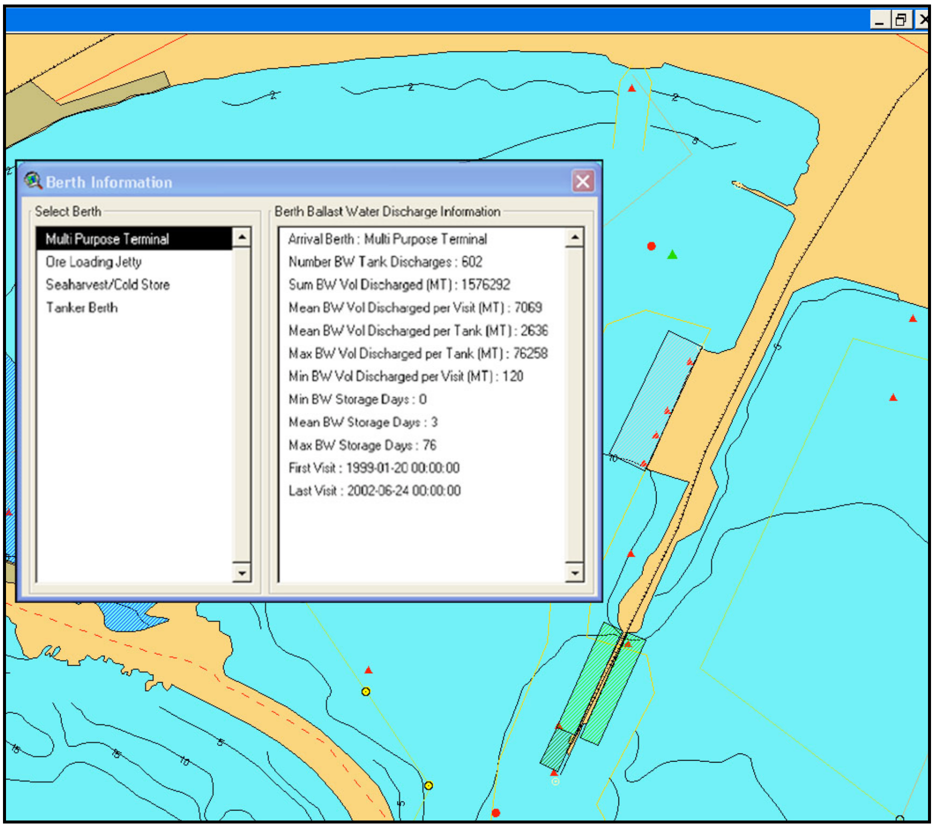

Figure 16. *BW discharge statistics displayed by GIS Port Map for the multi-purpose terminal*

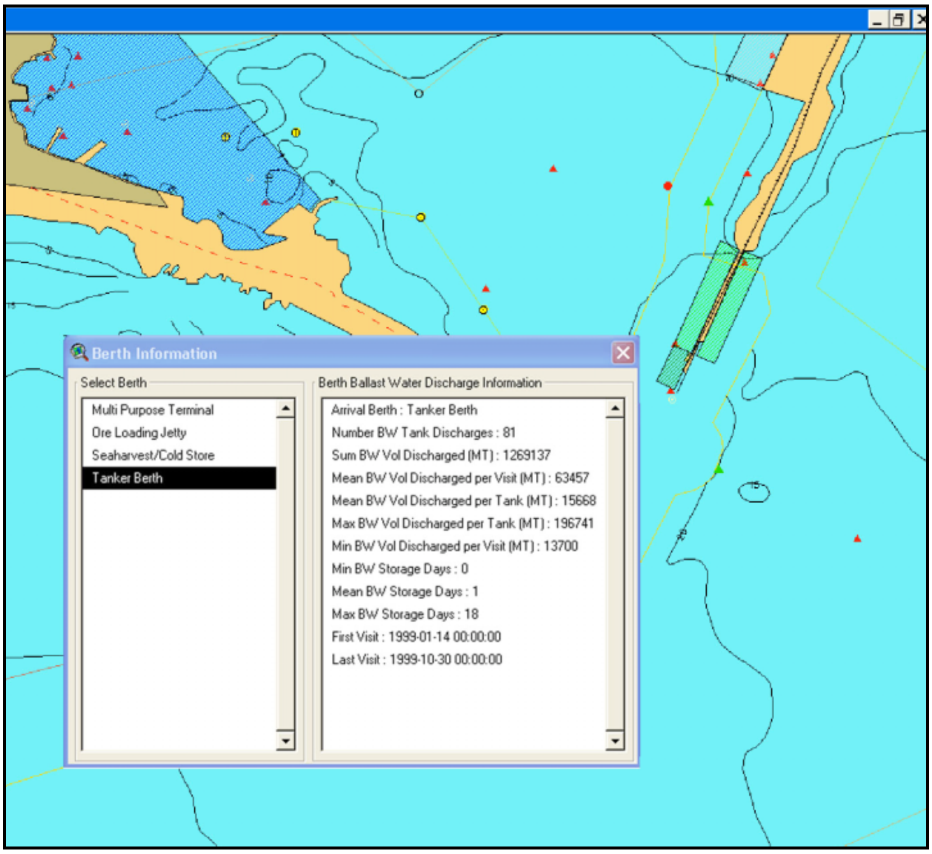

Figure 17. *BW discharge statistics displayed by GIS Port Map for the oil terminal*

4.4 Identification of source ports

From the 1315 vessel visit records and 1307 associated BW discharges in the Saldanha database, the total number of identified BW source ports was 131 (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 131 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 Saldanha Bay was Durban (9.2%), which was closely followed by Richards Bay (9.1%). This was followed by Rotterdam 5.1% and Port Talbot in the United Kingdom 4.1%.

Of the 131 identified source ports, the top 13 provided 50% of the source-identified discharges, while the next 23 ports contributed a further 25%, i.e. only 36 of all source ports (27.3%) accounted for 75% of the total number of source-identified BW discharges (Table 3). As noted earlier, the low number of individual tank discharges (1307) compared to the visits (1315), is due to (a) the need to include port shipping records prior to the regular use of BWRFs (all tanks combined), and (b) most 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 1315 vessel visits recorded in 1999-2002 was 29,647,954 tonnes. The various discharge percentages 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 similar but not the same as those for C1 (as ranked in Table 3). The source ports providing the largest volume of BW discharged at Saldanha were Rotterdam (2,176,478 tonnes; 7.3%) and Port Talbot (1,930,279 tonnes; 6.5%), followed by Singapore (1,480,113; 5.0%) and Immingham (1,239,844 tonnes; 4.2%; Table 3).

The top 13 of identified source ports provided 50% of the total discharged volume, and the next 17 ports a further 25%. Thus only 30 (22.7%) of all identified source ports accounted for 75% of the source-identified BW discharged at Saldanha Bay. Of the top 20 ports in terms of total discharge volume (64% of C2), three were in the Netherlands and three in China, two were in France, Japan, United Kingdom, and one each in Australia, Belgium, Germany, Israel, Italy, South Africa and Spain (Table 3).

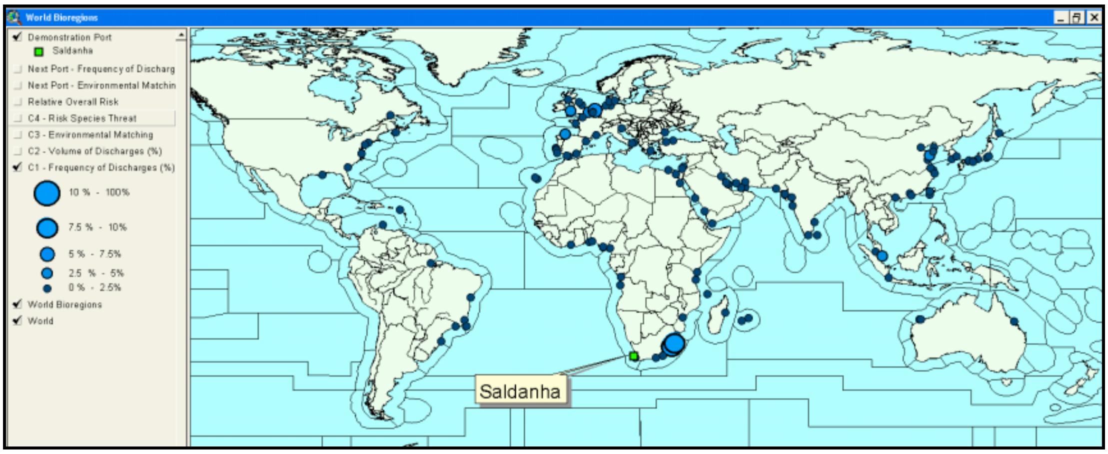

Figure 18. *GIS output showing location and relative importance of BW source ports with respect to frequency of tank discharges (C1) at Port of Saldanha Bay.*

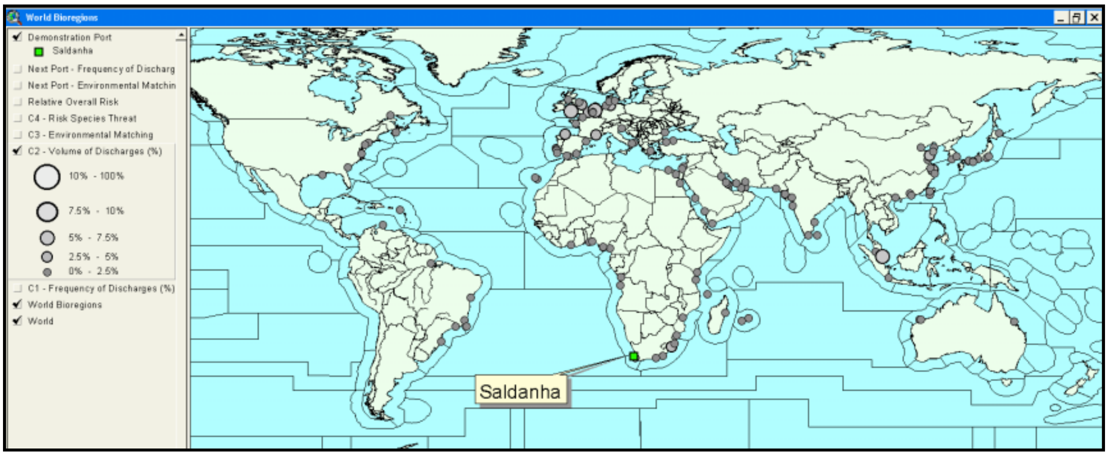

Figure 19. *GIS output showing location and relative importance of the source ports with respect to the volume of tank discharges (C2) at Port of Saldanha Bay*

***Table 3.** List of identified source ports in the Port of Saldanha Bay 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	ZADUR	Durban	South Africa	9.23%	792,587	2.67%
2	ZARCB	Richards Bay	South Africa	9.08%	344,915	1.16%
3	NLRTM	Rotterdam	Netherlands	5.14%	2,176,478	7.34%
4	GBPTB	Port Talbot	United Kingdom	4.08%	1,930,279	6.51%
5	SGSIN	Singapore	Singapore	3.03%	1,480,113	4.99%
6	FRDKK	Dunkerque	France	2.87%	1,233,657	4.16%
7	ESGIJ	Gijon	Spain	2.87%	1,061,479	3.58%
8	CNTAO	Qingdao (Longgang) Shandong	China	2.57%	1,162,229	3.92%
9	GBIMM	Immingham	United Kingdom	2.42%	1,239,844	4.18%
10	ZACPT	Cape Town	South Africa	2.42%	160,997	0.54%
11	BEANR	Antwerpen	Belgium	2.12%	879,467	2.97%
12	FRFOS	Fos sur Mer	France	2.12%	835,174	2.82%
13	NLIJM	IJmuiden	Netherlands	1.97%	810,328	2.73%
14	AUPWL	Port Walcott	Australia	1.97%	481,918	1.63%
15	DEHAM	Hamburg	Germany Federal Republic	1.82%	770,919	2.60%
16	CNSHA	Shanghai (Shihu) Shanghai	China	1.66%	753,403	2.54%
17	NLAMS	Amsterdam	Netherlands	1.66%	617,225	2.08%
18	CNNBO	Beilun	China	1.51%	700,037	2.36%
19	TRERE	Eregli	Turkey	1.36%	409,170	1.38%
20	KEMBA	Mombasa	Kenya	1.36%	68,621	0.23%
21	ROCND	Constanta	Romania	1.21%	348,237	1.17%
22	CNSHK	Shekou Guangdong	China	1.06%	397,229	1.34%
23	SAJED	Jeddah	Saudi Arabia	1.06%	206,253	0.70%
24	JPKSM	Kashima Ibaraki	Japan	0.91%	503,210	1.70%
25	ILHAD	Hadera	Israel	0.91%	426,653	1.44%
26	ITTAR	Taranto	Italy	0.91%	414,900	1.40%
27	EGEDK	El Dekheila	Egypt	0.91%	341,565	1.15%
28	USNEN	Norfolk-Newport News Virginia	United States	0.91%	71,284	0.24%
29	JPNGO	Nagoya Aichi	Japan	0.76%	579,098	1.95%
30	JPMIZ	Mizushima Okayama	Japan	0.76%	331,074	1.12%
31	ESALG	Algeciras	Spain	0.76%	323,903	1.09%
32	CNZJG	Zhangjiagang (Changjiagang) Jiangsu	China	0.76%	309,641	1.04%
33	TWKHH	Kaohsiung	Taiwan Province of China	0.76%	234,548	0.79%
34	INBOM	Mumbai (Ex Bombay)	India	0.76%	37,264	0.13%
35	GBRER	Redcar	United Kingdom	0.61%	299,242	1.01%
36	SAJUB	Jubail	Saudi Arabia	0.61%	273,075	0.92%
37	SIKOP	Koper	Slovenia	0.61%	264,689	0.89%
38	ESTAR	Tarragona	Spain	0.61%	239,097	0.81%
39	AUDAM	Dampier	Australia	0.61%	147,075	0.50%
40	CASEI	Sept Iles (Seven Is.) Quebec	Canada	0.61%	104,175	0.35%
41	ZAPLZ	Port Elizabeth	South Africa	0.61%	81,941	0.28%
42	SADMN	Damman	Saudi Arabia	0.61%	67,689	0.23%
43	IRBND	Bandar Abbas	Iran Islamic Republic of	0.61%	64,619	0.22%
44	CDMAT	Matadi	Congo Democratic Republic	0.61%	13,235	0.04%
45	NGLOS	Lagos	Nigeria	0.61%	13,033	0.04%
46	JPFKY	Fukuyama Hiroshima	Japan	0.45%	260,062	0.88%
47	GBHST	Hunterston	United Kingdom	0.45%	218,349	0.74%
48	JPCHB	Chiba Chiba	Japan	0.45%	214,803	0.72%
49	PTSIE	Sines	Portugal	0.45%	172,527	0.58%
50	FRLEH	Le Havre	France	0.45%	170,434	0.57%
51	JPKMT	Kimitsu Chiba	Japan	0.45%	161,849	0.55%
52	AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	0.45%	160,787	0.54%
53	NLVLI	Flushing (Vlissingen)	Netherlands	0.45%	157,231	0.53%
54	GRPIR	Piraeus	Greece	0.45%	140,011	0.47%
55	GIGIB	Gibraltar	Gibraltar	0.45%	123,552	0.42%
56	KRKAN	Kwangyang	Korea Republic of	0.30%	178,357	0.60%
57	ESCRS	Carboneras	Spain	0.30%	157,843	0.53%
58	KRKPO	Pohang	Korea Republic of	0.30%	157,592	0.53%
59	ILAKL	Ashkelon	Israel	0.30%	150,554	0.51%
60	JPWAK	Wakayama Wakayama	Japan	0.30%	147,728	0.50%
61	CNYNT	Yantai (Muping) Shandong	China	0.30%	140,751	0.47%
62	TW001	Mailiao	Taiwan Province of China	0.30%	132,797	0.45%
63	IDCIG	Cigading	Indonesia	0.30%	126,276	0.43%
64	PTSET	Setubal	Portugal	0.30%	123,229	0.42%
65	CNHUA	Huangpu (Xinzao) Guangdong	China	0.30%	119,019	0.40%

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

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

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
66	CNFAN	Fangcheng (Qinzhou) Guangxi	China	0.30%	117,975	0.40%
67	CNTXG	Tianjinxingang (Xingang) Tianjin	China	0.30%	112,462	0.38%
68	DEWVN	Wilhelmshaven	Germany Federal Republic Of	0.30%	110,735	0.37%
69	ITBDS	Brindisi	Italy	0.30%	102,834	0.35%
70	TRIST	Istanbul	Turkey	0.30%	74,790	0.25%
71	SGJUR	Jurong	Singapore	0.30%	60,636	0.20%
72	AEDXB	Dubai	United Arab Emirates	0.30%	57,509	0.19%
73	REPDG	Pointe des Galets	Reunion	0.30%	47,897	0.16%
74	BRSPB	Sepetiba	Brazil	0.30%	34,590	0.12%
75	INTUT	Tuticorin (New Tuticorin)	India	0.30%	31,356	0.11%
76	PKKHI	Karachi	Pakistan	0.30%	13,546	0.05%
77	CIABJ	Abidjan	Ivory Coast	0.30%	11,071	0.04%
78	MGTMM	Tamatave (Toamasina)	Madagascar	0.30%	10,924	0.04%
79	BRPOU	Ponta do Ubu	Brazil	0.30%	10,204	0.03%
80	JPYUR	Yura Wakayama	Japan	0.15%	119,819	0.40%
81	ANEUX	St Eustatius	Netherlands Antilles	0.15%	99,259	0.33%
82	DKENS	Enstedvaerkets Havn	Denmark	0.15%	94,730	0.32%
83	CALHA	La Have	Canada	0.15%	86,255	0.29%
84	ESSCT	Tenerife (Santa Cruz de Tenerife)	Spain	0.15%	85,413	0.29%
85	BHMAN	Manama	Bahrain	0.15%	83,729	0.28%
86	CNDLC	Dalian Liaoning	China	0.15%	81,330	0.27%
87	ANBUB	Bullen Bay	Netherlands Antilles	0.15%	79,894	0.27%
88	ILASH	Ashdod	Israel	0.15%	68,784	0.23%
89	DKSTG	Stigsnaesvaerkets Havn	Denmark	0.15%	64,772	0.22%
90	ESLPA	Las Palmas	Spain	0.15%	56,541	0.19%
91	CNLYG	Lianyungang Jiangsu	China	0.15%	55,031	0.19%
92	BHMIN	Mina Sulman	Bahrain	0.15%	54,425	0.18%
93	ESCEU	Ceuta	Spain	0.15%	50,526	0.17%
94	IRLVP	Lavan Island	Iran Islamic Republic of	0.15%	42,346	0.14%
95	PTLIS	Lisboa	Portugal	0.15%	37,293	0.13%
96	SAGIZ	Gizan	Saudi Arabia	0.15%	36,090	0.12%
97	USDVT	Davant	United States	0.15%	32,481	0.11%
98	USPHL	Philadelphia Pennsylvania	United States	0.15%	30,075	0.10%
99	BEGNE	Ghent/Gent	Belgium	0.15%	27,110	0.09%
100	AUHPT	Hay Point	Australia	0.15%	24,060	0.08%
101	AEJEA	Jebel Ali	United Arab Emirates	0.15%	22,857	0.08%
102	INBED	Bedi	India	0.15%	21,711	0.07%
103	USPHF	Hampton Roads	United States	0.15%	21,413	0.07%
104	LKTRR	Trincomalee	Sri Lanka	0.15%	20,451	0.07%
105	ZAELS	East London	South Africa	0.15%	20,451	0.07%
106	EGSGA	Safaga	Egypt	0.15%	18,045	0.06%
107	USSAV	Savannah Georgia	United States	0.15%	17,594	0.06%
108	JPABA	Abashiri Hokkaido	Japan	0.15%	17,541	0.06%
109	USNYC	New York New York	United States	0.15%	16,481	0.06%
110	INMAA	Chennai (Ex Madras)	India	0.15%	15,941	0.05%
111	KWMIB	Mina Abdulla	Kuwait	0.15%	15,880	0.05%
112	BJCOO	Cotonou	Benin	0.15%	13,744	0.05%
113	INIXY	Kandla (Muldwarka)	India	0.15%	11,934	0.04%
114	FRMTX	Montoir	France	0.15%	11,108	0.04%
115	MZBEW	Beira	Mozambique	0.15%	10,410	0.04%
116	INDAH	Dahej	India	0.15%	10,213	0.03%
117	MYPKG	Port Kelang	Malaysia	0.15%	10,105	0.03%
118	EGADA	Adabiya	Egypt	0.15%	9,880	0.03%
119	KMYVA	Moroni	Comoros	0.15%	9,624	0.03%
120	BRIBB	Imbituba	Brazil	0.15%	4,403	0.01%
121	TZDAR	Dar Es Salaam	Tanzania United Republic Of	0.15%	4,095	0.01%
122	NGBON	Bonny	Nigeria	0.15%	3,609	0.01%
123	BRMGU	Munguba	Brazil	0.15%	3,444	0.01%
124	BRSSA	Salvador	Brazil	0.15%	3,176	0.01%
125	AOLAD	Luanda	Angola	0.15%	2,165	0.01%
126	NGONN	Onne	Nigeria	0.15%	1,995	0.01%
127	MUPLU	Port Louis	Mauritius	0.15%	1,949	0.01%
128	PTLOS	Lagos	Portugal	0.15%	1,706	0.01%
129	MZMPM	Maputo	Mozambique	0.15%	1,534	0.01%
130	YEADE	Aden	Yemen	0.15%	1,450	0.00%
131	CMDLA	Douala	Cameroon	0.15%	1,233	0.00%

*C1 = proportion of all discharges (% of all discharges); 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 an issue for vessels departing the oil terminal and multipurpose berths, after uplifting BW alongside these berths.

Of the 183 possible BW destination ports (i.e. Next Ports of Call) in the 1999-2002 database, their location and proportional frequency are shown Figure 20 and listed in Table 4. The latter lists the top 33 destination ports that accounted for 75% of the recorded Next Ports of Call by all 1315 vessel departures. Table 4 also that many of the most frequent BW source ports were also very frequent destination ports, with over 33% of Next Ports of Call attributed to the ports of Durban, Beilun, Singapore, Rotterdam and Richards Bay (Figure 20).

Table 4 shows that of the 33 ports reported as the destinations of 75% of the vessels departing Saldanha Bay, twelve of these were in Western Europe, ten in East Asia, six in southern Africa, two in South America and one in North America.

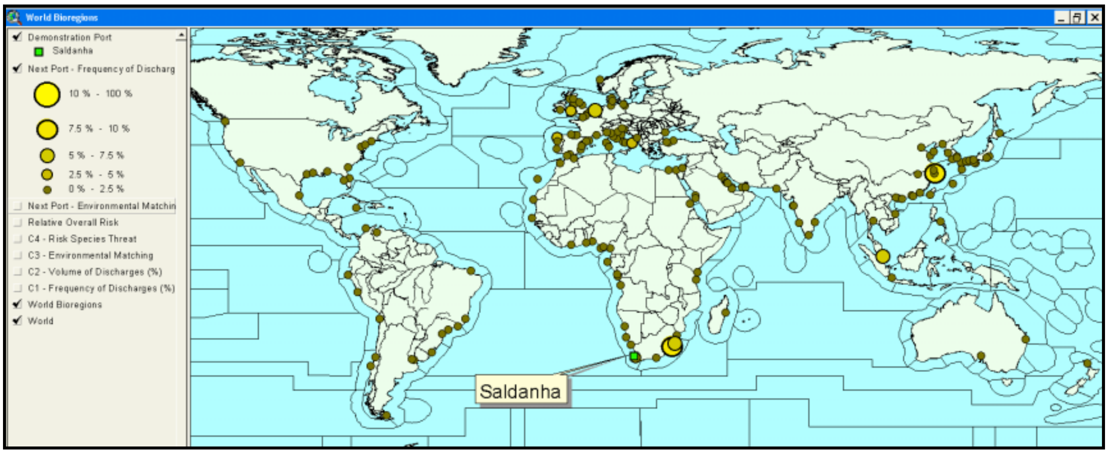

Figure 20. *GIS output showing location and frequency of destination ports, recorded as the Next Port of Call in the Port of Saldanha Bay BWRFs and shipping records.*

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

	UN Port Code	Port Name	Country	Frequency of Next Port Visit (%)	Cumulative Frequency %
1	ZADUR	Durban	South Africa	8.78	8.8
2	CNNBO	Beilun	China	8.51	17.3
3	SGSIN	Singapore	Singapore	5.34	22.6
4	NLRTM	Rotterdam	Netherlands	5.16	27.8
5	ZARCB	Richards Bay	South Africa	5.07	32.9
6	ZACPT	Cape Town	South Africa	4.71	37.6
7	GBPTB	Port Talbot	United Kingdom	3.44	41.0
8	ITTAR	Taranto	Italy	2.71	43.7
9	ESVGO	Vigo	Spain	2.62	46.3
10	DEHAM	Hamburg	Germany Federal Republic	2.44	48.8
11	CNTAO	Qingdao (Longgang) Shandong	China	2.26	51.0
12	SIKOP	Koper	Slovenia	2.26	53.3
13	GBRER	Redcar	United Kingdom	1.99	55.3
14	NAWVB	Walvis Bay	Namibia	1.90	57.2
15	JPKMT	Kimitsu Chiba	Japan	1.81	59.0
16	JPKSM	Kashima Ibaraki	Japan	1.63	60.6
17	NALUD	Luderitz	Namibia	1.54	62.2
18	BEANR	Antwerpen	Belgium	1.36	63.5
19	GBIMM	Immingham	United Kingdom	1.27	64.8
20	JPCHB	Chiba Chiba	Japan	1.27	66.1
21	ESVLC	Valencia	Spain	1.00	67.1
22	FRDKK	Dunkerque	France	1.00	68.1
23	KRKPO	Pohang	Korea Republic of	1.00	69.1
24	KRKAN	Kwangyang	Korea Republic of	0.81	69.9
25	AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	0.72	70.6
26	ESBIO	Bilbao	Spain	0.72	71.3
27	USLCH	Lake Charles Louisiana	United States	0.72	72.0
28	CNSHK	Shekou Guangdong	China	0.63	72.7
29	TWKHH	Kaohsiung	Taiwan Province of China	0.63	73.3
30	BRRIO	Rio de Janeiro	Brazil	0.54	73.8
31	CLSAI	San Antonio	Chile	0.54	74.4
32	AOLAD	Luanda	Angola	0.45	74.8
33	ESBCN	Barcelona	Spain	0.45	75.3
34	FRFOS	Fos sur Mer	France	0.45	75.7
35	PLSWI	Swinoujscie	Poland	0.45	76.2
36	ROCND	Constanta	Romania	0.45	76.6
37	AOCAB	Cabinda	Angola	0.36	77.0
38	CIPBT	Port Bouet	Ivory Coast	0.36	77.4
39	JPABA	Abashiri Hokkaido	Japan	0.36	77.7
40	JPKWS	Kawasaki Kanagawa	Japan	0.36	78.1
41	KEMBA	Mombasa	Kenya	0.36	78.4
42	NGLOS	Lagos	Nigeria	0.36	78.8
43	PTLEI	Leixoes	Portugal	0.36	79.2
44	PTSET	Setubal	Portugal	0.36	79.5
45	TRERE	Eregli	Turkey	0.36	79.9
46	USPHL	Philadelphia Pennsylvania	United States	0.36	80.2

4.6 Environmental similarity analysis

Of the identified 131 source ports and 183 destination ports, sufficient port environmental data were obtained to include 71% of the former and 51% of the latter in the multivariate similarity analysis by PRIMER. These ports accounted for 90% of all recorded BW discharges and 84.5% of all recorded departures respectively (Tables 5-6). Details of the 357 ports included in the multivariate analysis carried out for Saldanha Bay 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 Saldanha Bay to be part of the 'first-pass' risk assessment, those ports not included in the multivariate analysis were provided with environment matching coefficient estimates, and are noted as such in the database. The C3 estimates were based on their port type (Section 3.7) and geographic location with respect to the nearest comparable ports for which C3 had been calculated. A precautionary approach was adopted (i.e. the estimated values were made higher than the calculated C3s of the comparable ports). Providing C3 estimates allowed the database to include all of 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 Saldanha source and destination ports are in Figures 21 and 22 respectively. These plots and Tables 5-6 show that the port has a relatively high environmental similarity to a large number of its trading ports in the Mediterranean (i.e. C3s in the 0.6 - 0.8 range). This can be related to its geographical location, providing a broad range of its temperature regime due to upwelling events, plus a moderate annual of rainfall.

The most environmentally similar BW source port to Saldanha Bay was Piraeus in Greece (C3 = 0.777). This port was accompanied by 11 other widely distributed source ports having either calculated or estimated C3 matching coefficients above 0.7 (Table 5). Another widely dispersed group of ports (37) had relatively high C3 values in the 0.6-0.7 range (Table 5). The most environmentally dissimilar ports trading with Saldanha Bay in 1999-2002 were a mixture of cool water and brackish ports, Persian Gulf ports and ports in the humid tropics (Tables 5-6; Figures 21, 22).

As discussed in Section 4.6 and highlighted in Figure 20, the most frequent recorded next port of call was Durban (8.9% of all departures) and Beilun (Ningbo) in north-east China (8.5%), and these had relatively high (0.643) and moderate (0.580) environmental matching coefficients respectively (Table 6). While San Antonio had the highest environmental match (0.80), it was an infrequent next port of call (0.54% of all departures) and was not reported as a BW source port (Tables 3, 4).

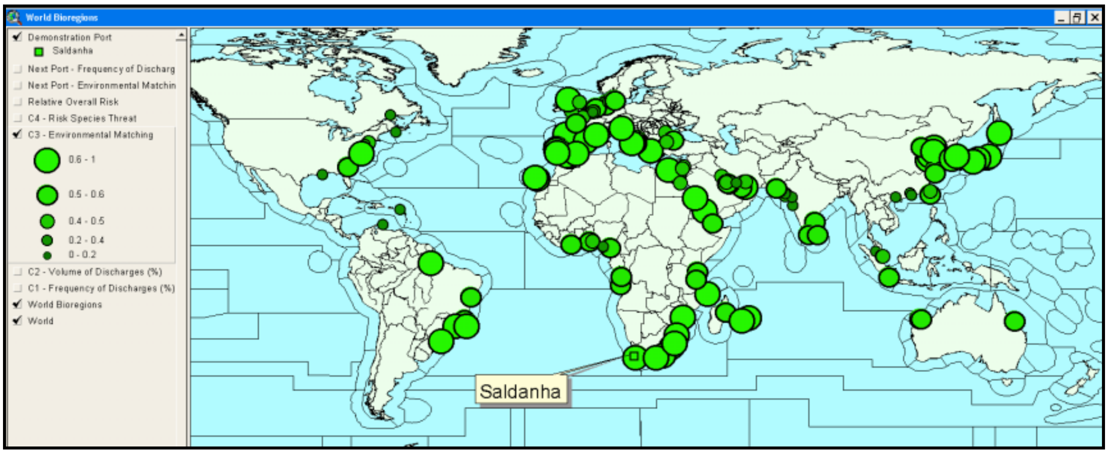

Figure 21. *GIS output showing the location and environmental matching coefficients (C3) of BW source ports identified for the Port of Saldanha Bay*

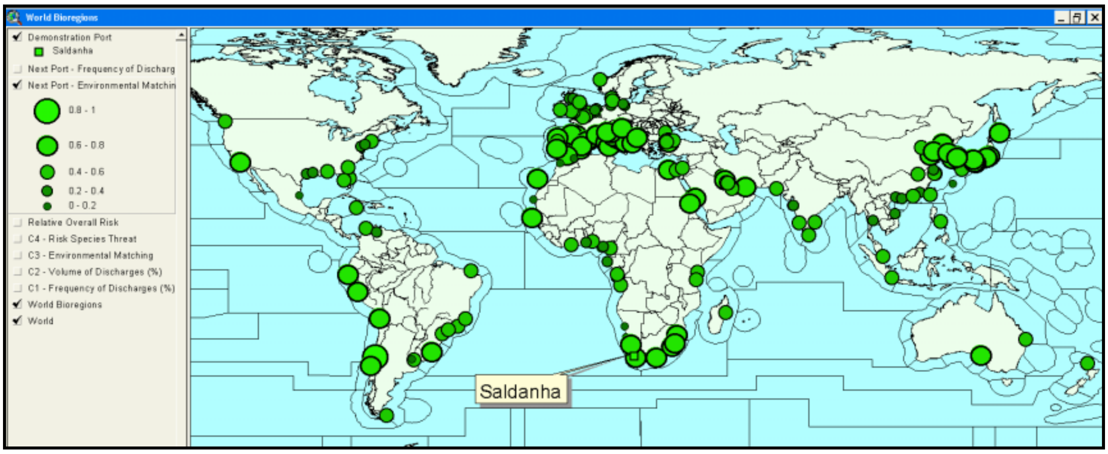

Figure 22. *GIS output showing the location and environmental matching coefficients (C3) of the destination ports identified for the Port of Saldanha Bay*

Table 5. *Source ports identified for Port of Saldanha Bay, 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
GRPIR	Piraeus	Greece	0.45%	**0.777**	
ZAELS	East London	South Africa	0.15%	**0.750**	Y
ITTAR	Taranto	Italy	0.91%	**0.744**	
ZAPLZ	Port Elizabeth	South Africa	0.61%	**0.742**	
JPWAK	Wakayama Wakayama	Japan	0.30%	**0.734**	
ESTAR	Tarragona	Spain	0.61%	**0.724**	
JPNGO	Nagoya Aichi	Japan	0.76%	**0.722**	
ESLPA	Las Palmas	Spain	0.15%	**0.721**	
PTLOS	Lagos	Portugal	0.15%	**0.712**	
JPYUR	Yura Wakayama	Japan	0.15%	**0.700**	Y
PTSET	Setubal	Portugal	0.30%	**0.700**	Y
REPDG	Pointe des Galets	Reunion	0.30%	**0.700**	Y
ESGIJ	Gijon	Spain	2.87%	**0.690**	
CNTAO	Qingdao (Longgang) Shandong	China	2.57%	**0.689**	
KRKAN	Kwangyang	Korea Republic of	0.30%	**0.687**	
FRFOS	Fos sur Mer	France	2.12%	**0.681**	
KRKPO	Pohang	Korea Republic of	0.30%	**0.680**	
PTSIE	Sines	Portugal	0.45%	**0.672**	
JPKSM	Kashima Ibaraki	Japan	0.91%	**0.664**	
ESSCT	Tenerife (Santa Cruz de Tenerife)	Spain	0.15%	**0.662**	
EGEDK	El Dekheila	Egypt	0.91%	**0.657**	
GIGIB	Gibraltar	Gibraltar	0.45%	**0.655**	
JPABA	Abashiri Hokkaido	Japan	0.15%	**0.653**	
CNYNT	Yantai (Muping) Shandong	China	0.30%	**0.653**	
BRIBB	Imbituba	Brazil	0.15%	**0.650**	Y
BRMGU	Munguba	Brazil	0.30%	**0.650**	Y
CNLYG	Lianyungang Jiangsu	China	0.15%	**0.650**	Y
ESCEU	Ceuta	Spain	0.15%	**0.650**	Y
SIKOP	Koper	Slovenia	0.61%	**0.648**	
ZACPT	Cape Town	South Africa	2.42%	**0.645**	
ZADUR	Durban	South Africa	9.23%	**0.643**	
ITBDS	Brindisi	Italy	0.30%	**0.640**	Y
USPHF	Hampton Roads	United States	0.15%	**0.635**	
USNEN	Norfolk-Newport News Virginia	United States	0.91%	**0.629**	
JPCHB	Chiba Chiba	Japan	0.45%	**0.626**	
JPKMT	Kimitsu Chiba	Japan	0.45%	**0.625**	
ESALG	Algeciras	Spain	0.76%	**0.623**	
SAJED	Jeddah	Saudi Arabia	1.06%	**0.619**	
ZARCB	Richards Bay	South Africa	9.08%	**0.617**	
CNDLC	Dalian Liaoning	China	0.15%	**0.615**	
GBHST	Hunterston	United Kingdom	0.45%	**0.603**	
BRSPB	Sepetiba	Brazil	0.30%	**0.602**	
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	0.45%	**0.600**	
ESCRS	Carboneras	Spain	0.30%	**0.600**	Y
KMYVA	Moroni	Comoros	0.15%	**0.600**	Y
MUPLU	Port Louis	Mauritius	0.15%	**0.600**	Y
MZBEW	Beira	Mozambique	0.15%	**0.600**	Y
MZMPM	Maputo	Mozambique	0.15%	**0.600**	Y
SAGIZ	Gizan	Saudi Arabia	0.15%	**0.600**	Y
JPFKY	Fukuyama Hiroshima	Japan	0.45%	**0.592**	
TRERE	Eregli	Turkey	1.36%	**0.588**	
AEJEA	Jebel Ali	United Arab Emirates	0.15%	**0.588**	
YEADE	Aden	Yemen	0.15%	**0.584**	
CNNBO	Beilun	China	1.51%	**0.580**	
NLIJM	IJmuiden	Netherlands	1.97%	**0.570**	
PTLIS	Lisboa	Portugal	0.15%	**0.569**	
JPMIZ	Mizushima Okayama	Japan	0.76%	**0.567**	
INTUT	Tuticorin (New Tuticorin)	India	0.30%	**0.567**	
BRSSA	Salvador	Brazil	0.15%	**0.564**	
AUHPT	Hay Point	Australia	0.15%	**0.563**	
PKKHI	Karachi	Pakistan	0.30%	**0.553**	

Table 5 (cont'd). *Source ports identified for Port of Saldanha Bay, 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
BRPOU	Ponta do Ubu	Brazil	0.00%	**0.551**	
DEWVN	Wilhelmshaven	Germany Federal Republic Of	0.30%	**0.551**	
BJCOO	Cotonou	Benin	0.15%	**0.550**	Y
CDMAT	Matadi	Congo Democratic Republic	0.61%	**0.550**	Y
CIABJ	Abidjan	Ivory Coast	0.30%	**0.550**	Y
CMDLA	Douala	Cameroon	0.15%	**0.550**	Y
CNTXG	Tianjinxingang (Xingang) Tianjin	China	0.30%	**0.550**	Y
FRMTX	Montoir	France	0.15%	**0.550**	Y
LKTRR	Trincomalee	Sri Lanka	0.15%	**0.550**	Y
MGTMM	Tamatave (Toamasina)	Madagascar	0.30%	**0.550**	Y
EGADA	Adabiya	Egypt	0.15%	**0.540**	Y
BHMIN	Mina Sulman	Bahrain	0.15%	**0.540**	
USSAV	Savannah Georgia	United States	0.15%	**0.539**	
TZDAR	Dar Es Salaam	Tanzania United Republic Of	0.15%	**0.537**	
SADMN	Damman	Saudi Arabia	0.61%	**0.536**	
BHMAN	Manama	Bahrain	0.15%	**0.536**	
AUDAM	Dampier	Australia	0.61%	**0.530**	
IDCIG	Cigading	Indonesia	0.30%	**0.523**	
AUPWL	Port Walcott	Australia	1.97%	**0.519**	
KEMBA	Mombasa	Kenya	1.36%	**0.518**	
INMAA	Chennai (Ex Madras)	India	0.15%	**0.515**	
TWKHH	Kaohsiung	Taiwan Province of China	0.76%	**0.510**	
AOLAD	Luanda	Angola	0.15%	**0.500**	Y
DKSTG	Stigsnaesvaerkets Havn	Denmark	0.15%	**0.500**	Y
GBRER	Redcar	United Kingdom	0.61%	**0.495**	
NLVLI	Flushing (Vlissingen)	Netherlands	0.45%	**0.495**	
IRBND	Bandar Abbas	Iran Islamic Republic of	0.61%	**0.488**	
NGLOS	Lagos	Nigeria	0.61%	**0.487**	
FRLEH	Le Havre	France	0.45%	**0.481**	
ILAKL	Ashkelon	Israel	0.30%	**0.480**	Y
ILHAD	Hadera	Israel	0.91%	**0.480**	Y
ROCND	Constanta	Romania	1.21%	**0.478**	
FRDKK	Dunkerque	France	2.87%	**0.471**	
KWMIB	Mina Abdulla	Kuwait	0.15%	**0.469**	
AEDXB	Dubai	United Arab Emirates	0.30%	**0.467**	
SAJUB	Jubail	Saudi Arabia	0.61%	**0.454**	
SGJUR	Jurong	Singapore	0.30%	**0.453**	
SGSIN	Singapore	Singapore	3.03%	**0.453**	
ILASH	Ashdod	Israel	0.15%	**0.451**	
USNYC	New York New York	United States	0.15%	**0.443**	
DKENS	Enstedvaerkets Havn	Denmark	0.15%	**0.440**	
TRIST	Istanbul	Turkey	0.30%	**0.418**	
GBPTB	Port Talbot	United Kingdom	4.08%	**0.413**	
EGSGA	Safaga	Egypt	0.15%	**0.400**	Y
INBED	Bedi	India	0.15%	**0.400**	Y
TW001	Mailiao	Taiwan Province of China	0.30%	**0.400**	Y
CASEI	Sept Iles (Seven Is.) Quebec	Canada	0.61%	**0.390**	
INBOM	Mumbai (Ex Bombay)	India	0.76%	**0.381**	
IRLVP	Lavan Island	Iran Islamic Republic of	0.15%	**0.379**	
NLRTM	Rotterdam	Netherlands	5.14%	**0.377**	
GBIMM	Immingham	United Kingdom	2.42%	**0.356**	
ANBUB	Bullen Bay	Netherlands Antilles	0.15%	**0.350**	Y
ANEUX	St Eustatius	Netherlands Antilles	0.15%	**0.350**	Y
CNFAN	Fangcheng (Qinzhou) Guangxi	China	0.30%	**0.350**	Y
CALHA	La Have	Canada	0.15%	**0.320**	
CNSHK	Shekou Guangdong	China	1.06%	**0.310**	Y
CNHUA	Huangpu (Xinzao) Guangdong	China	0.30%	**0.308**	
MYPKG	Port Kelang	Malaysia	0.15%	**0.303**	
NGBON	Bonny	Nigeria	0.15%	**0.303**	
CNZJG	Zhangjiagang (Changjiagang) Jiangsu	China	0.76%	**0.300**	Y
INDAH	Dahej	India	0.15%	**0.300**	Y
DEHAM	Hamburg	Germany Federal Republic Of	1.82%	**0.298**	
USPHL	Philadelphia Pennsylvania	United States	0.15%	**0.294**	
NGONN	Onne	Nigeria	0.15%	**0.286**	
BEGNE	Ghent/Gent	Belgium	0.15%	**0.281**	
NLAMS	Amsterdam	Netherlands	1.66%	**0.271**	
BEANR	Antwerpen	Belgium	2.12%	**0.261**	
USDVT	Davant	United States	0.15%	**0.246**	
CNSHA	Shanghai (Shihu) Shanghai	China	1.66%	**0.229**	
INIXY	Kandla (Muldwarka)	India	0.15%	**0.224**	

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

UN Port Code	Port Name	Country	Frequency of Next Port Visit (%)	Environmental Matching (C3)	C3 Estimated
CLSAI	San Antonio	Chile	0.54	**0.800**	Y
AUPBY	Port Bonython	Australia	0.09	**0.797**	
PEHCO	Huacho	Peru	0.09	**0.770**	Y
CLTAL	Talcahuano	Chile	0.09	**0.750**	Y
ITCAG	Cagliari	Italy	0.09	**0.750**	Y
ITNAP	Napoli	Italy	0.09	**0.750**	Y
ITTAR	Taranto	Italy	2.71	**0.744**	
ZAPLZ	Port Elizabeth	South Africa	0.18	**0.742**	
ESBCN	Barcelona	Spain	0.45	**0.734**	
ESTAR	Tarragona	Spain	0.18	**0.724**	
USLGB	Long Beach California	United States	0.09	**0.721**	
ESLPA	Las Palmas	Spain	0.18	**0.721**	
FRMRS	Caronte (Marseilles)	France	0.09	**0.715**	
PTSET	Setubal	Portugal	0.36	**0.700**	Y
ITCVV	Civitavecchia	Italy	0.27	**0.700**	Y
ESALC	Alicante	Spain	0.09	**0.700**	Y
ESCAS	Castellon de la Plana	Spain	0.09	**0.700**	Y
ESSAG	Sagunto	Spain	0.09	**0.700**	Y
ITPIO	Piombino	Italy	0.09	**0.700**	Y
ITSAL	Salerno	Italy	0.09	**0.700**	Y
PEPAI	Paita	Peru	0.09	**0.700**	Y
CNTAO	Qingdao (Longgang) Shandong	China	2.26	**0.689**	
SNDKR	Dakar	Senegal	0.18	**0.688**	
KRKAN	Kwangyang	Korea Republic of	0.81	**0.687**	
FRFOS	Fos sur Mer	France	0.45	**0.681**	
KRKPO	Pohang	Korea Republic of	1.00	**0.680**	
ESVGO	Vigo	Spain	2.62	**0.674**	
ESVLC	Valencia	Spain	1.00	**0.673**	
JPHHR	Higashiharima Hyogo	Japan	0.18	**0.670**	
JPKSM	Kashima Ibaraki	Japan	1.63	**0.664**	
ITLIV	Livorno	Italy	0.18	**0.663**	
ESPAS	Pasajes	Spain	0.18	**0.662**	
ITTRS	Trieste	Italy	0.18	**0.660**	
EGALY	Alexandria (El Iskandariya)	Egypt	0.09	**0.657**	
GIGIB	Gibraltar	Gibraltar	0.09	**0.655**	
JPABA	Abashiri Hokkaido	Japan	0.36	**0.653**	
CNYNT	Yantai (Muping) Shandong	China	0.18	**0.653**	
ITMDC	Marina di Carrara	Italy	0.27	**0.650**	Y
ITAOI	Ancona	Italy	0.18	**0.650**	Y
ITSPE	La Spezia	Italy	0.18	**0.650**	Y
KRCHF	Chinhae	Korea Republic of	0.18	**0.650**	Y
BRRIG	Rio Grande	Brazil	0.09	**0.650**	Y
ITSVN	Savona	Italy	0.09	**0.650**	Y
JPIHA	Niihama Ehime	Japan	0.09	**0.650**	Y
JPKOK	Kokura (Kitakyushu) Fukuoka	Japan	0.09	**0.650**	Y
JPKRE	Kure Hiroshima	Japan	0.09	**0.650**	Y
JPSHN	Shingu Wakayama	Japan	0.09	**0.650**	Y
KRTSN	Taesan	Korea Republic of	0.09	**0.650**	Y
YUKOT	Kotor	Yugoslavia (Fed Rep Of)	0.09	**0.650**	Y
SIKOP	Koper	Slovenia	2.26	**0.648**	
ZACPT	Cape Town	South Africa	4.71	**0.645**	
ZADUR	Durban	South Africa	8.78	**0.643**	
ITAHO	Alghero	Italy	0.18	**0.640**	
JPTAE	Tanabe	Japan	0.09	**0.640**	Y
ZANOL	Port Nolloth	South Africa	0.09	**0.640**	Y
KRUSN	Ulsan	Korea Republic of	0.09	**0.636**	
KRONS	Onsan	Korea Republic of	0.09	**0.635**	
JPUKB	Kobe Hyogo	Japan	0.09	**0.629**	
JPCHB	Chiba Chiba	Japan	1.27	**0.626**	
JPKMT	Kimitsu Chiba	Japan	1.81	**0.625**	
ITRAN	Ravenna	Italy	0.09	**0.624**	
ESALG	Algeciras	Spain	0.27	**0.623**	
JPKWS	Kawasaki Kanagawa	Japan	0.36	**0.620**	
SAJED	Jeddah	Saudi Arabia	0.09	**0.619**	
SDPZU	Port Sudan	Sudan	0.09	**0.618**	
ZARCB	Richards Bay	South Africa	5.07	**0.617**	
CNDDG	Dandong Liaoning	China	0.09	**0.610**	Y
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	0.72	**0.600**	
NAWVB	Walvis Bay	Namibia	1.90	**0.600**	Y
NALUD	Luderitz	Namibia	1.54	**0.600**	Y
MZMPM	Maputo	Mozambique	0.27	**0.600**	

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

UN Port Code	Port Name	Country	Frequency of Next Port Visit (%)	Environmental Matching (C3)	C3 Estimated
CLIQQ	Iquique	Chile	0.09	**0.600**	Y
ESAGP	Malaga	Spain	0.09	**0.600**	Y
ESSDR	Santander	Spain	0.09	**0.600**	Y
ITMNF	Monfalcone	Italy	0.09	**0.600**	Y
SA002	Ras al Ghar	Saudi Arabia	0.09	**0.600**	Y
TRDRC	Dernice	Turkey	0.09	**0.600**	Y
ESBIO	Bilbao	Spain	0.72	**0.599**	
JPSBS	Shibushi Kagoshima	Japan	0.09	**0.596**	
JPFKY	Fukuyama Hiroshima	Japan	0.18	**0.592**	
CNJIU	Jiujiang Jiangxi	China	0.09	**0.590**	Y
TRERE	Eregli	Turkey	0.36	**0.588**	
QADOH	Doha	Qatar	0.09	**0.587**	
CNNBO	Beilun	China	8.51	**0.580**	
CNNGB	Ningbo Zhejiang	China	0.09	**0.580**	
PTLEI	Leixoes	Portugal	0.36	**0.569**	
JPMIZ	Mizushima Okayama	Japan	0.18	**0.567**	
INTUT	Tuticorin (New Tuticorin)	India	0.09	**0.567**	
CNTSN	Tianjin Tianjin	China	0.18	**0.563**	
BRRIO	Rio de Janeiro	Brazil	0.54	**0.556**	
PKKHI	Karachi	Pakistan	0.18	**0.553**	
CIPBT	Port Bouet	Ivory Coast	0.36	**0.550**	Y
CGDJE	Djeno Terminal	Congo	0.18	**0.550**	Y
MGTMM	Tamatave (Toamasina)	Madagascar	0.18	**0.550**	
PHTBC	Tabaco/Legaspi	Philippines	0.18	**0.550**	Y
BRPNG	Paranagua	Brazil	0.09	**0.550**	Y
CMDLA	Douala	Cameroon	0.09	**0.550**	Y
AUBNE	Brisbane	Australia	0.09	**0.546**	
SA001	Qadimah	Saudi Arabia	0.09	**0.540**	Y
USSAV	Savannah Georgia	United States	0.09	**0.539**	
BRSSZ	Santos	Brazil	0.18	**0.538**	
TZDAR	Dar Es Salaam	Tanzania United Republic Of	0.18	**0.537**	
NZWRE	Whangarei	New Zealand	0.09	**0.536**	
BRVIX	Vitoria	Brazil	0.09	**0.532**	
KEMBA	Mombasa	Kenya	0.36	**0.518**	
INMAA	Chennai (Ex Madras)	India	0.09	**0.515**	
TWKHH	Kaohsiung	Taiwan Province of China	0.63	**0.510**	
QAUMS	Umm Said	Qatar	0.09	**0.507**	
KWMEA	Mina Al Ahmadi	Kuwait	0.09	**0.503**	
IDJKT	Jakarta Java	Indonesia	0.18	**0.502**	
AOLAD	Luanda	Angola	0.45	**0.500**	Y
AOCAB	Cabinda	Angola	0.36	**0.500**	Y
HRRJK	Rijeka Bakar	Croatia	0.18	**0.500**	Y
SARTA	Ras Tanura	Saudi Arabia	0.18	**0.500**	Y
USTPA	Tampa Florida	United States	0.18	**0.500**	Y
DKFAA	Faaborg	Denmark	0.09	**0.500**	Y
HRSUS	Rijeka Susak	Croatia	0.09	**0.500**	Y
USCLM	Port Angeles	United States	0.09	**0.500**	Y
USHVN	New Haven	United States	0.09	**0.500**	Y
USPCA	Port Canaveral	United States	0.09	**0.500**	Y
GBRER	Redcar	United Kingdom	1.99	**0.495**	
COBAQ	Barranquilla	Colombia	0.09	**0.490**	Y
NGLOS	Lagos	Nigeria	0.36	**0.487**	
FRLEH	Le Havre	France	0.09	**0.481**	
ROCND	Constanta	Romania	0.45	**0.478**	
FRDKK	Dunkerque	France	1.00	**0.471**	
FRDPE	Dieppe	France	0.09	**0.470**	Y
AEDXB	Dubai	United Arab Emirates	0.18	**0.467**	
SAJUB	Jubail	Saudi Arabia	0.09	**0.454**	
SGSIN	Singapore	Singapore	5.34	**0.453**	
ILASH	Ashdod	Israel	0.09	**0.451**	
ARBUE	Buenos Aires	Argentina	0.18	**0.450**	
BRFOR	Fortaleza	Brazil	0.27	**0.450**	Y
GBCDF	Cardiff	United Kingdom	0.09	**0.450**	Y
HKHKG	Hong Kong	Hong Kong	0.09	**0.448**	
DKAAR	Aarhus	Denmark	0.09	**0.440**	
USMOB	Mobile Alabama	United States	0.09	**0.437**	
INIXE	Mangalore (New Mangalore)	India	0.09	**0.431**	
TRIST	Istanbul	Turkey	0.09	**0.418**	
GBPTB	Port Talbot	United Kingdom	3.44	**0.413**	
EGPSD	Port Said	Egypt	0.09	**0.401**	
JMSLM	Savanna la Mar	Jamaica	0.27	**0.400**	Y
ARRGA	Rio Grande	Argentina	0.09	**0.400**	Y
IEDGV	Dungarvan	Ireland	0.09	**0.400**	Y
NOAES	Aalesund	Norway	0.09	**0.400**	Y
USLCH	Lake Charles Louisiana	United States	0.72	**0.392**	
USHOU	Houston Texas	United States	0.09	**0.389**	
INBOM	Mumbai (Ex Bombay)	India	0.09	**0.381**	
INNSA	Jawaharlal Nehru (Nhava Sheva)	India	0.09	**0.381**	
NLRTM	Rotterdam	Netherlands	5.16	**0.377**	

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 categorisation as either an unlikely, suspected or known harmful species (Section 3.9).

The risk species threat coefficient (C4) of each BW source port identified for Saldanha Bay are shown in Figure 23 and listed in Table 7. Table 8 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 February 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 Saldanha Bay PBBS, plus those listed in published and unpublished reports collated by Group C members (Appendix 5). Many of the species listed in the database 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 Saldanha Bay). 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 WA-IV (which is located very near its boundary with WA-V; Figure 7, Table 8).

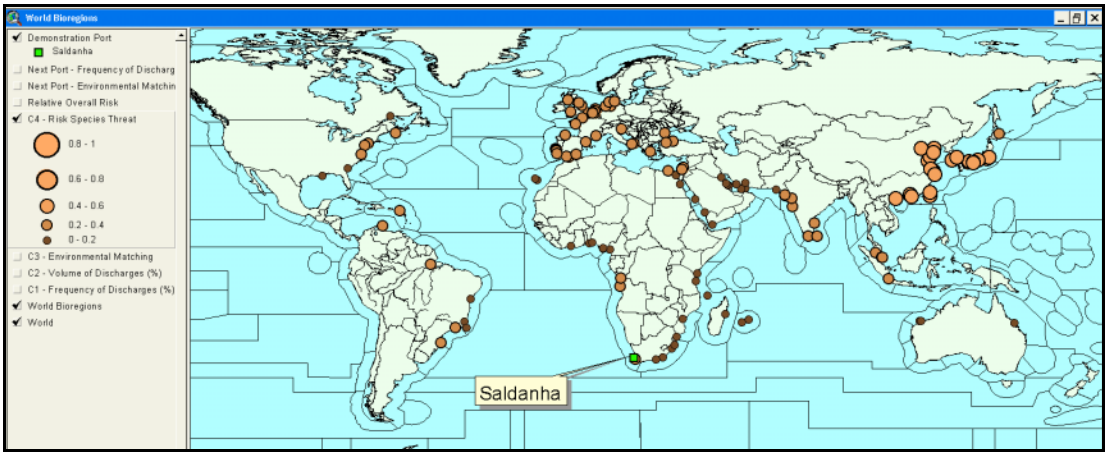

Figure 23. *GIS output showing the location and risk species threat coefficients (C4) of the BW source ports identified for the Port of Saldanha Bay*

Table 7. *Ranking of BW source ports identified for Port of Saldanha Bay, 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)
CNDLC	Dalian Liaoning	China	NWP-4c	12	11	12	165	0.419
CNLYG	Lianyungang Jiangsu	China	NWP-4c	12	11	12	165	0.419
CNNBO	Beilun	China	NWP-3a	12	11	12	165	0.419
CNSHA	Shanghai (Shihu) Shanghai	China	NWP-3a	12	11	12	165	0.419
CNTAO	Qingdao (Longgang) Shandong	China	NWP-4c	12	11	12	165	0.419
CNYNT	Yantai (Muping) Shandong	China	NWP-4c	12	11	12	165	0.419
CNZJG	Zhangjiagang (Changjiagang) Jiangsu	China	NWP-3a	12	11	12	165	0.419
JPCHB	Chiba Chiba	Japan	NWP-3b	12	11	12	165	0.419
JPFKY	Fukuyama Hiroshima	Japan	NWP-3b	12	11	12	165	0.419
JPKMT	Kimitsu Chiba	Japan	NWP-3b	12	11	12	165	0.419
JPMIZ	Mizushima Okayama	Japan	NWP-3b	12	11	12	165	0.419
JPNGO	Nagoya Aichi	Japan	NWP-3b	12	11	12	165	0.419
JPWAK	Wakayama Wakayama	Japan	NWP-3b	12	11	12	165	0.419
JPYUR	Yura Wakayama	Japan	NWP-3b	12	11	12	165	0.419
KRKAN	Kwangyang	Korea Republic of	NWP-3a	12	11	12	165	0.419
TW001	Mailiao	Taiwan Province of China	NWP-3a	12	11	12	165	0.419
CNTXG	Tianjinxingang (Xingang) Tianjin	China	NWP-4a	10	11	12	163	0.414
KRKPO	Pohang	Korea Republic of	NWP-4a	10	11	12	163	0.414
CNFAN	Fangcheng (Qinzhou) Guangxi	China	NWP-2	10	10	12	160	0.406
CNHUA	Huangpu (Xinzao) Guangdong	China	NWP-2	10	10	12	160	0.406
CNSHK	Shekou Guangdong	China	NWP-2	10	10	12	160	0.406
JPKSM	Kashima Ibaraki	Japan	NWP-4b	10	10	12	160	0.406
TWKHH	Kaohsiung	Taiwan Province of China	NWP-2	10	10	12	160	0.406
ESCRS	Carboneras	Spain	MED-II	16	5	12	151	0.383
ESTAR	Tarragona	Spain	MED-II	16	5	12	151	0.383
FRFOS	Fos sur Mer	France	MED-II	16	5	12	151	0.383
ITTAR	Taranto	Italy	MED-IV	16	5	12	151	0.383
JPABA	Abashiri Hokkaido	Japan	NWP-5	10	10	11	150	0.381
FRMTX	Montoir	France	NEA-IV	21	9	10	148	0.376
ESGIJ	Gijon	Spain	NEA-V	20	9	10	147	0.373
PTLIS	Lisboa	Portugal	NEA-V	20	9	10	147	0.373
PTLOS	Lagos	Portugal	NEA-V	20	9	10	147	0.373
PTSET	Setubal	Portugal	NEA-V	20	9	10	147	0.373
PTSIE	Sines	Portugal	NEA-V	20	9	10	147	0.373
BEANR	Antwerpen	Belgium	NEA-II	22	8	10	146	0.371
BEGNE	Ghent/Gent	Belgium	NEA-II	22	8	10	146	0.371
DEHAM	Hamburg	Germany Federal Republic Of	NEA-II	22	8	10	146	0.371
DEWVN	Wilhelmshaven	Germany Federal Republic Of	NEA-II	22	8	10	146	0.371
FRDKK	Dunkerque	France	NEA-II	22	8	10	146	0.371
FRLEH	Le Havre	France	NEA-II	22	8	10	146	0.371
GBHST	Hunterston	United Kingdom	NEA-II	22	8	10	146	0.371
GBIMM	Immingham	United Kingdom	NEA-II	22	8	10	146	0.371
GBPTB	Port Talbot	United Kingdom	NEA-III	19	9	10	146	0.371
GBRER	Redcar	United Kingdom	NEA-II	22	8	10	146	0.371
NLAMS	Amsterdam	Netherlands	NEA-II	22	8	10	146	0.371
NLIJM	IJmuiden	Netherlands	NEA-II	22	8	10	146	0.371
NLRTM	Rotterdam	Netherlands	NEA-II	22	8	10	146	0.371
NLVLI	Flushing (Vlissingen)	Netherlands	NEA-II	22	8	10	146	0.371
DKENS	Enstedvaerkets Havn	Denmark	B-III	21	8	10	145	0.368
DKSTG	Stigsnaesvaerkets Havn	Denmark	B-III	21	8	10	145	0.368
EGEDK	El Dekheila	Egypt	MED-V	16	5	11	141	0.358
ILAKL	Ashkelon	Israel	MED-V	16	5	11	141	0.358
ILASH	Ashdod	Israel	MED-V	16	5	11	141	0.358
ILHAD	Hadera	Israel	MED-V	16	5	11	141	0.358
ESALG	Algeciras	Spain	MED-I	15	5	11	140	0.355
ESCEU	Ceuta	Spain	MED-I	15	5	11	140	0.355
GIGIB	Gibraltar	Gibraltar	MED-I	15	5	11	140	0.355
GRPIR	Piraeus	Greece	MED-VI	15	5	11	140	0.355
ITBDS	Brindisi	Italy	MED-VII	15	5	11	140	0.355
SIKOP	Koper	Slovenia	MED-VII	15	5	11	140	0.355
TRIST	Istanbul	Turkey	MED-VIII	15	5	11	140	0.355

Table 7 (cont'd). *Ranking of BW source ports identified for Port of Saldanha Bay, 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)
BRIBB	Imbituba	Brazil	SA-IIB	20	6	9	128	0.325
BRSPB	Sepetiba	Brazil	SA-IIB	20	6	9	128	0.325
ROCND	Constanta	Romania	MED-IXB	13	5	9	118	0.299
INBED	Bedi	India	CIO-I	8	14	6	110	0.279
INBOM	Mumbai (Ex Bombay)	India	CIO-I	8	14	6	110	0.279
INDAH	Dahej	India	CIO-I	8	14	6	110	0.279
INIXY	Kandla (Muldwarka)	India	CIO-I	8	14	6	110	0.279
INMAA	Chennai (Ex Madras)	India	CIO-II	8	14	6	110	0.279
INTUT	Tuticorin (New Tuticorin)	India	CIO-II	8	14	6	110	0.279
LKTRR	Trincomalee	Sri Lanka	CIO-II	8	14	6	110	0.279
TRERE	Eregli	Turkey	MED-IXA	12	5	7	97	0.246
IDCIG	Cigading	Indonesia	EAS-VII	6	6	6	84	0.213
MYPKG	Port Kelang	Malaysia	EAS-VI	6	6	6	84	0.213
SGJUR	Jurong	Singapore	EAS-VI	6	6	6	84	0.213
SGSIN	Singapore	Singapore	EAS-VI	6	6	6	84	0.213
BRMGU	Munguba	Brazil	SA-IV	8	5	6	83	0.211
ANBUB	Bullen Bay	Netherlands Antilles	CAR-III	8	4	6	80	0.203
ANEUX	St Eustatius	Netherlands Antilles	CAR-III	8	4	6	80	0.203
AOLAD	Luanda	Angola	WA-IV	14	2	6	80	0.203
CDMAT	Matadi	Congo Democratic Republic	WA-IV	14	2	6	80	0.203
ZACPT	Cape Town	South Africa	WA-IV	14	2	6	80	0.203
CALHA	La Have	Canada	NA-ET1	10	3	6	79	0.201
USNEN	Norfolk-Newport News Virginia	United States	NA-ET3	10	3	6	79	0.201
USNYC	New York New York	United States	NA-ET3	10	3	6	79	0.201
USPHF	Hampton Roads	United States	NA-ET3	10	3	6	79	0.201
USPHL	Philadelphia Pennsylvania	United States	NA-ET3	10	3	6	79	0.201
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	IP-1	8	4	5	70	0.178
PKKHI	Karachi	Pakistan	IP-1	8	4	5	70	0.178
BRPOU	Ponta do Ubu	Brazil	SA-III	7	5	4	62	0.157
BRSSA	Salvador	Brazil	SA-III	7	5	4	62	0.157
IRBND	Bandar Abbas	Iran Islamic Republic of	AG-1	4	6	4	62	0.157
IRLVP	Lavan Island	Iran Islamic Republic of	AG-1	4	6	4	62	0.157
AEDXB	Dubai	United Arab Emirates	AG-5	1	6	4	59	0.150
AEJEA	Jebel Ali	United Arab Emirates	AG-5	1	6	4	59	0.150
BHMAN	Manama	Bahrain	AG-5	1	6	4	59	0.150
BHMIN	Mina Sulman	Bahrain	AG-5	1	6	4	59	0.150
KWMIB	Mina Abdulla	Kuwait	AG-3	1	6	4	59	0.150
SADMN	Damman	Saudi Arabia	AG-5	1	6	4	59	0.150
SAJUB	Jubail	Saudi Arabia	AG-3	1	6	4	59	0.150
ZADUR	Durban	South Africa	WA-V	13	2	4	59	0.150
ZAELS	East London	South Africa	WA-V	13	2	4	59	0.150
ZAPLZ	Port Elizabeth	South Africa	WA-V	13	2	4	59	0.150
ZARCB	Richards Bay	South Africa	WA-V	13	2	4	59	0.150
USDVT	Davant	United States	CAR-I	5	4	3	47	0.119
USSAV	Savannah Georgia	United States	CAR-VII	5	4	3	47	0.119
CASEI	Sept Iles (Seven Is.) Quebec	Canada	NA-S3	7	3	3	46	0.117
AUHPT	Hay Point	Australia	AUS-XII	10	1	3	43	0.109
EGADA	Adabiya	Egypt	RS-3	6	2	3	42	0.107
EGSGA	Safaga	Egypt	RS-3	6	2	3	42	0.107
SAGIZ	Gizan	Saudi Arabia	RS-I	0	0	0	0	0.107
SAJED	Jeddah	Saudi Arabia	RS-2	6	2	3	42	0.107
AUDAM	Dampier	Australia	AUS-II	7	1	2	30	0.076
AUPWL	Port Walcott	Australia	AUS-II	7	1	2	30	0.076
YEADE	Aden	Yemen	GA	3	3	1	22	0.056
MUPLU	Port Louis	Mauritius	EA-V	9	2	0	15	0.038
REPDG	Pointe des Galets	Reunion	EA-V	9	2	0	15	0.038
KEMBA	Mombasa	Kenya	EA-III	6	2	0	12	0.030
KMYVA	Moroni	Comoros	EA-III	6	2	0	12	0.030
MGTMM	Tamatave (Toamasina)	Madagascar	EA-III	6	2	0	12	0.030
MZBEW	Beira	Mozambique	EA-IV	6	2	0	12	0.030
MZMPM	Maputo	Mozambique	EA-IV	6	2	0	12	0.030
TZDAR	Dar Es Salaam	Tanzania United Republic Of	EA-III	6	2	0	12	0.030
CMDLA	Douala	Cameroon	WA-III	1	0	1	11	0.028
BJCOO	Cotonou	Benin	WA-II	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
ESSCT	Tenerife (Santa Cruz de Tenerife)	Spain	WA-I	0	0	0	0	0.000
NGBON	Bonny	Nigeria	WA-II	0	0	0	0	0.000
NGLOS	Lagos	Nigeria	WA-II	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 bioregion of Saldanha Bay (WA-IV)*

Group	Common Name	Species Name	Regional Status	Threat Status
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium (syn. Gonyaulax) catenella*	Cryptogenic	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium tamarense*	Introduced	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Ceratium furca*	Native	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Dinophysis acuminata*	Native	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gonyaulax grindleyi*	Native	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gymnodinium cf. mikimotoi*	Introduced	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gymnodinium galatheanum*	Native	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Heterocapsa triquetra*	Cryptogenic	Not suspected
Chlorophyta	Sea grapes	*Caulerpa filiformis*	Native	Suspected harmful species
Phaeophyta	Brown alga	*Aureococcus anophagefferens*	Introduced	Known harmful species
Raphidophycea	Raphidophyte	*Heterosigma akashiwo*	Native	Known harmful species
Cnidaria	Hydroid	*Coryne pusilla*	Introduced	Not suspected
Cnidaria	Hydroid	*Ectopleura crocea*	Native	Not suspected
Cnidaria	Sea anemone	*Metridium senile*	Introduced	Not suspected
Annelida	Polychate worm	*Desdemona ornata*	Native	Not suspected
Annelida	Sabellid fan worm	*Terebrasabella heterouncinata*	Native	Not suspected
Arthropoda	Bay barnacle	*Balanus improvisus*	Native	Not suspected
Arthropoda	European shore crab	*Carcinus maenas*	Introduced	Known harmful species
Arthropoda	Sea flea	*Corophium acherusicum*	Introduced	Not suspected
Arthropoda	Dromiid crab	*Dromia wilsoni*	Introduced	Not suspected
Arthropoda	Zebra barnacle	*Megabalanus zebra*	Native	Not suspected
Arthropoda	Giant barnacle	*Notomegabalanus algicola*	Native	Not suspected
Arthropoda	Crab	*Pilumnus hirsutus*	Introduced	Not suspected
Mollusca	Sea hare	*Aplysiopsis formosa*	Native	Not suspected
Mollusca	Scallop	*Argopecten irradians*	Native	Not suspected
Mollusca	Whelk	*Bullia annulata*	Native	Not suspected
Mollusca	Black mussel	*Choromytilus meridionalis*	Native	Not suspected
Mollusca	Trumpet shell	*Cymatium cutaceum africanum*	Native	Not suspected
Mollusca	White mussel	*Donax serra*	Native	Not suspected
Mollusca	Glaucid nudibranch	*Godiva quadricolor*	Native	Not suspected
Mollusca	Periwinkle	*Litorina saxatilis*	Introduced	Suspected harmful species
Mollusca	mussel	*Mytilus galloprovincialis*	Introduced	Known harmful species
Mollusca	Polycerid nudibranch	*Polycera hedgpethi*	Introduced	Not suspected
Ectoprocta/Cheilostomata	Sea moss (Bryozoan)	*Membranipora membranacea*	Introduced	Suspected harmful species
Urochordata	(tunicate)	*Ascidiella aspersa*	Cryptogenic	Not suspected
Urochordata	(tunicate)	*Botrylloides magnicoceum*	Native	Not suspected
Urochordata	Sea Vase (tunicate)	*Ciona intestinalis*	Introduced	Not suspected
Urochordata	(tunicate)	*Diplosoma listerianum*	Native	Not suspected

4.8 Risk assessment results

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

After calculating the RORs the database generates a large output table listing the source ports and their coefficients, risk-reduction factors and ROR, plus its assignment into one of the five ROR categories used for the GIS plot and its standardised ROR value (S-ROR; Section 3.10). Results from the project-standard BWRA for the Port of Saldanha Bay are listed in Table 9, and the GIS plot of the categorised RORs is shown in Figure 24.

From the 1315 visit records in the Saldanha database, the project standard identified 19 of the 131 source ports as representing the highest risk group (in terms of their BW source frequency, volume, environmental similarity and assigned risk species). These ports provided the top 20% of the total ROR, with individual values in the 0.21 - 0.25 range (Table 9). They were predominantly Mediterranean, South African and North Asian ports, led by Piraeus in Greece (ROR = 0.250;

S-ROR = 1.00), Taranto in Italy (ROR = 0.247 S-ROR = 0.997) and Gijon in Spain (0.245; S-ROR = 0.970; Table 9). The next group of high risk ports (22) were predominantly north Asian and Brazilian, with seven European ports (Table 9). The 41 highest risk and high risk ports comprised 31% of the total number of identified source ports.

The BW source ports in the low (28) and lowest (37) risk categories comprised 50% of the identified source ports, and these were a mixture of cool, warm and/or brackish water ports with a global distribution (Figure 24). The source port with the lowest ROR (0.07; S-ROR = 0.0) was the wet tropics port of Onne on the Nigerian coast (Table 9; Figure 24).

Based on the 1999-2002 pattern of shipping trade, the ROR results show that BW discharged from vessels arriving from the temperate and warm temperate open coastal ports in the Mediterranean and north Asian regions pose considerably more threat than those in the wet tropics and north American seaboard.

The results shown in Table 9 and Figure 24 are logical given Saldanha's biogeographic location, current pattern of trade and port type (a natural bay port). They also fit with the origins of the introduced species already present in Saldanha Bay (i.e. introductions from Europe and East Asia). The results therefore indicate that the project standard 'first-pass' treatment of the risk coefficients provides a useful benchmark for any investigative manipulation of the risk calculations and database.

The exposed and relatively rugged open coastlines of South Africa have not experienced the level of harmful invasive species seen in other regions. However the number of noxious phytoplankton species in Table 9 and recent history of bloom events shows that its enclosed bays and lagoons such as the Saldanha-Langebaan system are not immune to red tides caused by introduced species, as well as those which can be generated by native species as a result of natural upwelling and/or eutrophication in developed areas. It is also not yet clear if potentially harmful macrobenthic fauna such as *Carcinus maenas* may eventually spread by natural or vessel-mediated means into preferred sheltered rocky areas such as inside the entrance to Saldanha Bay.

Figure 25 shows the frequency distribution of the standardised ROR values. The relatively uniform shape of this plot shows there were no significant groupings of particularly high or low risk ports.

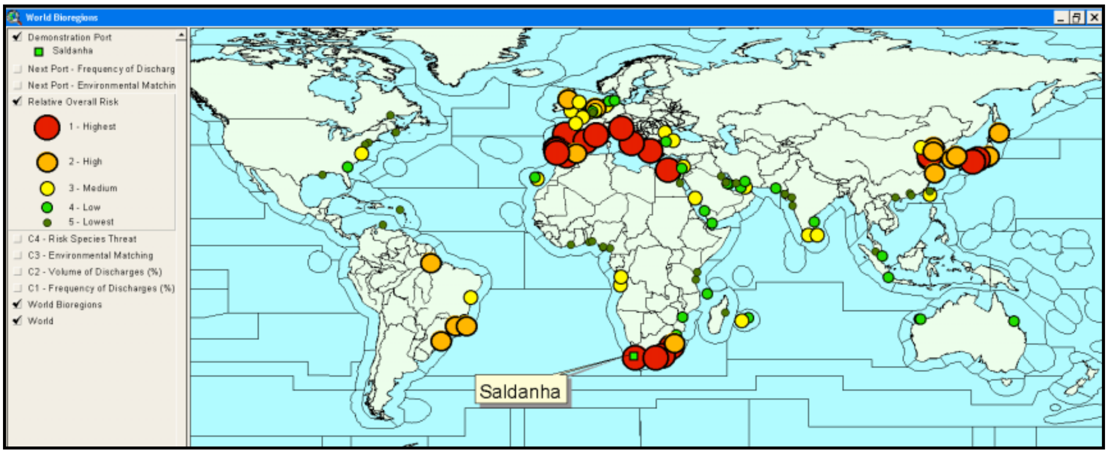

Figure 24. *GIS output showing the location and categories of relative overall risk (ROR) of source ports identified for the Port of Saldanha Bay*

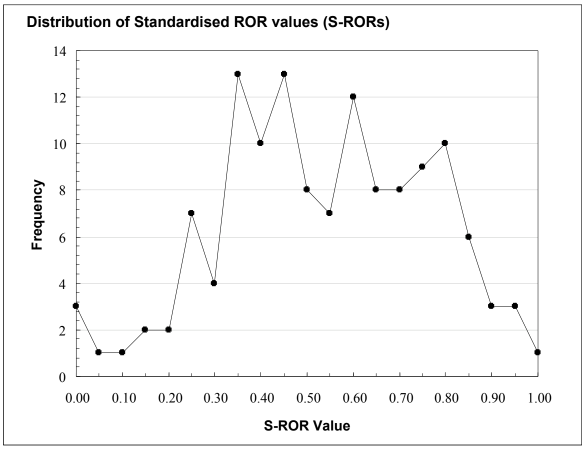

Figure 25. *Frequency distribution of the standardised ROR values for all identified source ports*

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

Port Code	Source Port	Country	C1 BW Freq	C2 BW Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match		C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk			
GRPIR	Piraeus	Greece	0.45%	0.47%	42,885	1.0	16	0.6	0.777		0.355	**0.250**	1.10	1.1	Highest	1.000
ITTAR	Taranto	Italy	0.91%	1.40%	87,219	1.0	16	0.6	0.744		0.383	**0.249**	1.10	2.2	Highest	0.997
ESGIJ	Gijon	Spain	2.87%	3.58%	85,372	1.0	15	0.6	0.690		0.373	**0.245**	1.08	3.3	Highest	0.970
ESTAR	Tarragona	Spain	0.61%	0.81%	57,078	1.0	16	0.6	0.724		0.383	**0.242**	1.07	4.4	Highest	0.955
FRFOS	Fos sur Mer	France	2.12%	2.82%	73,000	1.0	16	0.6	0.681		0.383	**0.240**	1.06	5.4	Highest	0.945
PTLOS	Lagos	Portugal	0.15%	0.01%	1,418	1.0	15	0.6	0.712		0.373	**0.234**	1.03	6.4	Highest	0.912
PTSET	Setubal	Portugal	0.30%	0.42%	55,510	1.0	14	0.6	0.700	Y	0.373	**0.233**	1.03	7.5	Highest	0.903
CNTAO	Qingdao (Longgang) Shandong	China	2.57%	3.92%	104,874	1.0	22	0.4	0.689		0.419	**0.230**	1.02	8.5	Highest	0.890
JPNGO	Nagoya Aichi	Japan	0.76%	1.95%	129,078	1.0	23	0.4	0.722		0.419	**0.229**	1.01	9.5	Highest	0.883
JPWAK	Wakayama Wakayama	Japan	0.30%	0.50%	67,800	1.0	22	0.4	0.734		0.419	**0.227**	1.00	10.5	Highest	0.874
PTSIE	Sines	Portugal	0.45%	0.58%	54,473	1.0	14	0.6	0.672		0.373	**0.227**	1.00	11.5	Highest	0.869
ZAELS	East London	South Africa	0.15%	0.07%	17,000	1.0	4	1.0	0.750	Y	0.150	**0.225**	0.99	12.5	Highest	0.863
ZAPLZ	Port Elizabeth	South Africa	0.61%	0.28%	40,500	1.0	3	1.0	0.742		0.150	**0.225**	0.99	13.5	Highest	0.861
EGEDK	El Dekheila	Egypt	0.91%	1.15%	65,000	1.0	15	0.6	0.657		0.358	**0.223**	0.98	14.5	Highest	0.849
ZADUR	Durban	South Africa	9.23%	2.67%	196,741	1.0	5	0.8	0.643		0.150	**0.220**	0.97	15.4	Highest	0.834
ZACPT	Cape Town	South Africa	2.42%	0.54%	44,033	1.0	1	1.0	0.645		0.203	**0.219**	0.97	16.4	Highest	0.829
SIKOP	Koper	Slovenia	0.61%	0.89%	67,060	1.0	18	0.6	0.648		0.355	**0.219**	0.97	17.4	Highest	0.827
GIGIB	Gibraltar	Gibraltar	0.45%	0.42%	45,703	1.0	14	0.6	0.655		0.355	**0.219**	0.97	18.3	Highest	0.827
JPYUR	Yura Wakayama	Japan	0.15%	0.40%	99,600	1.0	22	0.4	0.700	Y	0.419	**0.218**	0.96	19.3	Highest	0.822
ESCEU	Ceuta	Spain	0.15%	0.17%	42,000	1.0	14	0.6	0.650	Y	0.355	**0.217**	0.96	20.3	High	0.813
BRSPB	Sepetiba	Brazil	0.30%	0.12%	16,853	1.0	9	0.8	0.602		0.325	**0.217**	0.96	21.2	High	0.813
KRKAN	Kwangyang	Korea Republic of	0.30%	0.60%	78,876	1.0	23	0.4	0.687		0.419	**0.216**	0.95	22.2	High	0.809
ITBDS	Brindisi	Italy	0.30%	0.35%	70,142	1.0	16	0.6	0.640	Y	0.355	**0.215**	0.95	23.1	High	0.803
ESALG	Algeciras	Spain	0.76%	1.09%	65,438	1.0	14	0.6	0.623		0.355	**0.214**	0.94	24.1	High	0.797
KRKPO	Pohang	Korea Republic of	0.30%	0.53%	73,999	1.0	23	0.4	0.680		0.414	**0.213**	0.94	25.0	High	0.795
JPKSM	Kashima Ibaraki	Japan	0.91%	1.70%	75,612	1.0	23	0.4	0.664		0.406	**0.213**	0.94	26.0	High	0.793
BRMGU	Munguba	Brazil	0.15%	0.01%	2,863	1.0	13	0.6	0.650	Y	0.211	**0.212**	0.93	26.9	High	0.785
NLIJM	IJmuiden	Netherlands	1.97%	2.73%	75,397	1.0	17	0.6	0.570		0.371	**0.210**	0.93	27.8	High	0.775
ZARCB	Richards Bay	South Africa	9.08%	1.16%	23,074	1.0	5	0.8	0.617		0.150	**0.210**	0.93	28.7	High	0.774
ESCRS	Carboneras	Spain	0.30%	0.53%	67,553	1.0	16	0.6	0.600	Y	0.383	**0.210**	0.92	29.7	High	0.773
GBHST	Hunterston	United Kingdom	0.45%	0.74%	70,000	1.0	18	0.6	0.603		0.371	**0.209**	0.92	30.6	High	0.772
CNYNT	Yantai (Muping) Shandong	China	0.30%	0.47%	70,200	1.0	31	0.4	0.653		0.419	**0.207**	0.91	31.5	High	0.759
CNLYG	Lianyungang Jiangsu	China	0.15%	0.19%	45,745	1.0	28	0.4	0.650	Y	0.419	**0.205**	0.91	32.4	High	0.749
JPABA	Abashiri Hokkaido	Japan	0.15%	0.06%	14,581	1.0	25	0.4	0.653		0.381	**0.202**	0.89	33.3	High	0.730
BRIBB	Imbituba	Brazil	0.15%	0.01%	3,660	1.0	17	0.6	0.650	Y	0.325	**0.202**	0.89	34.2	High	0.730
JPCHB	Chiba Chiba	Japan	0.45%	0.72%	73,000	1.0	23	0.4	0.626		0.419	**0.201**	0.89	35.1	High	0.727
JPKMT	Kimitsu Chiba	Japan	0.45%	0.55%	48,552	1.0	23	0.4	0.625		0.419	**0.201**	0.89	36.0	High	0.723
PTLIS	Lisboa	Portugal	0.15%	0.13%	31,000	1.0	14	0.6	0.569		0.373	**0.199**	0.88	36.8	High	0.713
CNDLC	Dalian Liaoning	China	0.15%	0.27%	67,606	1.0	28	0.4	0.615		0.419	**0.197**	0.87	37.7	High	0.701
CNNBO	Beilun	China	1.51%	2.36%	82,000	1.0	27	0.4	0.580		0.419	**0.197**	0.87	38.6	High	0.701
BRPOU	Ponta do Ubu	Brazil	0.30%	0.03%	5,482	1.0	10	0.6	0.650	Y	0.157	**0.195**	0.86	39.4	High	0.689
FRMTX	Montoir	France	0.15%	0.04%	9,234	1.0	17	0.6	0.550	Y	0.376	**0.194**	0.86	40.3	Medium	0.688
JPFKY	Fukuyama Hiroshima	Japan	0.45%	0.88%	78,166	1.0	22	0.4	0.592		0.419	**0.193**	0.85	41.1	Medium	0.682
TWKHH	Kaohsiung	Taiwan Province of China	0.76%	0.79%	50,587	1.0	19	0.6	0.510		0.406	**0.192**	0.85	42.0	Medium	0.676
FRDKK	Dunkerque	France	2.87%	4.16%	114,246	1.0	17	0.6	0.471		0.371	**0.191**	0.84	42.8	Medium	0.668
TRERE	Eregli	Turkey	1.36%	1.38%	75,348	1.0	16	0.6	0.588		0.246	**0.191**	0.84	43.7	Medium	0.667
USNEN	Norfolk-Newport News Virginia	United States	0.91%	0.24%	24,000	1.0	18	0.6	0.629		0.201	**0.190**	0.84	44.5	Medium	0.664
JPMIZ	Mizushima Okayama	Japan	0.76%	1.12%	65,127	1.0	22	0.4	0.567		0.419	**0.188**	0.83	45.3	Medium	0.653
GBPTB	Port Talbot	United Kingdom	4.08%	6.51%	85,370	1.0	16	0.6	0.413		0.371	**0.185**	0.82	46.2	Medium	0.636
INTUT	Tuticorin (New Tuticorin)	India	0.30%	0.11%	20,165	1.0	13	0.6	0.567		0.279	**0.185**	0.81	47.0	Medium	0.633
REPDG	Pointe des Galets	Reunion	0.30%	0.16%	32,400	1.0	6	0.8	0.700	Y	0.038	**0.184**	0.81	47.8	Medium	0.628
GBRER	Redcar	United Kingdom	0.61%	1.01%	85,000	1.0	19	0.6	0.495		0.371	**0.183**	0.81	48.6	Medium	0.626
ESLPA	Las Palmas	Spain	0.15%	0.19%	47,000	1.0	13	0.6	0.721		0.000	**0.181**	0.80	49.4	Medium	0.614
NLRTM	Rotterdam	Netherlands	5.14%	7.34%	110,000	1.0	17	0.6	0.377		0.371	**0.181**	0.80	50.2	Medium	0.613
CNTXG	Tianjinxingang (Xingang) Tianji	China	0.30%	0.38%	47,485	1.0	22	0.4	0.550	Y	0.414	**0.181**	0.80	51.0	Medium	0.610
LKTRR	Trincomalee	Sri Lanka	0.15%	0.07%	17,000	1.0	13	0.6	0.550	Y	0.279	**0.180**	0.79	51.8	Medium	0.607
CDMAT	Matadi	Congo Democratic Republic Of	0.61%	0.04%	5,966	1.0	5	0.8	0.550	Y	0.203	**0.180**	0.79	52.6	Medium	0.606
ILHAD	Hadera	Israel	0.91%	1.44%	65,094	1.0	15	0.6	0.480	Y	0.358	**0.180**	0.79	53.4	Medium	0.605
USPHF	Hampton Roads	United States	0.15%	0.07%	17,800	1.0	21	0.4	0.635		0.201	**0.179**	0.79	54.2	Medium	0.603
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	0.45%	0.54%	71,655	1.0	13	0.6	0.600		0.178	**0.179**	0.79	54.9	Medium	0.603
FRLEH	Le Havre	France	0.45%	0.57%	61,074	1.0	17	0.6	0.481		0.371	**0.178**	0.79	55.7	Medium	0.598
DEWVN	Wilhelmshaven	Germany Federal Rep	0.30%	0.37%	52,049	1.0	20	0.4	0.551		0.371	**0.177**	0.78	56.5	Medium	0.588
AOLAD	Luanda	Angola	0.15%	0.01%	1,800	1.0	4	1.0	0.500	Y	0.203	**0.176**	0.78	57.3	Medium	0.586
SAJED	Jeddah	Saudi Arabia	1.06%	0.70%	32,919	1.0	13	0.6	0.619		0.107	**0.175**	0.77	58.1	Medium	0.580
BRSSA	Salvador	Brazil	0.15%	0.01%	2,640	1.0	8	0.8	0.564		0.157	**0.173**	0.76	58.8	Medium	0.567
ROCND	Constanta	Romania	1.21%	1.17%	56,115	1.0	18	0.6	0.478		0.299	**0.170**	0.75	59.6	Medium	0.553

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

Port Code	Source Port	Country	C1 BW Freq	C2 BW Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match		C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk			
AEJEA	Jebel Ali	United Arab Emirates	0.15%	0.08%	19,000	1.0	13	0.6	0.588		0.150	**0.170**	0.75	60.3	Low	0.551
ILASH	Ashdod	Israel	0.15%	0.23%	57,177	1.0	15	0.6	0.451		0.358	**0.167**	0.74	61.1	Low	0.536
ESSCT	Tenerife (Santa Cruz de Tenerife	Spain	0.15%	0.29%	71,000	1.0	15	0.6	0.662		0.000	**0.167**	0.73	61.8	Low	0.532
PKKHI	Karachi	Pakistan	0.30%	0.05%	10,000	1.0	13	0.6	0.553		0.178	**0.166**	0.73	62.5	Low	0.527
SGSIN	Singapore	Singapore	3.03%	4.99%	135,204	1.0	15	0.6	0.453		0.213	**0.165**	0.73	63.3	Low	0.524
IDCIG	Cigading	Indonesia	0.30%	0.43%	60,469	1.0	15	0.6	0.523		0.213	**0.165**	0.73	64.0	Low	0.520
NLVLI	Flushing (Vlissingen)	Netherlands	0.45%	0.53%	47,947	1.0	21	0.4	0.495		0.371	**0.163**	0.72	64.7	Low	0.513
DKSTG	Stigsnaesvaerkets Havn	Denmark	0.15%	0.22%	53,842	1.0	21	0.4	0.500	Y	0.368	**0.163**	0.72	65.4	Low	0.510
GBIMM	Immingham	United Kingdom	2.42%	4.18%	83,287	1.0	17	0.6	0.356		0.371	**0.161**	0.71	66.9	Low	0.501
TRIST	Istanbul	Turkey	0.30%	0.25%	46,170	1.0	16	0.6	0.418		0.355	**0.159**	0.70	67.6	Low	0.491
SADMN	Damman	Saudi Arabia	0.61%	0.23%	20,000	1.0	14	0.6	0.536		0.150	**0.159**	0.70	68.3	Low	0.487
BHMIN	Mina Sulman	Bahrain	0.15%	0.18%	45,241	1.0	14	0.6	0.540		0.150	**0.158**	0.70	69.0	Low	0.485
MUPLU	Port Louis	Mauritius	0.15%	0.01%	1,620	1.0	6	0.8	0.600	Y	0.038	**0.158**	0.70	69.7	Low	0.484
ILAKL	Ashkelon	Israel	0.30%	0.51%	68,400	1.0	50	0.4	0.480	Y	0.358	**0.158**	0.70	70.3	Low	0.483
BHMAN	Manama	Bahrain	0.15%	0.28%	69,600	1.0	14	0.6	0.536		0.150	**0.158**	0.70	71.0	Low	0.481
INMAA	Chennai (Ex Madras)	India	0.15%	0.05%	13,251	1.0	21	0.4	0.515		0.279	**0.157**	0.69	71.7	Low	0.478
MZBEW	Beira	Mozambique	0.15%	0.04%	8,653	1.0	6	0.8	0.600	Y	0.030	**0.157**	0.69	72.4	Low	0.475
MZMPM	Maputo	Mozambique	0.15%	0.01%	1,275	1.0	5	0.8	0.600	Y	0.030	**0.156**	0.69	73.1	Low	0.475
KMYVA	Moroni	Comoros	0.15%	0.03%	8,000	1.0	18	0.6	0.600	Y	0.030	**0.155**	0.68	73.8	Low	0.467
YEADE	Aden	Yemen	0.15%	0.00%	1,205	1.0	12	0.6	0.584		0.056	**0.155**	0.68	74.5	Low	0.465
USSAV	Savannah Georgia	United States	0.15%	0.06%	14,625	1.0	18	0.6	0.539		0.119	**0.153**	0.68	75.2	Low	0.457
AUHPT	Hay Point	Australia	0.15%	0.08%	20,000	1.0	20	0.4	0.563		0.109	**0.152**	0.67	75.8	Low	0.451
EGADA	Adabiya	Egypt	0.15%	0.03%	8,213	1.0	14	0.6	0.540	Y	0.107	**0.151**	0.67	76.5	Low	0.447
SAGIZ	Gizan	Saudi Arabia	0.15%	0.12%	30,000	1.0	12	0.6	0.600	Y	0.000	**0.151**	0.66	77.2	Low	0.442
AUPWL	Port Walcott	Australia	1.97%	1.63%	120,036	1.0	15	0.6	0.519		0.076	**0.150**	0.66	77.8	Low	0.439
DKENS	Enstedvaerkets Havn	Denmark	0.15%	0.32%	78,745	1.0	21	0.4	0.440		0.368	**0.148**	0.65	78.5	Low	0.427
IRBND	Bandar Abbas	Iran Islamic Republic of	0.61%	0.22%	16,028	1.0	13	0.6	0.488		0.157	**0.148**	0.65	79.1	Low	0.425
AUDAM	Dampier	Australia	0.61%	0.50%	65,000	1.0	15	0.6	0.530		0.076	**0.147**	0.65	79.8	Low	0.420
MGTMM	Tamatave (Toamasina)	Madagascar	0.30%	0.04%	5,000	1.0	5	0.8	0.550	Y	0.030	**0.144**	0.64	80.4	Lowest	0.407
CNSHK	Shekou Guangdong	China	1.06%	1.34%	59,235	1.0	19	0.6	0.310	Y	0.406	**0.144**	0.64	81.1	Lowest	0.407
TW001	Mailiao	Taiwan Province of China	0.30%	0.45%	72,905	1.0	22	0.4	0.400	Y	0.419	**0.144**	0.63	81.7	Lowest	0.404
CMDLA	Douala	Cameroon	0.15%	0.00%	1,025	1.0	7	0.8	0.550	Y	0.028	**0.143**	0.63	82.3	Lowest	0.402
INBED	Bedi	India	0.15%	0.07%	18,047	1.0	19	0.6	0.400	Y	0.279	**0.142**	0.63	82.9	Lowest	0.396
USNYC	New York New York	United States	0.15%	0.06%	13,700	1.0	18	0.6	0.443		0.201	**0.141**	0.62	83.6	Lowest	0.390
DEHAM	Hamburg	Germany Federal Republic Of	1.82%	2.60%	73,018	1.0	17	0.6	0.298		0.371	**0.141**	0.62	84.2	Lowest	0.389
AEDXB	Dubai	United Arab Emirates	0.30%	0.19%	46,271	1.0	13	0.6	0.467		0.150	**0.141**	0.62	84.8	Lowest	0.386
KWMIB	Mina Abdulla	Kuwait	0.15%	0.05%	13,200	1.0	16	0.6	0.469		0.150	**0.140**	0.62	85.4	Lowest	0.384
SAJUB	Jubail	Saudi Arabia	0.61%	0.92%	60,000	1.0	14	0.6	0.454		0.150	**0.140**	0.62	86.1	Lowest	0.381
CNHUA	Huangpu (Xinzao) Guangdong	China	0.30%	0.40%	59,235	1.0	19	0.6	0.308		0.406	**0.140**	0.62	86.7	Lowest	0.380
KEMBA	Mombasa	Kenya	1.36%	0.23%	13,599	1.0	7	0.8	0.518		0.030	**0.140**	0.62	87.3	Lowest	0.380
INBOM	Mumbai (Ex Bombay)	India	0.76%	0.13%	14,457	1.0	12	0.6	0.381		0.279	**0.139**	0.61	87.9	Lowest	0.378
TZDAR	Dar Es Salaam	Tanzania United Republic Of	0.15%	0.01%	3,404	1.0	16	0.6	0.537		0.030	**0.139**	0.61	88.5	Lowest	0.378
CIABJ	Abidjan	Ivory Coast	0.30%	0.04%	6,550	1.0	7	0.8	0.550	Y	0.000	**0.138**	0.61	89.1	Lowest	0.373
BJCOO	Cotonou	Benin	0.15%	0.05%	11,425	1.0	7	0.8	0.550	Y	0.000	**0.138**	0.61	89.7	Lowest	0.371
SGJUR	Jurong	Singapore	0.30%	0.20%	45,184	1.0	20	0.4	0.453		0.213	**0.136**	0.60	90.3	Lowest	0.359
BEANR	Antwerpen	Belgium	2.12%	2.97%	77,478	1.0	17	0.6	0.261		0.371	**0.133**	0.59	90.9	Lowest	0.346
NLAMS	Amsterdam	Netherlands	1.66%	2.08%	77,537	1.0	17	0.6	0.271		0.371	**0.133**	0.59	91.5	Lowest	0.342
CNFAN	Fangcheng (Qinzhou) Guangxi	China	0.30%	0.40%	50,699	1.0	27	0.4	0.350	Y	0.406	**0.130**	0.57	92.1	Lowest	0.326
BEGNE	Ghent/Gent	Belgium	0.15%	0.09%	22,535	1.0	18	0.6	0.281		0.371	**0.127**	0.56	92.6	Lowest	0.307
NGLOS	Lagos	Nigeria	0.61%	0.04%	5,500	1.0	7	0.8	0.487		0.000	**0.123**	0.54	93.2	Lowest	0.289
CNZJG	Zhangjiagang (Changjiagang) Ji	China	0.76%	1.04%	59,790	1.0	21	0.4	0.300	Y	0.419	**0.121**	0.54	93.7	Lowest	0.278
ANEUX	St Eustatius	Netherlands Antilles	0.15%	0.33%	82,510	1.0	17	0.6	0.350	Y	0.203	**0.119**	0.53	94.2	Lowest	0.265
IRLVP	Lavan Island	Iran Islamic Republic of	0.15%	0.14%	35,200	1.0	15	0.6	0.379		0.157	**0.119**	0.53	94.8	Lowest	0.265
ANBUB	Bullen Bay	Netherlands Antilles	0.15%	0.27%	66,412	1.0	17	0.6	0.350	Y	0.203	**0.119**	0.53	95.3	Lowest	0.265
CASEI	Sept Iles (Seven Is.) Quebec (Po	Canada	0.61%	0.35%	60,000	1.0	19	0.6	0.390		0.117	**0.117**	0.52	95.8	Lowest	0.256
EGSGA	Safaga	Egypt	0.15%	0.06%	15,000	1.0	13	0.6	0.400	Y	0.107	**0.117**	0.51	96.3	Lowest	0.251
CNSHA	Shanghai (Shihu) Shanghai	China	1.66%	2.54%	77,350	1.0	21	0.4	0.229		0.419	**0.110**	0.48	96.8	Lowest	0.213
MYPKG	Port Kelang	Malaysia	0.15%	0.03%	8,400	1.0	15	0.6	0.303		0.213	**0.108**	0.48	97.3	Lowest	0.204
USPHL	Philadelphia Pennsylvania	United States	0.15%	0.10%	25,000	1.0	18	0.6	0.294		0.201	**0.104**	0.46	97.7	Lowest	0.181
CALHA	La Have	Canada	0.15%	0.29%	71,700	1.0	20	0.4	0.320		0.201	**0.101**	0.45	98.2	Lowest	0.164
INIXY	Kandla (Muldwarka)	India	0.15%	0.04%	9,920	1.0	12	0.6	0.224		0.279	**0.098**	0.43	98.6	Lowest	0.148
INDAH	Dahej	India	0.15%	0.03%	8,490	1.0	60	0.2	0.300	Y	0.279	**0.089**	0.39	99.0	Lowest	0.098
NGBON	Bonny	Nigeria	0.15%	0.01%	3,000	1.0	7	0.8	0.303		0.000	**0.076**	0.34	99.4	Lowest	0.024
USDVT	Davant	United States	0.15%	0.11%	27,000	1.0	24	0.4	0.246		0.119	**0.074**	0.33	99.7	Lowest	0.012
NGONN	Onne	Nigeria	0.15%	0.01%	1,658	1.0	7	0.8	0.286		0.000	**0.072**	0.32	100.0	Lowest	0.000

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 Marine & Coastal Division of DEAT in Cape Town. This PC proved reliable and adequate for running the database, undertaking the similarity analyses, displaying the GIS maps and results and providing other project needs. A copy of the database is also maintained at the NPA Head office in Johannesburg. BWRFs are continuing to be collected and stored by NPA offices at Saldanha Bay, with the aim of entering these in large batches, rather than on a daily basis due to the workload of staff duties and requirements.

The mapping work was conducted on the PC provided for the BWRA project. Both Group A counterparts had limited previous experience with GIS and ESRI products, so required considerable initial guidance to master the basic use of ArcView. Both readily grasped the structure and management of the port map layers and metafiles, but were hindered in obtaining regular practise between consultants visits by their other duties and locations compared to the location and use of the project PC for other database entries. The Group A and Group C members received advice, training and guidance from Group B members regarding database BW entries and management, and Group C counterparts also provided demonstrations of port environment data needs and multivariate calculations. This helped ensure an adequate interchange of understanding about BWRA system operation and data management.

All NPA Group B counterparts had previous experience with PCs and Windows applications, so learned the data entry method and use of the Access database GUIs for editing the records, with little difficulty. As noted in Section 3.6, the most easily-trained and efficient BWRF database operators are those with substantial port and maritime work experience, plus previous hands-on experience with Windows applications. At the outset the Group B leader's understanding was reasonably strong in both areas and strengthened during the course of the Activity to the point where no further guidance should be necessary for working with the existing or a new port database. Group B commenced a record of commonly occurring errors, blanks and data-entry issues as part of the project team's information gap identifications and to inform members of other Groups. While the number of BWRFs was limited, the need to sort out and correct database entries that had been made by a student was educative.

By the second visit Group B plus some members from Groups A and C were proficient in using the accessory databases for BWRF checking and gap-filling (e.g. *Fairplay Ports Guide,* the *Lloyds Ship Register* and the consultants Excel spreadsheet for estimating BW discharge volumes). In the case of Group A, both the NPA and DEAT counterparts will need some limited assistance from an ESRI-familiar person if required to develop a new GIS map for another port, and will be able to provide useful guidance and important continuity to any future BW or other management projects involving GIS applications (Section 3.11; Appendix 2).

Group C members were unfamiliar with multivariate analysis but by the end of the consultants second visit had learned the basic requirements and use of the PRIMER package to conduct the environmental similarity analysis. All Group C counterparts contributed to the collation and assembly of port environmental data for important South African ports, as well as becoming competent in identifying the basic intertidal and subtidal habitat types and boundaries for the GIS Port Map (Section 3.7).

Group C did not contain any senior marine biologists but had access to their advice and information via the CFP-A, particularly for the collation of risk species information (Appendix 2). While this allowed the BWRA Activity to be completed, it raises the risk of a possible loss of continuity with respect to the database's use of bioregions and the structure and treatment of its risk species data tables, should the CFP-A not be involved in the future promulgation and use of BWRA activities in South Africa.

In fact in South Africa the lack of an 'active' senior marine scientist Group C from a government agency, university, research institute or similarly independent organisation (as opposed to relative junior scientists from contract-oriented consulting agencies such as CSIR), was unique among the Pilot Country BWRA project teams. In contrast, the NPA provided an excellent level of project support and counterparts, and comparable to that achieved by port authorities only in two other Pilot Countries (i.e. Iran and Ukraine).

4.10 Identification of information gaps

Ballast Water Reporting Forms

BWRFs were collected from April 2002 onward, representing the shortest period among the Pilot Countries, most of which had been collecting BWRFs for a year or more prior to the risk assessment. While the usage period was short, return rates were high and the level of critical errors or omissions was low, a feat that can be attributed to the attention and enthusiasm of the senior NPA officer at

Saldanha Bay, and his ability to obtain a cooperative response from ships' officers. The most common key omissions in both the BWRFs and NPA vessel visit records (in terms of key records required by the BWRA) were principally:

- 'Next Port of Call' left blank by oil tankers and some bulk carriers using the multipurpose terminal (probably because the Next Port is frequently unknown until near or after completion of cargo loading). Since the BWRF is normally completed and submitted soon after arrival, this is essentially a matter of timing and coordination with the ship, its local agent and/or port control.
- Lack of entries for BW Source/s and Uptake Date/s.
- Last country of call provided instead of last port of call (correctable for some cases where the same error had not occurred in the port's shipping records).

The following list summarises other omissions or mistakes that are not uncommon in BWRFs submitted at other Demonstration Sites:

- No exchange data in the BW exchange field (Part 4 of the BWRF; Appendix 1), or no reason given for not undertaking an exchange.
- BWRFS showing BW exchange data contained empty BW source cells (it is important to enter the source port/location details because exchanges are often well below 95% effective and never 100%).
- Salinity units omitted or else sometimes provided in SG units.
- Water depth provided in the universally confusing sea height field (actually means wave height).
- BW Discharge field left empty or provided with a small number, even by ships loading a full or part cargo and therefore having to discharge most if not all of their ballast.

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

Apart from lack of BWRF familiarity, the time provided for a ships' officer to complete a BWRF is another factor that can influence the number of mistakes and omissions. BWRFs provided to ships during their berthing or departure phases cannot be expected to receive the same level attention as forms already onboard the ship and completed prior to arrival. Reporting can be improved if shipping agents are requested to supply BWRF reminders (and blank forms where necessary) to ships 1-2 days prior to arrival, or to allow time for BWRF reporting after the ship has berthed and obtained permission to discharge. The former option will reduce the number of completed Next Port of Call entries, the latter option prevents use of the collected BWRF as an instrument to help assess BW discharge permission, and/or tank sampling and monitoring.

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

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

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

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

Port environmental and risk species data

It was particularly difficult to obtain reliable environmental information for many port's waters, particularly for the seasonal water temperature and salinity averages and extrema. This was true for ports in developed regions (e.g. North America, Europe and Japan) as it was for less developed areas or where considerable marine research has been undertaken. It was unclear how many of South Africa's ports may be exceptions to this general finding.

In the case of risk species distribution and status data, many national and regional data sets remain incomplete and/or unpublished, and there are none for South Africa. Many web sites that list introduced species for North American, Caribbean, European, Asian or Australasian regions do not clearly separate or identify which species are historical introductions (e.g. by the oyster aquaculture, fisheries, aquarium industry, sailing ship hulls) and which are recent (e.g. by ballast water and/or modern hull fouling vectors). Many lists do not identify the most 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 15 months (i.e. between the initial briefing in January 2002 and the final consultants visit in March 2003). The level of port and environmental experience brought to the project by South African counterparts and contributors from NPA, DEAT, CSIR and the universities, facilitated effective instruction and familiarisation of the BWRA system, with GIS expertise being the most limited of its three main components. In addition, NPA members of the team are hoping the BWRA can be repeated for other South African ports, particularly for the Port of Richards Bay.

If South Africa can develop a more strategic integration of its agencies which have expertise and complimenting roles in the various maritime, port, ecological and environmental health aspects of ballast water management, there is no doubt it can maintain a significant role in advancing ballast water management in the African region. Improved government coordination will allow South Africa to provide effective assistance, technical advice, guidance and encouragement to other port States in southern Africa, so that a clearer and more reliable picture can be formed on the role of shipping in the transfer of unwanted and potentially harmful aquatic species to and within the whole region.

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 that will facilitate future BWRA activities in Africa will comprise:

- promotion and dissemination of guidelines and instructions about purpose, value and method of BWRF reporting to ship's officers, shipping agents and port officers;
- need for more species surveys (PBBSs) such as those ongoing within South Africa and that planned for the Port of Mombasa (Kenya) by GloBallast;
- improved monitoring to obtain more reliable harbour water temperature and salinity data for ports in the region;
- development of a regional web-based database capable of exchanging and updating species and port survey information.

Apart from governments, it would be fruitful to encourage regional organisations, port authorities, shipping companies and key NGOs in the region to actively support efforts in the above areas.

5.1 Recommendations

- The IMO-style BW Reporting Form should be revised in Section 4 to read 'Wave height (m)' rather than the confusing 'sea height';
- To identify the locations where BW is discharged within a port, more useful BWRFs should include an entry for the berth or terminal name/number (instead of simply 'Port' and/or geographic coordinates, which are often left blank).
- Modifying the "Last Port of Call" field to provide a "Last Three (3) Ports of Call" question would assist BWRF verification checking and analysis for part-loaded vessels visiting multi-use terminals.
- To help decipher and interpret poorly written, incomplete or suspect BWRFs, port and database officers involved in the collation and checking of BWRFs should be given access to up-to-date copies of the *Lloyds Ship Register*, the *Fairplay Ports Guide, Lloyd's Maritime Atlas of World Ports* or equivalent publications. For any port using the GloBallast BWRA system, a copy of the world bioregions map should also be provided to the data-entry officers, so that the bioregion of any new port added to the database can be quickly identified.
- Any port officer whose duties include collecting or receiving BWRFs should be instructed to check that all relevant fields have been completed in legible script. A short BWRF

information kit and training course provided to port officers and local shipping agents could be developed by the NPA, particularly during the implementation of any future BW discharge monitoring and risk assessment activity at a port in South Africa or beyond.

- Owing to the large number of possible errors and misinterpretations that can be made with the existing BWRFs, it must always be remembered that people with a practical maritime knowledge and good background in port and shipping operations will be far more easier and cost effective to train for the implementation of BW monitoring and management activities.

5.2 BWRA recommendations and plans by Pilot Country

- It is recommended that IMO-MEPC should review the standard BWRF, with a view to improving its global application, relevance and user-friendliness under the new BW convention (see Section 5).
- It is recommended that South Africa implements a mandatory BW reporting system, and that the NPA, DEAT and SAMSA should collaborate to identify the most effective and cost-efficient regulatory and administrative mechanisms for managing the system.
- From the experience of the BWRA project at Saldanha Bay, the NPA recognises there will be a need to include BWRF database management as a task under the responsibilities of the appropriate NPA personnel. It is recommended that such duties will need to include (a) periodic BWRF data summaries and reporting to NPA and relevant agencies (including error analyses and advice), and (b) BWRF system guidance and training to port officers to ensure ships officers and shipping agents are fully briefed about South Africa's BW reporting requirements.
- To help expand South Africa's domestic and regional training capabilities, NPA intends to conduct further BWRAs for its major ports such as Richards Bay and Durban, and to assist DEAT in offers of assistance and encouragement to other African countries. The NPA will therefore continue collaborating with marine research institutions, CSIR, DEAT, SAMSA and local NGOs for:
  - obtaining and sharing relevant data and information on (a) port environments (including seasonal water temperature and salinity ranges and GIS mapping of marine habitats and resources) and (b) identification and evaluation of aquatic risk species via PBBS; and
  - assisting with the development, implementation and management of a user-friendly BWRF system for collecting reliable deballasting and ballasting information.
- DEAT, NPA and SAMSA will support the GloBallast Programme's Regional Strategic Action Plan for encouraging and assisting other African countries to execute port baseline biological surveys and collating port environmental data.
- DEAT, NPA and SAMSA will support the development of a regional database for biological invasion and port environmental and water quality data, as part of a network of such databases stemming from the GloBallast Programme. A key task of these databases would be regular updates of information on introduced species in port areas and their impacts, for improving risk assessment calculations and invasion predictions.

6 Location and maintenance of the BWRA System

The GloBallast BWRA hardware and software packages in South Africa are presently maintained at the Globallast Programme office in Cape Town, with a copy of the Saldanha Bay database maintained at the NPA offices in Johannesburg. The following people are currently responsible for maintaining and updating the following features of the BWRA system in South Africa:

Port resource mapping and GIS display requirements:

Name:	Ms Gail Nxumalo
Organisation:	Marine & Coastal Management Division, Department Environmental Affairs and Tourism.
Address:	6th Floor, Foretrust Building, Martin Hammerschlag Way, Foreshore, Cape Town, Republic of South Africa.
Tel:	+27 (0)21 402 3342
Fax:	+27 (0)21 421 5342
Email:	gnxumal@mcm.wcape.gov.za

Ballast water reporting form database:

Name:	Ms Leticia Greyling
Organisation:	National Ports Authority
Address:	Room 617 Head Office, 101 De Korte Street, Braamfontein, Johannesburg, Republic of South Africa
Tel:	+27-(0)11-242-4144
Fax:	+27-(0)11-242-4260
Email:	leticiag@npa.com.za

Port environmental and risk species data:

Name:	Ms Leticia Greyling (port environment data)
Organisation:	National Ports Authority of South Africa
Address:	Room 617 Head Office, 101 De Korte Street, Braamfontein, 2000, Johannesburg, Republic of South Africa
Tel:	+27-(0)11-242-4144
Fax:	+27-(0)11-242-4260
Email:	leticiag@npa.co.za

Name:	Mr Adnan Awad (risk species data)
Organisation:	GloBallast – South Africa.
Address:	c/o National Botanical Institute, Private Bag X7, Claremont 7735, Republic of South Africa.
Tel:	+27 (0)21 799 8815
Fax:	+27 (0)21 797-1561
Email:	Awad@nbi.ac.za

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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 Saldanha Bay, South Africa

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 led by Ms Leticia Greyling (National Ports Authority of South Africa, Johannesburg) and Dr Rob Hilliard (URS Australia Pty Ltd). Mr Adnan Awad (Globallast Programme – South Africa, Cape Town) provided BWRA project logistical support, computing equipment and the collation of risk species information for Group C.

Group A (GIS mapping)

Person: Ms Ashleigh Schoultz
Position: Group A Leader - GIS cartographer
Organization: National Ports Authority of South Africa, Durban.

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

Person: Ms Gail Nxumalo
Position: Group A – GIS cartographer and port map data collation
Organization: Department of Environmental Affairs and Tourism (Marine & Coastal Management Division), Cape Town.
Email: gnxumal@mcm.wcape.gov.za

Group B (database BW records)

Person: Ms Nokuthula Buthelezi
Position: Group B Leader – data entry and correction of BWRF reporting forms
Organization: National Ports Authority of South Africa, Port of Richards Bay.

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

Person: Mr Lerato Liphoto
Position: Group B - data entry of NPA ship visit records
Organization: CSIR Environmentek, Stellenbosch.
Email: lliphoto@csir.co.za

Group C (port environment and risk species data)

Person: Ms Leticia Greyling
Position: Group C Leader – BWRA calculation and results analysis
Organization: National Ports Authority of South Africa, Johannesburg.
Email: leticiag@npa.co.za

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

Person: Ms Saras Mundree
Position: Group C – collation of port environmental data and multivariate analysis
Organisation: CSIR Environmentek, Durban.
Email: smundree@csir.co.za

Person: Mr Adnan Awad
Position: Group C – collation of risk species data
Organization: GloBallast Programme Office, South Africa
Email: Awad@nbict.nbi.ac.za

In addition, Ms Frauke Munster from CSIR Environmentek (Stellenbosch) joined the BWRA team for the first consultants visit only, and requested to move between the three groups to learn about the complete BWRA process.

Project Manager

Steve Raaymakers
Programme Coordination Unit
International Maritime Organization
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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)	Shipping record & port data specialist
Port environmental data searcher (x2)	
Environmental similarity analyst (x2) Risk species networker / biologist	BWRA specialist

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

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

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

<u>Provisional Dates for 1st Visit (5 working days)</u>

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

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

1st Visit Activities:

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

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

Environmental Data Requirements - see next page, attached.

ATTACHMENT

TYPES OF ENVIRONMENTAL DATA FOR PORT SIMILARITY ANALYSIS

The project requires two types of port environmental data:

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

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

In the case of the quantitative parameters, these include:

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

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

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

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

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

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

APPENDIX 4

Information sources used for collating Port Environmental Data

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

Continued over…

Distance to nearest river mouth Catchment size of nearest river with significant flow	Grand Atlas of India; Atlas of Soviet States (1974); Times Atlas of World; Readers Digest Atlas of Rivers & Lakes; MS Encarta Deluxe Reference Library World Atlas [watershed layer] (2003). C-Map World for Windows 3.03 [river layer] (2001). Atlas of People's Republic of China. Atlases of Africa, Iran, Japan, Korea, South America. Grand Atlas of Japan and North Asia (1996). Heibonsha Cartographic Publishing Co. Ltd, Tokyo.	NIO, IBSS, Meridian GIS Meridian GIS Meridian GIS, MSA CSIR, PSO, FEEMA,E&E.
Distance to nearest smooth artificial wall Distance to nearest rocky artificial wall distance to nearest wood pilings/structures Distance to nearest high tide salt marsh/saline flats Distance to nearest sand beach or sand bar Distance to nearest stony/pebble/shingle beach Distance to nearest low tide mud flat Distance to nearest mangroves Distance to nearest natural rocky shore Distance to nearest subtidal firm sands Distance to nearest subtidal soft mud Distance to nearest seagrass meadow Distance to nearest subtidal rocky reef or pavement Distance to nearest coral reef (carbonate framework)	Port plans, hydrographic charts, coastal resource maps, OSCP plans. Saifullah SM, Khan SH & Ismail S, 2002. Mar Poll Bull. 44: 570-576. Danulat E, Muniz P, Garcia-Alonso J, Yannicelli B, 2002. Mar Poll Bull 44: 554-565. National coastal resource maps; Field observations noted on hydrographic charts. Probyn T, Pitcher G, Pienaar R & Nuzzi R, 2001. Mar Poll Bull 42: 405-408. Hilliard et al. (1997). EcoPorts Monograph12, Ports Corporation of Queensland, Brisbane. Unpublished data from National Hydraulic Laboratory, Colombo, Sri Lanka. Red Sea habitat information from Drs H Shalaby & T Rouphael, UNDP program, Cairo. Colour aerial photographs, Landsat thematic images, coastal resource studies (various). Interactive world coral reef distribution maps, Reefbase (UNEP/ICLARM). Interactive world mangrove distribution map, Reefbase (UNEP/ICLARM). Seagrass distribution maps (Americas, Asia, Australasia, Europe-Med). McComb, A. et al (1992). Seagrasses of the World, Academic Press, UK. Dusek ML & Kitchens WM, 2003. Vegetation of the Lower Savannah River Delta. Florida Cooperative Fish and Wildlife Unit, University of Florida. Marine habitat maps web-published by the Biodiversity Centre, Nature Conservation Bureau, Ministry of Environment, Japan.	CFP-As, CSIR, DMU, E&E, FEEMA, IBSS, IEMA, Meridian GIS, MPT-JNPT, MEPA, MSA, NIO, NPA, PSO, SA, UFP, UFRJ, Meridian GIS. http://www.reefbase.org/DataPhotos/dat_gis.asp http://www.biodic.go.jp/site_map/site.html http://www.wec.ufl.edu/coop/Annual_Reports/Marsha%27s%2520poster.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	Longitude		E	Port Type	Water Temperatures (°C) [WT]				Summer Air Temp°C [SART]		Winter Air Temp °C [WART]		Salinities (g/L) [SAL]				Tidal Ranges (m)	
		Deg	Min	S	Deg	Min	W		Mean Summer	Maximum Summer	Mean Winter	Lowest Winter	Mean day-time	Maximum daytime	Mean night-time	Lowest night-time	Mean in Wet period	Lowest in Wet period	Mean in Dry period	Max in Dry period	Mean Springs	Mean Neaps
Name of Port	CODE	LAT			LONG			PTYPE	MSUWT	USUWT	MWNWT	LWNWT	MSART	USART	MWART	LWART	MWSAL	LWSAL	MDSAL	UDSAL	MSPR	MNER
Abu Dhabi	AEAUH	24	32.0	N	54	23.0	E	3	30.5	35.5	21.0	16.0	36.5	45.0	19.0	8.0	38.0	38.0	39.5	42.0	1.6	0.4
Mina Zayed	AEMZD	24	32.0	N	54	23.0	E	3	30.5	35.5	21.0	16.0	36.5	45.0	19.0	8.0	38.0	38.0	39.5	42.0	1.6	0.4
Das Island	AEDAS	25	9.0	N	52	52.0	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	38.0	37.5	39.0	40.5	0.6	0.2
Port Rashid	AEPRA	25	16.0	N	55	16.0	E	3	30.5	34.6	23.0	16.0	33.0	47.0	19.0	8.0	38.5	37.0	40.0	42.0	2.1	0.3
Dubai	AEDXB	25	16.0	N	55	16.0	E	3	30.5	34.6	23.0	16.0	33.0	47.0	19.0	8.0	38.5	37.0	40.0	42.0	2.1	0.3
Fateh Oil Terminal	AEFAT	25	36.0	N	54	31.2	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	38.0	37.5	39.0	40.5	0.8	0.2
Fujairah	AEFJR	25	10.0	N	56	21.0	E	1	30.0	32.0	22.0	16.5	32.8	40.0	24.0	14.0	35.5	35.0	36.0	37.0	1.8	1.0
Jebel Ali	AEJEA	25	0.0	N	55	3.0	E	3	30.5	34.6	21.0	16.0	31.0	47.0	23.0	8.0	38.5	37.0	40.0	42.0	1.1	0.2
Jebel Dhanna	AEJED	24	12.0	N	52	40.0	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	39.0	38.0	39.5	41.0	0.8	0.2
Khor Al Fakkan	AEKLF	25	24.0	N	56	22.0	E	1	30.0	32.0	21.5	16.5	32.8	42.0	24.0	14.0	35.5	35.0	36.0	37.0	1.8	1.0
Um Al Qiwain	AEQIW	25	36.0	N	55	37.0	E	4	30.5	34.6	21.0	16.0	31.0	47.0	23.0	8.0	38.5	37.0	40.5	42.0	1.1	0.6
Ruwais Oil Terminal	AERUW	24	7.8	N	52	43.8	E	1	30.0	35.2	22.5	16.9	31.0	42.0	21.5	12.0	39.0	38.0	39.5	41.0	0.8	0.2
Sharjah	AESHJ	25	22.0	N	55	23.0	E	3	30.5	34.6	23.0	16.0	33.0	47.0	19.0	8.0	38.5	37.0	40.0	42.0	2.1	0.2
Zirku Island	AEZIR	24	52.2	N	53	4.2	E	1	30.0	35.2	22.5	16.9	31.0	43.0	21.5	12.0	38.0	37.5	39.0	40.5	0.8	0.2
Buenos Aires	ARBUE	34	34.0	S	58	23.0	W	5	*24.0*	*27.0*	*15.0*	*13.0*	*26.0*	*34.0*	*5.0*	*0.0*	*10.0*	*0.0*	*15.0*	*25.0*	1.3	0.6
Campana	ARCMP	34	9.0	S	58	58.2	W	6	*24.0*	*27.0*	*15.0*	*13.0*	*26.0*	*35.0*	*4.0*	*-3.0*	0.0	0.0	0.0	0.0	0.0	0.0
Dampier	AUDAM	20	39.0	S	116	43.0	E	4	26.5	31.0	23.0	19.0	36.0	45.0	14.0	7.0	34.8	34.1	35.1	35.5	5.6	2.8
Port Walcott (Cape Lambert)	AUPWL	20	37.0	S	117	11.0	E	1	26.5	31.0	23.0	20.0	*36.0*	*45.0*	*14.0*	*7.0*	34.9	33.8	35.1	35.5	6.0	2.9
Port Bonython	AUPBY	33	1.0	S	137	46.0	E	2	20.0	22.0	14.5	12.0	27.0	35.0	7.5	1.0	36.1	36.0	36.2	36.3	2.6	1.6
Whyalla	AUWYA	33	1.8	S	137	24.0	E	3	19.5	21.5	14.5	12.0	28.0	36.0	5.8	0.5	35.4	35.1	35.5	35.8	2.3	1.6
Port Pirie	AUPPI	33	10.2	S	138	1.8	S	2	20.0	21.5	14.5	12.0	*28.0*	*36.0*	*5.8*	*0.5*	36.5	35.8	37.2	38.0	2.7	1.7
Port Stanvac	AUPST	35	6.0	S	138	28.0	E	1	20.5	22.0	14.5	13.0	26.0	39.0	14.0	3.0	36.3	35.8	36.4	36.5	2.1	1.4
Western Port (now Hastings; AUHAS)	AUWEP	38	18.0	S	145	13.2	E	2	18.0	20.0	13.5	11.0	25.2	34.0	6.5	-4.0	35.3	35.0	35.4	35.5	3.3	2.2
Port Kembla	AUPKL	34	28.2	S	150	54.0	E	3	18.5	21.0	17.5	15.0	25.0	36.0	8.8	0.0	34.5	32.0	35.2	35.6	2.0	1.1
Brisbane	AUBNE	27	22.8	S	153	9.6	E	5	24.0	27.0	20.0	17.5	29.2	39.0	9.0	2.0	26.0	4.0	33.0	35.0	2.3	1.3
Bundaberg	AUBDB	24	46.0	S	152	23.0	E	5	25.7	29.2	19.8	15.7	29.0	36.6	16.0	5.1	35.1	25.0	35.4	36.0	2.4	1.2
Gladstone	AUGLT	23	51.0	S	151	15.0	E	4	26.0	28.5	22.0	20.0	31.0	38.0	14.0	8.0	34.1	31.0	35.2	35.5	4.0	1.7
Port Alma	AUPTL	23	35.0	S	150	52.0	E	5	26.8	28.7	21.1	19.5	29.0	39.1	11.0	6.0	30.0	20.0	35.0	36.0	4.0	1.9
Hay Point	AUHPT	21	16.0	S	149	19.0	E	1	27.0	30.0	21.5	19.0	29.0	36.6	14.0	6.7	34.9	33.0	35.3	36.5	4.8	2.2
Dallrymple Bay (= Hay Point Anchorage)	AUPDT	21	16.2	S	149	19.2	E	1	27.0	30.0	21.5	19.0	29.0	36.6	14.0	6.7	34.9	33.0	35.3	36.5	4.8	2.2
Mackay	AUMKY	21	6.0	S	149	20.0	E	3	26.2	31.0	19.5	18.0	30.5	36.6	14.8	6.7	35.0	31.0	35.3	36.5	4.5	2.1
Abbot Point	AUABP	19	53.0	S	147	5.0	E	1	28.4	32.4	23.4	19.3	31.0	37.4	18.0	9.4	34.7	24.3	35.3	36.5	2.0	0.8
Townsville	AUTSV	19	15.0	S	146	50.0	E	3	28.2	32.4	23.0	19.0	31.5	40.8	15.5	6.0	34.7	22.0	35.0	36.2	2.3	0.6
Lucinda	AULUC	18	31.0	S	146	19.0	E	1	28.0	31.0	24.0	21.0	31.0	37.0	18.0	14.5	34.4	20.0	35.0	37.0	2.2	0.6
Mourilyan	AUMOU	17	37.0	S	146	7.0	E	5	30.0	33.0	27.0	23.0	31.0	38.5	18.0	8.4	33.0	9.0	35.0	36.0	1.8	0.5
Cairns	AUCNS	16	55.0	S	145	47.0	E	4	27.0	31.0	23.6	18.5	32.0	38.3	17.5	9.2	34.4	5.0	35.0	35.3	1.8	0.4
Cape Flattery	AUCQP	14	59.0	S	145	21.0	E	2	28.0	30.0	24.0	21.0	31.0	38.4	22.0	11.3	33.6	32.0	35.0	35.5	1.7	0.4
Weipa	AUWEI	12	35.0	S	141	36.0	E	5	30.0	33.0	28.5	24.0	33.0	37.0	19.2	12.5	33.0	20.0	35.0	36.0	2.2	0.7
Karumba	AUKRB	17	29.0	S	140	50.0	E	6	30.0	32.0	28.0	24.0	32.0	38.0	18.5	14.2	24.0	0.0	35.0	39.0	3.3	2.5
Chittagong	BDCGP	22	13.0	N	91	48.0	E	5	29.0	32.4	25.0	19.0	30.0	33.0	19.0	13.0	2.0	0.0	7.0	12.0	4.9	2.1
Antwerpen	BEANR	51	14.0	N	4	28.0	E	6	*17.0*	*20.0*	*5.0*	*0.0*	21.5	30.0	2.2	-4.0	0.0	0.0	0.0	0.0	0.0	0.0
Ghent (Gent)	BEGNE	51	4.2	N	3	42.0	E	6	17.0	20.0	5.0	0.0	21.0	28.0	1.8	-5.0	0.0	0.0	0.0	0.0	0.0	0.0
Bourgas	BGBOJ	42	30.0	N	27	28.8	E	3	24.2	26.5	6.5	0.5	24.5	38.0	4.3	-16.0	17.0	16.4	18.1	19.5	0.1	0.0
Varna, Bulgaria	BGVAR	43	12.0	N	27	57.0	E	3	21.7	25.9	5.9	-0.5	24.0	38.0	3.5	-17.0	16.8	16.1	17.9	19.3	0.1	0.0
Sitra (Bahrain)	BHMAN	26	9.0	N	50	40.0	E	1	32.0	35.0	17.0	14.0	36.5	45.0	18.0	12.0	40.0	38.0	42.0	43.0	1.6	0.9
Mina Sulman (Al Manamah)	BHMIN	26	13.0	N	50	36.0	E	3	*32.0*	*35.0*	*17.0*	*14.0*	*36.5*	*45.0*	*18.0*	*12.0*	40.0	38.0	42.0	43.0	1.8	0.9
Itajai	BRITJ	26	54.0	S	48	39.7	W	6	26.2	28.0	19.1	17.5	23.0	30.6	17.6	1.3	3.0	0.0	4.9	15.0	1.2	0.3
Paranaguá	BRPNG	25	30.1	S	48	31.5	W	5	27.5	30.0	21.4	13.0	22.0	40.0	17.2	2.4	20.5	10.5	27.0	34.0	1.6	0.4
Santos	BRSSZ	23	55.0	S	46	20.0	W	4	26.5	30.5	21.5	17.0	23.7	39.0	19.0	6.4	28.0	24.0	28.5	33.5	1.3	0.4
Sepetiba	BRSPB	22	55.3	S	43	51.0	W	2	22.0	25.5	19.0	17.2	25.4	38.2	22.0	11.1	30.5	20.0	30.5	34.0	1.4	0.7
Rio de Janeiro	BRRIO	22	53.8	S	43	11.0	W	2	27.5	31.0	23.4	19.0	25.4	38.2	22.0	11.1	23.4	17.2	27.6	30.9	1.2	0.9
Ponta do Ubu	BRPOU	20	47.0	S	40	35.0	W	1	24.0	27.0	23.0	21.0	25.8	39.0	22.7	14.2	36.0	35.0	37.0	39.0	1.4	0.6
Vitória	BRVIX	20	19.2	S	40	19.1	W	5	25.0	28.0	22.0	20.0	25.8	39.0	22.7	14.2	20.5	12.0	27.0	34.0	1.3	0.5
Praia Mole	BRPRM	20	17.3	S	40	14.5	W	3	24.0	27.0	23.0	21.0	25.8	39.0	22.7	14.2	36.0	35.0	37.0	39.0	1.3	0.4
Tubarao	BRTUB	20	17.3	S	40	14.6	W	3	24.0	27.0	23.0	21.0	25.8	39.0	22.7	14.2	36.0	35.0	37.0	39.0	1.3	0.4

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

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

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

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

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

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

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	Driest 6 months	Wettest 6 months	No. of months for 75%	Distance to River Mouth (km)	Size of River Catchment (km^2)	Smooth artificial wall/jetty	Rocky artificial wall/jetty	Wood post/piles	High tide salt marsh	Sand beach	Stony Beach	Low tide mud flat	Mangrove	Natural rocky shore	Firm sands	Soft mud	Seagrass meadow	Rock reef /seafloor	Coral reef
Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
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

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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