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Ballast Water Risk Assessment

Port of Khark Island
Islamic Republic of Iran

AUGUST 2003

Final Report

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

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**Chris Clarke*, Terry Hayes*, Rob Hilliard*,
Nasser Kayvanrad+, Hassan Taymourtash+,
Ahmad Parhizi+, Vahid Yavari+ and
Steve Raaymakers#**

*Meridian GIS Pty Ltd, Perth, Western Australia
+Ports & Shipping Organisation, Ministry of Road and Transportation, Islamic Republic of Iran
#Programme Coordination Unit, GEF/UNDP/IMO Global Ballast Water Management Programme, International Maritime Organization

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International Maritime Organization
4 Albert Embankment, London SE1 7SR, UK
Tel +44 (0)20 7587 3251
Fax +44 (0)20 7587 3261
Email sraaymak@imo.org
Web http://globallast.imo.org

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Acronyms

BW	Ballast water
BWM	Ballast water management
BWRA	Ballast Water Risk Assessment
BWRF	Ballast Water Reporting Form (the standard IMO BWRF is shown in Appendix 1)
CFP	Country Focal Point (of the GloBallast Programme in each Pilot Country)
CFP/A	Country Focal Point Assistant
CRIMP	Centre for Research on Introduced Marine Pests (now part of CSIRO Marine Research, Hobart, Tasmania)
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
DSS	Decision support system (for BW management)
DWT	Deadweight tonnage (typically reported in metric tonnes)
GCC	Gulf Cooperation Council
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
IHO	International Hydrographic Organization
IMO	International Maritime Organization
I.R.	Islamic Republic of
IUCN	The World Nature Conservation Union
LAT	Lowest Astronomical Tide
MESA	Multivariate environmental similarity analysis
MEPC	Marine Environment Protection Committee (of the IMO)
NCC	National Cartographic Centre (I.R. Iran)
NIMPIS	National Introduced Marine Pests Information System (managed by CSIRO, Australia)
NIS	Non-indigenous species
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
PSO	Ports & Shipping Organisation, Ministry of Roads & Transportation (I.R. Iran)
ROPME	Regional Organization for the Protection of the Marine Environment (the ROPME Sea Area comprises the coastal and marine waters of Bahrain, Iraq, Islamic Republic of Iran, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates)
ROR	Relative overall risk
RSA	ROPME Sea Area
SAP	(Regional) Strategic Action Plan
SERC	Smithsonian Environmental Research Center (Washington DC, 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.
Baseline port survey	A biological survey to identify the types of introduced marine species in a port.
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).
Risk	The likelihood and magnitude of a harmful event.
Risk assessment	Undertaking the tasks required to determine the level of risk.
Risk analysis	Evaluating a risk to determine if, and what type of, actions are worth taking to reduce the risk.
Risk management	The organisational framework and activities that are directed towards identifying and reducing risks.
Risk species	A species deemed likely to become a harmful species if it is introduced to a region beyond its natural range, as based on inductive evaluation of available evidence.
Translocation	The transfer of an organism or its propagules into a location outside its natural range by a human activity.
Unintentional introduction	An unwitting (and typically unknowing) introduction resulting from a human activity unrelated to the introduced species involved (e.g. via water used for ballasting a ship or for transferring an aquaculture species).
Vector	The physical means or agent by which a species is transferred from one place to another (e.g. BW, a ship's hull, or inside a shipment of commercial oysters)

Lead agencies

Lead Agency for BW Issues in the Islamic Republic of Iran:

Contact person:	Mr Hassan Taymourtash
Position:	Director General of Safety and Maritime Protection Department and GloBallast Country Focal Point
Organization:	Ports and Shipping Organization, Ministry of Road and Transportation
Address:	No 751 Enghelab Avenue Tehran 1599661464 ISLAMIC REPUBLIC OF IRAN
Tel:	+98 21 8809555
Fax:	+98 21 8809367
Email:	taymourtash@ir-pso.com
Web:	www.ir-pso.com

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

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

This report describes the BWRA activity undertaken for the Port of Khark Island, which is the Demonstration Site managed by the Ports & Shipping Organisation (PSO) of the Islamic Republic of Iran. This capacity-building activity commenced in January 2002, with Meridian GIS Pty Ltd (Meridian) contracted to the GloBallast Programme Coordination Unit (PCU) to provide BWRA training and software. Under the terms of reference, the consultants worked closely with their in-country counterparts in a project team co-managed by Meridian and PSO for completing all required tasks. These tasks required two in-country visits by the consultants (in May and December 2002) to install the BWRA software and provide 'hands-on' instruction and guidance. Most of the data collation tasks were undertaken before, between and during these visits, with gap-filling work undertaken by the consultants prior to a short 'project wrap-up' visit in February 2003.

The first step was to collate data from IMO Ballast Water Reporting Forms (BWRFs) submitted by arriving ships 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 Khark Island by PSO. These records also help establish which next ports of call may have been a destination port for any BW taken up at Khark Island.

A multivariate procedure was then used to identify the 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, 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 are poorly known.

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

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

During each visit the consultants worked alongside their Pilot Country counterparts to provide skills-transfer as part of the capacity building objectives of the programme, with the project team divided into three groups. Group A mapped the port and its resources using ArcView GIS. This group included counterparts from I.R. Iran's National Cartographic Centre (Tehran) who provided much of the required GIS data in digital format. Group B was responsible for managing the customised Access database supplied by the consultants, and for entering, checking and managing the BW discharge data, as recorded on the BWRFs voluntarily submitted by arriving ships and/or derived from the port's shipping records. Group B used the database to identify BW source and destination ports, and it is designed for ongoing input and management of BWRFs. Group C undertook the environmental matching and risk species components of the Activity, using the PRIMER package to perform the multivariate analyses for determining the environmental distances between Khark Island 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 therefore established in Tehran 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. Seventeen source ports provided the top 20% of the total cumulative threat for the Port of Khark Island (in terms of their BW source frequency, volume, environmental similarity and assigned risk species). They were led by Kaohsiung in Taiwan Province (ROR = 0.229; S-ROR = 1.0), followed by five Middle East ports (Jebel Ali, Doha, Umm Said, Fujairah, and the Red Sea oil reception terminal at Ain Sukhana). Highest risk ports beyond the Middle East were Okinawa and Chiba (Japan) and Ulsan (Korea). The majority of ports in the next group were located in South and East Asia, including ports in India (2), Sri Lanka (1), Japan (7), China (1), Taiwan Province (1), Korea (2) and Philippines (1). Only one European port attained a 'high risk' category (Eleusis in Greece).

Low risk source ports were in north Europe, North America and South Africa, plus some in South and East Asia. The lowest risk port was the Port of Come by Chance, located in Newfoundland (Canada). The generally much higher threat of introductions posed by BW sources in the Middle East and Asia than in north America and Europe (an order of magnitude difference) is logical with respect to Khark Island's geographic location and current pattern of trade. The results also implied that any introduced species which establishes in a port in the ROPME Sea Area, or nearby Red Sea and west Arabian Sea, could be readily spread by local ship movements involving shuttle services, bunkering and/or part-loading of cargo.

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 the RSA, Next and Last Port of Call involving bunkering, crew-change or cargo top-up visits added to the problem. In the case of the Port of Khark Island, this was not a issue since almost all visiting ships arrive to collect liquid or dry bulk cargo. However, 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 Activity were successfully completed during the 13 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 I.R. Iran. 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 of the Port of Khark Island. This places the Islamic Republic of Iran in a strong position to provide assistance, technical advice, guidance and encouragement to other port States of the ROPME Sea Area.

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1 Introduction and Background

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

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

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

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

A port State may wish to apply its BW management regime uniformly to all vessels that call at its ports, or it may wish to assess the relative risk of 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,
- risk species data, and
- ballast water discharge risk coefficients.

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

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

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

This report describes and presents the results of the first Ballast Water Risk Assessment (BWRA) carried out for the Port of Khark Island, Islamic Republic of Iran, during 2002. This GloBallast Demonstrate Site is a major oil export terminal which is located in the north-west part of the ROPME Sea Area (Figure 2).

Figure 2. Location of Khark Island and other ports in the ROPME Sea Area

2 Aims & Objectives

The aims of the GloBallast BWRA for the Port of Khark Island 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 Khark Island 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 Khark Island.
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 Khark Island 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 Khark Island via standard IMO BWRFs.
6. Characterise as far as possible from existing data, the physical, chemical and biological environments for both Khark Island and each of its source and destination ports.
7. Develop environmental similarity matrices and indices to compare the Port of Khark Island 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 Khark Island, 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 of Khark Island was conducted by Meridian GIS Pty Ltd (Meridian), under contract to the GloBallast Programme Coordination Unit (PCU). 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.

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. The majority of tasks subsequently undertaken for the Port Khark Island were completed during two in-country visits by the consultants (2-9 May and 7-23 December 2002), with information searches and data collation undertaken by both consultant and pilot country team members between and after these visits. A two-day 'project wrap-up' visit was subsequently made by one of the consultants in February 2003.

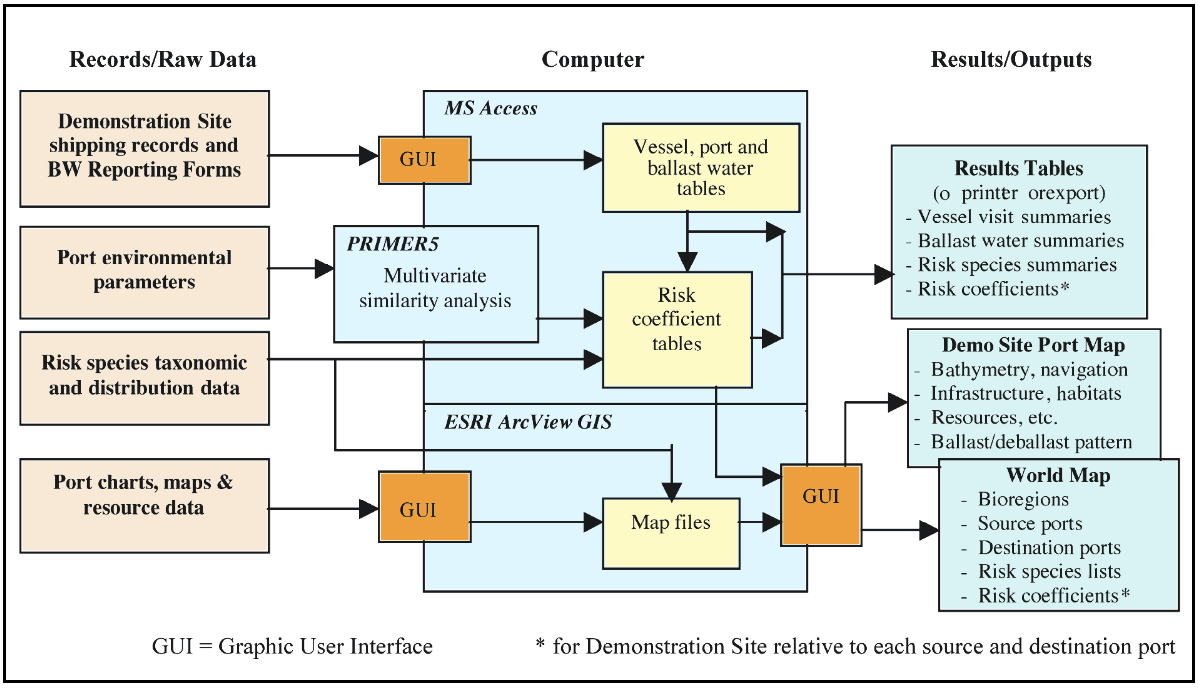

Figure 3. Schematic of the GloBallast BWRA system

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

- Install and test the Access, ArcView and PRIMER software and the functionality of the computer system at the Ports & Shipping Organisation (PSO) head offices in Tehran.
- Familiarise the project team with the GloBallast BWRA method by seminar and work-shopping.
- Commence GIS training and developing the port map for the Demonstration Site.
- Commence training on the use of the various Graphic User Interfaces (GUI) of the Access Database for inputting and editing BW discharge data.
- Visit Khark Island to obtain port shipping records, tour the port facilities and obtain habitat and coastal resource information.
- Review the port shipping records and available 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, the environmental and risk species data were added to the database, more vessel arrival, BW and voyage data were entered and checked, the first BWRA was undertaken, and a workshop was held to review the initial results and identify future actions.

During the third visit on 16-17 February 2003, the consultants supplied PSO with updated versions of the database and *BWRA User Guide* on CD-ROM, which included additional source port environment and risk species data (as obtained from the BWRA Activities conducted at the other five Demonstration Sites). The results of the February 2003 version 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.

NB. The requirement for arriving ships to submit IMO-style BWRFs (Appendix 1 and down-loadable from http://globallast.imo.org/guidelines) to the relevant port State authorities is a fundamental and essential first basic step for any port State wishing to commence a ballast water 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

[2] Several port States (e.g. Australia) and Demonstration Sites (e.g. Dalian, Odessa) have produced their own BWRFs, the latter using a translated format 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 4.12.

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 Australia Pty Ltd and other sources; Appendix 3).

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

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

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

3.2 Resource mapping of the demonstration port

The port resources were mapped using ArcView GIS to display the bathymetric, navigational and infrastructure features, including habitats and social-cultural features.

The National Cartographic Centre (NCC) in Tehran did not have an electronic chart covering Khark Island in digital format at the time of the first visit, but indicated a detailed hydrographic survey had recently been completed and that electronic bathymetric data would be available before December 2002. Thus the bathymetry and some navigational data were acquired digitally from a CARIS electronic chart provided by the NCC during the consultant's second visit.

[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.

NCC also supplied two 1:25,000 topographic sheets (6048 II NW and 6048 I SW) covering Khark Island, and these were acquired from a Microstation DGN format file, together with two 1:25,000 nautical charts of the neighbouring coast (Bandar Rig and Bandar Genaveh) in the same format. A small scale chart of the northern ROPME Sea Area (RSA) was also acquired. The topographic sheets were imported into ArcView and combined, and relevant data for the port map was also extracted from the other files. Features taken included the major roads, large buildings, tanks and cultural sites.

The Iranian nautical chart showing the port and its approaches (I.R. Iran Series No. 11; Jazireh-Ye Khark to Ganaveh) was also scanned for digital capture at 300 dpi. This chart also shows the nearby mainland coast and has small-scale insets showing the export terminals and small boat harbours at Khark Island. The images were registered in ArcView enabling extraction of relevant data including annotated habitat details collected during the team's port visit in May 2002. The latter comprised the boundaries of certain intertidal, subtidal and artificial marine habitats that were annotated to this chart during the port visit.

The scope of the port map therefore includes the rocky Khark Island and its nearby sand cay, the port's approaches and anchorage areas, and part of the adjacent mainland coastline. Symbols based on the international IHO/IALA system were used to depict navigational features. For clarity and convenience of data management and display, each 'theme' of information was added as a separate layer that were standardised as shown in Figure 4.

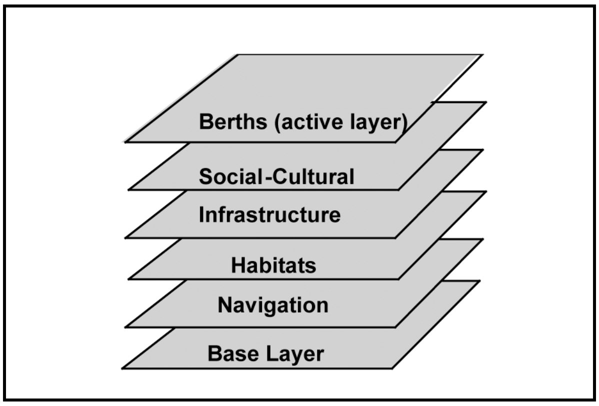

Figure 4. Thematic layers used for the Port Map GIS

The protocol for each layer is described in the GloBallast *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 Khark Island comprised:

- The island and mainland coastlines (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).

Some key land features, including main roads, hill tops, towers and other prominent structures, were also added to the base layer. The colour scheme of this layer closely followed that of standard nautical charts to maintain the familiar 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 symbols were therefore developed for this purpose, using the UK Hydrographic Office Chart No. 5011 (= IHO INT 1) as the main source for all point and pattern symbols.

Habitat Layer: This layer used a standardised, logical colour scheme to facilitate recognition of the main intertidal and subtidal habitat types in and near the port. It contains all habitat information obtained from the field observations and benthic sampling data from the PBBS, together with the annotations made by the BWRA team during the port tour. The latter was undertaken by launch, on foot and snorkelling during 6-7 May 2002, with the boat inspection including a full circumnavigation of the island. Colour 35 mm photographs and a 45 minute VHS video were obtained to record significant features. Delineation of some boundaries for the habitat layer was supplemented from features displayed by the nautical charts. These included the upper and lower boundaries of sand beaches, rocky shores, cliff lines, high tidal lagoons and marsh areas, and fringing coral reef. Symbols on the same charts that denoted the presence of sand, mud or rocky seafloor also helped fill in gaps.

Infrastructure Layer: This shows the key components of the port and its surrounding accommodation and petroleum processing and export facilities, including the main tank farms, small boat harbour, large buildings and other visually dominant structures on Khark Island.

Social-Cultural Layer: Features added to this layer included the urban and accommodation area used by the port and oil terminal workers, mosques and significant shipwrecks that have been essentially left undisturbed and respected as war grave sites. There is no dedicated fishing port on Khark Island, nor any recreational, commercial or mariculture fishery areas, so these type of social resources were not present for adding to this layer.

Berth Layer: An ‘active’ berth layer was added to show the principal berthing and anchoring areas at the Port of Khark Island. Their names and numbering system were supplied by PSO island staff. The same nomenclature was also used for the berthing area information stored in the Access database, to allow display of statistical summaries of the BW source and discharge data on the correct locations of the GIS port map (the GloBallast *BWRA User Guide* shows how the database-GIS link is established).

3.3 De-ballasting/ballasting patterns

The deballasting/ballasting patterns at Khark Island were ascertained during the port visit (6-7 May 2002) where a meeting was held with the PSO Harbour Master to confirm the range of overseas and domestic trade, pilotage and draft requirements, anchorage areas and deballasting/ballasting practises and locations. Port shipping records were also inspected during this visit, and batches of these were identified for photocopying to enable data verification and extraction at the PSO offices in Tehran.

Further information was obtained from the BWRFs that PSO had introduced to the Port of Khark Island in April 2000, plus analysis of the port shipping records for periods/visits where BWRFs were unavailable or incomplete[4]. It was relatively simple to determine where and which vessels probably discharged BW by identifying their type and berthing location, because the port has dedicated liquid and dry bulk export terminals plus a small vessel harbour where the various supplies and construction materials for operating the terminals and onshore facilities are imported. Most of the latter cargo arrives in coastal craft which have no ballasting requirement when unloading.

3.4 Identification of source ports

To provide confidence as to which ports are the predominant sources of BW discharged at Khark Island, a sample of approximately 1500 vessel visits was generated by collating information on as many ship visits as possible over the previous three years (March 1999 - November 2002) and adding

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

the details to the Access database. Source ports were therefore identified from the BWRFs, and from batches of photocopied shipping record sheets obtained from PSO's Khark Island office for March 1999 and subsequent months.

BWRFs were first collected from arriving ships by PSO staff at Khark Island in April 2000, and the number of ships voluntarily submitting these forms was close to 40 per month in the first year (i.e. approximately 60% of total arrivals). The forms were initially sorted by source port and country then entered into the database. Before a new port was added to the database, the port and country name spelling, its location coordinates, bioregion and unique UN Port Code number were checked using the Lloyds *Fairplay World Ports Guide* and world bioregion list in the database (port data input is detailed in the GloBallast *BWRA User Guide*).

Completed BWRFs for April and May 2000 (85) were cross-referenced with the port shipping records for the same period (140 visits). Of the 55 visits where ships had not (or incorrectly) completed a BWRF, 25 were mostly product and gas tankers shuttling between the Bandar Abbas refinery in southern I.R. Iran and Khark Island. The remaining 30 were crude oil tankers and two bulk carriers loading sulphur (Section 4.3).

For vessels arriving before BWRFs were requested by PSO, or which submitted incomplete or did not submit forms, details were obtained from the PSO port shipping records. However these records show only the *Last Port of Call*, which may not be the BW source. To confirm which last ports of call were probable BW sources (and avoid allocating a bunkering, crew-change or maintenance port as such), cross-checks were made of the source ports and last ports of call reported in other BWRFs. The Lloyds *Fairplay Port Guide* and *Lloyds Ship Register*[5] were also used to confirm source port trade and the vessel's IMO identification number, vessel type and DWT of arriving ships respectively.

Many gaps in the port shipping records or BWRFs could therefore be filled by checking, for any arrival, the vessel name, type and DWT, its previous visit history, last port/s of call and apparent charter/liner trade, and by using a customised Excel spreadsheet supplied by the consultants to estimate the amount BW discharged or taken up[6] (Figure 5).

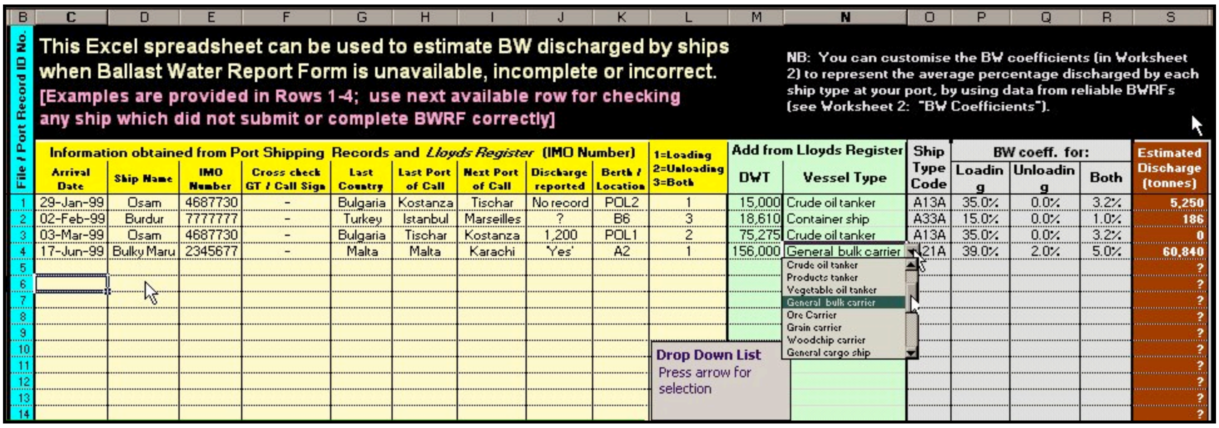

Figure 5. Working page of the Excel spreadsheet used to estimate BW discharges

The BWRFs were also analysed for completeness and accuracy. In the case of unusual (or missing) BW values, these were checked using the same Excel spreadsheet to determine likely volumes based on vessel type, DWT, last port/source port and loading record. This BWRF checking and gap-filling

[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*.

exercise was undertaken by Group B team members working in Tehran and Khark Island before and during the second in-country visit, with the database of almost 1500 vessel visits constructed by:

- entering visit details from the port shipping records for the pre-BWRF period (March 1999-April 2000) on the Excel spreadsheet, and using the *Fairplay Port Guide* and *Lloyds Ship Register* to add or correct port details, vessel names, IMO ship numbers, types and DWTs; and
- cross-checking incomplete, unusual or missing BWRFs with port shipping records, using the *Lloyds Ship Register*, *Fairplay Port Guide* and the Excel spreadsheet to correct errors or add missing data[4,5].

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

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

In the case of the Port of Khark Island, there is little import of bulk cargo except for some fuel products brought by a shuttle tanker from the Bandar Abbas refinery. Although the vast majority of ships departing Khark Island have no or very little BW on board, the next ports of call were added to the vessel visit data and examined, so that the Pilot Country team could gain experience for BWRAs undertaken for a more cargo import/BW export-oriented port.

Adding the next port of call also improves the trading history for each vessel, and these can be useful when trouble-shooting missing or incorrect BWRF data. As with the source ports, any new next port of call added to the database was provided with its country name, UN Port Code, world bioregion and location coordinates to enable its frequency of use by departing vessels to be displayed on the GIS world map (port input details are in the GloBallast *BWRA User Guide*).

3.6 BWRF database

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

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

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

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

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

Without these items the database cannot save a visit / tank record or any other associated information. Whether or not a saved record is included by the database for the risk analysis depends on which other BWRF fields were completed or gap-filled. Key items are the source port and volume for each (or all) ballast tanks discharged, and the berthing location. As described in Sections 3.4 and 3.5, important BWRF information that is missing or incorrect can usually be substituted or corrected by cross-checking with port shipping records, the *Lloyds Ship Register* and a comprehensive port directory such as the *Fairplay* guide. However this is time-consuming, and it is far more efficient and reliable for port officers to ensure the BWRF has been filled in correctly and completely at the time of submission (Section 4.12).

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

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

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

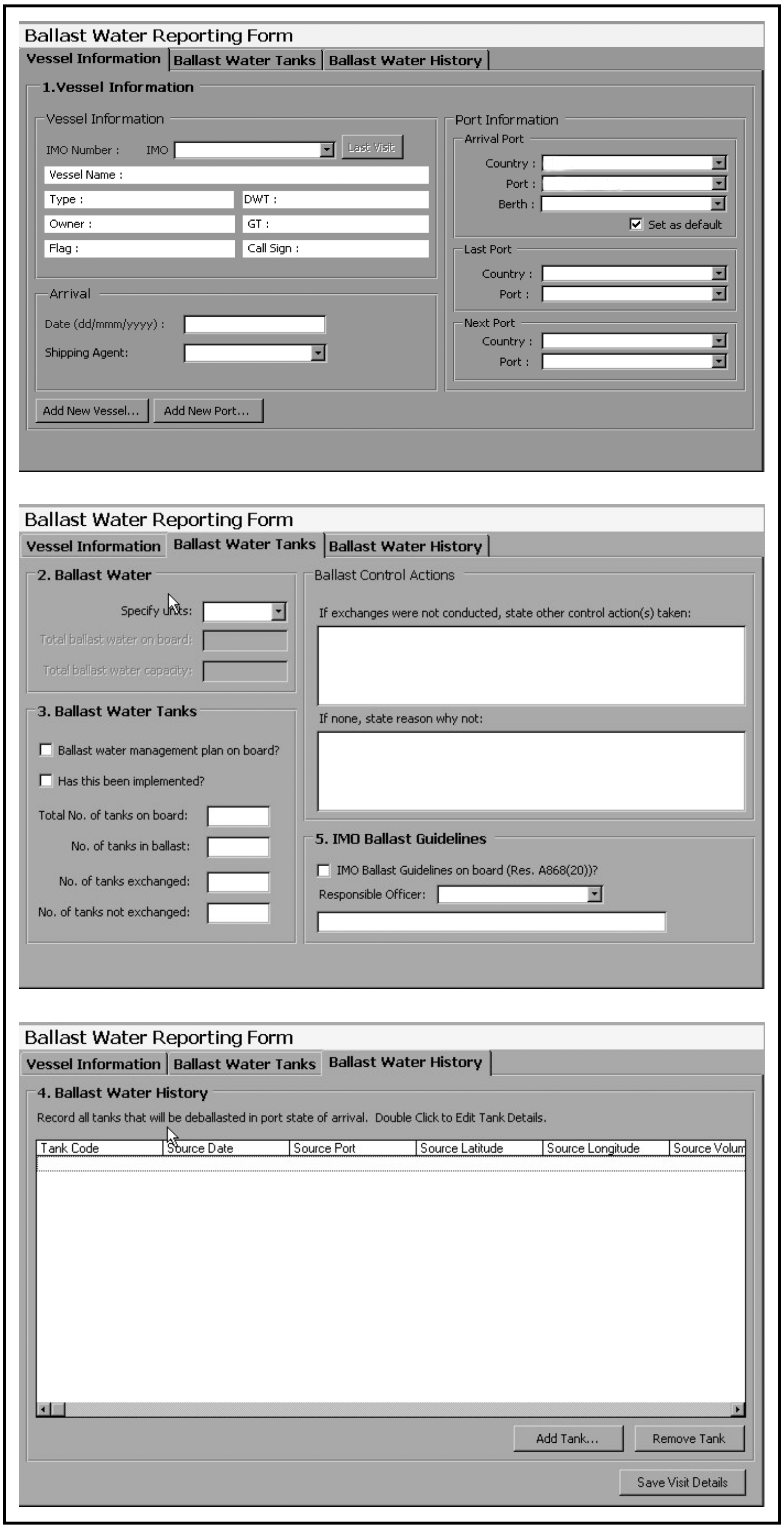

Figure 6. The three tabs of the GUI used for entering the BWRF data

3.7 Environmental parameters

During the briefing meetings in January 2002, the consultants provided a preliminary list of environmental parameters that would be used to generate the environmental matching coefficients between the Demonstration Sites and their main BW source ports and destination ports (Appendix 3). The provisional list was based on review of previous port-to-port environmental analyses undertaken for twelve trading ports in northeast Australia (Hilliard *et al*. 1997b). The final list of 34 parameters used for the six Pilot Countries (Table 1) was selected in February 2002, during a joint review of the provisional list by the consultants and scientists of the Institute of Biology of the Southern Seas (IBSS) in Odessa[7].

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

	Name	Variable Type
1.	Port type[8]	Categorical (1-6)
2.	Mean water temperature during warmest season (°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,

7 Distance categories from the berthing area/s to the nearest rocky artificial wall, smooth artificial wall and wooden artificial substrate were suggested by IBSS as they provide different types of hard port habitat.
8 Offshore terminal or mooring / Natural bay / Breakwater harbour / Tidal creek / Estuary / River port.
9 Kelp forest/macroalgae bank was not included but should be considered for future analysis.

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

A preliminary list of frequently recorded BW source ports and destination ports for the Port of Khark Island was made at the end of the first in-country visit in May 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 PSO's Group C members focussing on ports in and near I.R. Iran, and the consultants focussing on more distant ports in Asia, Europe, etc. To facilitate this task the consultants provided a customised Excel spreadsheet for collating the environmental data, which included guidance and reminder notes plus a format enabling direct export to PRIMER (Section 3.8).

Near the end of the second in-country visit, sufficient port environmental data had been collated to generate environmental matching coefficients for approximately 40% of all ports identified as trading with the Port of Khark Island, 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 with PSO in February 2003 (Section 3.1) and reported here.

3.8 Environmental similarity analysis

The more a BW receival port is environmentally similar to a ballast water source port, the greater the chance that organisms discharged with arriving BW can tolerate and remain in their new environment in 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 and establishment. This is the basis of the 'environmental matching' method, and it facilitates estimating the risk of ballast water 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 relates to the fact that some harmful species may have the ability to tolerate a relatively wide range of 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).

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

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

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11 While ecosystem disturbance, pollution, eutrophication and other impacts on habitats and water quality can increase the 'invisibility' 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.

bioregions for several large river systems to accommodate some important river ports that trade with one or more of the Demonstration Sites. 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).

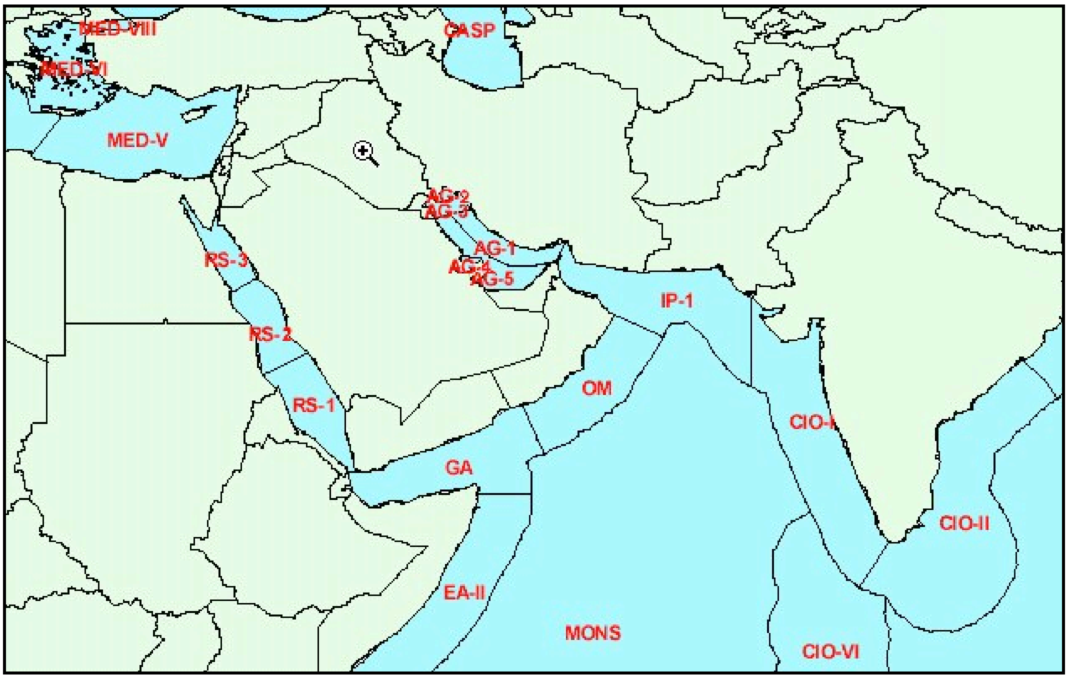

Figure 7. Part of the GIS world map of marine bioregions, showing the code names of the regions in and near the ROPME Sea Area

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 molluscs and dinoflagellate cysts found by the recent GloBallast PBBS of Khark Island (which became available during the second consultants visit). Some of the provisional dinoflagellate identifications and one gastropod identification (*Cavolinia tridentate*) represent range extensions into the northern RSA. PSO members of Group C also investigated the possible existence of introduced species lists held by marine biologists in agencies and universities in the RSA and Arabian Sea regions but none could be found.

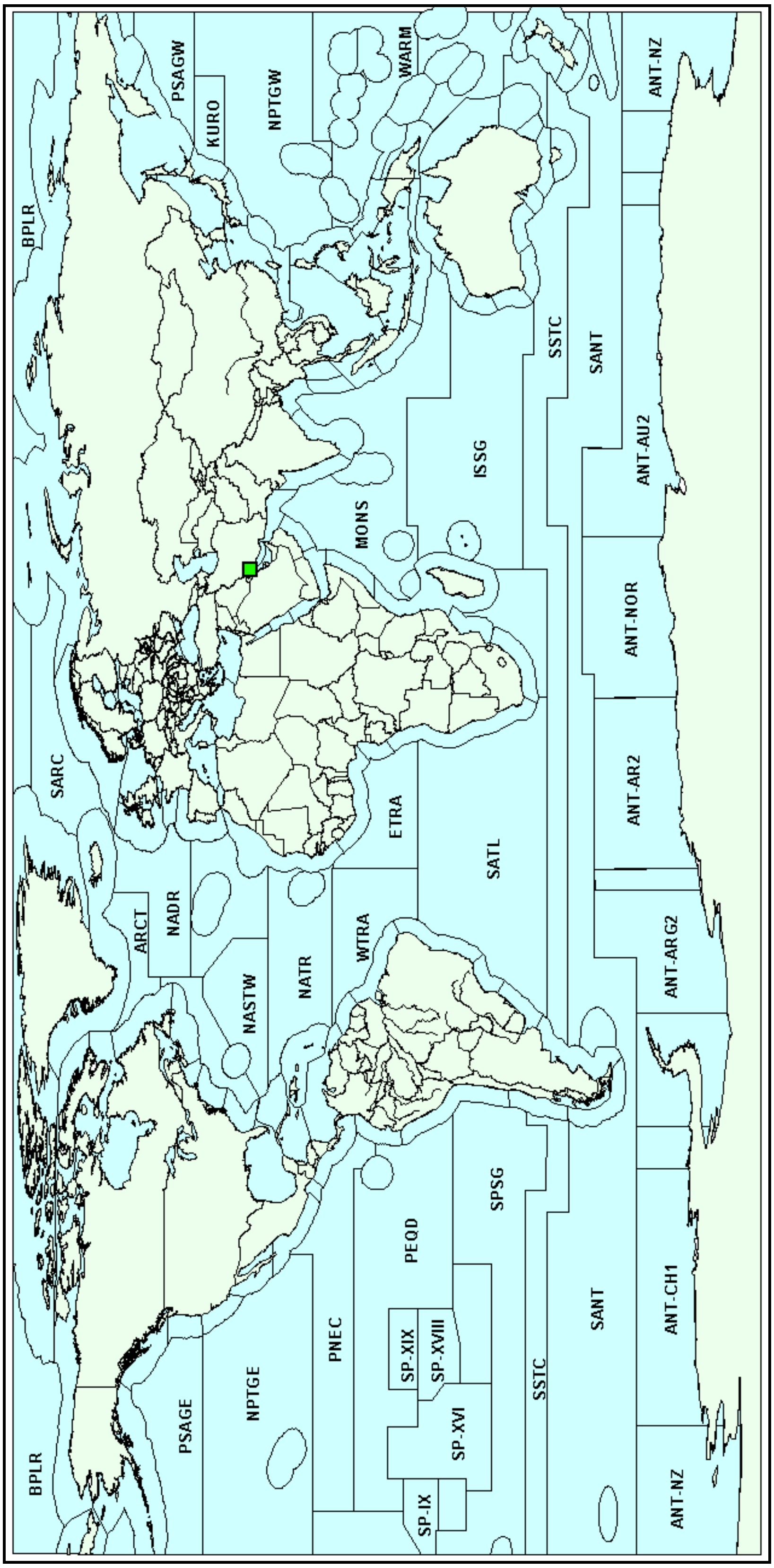

Figure 8. Complete GIS world map showing the marine bioregions
[to improve clarity, not all bioregion codes are shown in this example]

Sources used for developing the risk species database are listed in Appendix 5 and included a range of literature plus international and regional internet databases, including those being developed by the

Smithsonian Environmental Research Center (SERC), CSIRO's National Introduced Marine Pests Information System (NIMPIS), the Global Invasive Species Programme's (GISP) Global Invasive Species Database, and the Baltic, Nordic and Gulf of Mexico web sites. The database used for the 'first-pass' risk assessments and provided to the Demonstration Sites during the consultants last visit (February 2003) contains 421 species, but these do not represent a complete or definitive global list. Thus the database tables and their associated Excel reference file represent a working source and convenient utility of risk species information that can be readily updated and improved.

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

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

- **Lowest threat level**: This is assigned to species with no special status other than their reported or strongly suspected introduction by BW and/or hull fouling[14] in at least one bioregion (i.e. population/s with demonstrated genetic ability to survive transfer and establish in regions beyond their native range). A fixed weighting (1) is applied to each of these species when present in bioregions outside their native range. This was also the default level assigned to any new species when first added to the database.

- **Intermediate threat level**: This level is assigned to any species suspected to be a harmful species or invasive pest. Risk species assigned to this level receive a default weighting value of 3 in both their native and introduced bioregions.

- **Highest threat level**: This level is assigned to known harmful invasive species, as reported in institutional or government lists of aquatic nuisance species and pests, and/or in peer-reviewed scientific journals. The default weighting value applied to these species is 10.

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

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

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[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 <u>al</u>l 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.

[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

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:

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

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 BWRA are 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, *inter alia* :

- 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).
- Reliance on a restricted list of 'target' species that are known to be invaders in certain areas, but ignoring the possibly huge number of native species and unknown introduced species potentially present in source ports that may well be potential invaders at the receival port.
- Reliance on an extremely restricted knowledge of the distribution (both native and introduced) of the 'target' species, derived from extremely limited and restricted (both spatially and temporally) survey and monitoring efforts.
- Severe limitations in global understanding of general marine taxonomy, biodiversity, biogeography and environmental tolerance ranges of marine species.
- 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 ballast discharge, environmental matching and 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 the discharges of water and associated organisms that had been ballasted at each source port. A GUI enabling convenient alteration of the risk calculations and weighting values, plus use of ArcView to geographically display results, improves the system's value as an exploratory utility and demonstration tool.

'first-pass' BWRA such as reported here for Khark Island, but the revised database should not be copied for other port BWRAs.

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

Risk coefficients and risk reduction factors

For each source port, the database uses 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 used for the first-pass BWRA. The four risk coefficients calculated for each source port by the database are:

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 that comprise 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 are 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 shown 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.

[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.*

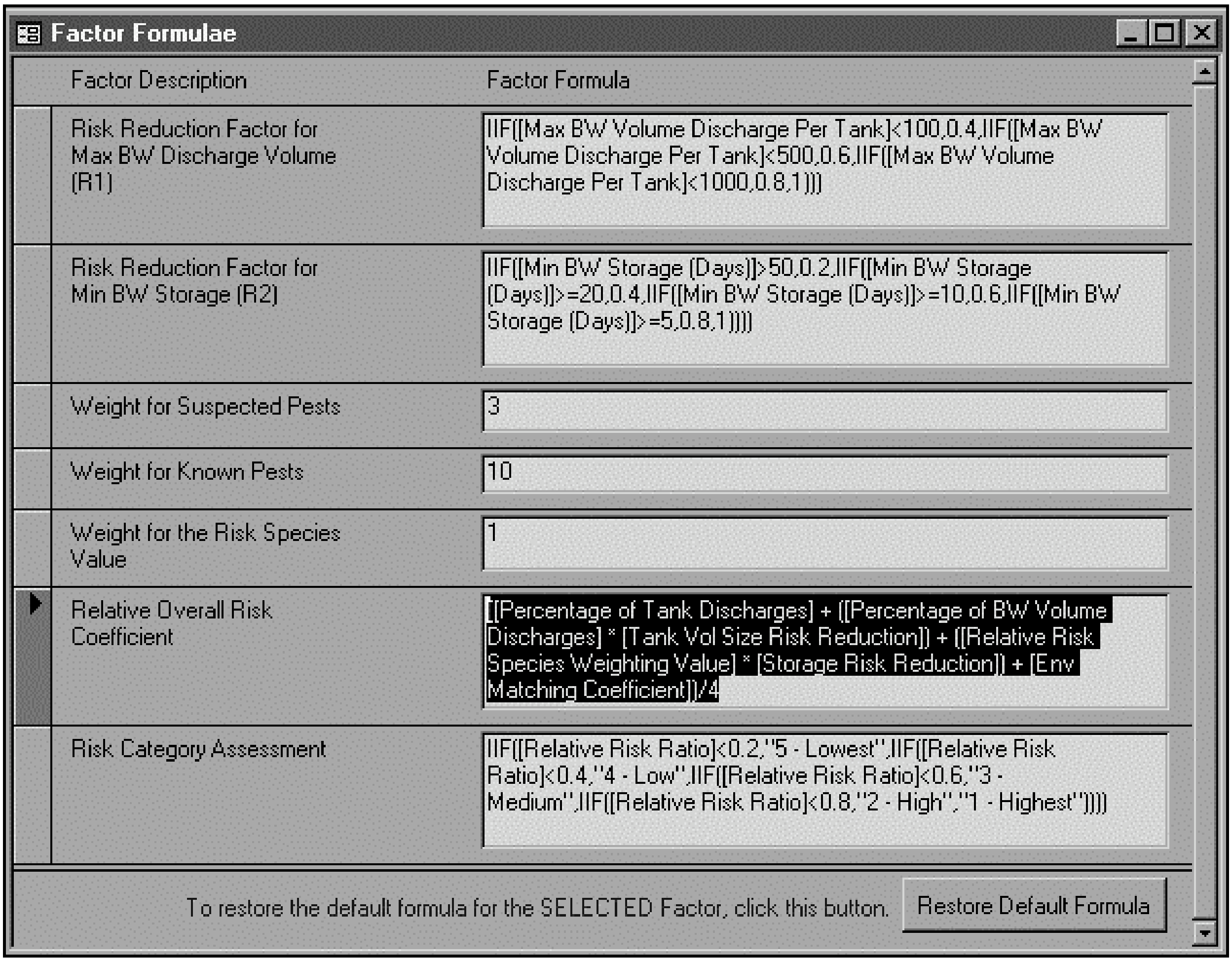


Figure 9. Database GUI used for manipulating the BWRA calculation and weightings

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);

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

- BWRF implementation was generally on a voluntary basis, with no formal mechanism compelling all vessels to submit fully completed forms at Khark Island;
- insufficient vessel inspection/ tank monitoring data were available for checking claimed exchanges and their locations (often unrecorded);
- discounting whether or not effective exchange/s were taking place (a) removed the need to predict the size of the risk reduction, and (b) was precautionary with respect to the ability of exchanges to remove all organisms taken up at the time of ballasting.

BWRA Calculation

As shown in Figure 9 and described in the GloBallast *BWRA User Guide*, the database GUI allows the six components of the BWRA calculation and the five weighting factors to be altered from the default, '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 that 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 (i.e. at relatively high C4 such as 0.2) but with an environment very dissimilar to the Demonstration Site (e.g. C3 = 0.2), then Equation (2) would reduce C4 by 0.04 (i.e. an 80% reduction). If the minimum tank storage time was relatively long (e.g. R2 was between 10-20 days for the quickest voyages, so W5 = 0.6), then C4 would be further reduced to 0.024 (i.e. an 88% reduction to its initial value).

Equation (2) is logical provided the database contains an accurate distribution of appropriately weighted risk species in the various 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 less influence on the size of C4.

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

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

Managing and displaying the results

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

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

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

Occasion/ Date [working days]	*BWA Activity Tasks*	*Consultants*	*Location and Counterparts**
Activity Kick-Off January 2002 [1.5 days]	Presentation, briefing and logistics meetings to: • Identify equipment and counterpart requirements • Develop provisional pilot country visit schedule	R Hilliard	NIO Offices in Goa. CFP/CFPAs from all Pilot Countries
1st Country Visit May 2002 [7 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	C Clarke T Hayes R Hilliard	PSO offices at Tehran and Khark Island. Group A counterparts Group B counterparts Group C counterparts

2nd Country Visit December 2002 [12 days]	• Update Database GUIs, add-ins & make ODBC links • Continue training and capacity building • Complete GIS mapping of port and resources • Complete BWRF database development and training • Complete port environmental data assembly/training • Complete environmental similarity analysis training • Generate environmental matching coefficients • Add risk species data to database, refine bioregions • Complete BWRA training and undertake first analysis • Hold seminar to review and discuss results • Discuss pilot country needs for future BWRA	C Clarke T Hayes R Hilliard	PSO Offices, Tehran Group A counterparts Group B counterparts Group C counterparts
3rd 'Wrap-up' Visit February 2003 [2 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	PSO office, Kish Is. Group A leader Group B leader Group C leader

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

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

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

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

- Guidance, ‘hands-on’ training and glossaries of terminology on the collation, checking, gap-filling and computerisation of BWRFs and principles of database management.
- Guidance and assistance on (a) search, collation and computer entry of environmental data for important BW source and destination ports, and (b) the terminology, networking, data collation and management requirements for species information used for the risk species threat coefficient.
- Tutorial, ‘hands-on’ training and assistance on theory, requirements and mechanics of multivariate similarity analyses of port and coastal environmental data.
- Tutorial, guidance, ‘hands-on’ training, seminars and PowerPoint material on BWRA approaches, methods and results evaluation.
- Supply of electronic *BWRA User Guide* with glossaries and technical appendices.

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

During the first consultant’s visit, the PSO leader of Group B arranged a demonstration of a prototype BWRF database that had been developed in Tehran. This was a self-extracting Delphi application using a ‘flat-sheet’ binary code database to facilitate the import, edit, management and export of BWRF data. The prototype did not use the tank discharges as the principal unit and had few features for accelerating data input, checking and protection, and was therefore not used. However some of its output features had user-friendly data selection and export/printing features and these were emulated in the revised database. The prototype was also revised and subsequently circulated to the other Pilot Countries by the PCU.

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, collating and checking the following BWRA components:

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

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

4 Results

4.1 Description of port

General features

The Port of Khark Island is located in the north-western end of the ROPME Sea Area (RSA) at 29^o 14.0' N and 50^o 19.0' E, and approximately 20 km to the nearest parts of I.R. Iran's mainland coast (Figures 2,11). It is a relatively small limestone rocky island (~50 km^2) with an undulating central escarpment and steep terraces. The latter terminate at the shoreline to form rocky ledges separated by narrow sand beaches. Much of the immediate sublittoral zone is a generally narrow and shallow platform (0-2 m LAT) which terminates at a fringing reef that slopes steeply into deeper waters (10-20 m LAT). Immediately north of the island is a low-lying, elongate and uninhabited sand cay supporting a partly vegetated ridge and surrounded by a fringing coral reef (see Section 4.2 for habitat details and maps).

The majority of Khark Island is occupied by infrastructure and facilities for the reception, processing and export of petroleum products and dry bulk sulphur and rock. Development of Khark Island commenced in the late 1950s and 1960s. The port is now one of the world's largest crude oil export terminals, with exports typically exceeding 75 million tonnes per annum.

Climate and weather

The divergent seasonal climate comprises very hot, arid summers with variable sea breezes and cool and generally dry winters dominated by cool northerly winds. Mean day-time temperatures regularly exceed 32^{o}C during summer (maxima to 47^{o}C) while night-time temperatures regularly fall below 17^{o}C in winter (minima to 7^{o}C). Rainfall is low, with over 75% of the annual average (156 mm) occurring in late winter-early spring (January-April). An annual wind rose showing the dominance of the northerly winds, which is typical of the RSA, is shown in Figure 10.

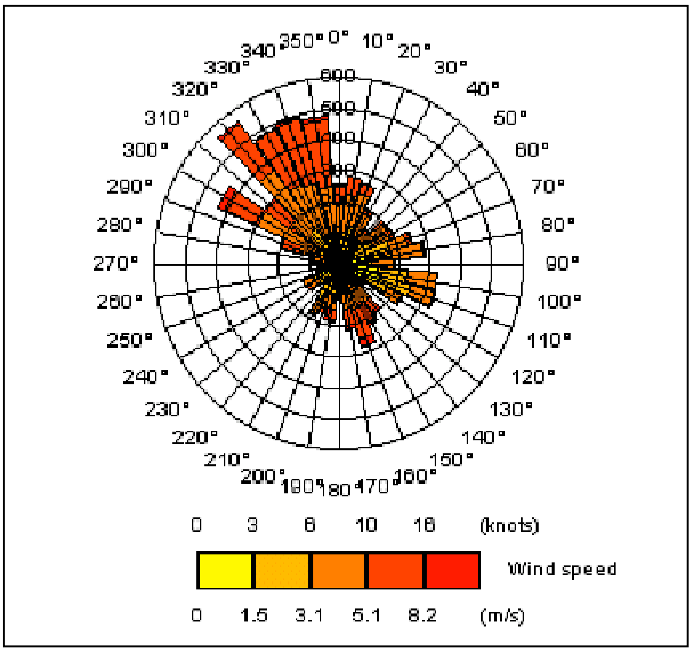


Figure 10. Annual wind rose typical of the RSA region (supplied by GEMS)

Hydrodynamic conditions

There has been no local hydrodynamic study at Khark Island that provides detailed water movement plots suitable for adding to the port map as a special layer. However the consultants were able to obtain broad-scale tidal plots for the RSA from Dr G. Hubbert (Global Environmental Modelling Systems (GEMS), Melbourne). Plots of the spring tide cycle are shown in Figure 11. These were generated by the GEMS three-dimensional Coastal-Ocean Model (GCOM3D) in a collaborative study with the US Navy Research Laboratory. The model is calibrated to local tide gauge data (sites are shown on Figure 11, including Khark Island) and it reveals the complexity of tidal-driven water movements in the RSA owing to the presence of amphidromic points (i.e. locations with zero tidal rise and fall).

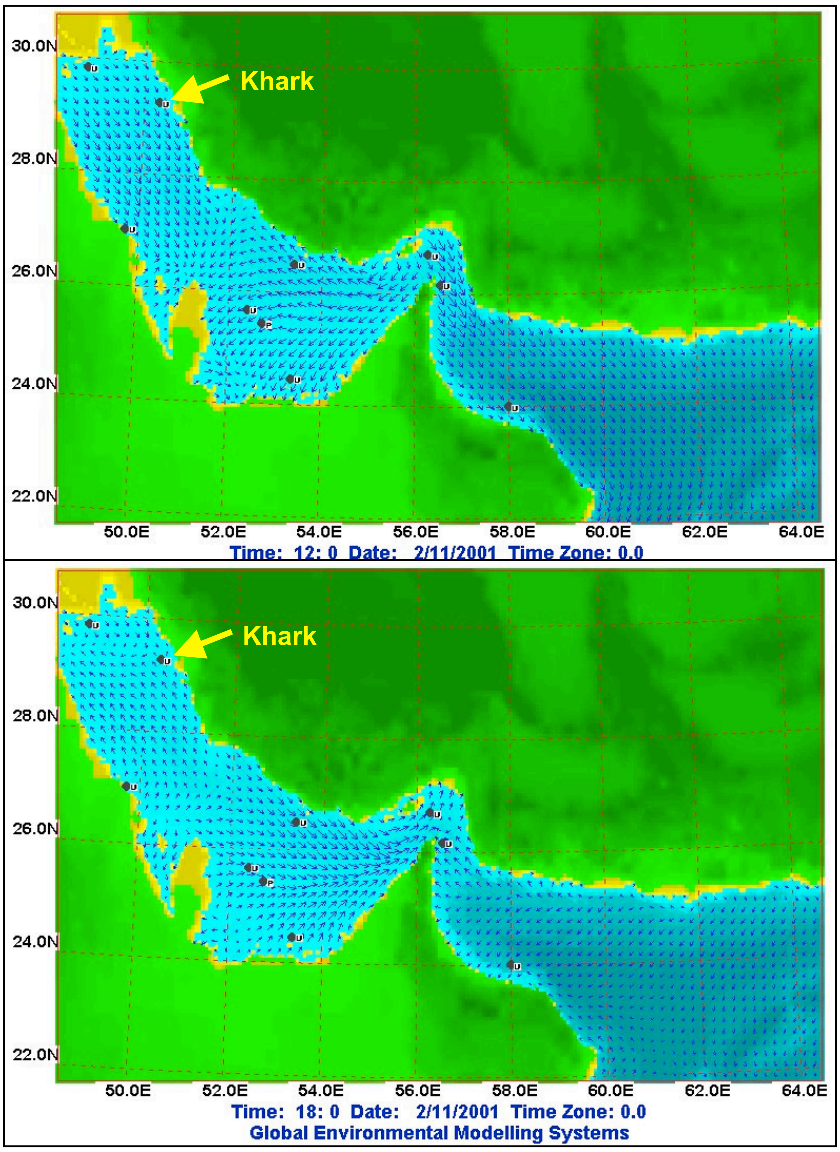


Figure 11. GCOM3D predictions of wind- and tidal-driven surface currents during strong northerly winds and spring tides, showing the complex circulation pattern and model verification locations in the RSA. Bottom plot shows the opposing tidal phase (supplied by GEMS, Melbourne).

Tidal currents at Khark Island are not particularly strong owing to the relatively small tidal range, which is close to 1.0 m during springs and 0.3 m during neaps. Strongest flows can be expected off the northern and southern tips of the island during spring flood and ebb tides, in directions past Khark Island that are generally parallel to the mainland coast.

During periods of strong north-westerly winds (as in the model outputs shown in Figure 11), the spring tidal flows provide little evidence of any net residual or 'background' surface water drift to the north-west or west in the Khark Island region. The latter is associated with a generally anti-clockwise surface current gyre which has been reported to frequently operate in the northern sector of the Gulf. This gyre is linked to both wind- and density-driven flows, including the movement of lower density surface waters from the Tigris and Euphrates rivers to the north, and from the oceanic waters moving into the RSA from the Straits of Hormuz and along the Iranian coast. The latter inward flow is linked to the significant evaporation losses within the RSA plus the underlying outward flow of dense hypersaline waters.

As shown in Figure 12, the shore-parallel flows past Khark Island are diminished when winds weaken or shift to the north and north-east (most frequent from winter to late spring /early summer). At these times there can be a significant offshore drift at Khark Island that is almost perpendicular to the coast, and forms part of the gyre that develops in the northern half of the RSA. The path of the gyre is depicted by the red arrows in Figure 12, which also shows how tidal currents can contribute to the gyre. The plots in Figures 11 and 12 therefore indicate that the majority of planktonic organisms deballasted at Khark Island, plus any locally produced planktonic eggs, larvae or other propagules, will tend to drift either parallel or away from I.R. Iran's mainland coast under most metocean conditions. The same pattern of movement is also known to have caused oil historically spilled near the Iranian coastline to eventually become deposited along parts of the central Saudi Arabian coastline.

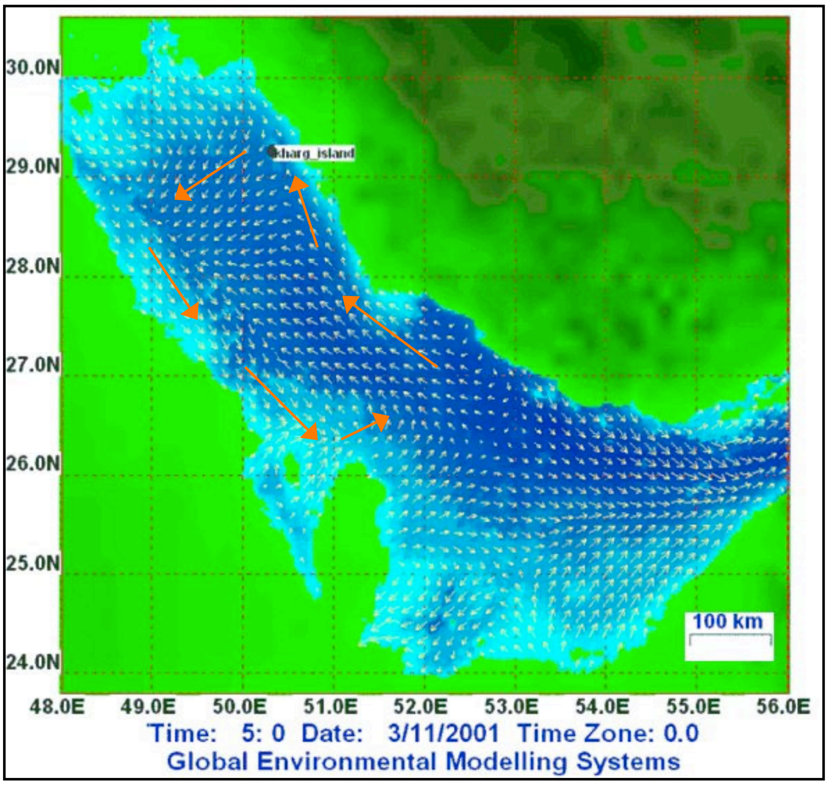


Figure 12. GCOM3 output for neap tide currents and weak northerly winds, plus red arrows depicting start of anti-clockwise gyre (supplied by GEMS, Melbourne).

Port development and maintenance

The Port of Khark Island contains the following three berthing areas and small vessel harbours:

- **Sea Island Terminal**: this is located just beyond the 20 m depth contour (iso-bath) on the west side of the island, and handles the deepest draft crude oil carriers, including the ULCCs and most VLCCs.

- **T Jetty**: Located on the east side of the island, berths on the T Jetty handle the smaller crude oil carriers and product tankers.
- **Chemical Jetty**: Located south of the T-Jetty, these berths plus the nearby gas mooring handle the chemical tankers, dry bulk carriers and gas tankers.
- **Small vessel harbours**: Local supply vessels are handled in the small harbour on the north-east corner of the island. The other small harbours are located near the base of the T Jetty, and these handle the tugs, line boats, patrol boats and port authority launches.

The three terminals and small vessel harbours of the port are shown in Figures 13.

Because of the naturally deep and open waters near the island, no significant capital dredging was required for developing the export berths, their approaches or the turning areas. Thus no routine maintenance dredging of the berths and approaches has been required. The basins of the small vessel harbours were developed by excavation and back fill, and they are protected by small, shore parallel rocky breakwaters.

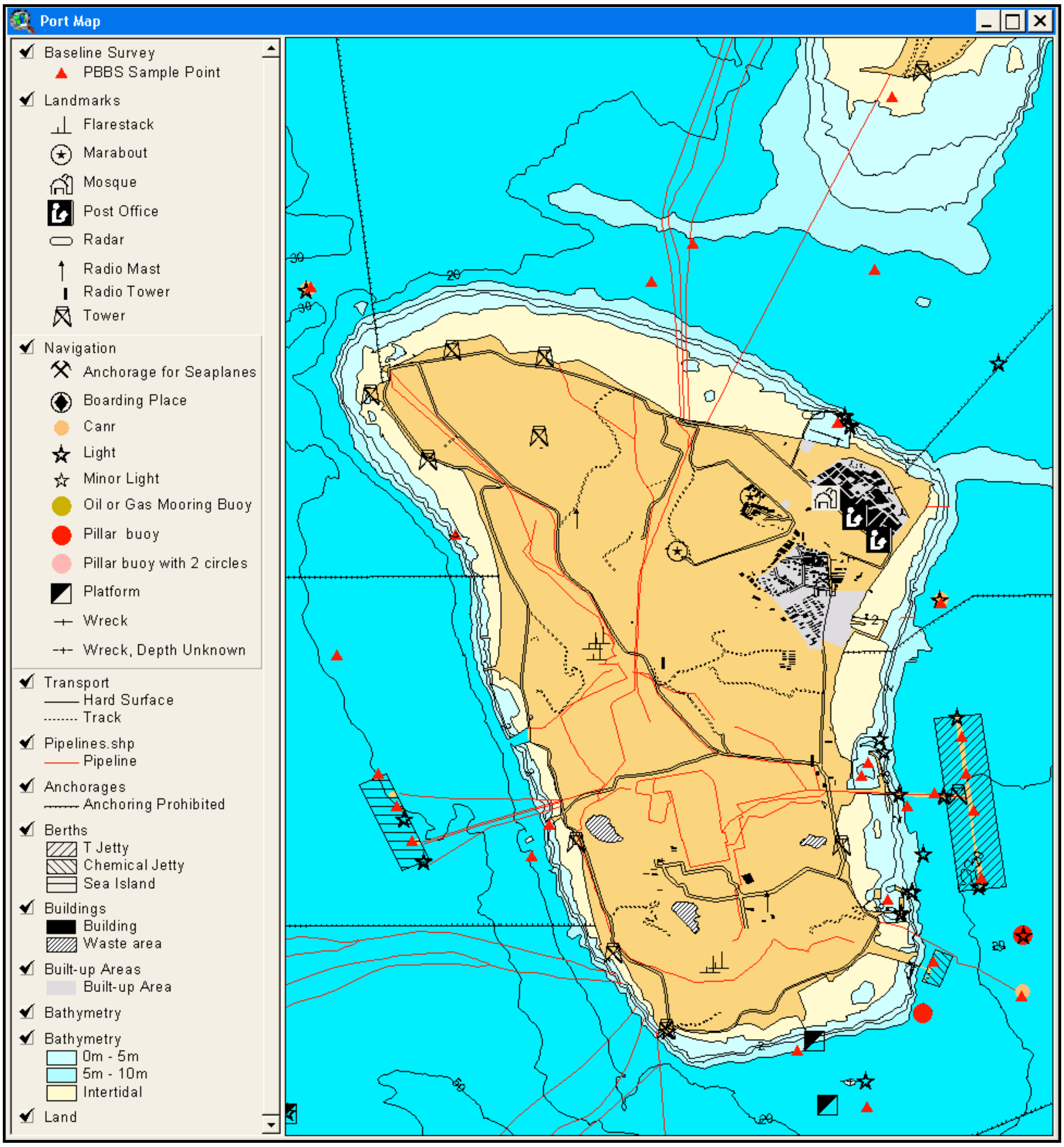


Figure 13. Part of the GIS Port Map showing navigation, infrastructure and the active berth layer for Khark Island.

4.2 Resource mapping

The subtidal habitats displayed on the GIS Port Map (Figure 14) show the following:

- Fringing coral reef slope (= with carbonate reef structure from corals and coralline algae).
- Sandy seafloor (= sands, muddy sands, shelly sands) – occurs in shallower areas off the base of fringing reef slopes.
- Muddy seafloor (= muds, sandy muds, shelly muds) – occurs in the deeper offshore areas.

There are no locally significant seagrass or seaweed beds (e.g.*Halodule, Laminaria, Dictyotis*, etc), although small patches of *Halodule* seagrasses are scattered along parts of the sandy reef platforms that skirt Khark Island and its neighbouring sand cay. The intertidal habitats of Khark Island comprise the following:

- Narrow rocky shore, reinforced in some areas with additional rock, masonry and concrete.
- Very narrow linear and pocket sand beaches which rim the top edge of the intertidal reef platform.
- Rocky breakwaters of the small vessel harbours.
- Intertidal reef platform with sandy veneers (most widely exposed during extreme low spring tides).

There are no high tidal salt flats, marsh areas or mangrove forests at the port. Muddy shorelines supporting mangroves fringe the nearby mainland coast, and this habitat is included on the GIS port map (it can be seen when the map is zoomed out or moved to the north-east). There are no gazetted or officially declared wildlife reserves, nature sanctuaries, seabird breeding sites or fish nursery areas, although the uninhabited island immediately north of Khark Island (Figures 13a, 14) is recognised by PSO as a relatively undisturbed area with coral reef, fish and wildlife conservation values.

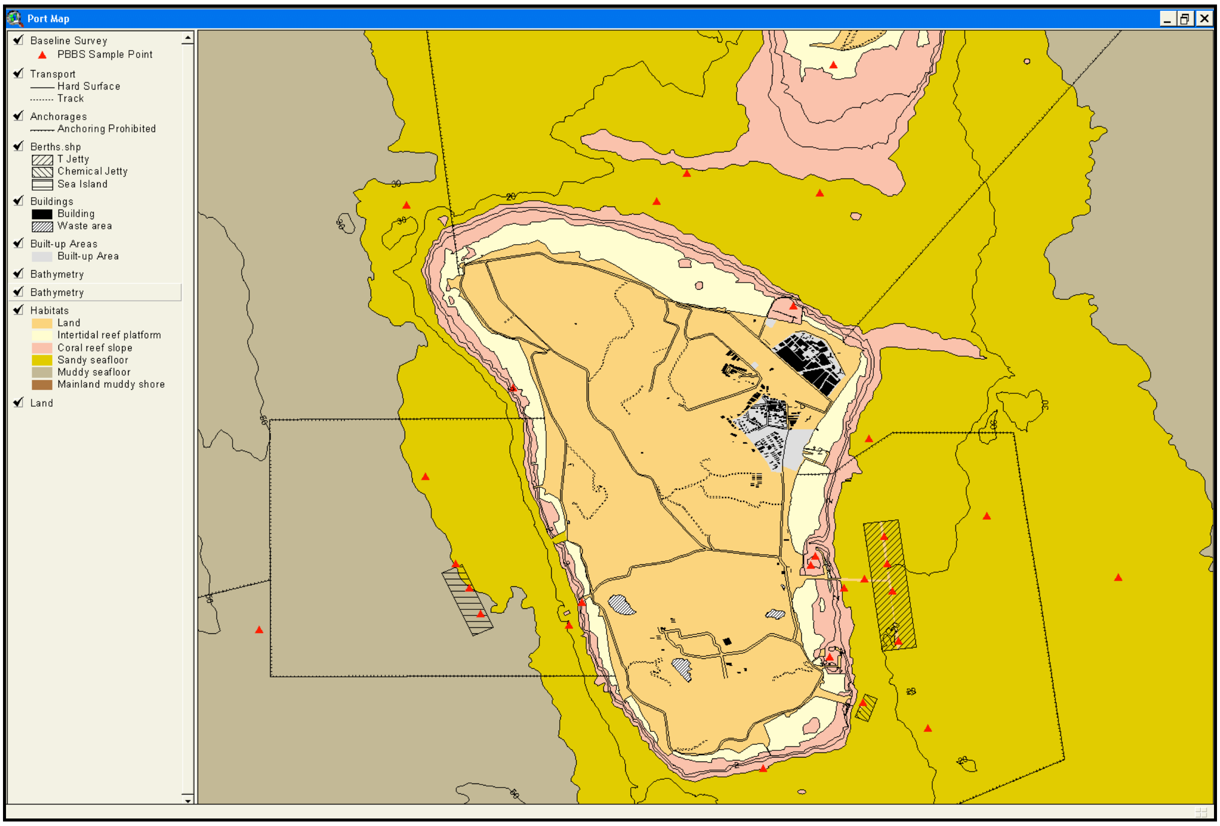


Figure 14. Part of the GIS Port Map showing the marine habitat layer.

The GIS port map shows the locations of the PBBS sampling sites (red triangle symbols; Figures 13, 14), so that results from the final survey report can be connected to these points at a later stage. The map also depicts the key navigational and offshore production features around the port, including the undersea production and export pipelines and the onshore pipelines (red lines). There are no geological or hydrological onshore features such as significant hilltops, local streams or tidal creeks, but the excavated areas containing groundwater seep/rainfall ponds and process water evaporation traps have been marked. The location of the roads, petroleum processing facilities and urban accommodation areas on Khark Island are shown, including the post offices and main mosque (Figure 13a).

4.3 De-ballasting/ballasting pattern

It was not difficult to establish the deballasting/ballasting pattern for the Port of Khark Island because it contains bulk export facilities and terminals only. The small vessel harbour where the various supplies and construction materials are received for operating the processing facilities and terminals is serviced by small coastal craft which do not have a ballasting requirement when unloading. Import of any bulk quantity of fuel is occasionally undertaken by the NITC (National Iranian tanker Company) tankers that shuttle between the refinery at Bandar Abbas and the T Jetty. It was therefore relatively straightforward to check which arrivals might have taken up BW and where this occurred (i.e. the T Jetty).

During the port meeting with the harbour master and chief pilot in May 2002, the deballasting practises of the arriving crude oil and dry bulk carriers were discussed. Because of the lack of swells in the enclosed RSA, vessels entering the RSA through the Straits of Hormuz (Figure 2) have usually already discharged any additional heavy weather ballast they may have required in the Indian Ocean.

By the time vessels reach Khark Island, they typically contain between 80-100% of normal ballast, unless they have already visited another terminal in the region for part-loading of cargo. The latter is not a common practise owing to the increased costs of making two port visits to load, and is generally restricted to the large, deepest draft carriers that can achieve a full load only at the deepest berths such as the Sea Island terminal at Khark Island.

As in other ports, the PSO port rules require arriving ships to retain sufficient ballast on board to maintain stability and steerage control and minimise windage until berthing is completed. Windage is very significant in the winter and spring months due to the strong northerly winds.

Over the March 1999 - November 2002 period covered by the shipping record and BWRF collation exercise, there were a total of 1489 vessel visits, with only a tiny percentage needing to uptake as opposed to discharge BW (i.e. a few of the product tanker visits from Bandar Abbas which delivered fuel and did not load crude oil in other tanks for the return journey). Of the 1489 visits, 444 were mostly ULCCs (ultra large crude carriers; >300,000 DWT) and VLCCs (very large crude carriers; 200,000 - 300,000 DWT) visiting the Sea Island terminal. Visits to the T-Jetty by some of the VLCCs and the smaller crude carriers totalled 946. Chemical tankers, LPG tankers and dry bulk carrier visits to the Chemical Jetty totalled 99 (the majority were chemical tankers).

The largest crude oil carrier visiting the port in 1999-2002 was the ULCC *Sea Giant* (555,051 DWT), with 52 other ULCCs making one or more visits. Over the same period the number of different VLCCs and smaller crude carriers which made at least one visit was 221 and 107 respectively. The number of different product tankers and chemical tankers visiting the port in this period was 16 and 32 respectively.

The database records the amount and sources of the BW of these arrivals, as taken from the BWRFs (2000-2002) and/or derived from the port shipping records (1999-2000). 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, as displayed by the GIS Port Map, are shown for each of the three terminals in Figures 15-17.

Because the database must accept and manage individual tank discharges as discrete units (as recorded in IMO standard BWRFs), the need to treat all BW tanks as a single entity for vessels arriving prior to the introduction of BWRFs at Khark Island, or which submitted incomplete BWRFs (Section 3.6), reduces the number of individual tank discharges actually made in 1999-2002 whilst inflating the mean and maximum tank discharge volumes. Thus the latter reflect the total ballast water capacity of the largest visiting vessels (Figures 15-17). This causes a more conservative outcome in terms of the BWRA results, but it is worth recognising that a database containing individual tank data collated from, say, a 12 month set of fully completed BWRFs will produce more precise BW source port values for the C1, C2 and R1 components (Section 3.10).

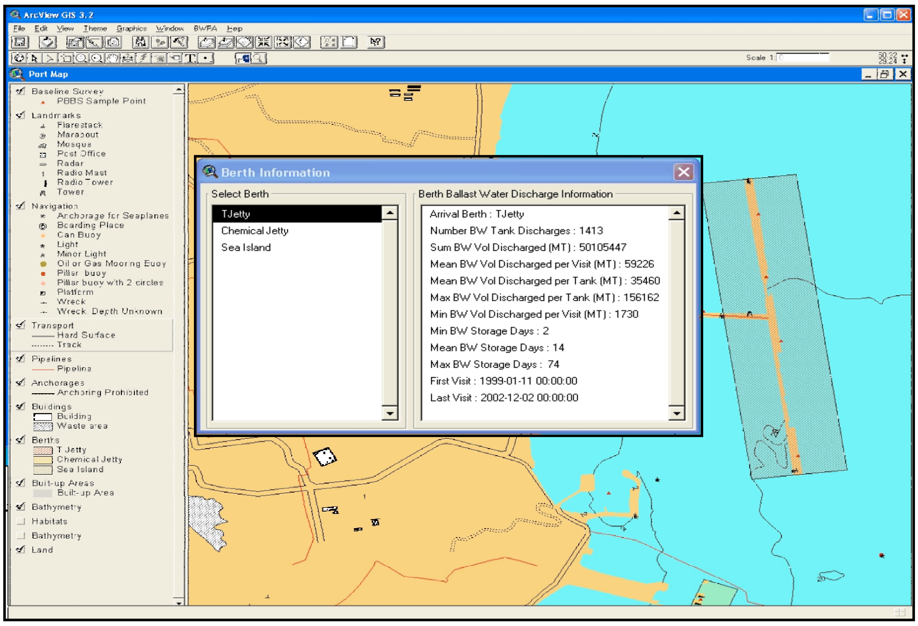


Figure 15. BW discharge statistics displayed by the GIS Port Map for the T-Jetty

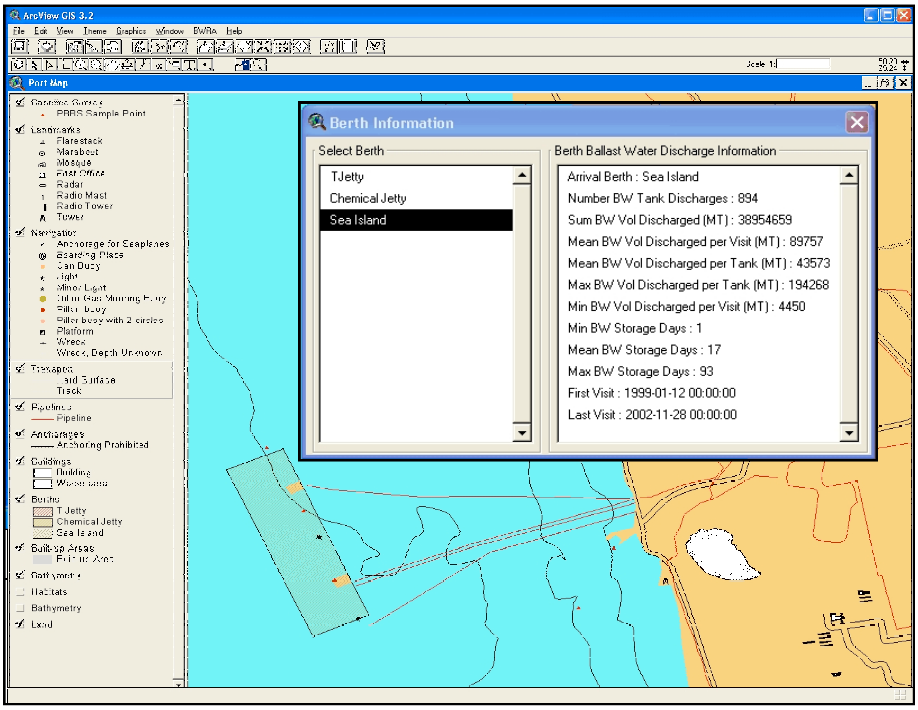


Figure 16. BW discharge statistics displayed by the GIS Port Map for the Sea Island Terminal at Khark Island.

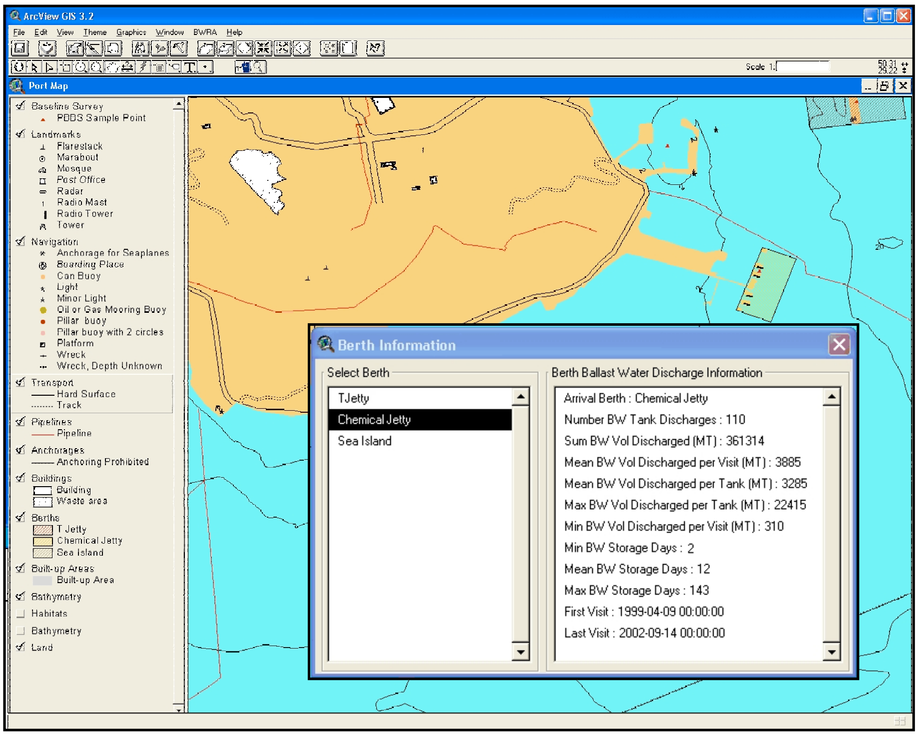


Figure 17. BW discharge statistics displayed by the GIS Port Map for the Chemical Jetty at Khark Island.

4.4 Identification of source ports

Of the 1489 vessel visit records and their associated 2421 tank discharges identified in the 1999-2002 database, the total number of identified BW source ports was 126, with two of these reported as sources of tank discharges but with no identifiable volumes (Table 3).

Figure 18 shows output from the GIS world bioregion map depicting the location and relative importance of the 126 BW source ports with respect to C1. As with all GIS outputs, it is 'zoomable' to allow all ports and symbols to be clearly delineated at smaller scales.

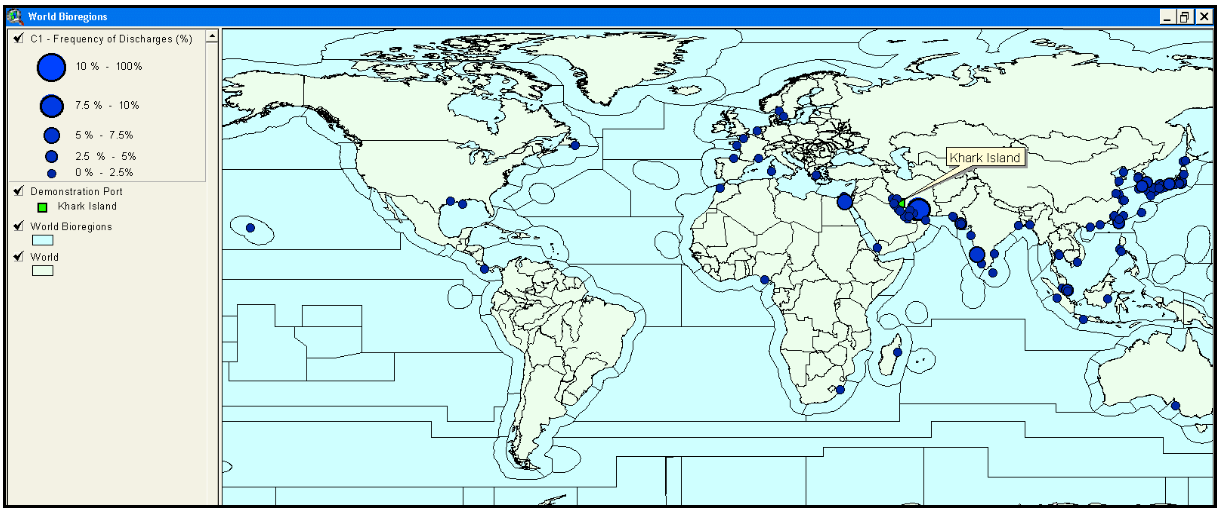


Figure 18. GIS output showing the location and relative importance of BW source ports with respect to frequency of tank discharges (C1) at Port of Khark Island.

Table 3. List of identified source ports in the Port of Khark Island 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	IRBND	Bandar Abbas	IR Iran	7.47%	3,009,951	3.4%
2	EGAIS	Ain Sukhana	Egypt	6.57%	7,350,531	8.2%
3	INIXE	Mangalore (New Mangalore)	India	5.06%	1,521,080	1.7%
4	JPCHB	Chiba Chiba	Japan	4.87%	3,905,179	4.4%
5	SGSIN	Singapore	Singapore	4.82%	4,149,467	4.6%
6	KRUSN	Ulsan	Rep Korea	4.11%	2,816,604	3.1%
7	TWKHH	Kaohsiung	Taiwan Province	4.02%	2,327,661	2.6%
8	JPMIZ	Mizushima Okayama	Japan	3.97%	2,297,129	2.6%
9	INSIK	Sikka (Jamnagar)	India	3.73%	2,451,769	2.7%
10	JPYKK	Yokkaichi Mie	Japan	2.79%	1,823,371	2.0%
11	KRYOS	Yosu	Rep Korea	2.60%	1,221,438	1.4%
12	ZADUR	Durban	South Africa	2.36%	1,918,468	2.1%
13	JPKSM	Kashima Ibaraki	Japan	2.08%	1,233,373	1.4%
14	AEFJR	Fujairah (Al-Fujairah)	UAE	1.94%	1,645,495	1.8%
15	KRTSN	Taesan	Rep Korea	1.94%	2,139,407	2.4%
16	JPKWS	Kawasaki Kanagawa	Japan	1.89%	1,481,745	1.7%
17	INCOK	Cochin	India	1.61%	568,770	0.6%
18	SARTA	Ras Tanura	Saudi Arabia	1.51%	2,431,908	2.7%
19	AEJED	Jebel Dhanna	UAE	1.47%	2,094,932	2.3%
20	JPKII	Kiire Kagoshima	Japan	1.47%	975,245	1.1%
21	THMAT	Mab Tapud	Thailand	1.37%	1,372,239	1.5%
22	KRONS	Onsan	Rep Korea	1.32%	1,184,046	1.3%
23	JPNGO	Nagoya Aichi	Japan	1.23%	1,308,554	1.5%
24	JPSAK	Sakai Osaka	Japan	1.18%	993,698	1.1%
25	CNNGB	Ningbo Zhejiang	China	1.13%	1,050,066	1.2%
26	JPOIT	Oita Oita	Japan	1.13%	855,513	1.0%
27	AEDXB	Dubai	UAE	1.04%	1,225,724	1.4%
28	JPSKD	Sakaide Kagawa	Japan	1.04%	656,748	0.73%
29	CNSDG	Shui Dong	China	0.99%	715,188	0.80%
30	TWMAI	Mailiao	Taiwan Province	0.99%	358,811	0.40%
31	JPUBJ	Ube Yamaguchi	Japan	0.95%	594,804	0.66%
32	TWKEL	Keelung (Sha Lung & Tanshoei)	Taiwan Province	0.85%	474,809	0.53%
33	JPYOK	Yokohama Kanagawa	Japan	0.80%	498,520	0.56%
34	GREEU	Eleusis	Greece	0.76%	305,191	0.34%
35	AEKLF	Khor Al Fakkan	UAE	0.71%	396,915	0.44%
36	IDCXP	Cilacap Java	Indonesia	0.71%	406,576	0.45%
37	PKKHI	Karachi	Pakistan	0.71%	334,494	0.37%
38	JPSEN	Sendai Kagoshima	Japan	0.57%	552,512	0.62%
39	THSRI	Sriracha	Thailand	0.57%	420,406	0.47%
40	LKCMB	Colombo	Sri Lanka	0.52%	252,612	0.28%
41	NLRTM	Rotterdam	Netherlands	0.52%	830,944	0.93%
42	PHBLG	Tabanga	Philippines	0.52%	411,560	0.46%
43	PHBTG	Batangas Luzon	Philippines	0.52%	458,956	0.51%
44	CNTAO	Qingdao (Longgang) Shandong	China	0.47%	805,077	0.90%
45	JPNGI	Negishi	Japan	0.47%	303,121	0.34%
46	JPTKY	Tokuyama Yamaguchi	Japan	0.47%	570,280	0.64%
47	KRCHA	Cheju	Rep Korea	0.47%	180,466	0.20%
48	FRDON	Donges	France	0.43%	877,740	1.0%
49	INVAD	Vadinar	India	0.43%	351,174	0.39%
50	IRBKM	Bandar Khomeini	IR Iran	0.43%	20,231	0.02%
51	JPTMK	Tomakomai Hokkaido	Japan	0.43%	450,527	0.50%
52	KWMEA	Mina Al Ahmadi	Kuwait	0.43%	516,448	0.58%
53	PHBTN	Bataan Mariveles	Philippines	0.43%	456,419	0.51%
54	INIXY	Kandla (Muldwarka)	India	0.38%	24,561	0.03%
55	SAJUB	Jubail	Saudi Arabia	0.38%	77,087	0.09%
56	AEJEA	Jebel Ali	UAE	0.33%	348,734	0.39%
57	JPMUR	Muroran Hokkaido	Japan	0.33%	304,866	0.34%
58	QAUMS	Umm Said	Qatar	0.33%	94,179	0.11%
59	CNQZJ	Quanzhou (Jinjiang) Fujian	China	0.28%	87,916	0.10%
60	ESBIO	Bilbao	Spain	0.28%	560,796	0.63%
61	IDBPN	Balikpapan Kalimantan	Indonesia	0.28%	31,185	0.03%
62	INBOM	Mumbai (Ex Bombay)	India	0.28%	228,983	0.26%
63	INHAL	Haldia	India	0.28%	136,799	0.15%

*C1 = proportion of all discharges (% of 2421 discharges); C2 = proportion of total discharge volume (%)

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

	UN Port Code	Source Port Name	Country	C1*	BW vol. (tonnes)	C2
64	IRSXI	Sirri Island Oil Terminal	IR Iran	0.28%	491,696	0.55%
65	PKBQM	Muhammad Bin Qasim	Pakistan	0.28%	48,964	0.05%
66	AEZIR	Zirku Island	UAE	0.24%	458,341	0.51%
67	GRPAC	Pachi	Greece	0.24%	134,495	0.15%
68	JPSAE	Saiki Oita	Japan	0.24%	40,984	0.05%
69	PAAML	Puerto Armuelles	Panama	0.24%	87,351	0.10%
70	INMAA	Chennai (Ex Madras)	India	0.19%	151,718	0.17%
71	ITPFX	Porto Foxi (Sarroch)	Italy	0.19%	107,557	0.12%
72	JPHIM	Himeji Hyogo	Japan	0.19%	196,184	0.22%
73	MYMKZ	Malacca	Malaysia	0.19%	340,872	0.38%
74	AESHJ	Sharjah	UAE	0.14%	19,327	0.02%
75	HKHKG	Hong Kong	Hong Kong	0.14%	168,500	0.19%
76	KWMIS	Mina Saud	Kuwait	0.14%	268,645	0.30%
77	OMMFH	Min-Al-Fahal	Oman	0.14%	202,871	0.23%
78	SADMN	Damman	Saudi Arabia	0.14%	15,837	0.02%
79	SARAR	Ras al Khafji	Saudi Arabia	0.14%	262,067	0.29%
80	USLOP	LOOP Terminal	United States	0.14%	289,130	0.32%
81	CNDLC	Dalian Liaoning	China	0.09%	75,088	0.08%
82	CNMEZ	Xiuyu (Meizhou)	China	0.09%	46,647	0.05%
83	CNZHE	Zhenjiang Zhejiang	China	0.09%	35,650	0.04%
84	CNZOS	Zhousan (Dinghai)	China	0.09%	140,634	0.16%
85	GRPIR	Piraeus	Greece	0.09%	41,543	0.05%
86	JPNGS	Nagasaki Nagasaki	Japan	0.09%	186,206	0.21%
87	JPSAI	Saijo	Japan	0.09%	38,647	0.04%
88	KROKP	Okpo	Rep Korea	0.09%	94,030	0.10%
89	QADOH	Doha	Qatar	0.09%	197,929	0.22%
90	SEBRO	Brofjorden	Sweden	0.09%	200,153	0.22%
91	SGJUR	Jurong	Singapore	0.09%	156,273	0.17%
92	SGTPG	Tanjong Pagar	Singapore	0.09%	37,588	0.04%
93	THRTT	Rayong TPI Terminal	Thailand	0.09%	59,899	0.07%
94	YEHOD	Hodeidah	Yemen	0.09%	42,430	0.05%
95	AUPST	Port Stanvac	Australia	0.05%	92,334	0.10%
96	BDCGP	Chittagong	Bangladesh	0.05%	47,309	0.05%
97	CACBC	Come By Chance	Canada	0.05%	142,247	0.16%
98	CNJIA	Jiangyin Jiangsu	China	0.05%	19,500	0.02%
99	EGPSD	Port Said	Egypt	0.05%	104,556	0.12%
100	EGSUZ	Suez (El Suweis)	Egypt	0.05%	94,472	0.11%
101	FRLAV	Lavera	France	0.05%	104,556	0.12%
102	FRLEH	Le Havre	France	0.05%	93,000	0.10%
103	IDPDG	Teluk Bajur/Padang Sumatra	Indonesia	0.05%	128,200	0.14%
104	INSAL	Salaya	India	0.05%	27,105	0.03%
105	IQBSR	Basra	Iraq	0.05%	92,943	0.10%
106	IQMAB	Mina Al Bakir	Iraq	0.05%	105,976	0.12%
107	IRLVP	Lavan Island	IR Iran	0.05%	28,898	0.03%
108	JPINS	Inoshima Hiroshima	Japan	0.05%	90,295	0.10%
109	JPKCZ	Kochi Kochi	Japan	0.05%	101,380	0.11%
110	JPOKA	Okinawa Okinawa	Japan	0.05%	85,900	0.10%
111	JPSMT	Shimotsu Wakayama	Japan	0.05%	99,920	0.11%
112	JPSMZ	Shimizu Shizuoka	Japan	0.05%	85,348	0.10%
113	JPTAM	Tamano Okayama	Japan	0.05%	19,000	0.02%
114	KRINC	Inchon	Rep Korea	0.05%	105,103	0.12%
115	KWSAA	Shuaiba	Kuwait	0.05%	3,385	0.00%
116	MAMOH	Mohammedia	Morocco	0.05%	35,000	0.04%
117	MGTMM	Tamatave (Toamasina)	Madagascar	0.05%	37,436	0.04%
118	MYJHB	Johor Bahru	Malaysia	0.05%	94,199	0.11%
119	NGABO	Abonnema	Nigeria	0.05%	32,226	0.04%
120	SEHAD	Halmstad	Sweden	0.05%	90,000	0.10%
121	SGKEP	Keppel Wharves	Singapore	0.05%	108,491	0.12%
122	USHNL	Honolulu Hawaii	United States	0.05%	37,181	0.04%
123	USSAB	Sabine	United States	0.05%	83,512	0.09%
124	VNVUT	Vung Tau	Viet Nam	0.05%	1,284	0.001%
125	AEDAS	Das Island	UAE	0.05%	<500	0.001%
126	IRBMR	Bandar Mashur	IR Iran	0.05%	<500	0.001%

*C1 = proportion of all discharges (% of 2421 discharges); C2 = proportion of total discharge volume (%)

The frequency data for the 126 source ports shown in Table 3 form the C1 values used in the calculation of relative overall risk (Section 3.10). The southern Iranian port of Bandar Abbas (Figure 2) was the most frequent source port in the BWRF and derived shipping records (i.e. 7.5% of all tank discharges). This was followed by Ain Sukhana (6.6%), which is the Egyptian terminal at the north end of the Red Sea (Figure 18). This transfer terminal receives crude oil for transferring to the Mediterranean coast by overland pipeline. The third most frequent source port was New Mangalore in India (5.1%), followed closely by Chiba (the large petrochemical and heavy industry region just north of Tokyo; 4.9%) and Singapore (4.8%; Table 3; Figure 18).

The total volume of BW discharged from the identified source ports was 76,277,003 tonnes. The various subtotal discharges for each source port shown in Table 3 and Figure 19 provide the C2 values used in the risk calculation (Section 3.10). The source port providing the largest volume of BW discharged at Khark Island was Ain Sukhana (8.2%). This was followed by Singapore (4.6%), Chiba (4.4%), Bandar Abbas (3.4%), Ulsan (Korea; 3.1%) and Sikka (Jamnagar) in India (2.7%).

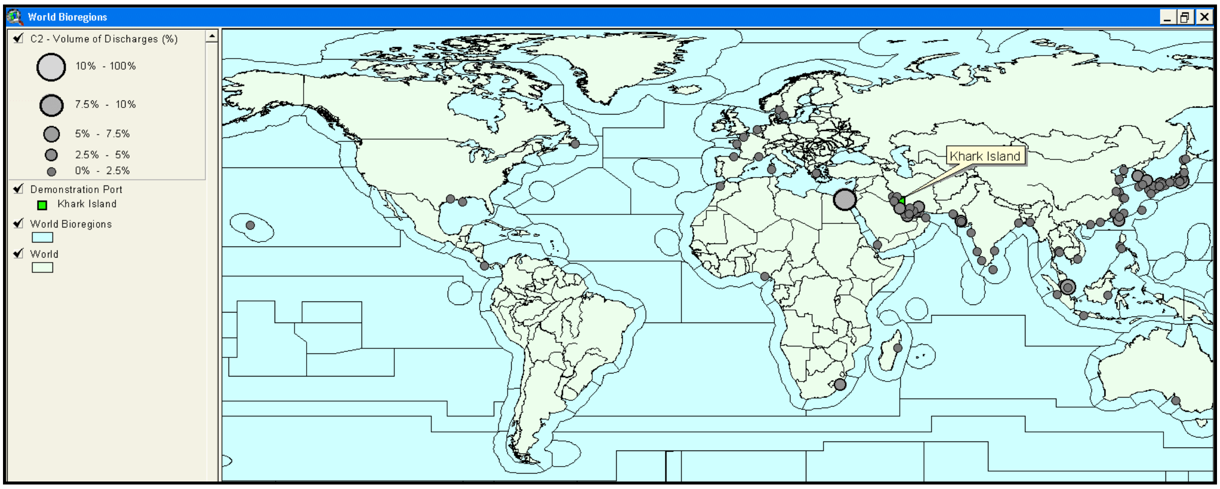


Figure 19. GIS output showing the location and relative importance of the source ports with respect to the volume of tank discharges (C2) at Port of Khark Island.

A further 13,322,507 tonnes was estimated to have been discharged from tanks for which no source port could be identified, and these visit records are not used by the database for the BWRA. However they indicate that the actual volume discharged at Khark Island in 1999-2002 was close to 90,000,000 tonnes.

The low number of individual tank discharges (2421) compared to the number of visits (1489), is due to (a) the need to include port shipping records prior to the regular use of BWRFs (all tanks combined), and (b) many vessels submitted a single, total discharge volume covering all their tanks on the BWRF.

Of the 126 identified source ports, the top 13 provided 50% of the source-identified volume and the next 16 ports a further 25% (i.e. 29 ports accounted for 75% of the 76,277,003 tonnes of source-identified BW; Table 3). Of the 5% of source ports located in or near the RSA, some such as Ras Tanura and Al Shaheen are oil terminals with few other facilities, while several are large bunkering, supply or maintenance ports (e.g. Fujairah, Dubai, Sharjah; Khor al Fakkan; see Figure 2). Because some VLCCs initially anchor and/or partly load at these ports before moving to Khark Island and were providing insufficient ballast tank information on the BWRFs, it could not be confirmed which of these ports may have been true BW source ports.

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. However this is not an issue for Khark Island since almost all ships depart loaded with liquid or dry bulk cargo.

Of the 119 destination ports in the 1999-2002 database, their location and proportional frequency reported next ports of call are shown Figure 20. The top 21 destination ports that accounted for >80% of the reported Next Ports of Call by all 1489 vessel departures are listed in Table 4. Most of these represent the destination of the petroleum, sulphur and rock cargoes exported from Khark Island. Exceptions were bunkering/crew change ports in the region plus Bandar Abbas, the latter almost certainly being the only destination port which actually receives BW taken up at Khark Island (i.e. by a few of the shuttle tankers that departed in ballast, having delivered fuel to Khark Island from the Bandar Abbas refinery and not loading for the return journey). The amount of BW uplifted at Khark Island by product tankers and taken to Bandar Abbas during 1999-2002 appears to be less than <50,000 tonnes.

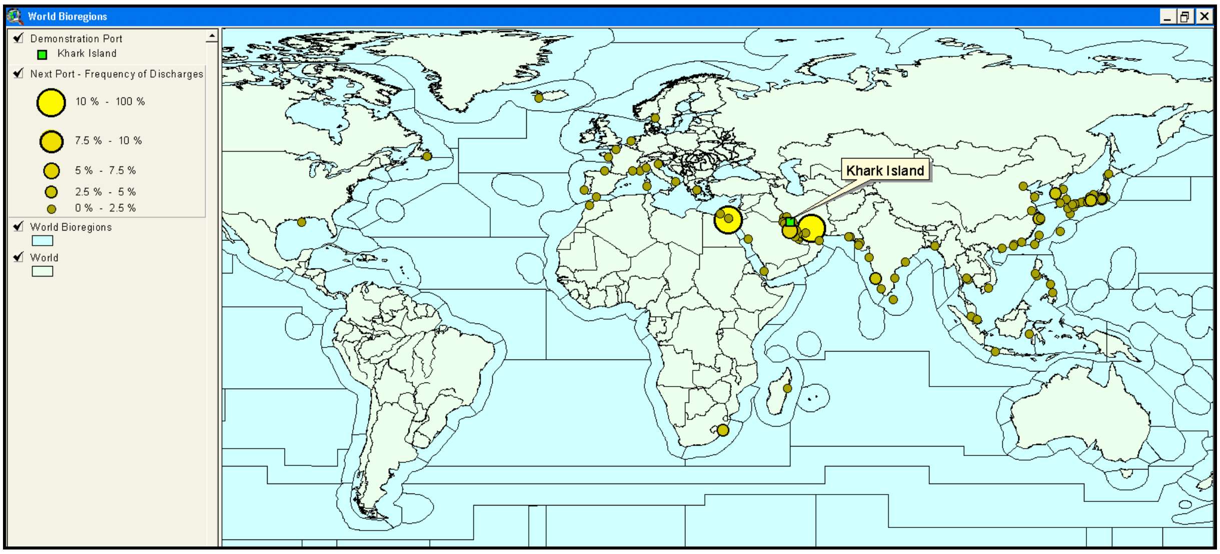


Figure 20. GIS output showing the location and frequency of destination ports, recorded as the Next Port of Call in the Port of Khark Island BWRFs and shipping records.

Table 4 shows that the refinery port of Bandar Abbas registered 17.2% of all destination port records, followed by the Egyptian oil reception terminal at Ain Sukhana in the Red Sea (12.5%), then Ras Tanura (7.1%), which has a deepwater artificial island oil terminal off the Saudi Arabian coast (Figure 2). The former ports plus the refinery terminals at Mangalore (India), Durban (South Africa), Taesan (Korea) and Ningbo (north-east China) accounted for over 50% of all recorded destination ports (Table 4). The sea island terminal at Ras Tanura has few facilities so the 1999-2000 records indicate that large crude carriers move both to and away from Khark Island for top-up cargo before departing the RSA.

Table 4. Destination ports accounting for >80% of all vessel departures from Khark Island in 1999-2002 (recorded as Next Ports of Call).

UN Port Code	Destination Port (Next Port of Call)	Country	Proportion of Departures	Cumulative Percentage
IRBND	Bandar Abbas	Iran Islamic Republic of	17.2%	17.2%
EGAIS	Ain Sukhana	Egypt	12.5%	29.7%
SARTA	Ras Tanura	Saudi Arabia	7.1%	36.8%
INIXE	Mangalore (New Mangalore)	India	5.0%	41.8%
ZADUR	Durban	South Africa	3.4%	45.1%
KRTSN	Taesan	Korea Republic of	3.1%	48.2%
CNNGB	Ningbo Zhejiang	China	2.9%	51.1%
JPYKK	Yokkaichi Mie	Japan	2.7%	53.8%
JPKWS	Kawasaki Kanagawa	Japan	2.5%	56.3%
JPKII	Kiire Kagoshima	Japan	2.2%	58.6%
JPCHB	Chiba Chiba	Japan	2.2%	60.7%
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	2.1%	62.8%
JPNGO	Nagoya Aichi	Japan	2.1%	64.9%
TWKHH	Kaohsiung	Taiwan Province of China	1.8%	66.7%
KRUSN	Ulsan	Korea Republic of	1.6%	68.3%
JPOIT	Oita Oita	Japan	1.5%	69.8%
INCOK	Cochin	India	1.4%	71.2%
AEZIR	Zirku Island	United Arab Emirates	1.3%	72.5%
INSIK	Sikka (Jamnagar)	India	1.2%	73.7%
LKCMB	Colombo	Sri Lanka	1.1%	74.8%
NLRTM	Rotterdam	Netherlands	1.1%	76.0%
PHBLG	Tabanga	Philippines	1.1%	77.1%
INVAD	Vadinar	India	1.1%	78.2%
PKKHI	Karachi	Pakistan	1.1%	79.3%
ESBIO	Bilbao	Spain	1.0%	80.3%
ITGOA	Genoa	Italy	1.0%	81.3%
OMMFH	Min-Al-Fahal	Oman	0.9%	82.2%

4.6 Environmental similarity analysis

Of the identified 126 source ports and 119 destination ports, sufficient port environmental data were obtained to include 75% of the former and 72% of the latter in the multivariate similarity analysis by PRIMER. These ports accounted for over 90% of the recorded tank discharges and 89% of all recorded departures respectively (Tables 5-6). Details of the 357 ports included in the multivariate analysis carried out for Khark Island 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 code).

To allow all identified BW source and next ports of Khark Island 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 Khark Island 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 Khark Island source and destination ports are in Figures 21 and 22 respectively. These plots and Tables 5-6 confirm the relatively high level of similarity between the Port of Khark Island and the majority of ports in the RSA and neighbouring Middle East regions (i.e. C3s in the 0.6 - 0.8 range).

The nearest similar source port beyond the Middle East was the tropical Japanese port of Okinawa (C3 of 0.581), while the nearest North American and European source ports were Sabine in Texas (0.560) and Piraeus in Greece (0.536). Unsurprisingly, the most environmentally dissimilar ports (<0.2) were in Iceland Canada, North-West Europe and Korea, plus some monsoonal ports in India, Sri Lanka and Bangladesh (Tables 5-6).

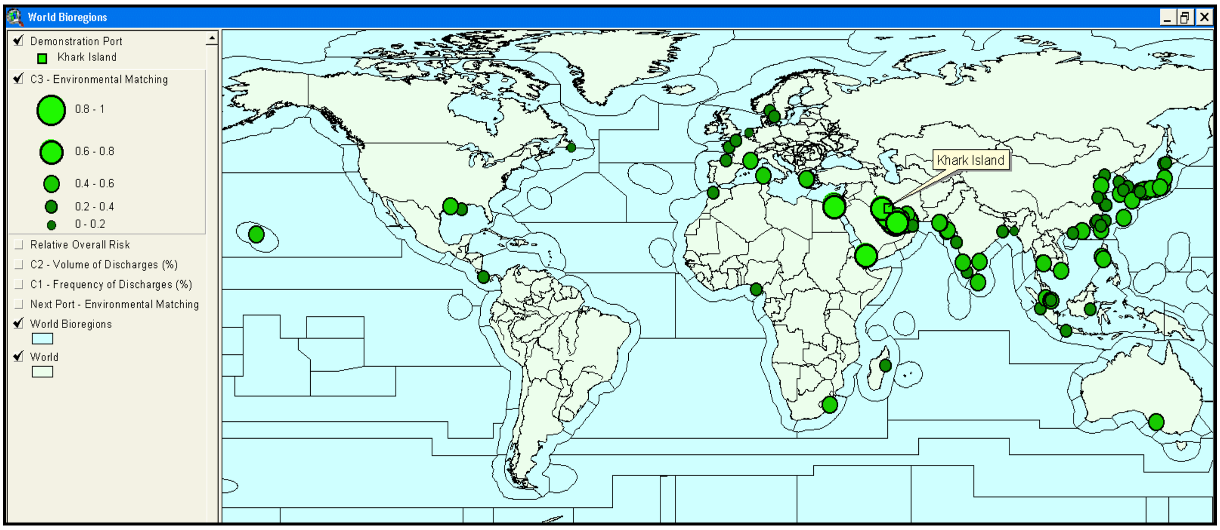


Figure 21. GIS output showing the location and environmental matching coefficients (C3) of BW source ports identified for the Port of Khark Island.

Table 5. Source ports identified for Port of Khark Island, 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
AEJEA	Jebel Ali	United Arab Emirates	0.33%	0.757	
QADOH	Doha	Qatar	0.09%	0.754	
QAUMS	Umm Said	Qatar	0.33%	0.750	
SAJUB	Jubail	Saudi Arabia	0.38%	0.731	
YEHOD	Hodeidah	Yemen	0.09%	0.699	
SADMN	Damman	Saudi Arabia	0.14%	0.678	
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	1.94%	0.674	
KWSAA	Shuaiba	Kuwait	0.05%	0.666	
KWMIS	Mina Saud	Kuwait	0.14%	0.658	
KWMEA	Mina Al Ahmadi	Kuwait	0.43%	0.655	
AEKLF	Khor Al Fakkan	United Arab Emirates	0.71%	0.651	
EGSUZ	Suez (El Suweis)	Egypt	0.05%	0.649	
AEZIR	Zirku Island	United Arab Emirates	0.24%	0.637	
EGAIS	Ain Sukhana	Egypt	6.57%	0.637	
AEDAS	Das Island	United Arab Emirates	0.02%	0.631	
SARTA	Ras Tanura	Saudi Arabia	1.51%	0.631	
AEJED	Jebel Dhanna	United Arab Emirates	1.47%	0.624	
JPOKA	Okinawa Okinawa	Japan	0.05%	0.581	
AESHJ	Sharjah	United Arab Emirates	0.14%	0.581	
IRBND	Bandar Abbas	Iran Islamic Republic of	7.47%	0.574	
TWKHH	Kaohsiung	Taiwan Province of China	4.02%	0.572	
USSAB	Sabine	United States	0.05%	0.560	
IRSXI	Sirri Island Oil Terminal	Iran Islamic Republic of	0.28%	0.556	
IRLVP	Lavan Island	Iran Islamic Republic of	0.05%	0.556	
AEDXB	Dubai	United Arab Emirates	1.04%	0.551	
VNVUT	Vung Tau	Viet Nam	0.05%	0.550	Estimated
PHBTG	Batangas Luzon	Philippines	0.52%	0.544	
PHBLG	Tabanga	Philippines	0.52%	0.540	Estimated
LKCMB	Colombo	Sri Lanka	0.52%	0.539	
GRPIR	Piraeus	Greece	0.09%	0.536	
PHBTN	Bataan Mariveles	Philippines	0.43%	0.527	
GREEU	Eleusis	Greece	0.76%	0.527	
JPSEN	Sendai Kagoshima	Japan	0.57%	0.515	Estimated
THMAT	Mab Tapud	Thailand	1.37%	0.486	Estimated
THRTT	Rayong TPI Terminal	Thailand	0.09%	0.486	Estimated
GRPAC	Pachi	Greece	0.24%	0.472	
AUPST	Port Stanvac	Australia	0.05%	0.471	
JPKII	Kiire Kagoshima	Japan	1.47%	0.470	
INSAL	Salaya	India	0.05%	0.468	
ITPFX	Porto Foxi (Sarroch)	Italy	0.19%	0.468	
PKKHI	Karachi	Pakistan	0.71%	0.467	
INVAD	Vadinar	India	0.43%	0.464	
JPHIM	Himeji Hyogo	Japan	0.19%	0.460	
JPSMT	Shimotsu Wakayama	Japan	0.05%	0.458	
KRCHA	Cheju	Korea Republic of	0.47%	0.446	Estimated
JPSMZ	Shimizu Shizuoka	Japan	0.05%	0.445	
MYMKZ	Malacca	Malaysia	0.19%	0.438	Estimated
JPKSM	Kashima Ibaraki	Japan	2.08%	0.436	
FRLAV	Lavera	France	0.05%	0.431	
JPTAM	Tamano Okayama	Japan	0.05%	0.429	
INMAA	Chennai (Ex Madras)	India	0.19%	0.428	

Table 5 cont. Source ports identified for Port of Khark Island, ranked according to the size of their environmental matching coefficient (C3)

UN Port Code	Source Port Name	Country	Proportion of BW discharged	Environmental Matching (C3)	C3 Estimated
PKBQM	Muhammad Bin Qasim	Pakistan	0.28%	**0.427**	
HKHKG	Hong Kong	Hong Kong	0.14%	**0.426**	
SGSIN	Singapore	Singapore	4.82%	**0.425**	
SGJUR	Jurong	Singapore	0.09%	**0.425**	
SGKEP	Keppel Wharves	Singapore	0.05%	**0.425**	
SARAR	Ras al Khafji	Saudi Arabia	0.14%	**0.425**	Estimated
JPINS	Inoshima Hiroshima	Japan	0.05%	**0.424**	
JPCHB	Chiba Chiba	Japan	4.87%	**0.421**	
JPNGI	Negishi	Japan	0.47%	**0.419**	
JPYOK	Yokohama Kanagawa	Japan	0.80%	**0.419**	
ZADUR	Durban	South Africa	2.36%	**0.418**	
JPSAK	Sakai Osaka	Japan	1.18%	**0.412**	
JPNGO	Nagoya Aichi	Japan	1.23%	**0.410**	
JPNGS	Nagasaki Nagasaki	Japan	0.09%	**0.409**	
INIXE	Mangalore (New Mangalore)	India	5.06%	**0.408**	
KROKP	Okpo	Korea Republic of	0.09%	**0.407**	Estimated
JPYKK	Yokkaichi Mie	Japan	2.79%	**0.403**	
CNTAO	Qingdao (Longgang) Shandong	China	0.47%	**0.401**	
JPKWS	Kawasaki Kanagawa	Japan	1.89%	**0.401**	
USHNL	Honolulu Hawaii	United States	0.05%	**0.400**	Estimated
JPKCZ	Kochi Kochi	Japan	0.05%	**0.397**	
INSIK	Sikka (Jamnagar)	India	3.73%	**0.396**	
JPSAE	Saiki Oita	Japan	0.24%	**0.394**	
JPSAI	Saijo	Japan	0.09%	**0.390**	Estimated
CNSDG	Shui Dong	China	0.99%	**0.390**	Estimated
CNQZJ	Quanzhou (Jinjiang) Fujian	China	0.28%	**0.390**	Estimated
CNMEZ	Xiuyu (Meizhou)	China	0.09%	**0.390**	Estimated
CNZHE	Zhenjiang Zhejiang	China	0.09%	**0.390**	Estimated
CNZOS	Zhousan (Dinghai)	China	0.09%	**0.390**	Estimated
CNJIA	Jiangyin Jiangsu	China	0.05%	**0.390**	Estimated
SGTPG	Tanjong Pagar	Singapore	0.09%	**0.390**	
JPOIT	Oita Oita	Japan	1.13%	**0.388**	
MAMOH	Mohammedia	Morocco	0.05%	**0.368**	Estimated
MYJHB	Johor Bahru	Malaysia	0.05%	**0.365**	Estimated
KRYOS	Yosu	Korea Republic of	2.60%	**0.363**	
KRTSN	Taesan	Korea Republic of	1.94%	**0.363**	Estimated
TWMAI	Mailiao	Taiwan Province Of China	0.99%	**0.362**	Estimated
CNDLC	Dalian Liaoning	China	0.09%	**0.360**	
JPSKD	Sakaide Kagawa	Japan	1.04%	**0.359**	
OMMFH	Min-Al-Fahal	Oman	0.14%	**0.356**	Estimated
KRONS	Onsan	Korea Republic of	1.32%	**0.355**	
KRUSN	Ulsan	Korea Republic of	4.11%	**0.348**	
ESBIO	Bilbao	Spain	0.28%	**0.346**	
THSRI	Sriracha	Thailand	0.57%	**0.345**	Estimated
JPUBJ	Ube Yamaguchi	Japan	0.95%	**0.340**	
JPMIZ	Mizushima Okayama	Japan	3.97%	**0.338**	
USLOP	LOOP Terminal	United States	0.14%	**0.337**	
MGTMM	Tamatave (Toamasina)	Madagascar	0.05%	**0.333**	Estimated
CNNGB	Ningbo Zhejiang	China	1.13%	**0.333**	
PAAML	Puerto Armuelles	Panama	0.24%	**0.328**	Estimated
NGABO	Abonnema	Nigeria	0.05%	**0.326**	Estimated
JPTKY	Tokuyama Yamaguchi	Japan	0.47%	**0.323**	
EGPSD	Port Said	Egypt	0.05%	**0.321**	
INBOM	Mumbai (Ex Bombay)	India	0.28%	**0.309**	
IDBPN	Balikpapan Kalimantan	Indonesia	0.28%	**0.300**	Estimated
IDPDG	Teluk Bajur/Padang Sumatra	Indonesia	0.05%	**0.300**	Estimated
IRBKM	Bandar Khomeini	Iran Islamic Republic of	0.43%	**0.293**	
TWKEL	Keelung (Sha Lung & Tanshoei)	Taiwan Province of China	0.85%	**0.293**	
IQBSR	Basra	Iraq	0.05%	**0.290**	Estimated
IQMAB	Mina Al Bakir	Iraq	0.05%	**0.290**	Estimated
IRBMR	Bandar Mashur	Iran Islamic Republic of	0.02%	**0.278**	
JPMUR	Muroran Hokkaido	Japan	0.33%	**0.264**	
INHAL	Haldia	India	0.28%	**0.264**	
FRDON	Donges	France	0.43%	**0.257**	
IDCXP	Cilacap Java	Indonesia	0.71%	**0.247**	
JPTMK	Tomakomai Hokkaido	Japan	0.43%	**0.225**	
INCOK	Cochin	India	1.61%	**0.217**	
FRLEH	Le Havre	France	0.05%	**0.217**	
SEBRO	Brofjorden	Sweden	0.09%	**0.200**	Estimated
SEHAD	Halmstad	Sweden	0.05%	**0.200**	Estimated
INIXY	Kandla (Muldwarka)	India	0.38%	**0.158**	
KRINC	Inchon	Korea Republic of	0.05%	**0.137**	
BDCGP	Chittagong	Bangladesh	0.05%	**0.125**	
NLRTM	Rotterdam	Netherlands	0.52%	**0.095**	
CACBC	Come By Chance	Canada	0.05%	**0.061**	

As discussed in Section 4.6 and highlighted in Table 6, there is probably only one destination that occasionally may receive BW from Khark Island (i.e. Bandar Abbas on the south coast of I.R. Iran; Figure 2).

Bandar Abbas' environmental matching coefficient with Khark Island is 0.574, which places it 24th in the list of 119 next ports (Table 6). Thus Bandar Abbas is on the boundary of the top 20% of destination ports which have the closest environmental matching to Khark Island.

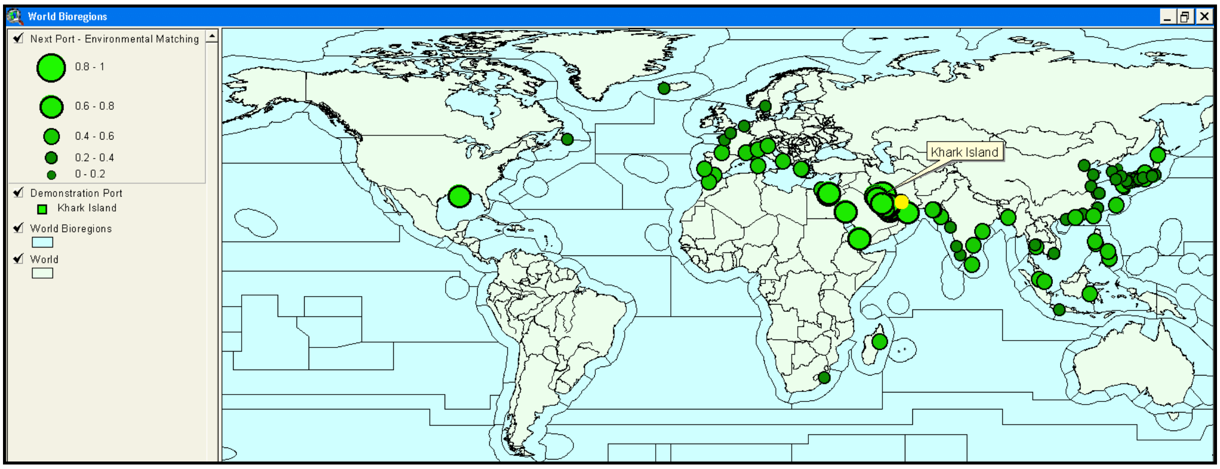
Table 6. Destination ports identified for Port of Khark Island, ranked according to the size of their environmental matching coefficient (C3)*

UN Port Code	Destination Port (Next Port of Call)	Country	Proportion of Departures	Environmental Matching (C3)	C3 Estimated
AEJEA	Jebel Ali	United Arab Emirates	0.2%	**0.757**	
QADOH	Doha	Qatar	0.1%	**0.754**	
QAHAL	Halul Island Terminal	Qatar	0.5%	**0.750**	Estimated
QAUMS	Umm Said	Qatar	0.2%	**0.750**	
SAJUB	Jubail	Saudi Arabia	0.7%	**0.731**	
EGADA	Adabiya	Egypt	0.1%	**0.700**	Estimated
QASHT	Al Shaheen Terminal	Qatar	0.4%	**0.678**	Estimated
AEFJR	Fujairah (Al-Fujairah)	United Arab Emirates	2.1%	**0.674**	
KWSAA	Shuaiba	Kuwait	0.2%	**0.666**	
KWMEA	Mina Al Ahmadi	Kuwait	0.3%	**0.655**	
AEKLF	Khor Al Fakkan	United Arab Emirates	0.3%	**0.651**	
EGSUZ	Suez (El Suweis)	Egypt	0.1%	**0.649**	
YERAI	Ras Isa Marine Terminal	Yemen	0.1%	**0.646**	
AEZIR	Zirku Island	United Arab Emirates	1.3%	**0.637**	
EGAIS	Ain Sukhana	Egypt	12.5%	**0.637**	
SARTA	Ras Tanura	Saudi Arabia	7.1%	**0.631**	
SARAR	Ras al Khafji	Saudi Arabia	0.2%	**0.631**	Estimated
AEDAS	Das Island	United Arab Emirates	0.6%	**0.630**	
AEJED	Jebel Dhanna	United Arab Emirates	0.3%	**0.624**	
AERUW	Ruwais	United Arab Emirates	0.1%	**0.624**	
SAYNB	Yanbu	Saudi Arabia	0.1%	**0.623**	
AEAJM	Ajman	United Arab Emirates	0.1%	**0.600**	Estimated
JPOKA	Okinawa Okinawa	Japan	0.1%	**0.581**	
IRBND	Bandar Abbas	Iran Islamic Republic of	17.2%	**0.574**	
TWKHH	Kaohsiung	Taiwan Province of China	1.8%	**0.572**	
PHLIM	Limay/Bataan	Philippines	0.1%	**0.564**	
IRSXI	Sirri Island Oil Terminal	Iran Islamic Republic of	0.2%	**0.556**	
IDMJU	Mamuju	Indonesia	0.1%	**0.553**	Estimated
AEDXB	Dubai	United Arab Emirates	0.2%	**0.551**	
FRANT	Antibes	France	0.1%	**0.550**	Estimated
VNVUT	Vung Tau	Viet Nam	0.1%	**0.550**	Estimated
IRBUZ	Bushehr	Iran Islamic Republic of	0.2%	**0.548**	
PHBTG	Batangas Luzon	Philippines	0.2%	**0.544**	
PHBLG	Tabanga	Philippines	1.1%	**0.540**	Estimated
LKCMB	Colombo	Sri Lanka	1.1%	**0.539**	
PHTAC	Tacloban Leyte	Philippines	0.1%	**0.529**	
PHBTN	Bataan Mariveles	Philippines	0.1%	**0.527**	
ITTAR	Taranto	Italy	0.2%	**0.527**	
GREEU	Eleusis	Greece	0.7%	**0.527**	
INVTZ	Visakhapatnam	India	0.1%	**0.515**	
ESALG	Algeciras	Spain	0.1%	**0.500**	
THMAT	Mab Tapud	Thailand	0.1%	**0.486**	Estimated
GRPAC	Pachi	Greece	0.8%	**0.472**	
JPKII	Kiire Kagoshima	Japan	2.2%	**0.470**	
ITGOA	Genoa	Italy	1.0%	**0.469**	
ITPFX	Porto Foxi (Sarroch)	Italy	0.1%	**0.468**	
JPGAM	Gamagori Aichi	Japan	0.1%	**0.467**	Estimated
PKKHI	Karachi	Pakistan	1.1%	**0.467**	
INVAD	Vadinar	India	1.1%	**0.464**	
ITVCE	Venezia (=Fusina)	Italy	0.2%	**0.463**	
JPHIM	Himeji Hyogo	Japan	0.2%	**0.460**	
JPTOY	Toyama Toyama	Japan	0.1%	**0.454**	
EGSKH	Sokhna	Egypt	0.1%	**0.450**	Estimated
MYMKZ	Malacca	Malaysia	0.2%	**0.438**	Estimated
JPKSM	Kashima Ibaraki	Japan	0.5%	**0.436**	
AEFAT	Fateh Terminal	United Arab Emirates	0.5%	**0.430**	
FRFOS	Fos sur Mer	France	0.2%	**0.428**	
INMAA	Chennai (Ex Madras)	India	0.2%	**0.428**	
PKBQM	Muhammad Bin Qasim	Pakistan	0.2%	**0.427**	
PHBXU	Butuan Bay/Masao	Philippines	0.1%	**0.427**	Estimated
HKHKG	Hong Kong	Hong Kong	0.1%	**0.426**	
SGSIN	Singapore	Singapore	0.6%	**0.425**	

* Bandar Abbas (highlighted in yellow) is almost certainly the only port receiving any regular import of BW from Khark Island, and only on an occasional basis (see Section 4.6).

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

UN Port Code	Destination Port (Next Port of Call)	Country	Proportion of Departures	Environmental Matching (C3)	C3 Estimated
SAJUT	Juaymah Terminal	Saudi Arabia	0.3%	**0.425**	
JPCHB	Chiba Chiba	Japan	2.2%	**0.421**	
JPYOK	Yokohama Kanagawa	Japan	0.2%	**0.419**	
ZADUR	Durban	South Africa	3.4%	**0.418**	
JPSAK	Sakai Osaka	Japan	0.1%	**0.412**	
JPOBM	Obama Fukui	Japan	0.1%	**0.410**	Estimated
JPNGO	Nagoya Aichi	Japan	2.1%	**0.410**	
JPNGS	Nagasaki Nagasaki	Japan	0.1%	**0.409**	
PTSIE	Sines	Portugal	0.2%	**0.408**	
INIXE	Mangalore (New Mangalore)	India	5.0%	**0.408**	
JPYKK	Yokkaichi Mie	Japan	2.7%	**0.403**	
CNTAO	Qingdao (Longgang) Shandong	China	0.2%	**0.401**	
JPKWS	Kawasaki Kanagawa	Japan	2.5%	**0.401**	
INSIK	Sikka (Jamnagar)	India	1.2%	**0.396**	
CNTSN	Tianjin Tianjin	China	0.1%	**0.395**	
JPOIT	Oita Oita	Japan	1.5%	**0.388**	
CNZHE	Zhenjiang Zhejiang	China	0.1%	**0.382**	Estimated
JPKRE	Kure Hiroshima	Japan	0.1%	**0.380**	Estimated
MAMOH	Mohammedia	Morocco	0.1%	**0.368**	Estimated
KRTSN	Taesan	Korea Republic of	3.1%	**0.363**	Estimated
CNHUI	Huizhou	China	0.5%	**0.360**	
KRSHO	Sokcho	Korea Republic of	0.1%	**0.357**	Estimated
OMMFH	Min-Al-Fahal	Oman	0.9%	**0.356**	Estimated
KRONS	Onsan	Korea Republic of	0.4%	**0.355**	
KRYOS	Yosu	Korea Republic of	0.2%	**0.350**	Estimated
KRUSN	Ulsan	Korea Republic of	1.6%	**0.348**	Estimated
ESBIO	Bilbao	Spain	1.0%	**0.346**	
THSRI	Sriracha	Thailand	0.2%	**0.345**	Estimated
JPTYO	Tokyo Tokyo	Japan	0.1%	**0.344**	
JPUBJ	Ube Yamaguchi	Japan	0.2%	**0.340**	
JPMIZ	Mizushima Okayama	Japan	0.2%	**0.338**	
USLOP	LOOP Terminal	United States	0.1%	**0.337**	
MGTMM	Tamatave (Toamasina)	Madagascar	0.2%	**0.333**	Estimated
CNNGB	Ningbo Zhejiang	China	2.9%	**0.333**	
CNNBO	Beilun	China	0.1%	**0.333**	
JPCTA	Chita Aichi	Japan	0.1%	**0.330**	Estimated
CNSDG	Shui Dong	China	0.6%	**0.330**	Estimated
CNSWA	Shantou (Chaoyang) Guandong	China	0.1%	**0.330**	Estimated
CNZOS	Zhousan (Dinghai)	China	0.1%	**0.330**	Estimated
JPTKY	Tokuyama Yamaguchi	Japan	0.4%	**0.323**	
EGAKI	Abu Qir	Egypt	0.1%	**0.321**	Estimated
INBOM	Mumbai (Ex Bombay)	India	0.6%	**0.309**	
IRABD	Abadan	Iran Islamic Republic of	0.1%	**0.300**	Estimated
TWKEL	Keelung (Sha Lung & Tanshoei)	Taiwan Province of China	0.1%	**0.293**	
IQMAB	Mina Al Bakir	Iraq	0.2%	**0.290**	Estimated
IRBMR	Bandar Mashur	Iran Islamic Republic of	0.2%	**0.278**	
FRDON	Donges	France	0.2%	**0.257**	
IDCXP	Cilacap Java	Indonesia	0.2%	**0.247**	
JPTMK	Tomakomai Hokkaido	Japan	0.1%	**0.225**	
INCOK	Cochin	India	1.4%	**0.217**	
FRLEH	Le Havre	France	0.2%	**0.217**	
SEBRO	Brofjorden	Sweden	0.2%	**0.200**	Estimated
INIXY	Kandla (Muldwarka)	India	0.2%	**0.158**	
BDCGP	Chittagong	Bangladesh	0.1%	**0.125**	
NLRTM	Rotterdam	Netherlands	1.1%	**0.095**	
CACBC	Come By Chance	Canada	0.1%	**0.061**	
ISSTR	Straumsvik	Iceland	0.1%	**0.010**	



NB: Port of Bandar Abbas (yellow highlight) appears to be the only port receiving BW uplifted at Khark Island on any regular basis.

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

4.7 Risk species

The risk species threat from a source port depends on the number of introduced and native species in its bioregion, and their categorisations as unlikely, suspected or known harmful species (Section 3.9). The risk species threat coefficient (C4) of each BW source port identified for the Port of Khark Island are listed in Table 7 and shown in Figure 23. Table 7 also lists the scores for the introduced, suspected and known harmful species of the source port bioregions, as had been added and assigned to the database's species tables by 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 has a regional bias due to the level of aquatic sampling and taxonomic effort in Australia/New Zealand, Europe and North America.

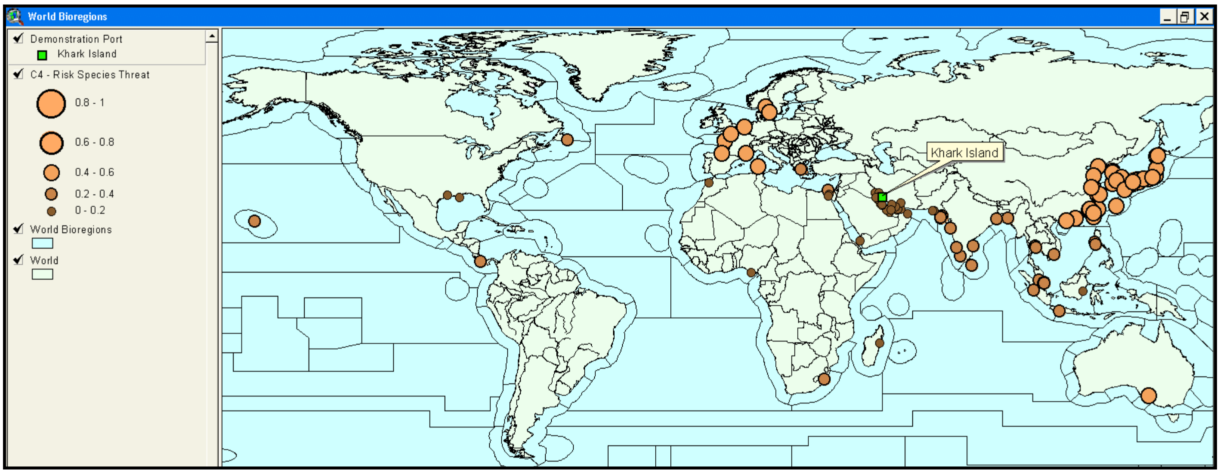


Figure 23. GIS output showing the location and risk species threat coefficients (C4) of the BW source ports identified for the Port of Khark Island

Table 7. Ranking of BW source ports identified for Port of Khark Island, 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)
AUPST	Port Stanvac	Australia	AUS-VII	39	4	14	191	**0.538**
CNJIA	Jiangyin Jiangsu	China	NWP-3a	15	11	12	168	**0.473**
CNMEZ	Xiuyu (Meizhou)	China	NWP-3a	15	11	12	168	**0.473**
CNNGB	Ningbo Zhejiang	China	NWP-3a	15	11	12	168	**0.473**
CNQZJ	Quanzhou (Jinjiang) Fujian	China	NWP-3a	15	11	12	168	**0.473**
CNZHE	Zhenjiang Zhejiang	China	NWP-3a	15	11	12	168	**0.473**
CNZOS	Zhousan (Dinghai)	China	NWP-3a	15	11	12	168	**0.473**
JPNGS	Nagasaki Nagasaki	Japan	NWP-3a	15	11	12	168	**0.473**
KRCHA	Cheju	Rep Korea	NWP-3a	15	11	12	168	**0.473**
KROKP	Okpo	Rep Korea	NWP-3a	15	11	12	168	**0.473**
KRYOS	Yosu	Rep Korea	NWP-3a	15	11	12	168	**0.473**
TWKEL	Keelung (Sha Lung & Tanshoei)	Taiwan Province of China	NWP-3a	15	11	12	168	**0.473**
TWMAI	Mailiao	Taiwan Province Of China	NWP-3a	15	11	12	168	**0.473**
CNDLC	Dalian Liaoning	China	NWP-4c	15	11	12	168	**0.473**
CNTAO	Qingdao (Longgang) Shandong	China	NWP-4c	15	11	12	168	**0.473**
KRINC	Inchon	Rep Korea	NWP-4c	15	11	12	168	**0.473**
KRTSN	Taesan	Rep Korea	NWP-4c	15	11	12	168	**0.473**
JPCHB	Chiba Chiba	Japan	NWP-3b	13	11	12	166	**0.468**
JPHIM	Himeji Hyogo	Japan	NWP-3b	13	11	12	166	**0.468**
JPINS	Inoshima Hiroshima	Japan	NWP-3b	13	11	12	166	**0.468**
JPKCZ	Kochi Kochi	Japan	NWP-3b	13	11	12	166	**0.468**
JPKII	Kiire Kagoshima	Japan	NWP-3b	13	11	12	166	**0.468**
JPKWS	Kawasaki Kanagawa	Japan	NWP-3b	13	11	12	166	**0.468**
JPMIZ	Mizushima Okayama	Japan	NWP-3b	13	11	12	166	**0.468**
JPNGI	Negishi	Japan	NWP-3b	13	11	12	166	**0.468**
JPNGO	Nagoya Aichi	Japan	NWP-3b	13	11	12	166	**0.468**
JPOIT	Oita Oita	Japan	NWP-3b	13	11	12	166	**0.468**
JPSAE	Saiki Oita	Japan	NWP-3b	13	11	12	166	**0.468**
JPSAI	Saijo	Japan	NWP-3b	13	11	12	166	**0.468**
JPSAK	Sakai Osaka	Japan	NWP-3b	13	11	12	166	**0.468**
JPSKD	Sakaide Kagawa	Japan	NWP-3b	13	11	12	166	**0.468**
JPSMT	Shimotsu Wakayama	Japan	NWP-3b	13	11	12	166	**0.468**
JPSMZ	Shimizu Shizuoka	Japan	NWP-3b	13	11	12	166	**0.468**
JPTAM	Tamano Okayama	Japan	NWP-3b	13	11	12	166	**0.468**
JPTKY	Tokuyama Yamaguchi	Japan	NWP-3b	13	11	12	166	**0.468**
JPUBJ	Ube Yamaguchi	Japan	NWP-3b	13	11	12	166	**0.468**
JPYKK	Yokkaichi Mie	Japan	NWP-3b	13	11	12	166	**0.468**
JPYOK	Yokohama Kanagawa	Japan	NWP-3b	13	11	12	166	**0.468**
KRONS	Onsan	Rep Korea	NWP-4a	11	11	12	164	**0.462**
KRUSN	Ulsan	Rep Korea	NWP-4a	11	11	12	164	**0.462**
CNSDG	Shui Dong	China	NWP-2	11	10	12	161	**0.454**
HKHKG	Hong Kong	Hong Kong	NWP-2	11	10	12	161	**0.454**
JPOKA	Okinawa Okinawa	Japan	NWP-2	11	10	12	161	**0.454**
TWKHH	Kaohsiung	Taiwan Province of China	NWP-2	11	10	12	161	**0.454**
JPKSM	Kashima Ibaraki	Japan	NWP-4b	11	10	12	161	**0.454**
JPMUR	Muroran Hokkaido	Japan	NWP-4b	11	10	12	161	**0.454**
JPSEN	Sendai Kagoshima	Japan	NWP-4b	11	10	12	161	**0.454**
JPTMK	Tomakomai Hokkaido	Japan	NWP-4b	11	10	12	161	**0.454**
FRDON	Donges	France	NEA-IV	21	9	10	148	**0.417**
ESBIO	Bilbao	Spain	NEA-V	20	9	10	147	**0.414**
SEBRO	Brofjorden	Sweden	B-I	22	8	10	146	**0.411**
SEHAD	Halmstad	Sweden	B-II	22	8	10	146	**0.411**
FRLEH	Le Havre	France	NEA-II	22	8	10	146	**0.411**
NLRTM	Rotterdam	Netherlands	NEA-II	22	8	10	146	**0.411**
FRLAV	Lavera	France	MED-II	17	5	11	142	**0.400**
ITPFX	Porto Foxi (Sarroch)	Italy	MED-II	17	5	11	142	**0.400**
EGPSD	Port Said	Egypt	MED-V	16	5	10	131	**0.369**
GREEU	Eleusis	Greece	MED-VI	16	5	10	131	**0.369**
GRPAC	Pachi	Greece	MED-VI	16	5	10	131	**0.369**
GRPIR	Piraeus	Greece	MED-VI	16	5	10	131	**0.369**
ZADUR	Durban	South Africa	WA-V	13	3	9	112	**0.315**
PAAML	Puerto Armuelles	Panama	SEP-H	34	5	6	109	**0.307**

Table 7 cont. Ranking of BW source ports identified for Port of Khark Island, 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)
INBOM	Mumbai (Ex Bombay)	India	CIO-I	8	13	5	97	0.273
INCOK	Cochin	India	CIO-I	8	13	5	97	0.273
INIXE	Mangalore (New Mangalore)	India	CIO-I	8	13	5	97	0.273
INIXY	Kandla (Muldwarka)	India	CIO-I	8	13	5	97	0.273
INSAL	Salaya	India	CIO-I	8	13	5	97	0.273
INSIK	Sikka (Jamnagar)	India	CIO-I	8	13	5	97	0.273
INVAD	Vadinar	India	CIO-I	8	13	5	97	0.273
INMAA	Chennai (Ex Madras)	India	CIO-II	8	13	5	97	0.273
LKCMB	Colombo	Sri Lanka	CIO-II	8	13	5	97	0.273
BDCGP	Chittagong	Bangladesh	CIO-III	8	13	5	97	0.273
INHAL	Haldia	India	CIO-III	8	13	5	97	0.273
USHNL	Honolulu Hawaii	United States	SP-XXI	27	7	4	88	0.248
CACBC	Come By Chance	Canada	NA-S2	10	3	6	79	0.223
PHBLG	Tabanga	Philippines	EAS-I	6	6	5	74	0.208
PHBTG	Batangas Luzon	Philippines	EAS-I	6	6	5	74	0.208
PHBTN	Bataan Mariveles	Philippines	EAS-I	6	6	5	74	0.208
THMAT	Mab Tapud	Thailand	EAS-I	6	6	5	74	0.208
THRTT	Rayong TPI Terminal	Thailand	EAS-I	6	6	5	74	0.208
THSRI	Sriracha	Thailand	EAS-I	6	6	5	74	0.208
VNVUT	Vung Tau	Viet Nam	EAS-I	6	6	5	74	0.208
MYJHB	Johor Bahru	Malaysia	EAS-VI	6	6	5	74	0.208
MYMKZ	Malacca	Malaysia	EAS-VI	6	6	5	74	0.208
SGJUR	Jurong	Singapore	EAS-VI	6	6	5	74	0.208
SGKEP	Keppel Wharves	Singapore	EAS-VI	6	6	5	74	0.208
SGSIN	Singapore	Singapore	EAS-VI	6	6	5	74	0.208
SGTPG	Tanjong Pagar	Singapore	EAS-VI	6	6	5	74	0.208
IDPDG	Teluk Bajur/Padang Sumatra	Indonesia	EAS-VII	6	6	5	74	0.208
IDCXP	Cilacap Java	Indonesia	EAS-VIII	6	6	5	74	0.208
AEFJR	Fujairah (Al-Fujairah)	UAE	IP-1	8	3	4	57	0.161
AEKLF	Khor Al Fakkan	UAE	IP-1	8	3	4	57	0.161
OMMFH	Min-Al-Fahal	Oman	IP-1	8	3	4	57	0.161
PKBQM	Muhammad Bin Qasim	Pakistan	IP-1	8	3	4	57	0.161
PKKHI	Karachi	Pakistan	IP-1	8	3	4	57	0.161
IRBND	Bandar Abbas	IR Iran	AG-1	4	5	3	49	0.138
IRLVP	Lavan Island	IR Iran	AG-1	4	5	3	49	0.138
IRSXI	Sirri Island Oil Terminal	IR Iran	AG-1	4	5	3	49	0.138
IQBSR	Basra	Iraq	AG-2	4	5	3	49	0.138
IRBKM	Bandar Khomeini	IR Iran	AG-2	4	5	3	49	0.138
IRBMR	Bandar Mashur	IR Iran	AG-2	4	5	3	49	0.138
IQMAB	Mina Al Bakir	Iraq	AG-3	1	5	3	46	0.130
KWMEA	Mina Al Ahmadi	Kuwait	AG-3	1	5	3	46	0.130
KWMIS	Mina Saud	Kuwait	AG-3	1	5	3	46	0.130
KWSAA	Shuaiba	Kuwait	AG-3	1	5	3	46	0.130
SAJUB	Jubail	Saudi Arabia	AG-3	1	5	3	46	0.130
AEDAS	Das Island	UAE	AG-5	1	5	3	46	0.130
AEDXB	Dubai	UAE	AG-5	1	5	3	46	0.130
AEJEA	Jebel Ali	UAE	AG-5	1	5	3	46	0.130
AEJED	Jebel Dhanna	UAE	AG-5	1	5	3	46	0.130
AESHJ	Sharjah	UAE	AG-5	1	5	3	46	0.130
AEZIR	Zirku Island	UAE	AG-5	1	5	3	46	0.130
QADOH	Doha	Qatar	AG-5	1	5	3	46	0.130
QAUMS	Umm Said	Qatar	AG-5	1	5	3	46	0.130
SADMN	Damman	Saudi Arabia	AG-5	1	5	3	46	0.130
SARAR	Ras al Khafji	Saudi Arabia	AG-5	1	5	3	46	0.130
SARTA	Ras Tanura	Saudi Arabia	AG-5	1	5	3	46	0.130
USLOP	LOOP Terminal	United States	CAR-I	4	4	2	36	0.101
USSAB	Sabine	United States	CAR-I	4	4	2	36	0.101
EGAIS	Ain Sukhana	Egypt	RS-3	6	2	2	32	0.090
EGSUZ	Suez (El Suweis)	Egypt	RS-3	6	2	2	32	0.090
MGTMM	Tamatave (Toamasina)	Madagascar	EA-III	6	2	0	12	0.034
IDBPN	Balikpapan Kalimantan	Indonesia	EAS-II	2	3	0	11	0.031
YEHOD	Hodeidah	Yemen	RS-1	4	2	0	10	0.028

Many of the species listed for these areas can be related to their history of species transfers for aquaculture, plus hull fouling on sailing vessels and the canal-caused invasions of the east Mediterranean (Suez), north-east Europe (Ponto-Caspian river canal links) and Great Lakes (St Lawrence River seaway).

The regional 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 Khark Island). 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 Khark Island (which is located on the boundary of bioregions AG1 and AG2; Figure 7, Table 8).

Table 8. Status of risk species assigned to the bioregions of Khark Island (AG-1, AG-2)

Group	Common Name	Species Name	Regional Status	Threat Status
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium minutum*	Cryptogenic	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Alexandrium tamarense*	Cryptogenic	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Cochlodinium polykrikoides*	Native	Suspected harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gymnodinium catenatum*	Introduced	Known harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gyrodinium impudicum*	Introduced	Suspected harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Gyrodinium instriatum*	Introduced	Suspected harmful species
Pyrrophyta/Dinophycae	Toxic dinoflagellate	*Peridinium pentagonum (Gran) Balech*	Introduced	Suspected harmful species
Cnidaria	Moon Jellyfish	*Aurelia aurita*	Cryptogenic	Suspected harmful species
Cnidaria	Sea jelly	*Phyllorhiza punctata*	Native	Not suspected
Arthropoda - Cirrepedia	Striped barnacle	*Balanus amphitrite amphitrite*	Cryptogenic	Not suspected
Arthropoda - Cirrepedia	Striped barnacle	*Balanus amphitrite cirratus*	Native	Not suspected
Arthropoda - Cirrepedia	Striped barnacle	*Balanus amphitrite hawaiiensis*	Cryptogenic	Not suspected
Arthropoda - Cirrepedia	Rosy barnacle	*Balanus trigonus*	Cryptogenic	Not suspected
Arthropoda - Isopoda	Sea lice	*Cilicaea lateraillei*	Native	Not suspected
Arthropoda - Decapoda	Crab	*Ashtoret lunaris*	Native	Not suspected
Arthropoda - Decapoda	Swimmer crab	*Charybdis hellerii*	Native	Known harmful species
Mollusc - bivalve	Red Sea cup oyster	*Chama elatensis*	Native	Not suspected
Mollusc - bivalve	Indo-Pacific rock oyster	*Saccostrea cucullata*	Native	Not suspected
Mollusc - gastropod	Indo-Pacific marine snail	*Cavolinia tridentate (Neibuhr 1775)*	Cryptogenic	Not suspected
Chordata - Pisces	Sleeper goby	*Butis koilomatodon*	Native	Not suspected
Chordata - Pisces	Combtooth blenny	*Ornobranchus punctatus*	Native	Not suspected
Chordata - Pisces	Sobaity sea bream	*Sparidenrax hasta*	Native	Not suspected

The species in Table 8 include preliminary identifications from the Khark Island PBBS, plus those listed in published and unpublished reports from the RSA (mostly the west side; AG-3, AG-5; Figure 7). Bandar Abbas (the only port identified to receive BW uplifted at Khark Island) is also in bioregion AG-1 , and the same species were also assigned to AG-3 and AG-5 because of the small size, circular water movements and lack of specific distribution data for the RSA (Figures 2, 7, 11-12).

4.8 Risk assessment results

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

After calculating the RORs the database generates a large output table listing the source ports and their coefficients, risk-reduction factors and ROR value, plus the five ROR categories used for the GIS plot and the standardised ROR values (S-ROR; Section 3.10). Results from the project-standard

BWRA for the Port of Khark Island are listed in Table 9, and the GIS plot of the ROR categories is shown in Figure 24.

Seventeen source ports provided the top 20% of the total cumulative threat for the Port of Khark Island, with ROR values in the 0.23-0.20 range (Table 9). These highest risk ports (in terms of their BW source frequency, volume, environmental similarity and assigned risk species) were led by Kaohsiung in Taiwan Province (ROR = 0.229; S-ROR = 1.0), followed by four RSA ports (Jebel Ali, Doha, Umm Said and Fujairah) and the Red Sea oil reception terminal at Ain Sukhana (ROR = 0.218; S-ROR = 0.95). Highest risk ports beyond the Middle East were Okinawa and Chiba (Japan) and Ulsan (Korea)(Table 9).

Of the 22 source ports in the high risk category, the majority were located in South Asia and East Asia, including ports in India (2), Sri Lanka (1), Japan (7), China (1), Taiwan Province (1), Korea (2) and Philippines (1). Only one European port attained the high risk category (Eleusis in Greece; ROR = 0.19; S-ROR = 0.81). Six ports in the RSA also attained this category but the frequency and amounts of BW actually sourced from these ports (as indicated in the BWRFs) are questionable.

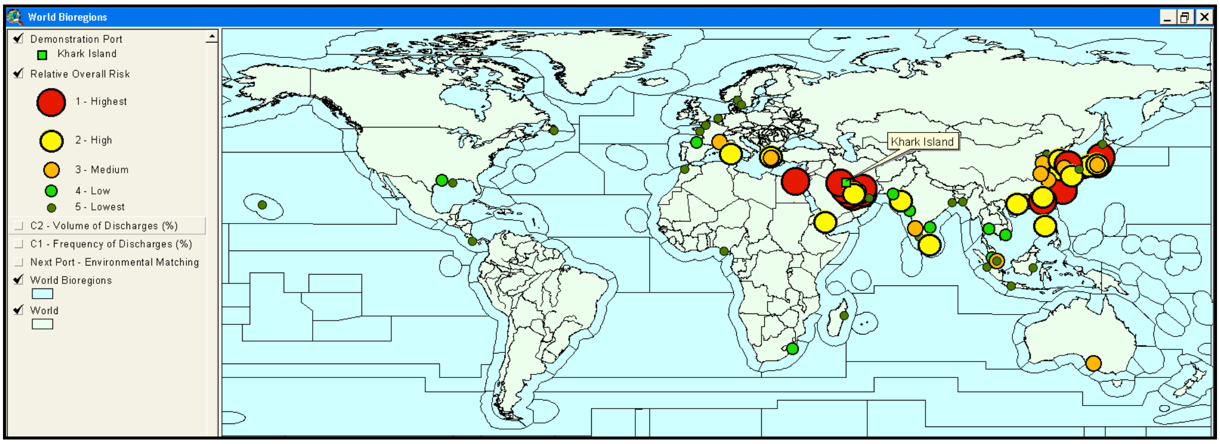


Figure 24. GIS output showing the location and categories of relative overall risk (ROR-cat) of source ports identified for the Port of Khark Island

The 64 source ports in the low (27) and lowest (37) risk categories include those in north Europe, North America and South Africa, plus a mixture of South and East Asian ports. These ports have relatively low environmental similarities (6-56%) and BW source frequencies (<2.5%). The source port with the lowest ROR (0.027) was the Port of Come by Chance (Newfoundland, Canada).

Based on the current pattern of shipping trade (1999-2002), the ROR results imply BW discharges by vessels arriving from north-east America represent a threat to Khark Island that is an order of magnitude less than many Asian and Middle East ports such as Kaohsiung, Jebel Ali and Ain Sukahna (Table 9).

The generally much higher threat of BW-mediated introductions posed by BW sources in the Middle East and Asia than in north America and Europe is logical with respect to Khark Island's geographic location and pattern of trade. It also implies that any introduced species which establishes in a port in the RSA or nearby Red Sea and west Arabian Sea could be readily spread by local ship movements involving shuttle services, bunkering and/or part-loading of cargo.

While the high temperature and salinity ranges experienced by the majority RSA ports no doubt help constrain the establishment of many unwanted marine plants and animals from the subtropical and tropical regions of East Asia and the Americas, the number of introduced and cryptogenic toxic dinoflagellates in Table 9 shows this region is not immune to the spread of harmful species. These could increase the severity of red tides in eutrophic coastal bays and lagoons beside rapidly-developing urban centres (a growing problem recognised by several GCC countries).

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

Port Code	Source Port	Country	C1 BW Freq	C2 BW Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match.	*Estimated*	C4 Risk Spp.	Relative Overall Risk (ROR)	% of total risk (ROR sum)	Cumulative Percentage	Risk Category	Standrdisd ROR
TWKHH	Kaohsiung	Taiwan Province	0.040	0.031	102,259	1.0	15	0.6	0.572		0.4535	**0.229**	1.15	1.15	Highest	1.00
AEJEA	Jebel Ali	UAE	0.003	0.005	111,238	1.0	2	1.0	0.757		0.1296	**0.224**	1.12	2.27	Highest	0.97
QADOH	Doha	Qatar	0.001	0.003	105,410	1.0	1	1.0	0.754		0.1296	**0.222**	1.11	3.38	Highest	0.97
QAUMS	Umm Said	Qatar	0.003	0.001	17,761	1.0	2	1.0	0.750		0.1296	**0.221**	1.11	4.49	Highest	0.96
AEFJR	Fujairah (Al-Fujairah)	UAE	0.019	0.022	147,588	1.0	2	1.0	0.674		0.1606	**0.219**	1.10	5.59	Highest	0.95
EGAIS	Ain Sukhana	Egypt	0.066	0.097	144,845	1.0	5	0.8	0.637		0.0901	**0.218**	1.09	6.68	Highest	0.95
SAJUB	Jubail	Saudi Arabia	0.004	0.001	35,791	1.0	1	1.0	0.731		0.1296	**0.216**	1.09	7.77	Highest	0.94
JPOKA	Okinawa Okinawa	Japan	0.000	0.001	85,900	1.0	19	0.6	0.581		0.4535	**0.214**	1.07	9.93	Highest	0.93
IRBND	Bandar Abbas	IR Iran	0.075	0.040	135,815	1.0	1	1.0	0.574		0.1380	**0.207**	1.04	10.97	Highest	0.89
AEKLF	Khor Al Fakkan	UAE	0.007	0.005	94,472	1.0	1	1.0	0.651		0.1606	**0.206**	1.03	12.00	Highest	0.89
SADMN	Damman	Saudi Arabia	0.001	0.000	11,044	1.0	1	1.0	0.678		0.1296	**0.202**	1.02	13.02	Highest	0.87
SARTA	Ras Tanura	Saudi Arabia	0.015	0.032	108,950	1.0	1	1.0	0.631		0.1296	**0.202**	1.01	14.03	Highest	0.87
JPCHB	Chiba Chiba	Japan	0.049	0.051	107,191	1.0	15	0.6	0.421		0.4676	**0.200**	1.01	15.04	Highest	0.86
JPSEN	Sendai Kagoshima	Japan	0.006	0.007	103,622	1.0	19	0.6	0.515	*E*	0.4535	**0.200**	1.00	16.04	Highest	0.86
KRUSN	Ulsan	Rep Korea	0.041	0.037	156,162	1.0	7	0.8	0.348		0.4620	**0.199**	1.00	17.04	Highest	0.85
KWSAA	Shuaiba	Kuwait	0.000	0.000	3,385	1.0	2	1.0	0.666		0.1296	**0.199**	1.00	18.04	Highest	0.85
KWMEA	Mina Al Ahmadi	Kuwait	0.004	0.007	104,995	1.0	1	1.0	0.655		0.1296	**0.199**	1.00	19.04	Highest	0.85
AEJED	Jebel Dhanna	UAE	0.015	0.028	109,164	1.0	1	1.0	0.624		0.1296	**0.199**	1.00	20.03	High	0.85
KWMIS	Mina Saud	Kuwait	0.001	0.004	94,362	1.0	1	1.0	0.658		0.1296	**0.198**	0.99	21.03	High	0.85
KRTSN	Taesan	Rep Korea	0.019	0.028	109,276	1.0	8	0.8	0.363	*E*	0.4732	**0.197**	0.99	22.02	High	0.84
JPKII	Kiire Kagoshima	Japan	0.015	0.013	100,057	1.0	16	0.6	0.470		0.4676	**0.194**	0.98	22.99	High	0.83
AEZIR	Zirku Island	UAE	0.002	0.006	101,742	1.0	2	1.0	0.637		0.1296	**0.194**	0.97	23.97	High	0.83
CNSDG	Shui Dong	China	0.010	0.009	84,200	1.0	6	0.8	0.390	*E*	0.4535	**0.193**	0.97	24.94	High	0.82
LKCMB	Colombo	Sri Lanka	0.005	0.003	34,500	1.0	7	0.8	0.539		0.2732	**0.192**	0.96	25.90	High	0.82
GREEU	Eleusis	Greece	0.008	0.004	80,625	1.0	13	0.6	0.527		0.3690	**0.190**	0.95	26.85	High	0.81
AEDAS	Das Island	UAE	0.000	0.000	0	0.4	1	1.0	0.630		0.1296	**0.190**	0.95	27.81	High	0.81
TWMAI	Mailiao	Taiwan Province Of China	0.010	0.005	55,000	1.0	9	0.8	0.362	*E*	0.4732	**0.189**	0.95	28.75	High	0.80
INVAD	Vadinar	India	0.004	0.005	100,231	1.0	4	1.0	0.464		0.2732	**0.187**	0.94	29.69	High	0.79
JPKSM	Kashima Ibaraki	Japan	0.021	0.015	95,600	1.0	17	0.6	0.436		0.4535	**0.186**	0.93	30.62	High	0.79
INSIK	Sikka (Jamnagar)	India	0.037	0.032	121,600	1.0	4	1.0	0.396		0.2732	**0.185**	0.93	31.55	High	0.78
KRCHA	Cheju	Rep Korea	0.005	0.002	102,123	1.0	12	0.6	0.446	*E*	0.4732	**0.184**	0.92	32.48	High	0.78
JPYKK	Yokkaichi Mie	Japan	0.028	0.024	100,514	1.0	17	0.6	0.403		0.4676	**0.184**	0.92	33.40	High	0.78
JPKWS	Kawasaki Kanagawa	Japan	0.019	0.019	97,038	1.0	17	0.6	0.401		0.4676	**0.180**	0.90	34.30	High	0.76
JPNGO	Nagoya Aichi	Japan	0.012	0.017	104,882	1.0	18	0.6	0.410		0.4676	**0.180**	0.90	35.20	High	0.76
JPSAK	Sakai Osaka	Japan	0.012	0.013	96,166	1.0	18	0.6	0.412		0.4676	**0.179**	0.90	36.11	High	0.76
PHBLG	Tabanga	Philippines	0.005	0.005	115,402	1.0	9	0.8	0.540	*E*	0.2085	**0.179**	0.90	37.01	High	0.76
JPYOK	Yokohama Kanagawa	Japan	0.008	0.007	94,779	1.0	17	0.6	0.419		0.4676	**0.178**	0.90	37.90	High	0.75
AESHJ	Sharjah	UAE	0.001	0.000	9,736	1.0	3	1.0	0.581		0.1296	**0.178**	0.89	38.80	High	0.75
YEHOD	Hodeidah	Yemen	0.001	0.001	39,030	1.0	25	0.4	0.699		0.0282	**0.178**	0.89	39.69	High	0.75
ITPFX	Porto Foxi (Sarroch)	Italy	0.002	0.001	53,273	1.0	17	0.6	0.468		0.4000	**0.178**	0.89	40.58	Medium	0.75
JPNGI	Negishi	Japan	0.005	0.004	94,032	1.0	15	0.6	0.419		0.4676	**0.177**	0.89	41.47	Medium	0.74
AEDXB	Dubai	UAE	0.010	0.016	144,845	1.0	2	1.0	0.551		0.1296	**0.177**	0.89	42.36	Medium	0.74
EGSUZ	Suez (El Suweis)	Egypt	0.000	0.001	94,472	1.0	10	0.6	0.649		0.0901	**0.176**	0.88	43.24	Medium	0.74
IRSXI	Sirri Island Oil Terminal	IR Iran	0.003	0.006	104,999	1.0	1	1.0	0.556		0.1380	**0.176**	0.88	44.13	Medium	0.74
HKHKG	Hong Kong	Hong Kong	0.001	0.002	99,809	1.0	16	0.6	0.426		0.4535	**0.175**	0.88	45.01	Medium	0.74
CNTAO	Qingdao (Longgang) Shandong	China	0.005	0.011	100,933	1.0	19	0.6	0.401		0.4732	**0.175**	0.88	45.88	Medium	0.73
GRPAC	Pachi	Greece	0.002	0.002	38,700	1.0	15	0.6	0.472		0.3690	**0.174**	0.88	46.76	Medium	0.73
INIXE	Mangalore (New Mangalore)	India	0.051	0.020	44,457	1.0	5	0.8	0.408		0.2732	**0.174**	0.88	47.64	Medium	0.73
JPNGS	Nagasaki Nagasaki	Japan	0.001	0.002	97,401	1.0	18	0.6	0.409		0.4732	**0.174**	0.87	48.51	Medium	0.73
IRLVP	Lavan Island	IR Iran	0.000	0.000	28,898	1.0	2	1.0	0.556		0.1380	**0.174**	0.87	49.38	Medium	0.73
SGSIN	Singapore	Singapore	0.048	0.055	106,981	1.0	5	0.8	0.425		0.2085	**0.174**	0.87	50.25	Medium	0.73
KROKP	Okpo	Rep Korea	0.001	0.001	90,702	1.0	19	0.6	0.407	*E*	0.4732	**0.173**	0.87	51.12	Medium	0.73
JPOIT	Oita Oita	Japan	0.011	0.010	104,578	1.0	17	0.6	0.388		0.4676	**0.173**	0.87	51.99	Medium	0.72
JPMIZ	Mizushima Okayama	Japan	0.040	0.030	104,200	1.0	17	0.6	0.338		0.4676	**0.172**	0.86	52.85	Medium	0.72
AUPST	Port Stanvac	Australia	0.000	0.001	92,334	1.0	20	0.4	0.471		0.5380	**0.172**	0.86	53.72	Medium	0.72
GRPIR	Piraeus	Greece	0.001	0.001	35,152	1.0	47	0.4	0.536		0.3690	**0.171**	0.86	54.58	Medium	0.72
PHBTG	Batangas Luzon	Philippines	0.005	0.006	95,000	1.0	13	0.6	0.544		0.2085	**0.170**	0.85	55.43	Medium	0.71
CNZOS	Zhousan (Dinghai)	China	0.001	0.002	101,376	1.0	15	0.6	0.390	*E*	0.4732	**0.169**	0.85	56.28	Medium	0.71
KRYOS	Yosu	Rep Korea	0.026	0.016	104,603	1.0	18	0.6	0.350	*E*	0.4732	**0.169**	0.85	57.13	Medium	0.70
CNZHE	Zhenjiang Zhejiang	China	0.001	0.000	34,989	1.0	15	0.6	0.390	*E*	0.4732	**0.169**	0.85	57.98	Medium	0.70
FRLAV	Lavera	France	0.000	0.001	104,556	1.0	15	0.6	0.431		0.4000	**0.168**	0.84	58.82	Medium	0.70
PHBTN	Bataan Mariveles	Philippines	0.004	0.006	101,870	1.0	18	0.6	0.527		0.2085	**0.166**	0.83	59.65	Medium	0.69

Table 9 cont. Source ports identified for the Port of Khark Island, as ranked according to their Relative Overall Risk (ROR)

Port Code	Source Port	Country	C1 Freq	C2 Vol	Max. Tank Disch (MT)	R1	Min. Tank Stor. (d)	R2	C3 Env. Match.	Estimated	C4 Risk Spp.	Relative Overall Risk (ROR)	% of Total Risk (Sum of ROR)	Cumulative Percentage	Risk Category	Standard Results
KRONS	Onsan	Rep Korea	0.013	0.016	103,602	1.0	13	0.6	0.355		0.4620	**0.165**	0.83	60.48	Low	0.69
JPSKD	Sakaide Kagawa	Japan	0.010	0.009	98,414	1.0	18	0.6	0.359		0.4676	**0.165**	0.83	61.31	Low	0.68
ZADUR	Durban	South Africa	0.024	0.025	141,588	1.0	12	0.6	0.418		0.3155	**0.164**	0.82	62.13	Low	0.68
JPHIM	Himeji Hyogo	Japan	0.002	0.003	83,088	1.0	22	0.4	0.460		0.4676	**0.163**	0.82	62.95	Low	0.67
INMAA	Chennai (Ex Madras)	India	0.002	0.002	51,911	1.0	7	0.8	0.428		0.2732	**0.163**	0.82	63.76	Low	0.67
JPSMT	Shimotsu Wakayama	Japan	0.000	0.001	99,920	1.0	21	0.4	0.458		0.4676	**0.162**	0.81	64.58	Low	0.67
THMAT	Mab Tapud	Thailand	0.014	0.018	102,568	1.0	12	0.6	0.486	*E*	0.2085	**0.161**	0.81	65.38	Low	0.66
CNNGB	Ningbo Zhejiang	China	0.011	0.014	106,651	1.0	17	0.6	0.333		0.4732	**0.161**	0.81	66.19	Low	0.66
PKKHI	Karachi	Pakistan	0.007	0.004	32,000	1.0	3	1.0	0.467		0.1606	**0.160**	0.80	66.99	Low	0.66
JPUBJ	Ube Yamaguchi	Japan	0.009	0.008	109,295	1.0	17	0.6	0.340		0.4676	**0.160**	0.80	67.79	Low	0.66
VNVUT	Vung Tau	Viet Nam	0.000	0.000	1,284	1.0	35	0.4	0.550	*E*	0.2085	**0.158**	0.80	68.59	Low	0.65
JPSMZ	Shimizu Shizuoka	Japan	0.000	0.001	85,348	1.0	21	0.4	0.445		0.4676	**0.158**	0.79	69.38	Low	0.65
INSAL	Salaya	India	0.000	0.000	27,105	1.0	11	0.6	0.468		0.2732	**0.158**	0.79	70.18	Low	0.65
JPTAM	Tamano Okayama	Japan	0.000	0.000	19,000	1.0	21	0.4	0.429		0.4676	**0.154**	0.77	70.95	Low	0.63
JPTKY	Tokuyama Yamaguchi	Japan	0.005	0.007	106,341	1.0	17	0.6	0.323		0.4676	**0.154**	0.77	71.72	Low	0.63
JPINS	Inoshima Hiroshima	Japan	0.000	0.001	90,295	1.0	20	0.4	0.424		0.4676	**0.153**	0.77	72.49	Low	0.63
ESBIO	Bilbao	Spain	0.003	0.007	98,000	1.0	19	0.6	0.346	*E*	0.4141	**0.151**	0.76	73.25	Low	0.62
USSAB	Sabine	United States	0.000	0.001	83,512	1.0	41	0.4	0.560		0.1014	**0.151**	0.76	74.01	Low	0.61
TWKEL	Keelung (Sha Lung & Tanshoei)	Taiwan Province of China	0.009	0.006	96,828	1.0	12	0.6	0.293		0.4732	**0.148**	0.74	74.75	Low	0.60
INBOM	Mumbai (Ex Bombay)	India	0.003	0.003	93,312	1.0	3	1.0	0.309		0.2732	**0.147**	0.74	75.49	Low	0.60
JPKCZ	Kochi Kochi	Japan	0.000	0.001	101,380	1.0	21	0.4	0.397		0.4676	**0.147**	0.74	76.22	Low	0.59
JPSAE	Saiki Oita	Japan	0.002	0.001	10,801	1.0	22	0.4	0.394		0.4676	**0.146**	0.74	76.14	Low	0.59
CNQZJ	Quanzhou (Jinjiang) Fujian	China	0.003	0.001	24,228	1.0	21	0.4	0.390	*E*	0.4732	**0.146**	0.73	76.95	Low	0.59
CNMEZ	Xiuyu (Meizhou)	China	0.001	0.001	24,000	1.0	22	0.4	0.390	*E*	0.4732	**0.145**	0.73	77.68	Low	0.59
CNJIA	Jiangyin Jiangsu	China	0.000	0.000	19,500	1.0	23	0.4	0.390	*E*	0.4732	**0.145**	0.73	78.41	Low	0.59
THRTT	Rayong TPI Terminal	Thailand	0.001	0.001	39,717	1.0	24	0.4	0.486	*E*	0.2085	**0.143**	0.72	79.13	Low	0.57
MYMKZ	Malacca	Malaysia	0.002	0.004	95,168	1.0	11	0.6	0.438	*E*	0.2085	**0.142**	0.71	79.84	Low	0.57
SARAR	Ras al Khafji	Saudi Arabia	0.001	0.003	98,000	1.0	1	1.0	0.425	*E*	0.1296	**0.140**	0.70	80.54	Lowest	0.56
PKBQM	Muhammad Bin Qasim	Pakistan	0.003	0.001	26,630	1.0	5	0.8	0.427		0.1606	**0.140**	0.70	81.25	Lowest	0.56
SGJUR	Jurong	Singapore	0.001	0.002	87,440	1.0	10	0.6	0.425		0.2085	**0.138**	0.69	81.94	Lowest	0.55
CNDLC	Dalian Liaoning	China	0.001	0.001	51,856	1.0	30	0.4	0.360		0.4732	**0.138**	0.69	82.63	Lowest	0.55
EGPSD	Port Said	Egypt	0.000	0.001	104,556	1.0	10	0.6	0.321		0.3690	**0.136**	0.68	83.32	Lowest	0.54
JPMUR	Muroran Hokkaido	Japan	0.003	0.004	92,397	1.0	18	0.6	0.264		0.4535	**0.136**	0.68	84.00	Lowest	0.54
FRDON	Donges	France	0.004	0.012	104,961	1.0	18	0.6	0.257		0.4169	**0.131**	0.66	84.65	Lowest	0.51
OMMFH	Min-Al-Fahal	Oman	0.001	0.003	90,996	1.0	2	1.0	0.356	*E*	0.1606	**0.130**	0.65	85.31	Lowest	0.51
SGTPG	Tanjong Pagar	Singapore	0.001	0.000	36,888	1.0	11	0.6	0.390		0.2085	**0.129**	0.65	85.96	Lowest	0.51
SGKEP	Keppel Wharves	Singapore	0.000	0.001	108,491	1.0	22	0.4	0.425		0.2085	**0.128**	0.64	86.60	Lowest	0.50
JPTMK	Tomakomai Hokkaido	Japan	0.004	0.006	94,366	1.0	19	0.6	0.225		0.4535	**0.127**	0.64	87.23	Lowest	0.50
USHNL	Honolulu Hawaii	United States	0.000	0.000	37,181	1.0	32	0.4	0.400	*E*	0.2479	**0.125**	0.63	87.86	Lowest	0.49
MYJHB	Johor Bahru	Malaysia	0.000	0.001	94,199	1.0	12	0.6	0.365	*E*	0.2085	**0.123**	0.62	88.48	Lowest	0.48
INHAL	Haldia	India	0.003	0.002	31,309	1.0	8	0.8	0.264		0.2732	**0.122**	0.61	89.09	Lowest	0.47
JPSAI	Saijo	Japan	0.001	0.001	35,972	1.0	56	0.2	0.390	*E*	0.4676	**0.121**	0.61	89.70	Lowest	0.47
THSRI	Sriracha	Thailand	0.006	0.006	96,356	1.0	12	0.6	0.345	*E*	0.2085	**0.120**	0.60	90.30	Lowest	0.46
FRLEH	Le Havre	France	0.000	0.001	93,000	1.0	19	0.6	0.217		0.4113	**0.116**	0.58	90.89	Lowest	0.44
INCOK	Cochin	India	0.016	0.007	37,000	1.0	6	0.8	0.217		0.2732	**0.115**	0.58	91.46	Lowest	0.44
IRBKM	Bandar Khomeini	IR Iran	0.004	0.000	3,430	1.0	1	1.0	0.293		0.1380	**0.109**	0.55	92.01	Lowest	0.41
IQBSR	Basra	Iraq	0.000	0.001	92,943	1.0	1	1.0	0.290	*E*	0.1380	**0.107**	0.54	92.55	Lowest	0.40
IDPDG	Teluk Bajur/Padang Sumatra	Indonesia	0.000	0.002	128,200	1.0	16	0.6	0.300	*E*	0.2085	**0.107**	0.54	93.09	Lowest	0.40
IDCXP	Cilacap Java	Indonesia	0.007	0.005	59,740	1.0	8	0.8	0.247		0.2085	**0.107**	0.54	93.62	Lowest	0.39
IQMAB	Mina Al Bakir	Iraq	0.000	0.001	105,976	1.0	1	1.0	0.290	*E*	0.1296	**0.105**	0.53	94.15	Lowest	0.39
IRBMR	Bandar Mashur	IR Iran	0.000	0.000	0	0.4	1	1.0	0.278		0.1380	**0.104**	0.52	94.67	Lowest	0.38
PAAML	Puerto Armuelles	Panama	0.002	0.001	26,547	1.0	54	0.2	0.328	*E*	0.3070	**0.098**	0.49	95.16	Lowest	0.35
USLOP	LOOP Terminal	United States	0.001	0.004	130,519	1.0	34	0.4	0.337		0.1014	**0.096**	0.48	95.65	Lowest	0.34
INIXY	Kandla (Muldwarka)	India	0.004	0.000	21,357	1.0	6	0.8	0.158		0.2732	**0.095**	0.48	96.12	Lowest	0.34
MAMOH	Mohammedia	Morocco	0.000	0.000	35,000	1.0	21	0.4	0.368	*E*	0.0000	**0.092**	0.46	96.59	Lowest	0.32
SEBRO	Brofjorden	Sweden	0.001	0.003	100,077	1.0	22	0.4	0.200	*E*	0.4113	**0.092**	0.46	97.05	Lowest	0.32
SEHAD	Halmstad	Sweden	0.000	0.001	90,000	1.0	26	0.4	0.200	*E*	0.4113	**0.092**	0.46	97.51	Lowest	0.32
MGTMM	Tamatave (Toamasina)	Madagascar	0.000	0.000	37,436	1.0	23	0.4	0.333	*E*	0.0338	**0.087**	0.44	97.94	Lowest	0.30
KRINC	Inchon	Rep Korea	0.000	0.001	105,103	1.0	20	0.4	0.137		0.4732	**0.082**	0.41	98.36	Lowest	0.27
NGABO	Abonnema	Nigeria	0.000	0.000	32,226	1.0	23	0.4	0.326	*E*	0.0000	**0.082**	0.41	98.77	Lowest	0.27
IDBPN	Balikpapan Kalimantan	Indonesia	0.003	0.000	17,469	1.0	71	0.2	0.300	*E*	0.0310	**0.077**	0.39	99.15	Lowest	0.25
BDCGP	Chittagong	Bangladesh	0.000	0.001	47,309	1.0	11	0.6	0.125		0.2732	**0.073**	0.36	99.52	Lowest	0.23
NLRTM	Rotterdam	Netherlands	0.005	0.011	114,835	1.0	20	0.4	0.095		0.4113	**0.069**	0.35	99.86	Lowest	0.21
CACBC	Come By Chance	Canada	0.000	0.002	142,247	1.0	91	0.2	0.061		0.2225	**0.027**	0.14	100.0	Lowest	0.00

Figure 25 shows the distribution of the standardised ROR values. The relatively wide spread of this plot reflects the large number of ports with similar BW source frequencies and environmental matching coefficients (e.g. 39 of the 126 source ports (31%) represent 40% of the cumulative threat; Table 9).

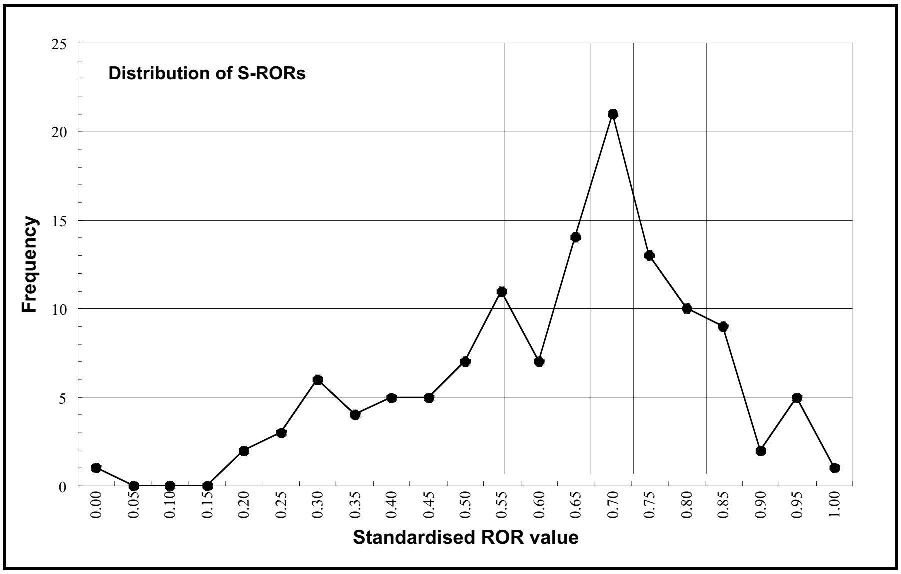


Figure 25. Frequency distribution of the standardised ROR values

Reverse BWRA

In the case of the cargo export-oriented Port of Khark Island, the only destination port reliably identified to receive BW from this Demonstration Site was Bandar Abbas (Section 4.5). The environmental similarity of Bandar Abbas is moderately high (C3 = 0.574) and this large coastal port is in the same bioregion that borders Khark Island (AG-1; Figures 2, 7). This suggests any harmful species that establishes a viable population at Khark Island has a reasonable chance of spreading to Bandar Abbas via BW-mediated transfers. In the case of the risk species assigned to bioregions AG-1/AG-2, the dinoflagellates capable of producing poisonous red tides in eutrophic coastal waters would pose a serious threat to the inshore waters of Bandar Abbas (Table 8).

4.9 Training and capacity building

The computer hardware and software provided by the GloBallast Programme for the BWRA activity was installed and is maintained at PSO's head office in Tehran. This PC, plus others made available by PSO for BWRF data entries and database management, proved reliable and adequate for developing the port map, displaying the results and providing other GIS and database needs.

All PSO counterparts were suitably experienced in the use of MS Windows applications and received basic training in map development using ArcView GIS. Because the PSO has a close working relationship with the National Cartographic Centre (NCC) in Tehran, which produces digital navigation charts of Iranian coastal waters using the CARIS system, the NCC provided several counterparts and information to help Group A develop the port map (Section 3.11; Appendix 2). There is no doubt that the PSO and NCC are capable of producing similar resource maps for future BWRA demonstration and training activities in the region.

As noted in Section 3.6, the most easily-trained and efficient database operators are those with port and maritime work experience, plus previous hands-on experience with Windows applications. This was the case for the PSO Group B counterparts, who had little difficulty in learning how to use the database efficiently, and who demonstrated a good ability to recognise and fix incorrect or missing ship, port and BW information on the BWRFs. Thus all Group B counterparts gained a good understanding of the reporting requirements and became proficient in using port shipping records and other databases for BWRF checking and gap-filling, including using the *Fairplay Ports Guide,* the *Lloyds Ship Register* and the Excel spreadsheet for estimating BW discharge volumes. PSO officers responsible for collecting BWRFs at Khark Island also received training and guidance to improve

BWRF return rates, completeness and reduced error rates. Group B members also undertook an error analysis of BWRF forms covering 16 month period (Section 4.10).

Of the three counterpart groups, Group C was the smallest (Appendix 2). Group C received instruction in the approach and methods of the environmental similarity analysis using the PRIMER package during the in-country visits by the consultants, with intensive 'hands-on' training provided in the second visit. The lead counterpart of Group B (Mr Nasser K Rad) also received training and advice and became equally adept at generating the C3 coefficients and importing them to the database. Collation of risk species information and regional networking with other marine scientists was undertaken by Dr Vahid Yavari (PSO's BWRA team leader and leading counterpart of Group C).

4.10 Identification of information gaps

Ballast Water Reporting Forms

BWRFs containing many empty or incorrect entries for BW source/s, uptake date/s and tank volumes intended to be discharged were not uncommon (as was the case for other Demonstration Sites where BWRF submission was voluntary). Some ships submitted a copy of their Ballast Water Management Plan instead of the BWRF. To determine trends among the BWRFs collected at the Port of Khark Island, an error analysis of submitted BWRFs was undertaken by Group B, and the results are shown in Table 10. The analysis covered three periods between April 2000 (month of BWRF inception at Khark Island) and October 2002.

Table 12. Errors in BWRFs submitted to Port of Khark Island - results from three periods of BWRF analysis*

Mnth	IMO No.	GT	Arrival Date	Last Port	Next Port	BW on board	BW capacity	No of Tanks	BW Source	Exchange details	Reason given	Disch vol	No Sign	Total No BWRFs
Apr	3	3	5	4	6	5	5	8	22	26	28	23	15	**42**
May	7	5	6	3	5	5	4	6	13	30	29	17	9	**43**
Jul	5	3	4	1	3	3	8	7	11	30	26	26	8	**42**
Aug	6	5	11	2	2	3	5	3	4	38	40	19	23	**55**
Sep	2	2	6	1	0	3	5	5	6	17	16	13	5	**41**
Oct	0	0	6	2	1	0	1	1	2	19	26	11	8	**30**
Nov	3	1	4	0	3	2	4	4	2	15	9	13	3	**40**
Dec	3	1	2	0	0	0	0	0	1	7	3	3	1	**12**
Jan	4	0	2	1	2	1	1	1	1	18	17	8	4	**38**
Feb	0	0	0	0	0	0	0	0	0	4	7	2	3	**10**
Mar	3	2	4	2	4	5	6	2	5	26	15	13	6	**39**
Sep	0	0	1	1	1	0	1	1	0	14	16	6	4	**43**
Oct	0	0	0	0	0	0	0	0	1	11	12	5	1	**26**
Total	**36**	**22**	**61**	**17**	**27**	**27**	**40**	**38**	**68**	**257**	**244**	**169**	**90**	**461**
%	8%	5%	13%	4%	6%	6%	9%	8%	15%	56%	53%	37%	20%	**%**

*April - December 2000 (excluding June); January - March 2002; September - October 2002.

The following list summarises the most common omissions or mistakes in submitted BWRFs:

- BW uptake date, source port/location and/or discharge volume were provided for none, only one, or just a few of the total number of tanks probably discharged.
- The BW exchange field (Part 4 of the BWRF; Appendix 1) was another problem area, with no exchange data (or no reason given for not undertaking an exchange being a common occurrence. Reasons typically provided for not undertaking a BW exchange were as follows (*comments by Group B are in italics*):
  - Severe weather conditions prevented exchange;
  - Concern over the ship's stability and strength;
  - Not a statutory/enforceable requirement of the port or national administration;

  - Ballast had been taken on at an offshore terminal (*'clear water' was considered safe?*);
  - Ballast had been taken up in the same sea area (*perceptive remark*);
  - Sea was clean (*presumably did not want to cause oil and/or species pollution?*);
  - Vessel had segregated ballast tanks (*presumably thinking of oil pollution control*?);
  - Ballast had been visually checked (*characteristics checked for were not stated*).

- Many vessels providing BW exchange data did not provide its original source details. It seems the ship officers were assuming that exchanges are virtually 100% effective, so the source details are not required. However it is important to enter the source port/location details because even the most effective exchanges are probably in the 90-95% range.
- The BW Discharge field of the BWRF (also in Part 4) was also a problem area, with ships appearing reluctant to enter this information although most were loading a full cargo and therefore must have discharged all or most of their ballast. Of the few entries which entered the salinity of the discharged ballast, all appeared to presume it was standard seawater (≈ 1.025 specific gravity).
- Some ships did not appear to understand the difference between the arrival port and next port (entering Khark Island in both boxes).

Table 12 and the above summary provide a useful guide as to which items port officers should immediately check when collecting or receiving any BWRF. Table 12 also shows there was an improvement in the error rate over the three periods of analysis. This was not unexpected since ships' officers, shipping agents and the port officers were gradually becoming familiar with the BWRF process following its inception at Khark Island and other ports around the world.

Apart from lack of BWRF familiarity, it was also recognised that the time available for a ships' officer to complete the form is another factor influencing the number of mistakes and omissions. BWRFs provided to ships during their berthing or departure phases cannot be expected to receive the same level attention as forms already onboard the ship and completed prior to arrival. Thus reporting can be improved if shipping agents send BWRF reminders (and blank forms where necessary) to ships 1-2 days prior to arrival.

The BWRF analysis revealed two other issues more specific to the RSA. The first stems from the frequent bunkering, provisioning and crew change operations undertaken by the majority of ships when entering or leaving the RSA (e.g. at Fujairah, Khor Fakkan). Such ports are frequently entered as the last or next port of call, although ballast discharges related to bunkering will not be large. Secondly, the last and next ports of call recorded on BWRFs and in port shipping records indicate that many tankers appear to temporarily anchor and/or load part of their cargo at a number of RSA oil terminals, both before or after visiting Khark Island. While this must decrease the amount of BW discharged at the final loading terminal, BW sources and volumes written in BWRFs collected at Khark Island were often contradictory (or omitted), indicating the BWRF had not been completed by an experienced senior officer. Unless BWRFs are completed accurately and fully by tankers visiting the RSA, a significant percentage of BW sources and discharge volumes will remain unclear.

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 BWRFs:

- Destination Port/s where either BW will be discharged or cargo actually offloaded (not necessarily the Next Port of Call - especially in the RSA).
- Berth number/location at the Demonstration Site (obtained 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 a port's waters, particularly for the seasonal water temperature and salinity averages and extrema. This was true for ports in very developed regions (e.g. North America, Europe and Japan) as it was for less developed areas.

In the case of species data, many national and regional data sets remain incomplete and/or unpublished, and there are none for the RSA or wider Middle East and African regions (except for the CIESM lists for the Mediterranean, which are not publicly listed on the web). Many sites list species which were historically introduced by the aquaculture, fisheries, aquarium industry or hull fouling vectors, while others do not provide the likely vector/s of their listed species.

5 Conclusions and Recommendations

The main objectives of the BWRA Activity were successfully completed during the course of this project, which took 13 months (i.e. between the initial briefing in January 2002 and the final consultants visit in February 2003). The level of port and maritime experience brought to the project by the PSO counterparts, together with the GIS expertise of the NCC counterparts, facilitated effective instruction and familiarisation of the BWRA system. This places I.R. Iran in a strong position to provide assistance, technical advice, guidance and encouragement to other port States of the RSA.

The Regional Strategic Action Plan (SAP) being developed by GloBallast and ROPME for coordinating BW management activities in the region provides the best mechanism for replicating the BWRF at other ports and oil terminals in the RSA.
Important items requiring attention for any future BW management activity in the RSA region comprise:

- availability of guidelines and instructions about BWRF reporting to ship's officers, shipping agents and port officers;
- relative lack of species surveys (PBBSs) in the RSA;
- lack of a regional web-based database for sharing and exchanging species survey information.

Organisations such as the Gulf Cooperation Council (GCC), ROPME and the major national oil producers and tanker companies in this region should be encouraged to support efforts in the above areas.

Recommendations

- To identify the locations where BW is discharged within a port, a more useful BWRF should include an entry for the berth or terminal name/number (instead of simply 'Port' and/or geographic coordinates, which was usually left blank).

- Owing to the number of bunkering/provisioning and part-loading calls made by tankers in the RSA, port States in this region should modify the "Last Port of Call„ field to provide a "Last Three (3) Ports of Call„ question.

- To help decipher and interpret poorly written, incomplete or suspect BWRFs, port and BW database entry officers should have access to up-to-date copies of the *Lloyds Ship Register*, the *Fairplay Ports Guide, Lloyd's Maritime Atlas of World Ports* or equivalent publications. For any port using the GloBallast BWRA system, a copy of the world bioregions map should also be provided to the data-entry officers so that the bioregion of any new port added to the database can be quickly identified.

- Any port officer whose duties include collecting or receiving BWRFs should be instructed to check that all relevant fields have been completed in legible script, and to decline any Ballast Water Management Plan offered by the vessel in lieu of a BWRF. A short BWRF information kit and training course provided to port officers and local shipping agents is strongly recommended, particularly during the implementation of the BWRF system at any port.

BWRA recommendations and plans by Pilot Country (IR Iran)

- More detailed training is required for the in-country teams in order to facilitate completely independent transfer of technics to other ports at national and regional level.

- More detailed BWRA *User Guide* should be provided to the pilot countries.
- Review of BWRF and inclusion of entries such as name/number of berths, last three ports of call and next ports of call and action taken regarding ballast water is highly recommended.
- BWRA results obtained should be verified by a detailed ballast water sampling and analysis programme. I.R. Iran has commenced working on a BW sampling and analysis proposal.
- Collection of BWRF is extended to other major Iranian Ports.

BWRA has been placed in the priority list of the principal actions of the ROPME Sea Area Regional Action Plan for ballast water control and management.

6 Location and Maintenance of the BWRA System

The GloBallast BWRF hardware and software packages in I.R. Iran are presently maintained at the PSO head offices in Tehran. The following people are currently responsible for maintaining and updating the following features of the BWRA system in I.R. Iran:

Port resource mapping and GIS display requirements:

Name:	Mr Ahmed Parhizi
Position:	Group A Team Leader and Head of Country Project Task Force
Organisation:	Ports and Shipping Organization, Ministry of Road and Transportation
Address:	No 751 Enghelab Avenue Tehran 1599661464 ISLAMIC REPUBLIC OF IRAN
Tel:	+98 21 880 9326
Fax:	+98 21 880 9555
Email:	parhizi@ir-pso.com

Ballast water reporting form database:

Name:	Mr Nasser Kayvanrad
Position:	Group B Team Leader
Organisation:	Ports and Shipping Organization, Ministry of Road and Transportation
Address:	No 751 Enghelab Avenue Tehran 1599661464 ISLAMIC REPUBLIC OF IRAN
Tel:	+98 21 880 9326
Fax:	+98 21 880 9555
Email:	kayvanrad@ir-pso.com

Port environmental and risk species data:

Contact person:	Dr Vahid Yavari
Position:	Group C Team Leader and Country Focal Point Assistant
Organization:	C/o Ports and Shipping Organization, Ministry of Road and Transportation
Address:	No 751 Enghelab Avenue Tehran 1599661464 ISLAMIC REPUBLIC OF IRAN
Tel:	+98 63 242 30550
Fax:	+98 63 242 30551
Email:	yavarivahid@hotmail.com Yavari@ir-pso.com

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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? YES_____ NO_____

TOTAL NO. OF TANKS ON BOARD_______ NO. OF TANKS IN BALLAST_______ IF NONE IN BALLAST GO TO NO. 5

NO. OF TANKS EXCHANGED_________ NO. OF TANKS NOT EXCHANGED___________

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

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

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

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

IF NONE, STATE REASON WHY NOT: ____________________

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

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

APPENDIX 2

Risk Assessment Team for the Port of Khark Island, Islamic Republic of Iran

The BWRA team contained three groups which undertook the GIS mapping (Group A), database development (Group B) and environmental matching/risk species (Group C) components of the Activity.

The activities of the three groups were coordinated by Dr Vahid Yavari (GloBallast Country Focal Point Assistant, Ports & Shipping Organisation) and Mr Chris Clarke (Meridian GIS Pty Ltd), under the directorship of Mr Hassan Taymourtash (GloBallast Country Focal Point, Ports & Shipping Organisation) with assistance of Mr Ahmad Parhizi (Ports & Shipping Organisation, Tehran).

Group A (GIS mapping)

Person: Mr Ahmad Parhizi
Position: Group A Leader
Organization: Ports & Shipping Organisation, Safety and Marine Protection Department
Email: parhizi@ir-pso.com

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

Person: Mr Hamid Reza Akrami
Position: Ports & Shipping Organisation Computer Network Administrator
Organization: Ports & Shipping Organisation, Administration
Email: akrami@ir-pso.com

Person: Mr Mohammad Hassan Khodammohmmad
Position: Group A - GIS cartographer
Organisation: National Cartographic Centre, Tehran
Email:

Person: Mr Mohammad Hossien Moshiri
Position: Group A - GIS cartographer
Organisation: National Cartographic Centre, Tehran
Email:

Person: Mr Houman Shirzadi
Position: Group A - GIS Computing and Port Map support
Organization: Ports & Shipping Organisation, Safety and Marine Protection Department
Email: houman_shirzadi@hotmail.com

Group B (BWRF & Access database)

Person: Mr Nasser Kayvanrad
Position: Group B Leader
Organization: Ports & Shipping Organisation, Safety and Marine Protection Department
Email: naseer@ir-pso.com

Person: Commander Terry Hayes
Position: Group B Counterpart Trainer
Organization: Meridian GIS Pty Ltd
Email: faydee@cqnet.com.au

Person: Mr Ebrahim Mosavi
Position: Group B – Port records, BW Report Forms and Port Shipping Records data extraction
Organization: PSO, Port of Khark Island

Person: Mr Abdolkarim Rezazadeh
Position: Group B – Port records, BW Report Forms and Port Shipping Records data extraction
Organization: PSO, Port of Khark Island

Person: Mr Abdolreza Jazebi
Position: Group B – BW Report Form and Port Shipping Record checking and database entry
Organization: PSO, Port of Khark Island

Person: Ms Roya Imam
Position: Group B – BW Report Form data checking and database entry
Organisation: PSO, Marine Protection Department, Tehran Office

Person: Mr Mostafa Zaredoost
Position: Group B - BW Report Forms checking and database management
Organization: PSO, Port of Bandar Il Khomeini

Person: Mr Morteza Dehghan
Position: Group B – BW Report Form data checking and database entry
Organization: PSO, Port of Bandar Il Khomeni.

Group C (Environmental & risk species data, ESM and BRWF)

Person: Dr Vahid Yavari
Position: Group C Leader – Risk Species Database
Organization: Ports & Shipping Organisation, Safety and Marine Protection Department
Email: yavari@ir-pso.com or yavarivahid@hotmail.com

Person: Dr Robert Hilliard
Position: Group C Counterpart Trainer
Organization: Meridian GIS Pty Ltd
Email: atsrob@iinet.net.au

Person: Mr Jamal Pakravan
Position: Group C - Port environmental data and environmental similarity analyses
Organization: Ports & Shipping Organisation, Marine Protection Department, Port of Bandar Abbas
Email: pakravan@ir-pso.com

Project Manager

Steve Raaymakers
Programme Coordination Unit
GEF/UNDP/IMO Global Ballast Water Management Programme
Marine Environment Division
International Maritime Organization
4 Albert Embankment, London SE1 7SR
United Kingdom
Ph +44 (0)20 7587 3251
Fax +44 (0)20 7587 3261
Email: sraaymak@imo.org
Web: http://globallast.imo.org

APPENDIX 3

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

PROJECT REQUIREMENTS AND PROVISIONAL SCHEDULE

REMINDER AND CHECK LIST FOR CFP/CFP-A

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

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

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

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

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

MS Word, MS Excel, MS Powerpoint.

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

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

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

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

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

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

Provisional Dates for 1st Visit (5 working days)

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

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

1st Visit Activities:

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

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

Environmental Data Requirements - see next page, attached.

ATTACHMENT

TYPES OF ENVIRONMENTAL DATA FOR PORT SIMILARITY ANALYSIS

The project requires two types of port environmental data:

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

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

In the case of the quantitative parameters, these include:

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

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

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

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

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

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

APPENDIX 4

Information sources used for collating Port Environmental Data

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

Continued over…

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

APPENDIX 5

Sources and references of Risk Species information

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APPENDIX 6

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

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

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

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

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

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

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the…			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
Salvador	*727*	*1384*	*8*	4	35,000	5	5	2	0	4	0	2	2	5	4	5	0	4	0
Come By Chance	530	660	8	5	200	5	0	0	0	0	4	0	0	5	3	3	0	5	0
Sept-Iles (Pointe Noire) Quebec	510	596	9	6	6,000	5	4	3	0	3	4	1	0	5	3	4	0	5	0
Halifax Nova Scotia	603	793	8	1	400	5	4	4	0	0	4	0	0	5	3	5	0	5	0
La Have	*603*	*793*	*8*	-3	2,000	5	1	4	0	0	5	0	0	5	3	3	0	5	0
Vancouver (British Columbia)	300	807	6	0	85,000	5	4	4	0	2	4	3	0	4	4	5	0	5	0
Roberts Bank (British Columbia)	*300*	*807*	*6*	0	85,000	5	3	3	0	3	4	3	0	4	4	4	0	5	0
Guangzhou Guangdong	341	1362	6	-112	400,000	5	4	4	4	1	0	5	1	2	2	5	1	1	0
Chiwan (Shenzhen) Guangdong	320	1604	6	4	1,000,000	5	3	5	0	3	2	1	3	3	2	5	2	3	2
Dalian Liaoning	183	457	7	35	1,500	5	5	5	2	3	4	4	0	5	4	5	2	4	0
Huangpu Guangdong	326	1606	6	-95	452,600	4	3	5	4	4	2	5	1	2	3	5	1	2	1
Beilun Zhejiang	464	947	8	-3	600	5	2	5	3	4	2	5	0	4	4	5	2	4	0
Ningbo (Beilun) Zhejiang	464	947	8	-3	600	5	2	5	3	4	2	5	0	4	4	5	2	4	0
Shanghai Shanghai	480	840	8	-40	1,500,000	5	3	5	2	1	0	5	0	1	3	5	1	1	0
Shanghai Baoshan	382	742	7	-45	1,500,000	5	4	4	2	1	0	5	0	1	3	5	1	1	0
Qinggdao Shandong	192	577	6	24	8,800	5	5	4	2	2	1	3	0	4	3	5	3	4	0
Tianjin Tianjin	278	603	8	0	71,600	5	5	5	2	3	1	3	0	2	4	5	2	1	0
Yantai Shandong	*190*	*500*	*7*	30	1,200	5	5	4	0	3	4	4	0	5	4	5	2	4	0
Cartagena	*80*	*863*	*3*	15	1,400	5	4	2	3	4	0	4	4	3	3	5	4	3	3
Kyrenia	*139*	*958*	*5*	120	40	5	5	5	0	3	4	1	0	4	4	2	4	5	0
Larnaca	139	958	5	25	50	5	5	5	0	4	4	1	0	4	4	2	4	5	0
Limassol	*41*	*411*	*4*	3	60	5	5	5	0	4	4	1	0	4	4	2	4	5	0
Bremen	322	428	8	-15	6,500	5	2	5	0	1	2	5	0	2	2	5	1	2	0
Hamburg	429	325	9	-105	9,000	5	4	5	0	1	2	5	0	1	2	5	0	0	0
Wilhelmshaven	*322*	*428*	*8*	1	750	5	5	4	2	3	2	5	0	1	4	5	2	1	0
Djibouti (Djibouti)	*14*	*33*	*6*	5	900	5	5	4	2	4	3	2	2	4	5	3	3	0	4
Enstedvaerkets Havn	293	411	9	*2*	*200*	5	2	3	1	2	4	2	0	5	2	5	1	5	0
Fredericia	*217*	*331*	*9*	8	300	5	4	4	1	2	4	2	0	4	2	5	1	5	0
Ain Sukhna	3	29	4	3	200	5	3	0	2	4	0	2	2	4	5	4	2	0	4
Alexandria (El Iskandariya)	10	186	4	45	2,000	5	4	0	2	4	3	0	0	3	5	5	3	3	0
Damietta	7	100	4	7	3,000	5	5	0	2	4	4	2	0	0	5	0	4	0	0
El Dekheila	10	186	4	52	2,000	5	4	0	2	4	3	0	0	3	5	5	3	3	0
Port Said	6	190	4	270	2,000,000	5	5	4	4	3	1	4	0	2	4	5	3	3	0
Suez (El Suweis)	*5*	*100*	*4*	63	200	5	5	4	2	4	0	3	3	4	5	3	1	2	1
Gijon	425	670	9	6	40	5	5	5	1	4	3	3	0	4	5	5	2	4	0
Bilbao	436	655	9	-2	4,500	5	4	4	2	3	3	5	0	3	3	5	2	2	0
Vigo	503	1303	6	14	400	5	4	3	2	3	4	2	0	5	5	5	2	5	0
Barcelona	349	241	9	11	5,000	5	5	5	0	3	2	2	0	3	5	5	3	3	0
Valencia	150	318	6	4	550	5	5	4	2	5	3	0	0	1	4	5	4	2	0
Algeciras	690	146	5	35	1,600	5	5	5	0	5	5	0	0	4	3	5	3	5	0
Las Palmas	17	159	4	1	60	5	5	3	0	4	3	0	0	4	5	5	3	5	0
Tenerife (Santa Cruz de Tenerife)	46	396	9	2	20	5	5	3	0	2	3	0	0	4	5	5	3	5	0
Tarragona	*349*	*241*	*9*	75	6,000	5	5	4	1	3	3	4	0	3	5	5	3	3	0
Dunkerque	264	347	9	27	1,800	5	5	3	2	4	4	4	0	0	4	5	0	0	0
Brest	404	724	8	20	600	5	4	4	2	3	4	3	0	4	5	5	3	5	0
Donges	336	475	8	-3	1,300	5	4	4	0	4	4	4	0	3	4	5	*3*	3	0
Fos sur Mer (Oil Terminal)	195	387	7	0	3,000	5	4	3	2	3	3	0	0	3	4	5	3	3	0
Lavera	195	387	7	0	3,000	5	4	4	2	3	3	0	0	3	4	5	3	3	0
Le Havre	405	723	7	0	6,500	5	4	4	0	4	4	4	0	4	4	5	*3*	3	0
Marseilles	*195*	*387*	*7*	0	3,000	5	4	5	2	3	3	0	0	3	4	5	3	3	0
Hunterston	443	662	8	30	2,400	5	4	3	1	5	3	4	0	4	5	5	0	4	0
Immingham	271	330	9	-20	4,900	5	5	4	2	3	3	5	0	0	3	5	0	0	0
Burry Port (Llanelly)	309	507	9	0	180	5	5	5	4	4	5	4	0	3	4	5	0	3	0
Port Talbot	385	534	9	2	280	5	5	5	2	4	4	4	0	2	4	5	0	2	0

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

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Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Livorno	343	565	8	20	4,100	5	5	5	2	4	4	0	0	3	3	5	3	4	0
Ravenna	346	411	9	0	2,000	5	5	4	0	3	3	4	0	3	3	5	2	4	0
Taranto	132	308	7	8	550	5	4	3	2	3	2	2	0	4	3	5	3	4	0
Venezia (=Fusina)	438	604	8	-2	1,200	5	5	4	2	3	1	3	0	3	3	5	3	2	0
Trieste	469	573	9	20	3,000	5	4	4	0	3	3	3	0	3	3	5	2	3	0
Aboshi Hyogo	400	900	7	3	480	5	5	3	2	2	4	2	0	4	3	4	3	4	0
Amagasaki Hyogo	431	885	7	0	7,600	5	4	2	0	3	4	2	0	3	3	2	3	4	0
Beppu Oita	465	1176	6	10	1,500	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Chiba Chiba	580	1100	7	18	880	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Kimitsu Chiba	580	1100	7	11	880	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Fukuyama Hiroshima	342	834	7	5	649	5	3	2	1	3	2	2	0	2	3	3	2	5	0
Higashi-Harima Hyogo	390	950	6	10	1,656	5	4	3	2	3	4	3	0	4	3	4	3	4	0
Himeji Hyogo	400	900	7	10	480	5	5	4	2	2	3	2	0	3	3	5	3	4	0
Hakata Fukuoka	509	1095	7	6	280	5	3	2	1	2	3	2	0	3	3	2	2	5	0
Imabari Ehime	450	899	4	2	70	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Innoshima Hiroshima	340	850	6	15	60	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Iwakuni Yamaguchi	499	1045	7	3	260	5	4	4	2	3	3	4	0	3	4	5	3	4	0
Kochi Kochi	798	1841	4	-4	640	5	3	4	3	3	3	4	0	4	3	5	3	4	3
Kakogawa Hyogo	402	916	7	1	1,656	5	4	2	2	2	3	2	0	3	3	4	3	4	0
Kiire Kagoshima	632	1607	6	20	100	4	4	2	2	3	4	2	3	4	4	3	2	5	2
Niigata Niigata	724	1065	6	-2	1,800	5	4	4	0	3	2	3	0	5	3	5	2	4	0
Kikuma Ehime	450	899	4	1	10	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Kinwan (Ishikawa) Okinawa	818	1320	7	5	10	5	4	2	2	4	4	3	4	4	4	5	4	0	4
Kanda Fukuoka	554	1106	7	4	40	4	3	2	1	3	4	2	0	4	3	2	2	5	0
Kinuura Aichi	478	1057	7	-2	350	5	4	4	2	3	2	3	0	3	3	5	3	4	0
Kagoshima Kagoshima	632	1607	6	2	260	5	4	4	2	3	4	2	2	4	3	3	2	5	3
Kashima Ibaraki	683	983	8	32	1,800	5	4	2	1	4	3	1	0	2	5	4	2	3	0
Kudamatsu Yamaguchi	635	1210	7	1	30	5	4	3	1	3	1	3	0	5	3	5	3	5	0
Kawasaki Kanagawa	570	1100	7	4	2,200	5	4	4	1	2	3	3	0	3	3	5	2	3	1
Maizuru Kyoto	781	1020	8	12	1,600	5	4	4	0	2	4	3	0	5	2	5	2	4	0
Mizushima Okayama	339	821	7	2	1,990	5	4	2	1	3	2	3	0	3	4	5	4	4	0
Moji (Kitakyushu) Fukuoka	554	1106	7	13	300	5	3	1	1	2	2	2	0	2	3	3	3	5	0
Muroran Hokkaido	724	1065	6	15	740	5	4	4	0	3	3	3	0	5	3	5	2	4	0
Matsuyama Ehime	450	899	4	12	270	5	3	4	2	3	3	4	0	3	3	5	3	4	0
Naha Okinawa	818	1320	7	2	15	5	4	4	3	4	2	3	3	3	4	5	4	0	4
Negishi (Yokohama) Kanagawa	548	1021	7	3	230	5	4	4	1	4	3	3	0	3	3	5	3	4	1
Nagoya Aichi	478	1057	7	2	900	5	4	4	2	4	1	3	0	3	3	5	4	5	0
Nagasaki Nagasaki	562	1417	6	-5	480	5	3	5	0	3	4	3	0	4	3	5	3	5	1
Oita Oita	465	1176	6	3	2,150	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Okinawa Okinawa	818	1320	7	2	15	5	4	4	3	4	2	3	3	3	4	5	4	0	4
Onomichi Hiroshima	340	850	6	2	60	5	3	5	2	3	3	4	0	3	4	5	3	4	0
Osaka Osaka	430	880	7	0	16,000	5	4	3	0	3	4	2	0	3	3	5	2	3	0
Saiki Oita	465	1176	6	18	2,150	4	3	2	1	3	4	2	0	4	3	4	2	5	0
Saganoseki Oita	465	1176	6	18	2,150	4	3	2	1	3	4	2	0	4	3	3	2	5	0
Sakai Osaka	420	850	7	1	1,600	5	4	4	0	3	4	2	0	4	4	4	3	4	0
Shibushi Kagoshima	632	1607	6	2	140	5	4	4	2	3	4	2	3	4	4	3	2	5	2
Sakaide Kagawa	358	775	7	4	120	4	4	3	0	2	2	2	0	2	4	4	2	5	0
Sakaiminato Tottori	848	1075	9	11	280	5	4	4	3	4	3	3	0	4	4	4	2	3	0
Shimotsu Wakayama	456	886	7	3	25	5	4	4	2	4	1	3	0	3	3	5	4	4	1
Shimizu Shizuoka	738	1356	7	1	900	5	4	4	1	3	4	3	0	4	4	5	3	4	0
Tamano (Uno) Okayama	339	821	7	23	1,990	5	4	2	1	3	2	3	0	3	4	5	4	5	0
Tobata (Kitakyushu) Fukuoka	554	1106	7	5	10	5	3	4	1	3	2	4	0	2	4	4	4	5	0
Tokuyama Yamaguchi	631	1213	7	1	70	5	4	3	1	3	1	4	0	5	3	5	3	5	0
Tomakomai Hokkaido	724	1065	6	0	10	5	4	4	0	3	3	3	0	5	3	5	2	4	0
Toyama Toyama	327	739	7	3	4,800	5	4	4	0	3	2	3	0	3	3	5	2	3	0

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Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
Tokyo Tokyo	585	1110	7	0	3,200	5	4	5	1	2	3	3	0	2	2	5	2	3	1
Ube Yamaguchi	631	1213	7	2	85	5	4	3	0	3	2	3	0	2	4	3	4	5	0
Kobe Hyogo	295	1021	6	2	50	5	3	4	0	3	4	4	0	4	3	5	4	4	0
Wakayama Wakayama	420	850	7	2	3100	5	4	4	2	4	1	3	0	4	3	5	4	5	0
Yokkaichi Mie	505	1082	7	13	900	5	4	4	2	3	1	3	0	3	3	5	4	5	0
Yokohama Kanagawa	548	1021	7	3	230	5	4	4	1	4	3	3	0	3	3	5	3	4	1
Yokosuka Kanagawa	550	1000	7	20	230	5	4	4	1	4	3	2	0	4	4	5	4	5	1
Mombasa	355	789	8	100	9,000	5	4	5	4	4	2	4	4	4	5	5	3	3	3
Kwangyang	344	958	7	7	2,100	5	3	4	1	3	3	2	0	4	4	4	3	2	0
Pohang	284	774	7	7	2,300	5	4	2	2	3	2	3	0	2	3	5	3	1	0
Kunsan	344	931	4	0	500	5	4	3	1	2	3	2	0	4	3	5	3	4	0
Mokpo (Mogpo)	344	931	4	7	1,000	5	4	3	2	2	2	2	0	5	3	5	2	4	0
Onsan	308	1175	6	3	900	5	4	3	2	2	2	2	0	1	3	3	4	4	0
Pusan	356	1032	7	15	1,690,000	5	4	2	0	3	2	4	0	2	3	2	3	2	0
Samcheon Po	361	933	7	16	400	5	3	2	1	2	1	2	0	1	4	4	3	2	0
Ulsan	344	942	7	3	900	5	4	2	0	3	1	2	0	1	3	3	4	4	0
Yosu (Yeosu)	344	958	7	26	2,100	5	3	3	1	3	3	2	0	4	3	3	4	5	0
Kuwait (Shuwaikh; KWSWK)	8	91	5	140	500,000	5	5	1	3	4	3	3	2	3	5	5	4	3	3
Mina Al Ahmadi	5	90	4	105	500,000	5	5	1	2	2	1	2	2	3	5	2	3	3	2
Mina Saud	15	95	4	160	500,000	5	4	1	2	4	2	3	3	4	5	2	2	2	2
Mina Abdulla	7	91	5	120	500,000	5	2	1	2	2	2	1	2	2	4	5	3	3	3
Shuaiba	5	90	4	115	500,000	5	5	1	2	3	2	2	2	3	5	2	3	3	2
Colombo	644	1597	7	22	880	5	5	4	1	4	3	2	2	3	4	5	3	3	1
Malta (Valletta)	117	493	7	200	120	5	5	5	0	3	4	0	0	4	4	0	4	5	0
Penang (Georgetown)	770	1351	8	0	480	5	4	4	0	4	3	1	1	3	5	4	4	4	4
Lumut	790	1450	8	-2	400	5	3	5	0	3	2	5	3	3	4	5	3	4	3
Port Kelang	885	1305	8	-1	650	5	3	3	0	2	4	1	1	4	5	4	3	5	5
Port Dickson	713	1600	7	6	400	5	2	3	0	4	2	3	3	4	4	5	4	4	4
Kapar Coal Terminal	885	1305	8	1	140	5	2	3	0	2	3	1	1	3	5	3	3	5	5
Pasir Gudang Johor	1101	1433	8	10	2,800	5	2	4	3	4	3	1	2	3	4	4	3	4	4
Bintulu Sarawak	1632	1993	9	9	3,700	5	4	4	0	2	1	3	3	1	5	3	3	2	2
Lagos	405	1336	6	0	18,000	5	4	5	0	3	0	5	4	2	3	5	3	2	0
Tin Can Island	405	1336	6	16	18,000	5	4	4	0	4	0	5	4	2	3	5	3	2	0
Port Harcourt	561	1798	6	-66	120,000	5	0	5	0	1	2	5	4	2	4	5	0	1	0
Onne	560	1800	6	-40	120,000	5	4	4	0	2	3	5	4	2	4	5	0	1	1
Bonny	605	1444	6	0	8,000	5	0	5	0	2	0	5	4	0	2	5	3	0	0
Europoort	362	469	8	0	2,500	5	5	3	0	3	3	4	0	1	2	5	1	0	0
Rotterdam	362	469	8	-10	2,500	5	5	4	0	2	2	4	0	0	2	5	1	0	0
Ijmuiden	475	365	9	-1	300	5	5	4	1	4	3	4	0	1	4	5	2	0	0
Amsterdam	472	360	9	-18	5,000	5	5	5	0	2	2	5	0	0	2	5	1	0	0
Flushing (Vlissingen)	480	370	9	-3	600	5	5	4	2	4	3	4	0	1	4	5	1	0	0
Auckland	497	687	8	3	200	5	4	3	2	2	2	2	0	3	3	5	2	2	0
Whangerei	487	673	9	0	600	5	0	4	1	5	3	5	0	5	4	5	2	4	0
Marsden Point	487	673	9	20	600	5	0	2	1	4	3	2	0	5	5	3	2	5	0
Callao (Lima)	6	14	6	10	400	5	5	4	2	4	3	2	0	3	5	5	3	4	0
Lae	1760	2699	8	2	7,980	5	4	4	2	2	1	1	2	1	5	2	3	1	4
Port Moresby	236	919	6	7	85	5	5	5	2	2	1	2	2	1	5	3	1	1	1
Daru	250	960	6	35	55,600	5	0	5	3	4	0	4	4	4	5	5	4	4	3
Batangas (Luzon)	365	1372	6	2	500	5	3	4	4	2	4	1	1	4	5	4	3	4	4
Bataan Mariveles	216	1607	6	25	900	5	3	4	4	2	4	1	1	4	5	4	3	4	3
Limay	216	1607	6	4	900	5	4	2	3	3	2	3	3	3	5	4	4	4	3
Manila	216	1607	6	6	120	5	4	4	1	2	2	1	3	2	3	5	3	4	4
Subic Bay (Sana Clara)	228	1797	6	4	1,800	5	5	3	1	3	3	3	4	3	5	3	3	4	3
Muhammad Bin Qasim	50	185	3	-30	240,000	5	4	4	3	2	0	5	4	2	2	5	1	1	0

Port Environmental Data - input file used for PRIMER Analysis	Total Rainfall (mm) [RF] for the...					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
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

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Name of Port	D6MRF	W6MRF	RNFL75	DISRVM	SIZRVC	INASMW	INARKW	INAWP	INHTSM	INSNDB	INSTNB	INLTMF	INMANG	INRKSH	SUFSND	SUSFTM	SUSGRM	SURKRF	SUCORF
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

More Information?

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

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

Cover designed by Daniel West & Associates, London. Tel (+44) 020 7928 5888 www.dwa.uk.com