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**STATUS AND TRENDS OF BALLAST WATER MANAGEMENT
IN THE UNITED STATES**

**FIRST BIENNIAL REPORT
OF THE
NATIONAL BALLAST INFORMATION CLEARINGHOUSE**

Submitted to United States Coast Guard

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LIST OF ABBREVIATIONS

BOB	Ballast On Board
CFR	Code of Federal Regulations
COTPZ	Captain of the Port Zone
EEZ	Exclusive Economic Zone
IMO	International Maritime Organization
MARAD	Maritime Administration
MSIS	U.S. Coast Guard Marine Safety Inspection Survey
mt	metric ton
NABS	National Ballast Survey
NIS	Nonindigenous Species
NISA	The National Invasive Species Act of 1996, P.L 104-332
NOBOB	No Ballast On Board
SERC	Smithsonian Environmental Research Center
USCG	United States Coast Guard

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EXECUTIVE SUMMARY

BACKGROUND

1. Biological invasions by non-native, invasive species are having significant ecological, economic, and human health impacts. Importantly, the rate of new invasions appears to be increasing.
2. For coastal marine ecosystems, the ballast water of ships is known to be an important mechanism for the transfer of non-native species, which are entrained unintentionally at one port and released at another.
3. Under the National Invasive Species Act of 1996 (NISA), Congress requires ships entering U. S. waters from outside the Exclusive Economic Zone (EEZ) to report ballast water management practices, including the retention of ballast water on board. (This reporting requirement excludes ships arriving to the Great Lakes ecosystem, as these are addressed separately by existing regulations.)
4. NISA also requests the masters of these ships to follow a suite of voluntary ballast water management guidelines to reduce the risk of introducing foreign organisms to the waters of the U. S. via discharged ballast water. The guidelines include the following actions:
 - (a) exchanging ballast water obtained from harbors or other coastal areas outside of the U.S. EEZ for mid-ocean water (obtained from areas at least 200 miles from any shore and with at least 2,000 meters of depth) prior to its release in U.S. coastal waters;
 - (b) retention (i.e. no discharge) of unexchanged ballast water that is derived from overseas coastal areas;
 - (c) use of an alternative ballast water management practice determined by the U.S. Coast Guard to be at least as effective as ballast water exchange in preventing invasions by nonindigenous species.
5. Ships are required to submit reports on ballast water management and discharge to the National Ballast Information Clearinghouse (hereafter Clearinghouse), a collaborative effort of the U. S. Coast Guard and the Smithsonian Environmental Research Center for the collection, management, and analysis of nationwide data on ballast water management and coastal invasions, pursuant 33 CFR §151.2045.
6. To determine the rate of compliance with the reporting requirement, the Clearinghouse compares the submitted reports with data on ship arrivals from the database of U. S. Foreign Waterborne Transportation Statistics maintained by the Department of Transportation's Maritime Administration (MARAD). The MARAD database is composed of data collected by the U. S. Customs Service and the Army Corps of Engineers.
7. To determine the rate of compliance with the voluntary ballast water management guidelines, the Clearinghouse analyzes the submitted data and estimates: (a) the number of vessels reporting discharge of ballast water according to ballast management practices (i.e., no exchange, discharge with some exchange, alternative treatment, or retention of ballast water) and, (b) the volume and proportion of discharged ballast water that underwent the various management practices.
8. To verify the accuracy of information reported by vessels, and to further educate the shipping industry about ballast water management requirements and guidelines under 33 CFR §151.2045, the U.S. Coast Guard implemented independent Verification Surveys aboard randomly selected arriving vessels. These surveys were carried out as a pilot program over the past 24 months.

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9. This biennial report is prepared to inform the U.S. Coast Guard, the Secretary of Transportation, and the U.S. Congress of the current status and trends for nationwide ballast water reporting, delivery, and management.

RESULTS

A. Compliance with Reporting

10. Nationwide compliance with reporting was low over the first 24 months (1 July 1999 – 30 June 2001) that mandatory reporting was in effect. Only 30.4% of the vessels that entered U. S. waters from outside the EEZ filed reports with the Clearinghouse, as required by the U.S. Coast Guard.
11. Compliance with reporting varied greatly among geographic regions, during the first 24 months. Compliance rates by region were as follows: Alaska – 20.8%; Caribbean – 16.6%; East Coast – 29.0%; Gulf Coast – 17.1%; West Coast – 66.5%; and Pacific Islands – 50.4% (calculated for Hawaiian ports only, as MARAD data do not include Guam).
12. Among individual Captain of the Port Zones (COTPZs) of the U.S. Coast Guard, compliance with reporting ranged from 87.9% in San Francisco, California to 10.1% in Providence, Rhode Island.
13. For the entire U.S., compliance with reporting did not improve substantially from the first year to the second (28.3% and 32.4%, respectively).
14. Among the three continental U.S. coastal regions, the Gulf Coast showed the least improvement in reporting compliance between years (0.5%) followed by the East Coast (5.2%).
15. On the West Coast (of the contiguous U. S.), compliance with the reporting requirement increased markedly (15.3%) between years, resulting primarily from an increase in California (which receives most ship arrivals). This increase was coincident with implementation of California state law, requiring submission of copies of the federal ballast water management reports to the State Lands Commission and authorizing monetary and criminal penalties for noncompliance.

B. Compliance with Voluntary Guidelines

16. Due to the poor nationwide reporting rate (30.4%), it remains difficult to estimate reliably the temporal and geographic patterns for (a) ballast water delivery and (b) use of the voluntary ballast water management practices.
17. Despite current low nationwide reporting, the National Ballast Survey and the Clearinghouse database were designed explicitly to provide fine-grained information on patterns of ballast water management and delivery by geographic location (port, coast, traffic pattern), time (month, year, and across years) and vessel type. Thus, the system is in place to evaluate and track management patterns across the country.
18. Here, we report some coarse patterns of ballast water management that emerge from the limited reports to date. However, as reporting rates rise and concomitant uncertainty diminishes, the NABS database will better describe the behavior of commercial vessels arriving to the U.S.
19. Of the 28,988 foreign arrivals that submitted reports from 1 July 1999 to 30 June 2001, 73.6% indicated no intention to discharge ballast water within U. S. territory, 12.9% declared no exchange of ballast water prior to discharge, and 13.0% of the reporting vessels declared some degree of ballast water exchange prior to discharge.

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20. Thus, of the 7,652 vessels that reported discharge of ballast water in U.S. waters, about half (51.2%) indicated some degree of mid-ocean exchange and 48.8% indicated discharge with no prior exchange.
21. Nationwide, approximately 29.7% (11.1 million metric tons, or mt) of the ballast water from foreign arrivals was reported as discharged into the U. S. without undergoing any exchange.
22. Of the vessels that reported no intent to discharge ballast water upon arrival, most carried ballast water. Only 12.8% (3,712 of 21,336 vessels) was reported as No Ballast on Board, or NOBOB.
23. Compliance with the voluntary guidelines varied greatly among regions. For the West Coast, most ships that discharged ballast reported it had undergone exchange (72.3% of ships), and most ballast water discharged was reported to have undergone some exchange (85.2% of the total volume). In contrast, on the East Coast, most ships (70.4%) that discharged ballast water reported they had not undertaken exchange, although most of the discharged ballast water had reportedly undergone some exchange (53.3% of total volume).
24. Compliance with voluntary guidelines also varied considerably by port system, or COPTZ. For example: Portland, Oregon received the highest volume of ballast water, (6.60 million mt) of which 91.5% underwent some degree of mid-ocean exchange prior to discharge; Juneau, Alaska had the highest percent of reported discharged ballast water that had undergone some exchange (98.1% of 113,050 mt); and Portland, Maine had the lowest percent of reported discharge that had undergone any exchange (0% of 17,559 mt).
25. Analysis of the locations reported for completion of ballast exchange, using a geographic information system, indicates a significant proportion of the reported exchange occurred in coastal areas (< 200 mi offshore), rather than mid-ocean as requested.

C. Verification Surveys

26. The U.S. Coast Guard pilot program for Verification Surveys is currently being evaluated, to explore the best options to verify accuracy of reporting. The pilot program tested the feasibility of a stratified, random survey that was implemented by U.S. Coast Guard across all 30 COPTZs in the country. The pending analyses will be used to examine both opportunities and constraints associated with ship arrival schedules, availability of personnel for verification, and specific methods.

CONCLUSIONS

27. Nationwide compliance with the mandatory reporting requirement remains low (34.7% for the month of June 2001, and 30.4% for the cumulative two year period) and exhibits no marked improvement over the last 12 months.
28. On the West Coast, compliance with reporting increased over the first 12 months to approximately 75%, coinciding with initiation of state regulations in California that (a) impose penalties for non-compliance and (b) include an active boarding program that targets 20-30% of arrivals. Compliance has increased between the first and second year for California, as well as Washington and Oregon (which have also passed state regulations).
29. Despite increased reporting on the West Coast, this represents only a small fraction (14%) of the nationwide ship arrivals from outside of the EEZ, and reporting did not increase appreciably along the Gulf Coast and East Coast (38% and 30% of all arrivals, respectively).

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30. At the present rate of improvement for reporting, full compliance with reporting will not occur for decades.
31. Many vessels that discharge ballast water in the U.S. are not implementing the voluntary ballast water management guidelines, based upon their reports. However, we cannot estimate accurately the full extent of non-compliance with ballast management guidelines due the very low rate of reporting by foreign arrivals to the U.S.

RECOMMENDATIONS

32. There exist currently numerous impediments preventing accurate measurement of the patterns of ballast water delivery and management in the U.S. Each of these should be the focus of specific action(s) by the U.S. Coast Guard to improve the current national assessment. Only with accurate estimates for ballast water discharge and management patterns can the U.S. Coast Guard (a) assess the effectiveness of regulations in changing ballast water management and (b) identify geographic areas, vessel traffic, or industry sectors for enhanced efforts, including education, to prevent introductions via ballast water.
33. **Of paramount importance, reporting must be improved to characterize the ballast water management of all vessels arriving to the U.S. ports.** This can be accomplished by one of two methods: (a) complete compliance with mandatory reporting by all vessel arrivals or (b) complete reporting by a representative sample of all vessels that results from a carefully designed stratified, random sampling program. The former approach is preferable, as it would yield the highest quality and quantity of data.
34. **The ballast water reporting requirement should be extended to include coastwise ship traffic, and ships should report ballast water management activities for all ports visited.** We believe there remains confusion about which vessels should report, and when they should report on ballast water management. Comprehensive (foreign and coastwise) reporting would remove any uncertainty about which traffic should report, improve overall data quality, and address important gaps in the current program:
 - Many ships enter the U.S. from outside of the EEZ and move coastwise. Although such traffic is meant to report the fate of any ballast water discharged in U.S. waters after entry, under the current reporting requirement, we believe many ships report discharge only for the first port of entry.
 - The transfer of coastal water itself is an important issue, resulting in discharge of large volumes at many ports (e.g., Valdez, Alaska and Chesapeake Bay), and can lead to unwanted biological invasions. Inadequate data exist currently about management and delivery of ballast water that originates within the U.S. (e.g., San Francisco Bay to Chesapeake Bay, Chesapeake Bay to New Orleans) upon which to make management and policy decisions.
 - The use of NOBOB (i.e., relatively empty) tanks for ballast operations upon arrival to the U.S. can result in the discharge of residual organisms from foreign sources that could result in new invasions. The use and management of these tanks, comprising 38.9% of all ballast tanks for reporting ships, is not addressed in the current program. However, reporting at each port (with the current form) would measure the extent, pattern, and potential importance of this practice.
35. **Additional information is required from each ship to better measure ballast water management.** Specifically, the capacity of each ballast tank is needed for the Clearinghouse to calculate directly the percent ballast water exchange, which is erroneous (and therefore unusable) on many ships' reports. In addition, instructions for the reporting form could be improved to illustrate how to prevent common errors associated with reporting of data for ballast water volume and exchange.

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36. **There remains a need for implementation of Verification Surveys, which are designed specifically to verify the accuracy of reporting by vessels.** Verification Surveys should be implemented, using a stratified, random sampling design across the entire country or at selected key ports. This approach is necessary to address accuracy for different geographic regions and vessel types over time.
37. **Fully implement use of the revised U.S. Coast Guard vessel tracking system (MSIS), to create a comprehensive database of key information for all vessel arrivals to each port.** The previous version of MSIS did not include standardized information on last port of call, restricting its utility for analyses by the Clearinghouse, and MARAD's data had significant gaps in some regions.
38. **To the maximum extent possible, encourage electronic submission of ballast water reporting by vessels.** This would serve to increase accuracy of data and reduce the time needed to make resulting data available. Further, electronic submission would reduce the effort required by the shipping industry.

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INTRODUCTION

Biological invasions are fundamentally changing the structure and function of the earth's ecosystems. Invasions result from the transfer and establishment of species outside of their historical range. The extent of invasions has become increasingly clear over the past decade, and many communities are now dominated by invading or nonindigenous species (NIS) in terms of number of organisms, biomass, and ecological processes. At the present time, it is clear that invasions have caused dramatic shifts in food webs, chemical cycling, disease outbreaks, and extinction rates.

There is now great public concern about invasions, driven in large part by observed ecological effects as well as economic impacts, such as crop and fishery losses, associated with invasions. For example, recent estimates suggest the economic impacts of NIS in the U.S. alone exceed \$100 billion per year. Although the impacts of most invasions remain unexplored, there is no doubt that biological invasions have become a major force of ecological change, as well as economic and human health impacts, operating on a global scale.

Recent studies suggest that invasion rates are continuing to increase. For example, the rate of known marine invasions in North America has increased exponentially over the past two hundred years. Furthermore, this pattern appears very robust across various habitats, taxonomic groups, and global regions. This apparent increase in invasion rate, combined with significant impacts, has further elevated public and scientific concerns about invasions in recent years.

In response to the increasing number of invasions, management strategies and policies are being advanced at state, regional, national and international levels. For example, the U.S. Congress has enacted two laws since 1990, and President Clinton signed an Executive Order, to limit the rate and impact of invasions. The Convention on Biological Diversity recognizes biological invasions as a significant threat to biological diversity and is exploring approaches to reduce this threat. Furthermore, many state and local policies are being implemented within the U.S. and elsewhere. Much of this response has focused on steps to prevent future invasions, with some additional effort focused on control and management of established invasions.

In coastal marine ecosystems, commercial shipping is considered to be the largest single transfer mechanism, or vector, for NIS. Historically, species have been transferred unintentionally on the hulls and in ballast of ships, resulting in hundreds to thousands of invasions worldwide. Today, ballast water of ships appears to be the leading source of invasions for coastal habitats in the U.S. and elsewhere. Ballast water is clean water taken on in one port, used for stability and trim during voyages, and discharged to various extents at future ports of call. In 1991, the U.S. alone received >70 million metric tons of ballast water from foreign ports. The use of ballast water by ships results unintentionally in the entrainment and dispersal of species around the globe.

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To reduce the risk of invasions associated with ballast water, vessel masters are being asked to manage their ships' ballast water, using practices that prevent the transport of organisms. The International Maritime Organization (IMO) has issued voluntary guidelines, including the use of open-ocean ballast water exchange, to limit transfer of coastal organisms in ballast water. In essence, ships are asked to flush out their ballast tanks at sea, reducing the concentration of coastal organisms, which have the greatest chance of becoming established at future ports of call. Many member countries have requested or required ships to comply with these guidelines. In addition, alternative treatment methods are at various stages of development and testing throughout the world.

The U.S. Congress has passed two laws that include guidelines and regulations for management of ships' ballast water. Here, we report on the status and trends of ballast water management, as directed by the most recent of these laws.

National Ballast Information Clearinghouse

The National Invasive Species Act of 1996 (NISA) directed the United States Coast Guard (USCG) in conjunction with the Smithsonian Environmental Research Center (SERC) to develop a National Ballast Information Clearinghouse (hereafter Clearinghouse). The Clearinghouse, located at SERC, plays a central role in the organization and analysis of national data concerning the transfer and invasion of nonindigenous species associated with the ballast water of ships.

Under NISA, Congress directed the Secretary of Transportation to promulgate regulations that (a) require vessel masters to report their ballast management practices when entering U. S. waters from beyond the 200 mile Exclusive Economic Zone (EEZ), and (b) describe a suite of voluntary ballast water management practices for use by such vessels. The voluntary guidelines include holding ballast water on board and open-ocean exchange (flushing) of ballast tanks that will be discharged in U.S. waters. The management practices are intended both to minimize the transfer of NIS in ballast water of ships and to reduce the risk of exotic species invasions associated with the release of ballast water.

A key element of NISA involves tracking the effectiveness of voluntary guidelines, as measured by (a) the level of compliance with voluntary guidelines, (b) changes in the rate and patterns of ballast water delivery, and (c) reduction in the rate of ballast-mediated invasions. The Clearinghouse was created to provide these analyses on a national scale.

National Ballast Survey

The Clearinghouse and the USCG have implemented the National Ballast Survey (NABS), to measure ballast water management and delivery patterns for commercial vessels that arrive to U.S. ports from outside the nation's EEZ.

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The NABS was designed explicitly to create a national database on ballast water to be used to measure: (1) rates of compliance with the ballast water reporting requirement; (2) rates of compliance with the voluntary management guidelines for holding or exchanging ballast water; (3) patterns of ballast water delivery and management (including exchange) according to vessel class for geographic region and season of arrival; (4) among-year changes in ballast water management by vessel class and geographic region; and (5) accuracy of data through use of multiple, independent data sources.

The NABS relies on three primary sources of data. These include:

1. Ballast water information reported directly to the Clearinghouse by arriving vessels;
2. Foreign waterborne Transportation statistics collected by the U.S. Customs Service and the U.S. Army Corps of Engineers. The Department of Transportation's Maritime Administration (MARAD) compiles these data on vessel arrivals to U.S. ports. For selected port systems where MARAD data were incomplete, Maritime Exchange data were required.
3. Verification surveys of vessels, arriving from outside the EEZ, conducted nationwide by the USCG.

Each of the data sets serves a specific and important function in the NABS. Use of these data can be viewed as a step-wise process:

- The ship-generated reports (data source 1, above) were intended to create a large, comprehensive data set that includes ballast water history for most vessels arriving to each U.S. port from outside of the EEZ.
- The MARAD data of arrivals at each port can identify all vessels, arriving from outside the EEZ, that are missing in the first data set, providing a measure of under-reporting and thus of compliance with NISA's mandatory reporting requirement.
- The Verification Survey is meant to provide "ground-truthing" for a subset of all arrivals to (1) estimate the accuracy of the first data set and (2) make statistical comparisons of ballast delivery patterns by vessel class, geographic region, and size.

Figure 1 summarizes the functional aspects of the National Ballast Survey. Data are submitted to the Clearinghouse from the multiple sources and entered into a relational database. The database is then queried, and the results are used to describe ship arrival and ballast water management patterns. Every two years, a biennial report of these patterns is to be submitted to the U.S. Coast Guard and Secretary of Transportation, and is used inform the U.S. Congress on implementation of NISA.

Other Clearinghouse Components: Marine Invasions Database and Research Directory

The NABS is only one component of the Clearinghouse. The Clearinghouse functions more generally as a centralized source of national information on marine invasions and on ballast water invasions issues. The following areas are being actively pursued.

- *The National Ballast Survey (NABS)* - Measurement of spatial and temporal patterns of ballast delivery / management for the U.S.;

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- *The National Marine and Estuarine Invasions Database* - Measurement of patterns and rates of coastal marine invasions for the U.S.;
- *Regional databases on invasion ecology* – Characterization of patterns and rates of invasion for selected bays and estuaries (e.g., Chesapeake Bay, San Francisco Bay, Puget Sound, Tampa Bay, Prince William Sound, Coos Bay, etc.).
- *The Aquatic Invasions Research Directory* - Creation of an internet-based, searchable database containing regularly updated international information on people, research, technology, policy, and management issues relevant to ballast water and aquatic invasions.
- *The Ballast Water Exchange Verification Project* Testing and development of *in-situ* and laboratory-based technologies for improved verification of ballast water exchange.

Purpose of Biennial Report

The overall goal of this report is to assess (a) compliance with the ballast water reporting requirement and (b) implementation of voluntary guidelines for ballast water management for the first two-year reporting period of NABS (1 July 1999 – 30 June 2001). The biennial report is meant to inform the U.S. Coast Guard, the Secretary of Transportation, and the U.S. Congress of the current status and trends for nationwide ballast water management and delivery. In addition, the report also provides conclusions about the overall implementation of the national program and recommendations to address critical gaps that currently exist.

APPROACH: ASSESSING COMPLIANCE

Compliance with Ballast Water Reporting

Compliance with the reporting requirement, and compliance with the voluntary guidelines, were assessed at three different geographic scales: national, regional (major coasts), and local port system (U.S. Coast Guard Captain of the Port Zone, COTPZ; Figure 2). Prior to all analyses, data received by the Clearinghouse underwent standard protocols to detect and remove erroneous records, including duplicate reports and numerical outliers beyond the realm of possibility. Further information on these procedures is available upon request.

Figure 3 defines which traffic patterns were included in the present analyses by NABS, illustrating (a) the variety of different shipping routes a vessel might follow before arriving at a U.S. or Canadian port and (b) which ones were included when estimating compliance with mandatory reporting requirements, as outlined in NISA. The following rules were applied to differentiate “foreign” arrivals (those included in the analyses) from “domestic” or “coastwise” arrivals (those excluded), under direction by the U.S. Coast Guard:

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- (1) All arrivals to the Pacific coast, Atlantic coast or Gulf of Mexico coast from countries other than the United States or Canada are designated as “foreign” arrivals.
- (2) Arrivals to or from U.S. island states or protectorates (e.g., Hawaii, Guam, and Puerto Rico) to or from any of the three mainland coasts are considered “foreign” arrivals since they depart the EEZ during transit.
- (3) Vessels that leave the Pacific coast of North America, traverse the Panama Canal, and arrive at the Atlantic or Gulf of Mexico coasts (and vice versa) are deemed “foreign” arrivals.
- (4) Since there are no available records to verify whether a coast-wise transit leaves the EEZ, all within coast transits, as well as those between the Atlantic and Gulf coasts were categorized as “domestic” arrivals.
- (5) For inter-island passage, only vessels that transited from a foreign country’s island to a U.S. state or protectorate were considered “foreign” arrivals.
- (6) Arrivals to the Great Lakes are excluded from the present analysis. These vessels are required to undertake ballast water exchange, and a separate program of the U.S. Coast Guard evaluates compliance for these vessels.

The analysis of compliance with reporting requires knowledge of actual arrivals, allowing the detection of non-reporting ships. For this analysis, we relied upon arrivals data from the Maritime Administration. To validate use of these data, we compared their quality to that of other sources of arrival information. Below, we present briefly the results of this comparison, providing a strong rationale for use of the Maritime Administration data.

Sources of Data on Vessel Arrivals

The Department of Transportation’s Maritime Administration (MARAD) compiles vessel arrival data that are collected by the U. S. Customs Service and the U. S. Army Corps of Engineers. To evaluate the completeness and utility of MARAD’s vessel arrival information, comparisons were made with two other databases 1) USCG Port State Control data from Advance Notice of Arrivals submitted to the COTPZs (creating the USCG or MSIS database) and 2) Maritime Exchange data from selected port systems (Baltimore, Boston, and San Francisco).

Comparison Between USCG and MARAD Databases

For 1998, the total number of vessel arrival reports recorded by the USCG was 85,319. Removal of all records listed as “Not Arrived-No Action Scheduled” reduced the number to 64,129 arrivals for the entire United States. For the same year, MARAD reported 92,379 total vessel arrivals. Removal from the MARAD data of vessels smaller than 300 gross tons, to reflect the same vessel sizes as targeted by the USCG, resulted in a total of 71,226 arrivals. The overall agreement between the two data sets (64,129 vs. 71,226) is good, with a difference of just 10%.

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The MARAD data set includes standardized identification of “Last Port of Call” and “Arrival Port”, data that are essential for tracking shipping patterns for the purposes of the NABS, but which are not consistently entered in the USCG database. The MARAD database thus divides vessel traffic into “Foreign” and “Domestic” arrivals, while there is no easy and reliable way to distinguish foreign from domestic arrivals using the USCG database. With the exception of mainland to island and island to mainland transits, all U.S. to Canada and Canada to U.S. arrivals outside the Great Lakes were designated as “domestic” arrivals in accordance with rules applied to ballast water reports as described in Introduction.

Comparison of MARAD and Maritime Exchange Data

To further test the completeness of the MARAD database, MARAD data were compared with data compiled by the independent Maritime Exchanges of Baltimore, Boston, and San Francisco (Table 1). In general, the agreement between the MARAD and Maritime Exchange estimates of the number of vessels arriving from foreign ports was quite good. For the Port of Baltimore, the data for 1997 and 1998 show nearly identical results. In the comparison with Maritime Exchange data for Boston and San Francisco between 1995 and 1997, MARAD reported somewhat higher numbers of foreign arrivals.

According to MARAD, vessel arrival data have become increasingly more accurate since 1997 (e.g., many fewer “unknown” entries for the ship type data field). The average number of MARAD reports deviated from Maritime Exchange data across all three ports by less than 9.6%. It is not clear how the quality of reporting varies between individual Maritime Exchange offices.

Selection of MARAD Data as the Baseline for Determining Reporting Compliance

The close agreement between the Maritime Exchange and MARAD data for foreign arrivals indicates that the MARAD “foreign arrival” designation is probably a close approximation of the vessel traffic that actually arrives from outside the EEZ. Moreover, the minor differences in total vessel arrivals reported by MARAD and the USCG further suggest that MARAD provides a good overall estimate of total ship arrivals to the U. S. When the extent of reporting, information content, and ease of accessibility were compared for MARAD, USCG, and Maritime Exchange databases, the MARAD database was deemed the most serviceable for use in the National Ballast Survey.

Constraints with MARAD Data and Adjustments

Although MARAD data were generally very good throughout the country, they were not available for a limited number of ports or limited time periods. This was especially problematic for Alaska, Hawaii, and Guam. To preclude over-estimation of reporting rates, the corresponding ballast water reporting forms were excluded from regional and national estimates of reporting compliance for particular months for Alaska and Hawaii

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(so indicated in figures), and compliance with reporting simply could not be estimated for Guam during this period.

For a few other ports, we were able to obtain arrivals data that were missing from MARAD through Maritime Exchanges. Specifically, we obtained arrivals for two months each in Los Angeles and New York from the local sources. In addition, we obtained and used data from local sources to correct inconsistencies (i.e., missing data) within the MARAD data for San Francisco Bay. (Note: While the Maritime Exchanges can provide very useful and high quality data, it is important to recognize that their geographic scope is often limited to a particular port system, and many regions of the country simply do not have these or other local entities that comprehensively track vessel arrivals.)

Compliance with Voluntary Exchange Guidelines

Although some gaps in the MARAD data limited use of all data in measuring compliance with mandatory reporting, all submitted ballast water reporting forms were used to determine the extent to which voluntary ballast water management guidelines were followed.

RESULTS

Compliance with Ballast Water Reporting Requirement

1. Nationwide Vessel Traffic.

The extent of vessel traffic to the U.S. as measured by the cumulative number of foreign MARAD arrivals, varied considerably among coastal regions (Fig. 4). The East Coast and Gulf Coast led the nation in foreign arrivals, accounting for 38% and 30% (respectively) of the 95,471 arrivals from 1 July 1999 to 30 June 2001. The West Coast represented only 14% of total arrivals, the Caribbean accounted for 16% of arrivals, whereas Alaska and Hawaii combined received only 2% of the traffic.

2. Nationwide Compliance.

The nationwide compliance with required ballast water reporting was 30.4% for the period 1 July 1999 to 30 June 2001 (Table 2). The Clearinghouse received 13,266 reports during year 1 and 15,722 during year 2, representing 28.3% and 32.4% compliance (respectively). Thus, less than 1/3 of all vessels required to report ballast water management information upon entry to the United States met this requirement, and there was relatively little improvement between years. When examined on a monthly basis (Figure 5), nationwide reporting rates also show a very slow increase in reporting compliance over the 24 months, occurring mostly in January 2000 (as discussed below).

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3. Regional Compliance.

Among the major mainland coasts, the West Coast (made up of California, Oregon, and Washington) had the highest regional compliance with the reporting requirement for the two-year period: 66.5% of arrivals submitted reports (Figure 6a, Table 2). In contrast, compliance with reporting was only 29.0% for the East Coast and 17.1% for the Gulf Coast during the same period. Hawaii, Alaska, and the Caribbean had 50.4%, 20.8%, 16.6% compliance respectively (Fig. 6b, Table 2).

The rate of compliance for each coast increased from year 1 to year 2 (Fig. 6a,b; Table 2), except for the Caribbean, which experienced decreased compliance (-3.7%). The West Coast had the greatest net increase (15.3%). The net increases for the remaining coastal regions were: Alaska (14.9%), Hawaii (7.9%), East Coast (5.2%), and the Gulf Coast (0.5%).

Monthly reporting rates for each coast also reflected the same patterns over time, showing the greatest improvement for the West Coast (Figs. 6a,b). To better characterize changes in reporting over time, we used linear regressions to measure the rate of change in reporting for the three major coasts, allowing us to estimate the number of years required for each coast to reach 100% compliance. The projected time periods necessary for complete compliance by mainland coasts were: 3.3 years on the West Coast ($y=1.27x+50.7$, $r^2=0.56$), 14.8 years on the East Coast ($y=0.43x+23.6$, $r^2=0.79$), and 58.3 years on the Gulf Coast ($y=0.12x+15.6$, $r^2=0.18$).

Although the overall performance for the West Coast, and the projected time to complete reporting is encouraging, this represents only a small amount (14%) of the total nationwide traffic. Most arrivals occur on the East and Gulf Coasts, for which reporting compliance lagged behind the West Coast and show only slight improvement over the past 24 months.

4. COTPZ Compliance

As with the nation and most regions, compliance with the reporting requirement was highly variable among COTPZs (Table 2). Reporting for COTPZs ranged from 10.1% to 87.9%, equaling or exceeding 50% in only 6 cases: San Francisco, Los Angeles, Seattle, Portland (OR), Honolulu, and Valdez. The relative high reporting and compliance rates for San Francisco and Los Angeles COTPZs may result from state law requiring ballast water reporting and authorizing penalties for noncompliance, effective as of 1 January 2000. It is noteworthy that compliance with reporting was relatively high (38-46%) in California at the start of NABS, compared to the other western states. This may have resulted from increased attention and the passage in October 1999 of a state law with the pending threat of penalty; furthermore, compliance increased markedly in January, when the law went into effect and penalties were possible for failure to report.

The high compliance of the Seattle COTPZ zone (64.5%) and Portland COTPZ (50.3%) may also result from state legislative activity. Washington State passed a law

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concerning ballast water that went into effect in 2001, and Oregon just recently passed a similar measure. In addition, relatively high compliance in Valdez (50.0%) may be associated with a targeted federal law requiring ballast water exchange for oil tankers in that port, as the number of arrivals recorded by MARAD was low and tankers comprised a relatively large fraction of the total for this period. However, MARAD reporting in Alaska was incomplete in the first three months of 2001, possibly influencing the compliance rates measured there.

Interestingly, compliance remains low in Maryland (34.8% in year 2), which passed a similar state law, but has not yet begun to impose penalties for failure to report. It will be instructive to examine compliance over time for states that implement state ballast water laws, particularly during the time periods surrounding the initiation of penalties for failure to report.

Compliance with Voluntary Exchange Guidelines

Under 33 CFR §151.2045, vessel masters were required to report specific information for discharged ballast water originating outside of the EEZ, including (a) whether or not ballast water was exchanged or otherwise treated, and (b) specific details of ballast water management on a per-tank basis, providing the volume, exchange method, and calculated percent of water exchanged. There are thus two possible measures for the rate of implementation of the voluntary guidelines for ballast water management operations. First, implementation of guidelines can be evaluated as the proportion of arriving vessels reporting exchange of all water discharged, or compliance on a *per capita* (ship) basis. Since the guidelines include retention of unexchanged or untreated ballast water, vessels that hold ballast water on board are considered to be in compliance with the voluntary guidelines. Second, implementation can be evaluated as the proportion of discharged ballast water by volume (across all ships) reported to have been exchanged, or the overall effect on the discharge of treated versus untreated ballast water (across the aggregate of reporting vessels).

The voluntary guidelines (33 CFR §151.2035(b)) request that vessel masters carrying ballast water into the waters of the U. S. after operating beyond the EEZ employ at least one of a suite of ballast water management practices. These include exchanging ballast water in areas at least 200 miles from any shore and at least 2,000 meters deep, or in an alternative ballast exchange zone approved by the COPTZ; retaining ballast water on board; using an alternative environmentally sound, USCG approved method of treatment; or discharging ballast water to an approved reception facility. Exchange, under 33 CFR §151.2025, includes flow-through exchange, in which three full volumes of open-ocean water are pumped through a ballast tank, and empty-refill exchange, in which a ballast tank is emptied completely and then refilled with mid-ocean water. Thus, for exchanged ballast water, full compliance with these voluntary guidelines includes water that has been exchanged 100% (one full tank volume) by empty-refill or 300% (three full tank volumes) by flow-through methods, or otherwise treated, or retained on board.

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Although the Clearinghouse database was designed explicitly to measure percent exchange and exchange method for each tank (per vessel), examination of the ballast water management reports submitted by vessels revealed many errors in the ships' reports. It appears that widespread confusion existed among ships crews regarding how to determine and report the percent of water exchanged. Furthermore, many reports did not indicate (as requested) whether the performed exchange was empty-refill or flow-through. Consequently, it was often not possible to determine whether a reported complete exchange was accomplished by pumping one or three full volumes of open-ocean water through a tank, or the method of exchange employed. Therefore, for discharging vessels, the extent of exchange was categorized as "Discharge with No Exchange", "Discharge with Some Exchange" and "Discharge with Unknown Exchange" (see below for further discussion of limitations to precise calculation and reporting of percent exchange).

Caution: Ideally, with a high level of reporting, the ballast water management reports submitted by vessels could be used to estimate the amount of treated and untreated (exchanged or otherwise) water discharged in the U. S. However, compliance with the reporting requirement was so low, only 30.4%, that reporting vessels cannot be considered representative of the larger population of all arriving ships entering U. S. waters.

Compliance with Voluntary Guidelines by Ship

1. National Compliance

Most (73.6%) of the reporting vessels indicated no intention to discharge ballast water (Tables 3a,b). Of the 28,988 vessels filing reports, only 7,652, or 26.4%, declared discharge of foreign ballast water within U. S. territory: 12.9% declared that no exchange had been conducted, while 13.0% of the reporting vessels declared some exchange (and the residual did not specify). Therefore, of the vessels that reported, 86.6% indicated they had followed the voluntary guidelines, either through retaining ballast water on board or by exchanging ballast water prior to discharge.

Although most reporting vessels did not discharge ballast water, it is noteworthy that of the 7,652 vessels that did report an intention to discharge, only about one half of these vessels reported some mid-ocean exchange prior to ballast water discharge. This pattern remained relatively constant throughout the 2 year of reporting (Fig. 7).

2. Regional Compliance

By region, the percent of reporting vessels that declared no discharge varied from 90.6% in Hawaii (89.7% for the Pacific Islands if Guam is included) to 21.0% in Alaska (Tables 3a,b).

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The West Coast reported the highest proportion of discharging vessels that underwent some exchange (73.9%) and the Caribbean reported the lowest proportion (20.3%), whereas the East and Gulf Coasts were intermediate (26.5% and 49.9% respectively; Fig. 8).

3. COTPZ Compliance

At the Captain of the Port Zone level, Los Angeles received the greatest percentage of the nation's ballast water reporting forms (6,099 forms, 21.0% of total) between 1 July 1999 and 30 June 2001. Miami received 3,878 forms (13.4%), and San Juan, Puerto Rico received 1,896 forms (6.5%). In Los Angeles 1,454 vessels reported discharge, of which 36.6% had no mid-ocean exchange and 61.6% had some exchange prior to discharge. This pattern was reversed in Miami (1,533 discharging vessels, 84.3% with no exchange, 15.1% with some exchange) and San Juan (433 discharging vessels, 79.4% with no exchange, 20.3% with some exchange) (Tables 3a, 3b). These results indicate very different ballast management practices and discharge patterns among the COTPZs that receive the greatest number of foreign arrivals.

Compliance Based on Percent Exchange by Volume

While the preceding approach provides an assessment of compliance on the basis of individual ships, from a biological perspective an important compliance measure is the proportion of discharged water that was exchanged. The ballast water reports submitted by vessels identify, on a per tank basis, the percent exchange accomplished for each tank discharged. However, it is clear from the ballast water reporting forms submitted that there is widespread confusion on how percent exchange is calculated and reported, despite detailed published instructions. Additionally, the current ballast water reporting form does not require that the capacity of all discharged ballast tanks be specified, precluding a crosscheck of reported percent exchange values. These constraints limited the resolution at which ballast water exchange could be analyzed and necessitated that ballast water exchange be categorized as "Discharge with No Exchange", "Discharge with Some Exchange", or "Discharge with Unknown Exchange".

1. Nationwide Compliance

Approximately 37.3 million metric tons (mt) of discharged ballast water was reported nationally (Table 4). Of this total, 25.6 million mt (68.7%) was reported to have undergone exchange, and 11.1 million mt (29.7 %) was reported as unexchanged (Table 4). Reported ballast water management practices and discharge patterns were relatively constant during the first 24 months of the mandatory reporting period (Fig. 9).

2. Regional Compliance

As with exchange practices on a per ship basis, the percent of the discharged volume that had undergone some exchange varied across the major regions (Fig. 10, Table 4). By

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volume, the region with the highest proportion of discharged volume that underwent some degree of exchange was the West Coast. The lowest volumetric proportion of discharge that underwent some exchange was in Alaska (Fig. 10).

3. COTPZ Compliance

There were four COTPZs that reported discharging greater than 1 million mt tons of non-exchanged water: Anchorage (1.89 million mt), Los Angeles (1.33 million mt), Houston (1.19 million mt), and Miami (1.05 million mt). This non-exchanged ballast water discharge made up the majority of all discharge in Miami (88.4%), Anchorage (79.3%), and Houston (50.6%) (Table 4). Conversely, seven COTPZs discharged more than 1 million mt of ballast water that had undergone some degree of exchange. These COTPZs were: Portland, Oregon (5.62 million mt, 91.5% of discharge), Los Angeles (4.71 million mt, 76.9% of discharge), New Orleans (3.15 million mt, 77.7% of discharge), Seattle (2.59 million mt, 89.1% of discharge), San Francisco (1.81 million mt, 85.8% of discharge), Hampton Roads, Virginia (1.34 million mt, 76.7% of discharge), and Houston (1.10 million mt, 46.9% of discharge). Juneau, Alaska, and Wilmington, North Carolina had the highest percentages of discharged ballast water reported to have undergone some exchange (110,873 mt, 98.1% of discharge and 294,633 mt, 92.2% of the discharge, respectively). Conversely, over 90% of the ballast water discharged into Portland, Maine and Jacksonville had not undergone any exchange at all.

Reasons for Not Conducting a Mid-Ocean Exchange

If a ballast water exchange was not performed prior to discharge, ships' masters were asked to provide the reason(s), on the ballast water reporting form. The open-ended nature of the question resulted in a large number of unique responses, complicating an analysis of the reasons for not exchanging ballast water. However, pooling the responses by loose categories (Table 5) suggests that an overt concern for the safety of the vessel and crew was not the over-riding reason for the low rate of ballast water exchange. Of the 1,208 vessels that reported discharging ballast water without exchanging, only 56 vessels or 4.6% of the vessels cited "safety", or some variant of the term or phrase as a reason for not conducting an exchange. A frequent reason cited for not conducting ballast water exchange was that the ship's itinerary precluded such an operation. In many such cases, there may have been an insufficient period of time during the voyage to conduct a complete exchange, either because the voyage was too short to permit an exchange, or the ship's route did not include areas 200 miles from shore and 2,000 meters deep.

Geographic distribution of ballast water exchange

Vessel masters are required to report the latitude and longitude for the end points of ballast exchange operations. These data were used with geographic information system software to construct a map showing the spatial distribution and density of exchange operations on a global scale (Fig. 11). Bathymetric data describing ocean depths of less

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than 2,000 meters were overlaid with ocean areas that were equal to or less than 200 nautical miles from land, creating a map of locations restricted by the mid-ocean exchange guidelines in NISA. The end-points of reported tank exchanges were then plotted on the map. The central regions of the Pacific and Atlantic oceans are clearly the sites of much of the exchanged ballast water discharged to U. S. waters, as requested in the voluntary guidelines. However, many points lie within the shaded, or restricted, areas, indicating that a portion of the ostensibly “exchanged” water that is discharged into the U. S. comes from locations in proximity to coasts. Perhaps the clearest examples of this can be seen in the Gulf of Mexico and along the Pacific coast of Mexico and Central America. Some of the incidences of exchanging ballast close to foreign coastlines may stem from a misunderstanding among ship’s masters that the guidelines request that water be exchanged 200 miles or more from any coast, not just from the U. S. coast. The shipping routes to the Gulf of Mexico from Mexico, Central America, the Caribbean, and portions of South America are likely highly constrained with respect to where mid-ocean exchange can take place, as few locations may meet the specified distance and depth criteria for exchange.

Verification Surveys

The U.S. Coast Guard implemented a pilot program for Verification Surveys. The survey was designed to randomly target vessel arrivals for boarding, based upon COPTZ, covering the entire coastal U.S. For each of 30 COTPZ, the target was set at 24 boardings per year for each of five ship types (Bulk Carrier, Container, General Cargo, Tanker, and Other). Thus, if all boardings were conducted, this would provide a ground-truthing for 3,600 arrivals each year.

The results of the pilot program are currently being evaluated to consider the best strategies available to verify accuracy of reporting. Although the Verification Surveys likely provided an important outreach and training activity by U.S. Coast Guard, the actual number of boardings by USCG was variable in space and time, and sometimes fell short of the anticipated goal. The shortfall resulted from both an uneven distribution of vessel arrivals (spatially and temporally) and, in some cases, conflicting demands upon USCG personnel.

Non-discharged Ballast Tanks: Fate and Potential Importance?

Approximately 70% of vessels that reported on ballast water management indicated no intent to discharge ballast water (Tables 3a, 3b). However, most of these vessels carried ballast water upon arrival: 87.2% of all reporting arrivals carried ballast water, and only 12.8% indicated “No Ballast on Board” (NOBOB; Table 6). The fate of this ballast water remains unknown.

Ships are required to report the fate of all ballast water to be discharged in the U.S. that originates from outside the EEZ (i.e., foreign ballast water). Nearly all reporting ships submit their report at the port of first entry. At this time, ships are to indicate the

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discharge of all foreign ballast water at the first port of entry, as well as all future ports, in the U.S. Should the actual pattern of discharge change from the projected plan, ships are required to submit an amended report to the Clearinghouse.

Many ships visit multiple U.S. ports after arrival from outside the EEZ, becoming coastwise traffic. In fact, nearly half (45.7%) of the 28,992 arrivals that reported ballast water management visited multiple U.S. ports upon arrival. However, ships rarely reported ballast water discharge to the Clearinghouse beyond the initial port of entry and amended forms were also rare. Although this may accurately represent ballast water discharge for these vessels, it may also result from confusion about the reporting requirement and underestimate actual ballast water discharge.

A related issue arises when considering empty ballast tanks that are used for ballast operations, including discharge, within the U.S. Although 12.8% of vessels are reported as NOBOB, 38.9% of all ballast tanks for reporting vessels were in NOBOB condition (Table 6). For vessels that reported at least one NOBOB tank, the average number of tanks/ship with and without ballast water were no different: 8.5 and 8.6, respectively (Table 7).

Although there are currently no guidelines in effect for ballast water management associated with NOBOB tanks, recent concerns have surfaced in the Great Lakes that use of NOBOB tanks after entry into U.S. waters may pose significant risks of introducing NIS. Specifically, although NOBOB tanks are relatively empty, they may still contain residual organisms that can be re-suspended and discharged by ballast operations. The extent to which vessels arriving to the U.S. from overseas use NOBOB tanks in subsequent ballast operations, either during coastwise movements or within the port of arrival, remains unknown.

CONCLUSIONS

Ballast Water Reporting

Nationwide compliance in reporting ballast water management by commercial ships was low and showed little improvement over the first 2-year period of mandatory reporting. For June 2001, the last month of the two-year period, the nationwide compliance with reporting was low, only 34.7% of arrivals subject to the reporting requirement.

Although compliance did improve markedly along the West Coast (composed of California, Oregon, and Washington) over the past 24 months, coinciding with initiation of state regulations, this represents only a small proportion (14%) of the nationwide vessel arrivals subject to reporting. In contrast, compliance in reporting for the East Coast and Gulf Coast, which together account for 68% of vessel arrivals required to report, showed little change during the same time period. Thus, at the present rate of improvement in reporting, full compliance will not occur for many decades.

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There remain some significant gaps in the MARAD data for Hawaii, Alaska, and Guam, making it difficult to accurately assess compliance with reporting for these locations. Although this has little impact on the overall pattern for the country, as these coasts account for only a small fraction (2%) of the cumulative vessel arrivals, it does limit assessment of compliance for these regions at the present time.

Ballast Water Management

Despite our summary of existing reports, it is currently not possible to assess ballast water delivery and management patterns for the U.S., because the rate of under-reporting is so severe: Most (69.6%) of vessel arrivals required to report simply failed to do so. Thus, the ballast management of most ships remains unknown, and it cannot be assumed the 30.4% of arrivals that do report are in any way representative of the entire population. Of ships that did report, most (>70%) reported no discharge of ballast water and were therefore following the voluntary guidelines. Of those that reported discharge, approximately half of the vessels indicated no exchange had occurred prior to discharge.

Analysis of the geographic locations of the ballast exchange endpoints as recorded by the reporting vessels indicated that an appreciable proportion of the exchanges had occurred within 200 miles of coastlines. This may be due to misunderstanding on the part of vessel masters that exchange is requested to occur at least 200 miles away from any coast, not just the U. S. coast.

General

Overall, the low level of reporting remains a significant problem for (a) interpreting compliance with voluntary guidelines and (b) tracking the ballast water delivery and management patterns for the country. Reporting by ships must increase dramatically to meet these objectives. However, there exist some additional factors, which prevent the current program from achieving its goals, including:

- Ballast water reporting requirements currently exclude a large component of vessel traffic in the U.S. and (even if compliance improves) therefore provides an incomplete picture;
- No Verification Surveys are currently in effect to verify the accuracy of reporting;
- Ballast water reports submitted by the ships often contained errors in the estimation of ballast water exchange;
- Tracking of vessel arrivals by MARAD and the U.S. Coast Guard still has some significant gaps;
- Use of electronic data submission by ships remains low.

Each of these elements should be the focus of specific action by the U.S. Coast Guard to improve the current program, allowing it to meet the objectives outlined in NISA. Below, we provide recommendations for action in each area.

RECOMMENDATIONS

1. Improve Ballast Water Reporting by Ships to Provide Representative Data.

A significant problem remains in acquiring the data necessary to measure ballast water delivery and management patterns for the country. In the present program, this exists as a severe lack of reporting by most vessels expected to submit information.

To address this problem, the U.S. Coast Guard has two possible avenues. First, the U.S. Coast Guard could take steps to maximize compliance with mandatory reporting by all vessels subject to the requirement. Alternatively, the U.S. Coast Guard could require or obtain complete reporting on a representative subset of vessels.

The former approach is most preferable, as it would result in the highest quality and quantity of data. In contrast, the latter involves a representative sampling of vessels and would require a stratified, random subsample of all vessels by vessel class, geographic location, and time (season and year). Although this second approach is theoretically feasible, it may require a large sample size, given the relatively large amount of variation in ballast water management that we expect among vessels, locations, and seasons.

2. Extend the Ballast Water Reporting Requirement to include (a) Coastwise Traffic and (b) Better Reporting for each Port of Arrival.

For a variety of reasons, the current reporting requirement misses a significant amount of vessel traffic and ballast water delivery.

- Many ships enter the U.S. from outside of the EEZ and move coastwise. Although such traffic is meant to report the fate of any ballast water discharged in U.S. waters after entry, under the current reporting requirement, we believe many ships report discharge only for the first port of entry.
- The transfer of ballast water from coastal (i.e., domestic) sources is an important issue by itself, resulting in discharge of large volumes at many ports (e.g., Valdez, Alaska and Chesapeake Bay), and can lead to unwanted biological invasions. Relatively little is known about management and delivery of ballast water that originates within the U.S. (e.g., San Francisco Bay to Chesapeake Bay, Chesapeake Bay to New Orleans). This information gap precludes the formation of critical management and policy decisions.
- The use of NOBOB (i.e., relatively empty) tanks for ballast operations upon arrival to the U.S can result in the discharge of residual organisms from foreign sources (that can result in new invasions). The use and management of these tanks, comprising 38.9% of all ballast tanks for reporting ships, is not

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addressed in the current program. However, comprehensive reporting for each port (with the current form) would measure the extent, pattern, and potential importance of this practice.

We believe there remains significant confusion about which vessels should report and when they should report. Comprehensive (foreign and coastwise) reporting would remove any uncertainty about which traffic should report, improve overall data quality, and address important gaps in the current program.

3. Implement Verification Surveys to Assess Accuracy of Reporting by Vessels.

There remains a need for Verification Surveys, designed specifically to assess the accuracy of reporting by vessels. As a minimum, this requires design and implementation of a random, stratified sampling of vessel arrivals across the country, to include different vessel classes, geographic locations (ports), and seasons. This is the basic design of the pilot program for a Verification Survey, implemented by the U.S. Coast Guard. Particular attention should be given to resources (i.e., dedicated staff) necessary to complete this survey, including (a) targeted use of Clearinghouse staff for surveys during selected time periods and (b) use of selected key ports to represent broader geographic regions.

4. Obtain Data on Ballast Tank Capacities.

Additional information is required from each ship to estimate ballast water management. Many errors exist on the ships' reports of "percent ballast water exchanged". As a result, we often cannot reliably estimate the percent of ballast water exchange performed on a "by tank" or "by vessel" basis. To correct this problem, we recommend two changes. First, the current reporting form should be modified, or some other mechanism implemented by U.S. Coast Guard, to obtain capacity for each ballast tank aboard reporting ships. Tank capacity is needed to calculate directly the percent ballast water exchange. Second, instructions on how to estimate percent ballast water exchange for the reporting form should be modified to include descriptions of common errors and how to avoid them.

5. Improve U.S. Coast Guard database for Vessel Arrivals.

Although vessel arrival data collected by MARAD provide good quality data for most ports, significant gaps existed for Hawaii, Alaska, and Guam. The U.S. Coast Guard routinely collects such data on arrivals via the Advanced Notice of Arrival, in which ships are required to report key information prior to arrival. Furthermore, the U.S. Coast Guard maintains these data in their own database. However, up until now, the U.S. Coast Guard data for each vessel arrival did not consistently include standardized identifications of the last port of call, making these data of limited utility for

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Clearinghouse analyses. Specifically, the arrivals database could not be used to distinguish foreign versus coastwise traffic.

In October 2001, the U.S. Coast Guard database began to include standardized input to the critical field of “last port of call”. Should this new system be implemented fully, it will create a valuable resource of data on all arrivals. We recommend that the U.S. Coast Guard encourage full implementation (i.e., entry of standardized last port of call data for all arrivals). Maritime exchanges often collect excellent arrivals data, offering an alternate source of information, but there exist only a limited number of exchanges and these cannot currently provide nationwide coverage for all arrivals. Thus, in our view, full implementation of the U.S. Coast Guard database offers the best opportunity to remove the existing gaps in the data on vessel arrivals.

6. Promote use of Electronic Reporting.

At the present time, most ships send reports to the Clearinghouse by FAX or mail. However, the use of electronic submission would greatly reduce the time required by ships to submit forms, since many fields of information remain unchanged at each submission. Electronic submission also would increase accuracy (removing problems associated with legibility), and reduce the effort in data entry and time needed to make the data accessible.

The Clearinghouse provides mechanisms for electronic submission, including (1) transmission of MS Excel™ or MS Word™ files via email and (2) use of an on-line form. Multiple modes for electronic submission have been in place on the Clearinghouse website (<http://invasions.si.edu/ballast.htm>) for the past 18 months.

We recommend that the U.S. Coast Guard promote and encourage, to the maximum extent possible, the electronic submission of data.

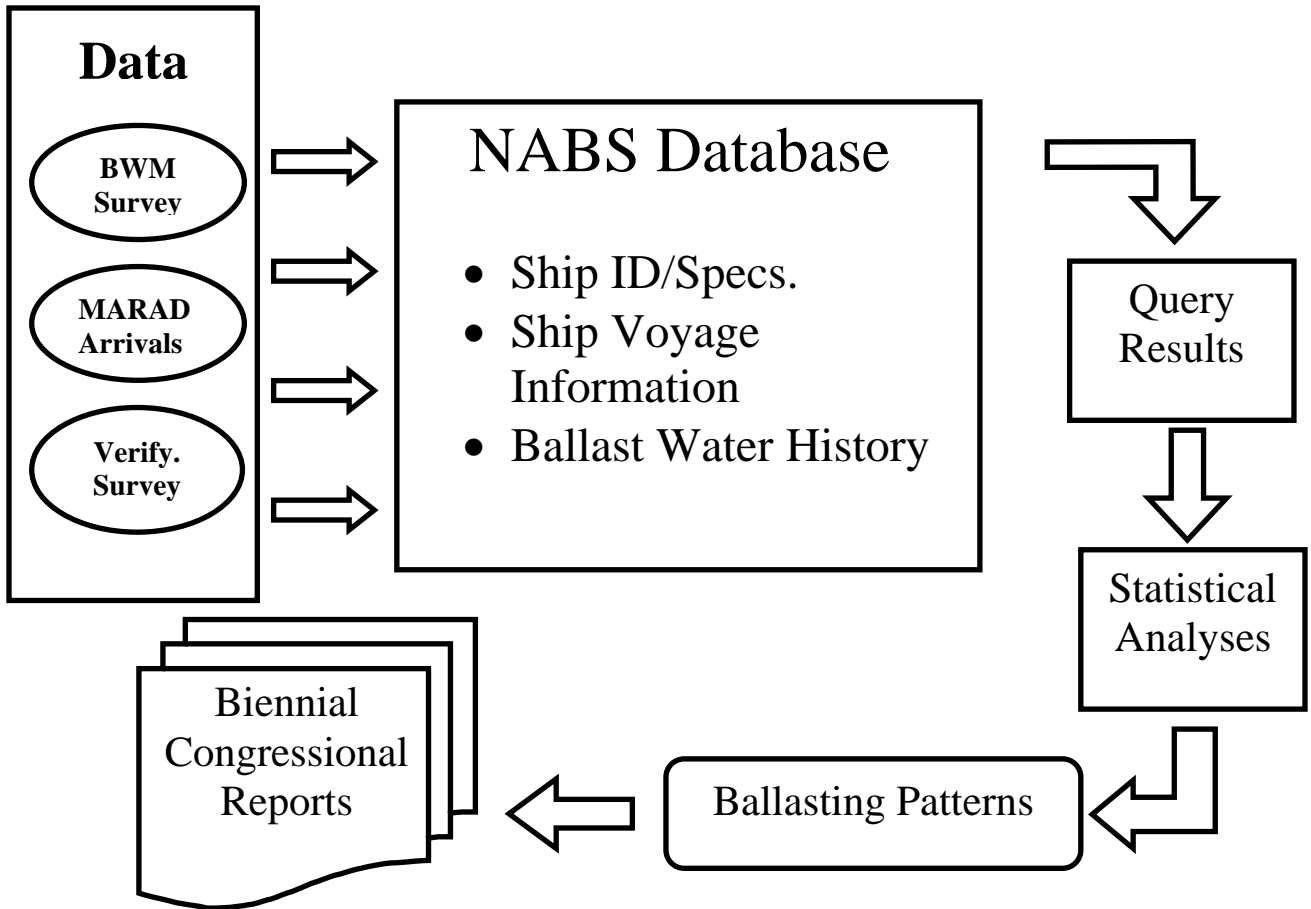


Figure 1. Flowchart describing the functional aspects of the National Ballast Survey (NABS).

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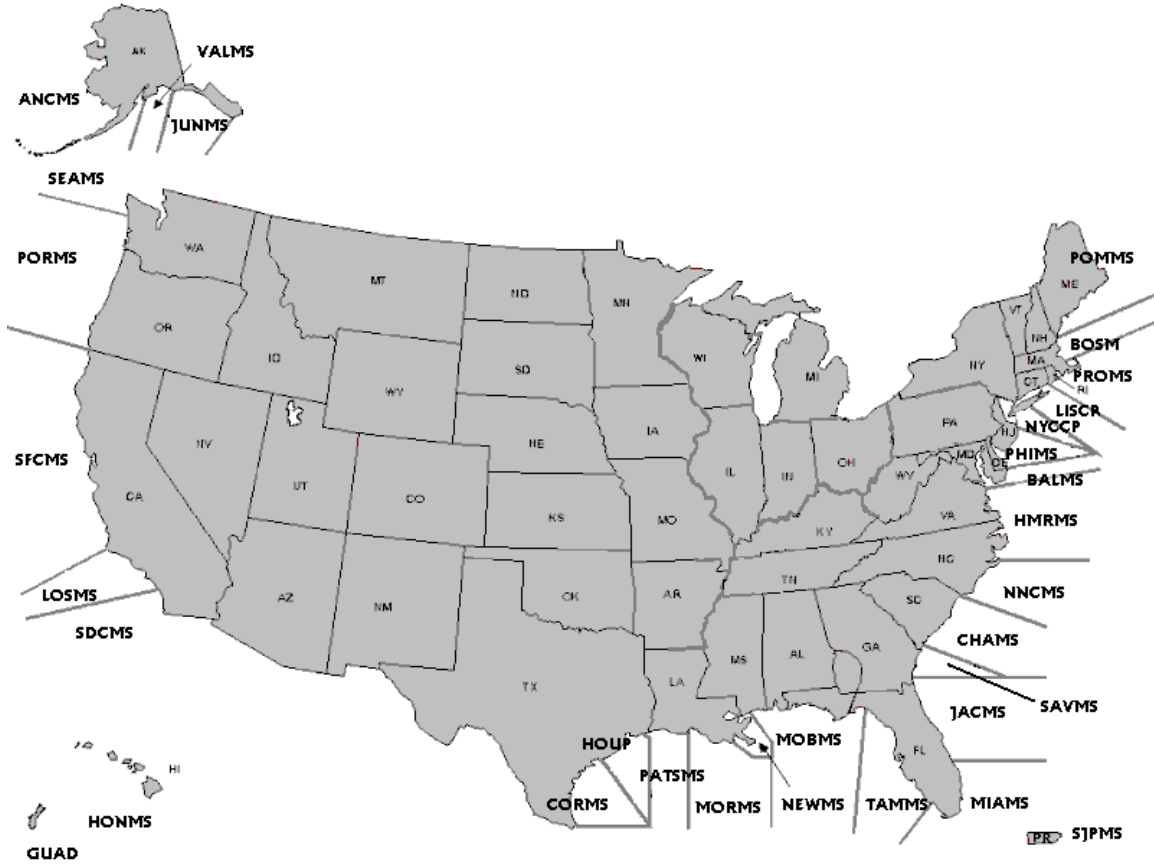


Figure 2. Captain of the Port Zone (COTPZ) designations for all coastal marine ports of the United States.

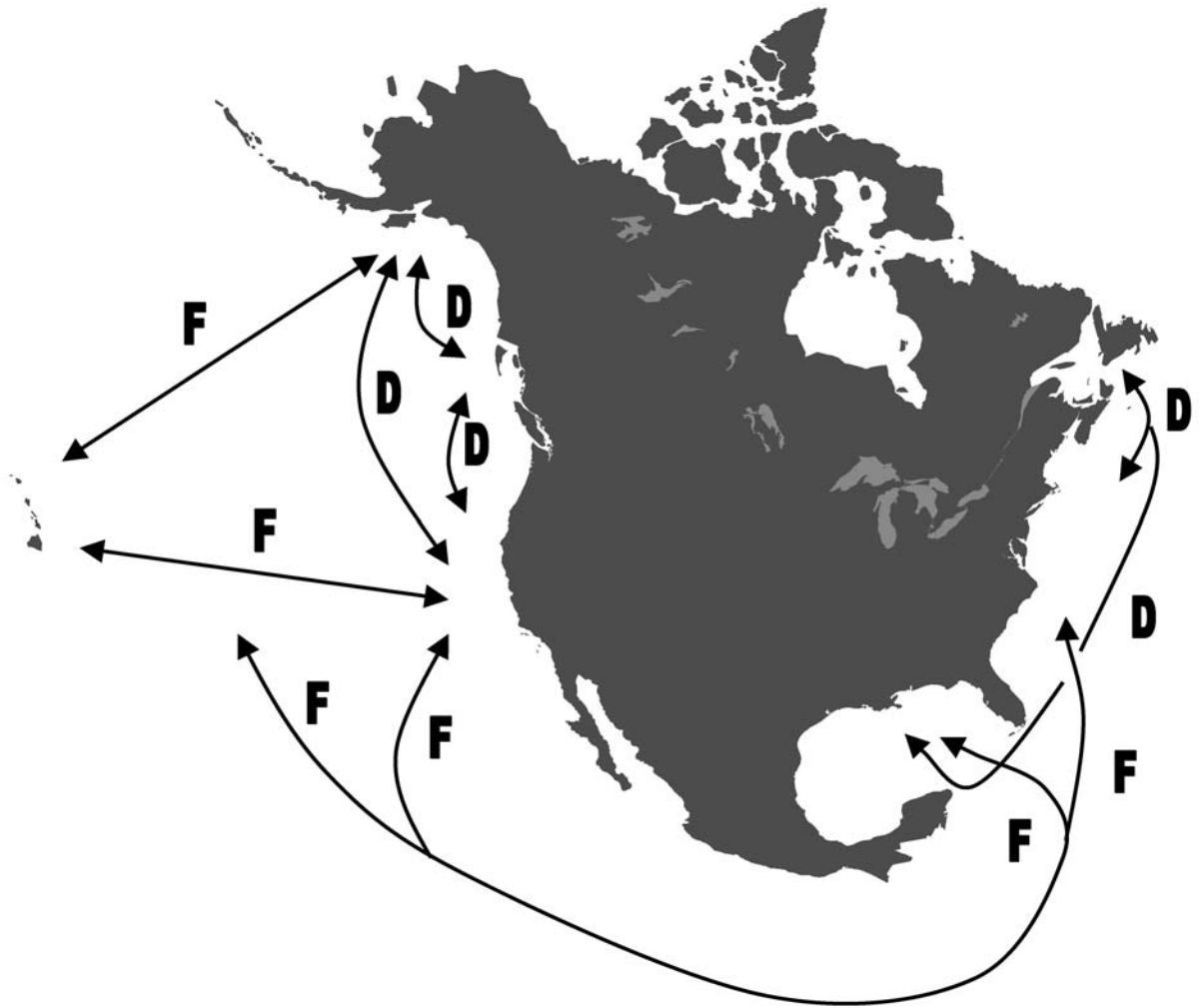


Figure 3. Foreign (F) and domestic (D) arrival designations for ships calling on ports of the United States and U.S. protectorates. Note: although not depicted on this map, transits between individual U.S. Caribbean islands were considered domestic while all other traffic to and from the Caribbean was deemed foreign.

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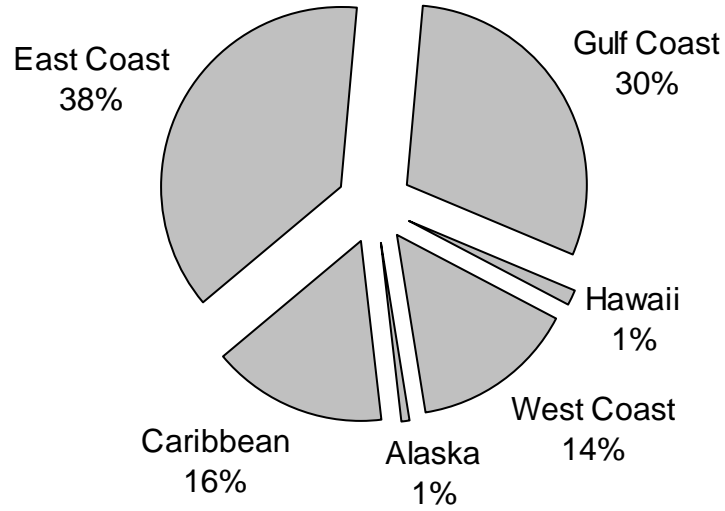


Figure 4. Percent foreign arrivals traffic by coast over two-year period from July 1999 to June 2001 (n= 95,471 arrivals). Data are from MARAD arrival reports from 1 July 1999 to 30 June 2001.

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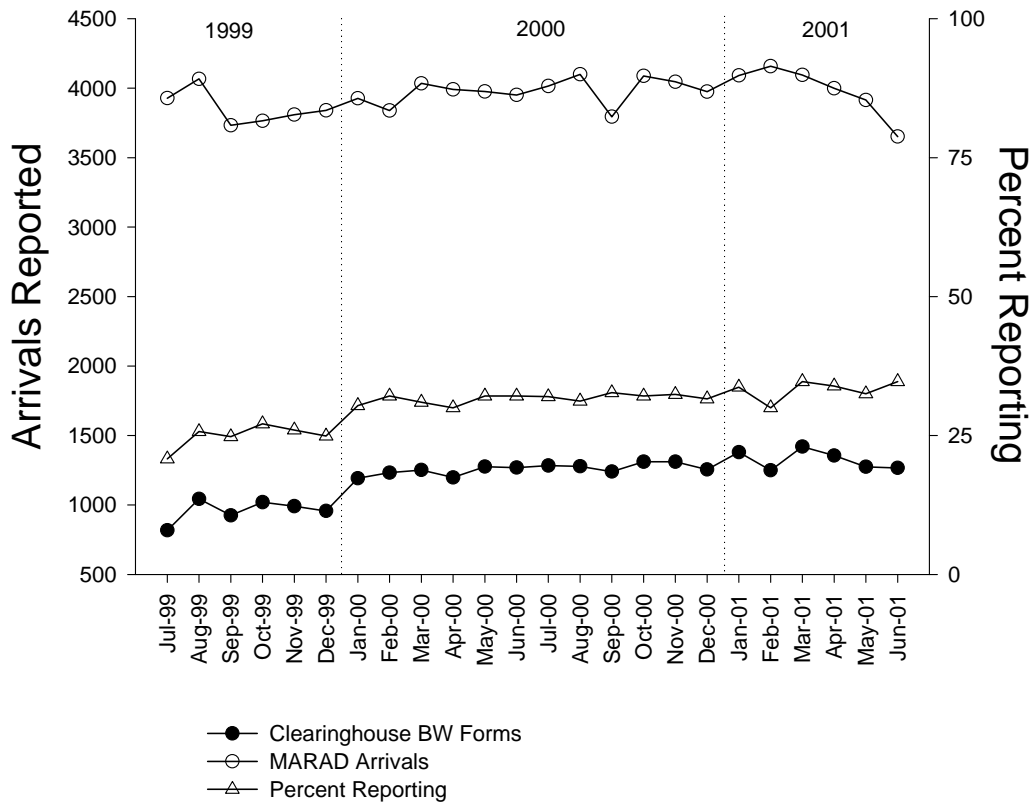


Figure 5. Monthly reporting rates for the nation by foreign arrivals from July 1999 to June 2001. Data are from National Ballast Survey (Clearinghouse) and Maritime Administration (MARAD) databases.

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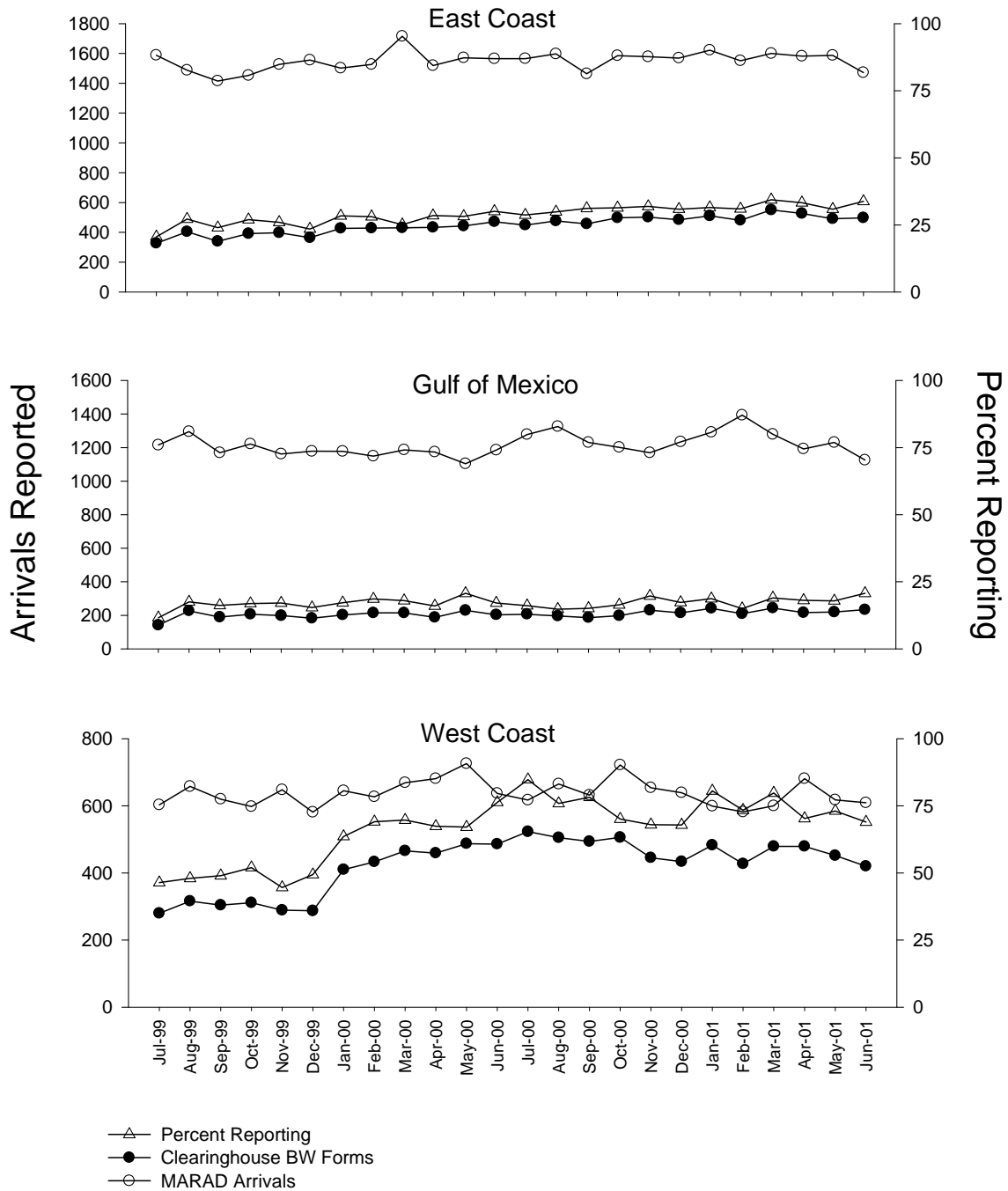


Figure 6a. Monthly reporting rates for East, Gulf of Mexico, and West coasts by foreign arrivals from July 1999 to June 2001. Data are from National Ballast Survey (Clearinghouse) and Maritime Administration (MARAD) databases.

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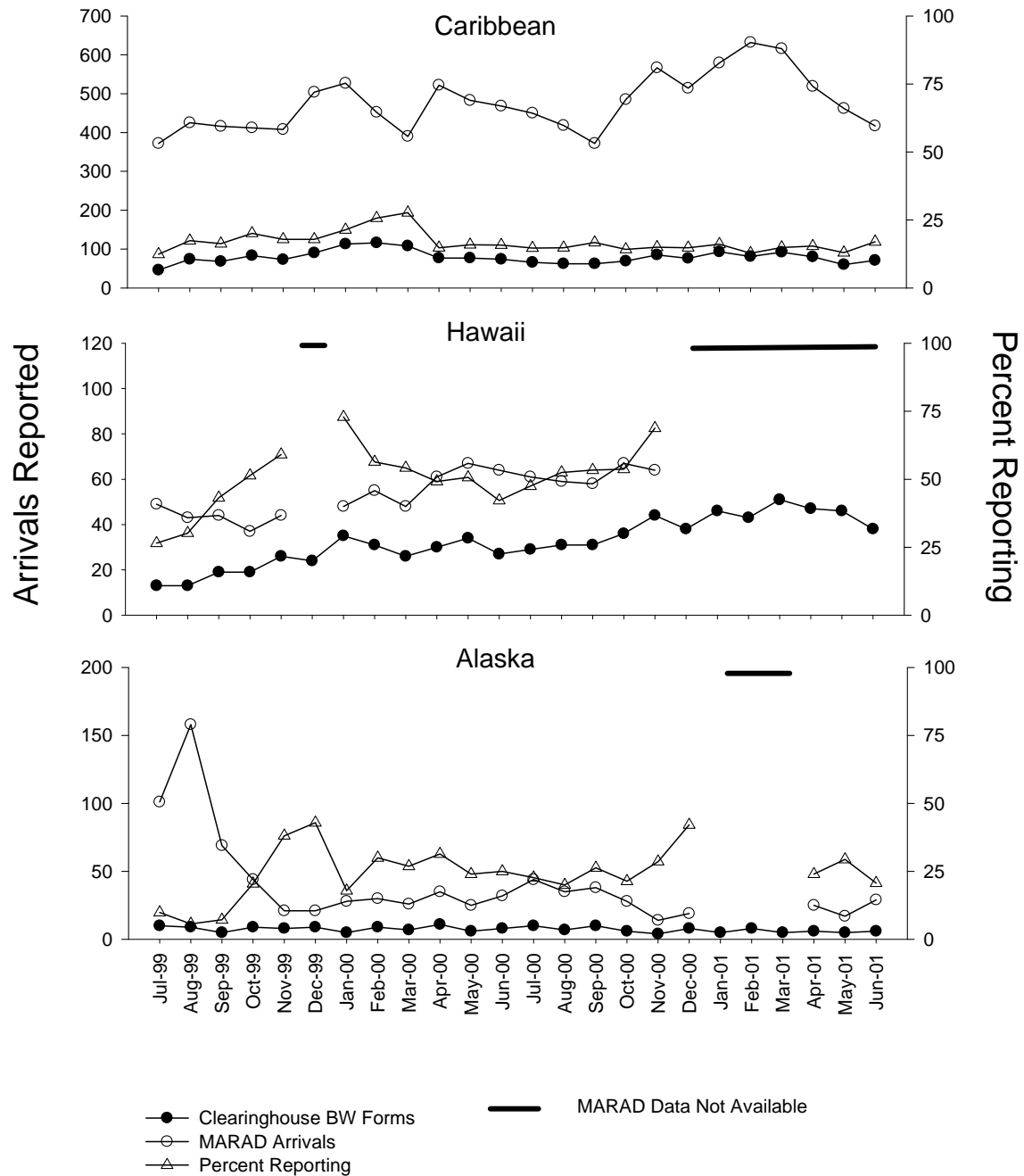


Figure 6b. Monthly reporting rates for the Caribbean, Hawaii, and Alaska coasts by foreign arrivals from July 1999 to June 2001. Data are from National Ballast Survey (Clearinghouse) and Maritime Administration (MARAD) databases.

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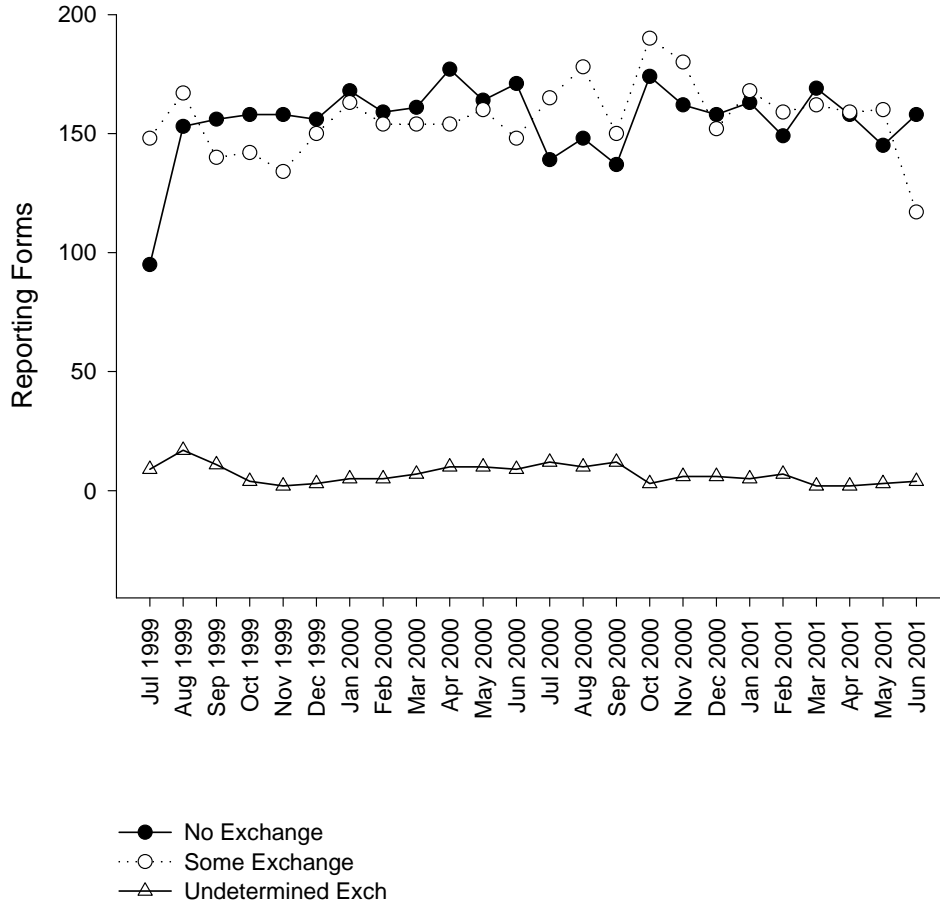


Figure 7. Nationwide monthly reported ballast water discharge by management strategy. Data from the National Ballast Survey (Clearinghouse) database (July 1999 to June 2001).

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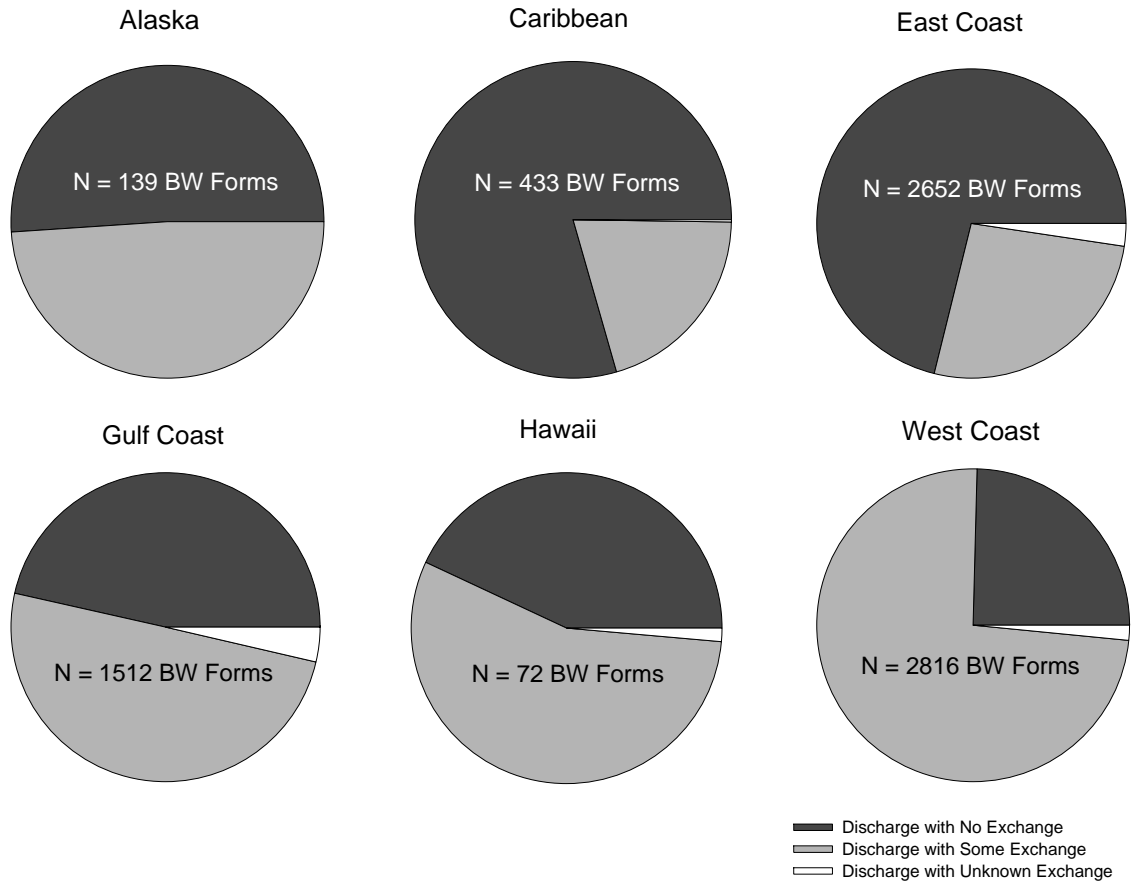


Figure 8. Proportion of ships discharging ballast water by coastal region and management strategy. Data from the National Ballast Survey database (Clearinghouse) (July 1999 to June 2001).

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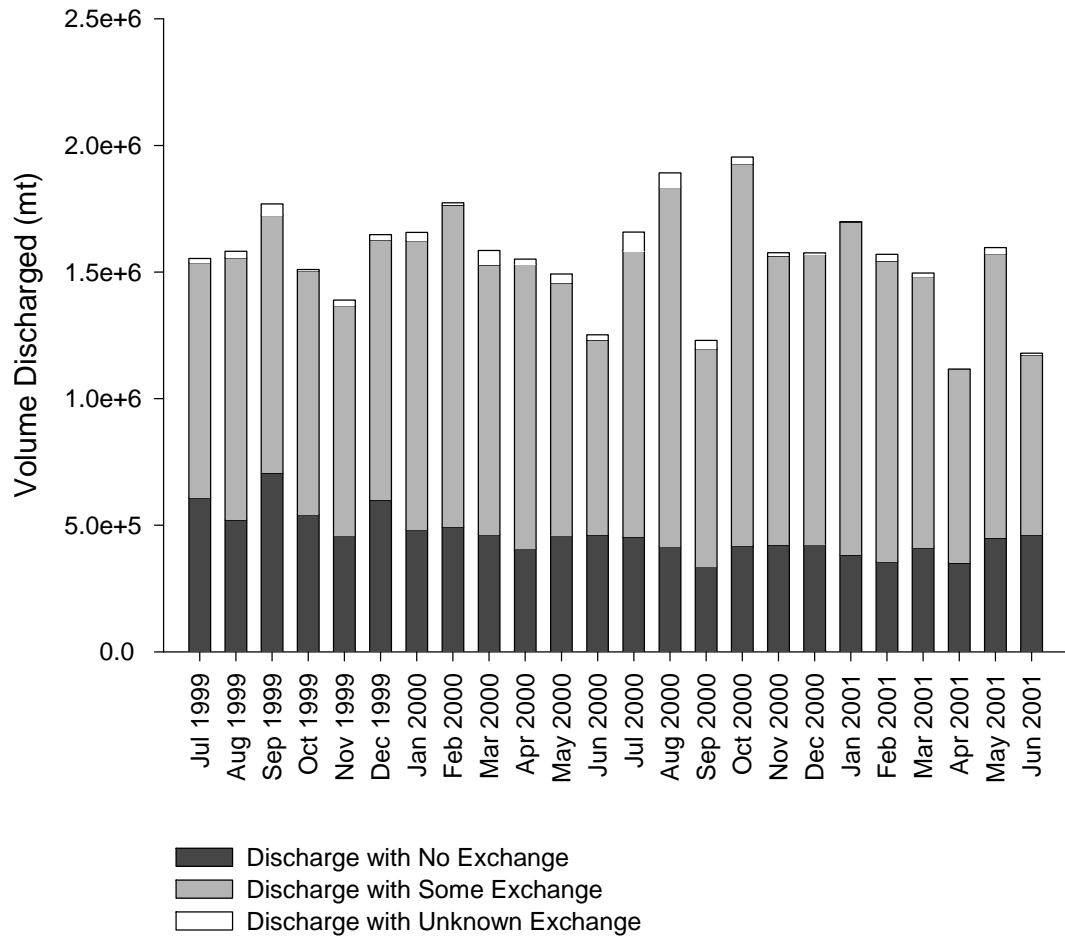


Figure 9. Nationwide monthly ballast water discharge volumes by management strategy. Data are from National Ballast Survey database (Clearinghouse) (July 1999 to June 2001).

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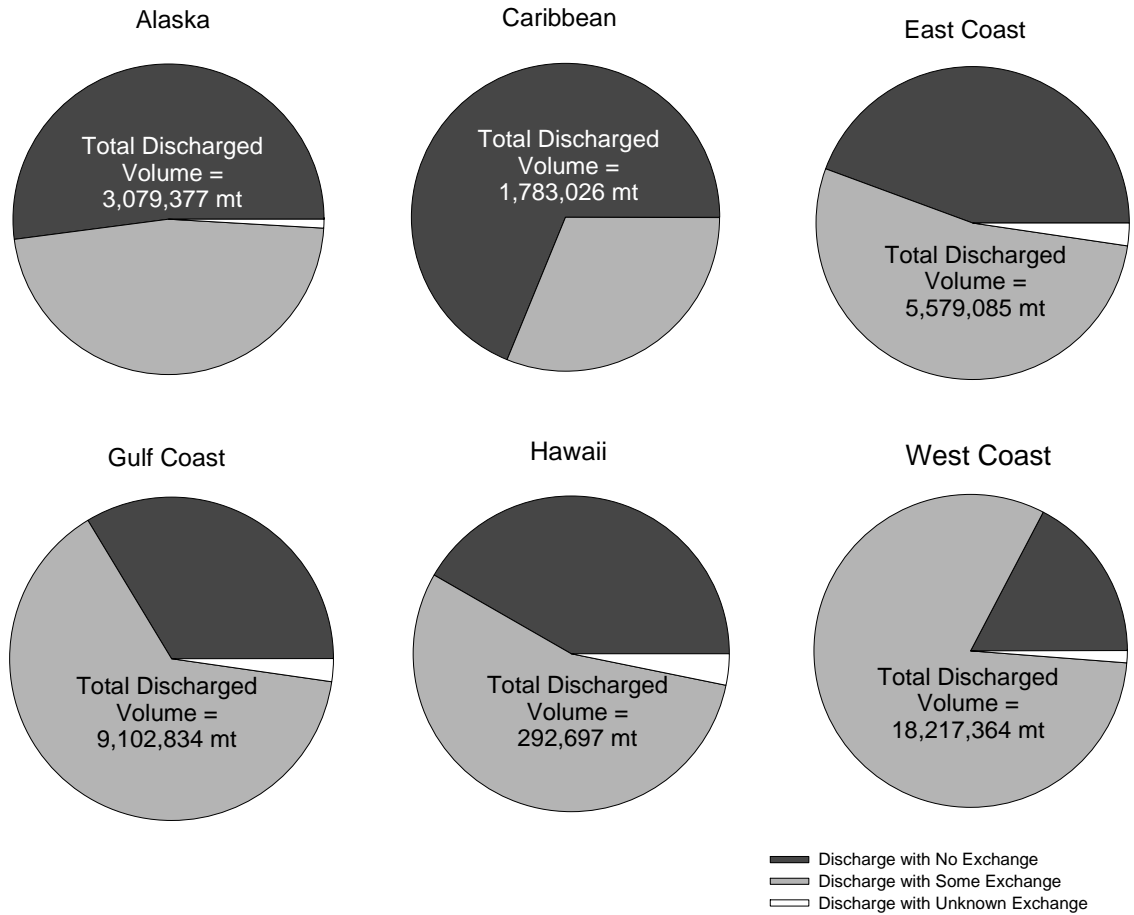


Figure 10. Proportion of ballast water discharged by coastal region and management strategy. Data from the National Ballast Survey database (Clearinghouse) (July 1999 to June 2001).

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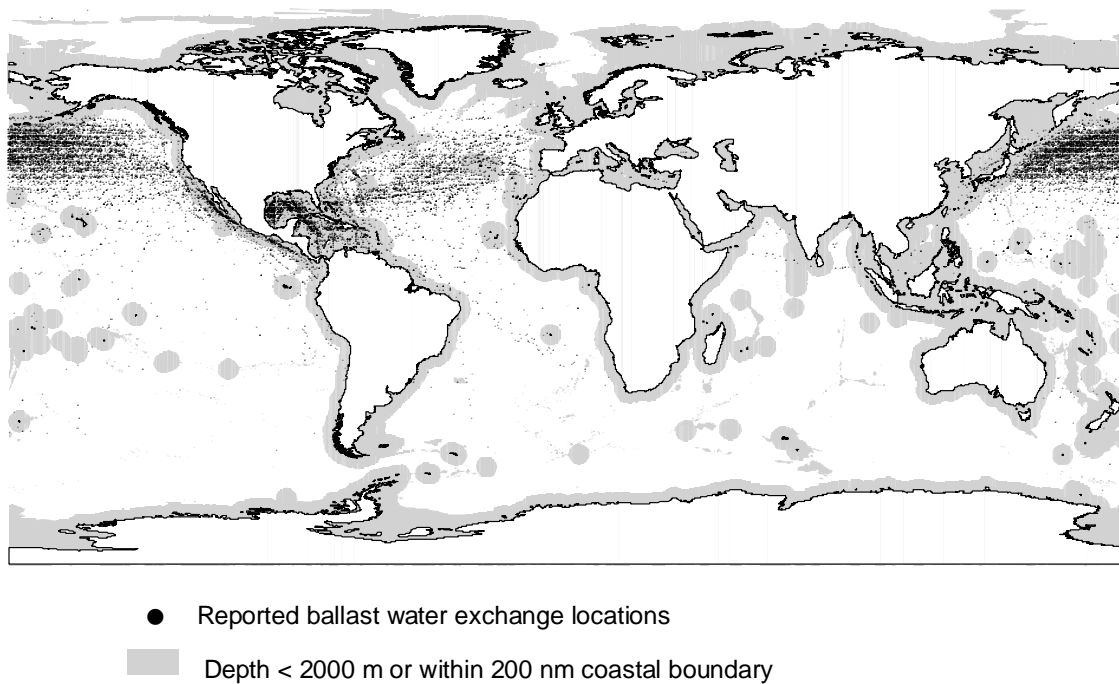


Figure 11. Reported ballast water exchange locations (end-points of exchange) for individual ballast tanks on vessels arriving to the United States between July 1999 and June 2001. Gray shading indicates zones within 200 nautical miles of coastlines and depths of less than 2,000 meters.

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Table 1. Comparisons of foreign arrivals as quantified by MARAD and Maritime Exchange.

Port	Year	<u>No. Foreign Arrivals</u>	
		Maritime Exchange	MARAD
Baltimore	1998 (first quarter)	150	151 (+0.01%)
Baltimore	1997	644	649 (+0.07%)
Boston	1997	495	554 (+12%)
San Francisco	1996	642	757 (+17%)
San Francisco	1995	715	816 (+14%)

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Table 2. Compliance with mandatory ballast reporting requirements, by coast and Captain of the Port Zone. Data from National Ballast Survey and MARAD databases (July 1999 to June 2001). Shaded rows show subtotals for broad coastal regions.

U. S. Coast	COTPZ	# BWR Forms Year 1	# MARAD Arrivals Year 1	% Reporting Rate Year 1	# BWR Forms Year 2	# MARAD Arrivals Year 2	% Reporting Rate Year 2	Total BWR Forms	Total MARAD Forms	% Reporting Rate Cumulative
Alaska	ANCMS	72	515	14.0%	66	213	31.0%	138	728	19.0%
Alaska	JUNMS	11	50	22.0%	13	41	31.7%	24	91	26.4%
Alaska	VALMS	13	25	52.0%	1	3	33.3%	14	28	50.0%
Alaska	Subtotal	96	590	16.3%	80	257	31.1%	176	847	20.8%
Carib	SJPMS	999	5,379	18.6%	897	6,031	14.9%	1,896	11,410	16.6%
East	BALMS	155	602	25.7%	219	629	34.8%	374	1,231	30.4%
East	BOSMS	112	439	25.5%	96	486	19.8%	208	925	22.5%
East	CHAMS	275	884	31.1%	360	923	39.0%	635	1,807	35.1%
East	HMRMS	125	488	25.6%	98	495	19.8%	223	983	22.7%
East	JACMS	518	2,144	24.2%	682	1,957	34.8%	1,200	4,101	29.3%
East	LISCP	30	75	40.0%	38	241	15.8%	68	316	21.5%
East	MIAMS	1,585	7,656	20.7%	2,293	7,545	30.4%	3,878	15,201	25.5%
East	NYCCP	823	2,380	34.6%	892	2,917	30.6%	1,715	5,297	32.4%
East	PHIMS	820	2,154	38.1%	731	2,086	35.0%	1,551	4,240	36.6%
East	POMMS	191	497	38.4%	178	381	46.7%	369	878	42.0%
East	PROMS	13	184	7.1%	17	112	15.2%	30	296	10.1%
East	SAVMS	175	654	26.8%	266	761	35.0%	441	1,415	31.2%
East	WNCMS	38	267	14.2%	56	240	23.3%	94	507	18.5%
East	Subtotal	4,860	18,424	26.4%	5,926	18,773	31.6%	10,786	37,197	29.0%
G of M	CORMS	213	1,147	18.6%	201	1,088	18.5%	414	2,235	18.5%
G of M	HOUCP	765	4,887	15.7%	870	4,963	17.5%	1,635	9,850	16.6%
G of M	MOBMS	184	1,496	12.3%	263	1,606	16.4%	447	3,102	14.4%
G of M	NEWMS	744	4,619	16.1%	752	5,030	15.0%	1,496	9,649	15.5%
G of M	PATMS	138	1,072	12.9%	169	1,213	13.9%	307	2,285	13.4%
G of M	TAMMS	348	992	35.1%	336	1,046	32.1%	684	2,038	33.6%
G of M	Subtotal	2,392	14,213	16.8%	2,591	14,946	17.3%	4,983	29,159	17.1%
Hawaii	HONMS	298	651	45.8%	481	896	53.7%	779	1,547	50.4%
Other	GUAD	93	N/A	N/A	100	N/A	N/A	193	N/A	N/A
West	LOSMS	2,792	4,301	64.9%	3,307	4,271	77.4%	6,099	8,572	71.2%
West	PORMS	442	942	46.9%	621	947	65.6%	1,063	1,889	56.3%
West	SDCMS	150	653	23.0%	228	674	33.8%	378	1,327	28.5%
West	SEAMS	556	1,050	53.0%	716	922	77.7%	1,272	1,972	64.5%
West	SFCMS	588	747	78.7%	775	804	96.4%	1,363	1,551	87.9%
West	Subtotal	4,528	7,693	58.9%	5,647	7,618	74.1%	10,175	15,311	66.5%
	Total	13,266	46,950	28.3%	15,722	48,521	32.4%	28,988	95,471	30.4%

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Table 3a. Year 1 compliance with voluntary ballast water management guidelines, by coast and Captain of the Port Zone. Data from National Ballast Survey database (July 1999 to June 2000). Shaded rows show subtotals for broad coastal regions.

U. S. Coast	COTPZ	# BWR Forms Year 1	# Zero Discharge	% Zero Discharge	# Zero Exchange	% Zero Exchange	# Some Exchange	% Some Exchange	# Unknown Exchange	% Unknown Exchange
Alaska	ANCMS	72	14	19.4%	35	48.6%	23	31.9%	0	0.0%
Alaska	JUNMS	11	2	18.2%	0	0.0%	9	81.8%	0	0.0%
Alaska	VALMS	13	3	23.1%	2	15.4%	8	61.5%	0	0.0%
Alaska	Subtotal	96	19	19.8%	37	38.5%	40	41.7%	0	0.0%
Carib	SJPMS	999	737	73.8%	214	21.4%	48	4.8%	0	0.0%
East	BALMS	155	139	89.7%	2	1.3%	13	8.4%	1	0.6%
East	BOSMS	112	87	77.7%	20	17.9%	5	4.5%	0	0.0%
East	CHAMS	275	210	76.4%	29	10.5%	31	11.3%	5	1.8%
East	HMRMS	125	79	63.2%	14	11.2%	30	24.0%	2	1.6%
East	JACMS	518	350	67.6%	151	29.2%	13	2.5%	4	0.8%
East	LISCP	30	27	90.0%	2	6.7%	1	3.3%	0	0.0%
East	MIAMS	1,585	943	59.5%	552	34.8%	85	5.4%	5	0.3%
East	NYCCP	823	670	81.4%	73	8.9%	62	7.5%	18	2.2%
East	PHIMS	820	760	92.7%	12	1.5%	46	5.6%	2	0.2%
East	POMMS	191	178	93.2%	6	3.1%	6	3.1%	1	0.5%
East	PROMS	13	12	92.3%	1	7.7%	0	0.0%	0	0.0%
East	SAVMS	175	139	79.4%	6	3.4%	26	14.9%	4	2.3%
East	WNCMS	38	28	73.7%	3	7.9%	7	18.4%	0	0.0%
East	Subtotal	4,860	3,622	74.5%	871	17.9%	325	6.7%	42	0.9%
G of M	CORMS	213	164	77.0%	21	9.9%	25	11.7%	3	1.4%
G of M	HOUCP	765	521	68.1%	118	15.4%	116	15.2%	10	1.3%
G of M	MOBMS	184	142	77.2%	12	6.5%	29	15.8%	1	0.5%
G of M	NEWMS	744	462	62.1%	135	18.1%	141	19.0%	6	0.8%
G of M	PATMS	138	108	78.3%	9	6.5%	21	15.2%	0	0.0%
G of M	TAMMS	348	233	67.0%	77	22.1%	33	9.5%	5	1.4%
G of M	Subtotal	2,392	1,630	68.1%	372	15.6%	365	15.3%	25	1.0%
Hawaii	HONMS	298	258	86.6%	17	5.7%	23	7.7%	0	0.0%
Other	GUAD	93	82	88.2%	3	3.2%	8	8.6%	0	0.0%
West	LOSMS	2,792	2,033	72.8%	277	9.9%	465	16.7%	17	0.6%
West	PORMS	442	174	39.4%	19	4.3%	247	55.9%	2	0.5%
West	SDCMS	150	118	78.7%	8	5.3%	22	14.7%	2	1.3%
West	SEAMS	556	372	66.9%	17	3.1%	165	29.7%	2	0.4%
West	SFCMS	588	440	74.8%	40	6.8%	106	18.0%	2	0.3%
West	Subtotal	4,528	3,137	69.3%	361	8.0%	1,005	22.2%	25	0.6%
Total	Year 1	13,266	9,485	71.5%	1,875	14.1%	1,814	13.7%	92	0.7%

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Table 3b. Year 2 compliance with voluntary ballast water management guidelines, by coast and Captain of the Port Zone. Data from National Ballast Survey database (July 2000 to June 2001). Shaded rows show subtotals for broad coastal regions.

U. S. Coast	COTPZ	# BWR Forms Year 1	# Zero Discharge	% Zero Discharge	# Zero Exchange	% Zero Exchange	# Some Exchange	% Some Exchange	# Unknown Exchange	% Unknown Exchange
Alaska	ANCMS	66	15	22.7%	34	51.5%	17	25.8%	0	0.0%
Alaska	JUNMS	13	3	23.1%	0	0.0%	10	76.9%	0	0.0%
Alaska	VALMS	1	0	0.0%	0	0.0%	1	100.0%	0	0.0%
Alaska	Subtotal	80	18	22.5%	34	42.5%	28	35.0%	0	0.0%
Carib	SJPMS	897	726	80.9%	130	14.5%	40	4.5%	1	0.1%
East	BALMS	219	201	91.8%	3	1.4%	15	6.8%	0	0.0%
East	BOSMS	96	94	97.9%	1	1.0%	1	1.0%	0	0.0%
East	CHAMS	360	315	87.5%	15	4.2%	30	8.3%	0	0.0%
East	HMRMS	98	63	64.3%	11	11.2%	23	23.5%	1	1.0%
East	JACMS	682	535	78.4%	128	18.8%	15	2.2%	4	0.6%
East	LISCP	38	35	92.1%	2	5.3%	1	2.6%	0	0.0%
East	MIAMS	2,293	1,402	61.1%	741	32.3%	147	6.4%	3	0.1%
East	NYCCP	892	764	85.7%	84	9.4%	37	4.1%	7	0.8%
East	PHIMS	731	671	91.8%	19	2.6%	39	5.3%	2	0.3%
East	POMMS	178	168	94.4%	4	2.2%	6	3.4%	0	0.0%
East	PROMS	17	17	100.0%	0	0.0%	0	0.0%	0	0.0%
East	SAVMS	266	212	79.7%	5	1.9%	46	17.3%	3	1.1%
East	WNCMS	56	35	62.5%	3	5.4%	17	30.4%	1	1.8%
East	Subtotal	5,926	4,512	76.1%	1,016	17.1%	377	6.4%	21	0.4%
G of M	CORMS	201	161	80.1%	28	13.9%	12	6.0%	0	0.0%
G of M	HOUCP	870	614	70.6%	90	10.3%	144	16.6%	22	2.5%
G of M	MOBMS	263	213	81.0%	10	3.8%	40	15.2%	0	0.0%
G of M	NEWMS	752	470	62.5%	120	16.0%	157	20.9%	5	0.7%
G of M	PATMS	169	141	83.4%	12	7.1%	13	7.7%	3	1.8%
G of M	TAMMS	336	242	72.0%	71	21.1%	23	6.8%	0	0.0%
G of M	Subtotal	2,591	1,841	71.1%	331	12.8%	389	15.0%	30	1.2%
Hawaii	HONMS	481	448	93.1%	15	3.1%	17	3.5%	1	0.2%
Other	GUAD	100	84	84.0%	2	2.0%	14	14.0%	0	0.0%
West	LOSMS	3,307	2,612	79.0%	252	7.6%	430	13.0%	13	0.4%
West	PORMS	621	264	42.5%	13	2.1%	340	54.8%	4	0.6%
West	SDCMS	228	199	87.3%	15	6.6%	13	5.7%	1	0.4%
West	SEAMS	716	503	70.3%	26	3.6%	187	26.1%	0	0.0%
West	SFCMS	775	644	83.1%	25	3.2%	105	13.5%	1	0.1%
West	Subtotal	5,647	4,222	74.8%	331	5.9%	1,075	19.0%	19	0.3%
Total	Year 2	15,722	11,851	75.4%	1,859	11.8%	1,940	12.3%	72	0.5%
Grand Total		28,988	21,336	73.6%	3,734	12.9%	3,754	13.0%	164	0.6%

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Table 4. Compliance with voluntary guidelines by volume for management of ballast water during period from July 1999 to June 2001. Shaded rows show subtotals for broad coastal regions.

US Coast	COTPZ	No Exchange [mt]	No Exchange [%]	Some Exchange [mt]	Some Exchange [%]	Unknown Exchange [mt]	Unknown Exchange [%]
Alaska	ANCMS	1,894,957	79.3%	493,655	20.7%	1,800	0.1%
Alaska	JUNMS	2,177	1.9%	110,873	98.1%	0	0.0%
Alaska	VALMS	222,062	38.6%	353,853	61.4%	0	0.0%
Alaska	Subtotal	2,119,196	68.8%	958,381	31.1%	1,800	0.1%
Carib	SJPMS	928,930	52.1%	837,495	47.0%	16,600	0.9%
East	BALMS	86,389	14.0%	508,524	82.5%	21,780	3.5%
East	BOSMS	48,207	85.7%	8,013	14.3%	0	0.0%
East	CHAMS	58,204	41.4%	74,315	52.9%	7,987	5.7%
East	HMRMS	370,686	21.3%	1,335,139	76.7%	35,190	2.0%
East	JACMS	274,989	90.0%	28,364	9.3%	2,184	0.7%
East	LISCP	4,276	88.6%	548	11.4%	0	0.0%
East	MIAMS	1,046,990	88.4%	133,511	11.3%	3,330	0.3%
East	NYCCP	150,048	53.8%	113,851	40.8%	15,243	5.5%
East	PHIMS	281,871	60.8%	163,756	35.3%	18,298	3.9%
East	POMMS	72,051	46.6%	71,651	46.4%	10,810	7.0%
East	PROMS	17,559	100.0%	0	0.0%	0	0.0%
East	SAVMS	40,938	13.8%	239,466	80.9%	15,457	5.2%
East	WNCMS	23,514	7.4%	294,633	92.2%	1,314	0.4%
East	Subtotal	2,475,722	44.4%	2,971,771	53.3%	131,593	2.4%
G of M	CORMS	453,238	60.1%	267,287	35.4%	34,064	4.5%
G of M	HOUCP	1,193,966	50.6%	1,105,637	46.9%	57,697	2.4%
G of M	MOBMS	106,493	19.1%	449,355	80.5%	2,289	0.4%
G of M	NEWMS	837,110	20.6%	3,154,942	77.7%	67,042	1.7%
G of M	PATMS	274,360	43.1%	336,925	53.0%	24,759	3.9%
G of M	TAMMS	196,920	26.7%	518,357	70.3%	22,393	3.0%
G of M	Subtotal	3,062,087	33.6%	5,832,503	64.1%	208,244	2.3%
Hawaii	HONMS	122,014	41.7%	161,256	55.1%	9,427	3.2%
Other	GUAD	11,733	31.1%	25,960	68.9%	0	0.0%
West	LOSMS	1,326,599	21.7%	4,705,304	76.9%	87,624	1.4%
West	PORMS	438,022	7.1%	5,621,938	91.5%	86,321	1.4%
West	SDCMS	18,001	12.7%	111,681	78.6%	12,354	8.7%
West	SEAMS	277,842	9.6%	2,588,297	89.1%	37,381	1.3%
West	SFCMS	296,831	14.1%	1,809,326	85.8%	3,160	0.1%
West	Subtotal	2,357,295	13.5%	14,836,546	85.2%	226,840	1.3%
	Total	11,076,977	29.7%	25,623,912	68.7%	594,504	1.6%

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Table 5. Reasons provided by vessel masters for not exchanging ballast water to be discharged in U. S. waters. The categories were constructed by the Clearinghouse, and individual reports were assigned as best as possible. Reporting period was July 1999 to June 2001.

Reason Provided	Total BWR Forms [#]	% of Total
Clean Ballast	184	15.2%
Itinerary	159	13.2%
N/A	127	10.5%
Other/Undecipherable	650	53.8%
Safety	56	4.6%
Ship's Design	32	2.6%
TOTAL	1,208	100%

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Table 6. Comparison of no ballast on board (NOBOB) and ballast on board (BOB) vessels and tanks based on total number of foreign arrivals and total tanks that arrived to U.S. ports between July 1999 and June 2001.

Vessel Condition	Vessel No.	%	Vessel No.	%
NOBOB	3,712	12.8%	3,712	12.8%
BOB	25,280	87.2%	25,280	87.2%
Total	28,992	100%	28,992	100%

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Table 7. Average number of NOBOB tanks and BOB tanks aboard 24,607 foreign arrivals that carried at least one NOBOB tank. Reporting period was from July 1999 to June 2001.

Tank Condition	Mean No. of Tanks	Standard Error
NOBOB tanks	8.6	0.05
BOB tanks	8.5	0.04
All Tanks	17.2	0.05