Appendix VII

GIS MAPPING OF MARINE VESSEL BALLAST WATER EXCHANGE ENDPOINT DATA IN ATLANTIC CANADA, FOR THE 2002 SHIPPING SEASON

Report to:

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GIS Mapping of Marine Vessel Ballast Water Exchange Data in Atlantic Canada, for the Year 2002 Shipping Season

ABSTRACT

The geographical information system (GIS) mapping of geo-referenced ballast water exchange volume endpoints recorded on Ballast Water Report Forms submitted to Marine Safety, Transport Canada, provides insight in ballast activities reported off Eastern Canada during the year 2002.

Vessel movement tracks and seasonal computer-modelled potential (interpolation) surface thematic maps rendered location information on preferred vessel exchange corridors and delineated high-value areas for ballast exchange volumes (reported endpoints) for vessel traffic approaching Eastern Canada from the United States, Europe and other international departure points.

The same Transport Canada ballast water data provided for a comparative, statistical analysis of shipping trends and patterns for Eastern Canada, with years 1998 and 2000.

A compact disk containing a digital copy of the GIS Mapping of Marine Vessel Ballast Water Exchange Endpoint Data in Atlantic Canada, for the 2002 Shipping Season report, the project database, the GIS-based (MapInfo format) vessel movement tracks and the computer-modelled potential (interpolation) surface thematic maps and the project metadata is contained on the project CD at the back cover of this report.

GIS Mapping of Marine Vessel Ballast Water Exchange Data in Atlantic Canada, for the Year 2002 Shipping Season

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1.0 INTRODUCTION

Commercial shipping ballast water quality and ballast water exchange has become a significant global issue over the last number of decades. During this period, oceanographers and environmental managers have witnessed the introduction of ballast water transported non-native species and pathogens into new areas, threatening indigenous life forms, the local ecology and human health. The result of these impacts has been the development of international policy to maintain standards for ballast water quality and exchange management. Notwithstanding, from a Canadian perspective, there has been little spatial examination of the actual volumes of commercial shipping ballast water released into the marine environment using the GIS spatial environment, specifically with vessel traffic reported approaching Atlantic Canadian ports.

The purpose of this report is to enlarge an earlier GIS ballast water exchange mapping application conducted for Transport Canada by Geocentric Mapping Consulting [1.]. The previous work prepared geo-referenced ballast water exchange activity endpoints in an MS Access database and derived a geographical information system (GIS) software-based thematically coloured marine vessel movement (ship track) map and a modeled contour map. Transport Canada supplied the data for the month of December 2001; the hardcopy data was contained on faxed Ballast Water Management Report Forms submitted to Transport Canada by marine vessel approaching Canada's Eastern Economic Zone (EEZ). The map outputs for December ballast exchange delineated common ballast water exchange areas for marine vessels transiting to Eastern Canadian and Gulf of St. Lawrence ports. The thematic mapping provided the basis for GIS mapping of the year 2002 data set of ballast water management report form data, with the plan of providing a bi-monthly, seasonal map display of ballast water exchange management activity by marine vessels entering Eastern Canada.

This study is similar to the earlier December 2001 mapping application in that the data was recorded in a database structure derived in the initial study, and the database attribute information (geo-referenced ballast water volume reported exchanged point locations) was mapped using similar modeling and programming techniques in the GIS environment. Discussions included in this report will include an overview of marine ballast water exchange and common exchange methods, a description of the data collected and data preparation for import to the GIS spatial environment, and a review of the GIS techniques used to derive ballast water thematics followed with a discussion of the resulting GIS map outputs. The report concludes with a comparative statistical review of year 2002 data with previous years (1998, 2000) and the report summary comments.

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1. GIS Mapping of Marine Vessel Ballast Water Exchange Data in Atlantic Canada submitted to Transport Canada, Dartmouth, NS by Geocentric Mapping Consulting, Falmouth, NS, January 2003.

2.0 MARINE VESSEL BALLAST WATER EXCHANGE

2.1 Definition of Ballast Water Exchange and Ballast Water Issues

Ballast water is the fresh or salt water carried by ships to provide stability and to adjust a vessel's trim for optimal steering and propulsion. The use of ballast water varies among vessel types, among port systems, and according to cargo and sea conditions. Ballast water often originates from ports and other coastal regions in one area, which are rich in planktonic organisms, and is discharged in new areas. As a result, a diverse mix of organisms is transported and released around the world with the ballast water of ships.

Today, ballast water appears to be the most important vectors for marine species transfer throughout the world. The discharge of ballast water or sediment into the waters of port states may result in the establishment of harmful aquatic organisms and pathogens, which may pose threats to indigenous human, animal and plant life, and the marine environment. Although other media have been identified as being responsible for transferring organisms between geographically separated water bodies, ballast water from ships appears to be among the most prominent.

2.2 Types of Ballast Exchange Common to Commercial Shipping

Ballast water exchange is a process of releasing the ballast taken aboard the ship in one area and discharging the water in a different geographic area. Vessels typically undertake two forms of ballast exchange, empty/refill or flow through of tanks. The exchange type employed is dependent on the quality of the ballast water in the hold(s). If the sea water quality is suspected of containing harmful pathogens or non-indigenous flora or fauna, the flow through method is used. Flow through exchange has the ballast water tanks exchanged by pumping seawater in gradually to dilute the poor quality ballast water before it is released to the ocean environment. This in effect has seawater filling or "flowing through" the ballast tanks(s) two or three times over tank capacity before dilution is complete.

To describe the vessel that is undergoing flow though exchange: the vessel is steaming along with the ballast tank deck covers open and sea water is being pumped into the tanks which overflow out of the holds over the deck of the ship. The empty/refill type of exchange is similar to flow through in that the deck is covered with ballast water being replaced by seawater. The difference is the volume taken into the tank(s) equals that expelled onto the ship deck; better quality source ballast water allows the empty/refill an option to the vessel's master.

Other than ballast water quality and harmful non-indigenous species contained therein, the second issue of concern is ballast water exchange location. Preferred locations for ballast exchange are discussed in the guidelines below.

2.3 Ballast Water Management Guidelines

The development and maintenance of guidelines for conducting ballast water exchange is officiated by the International Marine Organization (IMO), London, UK and 139 signatories countries, with each signatory having a ballast water management policy in-line with the IMO document. Canada is a participant in the international ballast management program through the Canadian Shipping Act, which contains provisions for enabling legislation. However, there are no regulations in force, and based on consultation with stakeholders under the auspices of the Canadian Marine Advisory Council, transport Canada established ballast water management guidelines, published as TP13617.

In Canada, ballast water management issues are administered jointly by Transport (as lead agency) in cooperation with Canadian Coast Guard and Fisheries & Oceans Canada. The purpose of the IMO Resolution 868, ballast water guidelines coordinated by IMO and participating countries, is to reduce environmental and health problems resulting from harmful aquatic organisms and pathogens carried from one place to the other in ship's ballast water. The Ballast Water Management Plan provides for safe and effective procedures for ballast water management and a means for keeping records to document the vessel's ballast water management practices. All vessels bound for signatory ports are required to submit Ballast Water Management Report Form reports to domestic agencies. In Canada, the report forms are commonly faxed to Transport Canada, which reviews and approves the ballast water information reported.

A portion of the guidelines is dedicated to advising preferred ballast exchange locations to mariners. However, based on the available scientific data available to date, no alternative exchange zone has been established in waters under Canadian jurisdiction on the east coast of Canada. Internationally, exchange is preferred in open ocean where seawater depth exceeds 2000 meters.

2.4 Transport Canada and the Ballast Water Reporting Form

The ballast water management reporting form provides vessels active in Canada's 200-mile EEZ boundary zone with the means for reporting their ballast water situation on board, prior to arrival at a Canadian port. The Canadian Ballast Water Management Guidelines are consistent with the International Marine Organization (IMO) regulations. All ships arriving at a Canadian port are contacted by Marine Communications and Traffic Services (MCTS) and requested to respond to a ballast water questionnaire developed in cooperation with Transport Canada, Marine Safety. Any enforcement action is initiated by Transport Canada, as appropriate.

The format of the ballast water management form submitted to Transport Canada varies slightly, however details provided is consistent between forms.

3.0 PROJECT DATA AND DATA PROCESSING

3.1 Acquisition of Ballast Water Management Form Data

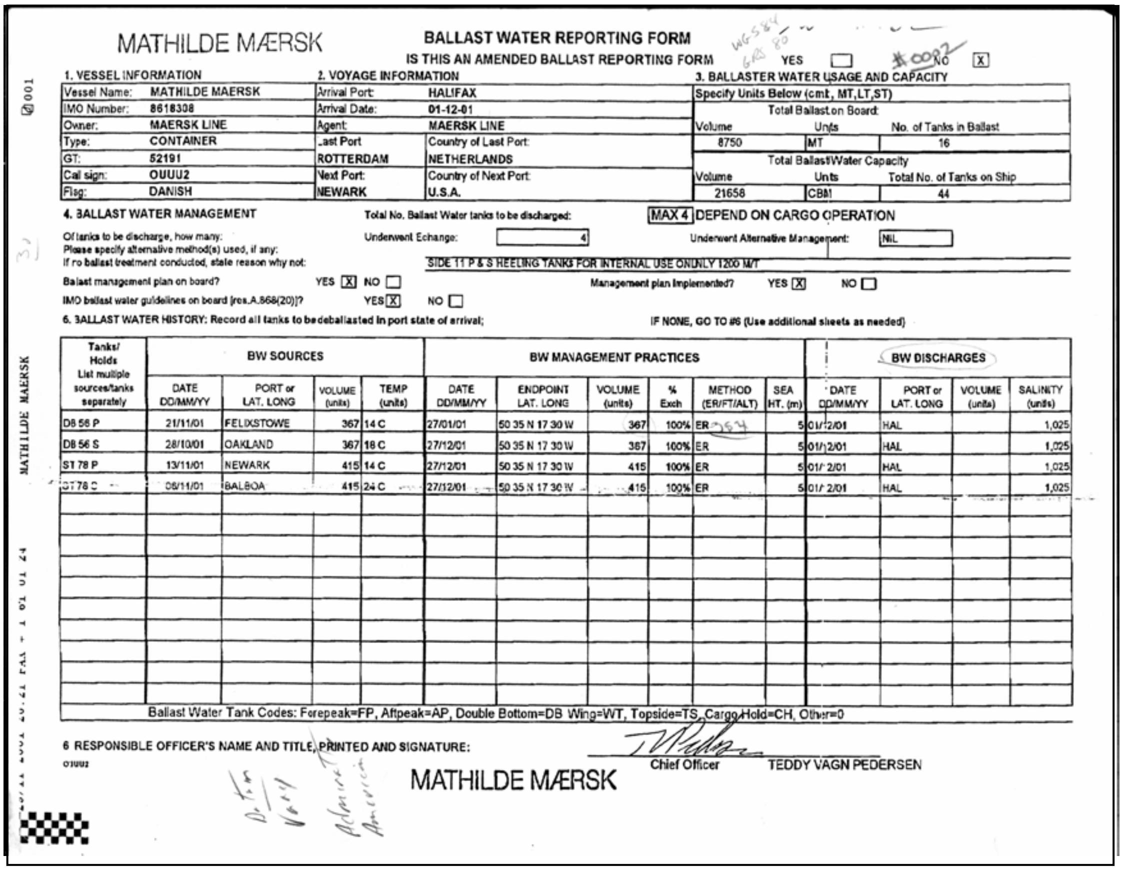
The ballast water reporting data for the year 2002 was provided by Marine Safety, Transport Canada, Dartmouth, NS. The data consisted of 3448 faxed, hard copies of ballast information received from vessel approaching the Atlantic Canada from foreign ports. The formats of the ballast water management report forms provided (Australian, American, United Kingdom, vessel owner designed, for example) varied slightly in recording. The variation was insignificant, however minor changes (additional fields) were made to the database structure used in the initial study.

3.2 Description of Ballast Water Management Report Form

The ballast water reporting form describes the ballast water management program for the vessel from its departure point. Submission of the form to Transport Canada is a requirement under the Canadian Shipping Act. The layout format of the reporting form varies per vessel, however, it consists of six sections that include Section 1 - Vessel Information, Section 2 - Voyage Information, Section 3 - Ballast Water Usage and Capacity, Section 4 - Ballast Water Management and Compliance, Section 5 - Ballast Water History and Section 6 - Responsible Officer's Signature.

A variation of this format is Section 1 - Vessel Information, Section 2 - Ballast Water, Section 3 - Ballast Water Tanks (includes Total Number of Tanks Aboard, No. of Tank in Ballast with a field describing No. of Tanks Not Exchanged), Section 4 - Ballast Water History, Section 5 - Ballast Water Compliance information and Section 6 - Responsible Officer's Signature.

A sample of the most common Ballast Water Reporting Form is shown in Figure 1. below.



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BALLAST WATER REPORTING FORM

IS THIS AN AMENDED BALLAST REPORTING FORM YES [ ] NO [X]

1. VESSEL INFORMATION		2. VOYAGE INFORMATION		3. BALLASTER WATER USAGE AND CAPACITY		
Vessel Name:	MATHILDE MAERSK	Arrival Port:	HALIFAX	Specify Units Below (cmt, MT,LT,ST)		
IMO Number:	8618308	Arrival Date:	01-12-01	Total Ballast on Board		
Owner:	MAERSK LINE	Agent:	MAERSK LINE	Volume	Units	No. of Tanks in Ballast
Type:	CONTAINER	Last Port	Country of Last Port:	8750	MT	16
GT:	52191	ROTTERDAM	NETHERLANDS	Total Ballast Water Capacity		
Call sign:	OUUU2	Next Port:	Country of Next Port:	Volume	Units	Total No. of Tanks on Ship
Flag:	DANISH	NEWARK	U.S.A.	21658	CBM	44

4. BALLAST WATER MANAGEMENT

Total No. Ballast Water tanks to be discharged: MAX 4 DEPEND ON CARGO OPERATION

Of tanks to be discharge, how many: Underwent Echange: 4 Underwent Alternative Management: NIL

Please specify alternative method(s) used, if any:

If no ballast treatment conducted, state reason why not: SIDE 11 P & S HEELING TANKS FOR INTERNAL USE ONLY 1200 M/T

Ballast management plan on board? YES [X] NO [ ] Management plan Implemented? YES [X] NO [ ]

IMO ballast water guidelines on board [res.A.868(20)]? YES [X] NO [ ]

6. BALLAST WATER HISTORY: Record all tanks to be deballasted in port state of arrival; IF NONE, GO TO #6 (Use additional sheets as needed)

Tanks/ Holds List multiple sources/tanks separately	BW SOURCES				BW MANAGEMENT PRACTICES						BW DISCHARGES			
	DATE DD/MM/YY	PORT or LAT. LONG	VOLUME (units)	TEMP (units)	DATE DD/MM/YY	ENDPOINT LAT. LONG	VOLUME (units)	% Exch	METHOD (ER/FT/ALT)	SEA HT. (m)	DATE DD/MM/YY	PORT or LAT. LONG	VOLUME (units)	SALINITY (units)
DB 56 P	21/11/01	FELIXSTOWE	367	14 C	27/01/01	50 35 N 17 30 W	367	100%	ER	5	01/12/01	HAL		1,025
DB 56 S	28/10/01	OAKLAND	367	18 C	27/12/01	50 35 N 17 30 W	367	100%	ER	5	01/12/01	HAL		1,025
ST 78 P	13/11/01	NEWARK	415	14 C	27/12/01	50 35 N 17 30 W	415	100%	ER	5	01/12/01	HAL		1,025
ST 78 C	08/11/01	BALBOA	415	24 C	27/12/01	50 35 N 17 30 W	415	100%	ER	5	01/12/01	HAL		1,025

Ballast Water Tank Codes: Forepeak=FP, Aftpeak=AP, Double Bottom=DB Wing=WT, Topside=TS, Cargo Hold=CH, Other=0

6 RESPONSIBLE OFFICER'S NAME AND TITLE, PRINTED AND SIGNATURE: Chief Officer TEDDY VAGN PEDERSEN

MATHILDE MÆRSK

Figure 1. Sample of typical Ballast Water Reporting Form submitted to Marine Safety, Transport Canada; reporting marine vessel ballast management practices.

3.2.1 Description of Ballast Water Management Report Form Sections

The ballast water reporting form is comprised of six reporting sections. A detailed description of the contents of the form is presented below:

Section One - Vessel Information: The vessel is required to provide the vessel name, IMO (International Marine Organization) number, vessel owner, vessel type, gross tonnage, call sign and flag under which the vessel is registered.

Section Two - Voyage Information: The vessel is required to submit the name of the arrival port, arrival date, the ship's agent, last port and the next port after the arrival ported listed above.

Section Three - Ballast Water Usage and Capacity: The vessel specifies the total ballast on board, total ballast water capacity, volume units and number of tanks in ballast.

Section Four - Ballast Water Management: The reporting vessel specifies the total number ballast water tanks to be discharged, the number of tanks are to be discharged, the number of tanks undertaking exchange, the vessel acknowledges if a ballast water management plan is on board and if the management plan is implemented, and the vessel acknowledges if the IMO ballast water guidelines on board.

Section Five - Ballast Water History: The ballast water history section is entered in data table. The table records the location of the vessel ballast water tanks/holds, tank ballast water sources (date, port or Latitude/Longitude, volume and ballast source temperature), ballast water management practices (date, ballast water exchange endpoint - Latitude/Longitude, ballast water volume exchanged, % exchanged, method of exchange - E/R (empty/refill)/FT (Flow Through)/ALT (Alternate Method), and sea height) and ballast discharges (date, Port or Latitude/Longitude, volume and salinity).

Section Six - Responsible Officer's Name and Title, Printed and Signature: The Ballast Water Report Form is a legal document and is endorsed by the officer responsible for the ballast management plan.

A review of the faxed ballast report form data set indicated recordable data on each of the 3448 fax sheets. Further, data recorded in Section Five - Ballast History provided a chronology of the ship's movement and ballast activity (latitude/longitude recorded by the vessel's officer) as it made for an Atlantic Canadian destination.

Similar to December project work, the reporting of the vessel's geo-referenced ballast exchange endpoint volume data made the data suitable for database preparation and import as a point location file into the spatial, geographical information systems (GIS) environment.

3.3 The Ballast Water Management Report Database

3.3.1 Ballast Water Management Report Database Description

To prepare maps representative of ballast water management activities by marine vessel approaching Eastern Canadian ports, a database populated with faxed information was required. The previous December 2001 project work had developed a ballast water information database structure using MS Access database management software; this database structure was used for data entry of the year 2002 data. A description of the data structure with slight modifications to the December 2001 version is provided in the following section. The modifications were necessary to enlarge the database reporting capability and make possible the development of a concurrent Vessel Traffic/Vessel

Shipping Patterns on the East Coast of Canada 2002 Shipping Season statistical data summary report.

3.3.2 Ballast Water Management Report Database Structure

The database structure was developed to provide thematic map-building attributes in the GIS environment and to prepare the Vessel Traffic/Vessel Shipping Patterns on the East Coast of Canada 2002 Shipping Season statistical summary report.

After reviewing the form, slight modifications to the existing relational database structure were made. The two tables of the relational database consisted of a Trip Information table and a Ballast Water History table, with the key field joining the tables being the project assigned Transport Canada Sheet Number (TC_Sheet#). The tabular relationship provided complete information for each record in the database and reduced repeated data entry.

The parameters selected from the faxed Reporting Forms for the database structure are shown in Table 1 by database table name and Ballast Water Management Report Form Section Number .

Database Table Name	**Database Field**	**Comments**
Trip_Information	TC_Sheet#	Project assigned to each fax
	Type (Vessel)	Section 1 - Type Vessel
	IMO#	Section 1
	GT	Section 1 - Gross Tonnage
	Arrive Port	Section 1[2.]
	Arrive Date	Section 1[2.]
	Last Port	Section 1[2.]
	Next Port	Section 1[2.]
	Total#Tanks	Section 3, Total #Tanks
	#Tanks_in_Ballast	Section 3, #of Tanks in Ballast
	#TanksX_reported	Section 3, #of Tanks in Ballast
	#TanksX_recorded	Section 5, # of Tanks Exchanged
	#Tank_notX	Section 3[3.] , # Tanks Not Exchanged
	#TankD_reported	Section 3[3.] , # of Tanks Discharged
	#TankD_recorded	Section 5, Number of Tanks Discharged
	Trip_comments	Comment field.

2. Section 2, depending on Ballast Water Management Report Form format

3. Data not recorded by vessel , depending on Ballast Water Management Report Form format

Database Table Name	Database Field	Comments
Ballast_Water_History		All fields Section 5
	Volume Units	Ballast Volume Unit -cbm,MT
	BWS_Date	Source Ballast Date
	BWS_Port	Source Ballast Port
	BWS_Volume_Tank	Source Tank Volume
	BWE_Date	Ballast Exchange Endpt. Date
	LATDEG_BWE_Endpt	Exch. Endpoint geo-reference
	LATMIN_BWE_Endpt	Exch. Endpoint geo-reference
	LONDEG_BWE_Endpt	Exch. Endpoint geo-reference
	LONMIN_BWE_Endpt	Exch. Endpoint geo-reference
	BWE_Volume_Tank	Ballast Tank Volume
	BWD_Date	Discharge Tank Date
	BWD_Port	Discharge Tank Port
	BWD_Volume	Discharge Tank Volume

Table 1. Ballast Water Management Database relational data structure.

Additional refinements to the two data table structures were MS Access database field input masks, validation rules and data entry forms for both databases. With the data structure designed for each database, inputting the data in the MS Access database followed.

3.4 Populating the Ballast Water Management Database

Database entry of the 3448 faxed ballast water management sheets consisted of reviewing each sheet and keying the data in MS Access data entry form containing fields from the two relational tables. The information read from the forms ranged from legible typed to hand-written data information, which was of fair to good quality. One sheet was removed because the information was unclear. Several of the poorer quality sheets reflected the quality of the fax equipment used for transmission to Transport Canada, and not the reporting entered by the vessel's officer.

The types of ballast water management report sheets consisted predominantly of Annex 1 - International Marine Organization compliant report forms. Other report forms was Canadian Coast Guard MCTS Ballast Water Compliance Forms documenting vessels entering Eastern Canada, company report forms (Thenamaris (Ships Management) Inc., Maersk, Eagle Baltimore, for example), hard copies of emailed and telexed information submitted by vessels.

The reports sheet read for data entry provided mostly complete ballast water management information to the Trip_Info and Ballast_Water_History database tables. There were instances where the report sheet was partially completed by the vessel's officer; it was common for the #Tanks Exchange Reported to be blank in Section 3 and #Tank Exchanged Recorded to be completed in Section 5. Another example of partially recording ballast activity was not reporting Ballast Water Discharge in Section 5. Previous discussions with Transport Canada clarified the issue of ballast water discharge not recorded on the faxed material; ballast discharge occurs, although not reported by the vessel.

Instances of partially completed ballast water information form were keyed into the database as read. Entering the data as shown, eliminated the subjectivity of data entry and provided information on how complete the ballast management information is when submitted to Transport Canada. Special attention was paid to data entry into the Trip_Info data table; if ballast exchange was not reported in Section 3, a character representing blank (or Null) data was recorded. Likewise, if ballast exchange was not recorded in Section 5 - Ballast Management History, a Null indicating character was placed in the proper Trip_Info database field. For example, if the ballast exchange information was blank in Section 3 and Section 5, the characters N and G were placed in the #TanksX_reported and #TanksX_recorded fields The reporting and recording of ballast discharge information was entered the same in the #TankD_reported and #TankD_recorded fields. Other fields such as Total#Tanks, #Tanks_in_Ballast and #Tank_notX were subject to similar coding in the database. Also, instances where the ballast water related data was not part of Report Form because of form format was recorded. (Table 1.). The coding provided a report on the completeness of marine vessel ballast water submissions (Appendix A), to Transport Canada.

3.4.1 Database Fields in the Ballast_Water_History Database

Similar attention was made of the geo-reference entered in Section 5 - Ballast Water History when entering Ballast Water Exchange Endpoint Latitude and Longitude. Several formats of recording were determined. Most of the Ballast Water Exchange Endpoint recording was degrees-decimal minutes or more commonly, degrees-minutes. A third, less common format was degrees-minutes-decimal seconds. The data in the former two formats were keyed into Latitude_degrees, Longitude_degrees, Latitude_minutes, Longitude_minutes, Latitude_decimal_minutes, and Longitude_decimal_minutes database fields. The third type, minutes-decimal seconds, was manually adjusted to decimal minutes and entered in the Latitude_decimal_minutes, Longitude_decimal_ minutes fields respectively.

Manipulations to generate Latitude_decimal and Longitude_decimal in preparation for import to the GIS were completed in the Query function of MS Access. Query processing in the database will be discussed below.

In regard to geo-reference, the datum for the geo-reference was not recorded on the forms. An inquiry to Transport Canada on datum suggested the each reporting vessel could use a different datum. The geocentric latitude/longitude GRS 80 datum was selected as suitable when importing the data to the GIS.

When entering ballast water volume exchanged care had to be taken since the volume exchanged recorded on the sheet could have been a multiple of the volume exchanged. This was common when the ballast exchange method was flow through, where as much as 300% of ballast tank capacity is pumped through tanks. The volume recorded in the database in this instance would be 100% of tank volume, not three times the volume.

3.4.2 Ballast Water Management Database Summary

The 3,448 Ballast Water Reporting Forms created 16,456 database records in the Ballast_Water_History data table and 3,448 records in the Trip_Info data table. Included in the two data tables were reports submitted from marine vessels destined for America, France (St. Pierre & Miquelon), West Canadian ports (Vancouver, Churchill, Manitoba and North West Territories) and Canadian to Canadian ports. The American data entered included ports bordering the Great Lakes, as well as United States Eastern Seaboard ports such as Boston and New York. Voyages between Atlantic Canadian ports were part of the data. Duplicate records, voyages to non-Eastern Canadian ports, Canadian domestic trips, and other incomplete records (null arrival date, arrival port, etc.) were removed from the Ballast_Water_History data table, leaving 14,542 records.

Similar records were removed from the Trip_Info data table (442 records). A number of the duplicates were the MCTS Centre Reports - St. John's and Halifax. An effort was made to match up MCTS Centre material with the corresponding Ballast Water Management Report form. The effort was somewhat diminished by the lack of information on the MCTS forms and the fact that the database did not record the name of the vessel as part of the record. The reasoning behind not recording the vessel name was to reduce data entry and that vessel names may change, but not the IMO identification. Removing the number of duplicate and non-study area records reduced the Trip_Info database to 3,006 records.

The final step to preparing the database for the GIS was joining the Ballast_Water_ History and Trip_Info data tables in the database, using a one to many relational join. The key field in the join was the TC_Sheet# field. The output from the join produced 3,006 Trip_Info records matched with 14,542 Ballast Water History records, with every record providing at least partial information.

A summary of the completeness of the Ballast Water Management Database is provided in Appendix A.

3.5 Database Manipulations to Prepare the Data for the GIS

To prepare the import of the Ballast Water Exchange data set to MapInfo, manipulations in the query function of MS Access were necessary. A series of data conversions and an extraction of a geo-referenced subset of data were completed.

The first step in the manipulations was to convert and concatenate the fields for latitude/longitude degrees, minutes, decimal minutes to latitude decimal minutes and longitude decimal minutes; this was followed by the standardizing the database volume units for ballast water source, exchange and discharge to cubic metres. Light Ton values were converting by a factor of (0.9842 LT = 1 MT)(.975) and Metric Tons by a factor of 1.035 cbm = 1MT, provided cubic metres.

The final step of manipulations was to filter the data set to include only those records containing open ocean ballast water exchange endpoint geo-reference reported. Several MS Access queries were performed on the 14,542 records to identify records with having these criteria. Queries extracting records with:

(1). LATDEG_BWE_Endpt >0
(2). LATDEG_BWE_Endpt=0 and LATMIN_BWE_Endpt >0
(3). LATDEG_BWE_Endpt=0, LATMIN_BWE_Endpt =0 and
LONDEG_BWE_Endpt>0
(4). LATDEG_BWE_Endpt <0.

The output from this procedure produced a data set of 8,487 records (58.36% of 14,542 records) representing 1427 (47.47%) of Ballast Water Reporting Forms. The derived data set contained open ocean ballast exchange records for vessels transiting to Atlantic Canadian ports from Europe and points south (America, Panama, Caribbean, and South America) during the year 2002. Database records not selected were records without geo-referenced ballast exchange endpoint positions, having no ballast water to exchange, having the position of exchange reported but no volume recorded, or having old ballast data recorded.

Examination of the 8487 sets of mappable point data on each of the ballast exchange reports indicated the ballast activity endpoint positions reported varied from one to 26 geo-referenced positions. The average number of locations reported was five positions, some of which reported the same location for each of the ballast exchange endpoints reported to Transport Canada.

Inspection of 8,487 points revealed null for ballast water exchange volumes reported for 160 records, no ballast water exchange date reported (5 records) and incomplete latitude/longitude coordinates (14 records). The data set was reduced to 8308 locations.

The import of the geo-referenced data into MapInfo GIS as a point layer with database attributes followed the MS Access query activity.

4.0 MAP CREATION IN MAPINFO GIS

4.1 Importing the Database into MapInfo GIS

The 8308 records from MS Access were imported into MapInfo Professional GIS software. The point data layer created was viewed in the MapInfo map window using the FAO Standardized Oceans Regions map for reference (Figure 2). The point data layer distribution showed 97% of the point data within FAO Zones A, B,G and F. The distribution is shown in the Table 2 below.

FAO Zone	Points	Percentage of Total Points
A	5055	62.5
B	2096	25.95
F	114	1.4
G	812	10.05
D,E,F,H,J,M	231	2.85

Table 2. Distribution of ballast water endpoints reported by vessel approaching Eastern Canada, classified by FAO standardized ocean regions.

The GIS overlay of the FAO Oceans Regions assisted in defining the study area. The area selected for the project study area was defined as an area bounded by -090W/15N and 00(Greenwich)/65N. This area captured 96 % (8014) of 8308 project data points. The outlying points in the data set were ballast water exchange endpoints located in the Pacific Ocean, off the east coast of northwest Africa and below the equator, in the South Atlantic. Since the outlying points would distort the GIS modeling (potential surface mapping) to be undertaken, 294 points were removed from the data set. The 294 points represented data from 52 ballast water reporting forms.

With the peripheral points in the data set removed, the data set of 8014 points was prepared for MapInfo ship track creation and SPANS GIS Potential mapping analysis.

Preceding the modeling, the imported point file was parsed to bi-monthly intervals. Parsing provided subsets, permitting an examination of ballast water exchange during the six bi-monthly periods for year 2002. The six point subsets extracted are shown in Table 3. by duration and point count/Ballast Water Management Report Form counts.

File Name	File Interval	Point Count / Report Forms
JFpts	01/01/2002 - 28/02/2002	1046 / 193
Mapts	01/03/2002 - 30/04/2002	1290 / 220
MJpts	01/05/2002 - 30/06/2002	1478 / 245
Japts	01/07/2002 - 31/08/2002	1553 / 278
Sopts	01/09/2002 - 31/10/2002	1459 / 258
NDpts	01/11/2002 - 31/12/2002	1188 / 216
Total Points / Report forms	N/A	8014 / 1410

Table 3. GIS point file bi-monthly point counts with 1412 Ballast Water Management Report forms representing 8014 plottable Ballast Water Exchange data.

4.2 Creation of the Vessel Ballast Exchange Track Movement Maps in MapInfo GIS

The intent of the Vessel Ballast Exchange Track Movement Maps is to display the ballast exchange endpoints reported by the vessel on the ballast exchange form as a series of points connected by a line (polyline). The resulting line represents the vessel's movement track while undertaking ballast exchange. Once the vessel track is created, it is "joined" in MapInfo to data from Sections 1 to Section 5 of the MS Access database, giving the track attributes that can be used to generate line attribute-based thematics. For example, the ship tracks can be classified and coloured according to the line's attribute - BWE_Volume_Tank.

The creation of the ballast exchange tracks was completed using MapInfo SQL and MapBasic programming software. The tasks were as follows:

1. In MapInfo SQL, extract from the ballast water exchange point file the TC Sheet# and the Sum of ballast volumes for each Ballast Exchange Report Form Sheet. The SQL result was two columns: one column of TC Sheet# and another sum of ballast exchange volumes. Save the .tab file as TCSheet_BallastVolumes.

2. In SQL, take TCSheet_BallastVolumes and remove sum of ballast exchange volumes field. Save as DOS .txt file. The .txt is a single column of numbers.

3. In MapBasic, create a program to read the DOS .txt file listing the single column of numbers (TC Sheet#) from Step 2; after reading the column of TC Sheet#, MapBasic places all records in ballast water exchange point file with a common TC Sheet# in a separate MapInfo .tab file, with the records sorted by the longitude field. This procedure produces plottable track files in MapInfo GIS.

4. In MapBasic, modify the MapInfo utility conndot.mbx to continuously read the DOS .txt file listing the TC Sheet# from Step 2; with each TC Sheet# read, a .tab file is called and opened and the sorted (by longitude) ballast exchange points contained are plotted, one polyline (with TC Sheet# attribute) at a time.

   After each polyline is plotted in the map window, the line is linked to the attributes from Sections 1to Section 3 of the original data set. The result of running the MapBasic routine is a ballast exchange movement tracks (polylines) with attributes.

5. In MapInfo, create a classified colour thematic map based on the Ballast Water Volume Exchange attribute attached to each ship movement track.

The GIS derived bi-monthly Ballast Water Exchange Movement Track outputs is discussed below.

4.3 GIS Potential Mapping in SPANS Analytical GIS

To compliment the plotting of the vessel movement exchange tracks (polylines), a technique to create potential thematic mapping surface representative of the ballast water exchange volumes based on geo-referenced ballast water exchange endpoint values was chosen. The SPANS modeling algorithm generates a surface by applying a sampling radius to each point in the data layer. The function generates a gridded surface representation with the value of each variable raster cell based on the value of each point whose sampling radius overlaps the centre of the cell. The function applies a weight based on the distance from the centre of the cell to each point used in calculating the output value. The greater the distance a raster cell is from the point, the less influence that point has in determining the output value. The user controls the effect distance has on determining the output value by specifying the size of the sampling radius and a rate of decay. The user also specifies the number of points closes to the centre of the variable raster cell to be considered in the calculation of an output value.

Other parameter settings include the sample radius inner, outer sample radius and decay rate. The inner sample radius setting is an area where the decay rate is constant when the weighted average computation is applied. The outer sampling radius decay rate can be set between .1 to 1.0 (constant) allowing the user to select the relationship between weight inversely proportional to distance and decay rate with distance, to obtain the most representative raster cell value.

The potential mapping chosen because the modeling process lends well to unevenly distributed data, such as ballast water exchange points (on a small scale, cartographically) which is non-continuous data typified by a high degree of variance and uneven distribution.

The creation of the potential mapping layers required the use of PCI SPANS Analytical GIS, a GIS variable raster modeling and display software.

The preparation of the bi-monthly potential maps started with a simple aggregation of the ballast water exchange endpoint point file. The aggregation technique was necessary because the point data had multiple values at a given point geo-reference, each with its own volume value. The aggregation algorithm summed the multiple values on the same point location. The reduction in the number points due to Simple Aggregation is shown in Table 4.

File Name	**Bi-monthly Interval**	**Point Count / Agg. Point Count**
AggJFpts	01/01/2002 - 28/02/2002	1046 / 619
AggMApts	01/03/2002 - 30/04/2002	1290 / 659
AggMJpts	01/05/2002 - 30/06/2002	1478 / 842
AggJApts	01/07/2002 - 31/08/2002	1553 / 874
AggSOpts	01/09/2002 - 31/10/2002	1459 / 774
AggNDpts	01/11/2002 - 31/12/2002	1188 / 686

Table 4. Aggregate points created for each bi-monthly interval, using MapInfo Vertical Mapper.

The next step of the GIS processing was to create an interpolated continuous surface grid layer based on the aggregated seasonal GIS point layers. The continuous surface is the output of the interpolation algorithm estimating grid values using ballast exchange endpoint volumes read from the point table.

The selection of SPANS GIS modeling capability over the MapInfo Vertical Mapper (used for the December 2001 data set mapping) software for point value interpolation was the parameters of the SPANS modeling algorithm better suited the data distribution. The SPANS outputs had tighter interpolation around the known values and did not populate the large areas of ocean having thin point data with modeled ballast water exchange values.

The SPANS potential map algorithm parameter values were entered into the algorithm to reflect the geographic distribution and variance in point values. The classification interval for the map output was the system default of 2331.3 cbm. The parameter settings are shown in Table 5.

Parameter	**Value**
Function	Weighted Average of Z-Values
Inner Radius (km)	10
Outer Radius (km)	50
Decay Rate	.5
Frequency	1
Maximum Neighbours	25

Table 5. SPANS Potential Mapping Surface parameter settings for modeling the reported ballast water exchange endpoint values.

The resultant seasonal ballast water exchange thematic potential map output is reviewed below in a discussion of project map outputs.

4.4 Discussion of Project Map Outputs

4.4.1. Distribution of Point Data

The GIS distribution of the 8014 recorded ballast water exchange point data provides a spatial view of the geo-referenced, recorded data by the marine vessel. In addition to the FAO ocean regions compilation, the points were classified by a scheme of location within Canada's Eastern Economic Zone and points beyond the 200 mile limit. A GIS query yielded 1091 reported ballast exchange endpoints (13.61% of the 8014 total data points) within Canada's EEZ. The points outside the EEZ were data located predominately along the US Eastern Seaboard and the mid-Atlantic Ocean, steaming from European ports.

The data points within Canada's EEZ was further classified by Area within the 200 mile boundary. The Area I, Area II, Area III and Area IV was a classification scheme used in a year 2000 vessel traffic/ vessel shipping patterns statistical study[4] completed by Transport Canada. A plot showing the distribution of points within the Areas 1 to 4 is shown in Figure 3.

4. Vessel Traffic/Vessel Shipping Patterns on the East Coast of Canada 2000 Shipping Season, Transport Canada, 2002.

A MapInfo point in polygon query provided values for the point data distribution for year 2002 per Area. The data was un-aggregated, consisting of all points for 2002. The output is shown in Table 6.

Area	Points	# Vessels
I	35	15
II	987	219
III	37	11
IV	29	12
Totals	1088	257

Table 6. Points distribution with Canadian EEZ by Area used in shipping pattern report for year 2000.

The GIS reports 1088 points captured within the defined areas. The remaining 3 points (total points, 1091) were located off northern Labrador, outside of Area IV. Two hundred fifty-seven marine vessels reported the 1088 points. Table 6 indicates Area II, encompassing ports east of Yarmouth to the northern tip of Cape Breton, is the most active ballast water exchange area for marine vessels, reporting 987 points from 219 vessels. The arrival port for these vessels includes ports in Nova Scotia, New Brunswick, Newfoundland, Gulf of St. Lawrence, Quebec and Great Lakes.

Having determined the year 2002 point distribution, the bi-monthly data sets were mapped in the GIS. Summary data is tabulated below (Table 7).

Bi-monthly	Area I		Area II		Area III		Area IV	
	Pts	Vessels	Pts	Vessels	Pts	Vessels	Pts	Vessels
January - February	3	2	106	25	15	2	5	1
March - April	2	1	121	25	1	1	4	1
May - June	8	5	207	44	6	3	3	2
July - August	2	1	210	53	11	3	11	5
September - October	12	4	166	37	0	0	5	2
November - December	8	2	186	38	4	2	1	1
	35	15	987	219	37	11	29	12

Table 7. Bi-monthly points within Geographic Areas defined in shipping report for year 2000.

The bi-monthly data table indicates Area II is the active ballast water exchange area for vessels transiting into Eastern Canada, primarily from ports on the United States Eastern Seaboard. This statement is made in terms of ballast water exchange endpoints reported. The period of July-August has a value of 210 exchange endpoints recorded by 53 vessels reporting. The period of least activity report for all areas was January-February and March-April, with an average of 1.66 vessels report exchange in the first period and 1.00 vessels in the latter duration. The activity in Area II for the two periods was 25 vessels reporting ballast water exchange endpoints. Activity in Areas I, II, III increases slightly during the balance of the year with Area I ranging from 1 to 5 vessel reporting activity, Area II ranging from zero to 3 active vessels and Area IV reporting a range of 1 to 5 vessels exchanging in the remaining four bi-monthly periods of the year. During the same period, Area II reports an average of 37.5 ships reporting in the autumn-early winter to a bi-monthly high of 53 vessels reported for July-August.

4.4.2. Distribution of Ship Movement Tracks

The thematic vessel movement tracks created in the MapInfo GIS reflect the bi-monthly point data set, giving a GIS polyline representation to the series of ballast exchange endpoints recorded in the vessel's ballast exchange activity log. Each polyline contained a database field ballast water volumes exchanged sum, extracted from the point that generated the vessel movement track. The sum value attribute enabled thematic ship track map for each bi-monthly period based on a classification of ballast water exchange endpoint volumes.

The number of vessel movement tracks developed for each bi-monthly period was a function of the number of recorded ballast activity points reported. The length and direction of the track reflected the number of geo-referenced point data read into the MapBasic program and plotted in the spatial environment. Where ballast exchange was reported at a single location for all ballast tanks, no line was created and the track was of zero length. There were instances where two tracks were plotted to represent ballast exchange endpoints reported at during two periods during the vessel's transect. A compilation of the bi-monthly movement tracks created in MapInfo is listed in Table 8; the range of ballast water volumes exchanged is also reported.

Period	Pt. Count	Track Count	Tracks of Zero Length	Min. - Max. Volume (cbm)	Mean (cbm)
January - February	1046	193	59	40 - 95,157	8608.08
March - April	1290	220	99	40.67 - 97,772.51	9,668.43
May - June	1478	245	91	93.0 - 83,494	11,480.26
July - August	1553	278	112	20.7 - 83,473.3	12,493.4
September - October	1459	258	92	15 - 83,272.5	12,980.09
November - December	1188	216	81	110.745 - 97,607.8	14,707.59
Totals		1410	534		

Table 8. Compilation of bi-monthly vessel movement tracks data

From Table 8, the number of zero length tracks impacts on the number of tracks plottable and reduces the quantitative value of assessing the volume of ballast water exchanged by marine traffic approaching the Canadian Eastern Economic Zone. Qualitatively, the movement tracks provided information on dominant shipping corridors where ballast exchange activity is conducted by marine vessels; comments can be made about the vessel movement track orientation and volumes reported.

The six bi-monthly periods exhibited similar movement patterns to the December 2001 one-month (of data) GIS mapping study. The distribution of the exchange endpoint movement tracks displayed two preferred areas: mid-Atlantic ocean while steaming from European and the Mediterranean ports and the other along the east coast of North America, south-southwest of Nova Scotia. The former can be subdivided into ships departing European ports north of Spain and Spanish, Mediterranean and Northwest African ports. Each subdivision was well defined, with one area of preferred exchange endpoints bounded by a rectangle with corner points -40W/52N and -12W/46N and the other -38W/45N and -15W/34N. These rectangles enclose European vessel traffic destined mostly to Maritime Canada and the Gulf of St. Lawrence ports (Montreal, Trois Riviere, Quebec City, Sept Isles). The second area south of Nova Scotia is rectangular area bounded by -79W/32N in the southern United States and extends along the entire American East Coast and thinly into the Canadian EEZ. There are clear vessel traffic patterns from New York, Boston and American ports to the north of these cities. The traffic in this area is mostly American vessel transiting to the Bay of Fundy, Halifax, Pt. Tupper, Come By Chance -Whiffen Head, NL and the Gulf of St. Lawrence (Figure 4).

The thematic ballast exchange map in Figure 4 illustrates the different volumes reported by vessels transiting from Europe, Mediterranean and America. The distribution of volume shown in the map legend indicates the higher volumes reported are thematically coloured red. The legend in Figure 4 indicates 1136 tracks (80.5% of total, including zero length tracks) report ballast water exchange volumes between 0 and 19,600 cbm. Data extracted (from the mapping) using an intersect polyline query through the three zones provided the following information:

Map Area	#Tracks	Min. Volume	Max. Volume	Mean
Europe	120	332	97,772.51	25,215.17
Mediterranean	50	800	81,297.1	11,603.24
America	122	838	74,935.9	23,217.74

Table 9. Vessel movement Track counts in three zones; Europe, Mediterranean and America.

The intersection line for the vessel transiting south of Nova Scotia was the Canadian EEZ boundary. The boundary intersected 122 ship movement tracks crossing over the EEZ line reporting ballast exchange endpoint activity. The larger scale map viewed in Figure 5 shows vessel traffic eastward of the 1000 metre and 2000 metre isobathymetric contours. The 1000m contour is coloured pink in Figure 5. An intersect line drawn through the landward of the 1000m isoline found 69 vessels were transiting landward of the 1000 m interval contour during the year 2002.

Examining this query output resulted in 36 vessels being oil tankers (Type reported as Crude Oil Tanker, Tanker, Product Tanker and Tanker in the database), 24 Bulk Cargo, 5 General Cargo and 4 assorted carriers. The common last ports reported for the 69 vessels included 8 departure ports reporting more than 4 voyages during year 2002 to Eastern Canada. The departure ports included Newington, NH (4), Portland, ME (9), Bayway, NJ (10), New York, NY (11), Baltimore, MD (4) and Philadelphia/Trainer, PA (7). The remainder of the ports was located in the New England states, except for 1 departure from Charleston, SC.

A seasonal examination of the point information was conducted using aggregate points-based potential mapping, since the vessel track mapping provided a more visual, qualitative view of vessel traffic patterns with vessel traffic counts. Potential mapping modeled the same point data (but aggregated), mapping the distribution of seasonal ballast water exchange endpoints and revealing anomalous, high value areas.

4.4.2 Potential Mapping of Ballast Water Exchange Endpoint Volumes

The seasonal potential maps modeled in SPANS Analytical GIS were derived from bi-monthly point data subsets of the ballast water geo-referenced point file. The model required the points to be aggregated, since more than one geo-referenced point at the same point location was treated as a single non-aggregated value by the model algorithm. MapInfo Vertical Mapper software was used to create the simple aggregate point layer. The effect of aggregation was to substantial reduced the number of points for each season. The aggregate bi-monthly files used to generate the potential surface maps are in Table 10.

Bi-monthly	Unaggregated # of points	Aggregate # of points
January - February	1046	619
March - April	1290	659
May - June	1478	842
July - August	1553	874
September - October	1457	774
November - December	1188	686

Table 10. Bi-monthly summary of unaggregated points and aggregated points.

The potential surface map created a GIS layer containing polygons modeled on the parameter settings discussed above. The algorithm output provided a default classification scheme with interval of 2331.3 cubic metres. The map legend has the upper most interval of the scheme green coloured, and green polygons contain the attribute value equal to or greater than 9,325.2+ cubic metres volume reported exchanged.

Parameter settings influencing the potential surface (the value of the variable raster cell) were the endpoint value, the outer search radius of 50 kilometres and the nearest 25 neighbouring points.

4.4.3 Bi-monthly Potential Mapping Output Discussion

4.4.3.1. January-February Bi-monthly Period Potential Map

The thematic potential map for January-February reveals twelve scattered 9,325.2+ cbm ballast water exchange locations in the mid-Atlantic. This represents vessels reporting exchanged endpoints where total ballast volumes exchanged was greater than 9,325.2+ cbm, while transiting to Eastern Canada destinations. The ballast exchanged values for the points range from 10,238 to 48,531 cbm with mean 29,097 cubic metres. Most high value areas (83%) are isolated, being greater than 60 kilometres from a neighbouring ballast water exchange endpoint location. (Figure 6).

The area within Canadian EEZ for the same period contained 2 isolated green zones and two larger areas comprised of more than one aggregate point location (Figure 6a). One of the isolated areas is south of Anticosti Island which reflects two vessels, a bulker destined for Sept Iles from Salem, MA exchanging 10, 404 cbm and a motor tanker to arrive at Quebec City, QC from Philadelphia, PA exchanging 29,792 cbm. The second point, east of Pt. Tupper, reflects one vessel reporting the endpoint for exchanging 34,993 cbm from six ballast tanks, while heading for Whiffen Head from Portland, ME.

The larger green areas with values greater than 9,325.2+ cbm are southwest of Nova Scotia. One zone is along the southern Canadian 200-mile limit boundary, and the other is closer to shore, southwest of Cape Sable. There are several 9,325+ cbm points responsible for each zone, with the modeled area around these points being influenced by the lesser valued points (less than 9,325.2 cbm) found to be within the model's 60 kilometer sampling radius.

The model output shows the green area along the EEZ boundary has 20% of its area inside the EEZ boundary, with the balance in US territorial waters. With the exception of a single aggregate point, all the other points responsible for the green endpoint exchange area are situated in American waters. The single aggregate point is located 1.1 kilometers inside the 200 Mile Limit and 2.8 kilometers east of the 2000 meter isobath. With the exception of this point, the northern boundary of the green area is based on ballast water exchange endpoints points located in American waters.

The high-value area southwest of Cape Sable reflects five vessels reporting ballast exchange endpoints within forty to seventy kilometers from Nova Scotian coastline. Of the five vessels, the same bulk cargo vessel (based on IMO number) reports ballast exchange endpoints for three voyages to Halifax (twice) and one to Pt. Tupper from Newington and Portsmouth, NH respectively. The bulker reports endpoints for ballast exchange volumes of 12,377 cbm, 12,481 cbm, and 12,658 cbm at these locations. The remaining points are bulk cargo ships destined for Halifax from Portland, ME and Brayton Pt., MA. The volumes reported are 17,207 cbm from 5 ballast tanks and 22,440 cbm from 7 tanks exchanged. A single point influences the southeast end of the high value green area, a tanker destined for Pt. Tupper from Bayway, NJ. The tanker reports 15,220 cbm at the exchange endpoint for two ballast tanks.

In total 130 ballast exchange endpoints (including high value points locations discussed above) with the EEZ, representing 30 voyages (95% from the USA) recording a ballast water exchange endpoint(s) within the Canadian 200-mile Limit. Fourteen of these voyages reporting exchange seaward of the 2000-metre isobath; of the remaining 15 voyages, 14 reported ballast exchange endpoints landward of the 2000-metre interval and one in the Laurentian region.

An overlay of the ship tracks for January-February over the potential map data for the same period displays a representation of the 30 voyages representing the 130 points. The overlay shows four tracks having no related endpoints crossing into US territorial waters.

This suggests, with the first endpoint reported for this group being 280 kilometres northeast of the EEZ, that exchange was initiated after crossing over the Canadian 200-mile limit. Fifteen other voyages reported endpoints in US territorial waters crossing into the Canadian EEZ. The remaining eleven ballast exchange endpoints recorded voyages where the ship tracks were zero length; occurring at the same geo-reference. Similar to the above, with ballast exchange commencement not reported, ballast exchange for a number of the eleven zero length ship tracks could have occurred within the Canadian EEZ.

4.4.3.2. March-April Bi-monthly Period Potential Map

The bi-monthly interval March-April potential map shows the mid-Atlantic to have more single point, high-value ballast exchange endpoints. The 31 single high-value points were less dispersed than the January-February display, with only 25% isolated anomalous areas (Figure 7). This reflects the slight increase in vessel traffic (315 points) reported for the period March-April over January-February (295 points). The remaining high-value polygons areas were less symmetric, sharing a common area boundary with neighbouring polygons. The high-values areas for the mid-Atlantic traffic ranged from 9,316 to 74,924 cbm, with a mean of 21,473 cbm.

The high-value exchange endpoint activity reported off Nova Scotia within the 200-Mile Limit showed non-symmetry isolated anomalous areas outside the EEZ boundary and two nearly adjacent green areas southwest of Cape Sable and one seaward of the 2000 metre isobath (Figure 7a). One of the adjacent areas represents two bulk cargo vessels from the New York City area destined for Halifax reporting exchange endpoint volumes of 12,962 and 22,548 cbm. A yellow area northwest of this area represents four vessels reporting exchange endpoints (one the vessels twice, separate voyages) between 6,993-9,325 cbm. Three of the vessels are bulk cargo, two destined for Halifax and one Auld's Cove from Portsmouth, NH and Newington, NH. The third vessel is a tanker headed for Whiffen Head from Portland, ME. The seaward high-value area is a single bulk cargo vessel from Sparrows Pt., MD destined for Sept Iles reporting 10,146 cbm exchanged.

The endpoint reporting inside the EEZ is less than the previous period (128 points), however the point locations are more defined along the coast of mainland Nova Scotia and parallel to the 2000 metre isobath, where US tankers were heading for Whiffen Head and Come By Chance, NL. The number of vessel voyages having exchange endpoints during March-April is 26 vessels, eleven tankers, two container ships and 13 bulk/general cargo vessels.

An overlay of ship tracks reports 26 ship tracks comprise the points within the EZZ, eight of which are zero length tracks. Nine vessel tracks begin in US Territorial waters and report the last endpoint of the voyage in Canadian waters. Nine tracks report the first endpoint within the Canadian EEZ and report others along the Nova Scotian coast or along the 2000-metre isobath.

4.4.3.2. May-June Bi-monthly Period Potential Map

The bi-monthly interval May-June potential map shows the mid-Atlantic to have more single point, high-value ballast exchange endpoints than the two previous bi-monthly periods, with 33 single high-value points (Figure 8). The range of ballast water exchange endpoint volumes was 9,860-64,152 cbm with an average value of 17, 432 cbm. The distribution pattern of the high-value points shows 69.7% located with +/−5 degrees of 49°N, with fourteen bulk cargo vessels (93%) destined for Sept Iles and Port Cartier, QC and one bulk cargo heading for Shelburne, NS. The vessels had origins in the Netherlands (8 ships), United Kingdom/France/Germany (5 ships) and Faroe Islands (1 ship). South of 49°N, bulk cargo vessels, some with origins in the Mediterranean, account for the 10 high-value ballast exchange endpoints between 40°N and 42°N latitude in the mid-Atlantic.

The mid-Atlantic data was less dispersed than previous bi-monthly periods, part of this reflects the 27% increase in data points for the May-June period with 701 points representing 131 vessels reported transiting from Europe to Eastern Canada. The majority of vessels were bulk/general cargo (37.5%), container ships (33%) and tankers (21%).

The high-value exchange endpoint activity reported off Nova Scotia within the 200-Mile Limit shows isolated and adjacent non-symmetry 9,325+ areas ninety kilometres southwest of Liverpool, NS and due east of Canso (Figure 8a). There is also a smaller high-value green area east of Halifax adjacent to a yellow 6,993-9,325 cbm-coloured area. The high-value area situated off Liverpool is two ships which report endpoints for all tanks exchanged at the single location; one bulk cargo destined for Halifax from Burlington, NJ and the other from New York to Whiffen Head.

East of Canso, two exchange endpoint locations contribute to the two high-value areas. The closest to Canso (40 kilometres southwest) is a tanker headed for Pt. Tupper exchanging 9 ballast tanks for a cumulative total of 17, 382 cbm. The other area (150 kilometres east of Canso) is the same tanker reported off Liverpool reporting another exchange endpoint for 4 tanks having volume 18,264 cbm.

The coast off Nova Scotia has more 6,993-9,325 cbm and 4662-6,993 cbm continuous areas. The pattern of tanker vessels (16 ships) transiting to Whiffen Head and Come By Chance is evident. These vessels are within 50 kilometres either side of the 2000 metre isobath. Other vessels (4 ships) in the group are bulk carriers, destined for Quebec ports.

An overlay of ship tracks reports 26 ship tracks comprise the points within the EZZ, eight of which are zero length tracks. Twenty-one vessel tracks begin in US Territorial waters and report endpoint(s) of the voyage in Canadian waters. Sixty-six percent of the vessels are bulk cargo destined for various Nova Scotia (Halifax, Pt. Tupper), Newfoundland (Lower Cove) and Laurentian ports (Quebec City, Contrecouer, Magdeleine Islands). The balance were tankers headed for Whiffen Head and Come By Chance, Newfoundland. The departure ports were Philadelphia and New England ports, to the north. The exceptions were Savannah, GA and Charleston, SC. Seventeen tracks (76% tankers) reported the first endpoint within the Canadian EEZ. Six vessels were zero length tracks, reporting all tanks exchanged at a single geo-referenced point. The range of the total endpoint volumes reported by the 17 vessels was 220 cbm to 57,266 cbm, with average volume for the endpoints 16,724 cbm. A tanker destined for Whiffen Head from Philadelphia, PA reported the 57,266 cbm.

4.4.3.4. July-August Bi-monthly Period Potential Map

The bi-monthly interval July-August potential map shows the mid-Atlantic to have a similar single point, high-value ballast exchange endpoints with May-June, 34 single high-value points (Figure 9). The range of ballast water exchange endpoint volumes was 9,756-64,152 cbm with an average value of 22,089 cbm. The distribution pattern of the high-value points shows 62% located with +/−5 degrees of 49°N, with twelve bulk cargo vessels destined for Sept Iles and Port Cartier, QC. The vessels had origins in the Netherlands (6 ships), United Kingdom/France/Belgium (3 ships) and Spain (2 ships).

Similar to the previous period, the data was less dispersed than earlier bi-monthly periods, partially reflecting the 636 points (including above) representing 125 vessels reported transiting from Europe to Eastern Canada. The majority of vessels were bulk/general cargo (42%), container ships (34%) and tankers (11%). Other vessels were tugs, lift vessels and supply ships.

South of 49°N, bulk cargo vessels, some with origins in the Mediterranean account for the high-value ballast exchange endpoints between 40°N and 42°N latitude in the mid-Atlantic. The 123 points representing 35 vessels transiting from Spain and Mediterranean ports. The majority of traffic is bound for Halifax (37%) and Laurentian ports (63%). Vessel types were 62% container ships, 23% bulk/general cargo and 14% tankers.

The traffic pattern for the mid-Atlantic for July-August suggests vessels in the above grouping (and points north) has two routes for approaching Eastern Canada: the Strait of Belle Isle and the Gulf of St. Lawrence. The traffic has noticeably shifted northwards during the interval, nearer the most eastward demarcation of the 2000 metre contour.

The high-value exchange endpoint activity reported off Nova Scotia within the 200-Mile Limit shows nearly adjacent non-symmetric 9,325+ areas varying from 50 to 100 kilometres along the Nova Scotian coastline between Cape Sable and Canso (Figure 9a). Numerous vessels account for each high-value area. Southeast of Cape Sable, eleven tankers report exchange endpoints, with the same tanker (IMO# 9111632) reporting exchange at this location over five voyages during the bi-monthly interval. Departure is from Bayway NJ and Riverhead, USA, bound for Whiffen Head.

Twelve endpoints representing 10 tanker exchange endpoints comprise the larger high-value area to the north, along the coastline. The tankers are destined for Whiffen Head and Come By Chance, from New England states. The mean volume exchanged at the endpoints was 16,832 cbm. The high-value area north of this area is east of Canso. Three tankers report average endpoint of exchange as 14,614 cbm. An overlay of the ship tracks GIS layer shows many points in each high-value areas to be along the same ship track.

The ship track overlay also reveals 63 vessels crossing over the EEZ reporting ballast exchange endpoints in US territorial water and inside the EEZ. Twenty-four ship tracks are reported having the ship track origin first reported inside the Canadian 200-mile limit.

4.4.3.5. September-October Bi-monthly Period Potential Map

The bi-monthly interval September-October potential map shows the mid-Atlantic to have a similar single point, high-value ballast exchange endpoints with bi-monthly periods May-June and July-August; 47 high-value areas with an average of 18,245 cbm (Figure 10). Similar to previous periods, the distribution pattern of the high-value point derived areas shows fifteen bulk cargo vessels destined for Sept Iles and Port Cartier, QC within the +/−5 degrees of 49°N. The vessels had origins in the Netherlands (9 ships), United Kingdom/France/Belgium/Germany/Denmark (5 ships) and Spain (1 ships). The remaining ships were a supply and a container ship headed for Halifax.

Similar to the previous period, the data was less dispersed than earlier bi-monthly periods. Fewer ballast exchange endpoints were recorded (525) representing 103 vessels (including above) reported transiting from Europe to Eastern Canada. The majority of vessels were container ships (43.6%), bulk/general cargo (41.7%), and tankers (8%). Other vessels were passenger and supply ships.

South of 49°N, bulk cargo vessels, most with origins in the Mediterranean account for the 7 high-value ballast exchange endpoints between 40°N and 42°N latitude in the mid-Atlantic; the mean value of exchange endpoint is 12,511 cbm.

The high-value exchange endpoint activity reported off Nova Scotia within the 200-Mile Limit shows two extensive non-symmetric 9,325+ zones lying off 40 to 80 kilometres) the Nova Scotian coastline between Cape Sable and Sheet Harbour, NS (Figure 10a). Similar to the previous bi-monthly period, numerous vessels account for each high-value area. The area paralleling the southeast coast reports 16 high-value points, average value 16,348 with range 1,193 to 38,804 cbm. The points represent 13 ballast water management reports to Transport Canada. Three vessels are type bulk cargo and 10 tanker voyages, with the same tanker (IMO# 9123192) reporting exchange at this location over four voyages and another tanker over three voyages, during the bi-monthly interval. Departure was from port Philadelphia/Trainer PA north to Portland, ME bound for Port Tupper and Whiffen Head.

The high-value area east of Halifax has four oil carriers averaging 12,222 cbm. An overlay of the ship tracks for the period indicate a number of the vessels reporting an exchange endpoint in this zone did the same in the other area previously discussed.

The ship track overlay also reveals 45 vessels crossing over the EEZ reporting ballast exchange endpoints in US territorial water and inside the EEZ. The number is fewer than report for the previous period. Sixteen ship tracks are reported having the ship track origin first reported inside the Canadian 200-mile limit.

4.4.3.6. November-December Bi-monthly Period Potential Map

The bi-monthly interval November-December potential map shows the mid-Atlantic to have a slightly similar pattern with bi-monthly periods January-February. This is reflected in the large isolated high-values areas, which make up 63% of the thirty-eight 9,325.2+ cbm ballast water exchange locations in the mid-Atlantic (Figure 11). The distribution pattern of the high-value point derived areas shows a percentage (26%) of high-value exchange endpoints at 60°N between longitudes -15°W and -46W. The areas represent six-bulk/general cargo vessels exchanging while transiting through the area destines for the Quebec north-shore - Sept Iles and Port Cartier. The number of areas (16 locations) reporting high-value endpoints within the +/−5 degrees of 49°N is less dense fewer than July-August and September-October. The exchange at the endpoints shows a range of 10,212 to 83,494 cbm, with a mean of 22,747 cbm. The eight vessels had origins in the Netherlands (5 ships), United Kingdom/France/Poland (3 ships).

Similar to the January-February, the data set was dispersed, with fewer ballast exchange endpoints recorded (306) representing 60 vessels (including above) reported transiting from Europe to Eastern Canada. The majority of vessels were bulk/general cargo (48%), container ships (38%), and tankers (6%). Other vessels were a supply ship and types unknown.

South of 49°N, bulk cargo vessels, most with origins in the Mediterranean account for the seven high-value ballast exchange endpoints between 40°N and 42°N latitude in the mid-Atlantic; the mean value of exchange endpoint is 13,529 cbm. In total thirty-seven were located in the geographic area. The majority of vessels were container ships (48.6%), bulk/general cargo (32.4%), and tankers (13.5%). Other vessels were types unknown.

The high-value exchange endpoint activity reported off Nova Scotia within the 200-Mile Limit shows eight 9,325+ zones lying off the Nova Scotian coastline between Cape Sable and Sheet Harbour, NS (Figure 11a). The areas can be grouped into two zones based on distance from the coastline. Three high-value areas are within 40-80 kilometres, each having more than one high-value point, except for the single point in the most northern anomaly off Sheet Harbour. The mean value for points was 14,958 cbm. The points represent three oil tankers from Portland, ME destined for Whiffen Head. One of the vessels (IMO# 9181534) reported exchange endpoints in the area over two voyages. The next area of high-value areas is 150 kilometres off the coast to the 200-Mile Limit. Of the five areas, two border /cross-over the EEZ off southwest Nova Scotia (comprised of nine points, mean -12,045 cbm), one is 150 kilometres east of Liverpool, NS (comprised of four points, mean - 14,118cbm) and two are located east of the 2000 metres isobath (one point 50,582 cbm and the other 16,757 cbm). The former two areas report six tanker and three bulk cargo voyages responsible for the high-value areas. Of the tanker voyages, one tanker made four of the six transits; destinations were Pt. Tupper and Whiffen Head, with last ports Bayway, NJ and Trainer, PA. The two high-value zones east of the 2000 isobath were locations where vessels reported all tanks exchanged at a single location. Both tankers were bound for Whiffen Head and Come By Chance from New York, NY and Philadelphia, PA.

The ship track overlay also reveals 50 vessels crossing over the EEZ reporting ballast exchange endpoints in US territorial water and inside the EEZ; an 11% increase compared to the previous period. Fourteen ship tracks are reported having the ship track origin first reported inside the Canadian 200-mile limit.

In comparison to September-October bi-monthly period, November-December potential maps show the largest high-value areas. A comparison of all the bi-monthly periods in one image is shown in Figure 12.

4.4.3.7. Bi-monthly Period Potential Map Area Analysis

The areas generated by the model reflect the aggregate point locations, the model parameters and the ballast water exchange endpoint volume attribute information. The intervals in the table (Table 11.) are Class 1 - 0.0-2331.3 cbm, Class 2 - 2331.3-4662.6 cbm, Class 3 - 4662.6-6,993.9 cbm, Class 4 - 6,993.0-9,325.2, and Class 5 - 9,325.2+ cbm. The source of the area summary data was the potential map for each bi-monthly period.

Bi-month Period	January-February	March-April	May-June	July-August	September - October	November December
	(km^2)	(km^2)	(km^2)	(km^2)	(km^2)	(km^2)
Class						
1	2,651,453	2,499,327	2,656,236	2,722,593	2,496,485	2,103,716
2	492,0707	488,482	726,082	750,991	563,609	663,909
3	119,962	268,420	327,006	349,988.	334,977	382,470
4	44,039	112,124	139,690	257,592	193,825	232,949
5	189,973	372,639	421,328	400,936	570,650	472,010
Total Area	3,517,026	3,769,755	4,343,675	4,548,328	4,192,892	3,870,666

Table 11. Bi-monthly summation of potential map areas, classified by ballast water exchange endpoints volumes. area

The above table shows Classes 2 (2331.3 - 4662.6 cbm) through Class 5 (9325+ cbm) area representations increasing from January-February to July-August. The increase reflects the increased traffic and the higher ballast water exchange endpoint volumes. The square kilometres area coverage of the fifth classification (9325+ cbm) decreased slightly in July-August, followed by the highest value reported (570,650 km^2) in September-October. The November-December period was higher than the preceding July-August interval, and less aggregate points (686) than previous bi-monthly periods.

5.0 VESSEL TRAFFIC AND SHIPPING PATTERNS ON THE EAST COAST OF CANADA, FOR THE YEAR 2002 SHIPPING SEASON

The ballast water management report database provided an opportunity to examine vessel traffic and shipping patterns and compare results with previous analysis[5,6] conducted using ECAREG data for years 1998 and 2000, supplied by the Eastern Canada Region - Traffic Services branch of Canadian Coast Guard.

In addition, the Transport Canada ballast water exchange 2002 data set permitted a tabulation of partial ballast conditions by vessels transiting into Eastern Canada, an attribute not clearly defined in the ECAREG data set.

5.1 Methodology of Analysis

The ballast water analysis for year 2002 follows the methodology used by Harvey et al (1999)[7]. The data used in the statistical analysis was the Ballast Water Management Report forms submitted to Marine Safety, Transport Canada during the year 2002 shipping season.

From previous database discussion, the Trip_Info and the Ballast_Water_History tables of the database contained the data from Sections 1. to Section 5 of the faxed Ballast Water Report forms. Data table parameters included the Vessel's IMO Number, Vessel Type, Vessel Gross Tonnage (GT), Total # of Ballast Tanks, Total # Tanks in Ballast, Number of Tanks Reported Exchanged, Number of Tanks Recorded Exchanged, # Tanks

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[5] CEF Consulatnts Ltd, 2000. Vessel Traffic/Vessel Shipping Patterns on the East Coast of Canada.

[6] Marine Safety, Transport Canada, 2001. Vessel Traffic/Vessel Shipping Patterns on the East Coast of Canada 2000 Shipping Season.

[7] Harvey, M., M. Gilbert, D. Gauthier and D.M.Ried, 1999. A preliminary assessment of risks for the ballast water-mediated introduction of nonindiginous marine organisms in the Eustary and Gulf of St. Lawrence. Can. Tech. Rep. Fish. Aqat. Sci. 2268:x +56p.

Not Exchanged (where available, because of Report format), #Tanks Reported Discharged, #Tanks Recorded Discharged, Arrival Port, Arrival Date, Last Port and Next Port. The Trip_Info and the Ballast_Water_History data table was used for the shipping season statistical analysis.

The data set was restricted to vessels reporting the Last Port as foreign and vessels reporting ballast on board as full or partial, or carrying all cargo[8]. The full ballast condition existed for a vessel when the Report information reported where Total # of

Ballast Tanks - Total # Tanks in Ballast equaled zero or 1 tank in ballast. The one tank usually being a forepeak tank vessel to maintain maneuverability or ballast un-pumpables. Partial ballast reflected Total # of Ballast Tanks - Total # Tanks greater than 1 and in cargo equaled zero reported for Total # Tanks of Ballast.

In plots, null values were not included as the value distorted percentage in ballast condition.

Following the preparation format for the 2000 shipping study[6], the arrival ports were classified by ballast condition before being regrouped into four geographic areas corresponding to: Bay of Fundy and SW Nova Scotia having Yarmouth as its eastward limit (Area 1), mainland Nova Scotia and Cape Breton (Area II), Prince Edward Island, Gulf of St. Lawrence side of New Brunswick and Quebec, Saint Lawrence Basin and Great Likes (Area III) and the ports on the Island of Newfoundland (Area IV).

Only ports having greater than two vessels visiting the port were used. Ports in close proximity were grouped, such as Halifax-Dartmouth and Saint John-Canaport. To examine seasonal patterns, vessels were further categorized by vessel type and season: winter (January-March), spring (April-June), summer (July-August), and autumn (September-December). Lastly, vessels were classified by the country of their last port of call to determine the general transport routed between the Eastern Atlantic Canadian ports and other regions of the world.

5.2 Year 2002 Shipping Season Results Discussion

During the 2002 shipping season, 3,006 vessels departed foreign ports, including US ports outside the 200 nautical limit of the Exclusive Economic Zone (EEZ) limit, arriving at Canadian ports located on the east coast of Canada, St. Lawrence River, and Great Lakes (Figure 13). The number of ships arrived in year 2002 was less than the 5504 foreign vessels reported in 2000. Transport Canada advised the difference reflects that all vessels arriving from outside the Canada EEZ report to the Canadian Coast Guard. A number of these vessels have no ballast on board. The ships having no ballast would not submit an IMO-compliant Ballast Water Report Form to Transport Canada. Transport

[8] Fifty-nine vessels reporting null ballast activity included in data set.

Canada also advised, other submissions to Marine Safety could have been misplaced, and were not included in the project data set. Recognizing these conditions constrain the intended comparative analysis between the two databases; further comments comparing the ECAREG and the Ballast Water Report database will illustrate the differences in terms of what each reports and are not be interpreted as a true comparison.

During 2002, 3006 vessels transited into Eastern Canada destined for ports in Atlantic Canada, Quebec and Ontario. Of the total records, 73% (2135) visited 28 ports located in the Atlantic Region. The number of port arrivals is fewer than visited in 1998 (67) and 2000 (35).

Of the Atlantic provinces arrivals (2135 vessels) not all reported complete ballast water management information detailing full ballast, partial ballast or in cargo conditions. A total of 59 vessels reported null for Total # Tanks on Board and #Tanks in Ballast on board on the Report form. The 59 records were recorded as null contained other attribute information (vessel type, last port) that provided in ballast information. The records remained in the data set for the arrival and departure, vessel type, seasonal and origin of departure statistical compilation.

Of the 2135, the majority of vessels (55%) were destined for Area II. The primary arrival ports were Halifax (74%) and Pt. Tupper area (including Auld's Cove and Mulgrave) with 17% of arrivals. On a percentage basis Halifax had a higher share of foreign arrivals compared with years 1998 (49%) and 2000 (36%) ECAREG reporting. The shipping volume to Halifax, however, is lower than 1998 (1352 ships) and 2000 (1218), with 869 vessels reporting partial ballast (782), full ballast (54) or in cargo (33) conditions on board.

The Pt. Tupper area had 196 ship arrivals during 2002. This is an increase of 55% over 1998 (109) and a 35% (265) decrease over 2000 ECAREG reporting. Vessels arriving in the Pt. Tupper area during 2002 reported partial ballast (177), full ballast (10) and in cargo (9) conditions on board.

Geographic Area I was the arrival destination for 28% of vessels entering Atlantic Canada. A large number of vessels were destined for Saint John (493), Hantsport (100) and Bayside (23). The ballast water reporting data revealed 98.6% of vessel destined for Saint John, 100% destined for Hantsport and 91% destined for Bayside to be in partial ballast. Statistically, Area I was found to have less shipping volume than years 1998 (30%) and 2000 (37%). One factor contributing to fewer vessels was no records were reported for Yarmouth in the 2002 Ballast Water Management Report form data set. The port of Yarmouth contributed 344 arrivals to Area I in year 2000.

Other areas of importance for foreign arrivals were Come By Chance (85 ships) with 94% in partial or full ballast and 6% in cargo, Whiffen Head (93 ships) with 100% in partial or full ballast. Corner Brook (28 ships) with 100% in partial or full ballast. The number of arrivals for all Area IV ports are similar to the other geographic areas with in having fewer counts of vessels compared to years 1998 and 2000 ECAREG data. The one arrival reporting a large difference with year 2000 data was St. John's (21 ships) with 95% in partial or full ballast; St. John's reported 93 ships in 2000 ECAREG data.

Consistent with previous studies a number of smaller ports in all geographic areas make up a high percentage of port arrivals, including those in Newfoundland, Prince Edward Island and Nova Scotia. In Newfoundland, Botwood (14 ships) with 100% in partial ballast, Lower Cove (15 ships) with 60% in partial ballast and 40% in full ballast, Stephenville (6 ships), 100% in partial ballast, Argentia (18 ships) with 94% vessels in partial ballast and 6% full ballast, Marystown (2 ships) in partial ballast, Bay Roberts (23 ships), 91 % in partial ballast and 9% in full ballast. All ports reported fewer vessels than previous years of ECAREG data.

In Nova Scotia, Little Narrows (30 ships) reporting 97% in partial ballast and 3% in full ballast. The Little Narrows arrivals were lower than year 2000, which had 33 ships. Liverpool (17 ships) with 100% in partial ballast condition reported an increase of 41% over the 12 vessels arriving last year. Pictou (3 ships) with 100% in partial ballast reported a decrease of 80% in vessel traffic compared to the ECAREG data set. Shelburne (19 ships) with 78% in partial ballast and 12% in full ballast. The port of Shelburne indicates a 26% increase in traffic over year 2000. Pugwash (5 ships) with 100% in full ballast had no comparative data from previous years.

In the Gulf basin, New Brunswick and Prince Edward Island, Area III ports Belledune (25 ships) with 20 in partial ballast, 4 in full ballast and 1 in cargo. The vessel arrivals for this port decreased 35% from year 2000, as it did for Dalhousie (52% decrease with 22 ships) with 73% in partial ballast, 4% in full ballast and 23% in cargo.

The Prince Edward Island ports Charlottetown (4 ship) reported 75% in partial and 25% full ballast and Summerside (3 ships) with 66% in full ballast and 33% in cargo. The Prince Edward Island port showed similar decreased port arrivals than year 2000 (13 ships and 6 ships respectively).

For comparison of port arrivals and percentage ballast condition with previous years ECAREG data results were tabulated (Table 12).

Area	Port	Arrival 1998	% in ballast	Arrival 2000	% in ballast	Arrival 2002	% in ballast[9]
1	Bayside			48	65	23	100
1	Hantsport			119	100	100	100
1	Saint John			534	49	486	98.6
2	Aulds Cove			N/A	N/A	20	87
2	Halifax			1215	13	836	96.2
2	L.Narrows			33	100	30	100
2	Liverpool			12	83	17	100
2	Mulgrave			78	63	3	100
2	Pictou			15	88	3	100
2	Pt. Tupper	109	66	137	69	164	96.5
2	P.Hawkesb.			50	80	N/A	N/A
2	Pugwash			N/A	N/A	5	100
2	Sheet Hbr.			15	46	11	100
2	Shelburne			37	3	19	100
2	Sydney			6	50	17	74
2	Yarmouth			344	0	N/A	N/A
3	Charlott'n			13	61	4	100
3	Summerside			6	75	2	67
3	Souris			3	100	N/A	N/A
3	Belledune			57	37	24	96
3	Dalhousie			42	38	17	77
3	Magd. Islds			N/A	N/A	5	100
3	New Castle			8	0	N/A	N/A
4	Argentia			36	11	18	100
4	B.Roberts			34	9	5	83
4	Botwood			27	93	14	100
4	Bull Arm			13	8	N/A	N/A
4	CB Chance			139	85	80	94
4	Concptn Bay			15	80	N/A	N/A
4	C. Brook	113	55	58	47	28	100
4	Hbr. Grace			16	56	N/A	N/A
4	Holyrood			13	0	N/A	N/A
4	Lower Cove			19	100	15	100
4	Marystown			5	0	2	100
4	St. John's			93	20	21	95
4	Stephenville			21	85	6	100
4	WhiffenHead			52	100	93	100

Table 12. Atlantic Canadian arrival ports for shipping years 1998, 2000 and 2002, with percentage of ships in ballast.

[9] Includes partial and full ballast conditions; in cargo vessels not included.

Figure 14 illustrates the percentage partial and full ballast activity by vessels entering Eastern Canada. The data presented includes ballast activity for Quebec and Ontario (the complete 3006 record data set).

5.2.1 Shipping Season Vessel Types

The vessel type data was standardized to six vessel types including Bulk, Tanker, Container, General Cargo, Passenger and Other vessels, which included heavy lift, tugs, seismic and other service vessels. A lookup table exhibiting all vessel type descriptions and classification scheme was developed (Appendix A).

The vessel type data results included all ports (3006, including Quebec and Ontario) in Eastern Canada.

The data indicated the highest percentage (35.76%) of marine traffic entering Eastern Canada was container ships. Areas II (656 ships, mainly the port of Halifax) and Area III (305 ships, mainly the port of Montreal, and St. Lawrence ports) accounted for the higher percentage of container ships.

Tanker traffic entering Eastern Canada was the second highest vessel type with 28% of vessels. Areas I (350 ships, mainly Saint John), Area II (209 ships, mainly Halifax and Pt. Tupper) and Area IV (185 ships, mainly Come By Chance and Whiffen Head) made up the group.

The distribution of bulk carriers was the third highest group with 22.65% of vessels. Areas with high bulk cargo traffic included Areas III (314 ships, mainly Quebec ports of Sept Iles, Port Cartier, Montreal, Quebec City and other upper St. Lawrence ports), Area II (198 ships, mainly Halifax, Pt. Tupper, Little Narrows, Auld's Cove, Sheet Harbour and Liverpool) and Area I (148 ships, mainly Hantsport, Bayside and Saint John).

General cargo ship entering Eastern Canada totaled 248 vessels (8.28%). The vessel types were highest in Area III (119 ships, mostly Quebec ports and lesser, Belledune and Dalhousie), Area II (60 ships, mainly Halifax, Shelburne, Sheet Harbour, Sydney ports). Area I and Area IV contributed less than 15% general cargo traffic for year 2002, respectively.

The summaries by the four geographic areas by vessel type are contained in Table 13.

Area	Vessel Types						
No.	Bulk	Tanker	Container	General	Passenger	Other	Total
I	148	350	71	36	16	12	633
II	198	209	656	68	48	24	1203
III	314	94	305	111	7	43	874
IV	21	185	43	34	8	5	296
Total	681	838	1075	249	79	84	3006

Table 13. Vessels entering Eastern Canada in year 2000, by vessel type.

The data in the above table is shown in Figure 15.

A filter to remove the St. Lawrence River area influence on the Area III resulted in 92.5% of the data being Quebec ports traffic, leaving 66 arrivals to the New Brunswick and Prince Edward Island ports in Area III. Bulk cargo vessels (15 ships) visiting Belledune and Dalhousie, New Brunswick accounted for all arrivals except for one in Summerside. Similarly, 100% (8 ships) of tankers and container vessels (15 ships) in year 2002 landed in these two ports.

5.2.2 Seasonal Variation of Vessel Traffic

The Seasonal Variation of vessel traffic in the Eastern Canada areas provided results in Table 14.

Area	Seasonal Intervals				
No.	Spring	Summer	Fall	Winter	Total
I	151	179	146	157	633
II	308	319	300	276	1203
III	241	222	236	175	874
IV	71	81	89	55	296
Total	771	801	771	663	3006

Table 14. Quarterly seasonal variation in vessel traffic.

A graph of seasonal percentages (Figure 16.) reveals seasonal variation between geographic areas. In all areas, the patterns were slightly different. Area IV - Newfoundland shows the highest traffic in the fall seasonal (30.07%), compared to least port activity in winter (18.58%). Area I (28.28%) and Area II (26.51%) indicate the July-

September season as the dominant period for arrivals; however, in Area I the winter period (24.8%) reports the second highest volume while Area II reports spring with 25.60% of vessels in year 2002. Area II reports the winter (23.09%) to be a period of lesser activity similar, to Area IV. Area III - Laurentian (including Quebec and Ontario

ports) indicates highest volumes in spring (27.57%) and fall (26.88%). Least traffic in Area IV is in winter with 20.02% arrivals. The winter trend for Area IV was similar to the year 2000 result.

A further filtering of data by number of arrival by type in each season (Figure 17) revealed Fundy and Newfoundland have traffic dominated by tankers in all seasons, although the volume arriving in each area is different. Over eighty tankers arrived in Area I (mostly Saint John) during every season, while in Newfoundland tanker traffic was lowest in winter (31 vessels) and continued to increase in spring (45 ships) and summer (48 ships) to a high of 61 vessels reporting for the autumn.

The Laurentian and Scotian areas showed bulk cargo and container shipping dominate the port activities in these areas. Bulk cargo and container vessels were the most arrivals in Area III in all seasons. Arrivals in Laurentian were mainly ports such as Sept Iles, Port Cartier and the urban centres Quebec City and Montreal. Likewise, container ship arrivals were highest for all seasons in Area II, with Halifax receiving most of the traffic.

The tables below were plotted in Figure 17.

Area I	**Season**			
Type	Winter	Spring	Summer	Fall
Bulk	40	37	39	34
Tanker	84	88	87	88
Container	17	14	21	18
General	8	9	15	6
Pass. & other	8	3	17	0
Totals	157	151	179	146

Table 15. Area I season counts (633 total for all seasons) of ships arriving by vessel type.

Area II	**Season**			
Type	Winter	Spring	Summer	Fall
Bulk	39	51	52	56
Tanker	49	40	67	52
Container	171	179	150	155
General	11	22	16	20
Pass. & other	7	16	34	16
Totals	277	308	319	299

Table 16. Area II season counts (1203 total for all seasons) of ships arriving by vessel type.

Area III	**Season**			
Type	Winter	Spring	Summer	Fall
Bulk	59	87	77	91
Tanker	19	27	28	20
Container	63	70	78	75
General	26	46	26	38
Pass. & other	9	11	13	11
Totals	176	241	222	235

Table 17. Area III season counts (874 total for all seasons) of ships arriving by vessel type.

Area IV	**Season**			
Type	Winter	Spring	Summer	Fall
Bulk	3	6	7	5
Tanker	31	45	48	61
Container	15	10	6	12
General	5	8	10	11
Pass. & other	1	2	3	0
Totals	55	71	74	89

Table 18. Area IV season counts (296 total for all seasons) of ships arriving by vessel type.

5.2.3 Foreign Vessel Origins

The foreign vessel traffic into Canada's Eastern Economic Zone in 2002 originated from 66 countries located in North and South America, Europe, Asia and Africa. The majority of foreign traffic originated from the east coast of the United States, the west coast of Europe and northern South America and the Caribbean islands (Table 19). Other regions contributed 10 or less port arrivals, making up 67% of the departure points and only 133 arrivals. This trend is consistent with years 1998 and 2000 analysis.

The breakdown of vessel traffic in the four East Coast geographic areas of activity based on vessel origin shows the largest portion of total traffic to all Areas except Area III was from the United States with 53.35%. American tanker and bulk cargo vessels accounted for 92% of volume arriving in Area I, mainly in Saint John and Hantsport.

Area II had 49.04% of ships from America, mostly tankers from ports Philadelphia north to Searsport, ME; most of the container ships vessels in this percentage made port in Area II enroute to West Europe. The container traffic into Scotian from West Europe (35.83%) was mostly from United Kingdom, Spain, Netherlands and France. Italy was a large contributor to the 4.82% from the Mediterranean The Caribbean/Americas consisted of 5.82%, mainly bulk/general cargo and containers.

Area III had a different pattern with 54.69% of vessels being bulk and container ships from Western Europe ports, with most container traffic berthing at Montreal. Quebec City had an even ratio (50/50) of container/cargo to tanker vessels arriving. The majority of bulk vessels into Area IV from West Europe was destined for the Quebec north shore ports of Sept Iles, Port Cartier and Port Alfred. America accounted for 25.71% of arrivals in Laurentian area. The cargo/container traffic arriving mostly at ports between Matane and Montreal made up 76.8% of volume, with tankers 16 percent.

In Area IV, United States had 67.91% of arrivals, mainly tanker traffic from ports Jacksonville, FL north to Portland, ME, with the return voyages to the Eastern Seaboard. The traffic arriving from north Europe and west Europe was mostly bulk, general, multipurpose, container with fewer tankers.

Area	Departure Origin	Percent
United States	1,596 (53.09)	53.09
Caribbean, S. America	179 (5.95)	5.95
N. Europe	94 (3.13)	3.13
W. Europe	967 (32.17)	32.17
Mediterranean (includes M. East)	97 (3.23)	3.23
Africa	39 (1.30)	1.30
Asia	33 (1.10)	1.10
At sea	1 (0.03)	0.03

Table 19. The origins of vessels entering Eastern Canada from different areas of the world.

5.2.4 Origin of Ballast Water Destined for Eastern Canada

In addition to revealing the ballast condition of vessels entering Eastern Canadian ports, the Ballast Water Management Report provided information on the source of ballast and ballast exchange activities, and ballast water discharge.

The ballast water source was reported by vessels transiting into Eastern Canada from sixty- four countries and the open ocean, with more than one departure point from several countries. Sources were located in North and South America, Europe, Asia and Africa. Since vessels contained ballast water from various international ports, compilation was by the origin of ballast in individual tanks. Further, whether the source ballast water was exchanged while in transit to Eastern Canada was extracted. The data represented 14,542 ballast water source records from the Ballast_Water_History data table, reflecting 3006 voyages to Eastern Canada.

The ballast water information was grouped into similar groupings as the year 2000 study: North America, Central and South America, Caribbean, Europe (including Mediterranean countries), Africa, Asian and Middle East. (Appendix A)

The majority of the ballast water source in ships ballast tanks was the United States with 7177 (49.35%) tanks, representing 1131 vessels from 132 US ports. Of the 7177 tanks reported with ballast water, a total of 3373 (47%) tanks reported ballast exchanged enroute (in the open ocean) to Eastern Canada by 549 vessels. Conversely, 612 vessels did not exchange 3804 tanks. Thirty vessels reported tanks conducted exchange, while other ballast tanks onboard remained un-exchanged with original source ballast during the voyage to Eastern Canada.

Europe accounted for 2,663 (18.31%) of ballast water in ballast tanks; representing 549 vessels from 138 ports. Of the 2,663 tanks, 2419 (90.84%) tanks were exchanged enroute to Canada. Conversely, 87 vessels did not exchange 244 tanks. Twenty-nine vessels reported tanks conducted exchange, while other ballast tanks onboard remained un-exchanged with original source ballast during the voyage to Eastern Canada.

The open-ocean was reported as the ballast water source for 2125 tanks by 635 vessels, with 1009 tanks undergoing exchange as part of a ballast water management plan.

Ballast water sources from the Caribbean, Middle East, Africa, Asia and Canada totaled 935 tanks (6.43%). The percentage of tanks exchange for the group was 68.45% (640 tanks)

A portion of the data containing 1,642 records (11.29%) was ballast water source unknown or not provided.

A summary of the above discussion is shown in Table 20.

Area	# Tanks of Source Ballast Water	# Tank of Source Ballast Water Exchanged Enroute
United States	7,177 (49.35)	3,373 (47.00)
Canada	283 (1.95)	59 (20.85)
Caribbean, S. America	265 (1.82)	220 (83.01)
Europe (N., W., Mediter.)	2,663 (18.31)	2,419 (90.84)
Middle East	108 (0.74)	97 (89.81)
Africa	102 (0.74)	102 (100.00)
Asia	177 (1.22)	162 (91.52)
Open Ocean	2,125 (14.61)	1,009 (47.48)
Unknown/NULL	1,642 (11.29)	678 (41.29)

Table 20. Number of tanks of ballast water, by source, entering Eastern Canada in year 2002. The number of tanks exchanged enroute to Eastern Canada is shown the right column, percentage in parenthesis.

5.2.5 Ballast Condition of Vessels Entering Eastern Canada

The comparison of ballast condition by arrival port in the four geographic areas was examined earlier in Section 5.2. In Section 5.2, the data was reviewed in terms of the ballast condition being partial ballast, full ballast or in cargo. This section provides discussion on a percentage breakdown of the partial ballast condition of vessels destined for Eastern Canadian ports, by vessel origin.

5.2.5.1 Ballast Condition of Vessels Arriving at Area I Ports

American vessels accounted for 580 voyages to the ports of St. John, Bayside, Hantsport and other locations. Thirty-one American vessels (5.34%) reported full ballast, three ships (0.52%) with no ballast and 524 (90.35%) in partial ballast. For the vessels in partial ballast Table 21 shows 47.81% (261 ships) to be 75% or more in ballast approaching Area I.

Western Europe arrivals to Area I were 24 vessels. Twenty-one of twenty-nine vessels reported ballast, two full and 19 partial ballast. Ship with partial ballast greater than 50% were 11 container vessels, with origins in the United Kingdom and France. Vessel reporting less than 50% ballast were tankers (6) and container ships (2) from United Kingdom, France and Netherlands.

Arrivals from North Europe, Caribbean-South America, Mediterranean, Africa and Asia contribute a minor component of traffic and ballast water to Area I; most vessels arrived with less than 25% ballast.

A compilation of ballast conditions by area of origin for Area I is below.

Origin	Ship Count	Full Ballast 100%	No Ballast 0%	Partial Ballast >0 and <100%	No ballast Data
America	580	31 (5.34%)	3 (0.52)	524 (90.35%)	22 (3.79%)
West Europe	24	2 (8.3%)	2 (8.3%)	19 (79.17%)	1 (4.16%)
North Europe	16	1 (6.25%)	1 (6.25%)	14 (87.5%)	-
Carib. S.Amer.	9	1 (11.1%)	1 (11.1%)	4 (44.4%)	3 (33.3%)
Mediter.	2	-	-	2 (100%)	-
Africa	2	-	-	2 (100%)	-
Asia	-	-	-	-	-

Origin	Partial Ballast >0 and <= 25%	Partial Ballast >25% and <=50%	Partial Ballast >50% and <=75%	Partial Ballast >75% and <100%
America	29 (5.31%)	106 (19.41%)	128 (23.44%)	261 (47.80%)
West Europe	5 (26.32%	3 (15.78%)	8 (42.10%)	3 (15.78%)
North Europe	8 (57.14%)	5 (35.71%)	1 (7.14%)	-
Caribbean S. America	1 (25.0%)	1 (25.0%)	1 (25.0%)	1 (25.0%)
Mediterran.	2 (100%)	-	-	-
Africa	2 (100%)	-	-	-
Asia	-	-	-	-

Table 21. Ballast condition of vessels destined for Area I ports, with origin of departure.

5.2.5.2 Ballast Condition of Vessels arriving at Area II ports.

For Area II, American departures accounted for 590 arrivals. Fifty-five ships reported arriving in full ballast and seventeen with no ballast. Vessels in full ballast 26 (47%) were cargo, 16 (29.09%) containers and 13 (24%) tankers.

Sixty-five percent of vessels maintaining the no ballast condition were passenger vessels, with the remainder bulk cargo and tankers. Seven vessels did not report sufficient ballast data.

The percentages in partial ballast in Table 22 shows 34 (77%) vessels reporting >0 and <=25% partial ballast are passenger. Likewise, a similar majority of vessels (72.58%) are container ships in the >25 and <=50% and the >50-<=75% categories (58% container, 24% bulk cargo 24% and tankers below 15%). Most vessels (217 ships) have partial ballast between 75% and <100% on arrival; where bulk cargo vessels make up 36.86%, containers 33.17%, and tankers 28.11%.

The other major origin for vessels destined for Area II is Western Europe, with 446 vessels. Thirty vessels reported full ballast, the majority (22 ships) were car carriers or container ships from United Kingdom, Germany, Spain and France. The majority of traffic (377 vessels) was in partial ballast, with 267 of the ships (70.82%) in partial ballast being container ships. Of the 267 vessels, 199 (74.5%) arrived with greater than 50% ballast in tanks. Nine vessels reported no ballast on board; six of these ships were tankers and 3 bulk cargo.

Caribbean-South America (70 ships) and Mediterranean (51 ships) departure points account for less significant vessel traffic to Area II. Thirty-six vessels arrived from the Caribbean in partial ballast, with the majority (97%) of traffic bulk cargo or container. Five bulker vessels accounted for the seven ships arriving in full ballast. Conversely, 8 of the 13 vessels with zero ballast were bulk cargo ships; the five ships were tankers.

Of the vessels of Mediterranean origin arriving if Eastern Canada, 48 ships were partial ballast. Most vessels were container ships (39 ships) having partial ballast greater than 50 percent.

The Africa and Asian trade with Area II is below 15 ships visiting from each region; with at least half of vessels arriving with greater than 50 % partial ballast. The majority of vessels from these countries were bulk cargo (12 ships from Africa and Asia) and tanker (8 ships from Africa and Asia) traffic.

North Europe is another low traffic volume (20 vessels) for Area II. Sixteen ships arrived in partial ballast, with 56.25% (9 vessels) with partial ballast >0 and less than 25%. The common vessels types arriving in year 2002 were cargo (6 ships), tanker (5 ships) and container (3 ships).

A compilation of ballast conditions by area of origin for Area II is below (Table 22).

Origin	Ship Count	Full Ballast 100%	No Ballast 0%	Partial Ballast >0 and <100%	No ballast Data
America	590	55 (9.32%)	17 (2.8%)	511 (86.6%)	7 (1.18%)
West Europe	446	30 (6.73%)	9 (2.0%)	377 (84.5%)	30 (6.73%)
North Europe	20	-	2 (10.0)	16 (80.0%)	2 (10.0%)
Carib.-S.Amer.	70	7 (10.0%)	13 (18.5%)	36 (51.43%)	14 (20.0%)
Medit.	51	1 (1.96%)	-	48 (94.11%)	2 (3.92%)
Africa	14	-	4 (28.57%)	7 (50.0%)	3 (21.43%)
Asia	11	-	1 (9.09%)	9 (81.8%)	1 (9.09%)

Origin	Partial Ballast >0 and <= 25%	Partial Ballast >25% and <=50%	Partial Ballast >50% and <=75%	Partial Ballast >75% and <100%
America	34 (5.31%)	62 (19.41%)	198 (23.44%)	217 (47.80%)
W.Europe	33 (5.03%)	73 (19.36%)	150 (39.79%)	121 (32.09%)
North Europe	9 (56.25%)	1 (6.25%)	2 (12.5%)	4 (25.0%)
Carib. - S.America	1 (2.77%)	11 (30.55%)	10 (27.77%)	14 (38.88%)
Medit.	9 (18.75%)	-	15 (31.25%)	24 (50.0%)
Africa	4 (57.14%)	1 (14.28%)	-	2 (28.57%)
Asia	7 (77.7%)	1 (11.11%)	-	1 (11.11%)

Table 22. Ballast condition of vessels destined for Area II ports, with origin of departure.

5.2.5.3 Ballast Condition of Vessels Arriving at Area III Ports

In Area III, America departures accounted for 225 arrivals. Cargo ships accounted for 48% (14) of the 29 vessels arriving in full ballast and 75% (6) of vessels arriving with no ballast. The majority of vessels (112 -49.77%) arriving in Area III from America had greater than 50% partial ballast. Sixty-nine vessels were bulk carriers followed by tankers (17 ships) and container ships (25 ships).

Western Europe arrivals (463 vessels) to Area III were greater than United States voyages. Twenty-nine vessels reported full ballast and ten voyages reported no ballast on board. The number of vessels reporting partial ballast enroute was 392 ships (84.67%). The majority of vessels (239 ships) reported ballast less than 50 percentage. Of the 239 vessels, 181 were container ships, followed by 34 bulk cargo liners and 17 tankers. Vessels reporting greater than 50% partial ballast (143 ships) were bulk cargo (94), containers (42) and tankers (7).

The Caribbean-South American countries reported 89 visits to Area III ports in year 2002. Thirty-one vessels (includes 26 bulk cargo) reported no ballast enroute, mostly to St. Lawrence River ports. The majority of traffic (31 ships) had partial ballast less than 50 percent, with vessel types bulk cargo (24 ships) and tanker (7 ships); vessels having ballast greater than 50% were bulk cargo (7 ships) and containers (2 ships).

The origins North Europe (25 ships), Mediterranean (28 ships), Africa (22 ships) and Asia (22 ships) contributed little significant traffic volume to Area III. From these origins, more than 60% vessels reported partial ballast to be less than 50 percent of capacity. Vessel traffic in this group consisted of types cargo (43 ships), tankers (10 ships), and container (2 ships). A compilation of ballast conditions by area of origin for Area III is below (Table 23).

Origin	Ship Count	Full Ballast 100%	No Ballast 0%	Partial Ballast >0 and <100%	No ballast Data
America	225	29 (12.8%)	8 (3.5%)	158 (70.22%)	30 (13.33%)
West Europe	463	29 (6.36%)	10 (2.2%)	392 (84.67%)	32 (6.9%)
North Europe	25	2 (8.00%)	4 (16.0%)	19 (76.0%)	-
Carib. - S.Amer.	89	5 (56.18%)	31 34.8%)	44 (49.44%)	9 (10.11%)
Medit.	28	6 (21.43%)	3 (10.7%)	18 (64.28%)	2 (7.14%)
Africa	22	2 (9.09%)	5 (22.3%)	14 (63.63%)	1 (4.55%)
Asia	22	1 (4.55%)	4 (18.2%)	14 (63.63%)	3 (13.63%)

Origin	Partial Ballast >0 and <= 25%	Partial Ballast >25% and <=50%	Partial Ballast >50% and <=75%	Partial Ballast >75% and <100%
America	20 (12.65%)	26 (16.46%)	54 (34.18%)	58 (36.71%)
West Europe	108 (27.55%)	131 (33.41%)	70 (17.86%)	83 (21.17%)
North Europe	17 (89.47%)	1 (5.26%)	-	1 (5.26%)
Caribbean-S.America	23 (52.27%)	8 (18.18%)	7 (15.90%)	6 (13.63%)
Mediterrean	6 (33.33%)	3 (16.66%)	3 (16.66%)	6 (33.33%)
Africa	9 (64.28%)	1 (7.14%)	1 (7.14%)	3 (21.43%)
Asia	10 (71.43%)	2 (14.28%)	1 (7.14%)	1 (7.14%)

Figure 23. Ballast condition of vessels destined for Area III ports, with origin of departure.

5.2.5.4 Ballast Condition of Vessels Arriving at Area IV Ports

In Area IV, America departures accounted for 201 arrivals. Tankers accounted for 102 (70.83%) of the vessels in partial ballast (144), and 23 of the 30 ships in full ballast. The majority of these vessels had greater than 75% partial ballast, with 97 ships (95.09%) of the 102 reported.

Western Europe arrivals to Area IV were 34 vessels. Two vessels (one tanker, one bulk cargo) reported full ballast. Three ships (two tankers and one passenger) reported no ballast. Partial ballast accounted for 70.58% of total traffic, with less than 50% in ballast containing nine vessels of type tanker (4 ships), bulk cargo (1) and others (3). Vessels (15 ships) having greater than 50% partial ballast included container (8 ships), cargo (6 ships) and tankers (1).

North Europe reported similar visits (33 trips) as West Europe to Area IV. Twenty-seven vessels reported partial ballast on board, with the majority of vessels (21 ships) having greater than 50% ballast capacity. Vessel types in this group included containers (11 ships), bulk cargo (6 ships) and tanker/other vessels (4 ships).

The origins Caribbean (11 ships), Mediterranean (16 ships) and Africa (1 ship) account for little traffic to Newfoundland. The African vessel arrived in 100% ballast. The majority of vessels (18 ships) from the Caribbean and Mediterranean were in partial ballast; with greater than fifty percent (5 ships) of the Caribbean vessels having partial ballast greater than 50 percent, while the majority (9 ships) of Mediterranean vessels were less than 50% partial ballast. Six of these vessels were tankers.

No Asian traffic was reported to Area IV.

A compilation of ballast conditions by area of origin for Area IV is below (Table 24).

Origin	Ship Count	Full Ballast 100%	No Ballast 0%	Partial Ballast >0 and <100%	No ballast Data
America	201	30 (14.9%)	0 (0.0%)	144 (71.64%)	27 (13.33%)
West Europe	34	2 (6.66%)	3 (10.0%)	24 (80.0%)	5 (14.71%)
North Europe	33	1 (33.33%)	-	27 (81.81%)	5 (15.15%)
Carib.-S.Amer.	11	1 (9.09%)	2 (18.2%)	8 (72.72%)	-
Medit.	16	3 (18.75%)	2 (12.5%)	10 (62.5%)	1 (6.25%)
Africa	1	1 (100.0%)	-	-	-
Asia	-	-	-	-	-

Origin	Partial Ballast >0 and <= 25%	Partial Ballast >25% and <=50%	Partial Ballast >50% and <=75%	Partial Ballast >75% and <100%
America	3 (12.65%)	8 (16.46%)	22 (34.18%)	111 (36.71%)
West Europe	5 (20.83%)	4 (16.67%)	7 (29.16%)	8 (33.33%)
North Europe	1 (3.70%)	5 (18.51%)	9 (33.33%)	12 (44.44%)
Caribbean-S.America	2 (25.0%)	1 (12.5%)	4 (50.0%)	1 (12.5%)
Mediterrean	7 (70.0%)	2 (20.0%)	1 (10.0%)	-
Africa	-	-	-	-
Asia	-	-	-	-

Figure 24. Ballast condition of vessels destined for Area IV ports, with departure origin.

5.2.6 Ballast Water Discharge

A slight majority of records (51.23%) recording ballast water tank discharge in the Ballast_Water_History database (14,542 records), showed no data recorded (null). The 7525 records reporting discharge from ballast water tanks represented 1226 voyages into Eastern Canada; more than one location was recorded for discharge by 164 of the 1226 voyages. For example, vessels destined for Hantsport conducted discharge of tanks in the Bay of Fundy and at Hantsport, NS. Eighty-three vessels reported at sea discharge of 371 tanks. The summary of discharge locations in Eastern Canada is shown in Table 25.

Location of Discharge	#Vessels discharging in Port	Total #tanks discharged by vessels/ avg. volume per vessel (cbm)	#Vessels - no discharge in Port
St. John NB	280	1447 / 2,254	4
Belledune, Dalhousie, NB	20	121 / 588.02	2
Bay of Fundy	73	661 / 517.95	nil
Bayside, NB	7	84 / 1,417.02	1
Botwood, NL	12	12 / 566.77	nil
Come By Chance, NL	14	12 / 5,064.99	2
Corner Brook, NL	12	36 / 559.01	1
Lower Cove, NL	12	105 / 1,767.20	1
St. John's, NL	7	26 / 180.69	2
Stephenville, NL	12	55 / 548.79	nil
Whiffen Head, NL	69	360 / 10,041.43	2
Auld's Cove, NS	15	121 / 3,227.65	nil
Bras D'Or Lakes, NS	4	46 / 377.25	nil
Cabot Strait, NS	1	10/ 10	nil
Halifax, NS	159	778 / 1,185.90	3
Hantsport, NS	76	306 / 412.68	nil
Little Narrows, NS	4	28 / 954.84	nil
Liverpool, NS	5	19 / 1282.94	1
Pictou, NS	3	19 / 356.42	nil
Pt. Tupper, NS	101	517 / 6536.85	nil
Pugwash, NS	1	4 / 438.5	nil
Sheet Hbr, NS	8	54 / 3441.64	nil
Shelburne, NS	-	-	1
Sydney, NS	7	24 / 924.17	nil
QC, ON ports			11
At sea	85	371 / 775.18	nil

Table 25. Summary of Eastern Canadian ports (includes open ocean) receiving ballast water discharge.

6.0 PROJECT SUMMARY

Ballast Water Reporting Forms submitted to Marine Safety, Transport Canada, Dartmouth, Nova Scotia provided 3006 records for foreign marine vessels entering Eastern Canada during year 2002. In addition to each record providing information on marine vessel description, departure-arrival data and ballast description (number of tanks, vessel capacity), the Reporting Form provided information on vessel ballast source water, latitude-longitude positions for ballast water exchange volumes and endpoint locations, and ballast discharge.

The Report Form information was entered into a relational database consisting of two tables - Trip_Info and Ballast_Water_History, in MS Access database software. The geo-reference ballast water exchange endpoints (with volume exchanged attribute) were imported to the geographical information system spatial environment for thematic vessel movement track creation and potential surface modeling (inverse distance weighing and interpolation). The same data set was statistically compiled to evaluate year 2002 shipping patterns and compare the data with previous studies, from years 1998 and 2000.

The creation of the vessel tracks was completed using a MapInfo GIS programming software application that joined together reported endpoints as line to represent the vessels transect approaching Eastern Canada. The lines created had "attached" the ballast water volume exchanged reported at the endpoint, permitting thematic colouring. The lines represent joined endpoints of exchange; where the exchange commenced was not provided on the Ballast Water Reporting Form. Notwithstanding, the endpoints provide the vessel's course while approaching Eastern Canada. The tracks clearly delineated preferred ballast water exchange corridors approaching Eastern from America, Europe (North and Western) and the Mediterranean for year 2002.

An aggregated form of the same point data used to produce the tracks was applied to develop seasonal potential surface maps, using parameter settings best suited to the data character and distribution. High-values areas were shown along the southwest coast of Nova Scotia and paralleling the 2000 metre isobath, inside the Canadian Eastern Economic Zone. In some instances, ballast water exchange endpoint values responsible for the high-value areas, over time, were found to be related to the same vessel. The July-August and September-October bi-monthly intervals reflected the highest exchange activity, off the Nova Scotian coastline.

Statistically the database provided some comparative statistics to the previous years (1998 and 2000), ECAREG-based studies. The data set, though smaller in number of records because of the data collection formats and mandate differences between Transport Canada and Canadian Coast Guard, provided basically consistent results. The database provided new information on the types of vessels entering the for geographic regions by season; Area I - Tanker dominant all seasons, Area II - Container ships dominate all periods, Area III - Bulk/General Cargo and container vessels and Area IV -

Tankers dominate, with the heaviest period in the autumn. The data set allowed detailed discussion and compilation of the partial ballast condition of vessels entering Eastern Canada. Parsing the data by geographic region indicated, a significant number of vessels (> 70%) destined for Eastern ports have partial ballast on board.

The data has been prepared to permit future study of ballast issues. A detailed examination of American vessel traffic approaching the Atlantic Region is suggested. With America contributing 53% of total vessel traffic to Eastern Canada and traffic volume as high as 92% destined for geographic Area I is from the United States. The data can be queried to determine which American state is contributing the largest portion of ballast exchange activity, with source water originating in 132 American ports.

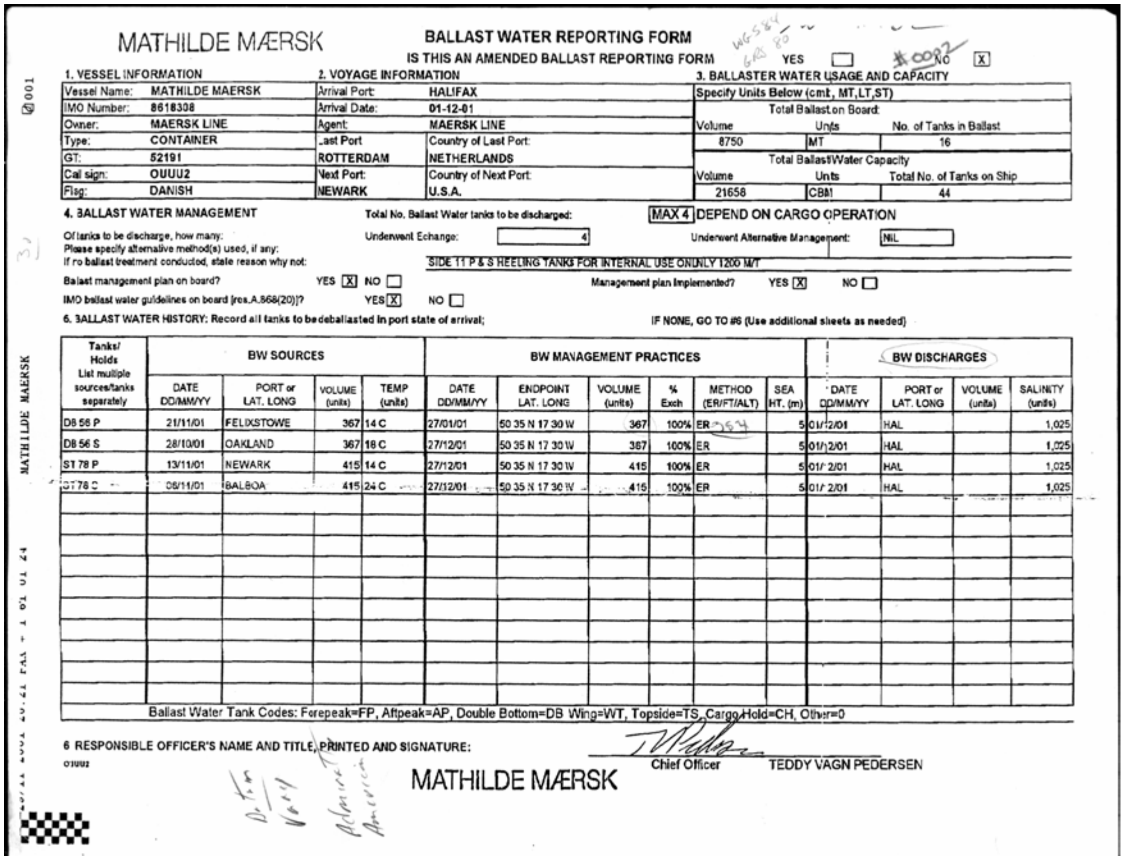
7.0 ACKNOWLEDGEMENTS

I would like to thank Mike Balaban, Marine Safety, Transport Canada for input during the project and for recognizing geographical information systems (GIS) as an analytical tool suited to examining geo-referenced ballast water exchange endpoint data.

I would also like to thank Geoff Howell and staff, Interpretation and Integration, Environment Canada for access to SPANS modeling software.

Lastly, Paul Brodie, onboard ballast water management systems researcher, for providing better understanding of ballast water/cargo management aboard marine vessels.

8.0 FIGURES - PROJECT MAPS



MATHILDE MÆRSK

BALLAST WATER REPORTING FORM

IS THIS AN AMENDED BALLAST REPORTING FORM YES ☐ NO ☒

1. VESSEL INFORMATION		2. VOYAGE INFORMATION	
Vessel Name:	MATHILDE MAERSK	Arrival Port:	HALIFAX
IMO Number:	8618308	Arrival Date:	01-12-01
Owner:	MAERSK LINE	Agent:	MAERSK LINE
Type:	CONTAINER	Last Port	Country of Last Port:
GT:	52191	ROTTERDAM	NETHERLANDS
Cal sign:	OUUU2	Next Port:	Country of Next Port:
Flag:	DANISH	NEWARK	U.S.A.

3. BALLASTER WATER USAGE AND CAPACITY

Specify Units Below (cmt, MT,LT,ST)

Total Ballast on Board		
Volume	Units	No. of Tanks in Ballast
8750	MT	16
Total Ballast Water Capacity		
Volume	Units	Total No. of Tanks on Ship
21658	CBM	44

4. BALLAST WATER MANAGEMENT

Total No. Ballast Water tanks to be discharged: MAX 4 DEPEND ON CARGO OPERATION

Of tanks to be discharge, how many: Underwent Echange: 4 Underwent Alternative Management: NIL

Please specify alternative method(s) used, if any:

If no ballast treatment conducted, state reason why not: SIDE 11 P & S HEELING TANKS FOR INTERNAL USE ONLY 1200 M/T

Ballast management plan on board? YES ☒ NO ☐ Management plan Implemented? YES ☒ NO ☐

IMO ballast water guidelines on board [res.A.868(20)]? YES ☒ NO ☐

6. BALLAST WATER HISTORY: Record all tanks to be deballasted in port state of arrival; IF NONE, GO TO #6 (Use additional sheets as needed)

Tanks/ Holds List multiple sources/tanks separately	BW SOURCES				BW MANAGEMENT PRACTICES						BW DISCHARGES			
	DATE DD/MM/YY	PORT or LAT. LONG	VOLUME (units)	TEMP (units)	DATE DD/MM/YY	ENDPOINT LAT. LONG	VOLUME (units)	% Exch	METHOD (ER/FT/ALT)	SEA HT. (m)	DATE DD/MM/YY	PORT or LAT. LONG	VOLUME (units)	SALINITY (units)
DB 56 P	21/11/01	FELIXSTOWE	367	14 C	27/01/01	50 35 N 17 30 W	367	100%	ER	5	01/12/01	HAL		1,025
DB 56 S	28/10/01	OAKLAND	367	18 C	27/12/01	50 35 N 17 30 W	367	100%	ER	5	01/12/01	HAL		1,025
ST 78 P	13/11/01	NEWARK	415	14 C	27/12/01	50 35 N 17 30 W	415	100%	ER	5	01/12/01	HAL		1,025
ST 78 S	08/11/01	BALBOA	415	24 C	27/12/01	50 35 N 17 30 W	415	100%	ER	5	01/12/01	HAL		1,025

Ballast Water Tank Codes: Forepeak=FP, Aftpeak=AP, Double Bottom=DB Wing=WT, Topside=TS, Cargo Hold=CH, Other=0

6 RESPONSIBLE OFFICER'S NAME AND TITLE, PRINTED AND SIGNATURE: Chief Officer TEDDY VAGN PEDERSEN

MATHILDE MÆRSK

Figure 1. Sample of typical Ballast Water Reporting Form submitted to Marine Safety, Transport Canada reporting marine vessel ballast management practices.

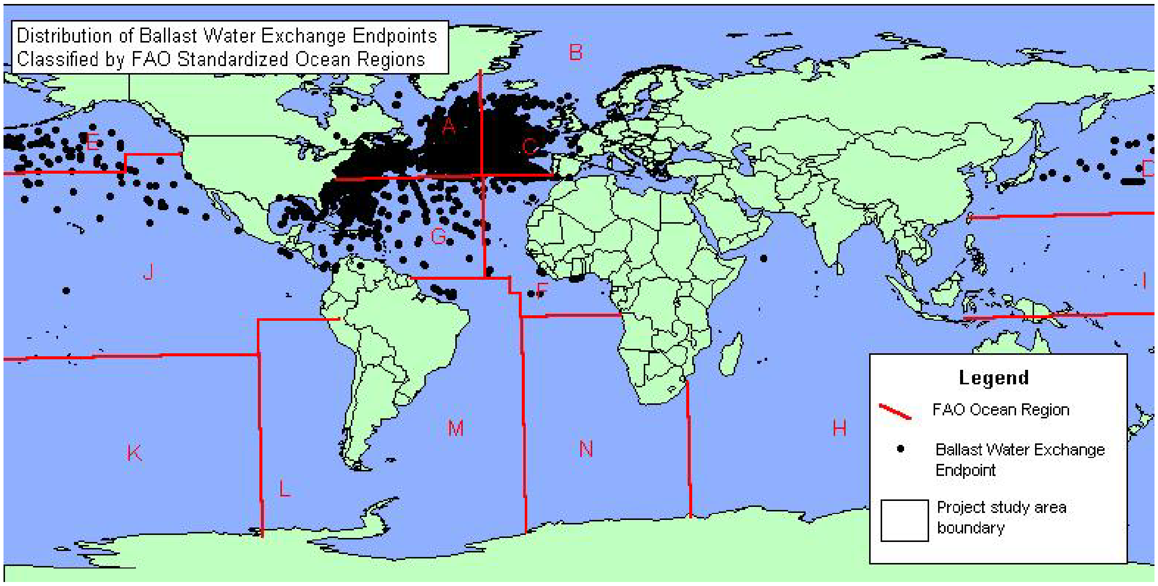


Figure 2. Ballast Water Exchange Endpoints reported on Ballast Water Management Report forms to Transport Canada for the year 2002, with FAO Ocean Regions overlay. Total points = 8308.