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Analysis of Ballast Water Discharges into the Great Lakes from Overseas Vessels from 2010 to 2013

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SECTION 1
INTRODUCTION

Ballast water discharges are cited as one of the primary sources or vectors for the spread of aquatic nuisance species (ANS) (National Research Council, 2008). Depending on where ships take on ballast water, virtually all organisms in the water column, either swimming or disturbed from bottom sediments, can be taken into ships' ballast tanks. These organisms include holoplankton (free-floating), meroplankton (larval stages of bottom dwelling organisms), upper water column nekton (active swimming), and demersal (near bottom dwelling) organisms (California EPA, 2002). When live organisms in ballast tanks are transported between water bodies and discharged, they have the potential to establish new populations and cause physical and behavioral disturbances to the native organisms due to competition for food, space and other valuable resources (Hayes and Landis, 2004).

In the Great Lakes, ballast water from ocean-going vessels known as seaway-sized transoceanic vessels or "Salties" are a primary vector for introduction of ANS from regions throughout the world. The vast majority of these vessels are bulk carriers (bulkers), although there are also a small number of general cargo carriers, heavy lift ships, and tankers in service. Unlike the larger bulkers that travel the Great Lakes (i.e., Lakers), Salties are small enough to transit to the upper Great Lakes through the Welland Canal. Salties generally follow a "steel in - grain out" trade pattern, whereby iron and steel and other high value cargos generally arrive from Europe, and are off-loaded in a series of lower lake ports. These vessels then load products such as grain and transport these materials back to ports in Europe (Cangelosi and Mays, 2006).

To reduce the chance that Salties will discharge living organisms into the Great Lakes from ballast water tanks, USEPA,[1] United States Coast Guard (USCG),[2] and Transport Canada[3] (TC) regulations and permits require all vessels entering waters under Canadian and U.S. jurisdiction from outside the Exclusive Economic Zone (EEZ) to conduct ballast water

[1]Among other things, the EPA Vessel General Permit (VGP) requires all vessels that are equipped to carry ballast water and enter the Great Lakes to conduct ballast water exchange and saltwater flushing. Eventually, vessels must meet numeric ballast water treatment limits using one of several methods. Certain vessels must continue to exchange ballast water if they use a shipboard ballast water treatment system to meet limits to minimize risk of invasion into the Lakes.

[2] Federal Register, Volume 77, #57, 17254-17320. Final Rule, *Standards for Living Organisms in Ships Ballast Water Discharged in U.S. Waters.* March 23, 2012.

[3]Canadian Shipping Act, 2001, Ballast Water Control and Management Regulations, require vessels entering the Great Lakes through the Saint Lawrence Seaway to report their status regarding exchange or flushing.

exchange[4] (BWE), or ballast water flushing[5] for vessels having no ballast on board (NOBOB), prior to entering the Saint Lawrence Seaway System. Federal regulations and permit requirements call for vessels to conduct mid-ocean BWE or ballast water flushing in an area 200 nautical miles (nm) from any shore such that resultant ballast water, or residual ballast water in the case of NOBOB vessels, has a salinity of 30 parts per thousand (ppt) or greater.

BWE and ballast water flushing reduce invasion risk in two primary ways: 1) a large percentage of the freshwater living organisms are physically removed from ballast tanks by discharging them into the open ocean and replaced with marine or pelagic species (Choi, et al., 2005; Wonham et al., 2005; Ruiz and Smith, 2005), and 2) for freshwater and brackish water systems, a high salinity environment is created that causes osmotic shock to remaining fresh water organisms hidden in ballast tank sediments (Hart et al, 1991). The combined physical removal and mortality due to salinity shock is estimated to be at least 95 percent effective for ships carrying ballast from fresh water ports (Gray et al., 2007; Bailey et al., 2006).

The effectiveness of BWE and seawater flushing is further evident when comparing the current rates of invasions with those prior to development of the current BWE and/or seawater flushing regulations. Researchers evaluated the annual discovery rate of new ANS in the Great Lakes attributed to shipping and found a decrease starting in the mid-to-late 1990s that coincided with the implementation of mandatory BWE requirements (Bailey et al., 2011).

To verify compliance with the regulatory requirements for BWE or flushing, the USCG and Transport Canada's Marine Safety Division (TCMS) require vessels bound for the Great Lakes from outside the EEZ to submit St. Lawrence Seaway Ballast Water Reporting Forms. For vessels bound for U.S. ports on the Great Lakes, the St. Lawrence Seaway Ballast Water Reporting forms must be faxed or emailed to the USCG office in Massena, NY, at least 24 hours prior to arrival in Montreal. The reporting forms must indicate:

- the overseas port where ballast water was loaded,
- if exchange or flushing was conducted prior to entering the Seaway,
- the longitude and latitude where exchange or flushing took place,
- the method used for exchange or flushing (empty-refill or flow-through) and which Great Lakes ports the exchanged or flushed ballast water will be discharged into, and

[4] As defined by the VGP and U.S. Coast Guard regulations, "exchange" means to replace the water in a ballast tank using either "flow through exchange" or "empty/refill exchange." "Flow through exchange" means to flush out ballast water by pumping in water from the mid-ocean or "coastal exchange zone" (as applicable) into the bottom of the tank and continuously overflowing the tank from the top until three full volumes of water have been changed to minimize the number of organisms remaining in the tank. "Empty/refill exchange" means to pump out the ballast water taken on in ports, estuarine, or territorial waters until the tank is empty, then refill it with water from the mid-ocean or "coastal exchange zone" (as applicable); masters/operators should pump out as close to 100 percent of the ballast water as is safe to do so. *[adapted from 33 CFR 151.2025]*

[5] As defined by the VGP and U.S. Coast Guard regulations, for vessels entering the Great Lakes, "saltwater flushing" means the addition of "mid-ocean" water to empty ballast water tanks; the mixing of the added water with residual ballast water and sediment through the motion of the vessel; and the discharge of the mixed water until loss of suction, such that the resulting residual water remaining in the tank has either a salinity greater than or equal to 30 parts per thousand or a salinity concentration equal to the ambient salinity of the location where the uptake of the added water took place.

- the next vessel ports of call.

For vessels bound for Canadian ports on the Great Lakes, St. Lawrence Seaway Ballast Water Reporting forms must be emailed to Transport Canada's office in Quebec 96 hours prior to arrival in Montreal. The 96-hour reports sent to Transport Canada also require information on where ballast water was loaded, if exchange or flushing was conducted prior to entering the Seaway, the longitude and latitude where exchange or flushing took place, the method used for exchange or flushing (empty-refill or flow-through) and the proposed ballast water discharge port.

This document compiles and analyzes information on ballast water discharges from ocean-going vessels entering the Great Lakes through the St. Lawrence Seaway System (SLSS) from 2010 to 2013. The purpose of this analysis is to provide a series of tables, plots, and graphics that for use as background when analyzing ballast mediated ANS invasion risks into the Great Lakes by vessels arriving from outside the EEZ.[6] EPA compiled the data used in this analysis from the National Ballast Information Clearinghouse (NBIC), Transport Canada (TC), and the Vessel General Permit (VGP) electronic Notice of Intent (eNOI) database.

This document includes:

- a brief synopsis of the environmental issues and regulatory requirements for ocean going vessels entering the Great Lakes with respect to ballast water,
- a description of data sources,
- methods used by EPA to extract and compile information on vessels entering the Great Lakes and their ballast water management programs,
- limitations and qualifiers for the data used in the analysis, and
- results of the data analysis and discussion of findings.

[6] The U.S. Exclusive Economic Zone (EEZ) extends no more than 200 nautical miles from the territorial sea baseline and is adjacent to the 12 nautical mile territorial sea of the U.S., including the Commonwealth of Puerto Rico, Guam, American Samoa, the U.S. Virgin Islands, the Commonwealth of the Northern Mariana Islands, and any other territory or possession over which the United States exercises sovereignty.

SECTION 2
OBJECTIVES, DATA SOURCES, AND APPROACH

This document compiles information on overseas vessels entering U.S. waters of the Great Lakes through the Saint Lawrence Seaway from 2010 to 2013 to address the following questions:

- How many overseas vessels enter the Great Lakes annually and from what countries and/or ports?
- What is the number of times the same vessel makes round-trip voyages between overseas ports and the Great Lakes each year?
- What types of vessels are entering the Great Lakes from overseas ports, what is the average age of these vessels, and how much ballast water can they carry?
- How many overseas vessels enter the Great Lakes annually having no ballast on board (NOBOBs)?
- Which Great Lakes ports are most frequented by overseas vessels and which receive the greatest amounts of ballast water discharges from these vessels?
- Which overseas ports are providing ballast water discharged into the Great Lakes and what is the salinity of these overseas ports?
- What is the distance and time interval between ballast water loading at overseas ports and discharge into the Great Lakes, and what is the time interval between ballast water exchange and/or flushing and discharge into the Great Lakes?
- How many overseas vessels entering the Great Lakes are conducting flow-through versus empty refill during ballast water exchange?
- How many overseas vessels entering the Great Lakes have ballast water treatment systems on board?

2.1 DATA SOURCES

Four data sources provided the information needed to answer the questions listed above. The first and primary source of data was the National Ballast Information Clearinghouse (NBIC).[7] The NBIC is a joint program between the Smithsonian Environmental Research Center (SERC) and the United States Coast Guard that collects, analyzes, and interprets data on the ballast water management practices of commercial ships that operate in the waters of the U.S.. For vessels bound for the Great Lakes, the NBIC dataset is compiled from information provided on the 24-hour St. Lawrence Seaway (SLS) Ballast Water Reporting forms or NBIC Ballast Water Management Reporting Forms submitted to the U.S. Coast Guard.

[7] National Ballast Information Clearinghouse. NBIC Online Database. Electronic publication, Smithsonian Environmental Research Center & United States Coast Guard. Available from http://invasions.si.edu/nbic/search.html; searched 21 December 2013.

EPA's second source of information was provided by Transport Canada (TC).[8] TC receives 96-hour SLS Ballast Water Reporting forms and verifies the vessels have conducted either ballast water exchange or ballast water flushing before allowing the vessel to proceed to Canadian ports on the Great Lakes. Although the majority of 96-hour SLS Ballast Water Reporting forms should also be provided to the NBIC, a significant number were found to be absent from the NBIC dataset. Therefore, both data sources were required for a complete record.

TC also provided EPA's third source of information: a copy of the inspection database for years 2010-2013.[9] This database contains information about vessel inspection dates and ballast water management practices. Vessel inspections were required prior to entry into the Great Lakes. EPA used the inspection dates and the International Maritime Organizations (IMO) numbers in this data source to identify vessels that entered the Great Lakes in 2010, for reasons described in Section 2.2.1 of this report.

EPA's fourth source of information was EPA's 2013 VGP eNOI database. [10] The eNOI database includes information on nearly 30,000 vessels that discharge ballast water and other vessel discharges into U.S. waters. The eNOI database contains information about onboard treatment systems, including: system type, manufacturer, capacity, average and peak flow rates, residual waste, sediment disposal methods, and cleaning frequency. In addition, the eNOI database contains vessel characteristics (e.g., age, length, tonnage, flag, homeport, and dates of the last and next scheduled dry dock). For this study, EPA matched the IMO numbers in the eNOI database to the IMO numbers for vessels entering the Great Lakes provided in the combined NBIC and TC dataset to determine the number and characteristics of overseas vessels entering the Great Lakes between 2010 and 2013 with ballast water treatment systems on board.

2.2 METHODS

For this study, EPA created two composite datasets containing information for vessels traveling to U.S. and Canadian ports within the Great Lakes and St. Lawrence Seaway system. The first composite dataset, referred to as the vessel voyage information dataset, provided vessel arrival information and was used to analyze voyaging patterns and vessel characteristics. EPA identified and removed duplicate voyage data prior to data analysis and supplemented the data with information from EPA's VGP eNOI database. The second composite dataset, referred to as the ballast tank information dataset, provided information about ballast tanks for the vessels arriving in the Great Lakes and was used to analyze ballast water sources, management practices, and discharge amounts. Both datasets were culled to include only vessels that had voyages that originated from ports beyond the EEZ and that traveled to ports west of Montreal. The following subsections describe the methods used to create each of the datasets used in the analysis.

2.2.1 Vessel Voyage Information

To create the vessel voyage information dataset, EPA first combined all the NBIC data and only the TC data for 2011 to 2013 for vessels entering the Great Lakes. The 2010 TC data provided to EPA were excluded because they contained a large number of vessels that had docked at Montreal and discharged ballast water without proceeding into the Great Lakes. To

[8] Transport Canada dataset provided by Chris Wiley on August 26, 2014.

[9] Transport Canada inspection record provided by Laurent Jean on January 8, 2014.

[10] USEPA 2013 Vessel General Permit eNOI dataset provided by Jack Faulk on December 23, 2013.

represent Great Lakes entry for 2010 arrivals, EPA included only records identifiable by IMO and arrival dates within the inspection dataset, or with arrival ports, discharge ports, or last ports within the Great Lakes. Specifically, EPA identified matching voyage records if the inspection date (within the inspection database) and arrival date (from the TC database) for any specific IMO occurred within one week. EPA did not use the inspection data for years 2011 to 2013.

EPA further reduced data from the NBIC and reduced TC databases to include only arrivals from beyond the EEZ. Specifically, for the TC database, EPA retained data records if the designated source of ballast water was listed as a non-U.S., non-Canadian port. For the NBIC dataset, EPA retained data records for which the transit type was designated "overseas." In addition, EPA retained records for which the transit type was designated "coastwise" or "unknown," provided that at least one tank associated with the voyage contained ballast water from a non-U.S., non-Canadian source port.

To create the composite vessel voyage information dataset, EPA converted the reduced TC dataset from a tank-based organization to a voyage-based organization to match the vessel arrival organization of the NBIC dataset.[11] Specifically, EPA stripped the reduced TC dataset of data specific to tanks (volume, source port, etc.) and retained the data unique to each vessel and voyage. After linking to and combining the TC dataset with the NBIC dataset, EPA examined the composite dataset to identify duplicate voyage records based on matching IMO, arrival-last-next ports, and arrival dates. When identified as duplicates, the record with the most information about the number of tanks on board, in ballast, discharged, exchanged, or handled with alternative methods, was preserved, while the records with less information were removed from the composite dataset. Vessel length and age were pulled from the eNOI record by IMO number and inserted into the composite dataset.

2.2.2 Ballast Tank Information

To create the composite ballast tank information dataset, EPA combined the complete reduced TC database (i.e., 2010 to 2013) with the reduced tank data table of the NBIC dataset to form a composite dataset of tank information for voyages from beyond the EEZ and entering the Great Lakes. No manipulation was necessary as both datasets were organized by tank. EPA was unable to identify and remove duplicate records for this composite dataset. This was because each vessel contains multiple tanks with many of these tanks having the same ballast water capacity and likely filled and discharged at the same ports. Lacking a unique tank identifier, it was not possible to distinguish between multiple reporting of the same tank (i.e., duplicate records) and reporting of multiple tanks on the same ship (i.e., not duplicate records). Accordingly, EPA retained all records, including an unknown number of duplicate records in the composite dataset. As a result, the analysis of ballast water amounts unavoidably overestimates the actual amounts, providing an upper bound to the amount of ballast water carried and discharged in the Great Lakes.

[11] The NBIC database consisted of two linked tables. The first table was organized by vessel arrival. The second table was organized by ballast water tank. These tables were linked by an arrival ID number.

2.3 DATA QUALITY

The NBIC data provided by SERC underwent their quality assurance and quality control (QA/QC) processes. These processes included measures such as removing duplicate ballast water reporting forms that were amended or were resubmitted; standardizing vessel types, port names, dates, latitudes/longitudes and ballast water capacities and amounts; and removing duplicate tank data reported on multiple ballast water reporting forms.

Ballast water management reporting forms are first submitted to the U.S. Coast Guard, TC, and the Saint Lawrence Seaway Commission, and are then forwarded to the NBIC. Vessels are required to report on all ballast water tanks, even if empty, and to project where the tanks will be discharged in the Great Lakes. Ballast water reporting forms are also submitted directly to the NBIC at each U.S. arrival port. As a result, the same discharge events can be reported twice − once on the ballast water reporting form submitted to either the U.S. Coast Guard or TC before the vessel enters the St. Lawrence Seaway, and again on the ballast water reporting form submitted to the NBIC as the vessel transits within the Great Lakes to U.S. ports. The NBIC tries to remove duplicate reported discharges; however, this reduction had not been completed for 2013 when the data was provided to EPA. In addition, vessels entering Canadian ports on the Great Lakes are only required to submit ballast water reporting forms for their overseas arrival and not for ballast water discharges within the Great Lakes. Therefore, the record of individual port arrivals and ballast water discharges may be incomplete for the Canadian side of the Great Lakes. EPA identified and removed duplicate transit records when combining the TC and NBIC datasets as described in Section 2.2.1.

EPA identified an inconsistency between the total numbers of vessels entering the Great Lakes from overseas or with overseas sources of ballast water found in this analysis (roughly 275 vessels annually) and the substantially higher number of nearly 400 vessel entries reported in the annual reports of the Great Lakes Seaway Ballast Water Working Group.[12] The vessel counts in the annual reports were derived from the TC inspection record. Comparison of the two datasets revealed that not all of the inspected vessels were included in the NBIC or TC datasets. In addition, not all of the records for vessels entering the Great Lakes from overseas (or with overseas ballast water) in the combined NBIC-TC dataset were found in the TC inspection record. EPA did not investigate why records in the inspection database were excluded from the provided NBIC and TC datasets; however, EPA notes that use of the inspection records was limited to verification of Great Lake entry for TC transit records for 2010 as discussed in Section 2.2.1.

As discussed in Section 2.2.2, EPA was unable to identify and remove duplicate tank records between the TC and NBIC data sources. Thus, the amounts of ballast water discharged reported in this document represent an upper bound in the amount discharged.

[12] The Great Lakes Seaway Ballast Water Working Group annual reports are available for download:
2010 (415 vessel transits): http://www.greatlakes-seaway.com/en/pdf/2010_BW_Rpt_EN.pdf
2011 (396 vessel transits): http://www.greatlakes-seaway.com/en/pdf/2011_BW_Rpt_EN.pdf
2012 (386 vessel transits): http://www.greatlakes-seaway.com/en/pdf/2012_BW_Rpt_EN.pdf
2013 (371 vessel transits): http://www.greatlakes-seaway.com/en/pdf/2013_BW_Rpt_EN.pdf

SECTION 3
ANALYSIS RESULTS AND DISCUSSION

Section 3 of this report presents information on vessels entering the Great Lakes and their ballast water discharges. Section 3.1, Vessel Characteristics, provides information on the number and types of overseas vessels entering the Great Lakes, their size and age, their ballast water capacity and if they enter the Great Lakes ballasted or declare no ballast on board (NOBOB). Section 3.2, Voyage Patterns, provides information on the last overseas ports the vessels visited before entering the Great Lakes; overseas ports where ballast water was loaded; the distance the vessels traveled from overseas to reach the destination port on the Great Lakes; and the vessels' voyage time between the last overseas port and the Great Lakes port. Finally, Section 3.3, Ballast Water Discharges, provides information on ballast water discharges into the Great Lakes, including the amounts and discharge ports; if ballast water exchange or flushing was conducted while in transit and the method; and if ballast water treatment is provided on any of the overseas vessels entering the Great Lakes. EPA presents most of the information in a series of tables and graphs (bar and box plots). Geographical Information System (GIS) maps show the routes vessels travel from overseas ports into the Great Lakes and the amounts of ballast water discharged into both U.S. and Canadian ports.

3.1 VESSEL CHARACTERISTICS

The types of vessels entering the Great Lakes are dictated by the types of cargo being shipped from overseas. Table 1 lists the types and numbers of vessels entering the Great Lakes from overseas from 2010 through 2013, while Figure 1 presents this data graphically. Three major types of vessels entered the Great Lakes in nearly equal proportions. Bulkers[13] were the most common overseas vessels entering the Great Lakes during the period from 2010 through 2013, with the peak year for bulkers being 2013. General cargo vessels[14] made up the second largest type, with the peak year for general cargo vessels being 2010. Tankers[15] entered the Great Lakes at only slightly lower numbers than bulkers and general cargo vessels during most years, and were the most common vessel type in 2012.

Total numbers of vessels entering the Great Lakes from overseas, or with overseas sources of ballast water, were similar in 2010, 2012, and 2013. The number was slightly less in 2011. EPA notes that these totals are substantially lower than the nearly 400 vessel entries reported in the annual reports of the Great Lakes Seaway Ballast Water Working Group; EPA further discusses this inconsistency in Section 2.3.

[13] Bulkers are merchant ships specially designed to transport unpackaged bulk cargo, such as grains, coal, ore, and cement in its cargo holds.
[14] General cargo vessels are merchant ships that transport packaged cargo and include container ships, freighters, heavy lift ships, and roll-on/roll-off ships.
[15] Tankers or tank ships are merchant vessels designed to transport liquids or gases in bulk. Major types of tankers include oil tankers, petroleum tankers, chemical tanker, and gas carriers.

Table 1. Types of Overseas Vessels Entering U.S. and Canadian Ports on the Great Lakes

	Number of Vessels Arriving from Overseas Ports (Per Year) [a]				
Vessel Type	**2010**	**2011**	**2012**	**2013**	**Percentage of Total Vessels by Type (2010 – 2013)**
Bulker	90	71	92	123	34.2%
General Cargo	108	95	90	73	33.3%
Tanker	73	69	100	87	29.9%
Other	18	3	5	2	2.5%
Total	**289**	**238**	**287**	**285**	

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] The number of arrivals reported here are based on analysis of the combined TC-NBIC dataset. These data have not been validated by EPA. EPA discusses a discrepancy with the numbers reported by the Great Lakes Ballast Water Working Group annual reports, which are based on the inspection database, in Section 2.3.

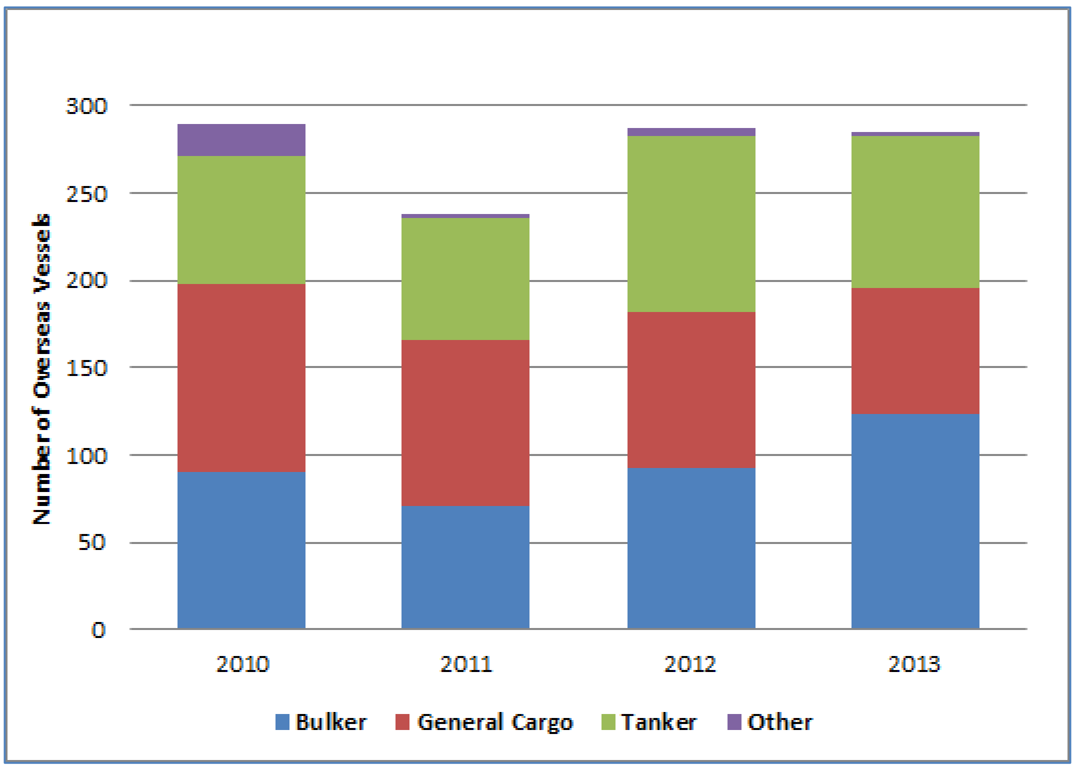

Figure 1. Total Number of Vessels Entering U.S. and Canadian Ports on the Great Lakes by Year and Vessel Type from 2010 to 2013

The length, beam (width), and draft of these overseas vessels determine which can proceed past the ports on Lake Ontario and enter the upper Great Lakes (Erie, Huron, Michigan, and Superior) through the Welland Canal.[16] According to Cangelosi and Mays, overseas vessels

[16] The Welland Canal can accommodate vessels having a maximum length of 740 feet, a maximum width of 78 feet, and a maximum draft of 26 feet 3 inches. Source: Welland Canal Section of the St. Lawrence Seaway available at http://www.greatlakes-seaway.com/en/pdf/welland.pdf.

proceeding through the Welland follow a "steel in – grain out" pattern, arriving from overseas ports loaded with products such as steel or other types of high value cargo, off-load the cargo in Great Lakes ports such as Cleveland, Toledo, Detroit, and Chicago and then travel to ports such as Duluth-Superior or Thunder Bay, Ontario to load grain before returning overseas (Cangelosi and Mays, 2006).

Table 2 provides data on the vessels entering the Great Lakes, including total number of unique vessels arriving from overseas, average weights (gross tons), length, age, number of ballast water tanks, and total number of voyages with NOBOB. EPA notes that the number of unique vessels identified in Table 2 is less than the number of vessels listed in Table 1 because Table 1 captures multiple voyages of the same vessels to the Great Lakes each year. The age and length of vessels entering the Great Lakes from 2010 through 2013 were determined by comparing the vessel IMO numbers in the NBIC and TC datasets with the 2013 VGP eNOI dataset. As the 2013 VGP eNOI dataset generally does not include vessels that travel to Canada but not the U.S., the ages and lengths represented here are not comprehensive. Four vessels with lengths longer than 740 feet arrived in Montreal on four different voyages from 2010 through 2013. All other vessels bound for the upper Great Lakes from 2010 through 2013 were less than 740 feet in length.

Table 2. Tonnage, Lengths, Ages and Ballast Water Capacity of Overseas Vessels Entering the Great Lakes from 2010 through 2013

Description	Year			
	2010	2011	2012	2013
Total Number of Unique Vessels Arriving in the Great Lakes from Overseas[a]	201	179	207	187
Average Tonnage of all Vessels Arriving from Overseas (Gross Tons ± Standard Deviation)	12,963 ± 6,748	12,679 ± 7,104	14,296 ± 8,782	12,998 ± 7,053
Average Length of all Vessels Arriving from Overseas (Feet ± Standard Deviation)	506 ± 93	492 ± 121	524 ± 115	518 ± 105
Average Age of all Vessels Arriving from Overseas (Years ± Standard Deviation)	10 ± 7	12 ± 10	12 ± 9	9 ± 6
Average Number of Ballast Water Tanks on all Vessels Arriving from Overseas (Ballast Tanks ± Standard Deviation)	19 ± 5	19 ± 6	18 ± 5	19 ± 5
Total Number of Voyages from Overseas with NOBOB	39	28	58	37

Source: National Ballast Information Clearinghouse, Transport Canada and VGP 2013 eNOI database.

[a] Unique vessels are those that arrived at least one time in the Great Lakes during the specified year. The numbers do not reflect multiple visits to the Great Lakes from overseas by the same vessel during the sailing season.

The ballast water capacity data for various vessel types entering the Great Lakes from 2010 through 2013 are shown in Table 3 and Figure 2. The data show that bulkers have more than double the ballast water capacities of general cargo ships and small tankers able to reach the upper Great Lakes for most years. Average ballast water capacities for the bulkers entering the Great Lakes from overseas between 2010 and 2013 ranged from 14,973 to 15,879 MT, while general cargo ships averaged between 4,599 to 6,003 MT of ballast water. The ballast water capacities of tankers entering the Great Lakes between 2010 and 2013 averaged 5,687 to 10,132 MT. In several cases, a few very large vessels of each type strongly influenced the means and standard deviations.

Table 3. Ballast Water Capacities of the Three Primary Vessel Types Entering the Great Lakes from Overseas

Year	Average Ballast Water Capacity by Vessel Type Arriving in the Great Lakes (Metric Tonnes ± Standard Deviation)		
	Bulkers	General Cargo	Tankers
2010	14,973 ± 4,651	4,599 ± 1,419	5,687 ± 2,962
2011	15,477 ± 4,477	6,003 ± 4,228	10,132 ± 15,125
2012	15,039 ± 4,536	5,247 ± 2,676	6,232 ± 4,005
2013	15,879 ± 3,813	5,008 ± 2,712	6,675 ± 3,607

Source: National Ballast Information Clearinghouse and Transport Canada.

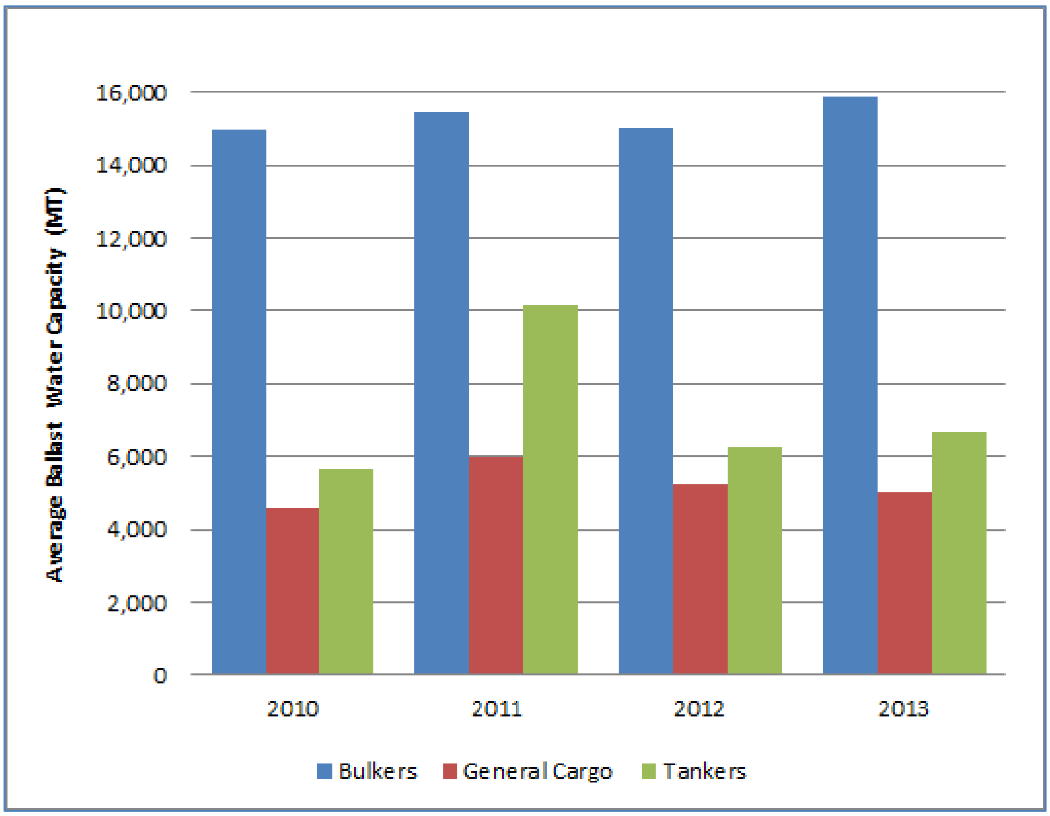

Figure 2. Average Ballast Capacities of the Three Primary Vessel Types Entering the Great Lakes from Overseas from 2010 to 2013

3.2 VOYAGE PATTERNS

Vessels entering the Great Lakes from overseas generally originated in Western and Northern Europe; however, a few vessels came from as far as Vietnam and South Korea. Table A-1 in Appendix A provides a list of the last overseas ports reported on the ballast water reporting forms and the number of vessels originating from these ports from 2010 through 2013. These data show that vessels arrived in the Great Lakes from 201 different ports around the world.

Figure 3 is a map illustrating vessel routes from last ports of call to the Great Lakes. The most common vessel routes are shown with the thickest vessel route lines. For visual simplicity, routes originating from neighboring ports (within 100 km) are combined into single route lines and routes from the least common countries are not included. This map represents a roughly 2/3^{rds} of the vessel routes.

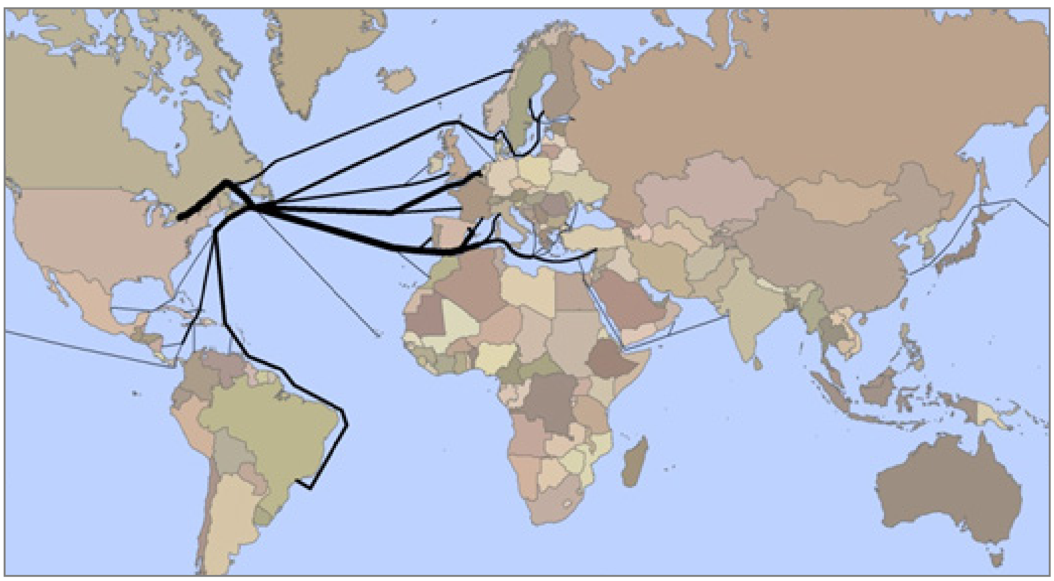

Figure 3. Most Common Vessel Routes from Countries Around the World into the Great Lakes

Figure 4 is a bar graph showing the top 12 last overseas ports for vessels bound for the Great Lakes for 2010 through 2013. These 12 ports alone account for 40 percent of the overseas last ports for all vessels bound for the Great Lakes. Not all of the last ports are the ballast water source ports. For example, none of the most prevalent last overseas ports are included in the top 12 overseas ballast water source ports. Hence, the last port is often not the ballast water source port as a vessel may or may not take on ballast water at the last port. In addition, vessels may carry ballast water from multiple ports and do not always discharge all of their tanks within the Great Lakes.

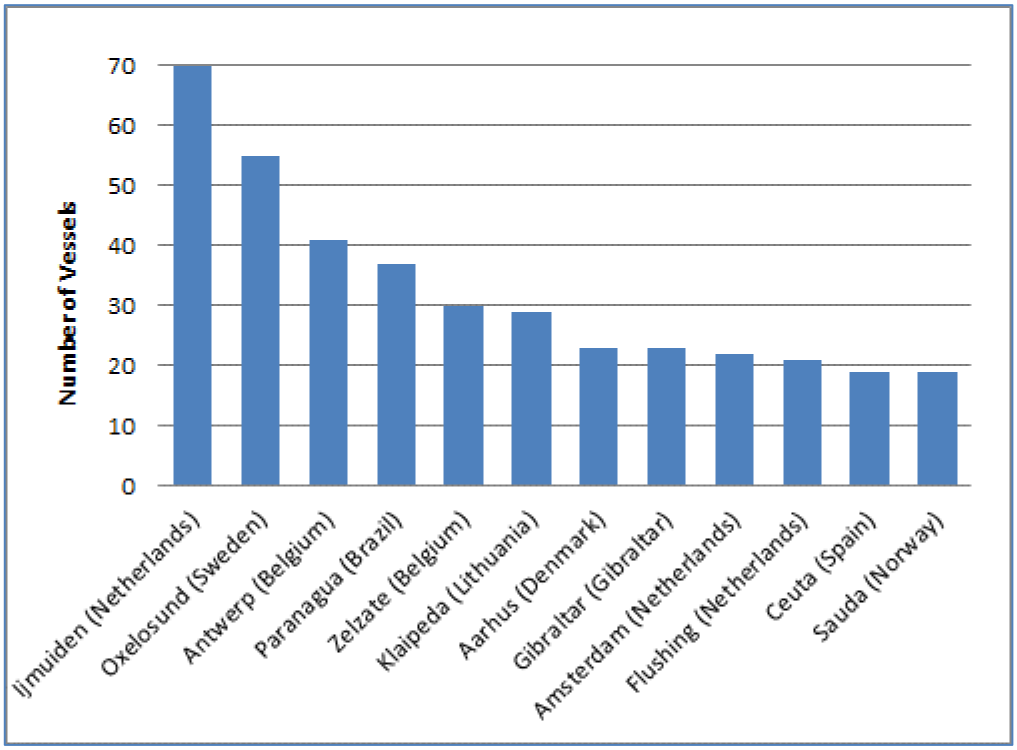

Figure 4. Top 12 Last Ports of Call for Overseas Vessels Before Entering the Great Lakes from 2010 to 2013

Figure 5 is a box and whisker plot showing the distances between these overseas last ports and the Great Lakes for vessels arriving from 2010 through 2013. In general, overseas vessels leaving from ports in Northern Europe such as Ijmuiden, Antwerp, and Oxelosund travel nearly 4,000 nm to reach ports on the Great Lakes.[17] Vessels traveling from ports in South America such as Paranagua in Brazil travel approximately 6,000 nm to reach the Great Lakes, while a few vessels traveling from ports like Kwangyang in South Korea or Sydney in Australia, travel nearly 12,000 nm to reach the Great Lakes. The shortest voyages originated in the Caribbean, Greenland, or the Azores (Portugal), traveling approximately 2,600 nm.

[17] Average distance estimated based on the overseas port and Cleveland, Ohio in the Great Lakes from http://www.sea-distances.org/

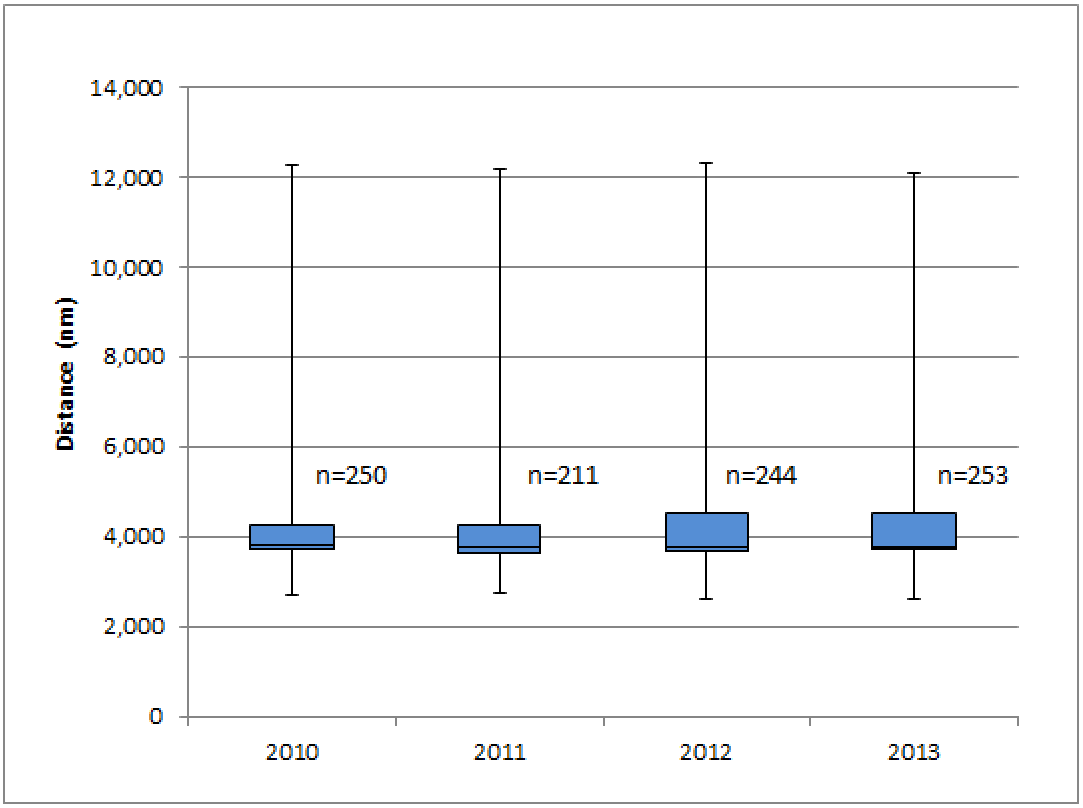

Figure 5. The Distance (nm) Between the Last Port and Ballast Water Discharge in the Great Lakes from 2010 to 2013

The time between loading ballast water at an overseas port and discharging ballast water into the Great Lakes can affect the efficacy of treatment. Longer storage time in ballast tanks can reduce plankton densities as food supply and oxygen decline (Briski et al., 2013; Drake et al., 2002). Conversely, longer residence times between treatment and discharge can allow organisms to reproduce within the ballast tanks, increasing the risk of establishing new populations upon release (Gollasch et al., 2000). Figure 6 is a box and whisker plot showing the time interval between ballast water loading at overseas ports and ballast water discharge into the Great Lakes for 2010 through 2013. On average, the time ballast water remains in ballast tanks on vessels entering the Great Lakes from overseas is approximately 30 days but could range from as many as 332 days and as few as 6 days, with a median duration of 23 days. The highest number of days likely represents vessels retaining ballast on multiple voyages. Differences between the shortest and longest time intervals also depend on the locations of the load ports and discharge ports. Vessels loading ballast water in Asian ports and discharging in the western Great Lakes ports such as Duluth-Superior have longer intervals between loading and discharge than do vessels loading ballast water in Western Europe and discharging in ports on Lakes Ontario and Erie.

Figure 7 is a box and whisker plot showing the time interval between open-ocean ballast water exchange or flushing and discharge. The time between open-ocean ballast water exchange and discharge into the Great Lakes averages approximately 14 days, but could range from as many as 102 days and as few as 1 day, with a median duration of 13 days.

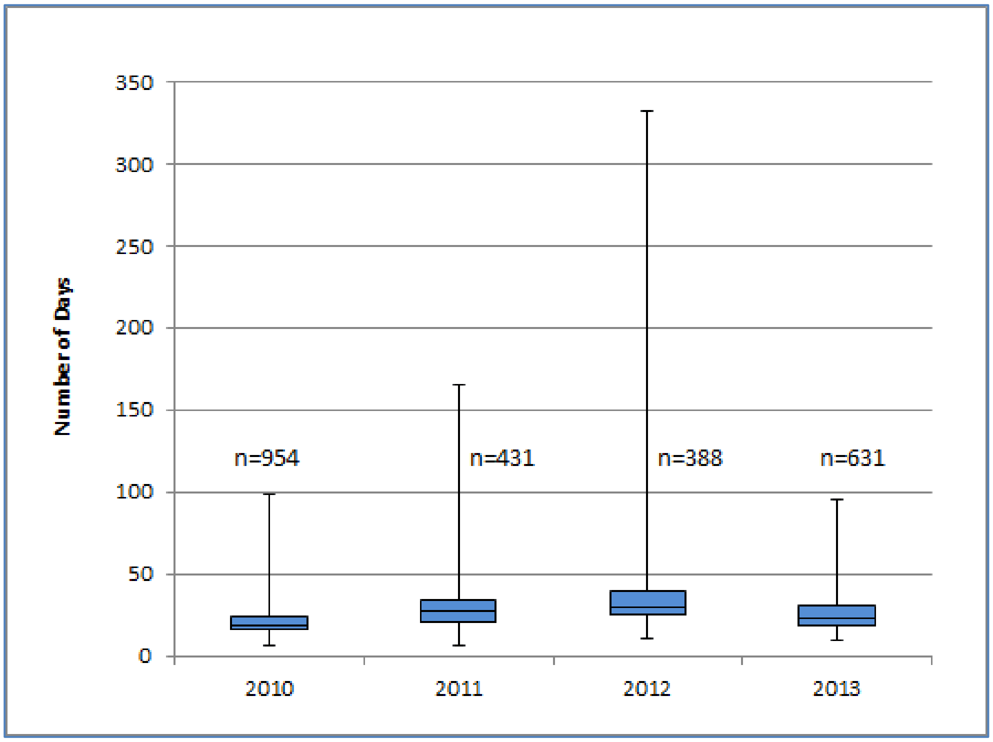

Figure 6. The Number of Days Between Ballast Water Loading at Overseas Ports and Ballast Water Discharge into the Great Lakes for 2010 Through 2013 (Regardless of Flushing or Exchange)

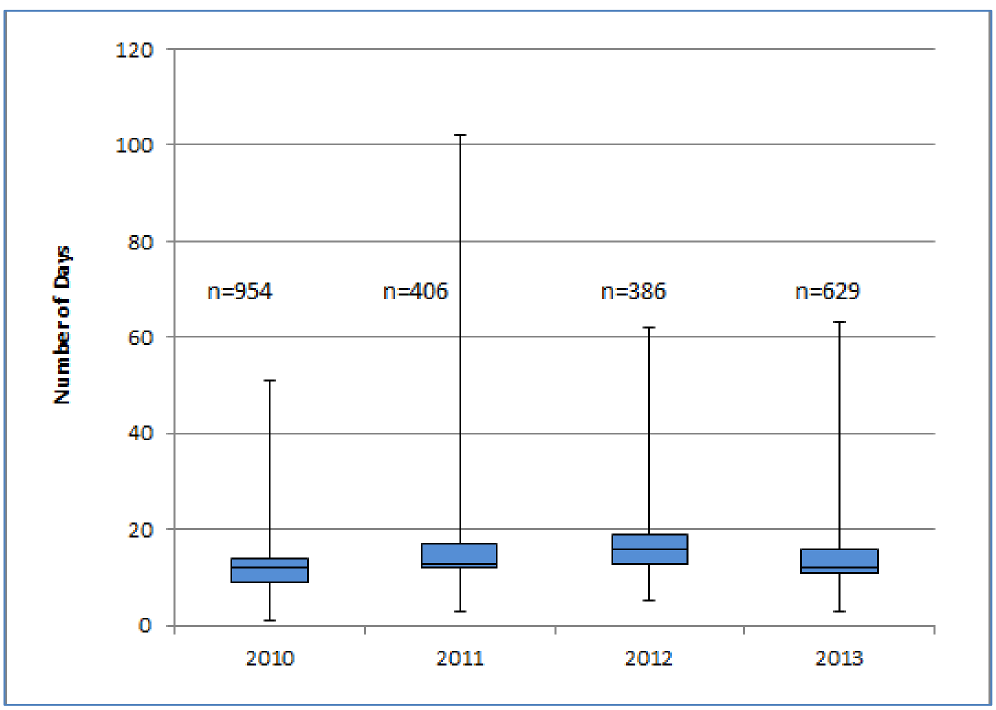

Figure 7. The Number of Days Between Ballast Water Exchange/ Flushing and Discharge into the Great Lakes

Within the Great Lakes and St. Lawrence Seaway, 45 U.S. and Canadian ports received overseas vessels headed for the Great Lakes from 2010 through 2013. Table A-2 in Appendix A lists each port and the number of overseas vessels that docked at each from 2010 through 2013. Information on the total number of vessels entering the Great Lakes and their destination port (U.S. or Canadian) is provided in Table 4. The data shows that on average, 275 overseas vessel arrivals are recorded for the Great Lakes annually. This number includes a count of each separate voyage. The data in Table 4 also show that far more overseas vessels docked at Canadian ports than U.S. ports when first arriving on a voyage into the Great Lakes between 2010 and 2013.

On the U.S. side of the Great Lakes, the port at Cleveland, Ohio on Lake Erie received the largest number of overseas vessels between 2010 and 2013, followed by Duluth-Superior on Lake Superior, and Toledo on Lake Erie. The ports at Hamilton, Ontario and Toronto on Lake Ontario received the largest number of overseas vessels docking at Canadian ports between 2010 and 2013. Of the ports in the Great Lakes and on the St. Lawrence Seaway, the port at Montreal received the greatest number of overseas vessels docking between 2010 and 2013 en route to other Great Lakes ports, receiving more than two and a half times more overseas vessel arrivals than any other port. Figure 8 is a bar graph representing the number of vessels docking at each Great Lakes and St. Lawrence Seaway port from 2010 through 2013 en route to the Great Lakes. Figure 8 represents the first arrival port recorded in the datasets for vessels entering the Great Lakes.

Table 4. Overseas Vessel Voyages Arriving at U.S. and Canadian Ports en route to the Great Lakes

Arrival Country	Number of Overseas Vessel Arrivals (Per Year)			
	2010	2011	2012	2013
Total Overseas Vessel Voyages to All Great Lakes Ports[a]	289	238	287	285
Total Overseas Vessel Voyages to U.S Great Lakes and St. Lawrence Seaway Ports	70	66	78	77
Total Overseas Vessel Voyages to Canadian Great Lakes and St. Lawrence Seaway Ports	218	170	207	205

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] Note that the total number of arrivals includes 8 voyages with the arrival port designated as the St. Lawrence Seaway. As such, these vessel voyages are not represented in the total arrivals at either U.S. or Canadian ports.

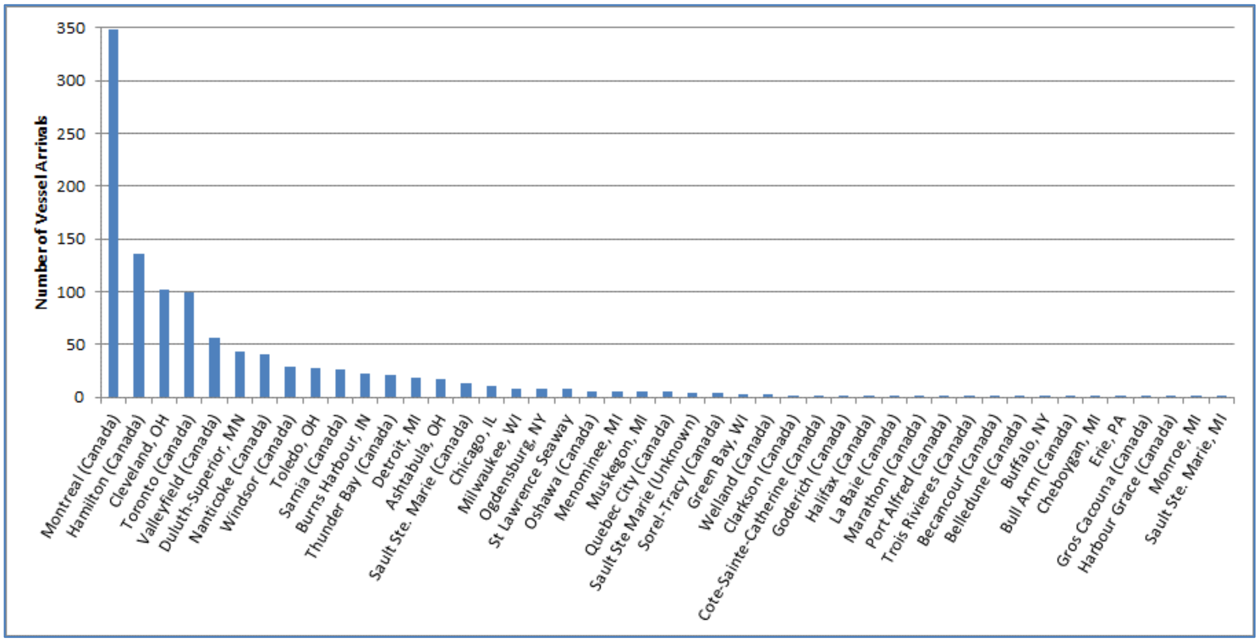

Figure 8. Cumulative Number of Overseas Vessels Arriving at Great Lakes and St. Lawrence Seaway Ports as the First Arrival Port from 2010 to 2013

A number of vessels entering the Great Lakes between 2010 and 2013 made multiple voyages in the same year. For example, in 2010, the MBC Iryda traveled between Ijmuiden in the Netherlands and Cleveland, Ohio, on four separate voyages. In 2013, the M/V Stella Polaris traveled between Zelzate, Belgium, and Hamilton, Ontario, on eight separate occasions. Table 5 shows the percentage of vessels that made multiple voyages to the Great Lakes from overseas between 2010 and 2013. On average, 29 percent of the vessels that enter the Great Lakes make multiple trips between overseas ports annually.

Table 5. Percentage of Overseas Vessels Making Multiple Voyages to the Great Lakes

Year	Total Number of Overseas Vessels Arriving in the Great Lakes from Overseas[a]	Total Number Unique Vessels Arriving in the Great Lakes from Overseas[b]	Number of Vessels that Entered the Great Lakes on Multiple Voyages From Overseas[c]	Percentage of Vessels that Entered the Great Lakes on Multiple Voyages from Overseas
2010	289	201	65	32%
2011	238	179	43	24%
2012	287	207	54	26%
2013	285	187	66	35%

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] The number of voyages. If a vessel enters the Great Lakes on six voyages in a single year, this vessel is counted six times.

[b] The number of unique vessels to enter the Great Lakes during a particular year. If a vessel enters the Great Lakes on six voyages in a single year, it is only counted once.

[c] The number of unique vessels to enter the Great Lakes on more than one voyage in a particular year.

3.3 BALLAST WATER DISCHARGES

Figure 9 is a map of the Great Lakes depicting the cumulative amount of ballast water discharged (in MT) at each U.S. and Canadian port by overseas vessels during the four-year period. Larger amounts of ballast water discharges are depicted by larger diameter markers for each port. Figure 10 is a bar graph listing the top 10 U.S. and Canadian Great Lakes ports receiving ballast water from overseas vessels from 2010 through 2013. Duluth-Superior, Thunder Bay, and Hamilton stand out for receiving the largest amounts of ballast water cumulatively during the four year period. Though variability exists from year to year, these three ports consistently receive the largest amount of ballast water. Table 6 shows the amount of ballast water discharged (in metric tons (MT)) at U.S. and Canadian ports from overseas vessels into the Great Lakes each year from 2010 through 2013.[18]

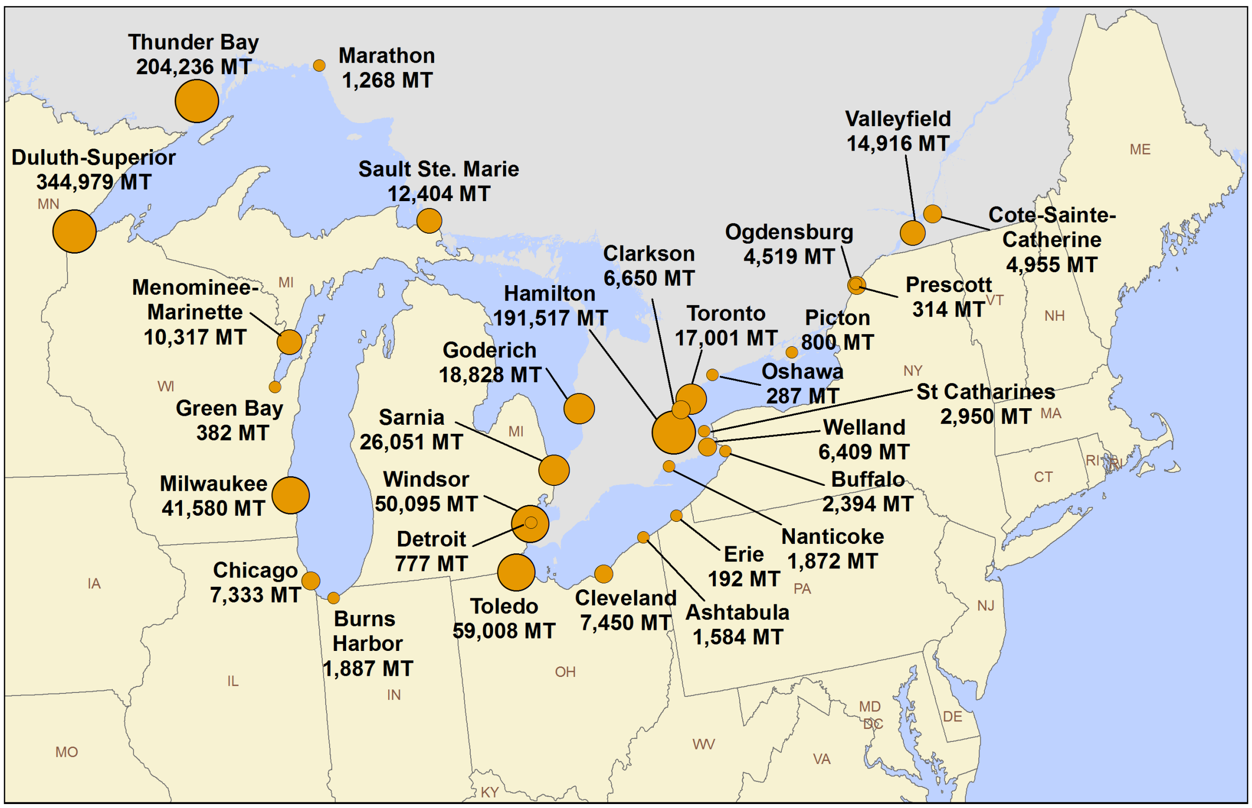

Figure 9. Cumulative Amount of Ballast Water Discharged (in MT) from Overseas Ports from 2010 to 2013

Table 7 shows the distribution of ballast water discharges into the Great Lakes by vessel type, and Figure 11 is a bar chart showing total discharges by vessel type from 2010 through 2013. As shown in Table 7 and Figure 11, bulkers were responsible for the largest amount of ballast water discharged into the Great Lakes for the four-year period, discharging nearly 579,000 MT of ballast water into the Great Lakes between 2010 through 2013. General cargo ships discharged nearly 416,000 MT; five times more ballast water discharges than tankers. The large amount of ballast water discharged into Duluth-Superior and Thunder Bay, Ontario

[18] The amounts of ballast water discharged reported in this section represent an upper bound. See Section 2.3, Data Quality, for further discussion.

(Canada) (see Table 6, Figure 9, and Figure 10) is indicative of the high number of bulkers entering these ports to load grain and iron ore. The reported amounts of ballast water discharged in 2011 and 2012 are substantially lower than the amounts reported for 2010 and 2013, despite records of a similar number of voyages of vessels with similar total ballast water capacities.

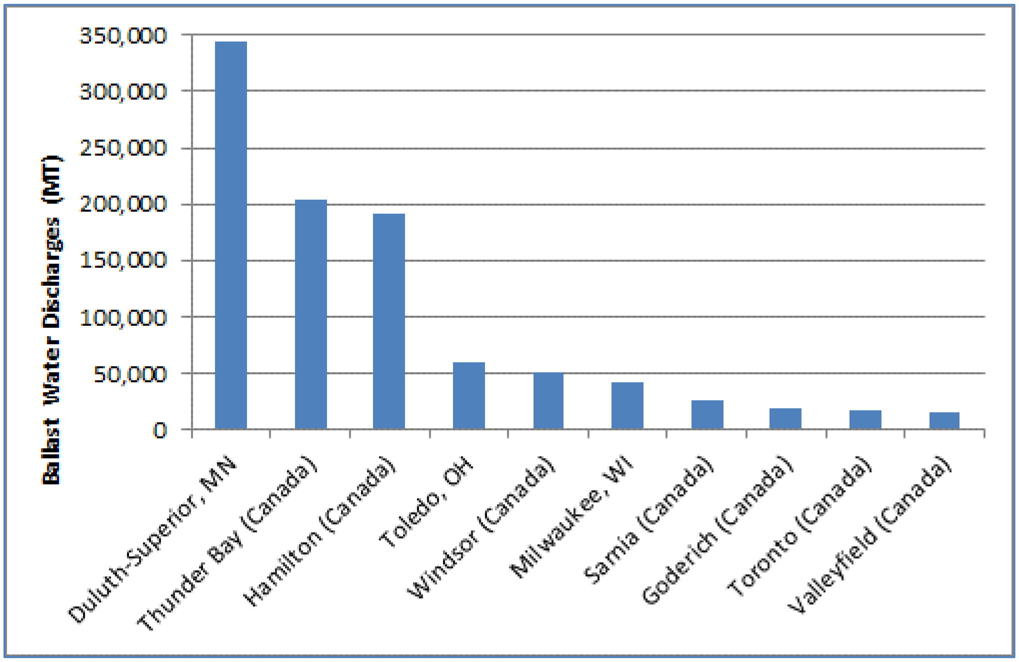

Figure 10. The Top 10 Great Lakes Ports Receiving Ballast Water Discharges from Overseas Vessels from 2010 through 2013

The port at Duluth showed a drop in ballast water discharges by 50 to 60 percent for the 2011 and 2012 sailing season as compared to the 2010 and 2013 sailing seasons (see Table 6). A review of cargo data provided by the Duluth Seaway Port Authority[19] shows a dramatic decrease in overseas imports and exports between 2010 and 2011. In 2010, overseas vessels docking in Duluth hauled 1.6 million tons of cargo but only 1 million tons in 2011. Shipping into Duluth rebounded in 2012 to 2.1 million tons, and in 2013 total overseas imports and exports were 2.4 million tons. Thunder Bay, Ontario (Canada) also had a large decrease in ballast water discharges in 2011 and 2012. At Thunder Bay, Ontario, exports (primarily grain) decreased from 7.8 million MT in 2012 to 6.5 million MT in 2013.[20] Although the overseas cargo data between 2010 and 2011 may explain the sudden decrease in ballast water discharged at Duluth, it does not explain the lower ballast discharges in 2012 in Duluth or Thunder Bay. EPA expects that while some of the decrease in ballast water amounts represents a real shift in shipping patterns, some represents the over estimation of discharges caused by duplication in the data.

[19] Duluth Seaway Port Authority, http://www.duluthport.com/port-stats.php

[20] Thunder Bay Port Authority, 2013 Annual Report, http://www.portofthunderbay.com/upload/documents/1505_port-authority_2013-annual-report_8.pdf

Table 6. Ballast Water Discharges at U.S. and Canadian Ports on the Great Lakes from Overseas Vessels

U.S. and Canadian Great Lakes Ports	Ballast Water Discharges (Metric Tonnes)				Total Ballast Water Discharges 2010 – 2013 (Metric Tonnes)[a]
	2010	**2011**	**2012**	**2013**	
Ashtabula, OH	0	0	0	1,584	1,584
Buffalo, NY	0	0	0	2,394	2,394
Burns Harbor, IN	462	1,425	0	0	1,887
Chicago, IL	7,150	0	132	51	7,333
Clarkson (Canada)	1,229	2,845	0	2,576	6,650
Cleveland, OH	307	2,314	4,830	0	7,450
Cote-Sainte-Catherine (Canada)	1,254	0	2,488	1,213	4,955
Detroit, MI	310	75	0	392	777
Duluth-Superior, MN	132,428	50,343	52,566	109,642	344,979
Erie, PA	0	192	0	0	192
Goderich (Canada)	18,588	240	0	0	18,828
Green Bay, WI	0	0	382	0	382
Hamilton (Canada)	66,393	27,134	11,806	86,184	191,517
Marathon (Canada)	1,268	0	0	0	1,268
Menominee-Marinette, MI	0	3,337	6,490	490	10,317
Milwaukee, WI	41,332	248	0	0	41,580
Nanticoke (Canada)	301	559	1,012	0	1,872
Ogdensburg, NY	0	0	4,519	0	4,519
Oshawa (Canada)	0	0	287	0	287
Picton (Canada)	800	0	0	0	800
Prescott (Canada)	0	314	0	0	314
Sarnia (Canada)	2,564	6,744	1,752	14,991	26,051
Sault Ste. Marie (Canada)	12,404	0	0	0	12,404
St Catharines (Canada)	0	0	0	2,950	2,950
Thunder Bay (Canada)	118,050	25,704	24,039	36,443	204,236
Toledo, OH	23,313	448	15,634	19,614	59,008
Toronto (Canada)	4,920	3,454	3,927	4,700	17,001
Valleyfield (Canada)	12,911	1,147	110	748	14,916
Welland (Canada)	0	138	0	6,271	6,409
Windsor (Canada)	30,464	1,247	1,173	17,211	50,095
Lake Ontario	0	1,196	6,300	121	7,617
Great Lakes	0	773	0	0	773
Unknown	2,418	7,387	1,194	18,588	28,061
Totals	**478,866**	**137,264**	**138,641**	**326,164**	**1,080,934**

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] The amounts of ballast water discharged reported in this table represent an upper bound.

Table 7. Ballast Water Amounts Discharged into U.S. and Canadian Waters on the Great Lakes from Overseas Vessels by Vessel Type

Vessel Type	Ballast Water Discharged (MT/yr)[a]				Total Ballast Water Discharged from 2010 – 2013 (MT)[a]
	2010	2011	2012	2013	
Bulker	289,434	45,206	36,942	207,213	578,796
General Cargo	159,759	73,956	90,081	92,008	415,804
Tanker	24,731	17,910	11,617	26,942	81,200
Other	4,942	192	0	0	5,134
Total	**478,866**	**137,264**	**138,641**	**326,164**	**1,080,934**

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] The amounts of ballast water discharged reported in this table represent an upper bound .

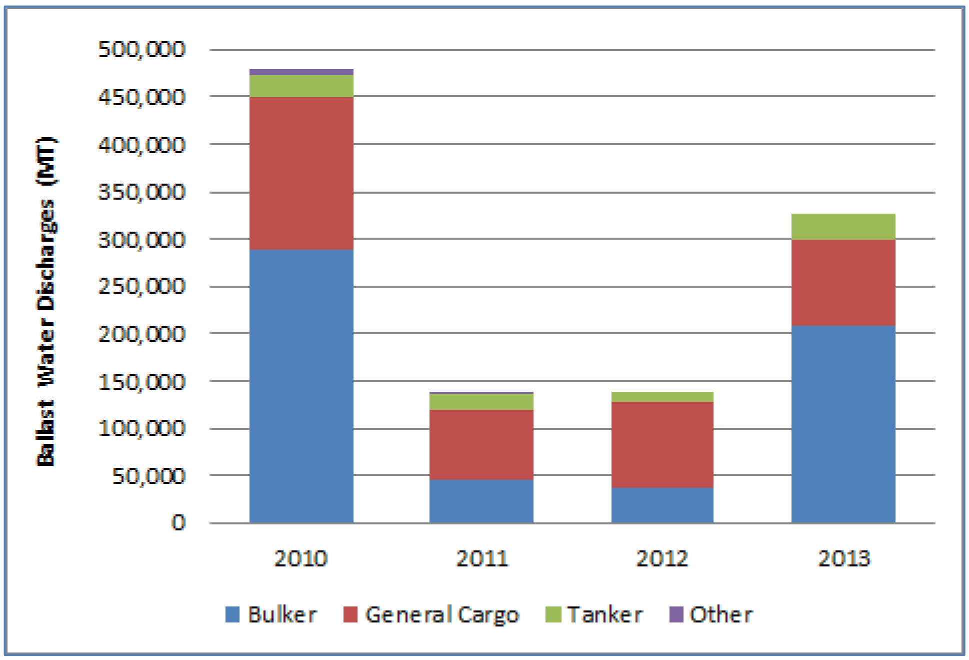

Figure 11. Ballast Water Discharges by Vessel Type into U.S. and Canadian Great Lakes Ports from Overseas Vessels

A list of overseas ports where ballast water was originally loaded and subsequently discharged into the Great Lakes[21] is provided in Table A-3 in Appendix A. Table 8 lists the 12 source ports with the highest amounts cumulatively discharged into the Great Lakes during 2010 to 2013. Figure 12 is a bar graph showing these top 12 overseas ports where ballast water was loaded and then discharged into the Great Lakes. From 2010 through 2013, vessels that loaded ballast water in Ghent, Belgium discharged the greatest amount of ballast water into the Great Lakes. However, the source ports with the highest amount of ballast water discharged varies from year to year, including Rotterdam (Netherlands), Borg Havn IKS (Norway), Ghent (Belgium), and Jiangyin (China) respectively in 2010, 2011, 2012, and 2013. Approximately

[21] All vessels entering the Great Lakes must conduct either open-ocean ballast water exchange or ballast tank flushing and therefore discharges of ballast water into the Great Lakes by overseas vessels should be primarily open-ocean seawater and not fresh water or brackish water from coastal environments.

1,081,000 MT of ballast water from overseas ports was discharged into the Great Lakes from 2010 to 2013.

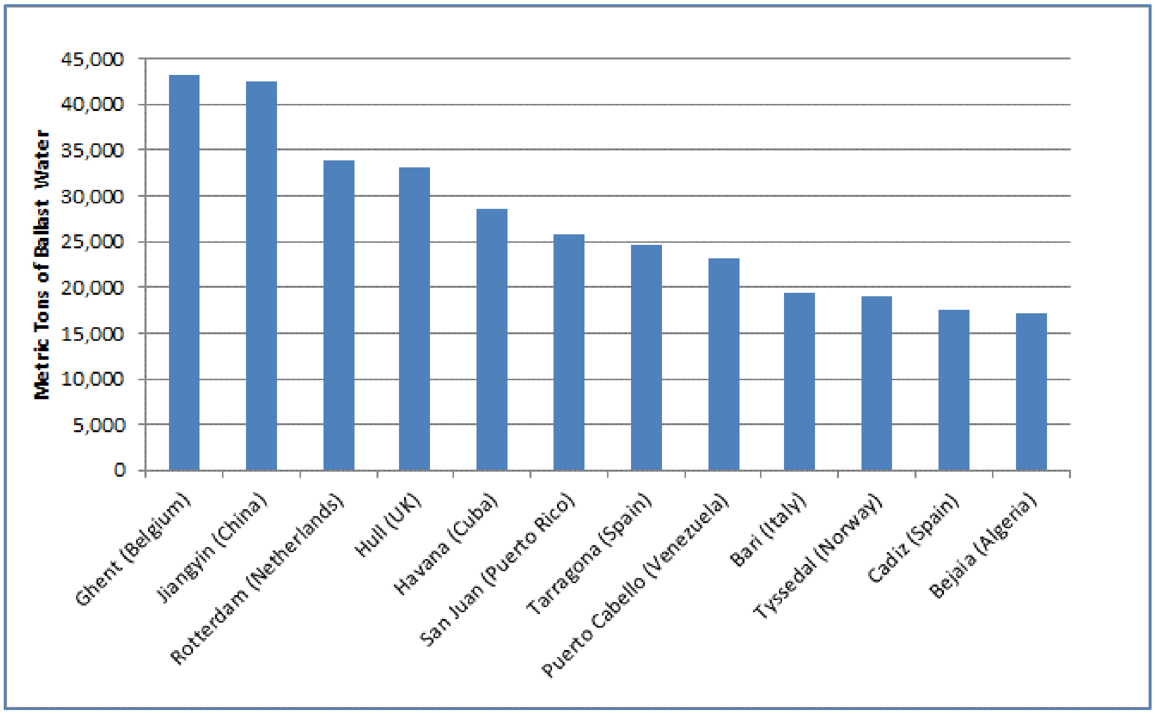

Figure 12. Bar Graph Showing Top 12 Overseas Ports where Ballast Water was Loaded and Discharged into the Great Lakes from 2010 through 2013

Table 8. Amount of Ballast Water Discharged into the U.S. and Canadian Waters of the Great Lakes from the Top 12 Overseas Ports by Source Port

Country Where Ballast Water was Loaded	Overseas Port Where Ballast Water was Loaded	Amount of Ballast Water Discharged into the Great Lakes from the Overseas Port (MT)[a]				Total Amount of Ballast Discharged into Great Lakes from Overseas Port (2010 - 2013)[a]
		2010	2011	2012	2013	
Belgium	Ghent	16,251	7,297	12,600	7,061	43,209
China	Jiangyin	0	0	0	42,443	42,443
Netherlands	Rotterdam	29,009	673	2,488	1,605	33,775
United Kingdom	Hull	1290.6	5350.3	4210	22,305	33,156
Cuba	Havana	20328.2	7776	0	440	28,544
Puerto Rico	San Juan	23114.88	0	0	2,630	25,745
Spain	Tarragona	16,646	0	0	7,924	24,570
Venezuela	Puerto Cabello	870	0	0	22178	23,048
Italy	Bari	19398	0	0	0	19,398
Norway	Tyssedal	0	0	0	19002.2	19,002
Spain	Cadiz	0	0	0	17,512	17,512
Algeria	Bejaia	17,092	0	0	0	17,092

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] The amounts of ballast water discharged reported in this table represent an upper bound.

Historically, a large percentage of vessels entering the Great Lakes have either no ballast on board or no pumpable ballast on board (NOBOB) (Johengen and Reid, 2005; Niimi and Reid, 2003). A smaller percentage of vessels from overseas that enter the Great Lakes carry some ballast water. Table 9 shows the total number of ballast tanks for all vessels arriving in the Great Lakes from overseas, the number of tanks in ballast, the number of tanks to discharge, and the number of tanks that underwent ballast water exchange or an alternative method such as ballast water flushing. Table 9 also shows the percentage of total tanks that did not discharge ballast due to carrying cargo, lack of operation, or retaining ballast for the duration of the voyage in the Great Lakes. Finally, it lists the percentage of ballast tanks that underwent ballast water exchange and the percentage that were discharged.[22] The data show that a larger number of ballast water tanks underwent alternative method treatment than underwent exchange prior to arrival in the Great Lakes.[23] In total, ballast tanks on overseas vessels entering the Great Lakes are exchanged or flushed at a rates ranging between 81 and 85 percent. As a result, the majority of ballast water discharges consist of high salinity ocean water. The data also show a decrease in both the numbers of tanks entering the Great Lakes and numbers discharged in the Great Lakes during 2011 and 2012, relative to 2010 and 2013. Due to compatibility issues between the NBIC and TC datasets, Table 9 presents results only from the NBIC dataset and does not represent the entirety of vessels entering the Great Lakes.[24]

Table 9. Ballast Tank Exchange or Flushing for Overseas Vessels Entering the Great Lakes

	2010	2011	2012	2013
Total Number of Ballast Water Tanks Entering the Great Lakes	3,358	3,376	3,195	3,487
Total Number of Ballast Water Tanks in Ballast Entering the Great Lakes	1,500	1,177	1,159	1,173
Total Number of Ballast Water Tanks Discharged into the Great Lakes	1,023	483	488	585
Percentage of All Ballast Tanks Entering the Great Lakes that Were Discharged into the Great Lakes	30%	14%	15%	17%
Percentage of Tanks Filled with Cargo, Not Operational, or Retaining Ballast Water for the Duration of the Voyage on the Lakes	70%	86%	85%	83%
Total Number of Ballast Water Tanks That Underwent Exchange	1,343	851	967	749
Percentage of Ballast Tanks that Underwent Exchange	40%	25%	30%	21%
Total Number of Ballast Water Tanks Reported as Undergoing Alternative Treatment[a]	1,438	2,022	1,699	2,084
Percentage of Ballast Water Tanks Reported as Undergoing Alternative Treatment[a]	43%	60%	53%	60%

Source: National Ballast Information Clearinghouse.

[a] Alternative treatment has been reported on 24 and 96 hour Saint Lawrence Seaway Ballast Water Reporting forms as flushing, partial open ocean ballasting and deballasting, etc. EPA did not validate the data against the 24 and 96 hour Saint Lawrence Seaway Ballast Water Reporting forms. In some cases, exchange may have been included in the definition of alternative methods.

[22] Note that many tanks that have undergone alternative treatments were no longer reported as being 'in ballast.' Therefore, all percentages were calculated as a fraction of the total number of tanks on board.

[23] EPA did not validate the data against the 24 and 96 hour Saint Lawrence Seaway Ballast Water Reporting forms. In some cases, exchange may have been included in the definition of alternative methods.

[24] The TC datasets does not include the total number of tanks on board. The TC dataset contains the number of tanks in ballast, number exchanged, and the number that underwent alternative treatment.

A comparison of the vessel IMO numbers for all vessels that reported having a ballast water treatment system in the 2013 VGP eNOI database to the NBIC dataset found that no vessels entering the Great Lakes from 2010 through 2013 reported having ballast water treatment systems installed. This is not surprising and is consistent with other published information regarding the lack of ballast water treatment systems installed on vessels entering the Great Lakes through the SLS system (Great Lakes Seaway Ballast Water Working Group, 2013). Although both U.S. Coast Guard and USEPA recently promulgated new ballast water requirements, the requirements are being phased in over a number of years. Based on the compliance schedules in the regulations, the majority of vessels entering the Great Lakes should have ballast water treatment systems installed within the next 5 to 10 years, or must arrange for an alternate form of ballast water management (e.g., onshore treatment or no discharge).

SECTION 4
SUMMARY

During the years 2010 through 2013, 179 to 207 unique overseas vessels entered the Great Lakes on approximately 275 voyages annually. These vessels were fairly equally split between bulkers, general cargo vessels, and tankers, and had an average weight of 13,260 gross tons, an average length of 509 feet, and an average age of 10.6 years. One-quarter to one-third of these vessels entered the Great Lakes on multiple voyages per year. Most voyages began in Northern Europe and ended at Canadian ports. Voyages averaged 2,600 nm up to a maximum of 12,300 nm. Ballast water holding times averaged 30 days from loading to discharge with a maximum of 332 days. Each year, between 70 and 86 percent of ballast water tanks on board vessels entering the Great Lakes from overseas were filled with cargo, not operational, or retained ballast water for the duration of the voyage. Mid-ocean ballast water exchange rates per ballast tank ranged between 21 percent and 40 percent for 2010 through 2013, and the rates of alternative treatment per ballast tank ranged from 43 percent to 60 percent for 2010 through 2013. The average time between ballast water management activities and discharge was 14 days. Approximately 1,081,000 MT of ballast that originated overseas was discharged into the Great Lakes between 2010 and 2013.[25] The majority of the water discharged was carried aboard either bulkers or general cargo vessels and was discharged at the ports of Duluth-Superior, Thunder Bay, or Hamilton.

These numbers validate previous information (Cangelosi and Mays, 2006) that overseas vessels from all areas of the globe are entering the Great Lakes, and that many of these vessels have loaded ballast water in overseas freshwater ports that could harbor invasive species. Although current U.S. and Canadian regulations require overseas vessels to perform open-ocean ballast water exchange and flushing to physically remove and kill freshwater organisms prior to entering the Great Lakes, some organisms may remain (Ruiz and Reid, 2007). Additional requirements to both treat and exchange ballast water have the possibility of providing further protection against invasion, but the added level of protection has not been quantified. In the interim, both the U.S. and Canada will continue to enforce the current ballast water regulations while on-going research is conducted to find more effective mechanisms to protect the Great Lakes from ballast water mediated invasions.

[25] As discussed in Section 2.3, the amount of ballast water discharged reported represents an upper bound in the amount discharged.

SECTION 5
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APPENDIX A:
DATA TABLES — VESSEL ARRIVALS BY LAST AND ARRIVAL PORTS;
BALLAST WATER DISCHARGE AMOUNT BY SOURCE PORT

Table A-1. Last Ports of Overseas Vessels Before Entering the Great Lakes

Last Overseas Port Prior to Entering Either U.S. or Canadian Ports on the Great Lakes	Distance to the Great Lakes (nm)[a]	Number of Overseas Vessels Entering U.S. and Canadian Great Lakes Ports				Total Number of Vessels from the Overseas Port (2010 – 2013)
		2010	2011	2012	2013	
Aalborg (Denmark)	3,865	3	2	0	0	5
Aarhus (Denmark)	3,898	8	12	3	0	23
Abidjan (Ivory Coast)	5,144	1	0	0	2	3
Acajutla (El Salvador)	4,514	0	0	1	0	1
AES Andres LNG Terminal (Dominican Republic)	3,049	0	1	0	0	1
Algeciras (Spain)	3,639	2	2	0	0	4
Altamira (Mexico)	3,809	1	1	2	1	5
Amsterdam (Netherlands)	3,773	6	8	4	4	22
Annaba (Algeria)	4,274	1	1	0	0	2
Antofagasta (Chile)	5,809	1	0	1	2	4
Antwerp (Belgium)	3,750	8	8	8	17	41
Aviles (Spain)	3,424	3	1	8	1	13
Balboa (Panama)	3,684	2	0	4	2	8
Barcarena (Brazil)	4,134	0	0	0	1	1
Barcelona (Spain)	4,150	1	0	0	0	1
Bari (Italy)	4,973	2	0	0	0	2
Barranquilla (Colombia)	3,483	1	1	1	0	3
Batangas (Philippines)	11,906	5	2	0	0	7
Batumi (Georgia)	6,021	0	0	1	0	1
Bayonne (France)	3,601	1	1	1	1	4
Bejaia (Algeria)	4,148	1	0	0	1	2
Bergen (Norway)	3,612	0	0	0	1	1
Bilbao (Spain)	3,546	0	0	2	1	3
Borg Havn IKS (Norway)	3,798	0	1	0	0	1
Braefoot Bay (United Kingdom)	3,522	1	0	0	0	1
Brake (Germany)	3,844	1	2	3	6	12
Bremen (Germany)	3,865	5	2	3	0	10
Brixham (United Kingdom)	3,427	0	1	0	0	1
Brofjorden (Sweden)	3,795	0	1	0	0	1
Brunsbuttel (Germany)	3,833	0	0	4	4	8
Brussels (Belgium)	3,755	1	1	3	1	6
Buenaventura (Colombia)	4,038	0	1	0	1	2
Cabo Rojo (Dominican Republic)	3,185	0	0	0	1	1
Cadiz (Spain)	3,585	0	0	0	1	1
Campana (Argentina)	7,023	3	2	1	1	7
Cartagena (Colombia)	3,529	0	1	1	1	3
Ceuta (Spain)	3,639	5	4	5	5	19

Table A-1. Last Ports of Overseas Vessels Before Entering the Great Lakes

Last Overseas Port Prior to Entering Either U.S. or Canadian Ports on the Great Lakes	Distance to the Great Lakes (nm)[a]	Number of Overseas Vessels Entering U.S. and Canadian Great Lakes Ports				Total Number of Vessels from the Overseas Port (2010 – 2013)
		2010	2011	2012	2013	
Ceyhan (Turkey)	5,657	1	0	0	0	1
Coatzacoalcos (Mexico)	3,721	0	2	0	2	4
Constantza (Romania)	5,631	5	4	1	4	14
Corinto (Nicaragua)	4,365	0	0	1	0	1
Cumana (Venezuela)	3,380	0	1	0	0	1
Dakar (Senegal)	4,017	1	0	0	0	1
Damietta (Egypt)	5,525	2	0	0	0	2
Dandong (China)	12,311	0	0	1	0	1
Davao (Philippines)	12,072	0	0	0	1	1
Dneprovsko-Bugsky (Ukraine)	5,830	0	0	1	0	1
Dunkirk (France)	3,651	0	1	0	1	2
Ehoala (Madagascar)	9,000	0	0	1	1	2
Emden (Germany)	3,813	2	3	1	3	9
Eregli (Turkey)	5,545	0	0	1	0	1
Esbjerg (Denmark)	3,759	0	2	2	0	4
Falmouth (United Kingdom)	3,366	0	1	0	1	2
Ferrol (Spain)	3,321	1	4	2	0	7
Finnart (United Kingdom)	3,375	1	3	1	0	5
Floro (Norway)	3,612	0	0	0	1	1
Flushing (Netherlands)	3,700	4	3	6	8	21
Freeport (Unknown)		0	1	4	1	6
Freeport (Bahamas)	2,733	1	1	2	0	4
Freetown (Sierra Leone)	4,474	1	0	0	0	1
Garrucha (Spain)	3,829	0	0	0	1	1
Gdansk (Poland)	4,188	1	0	1	0	2
Gdynia (Poland)	4,184	0	0	1	3	4
Gemlik (Turkey)	5,435	0	0	0	1	1
Georgetown (Guyana)	3,563	1	0	1	0	2
Ghent (Belgium)	3,730	4	1	1	1	7
Gibraltar (Gibraltar)	3,639	8	3	8	4	23
Gijon (Spain)	3,434	1	1	0	0	2
Glomfjord (Norway)	3,925	0	1	0	1	2
Gothenburg (Sweden)	3,815	1	0	0	2	3
Guanta (Venezuela)	3,380	0	0	0	1	1
Gwang Yang (South Korea)	11,850	0	0	1	0	1
Hamburg (Germany)	3,867	2	4	0	1	7
Havana (Cuba)	2,983	1	1	0	0	2
Heroya (Norway)	3,784	0	1	0	1	2
Hodeidah (Yemen)	6,710	0	1	0	0	1

Table A-1. Last Ports of Overseas Vessels Before Entering the Great Lakes

Last Overseas Port Prior to Entering Either U.S. or Canadian Ports on the Great Lakes	Distance to the Great Lakes (nm)[a]	Number of Overseas Vessels Entering U.S. and Canadian Great Lakes Ports				Total Number of Vessels from the Overseas Port (2010 – 2013)
		2010	2011	2012	2013	
Huelva (Spain)	3,565	2	0	0	0	2
Hull (United Kingdom)	3,687	0	0	0	1	1
Ijmuiden (Netherlands)	3,758	19	17	15	19	70
Illichivsk (Ukraine)	5,777	0	1	1	0	2
Ilulissat (Greenland)	2,684	1	0	0	0	1
Immingham (United Kingdom)	3,680	0	0	2	0	2
Iskenderun (Turkey)	5,657	0	0	0	1	1
Izmir (Turkey)	5,276	0	0	0	1	1
Jorf Lasfar (Morocco)	3,557	1	0	0	0	1
Kaliningrad (Russia)	4,223	1	1	0	2	4
Klaipeda (Lithuania)	4,239	6	6	13	4	29
Kvinesdal (Norway)	3,622	0	2	0	3	5
Kwangyang (South Korea)	11,850	0	0	1	0	1
La Spezia (Italy)	4,504	0	0	0	1	1
Lagos (Portugal)	3,508	0	1	0	0	1
Lavera (France)	4,320	4	4	2	4	14
Lazaro Cardenas (Mexico)	5,550	0	1	1	0	2
Le Havre (France)	3,558	0	2	1	0	3
Leixoes (Portugal)	3,343	0	0	1	0	1
Lianyungang (China)	12,260	1	0	0	0	1
Linden (Guayana)	3,621	3	3	2	3	11
Lisbon (Portugal)	3,396	1	1	0	1	3
Liverpool (United Kingdom)	3,456	0	2	0	1	3
Livorno (Italy)	4,498	1	0	0	0	1
Maceio (Brazil)	4,847	2	2	4	1	9
Manzanillo (Panama)	3,645	0	0	1	0	1
Maputo (Mozambique)	8,665	0	0	1	0	1
Maracaibo (Venezuela)	3,450	0	0	0	2	2
Martas (Turkey)	5,374	1	0	0	0	1
Matanzas (Venezuela)	3,610	1	0	0	0	1
Mersin (Turkey)	5,596	0	0	0	1	1
Misurata (Libya)	4,800	1	0	0	0	1
Moa (Cuba)	2,926	0	0	0	1	1
Mokpo (Korea, Republic of)	12,000	1	0	0	0	1
Monfalcone (Italy)	5,286	0	0	1	0	1
Mongstad (Norway)	3,612	0	1	0	0	1
Muuga (Estonia)	4,451	0	0	1	0	1
Nemrut Bay (Turkey)	5,276	0	1	1	0	2

Table A-1. Last Ports of Overseas Vessels Before Entering the Great Lakes

Last Overseas Port Prior to Entering Either U.S. or Canadian Ports on the Great Lakes	Distance to the Great Lakes (nm)[a]	Number of Overseas Vessels Entering U.S. and Canadian Great Lakes Ports				Total Number of Vessels from the Overseas Port (2010 – 2013)
		2010	2011	2012	2013	
Newcastle upon Tyne (United Kingdom)	3,568	0	1	0	0	1
Newport (United Kingdom, Wales)	3,385	0	0	0	1	1
Nhava Sheva (India)	8,594	0	0	1	0	1
Nouakchott (Mauritania)	3,917	1	0	0	0	1
Novorossiysk (Russia)	5,891	0	1	0	1	2
Odessa (Ukraine)	5,777	0	0	1	0	1
Onne (Nigeria)	5,824	0	0	1	0	1
Onsan (South Korea)	12,172	0	1	0	0	1
Oulu (Finland)	4,753	0	0	0	1	1
Oxelosund (Sweden)	4,259	18	15	12	10	55
Paldiski-Port Of Tallinn (Estonia)	4,420	0	0	1	0	1
Panama (Panama)	3,684	1	0	1	1	3
Panama Canal (Panama)	3,684	0	0	1	0	1
Panama City (Panama)	3,684	1	0	0	0	1
Paramaribo (Suriname)	3,639	1	0	0	0	1
Paranagua (Brazil)	6,106	0	2	17	18	37
Pasajes (Spain)	3,591	1	1	0	0	2
Pembroke (United Kingdom)	3,353	0	1	3	5	9
Phu-my (Vietnam)	11,208	0	0	1	0	1
Piraeus (Greece)	5,116	3	0	2	0	5
Point Lisas (Trinidad)	3,350	0	0	2	1	3
Pointe a Pierre (Trinidad and Tobago)	3,350	0	1	1	0	2
Pointe-a-Pitre (Guadeloupe)	3,023	1	0	0	0	1
Ponta Delgada (Portugal)	2,625	0	0	2	0	2
Porsgrunn (Norway)	3,786	4	0	0	0	4
Portland (Unknown)		0	0	1	2	3
Portland (United Kingdom)	3,450	0	0	0	1	1
Porvoo (Finland)	4,499	3	0	0	0	3
Praia da Vitoria (Portugal)	2,620	0	0	0	1	1
Praia Mole (Brazil)	5,528	1	2	1	1	5
Puerto Cabello (Venezuela)	3,392	0	0	0	2	2
Puerto Cortes (Honduras)	3,530	1	0	0	1	2
Puerto Jose (Venezuela)	3,391	0	1	0	0	1
Puerto Quetzal (Guatemala)	4,573	0	0	2	4	6
Punta Lobitos (Peru)	4,506	1	0	1	0	2
Punta Patache (Chile)	5,664	2	0	0	0	2

Table A-1. Last Ports of Overseas Vessels Before Entering the Great Lakes

Last Overseas Port Prior to Entering Either U.S. or Canadian Ports on the Great Lakes	Distance to the Great Lakes (nm)[a]	Number of Overseas Vessels Entering U.S. and Canadian Great Lakes Ports				Total Number of Vessels from the Overseas Port (2010 – 2013)
		2010	2011	2012	2013	
Raahe (Finland)	4,753	1	0	1	1	3
Rades (Tunisia)	4,429	1	0	0	0	1
Recife (Brazil)	4,724	2	0	0	1	3
Redcar (United Kingdom)	3,591	0	1	0	0	1
Reydarfjordur (Iceland)	3,121	0	0	1	0	1
Richards Bay (South Africa)	8,371	6	5	1	4	16
Riga (Latvian)	4,391	0	1	0	4	5
Rio de Janeiro (Brazil)	5,797	0	0	1	0	1
Rio Haina (Dominican Republic)	3,062	1	0	0	0	1
Rostock (Germany)	4,031	2	1	1	2	6
Rotterdam (Netherlands)	3,745	3	2	2	8	15
Saint Croix (U.S. Virgin Islands)	2,948	0	1	0	0	1
Saint Eustatius (Netherlands)	2,953	0	0	0	1	1
Saint Petersburg (Russia)	4,613	0	4	2	0	6
Saldanha Bay (South Africa)	7,520	0	0	0	1	1
San Juan (Puerto Rico)	2,900	4	2	2	3	11
San Pedro (Ivory Coast)	5,000	0	1	0	1	2
Santander (Spain)	3,508	0	0	1	0	1
Santos (Brazil)	5,984	3	2	5	7	17
Sauda (Norway)	3,598	4	1	8	6	19
Seville (Spain)	3,623	1	0	0	0	1
Sillamae (Estonia)	4,451	1	1	0	0	2
Sines (Portugal)	3,418	0	1	2	1	4
Skagen (Denmark)	3,770	0	2	1	1	4
Skoldvik (Finland)	4,499	0	1	0	2	3
Sluiskil (Netherlands)	3,712	0	0	0	1	1
St Croix (Virgin Islands)	2,948	2	1	0	0	3
St Pierre (Saint Pierre and Miquelon)	3,400	0	0	0	1	1
Sydney (Australia)	11,357	1	0	0	0	1
Szczecin (Poland)	4,081	2	1	2	1	6
Tampico (Mexico)	3,809	9	0	0	0	9
Taranto (Italy)	4,868	0	0	1	0	1
Tarragona (Spain)	4,116	4	4	5	1	14
Tees (United Kingdom)	3,591	0	0	2	1	3
Teesport (United Kingdom)	3,591	0	1	0	0	1
Teesside (England)	3,591	0	1	0	0	1
Terneuzen (Netherlands)	3,712	0	0	1	1	2

Table A-1. Last Ports of Overseas Vessels Before Entering the Great Lakes

Last Overseas Port Prior to Entering Either U.S. or Canadian Ports on the Great Lakes	Distance to the Great Lakes (nm)[a]	Number of Overseas Vessels Entering U.S. and Canadian Great Lakes Ports				Total Number of Vessels from the Overseas Port (2010 – 2013)
		2010	2011	2012	2013	
Tilbury (United Kingdom)	3,683	1	0	0	0	1
Tornio (Finland)	4,753	1	0	0	0	1
Tuapse (Russian Federation)	5,926	0	0	2	1	3
unavailable	0	0	1	0	0	1
United Kingdom (United Kingdom)	3,456	0	1	0	0	1
Ust-Luga (Russia)	4,513	2	3	2	0	7
Valencia (Spain)	4,022	0	1	0	0	1
Valletta (Malta)	4,619	0	0	1	3	4
Valparaiso (Chile)	6,299	0	0	0	1	1
Veracruz (Mexico)	3,773	2	0	1	1	4
Vigo (Spain)	3,328	1	1	0	0	2
Vila do Conde (Brazil)	4,134	0	0	0	2	2
Vlissingen (Netherlands)	3,700	2	1	3	1	7
Zelzate (Belgium)	3,725	8	5	9	8	30

Source: National Ballast Information Clearinghouse, Transport Canada, http://www.sea-distances.org/.

[a] Average distance estimated based on the overseas port and Cleveland, Ohio in the Great Lakes from http://www.sea-distances.org/

Table A-2. Overseas Vessels Arriving at U.S. and Canadian Ports en route to the Great Lakes

U.S. and Canadian Great Lakes and St. Lawrence Seaway Ports	Number of Overseas Vessel Arrivals (Per Year)				Total Number of Vessel Arrivals at the Great Lakes Port (2010 – 2013)
	2010	2011	2012	2013	
Ashtabula, OH	4	6	2	5	17
Becancour (Canada)	0	1	0	0	1
Belledune (Canada)	1	0	0	0	1
Buffalo, NY	0	0	0	1	1
Bull Arm (Canada)	0	0	0	1	1
Burns Harbour, IN	4	7	7	4	22
Cheboygan, MI	1	0	0	0	1
Chicago, IL	4	3	2	2	11
Clarkson (Canada)	0	1	0	1	2
Cleveland, OH	22	23	25	32	102
Cote-Sainte-Catherine (Canada)	0	1	1	0	2
Detroit, MI	4	5	5	5	19
Duluth-Superior, MN	15	7	9	12	43
Erie, PA	0	1	0	0	1
Goderich (Canada)	1	0	0	1	2
Green Bay, WI	0	0	2	1	3
Gros Cacouna (Canada)	1	0	0	0	1
Halifax (Canada)	0	1	0	1	2
Hamilton (Canada)	29	27	39	41	136
Harbour Grace (Canada)	1	0	0	0	1
La Baie (Canada)	0	2	0	0	2
Marathon (Canada)	1	1	0	0	2
Menominee, MI	2	1	1	1	5
Milwaukee, WI	5	1	0	2	8
Montreal (Canada)	115	62	78	94	349
Monroe, MI	0	0	1	0	1
Muskegon, MI	0	0	5	0	5
Nanticoke (Canada)	6	15	14	6	41
Ogdensburg, NY	0	0	8	0	8
Oshawa (Canada)	3	1	2	0	6
Port Alfred (Canada)	1	0	0	1	2
Quebec City (Canada)	1	2	1	1	5
Sarnia (Canada)	10	6	6	5	27

Table A-2. Overseas Vessels Arriving at U.S. and Canadian Ports en route to the Great Lakes

U.S. and Canadian Great Lakes and St. Lawrence Seaway Ports	Number of Overseas Vessel Arrivals (Per Year)				Total Number of Vessel Arrivals at the Great Lakes Port (2010 – 2013)
	2010	2011	2012	2013	
Sault Ste Marie (Unknown)[a]	0	0	3	1	4
Sault Ste. Marie (Canada)	5	5	2	2	14
Sault Ste. Marie, MI	0	0	0	1	1
Sorel-Tracy (Canada)	1	1	1	1	4
St Lawrence Seaway	1	2	2	3	8
Thunder Bay (Canada)	5	7	7	2	21
Toledo, OH	5	7	6	10	28
Toronto (Canada)	10	14	41	34	99
Trois Rivieres (Canada)	0	0	0	2	2
Valleyfield (Canada)	20	16	12	8	56
Welland (Canada)	0	1	0	2	3
Windsor (Canada)	11	11	5	2	29

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] These records did not include Latitude or Longitude to indicate either Canadian or U.S. port.

Table A-3. Amount of Ballast Water Discharged by Overseas Ballast Water Source Port

Overseas Port Where Ballast Water was Loaded	Ballast Water Discharges (Metric Tonnes)[a]				Total Amount of Ballast Discharged into Great Lakes from Overseas Ports (2010-2013)[a]
	2010	2011	2012	2013	
Aalborg	1,846	0	0	0	1,846
Aarhus	2,169	4,299	776	0	7,244
Abidjan	0	0	0	845	845
Agadir	0	0	0	1,421	1,421
Algiers (Algeria)	2,440	0	0	0	2,440
Almeria	0	24	0	0	24
Altamira	0	645	0	0	645
Amsterdam	290	0	0	170	460
Amsterdam (Netherlands)	11,527	0	0	0	11,527
Anchorage	2,079	0	0	0	2,079
Annaba	14,620	0	0	0	14,620
Antwerp	6,279	5,172	0	3,866	15,317
Arzew	0	0	1,126	0	1,126
Aviles	0	0	9,590	0	9,590
Baltic Sea	0	230	0	0	230
Baltiysk	0	0	159	0	159
Bari	19,398	0	0	0	19,398
Barranquilla	0	40	0	0	40
Batangas	0	362	0	0	362
Bayonne	406	0	0	0	406
Beira	2,984	0	0	0	2,984
Bejaia	17,092	0	0	0	17,092
Bilbao	1,589	0	430	0	2,018
Birkenhead	0	165	0	0	165
Borg Havn IKS	0	9,422	0	0	9,422
Braefoot Bay	1,268	0	0	0	1,268
Brake	611	0	0	0	611
Brake (Germany)	611	1,636	400	0	2,647
Bremen	0	0	585	0	585
Brunsbuttel	0	2,786	0	235	3,021
Brussels	145	0	1,774	253	2,172
Buenaventura	5,607	0	0	0	5,607
Cadiz	0	0	0	17,512	17,512

Table A-3. Amount of Ballast Water Discharged by Overseas Ballast Water Source Port

Overseas Port Where Ballast Water was Loaded	Ballast Water Discharges (Metric Tonnes)[a]				Total Amount of Ballast Discharged into Great Lakes from Overseas Ports (2010-2013)[a]
	2010	2011	2012	2013	
Cartagena	0	0	0	4,959	4,959
Cartagena (Spain)	0	0	0	4,609	4,609
Casablanca	0	0	45	0	45
Ceuta	60	0	0	334	394
Ceyhan	6,763	0	0	0	6,763
Chennai	0	4	0	0	4
Cienfuegos	0	0	0	2,256	2,256
Corunna (Spain)	0	236	0	0	236
Cuxhaven	1,873	0	0	0	1,873
Dakar	8,526	0	0	4,554	13,081
Dar es Salaam	3,868	0	0	0	3,868
Delfzijl	0	240	0	0	240
Diliskelesi	0	0	268	0	268
Dordrecht	4,053	3,857	878	4,310	13,098
Durban	0	0	0	121	121
Emden	50	0	0	243	293
English Channel	742	0	0	0	742
Ensenada	0	2,434	0	0	2,434
Esbjerg	2,211	0	0	0	2,211
Farsund	0	0	0	1,206	1,206
Ferrol	203	0	1,120	0	1,322
Finnsnes	0	0	0	1,616	1,616
Flushing	345	0	2,026	5,024	7,395
Fos	0	0	60	0	60
Freeport	0	0	8	0	8
Freeport (Bahamas)	0	0	8	0	8
Freetown	1,590	0	0	0	1,590
Gandia	0	345	0	607	952
Gavle	0	0	3,096	0	3,096
Gdynia	0	0	5,946	0	5,946
Ghent	16,251	7,297	12,600	7,061	43,209
Gibraltar	3,630	0	410	0	4,040
Greenore	0	0	5,005	0	5,005
Greenore (Irish Republic)	0	0	5,344	0	5,344

Table A-3. Amount of Ballast Water Discharged by Overseas Ballast Water Source Port

Overseas Port Where Ballast Water was Loaded	Ballast Water Discharges (Metric Tonnes)[a] 2010	2011	2012	2013	Total Amount of Ballast Discharged into Great Lakes from Overseas Ports (2010-2013)[a]
Haraholmen	0	40	0	0	40
Havana	20,328	7,776	0	440	28,544
Heroya	0	500	120	0	620
Holla	0	4,223	0	0	4,223
Huelva	14,307	0	0	0	14,307
Hull	1,291	5,350	4,210	22,305	33,156
Immingham	8,536	3,054	0	0	11,590
Inkoo	260	0	0	0	260
Iskenderun	0	0	0	6,986	6,986
Jiangyin	0	0	0	42,443	42,443
Jorf Lasfar	5,182	3,914	0	5	9,100
Kaliningrad	0	0	159	0	159
Kaohsiung	0	274	1,612	0	1,886
Kawasaki	0	0	889	0	889
Kemi	0	112	9,892	0	10,004
Klaipeda	8,602	0	0	0	8,602
Kokkola	1,036	0	0	0	1,036
Kotka	0	0	0	1,000	1,000
Kubikenborg	0	3,140	0	0	3,140
Kvinesdal	0	422	0	0	422
La Guaira	0	0	0	1,412	1,412
La Spezia	0	0	0	1,170	1,170
Lagos	801	0	0	0	801
Lavera	0	420	805	0	1,225
Leghorn	0	80	0	0	80
Lisbon	8,846	100	0	0	8,946
Mantyluoto	0	0	476	0	476
Mantyluoto (Finland)	0	20	3,901	380	4,301
Maracaibo	0	0	0	11,781	11,781
Marina di Carrara	0	0	0	20	20
Milos Island	224	0	0	0	224
Misurata	7,299	0	0	0	7,299
Moa	10,330	0	0	2,701	13,031
Moerdijk	0	519	0	0	519

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Overseas Port Where Ballast Water was Loaded	Ballast Water Discharges (Metric Tonnes)[a]				Total Amount of Ballast Discharged into Great Lakes from Overseas Ports (2010-2013)[a]
	2010	2011	2012	2013	
Mosjoen	0	0	0	4,322	4,322
Mumbai	0	114	0	0	114
Mundra	0	200	0	0	200
Naples	0	0	2,645	750	3,395
Nemrut Bay	0	0	420	0	420
Nordenham	0	0	70	0	70
North Sea	0	200	0	0	200
Nouakchott	15,184	0	0	0	15,184
Nuevitas	0	0	0	2,534	2,534
Onsan	300	0	0	0	300
Oxelosund	0	4,523	0	875	5,398
Paldiski	0	3,732	0	0	3,732
Pecem	0	1,888	0	0	1,888
Pitea	0	40	0	0	40
Pori	0	20	0	0	20
Porsgrunn	104	0	0	0	104
Port Hedland	266	0	0	0	266
Puerto Cabello	870	0	0	22,178	23,048
Puerto Cortes	8,669	0	0	0	8,669
Puerto Quetzal	0	0	865	0	865
Raahe	369	0	0	0	369
Rades	9,484	0	0	0	9,484
Rauma	0	0	0	300	300
Ravenna (Italy)	4,693	0	0	0	4,693
Rio Haina	1,730	0	0	7,562	9,292
Ronnskar	0	0	3,629	0	3,629
Rotterdam	29,009	673	2,488	1,605	33,775
Saganoseki	0	0	2,616	0	2,616
Sagunto	0	0	400	0	400
Saint Petersburg (Russia)	0	48	0	4,793	4,840
Salaverry	6,100	0	0	0	6,100
San Juan	23,115	0	0	2,630	25,745
San Lorenzo (Argentina)	525	0	0	0	525
San Pedro	0	0	0	180	180

Table A-3. Amount of Ballast Water Discharged by Overseas Ballast Water Source Port

Overseas Port Where Ballast Water was Loaded	Ballast Water Discharges (Metric Tonnes)[a] 2010	2011	2012	2013	Total Amount of Ballast Discharged into Great Lakes from Overseas Ports (2010-2013)[a]
San Pedro (Ivory Coast)	0	0	0	180	180
Santander	7,354	0	0	0	7,354
Santos	13,733	0	0	0	13,733
Sauda	0	230	461	0	691
Savona	600	0	0	0	600
Savona-Vado	0	0	2,116	3,483	5,599
Sechelt	0	11,474	0	0	11,474
Sete	0	0	10,006	0	10,006
Setubal	0	243	0	0	243
Shanghai	3,273	0	0	0	3,273
Shannon Estuary	0	0	0	211	211
Skikda	0	0	0	8,807	8,807
Sundsvall	0	1,781	0	5,323	7,104
Swinoujscie	0	0	680	0	680
Sydney	0	0	0	1,062	1,062
Szczecin	2,210	935	1,221	0	4,366
Tananger	222	0	0	0	222
Taranto	0	620	0	0	620
Tarragona	16,646	0	0	7,924	24,570
Tartous	998	0	0	0	998
Tema	0	0	0	6,481	6,481
Tilbury	16,111	0	0	145	16,256
Tornio (Finland)	15	0	0	0	15
Townsville	0	0	180	0	180
Tripoli (Libya)	1,666	0	0	0	1,666
Tuzla	0	0	2,376	0	2,376
Tyne	0	1,074	0	0	1,074
Tyssedal	0	0	0	19,002	19,002
Ulsan	0	0	700	0	700
Umea	0	36	0	0	36
Umm Qasr	0	0	353	0	353
Venice	0	0	0	6,705	6,705
Venice (Italy)	0	0	0	6,878	6,878
Ventspils	59	0	0	0	59

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Overseas Port Where Ballast Water was Loaded	Ballast Water Discharges (Metric Tonnes)[a]				Total Amount of Ballast Discharged into Great Lakes from Overseas Ports (2010-2013)[a]
	2010	2011	2012	2013	
Viana do Castelo	0	0	5,004	0	5,004
Vlissingen	1,360	0	349	1	1,710
Vlissingen Anchorage	0	0	0	1	1
Zelzate	1,656	3,534	3,104	2,168	10,462
unavailable	0	0	0	253	253
unknown	0	0	325	0	325
LAT LON	52,442	25,723	19,095	45,688	142,948
blank	31,934	11,040	5,822	12,280	61,076
Total	**478,866**	**137,264**	**138,641**	**326,164**	**1,080,934**

Source: National Ballast Information Clearinghouse and Transport Canada.

[a] The amounts of ballast water discharged reported in this table represent an upper bound