

NATIONAL BALLAST INFORMATION CLEARINGHOUSE

INTERIM REPORT (October 2000)

Results of the First Year of Data Management and Analysis:
Shipping Industry Compliance with Mandatory Ballast Water Reporting Requirements
Shipping Industry Compliance with Voluntary Ballast Water Management Guidelines

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EXECUTIVE SUMMARY

Background

1. Under the National Invasive Species Act of 1996 (NISA), Congress requires ships entering U. S. waters from outside the EEZ to report ballast water management practices, including the retention of ballast water on board.
2. NISA also requests ship's masters 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: (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 2000 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.
3. Ships are required to submit reports on ballast water management and discharge to the National Ballast Information Clearinghouse, a collaborative data management and analysis effort of the U. S. Coast Guard and the Smithsonian Environmental Research Center, pursuant CFR §151.2045.
4. To determine the rate of compliance with the reporting requirement, the Clearinghouse compares the submitted reports with the data on ship arrivals from the database of U. S. Foreign Waterborne Transportation Statistics maintained by the Department of Transportation's Maritime Administration (MARAD). Data for the MARAD database are collected by the U. S. Customs Service and the Army Corps of Engineers.

5. 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 complete exchange or retention of ballast water and, (b) the volume and proportion of discharged ballast water that underwent complete exchange, partial exchange, and no exchange.
6. To verify the accuracy of information reported by vessels, and to further educate the shipping industry about ballast water management requirements and guidelines under CFR §151.2045, U.S. Coast Guard has implemented independent Verification Surveys aboard arriving vessels that are randomly selected. The Clearinghouse analyzes these surveys and reports on the results.

Results

7. Over the first 12 months (1 July 1999 – 30 June 2000) that the rule was in effect, only 20.8 % of the vessels that entered U. S. waters from outside the EEZ filed mandatory reports with the Clearinghouse, as required by the U.S. Coast Guard.
8. On a regional basis, compliance with the reporting requirement never reached 40% for the 12-month period. Compliance rates by region were: Alaska – 5.5 %, Caribbean - 10.5 %, East Coast – 20.7 %, Gulf Coast 13.9 %, West Coast – 36.3 %, and Pacific Islands – 18.1 % (calculated for Hawaiian ports only, as MARAD data do not include Guam).
9. Among Captain of the Port Zones (COTPZs), compliance with reporting ranged from 63.0% in San Francisco to 0.9% in Juneau.
10. For the entire U.S., compliance with reporting improved only slightly over the 12-month period, remaining between 23% and 29% from October 1999 through June 2000.
11. Only for the West Coast of the contiguous U. S. did compliance with the reporting requirement increase markedly over time, 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.
12. Due to the poor nationwide reporting rate (20.8%), it remains difficult to estimate reliably (a) the patterns of ballast water delivery and (b) the compliance with voluntary guidelines for ballast water management.
13. Of the 12,170 vessels that submitted reports: 70.7% indicated no intention to discharge ballast water within U. S. territory; 14.1% declared no exchange of ballast water prior to discharge; and 8.9% and 6.3% of the reporting vessels declared partial and complete exchange, respectively, of ballast water prior to discharge.
14. Of the 3,560 vessels that reported an intention to discharge ballast water, compliance with the voluntary guidelines was low: Only 21.4% reported having conducted a complete (100%) mid-ocean exchange of the volume of water to be discharged.
15. Nationwide, approximately 42% (10.2 million metric tons, or MT) of the foreign water reported discharged into the U. S. had not been exchanged completely as requested in the voluntary guidelines.

16. Compliance with the voluntary guidelines varied greatly among regions and COTPZs. Regionally, the Pacific Islands had the largest percent of the total volume of discharged ballast water that had been completely exchanged (88.9%), while Alaska had the lowest (37.2%). Among COTPZs, Juneau, Alaska, had the highest percent of reported completely exchanged discharged ballast water (100% of 33,010 MT), while Long Island, NY and Providence, RI, had the lowest, at 0% of 1,773 MT and 17,559 MT, respectively.
17. Analysis of the locations reported for completion of ballast exchange, using a geographic information system, suggests that a significant proportion of the volume of ballast water reported as exchanged actually came from coastal areas (< 200 mi offshore), rather than mid-ocean as requested.
18. Implementation of verification surveys by USCG field units was extremely uneven and did not meet established goals in three important areas: (a) Only a small percentage of the needed boardings have occurred (e.g., for July 2000, only 40% of the COTPZs submitted any survey reports to the Clearinghouse, and the nationwide survey rate is far below the 300/month target; (b) Of those surveys conducted, most do not conform to the survey guidelines and cannot be used in analyses; and (c) the use of outdated survey questions, compounded by a high rate of omissions and errors, further erodes the number of usable surveys.

Conclusions

19. Nationwide compliance with the mandatory reporting requirement remains quite low:
 - Only 20.8% of arrivals subject to the reporting requirement submitted reports for the first 12 months, since this requirement began.
 - There was only a slight increase in reporting nationwide, with an increase from 15.4% in June 1999 to a high of 31% in February 2000, followed by a decrease to 23.9% in June 2000.
20. In contrast, compliance with reporting in California increased over the past 12 months to approximately 75%, coinciding with state regulations that (a) impose penalties for non-compliance and (b) an active boarding program that targets 20-30% of arrivals.
21. Although it is clear that many vessels that discharge ballast water in the U.S. are not in compliance with voluntary guidelines, based upon their reports, we cannot estimate accurately the extent of non-compliance with these guidelines due to the very low rate of reporting.
22. Vast improvements in both reporting compliance by ships and implementation of the U.S. Coast Guard Verification Surveys are required to characterize compliance with the voluntary guidelines as requested under NISA. Without improved reporting, we cannot estimate nationwide compliance from submitted information and must rely on U.S. Coast Guard Verification Surveys, which remain inadequate for this purpose.

INTRODUCTION

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 Water 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 to (1) minimize the transfer of nonindigenous species in ballast water of ships and (2) reduce the risk of exotic species invasions associated with the release of ballast water.

National Ballast Survey

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.

The Clearinghouse and the USCG have implemented a nationwide program, 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.

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 currently 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. These data on vessel arrivals to U.S. ports are compiled by the Department of Transportation's Maritime Administration (MARAD);

3. Verification surveys of vessels, arriving from outside the EEZ, that are 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) will create a large, comprehensive data set that includes ballast water history for, ideally, most vessels arriving to each U.S. port from outside of the EEZ.
- The MARAD data of all arrivals at each port will identify vessels, arriving from outside the EEZ, that are missing in the first data set, providing a measure of under-reporting.
- The USCG 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. This survey is designed to randomly sample 120 vessels in each of 30 Captain of the Port Zones (Figure 1) (i.e., 24 boardings for each of five ship types in each COTPD).

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 statistically tested to describe arrival and ballasting patterns. Following two years of data collection, a final report of these patterns will be submitted to Congress.

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.

- Measurement of spatial and temporal patterns of ballast delivery / management (from the National Ballast Survey and other sources);
- Expansion of the National Marine and Estuarine Invasions Database to characterize patterns and rates of nonindigenous species invasions;
- Development of regional databases on invasion ecology, including data compiled from the scientific literature as well as from field collections by SERC and SERC-collaborators at field locations around the nation (e.g., Chesapeake Bay, San Francisco Bay, Puget Sound, Tampa Bay, Prince William Sound, Coos Bay, etc.). This relational database system allows analyses of marine and estuarine invasions at multiple spatial scales (i.e., embayment, coast, and nation).
- Expansion of the Aquatic Invasions Research Directory. The Directory is an internet-based, searchable database containing regularly updated international information on people, research, technology, policy, and management issues relevant to aquatic invasions.
- Implementation of the Ballast Water Exchange Verification Project, designed to simultaneously test and compare a suite of *in-situ* and laboratory-based technologies for improved verification of ballast water exchange.

Purpose of Interim Report

The overall goal of this report is to provide an analysis of NABS 12 months after the reporting requirement went into effect. More specifically, we wished to assess the compliance with reporting and the compliance with voluntary guidelines after a one-year period, to provide feedback to the shipping industry. In addition, we wished to assess the overall implementation of the national program and address any critical gaps that may exist.

APPROACH: ASSESSING COMPLIANCE

Compliance with the reporting requirement, and compliance with the voluntary guidelines, were assessed at three different geographic scales: national, regional (major coasts), and COTPZ (local port system). Prior to all analyses, data received to 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.

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 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 quite close, with a difference of just 10%.

The MARAD data set includes standardized fields for "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 contained 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.

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 what 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.

RESULTS

Compliance with Ballast Water Reporting Requirement

1. Nationwide Compliance.

The nationwide compliance with required ballast water reporting was 20.8%, for the first 12-month period following implementation of the requirement (Table 2). Thus, only about one fifth of all vessels required to report ballast water discharge and management upon entry to the United States from outside of the EEZ met this requirement.

2. Regional Compliance.

With the exception of the West Coast (the contiguous states of Washington, Oregon, and California), regional compliance with the reporting requirement did not exceed 21% and showed no evidence of improvement over time (Figure 2). Despite strong seasonal variation in the number of ship arrivals subject to the reporting requirement (as indicated by the MARAD data) the number of reports received by the Clearinghouse was

remarkably stable, except for the Pacific Islands and the West Coast. The strong seasonal variation and low expected sample size for the Pacific Islands, combined with relatively stable reporting, resulted in a strong seasonal pattern for compliance.

Only the West Coast demonstrated an increase in reporting through the 12-month period (Figure 2). This resulted initially from a seasonal decrease in MARAD arrivals, followed by an increase in reporting. Most of the increase in reporting was attributed to a striking jump between December 1999 and January 2000 for California, reaching approximately 75% compliance by the end of the 12-month period (Figure 3). Chi-square analysis of the proportions of reporting and non-reporting arrivals to California indicated that compliance with the reporting requirement was significantly lower before versus after January ($X^2 = 562.3$, $df=1$, $p \leq 0.01$). A more gradual, but significant ($X^2 = 28.6$, $df = 1$, $p \leq 0.01$) increase from 19.8% to 35.5% was observed in the reporting rate for vessels in Oregon, although this contributed little to the overall temporal pattern on the West Coast (Figure 3), due to the relatively small number of arrivals compared to California. For Washington, there was a less marked, but still significant ($X^2 = 9.6$, $df = 1$, $p \leq 0.01$) increase in compliance from 17.2% to 21.3%.

We attribute the striking increase in compliance for California to the implementation of a state law, requiring ballast water reporting and authorizing penalties for noncompliance, effective as of January 1, 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 significantly in January, when the law went into effect and penalties were in possible for failure to report. In contrast, compliance remains lower in Washington and Maryland, both of which passed similar laws but have not yet begun to impose penalties for failure to report. It will be very instructive to examine compliance over time for these states, particularly during the time periods surrounding the initiation of penalties for failure to report.

3. COTPZ Compliance

As for the nation and most regions, compliance with the reporting requirement was also low, although highly variable, among COTPZs (Table 2). Reporting for COTPZs ranged from 0.9 to 63.0%, exceeding 50% in only 3 cases: San Francisco, Los Angeles, and Valdez. It may be that the relatively high reporting and compliance rates for San Francisco and Los Angeles COTPZs result from state law. Furthermore, the high compliance (62.5%) at Valdez may result from 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. In the case of Philadelphia, where compliance was 48.7%, nearly as great as the above 3 cases, there is no state law; we remain uncertain about the circumstances that may explain this as an outlier from the rest of the country.

Compliance with Voluntary Exchange Guidelines

Under CFR §151.2045, vessel masters were required to report whether or not ballast water was exchanged or otherwise treated, and document 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 of compliance with the voluntary guidelines for ballast water management operations: the proportion of arriving vessels reporting complete exchange of all water discharged, and the proportion of the volume, across all ships, reported to have been exchanged completely. The former evaluates compliance on a *per capita* (ship) basis, the latter evaluates the overall compliance of the aggregate reporting vessels in treating discharged water to reduce the probability of introducing foreign organisms to U. S. waters. In addition, because the guidelines also recommend retention of unexchanged or untreated ballast water, vessels that hold ballast water on board are considered to be in compliance with the voluntary guidelines.

The voluntary guidelines (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 2000 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 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. However, examination of the ballast water management reports submitted by vessels revealed widespread confusion 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 100% exchange was accomplished by pumping one or three full volumes of open-ocean water through a tank, or the method of exchange employed. Therefore, the most liberal interpretation was used, and all reported exchanges of 100% or more were considered to be “complete” exchanges.

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 20.8%, 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 (70.7%) of the reporting vessels indicated no intention to discharge ballast water (Table 3). Of the 12,170 vessels filing reports, only 3,560, or 29.3%, declared an intention to discharge foreign ballast water within U. S. territory. Of the reporting vessels, 14.1% declared that no exchange had been conducted, while 8.9% and 6.3% of the reporting vessels declared partial and complete exchange, respectively, of ballast water prior to discharge. Therefore, of the vessels that reported, 76.7% were in compliance with 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 3,560 vessels that did report an intention to discharge, only 21.4% reported having conducted a complete (100%) mid-ocean exchange of the volume of ballast water to be discharged (Table 3). Almost half of the vessels (48.1%) intending to discharge ballast water reported not exchanging, while slightly less than a third (30.5%) reported conducting an incomplete (< 100%) exchange.

2. Regional Compliance

By region, the percent of reporting vessels that declared no discharge varied from 91.3% in the Pacific Islands to 16.5% in Alaska (Table 3, Fig. 4), while the percent of reporting vessels declaring a complete exchange varied from a high of 15.4% in Alaska to a low of 1.0% in the Pacific Islands. Of those vessels that reported an intention to discharge ballast water, the percent that conducted a complete exchange varied from a low of 7.6% of 157 vessels in the Caribbean to a high of 29.0% of 1401 vessels on the West Coast (Table 3).

3. COTPZ Compliance

Of the COTPZs with the largest number of reported dischargers, the percent of such vessels that had exchanged completely varied from 2.9% of 611 vessels in Miami to 24.1% of 796 vessels in Los Angeles. Juneau, AK, and Baltimore, MD, had the highest percent of discharging vessels that reported having conducted a complete exchange (57.2% and 44.0%, respectively), while Long Island, NY, and Providence, RI, (both at 0% of 1 and 3 vessels respectively) had the lowest percentage of vessels reporting complete exchange.

Although compliance with the federal reporting requirement increased in California, following passage of state ballast water legislation authorizing penalties for nonperformance, a corresponding increase in the rate of ballast water exchange, on a per ship basis, was not observed (Fig. 5). There was very little difference between six-month time periods in 1999 and 2000 in the percent of vessels reporting either partial or complete exchange. The major difference was an increase in the number, and percent, of vessels reporting no discharge of ballast water, compared to the number and percent of vessels reporting discharge of exchanged or unexchanged ballast water ($X^2 = 34.5$, $df = 1$, $p \leq 0.001$). There are a number of non-exclusive explanations for this change. Perhaps the simplest is that, prior to passage and enforcement of the California legislation, vessels

that were not intending to discharge ballast water simply did not consider it necessary to report.

Compliance based on percent exchange by volume, across all reporting vessels.

While the preceding approach provides an assessment of compliance on the basis of individual ships, from a biological perspective the more 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.

1. National Compliance

Nationally, of the approximately 17.4 million metric tons (MT) of ballast water reported discharged, almost 5.3 million MT, or 30.8 %, had not been exchanged (Table 5). Approximately 8.1% of the discharged water had been incompletely (<100%) exchanged, while 58.6 % of the water had been exchanged at least 100%. Overall, almost 40% (6.8 million MT) of the foreign water reported discharged into the U. S. had not been exchanged completely as requested in the voluntary guidelines.

2. Regional Compliance

As with exchange practices on a per ship basis, the percent of the discharged volume that had undergone complete exchange varied across the major regions (Table 5, Fig. 6). The Pacific Islands had the highest percent volume exchanged completely (88.9%), although for a relatively small total discharge (45,534 MT). The West Coast (69.9%), Gulf of Mexico (57.8%), East Coast (43.7%), Alaska (37.2%), and Caribbean (29.6%), regions had sequentially decreasing proportions of discharged ballast water that had been completely exchanged.

3. COTPZ Compliance

Among the individual COTPZs, Juneau, Alaska, had the highest percent of discharged ballast water reported to have been completely exchanged (100% of 33,010 MT), while Long Island, NY, and Providence, RI, had the lowest, at 0% of 1,773 MT and 17,559 MT, respectively.

Reasons for not conducting a mid-ocean exchange of ballast water

Ships' masters were asked to provide, on the ballast water reporting forms, a rationale for not conducting a mid-ocean exchange of ballast water. 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 4) 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 1,712 vessels that reported discharging ballast water without exchanging, only 17.5% of the 1,155 vessels that provided reasons for not conducting an exchange cited "safety", or some variant of the term or phrase. The most 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 2000 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. 7). To produce the map, the area of the world's oceans was divided into 1,000 km² grid cells, and the number of reported ballast exchange end points tabulated for each cell. 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, the shaded regions of the map extend to the edge of the continents, 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 the Sea of Cortez, and in the western and eastern Mediterranean Sea. 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.

USCG Verification Surveys

The target Coast Guard ground-truthing boarding rate is 3,600 per year. This value assumes that each of 30 COTPZs will make 24 boardings for each of 5 different ship types (Bulk Carrier, Container, General Cargo, Tanker, and Other), according to a randomized schedule provided by the Clearinghouse, per year. In response to several problems identified in the original survey data form, a revised ground-truthing form was distributed in electronic and hard copy form to each of the COTPZs in May 2000. This analysis focuses on the two month period (June and July) following the release of the modified Coast Guard Boarding form. The nationwide boarding quota for these two months was 600. All USCG reports (new and old formats) received by the Clearinghouse with boarding dates from June and July 2000 were included in the present analysis.

Several performance deficiencies by the USCG field units were identified through analysis of the forms submitted in June and July. These included low submission rates (24% in June and 11.3% in July 2000), submission of unusable reports (boardings not according to the official random schedule), and incorrectly completed forms (Table 6). Only 21 of 30 COTPZs submitted ground-truthing forms to the Clearinghouse for the month of June. In July, this number dropped to 12 COTPZs. The number of forms submitted was thus well below the 300/month quota specified in the official boarding schedule. In June, only 72 of the 113 (67.3%) reports received coincided with the official boarding schedule, and just 34 of 68 (50%) reports in July were official boardings. Of the 106 official reports received in June and July 2000, 27 came from vessels discharging

ballast water, of which only 15 (55.5%) included salinity readings (Table 6). All other boardings that did not conform to the randomized sampling design of the ground-truthing protocol were unusable.

The number of officially scheduled boardings for the two-month period of June and July 2000 was 600. According to reports of boarding activity from each of the Marine Safety Offices, compiled by U. S. Coast Guard Headquarters, on approximately 200 occasions, no appropriate vessels type were available. During the same time period, 181 ground-truthing boardings were completed, but only 106 of these were officially scheduled, the remaining boardings were invalid for purposes of ground-truthing (Table 6). Despite the reduced number of occasions when appropriate ship type were present (600–200) the rate of boarding was still very low ($106/400 = 26.5\%$).

The results from the Coast Guard Ground-truthing boardings of June and July 2000 reveal four critical problems with this effort. First and foremost, only a small percentage of the requested vessel boardings are being reported to the Clearinghouse. Second, 41.4% of reported boardings do not conform to the guidelines of the boarding protocol and therefore are of no analytical use for measuring the accuracy of vessel ballast water management reporting. Third, since May 2000, most boarding officers continue to use the outdated version of the ground-truthing form, which contains several ambiguous questions that complicate or prevent analyses. Fourth, the percentage of ground-truthing reports that include omissions and clerical errors is quite high. Each of these problems significantly diminishes the number of usable forms and makes it impossible to statistically test the accuracy of the ballast water delivery and exchange data reported by commercial vessels.

CONCLUSIONS

In conclusion, overall national compliance in reporting by ships was low (20.8%) and showed no evidence of improving throughout the 12-month period (Fig. 8a). As of June 2000, compliance with the reporting requirement remained at just under 24% of the vessels subject to the reporting requirement, as identified by the MARAD database on foreign waterborne commerce.

Of the ships that did report, overall compliance with the voluntary ballast water management guidelines was above 75%, most of which were vessels that did not discharge. However, of the 3,560 discharging vessels, only about 22% reported having conducted a complete (100%) exchange of ballast water prior to discharge. In terms of the volume of ballast water reported discharged during the 12 month period, almost 40% had not been exchanged completely. As these estimates are the most liberal possible, it may be that significantly more of the discharged water was in fact not exchanged completely. Because the reporting rate was so low, these data are not likely to be representative of the practices of the industry in general. 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 likely 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.

As observed for compliance with reporting, there was no obvious increase in compliance with voluntary guidelines over time. Over the course of the 12-month period, there was little or no systematic increase in the rate at which ships reported complete or partial exchange (Fig. 8b). There was, however, an early and sharp increase in the rate at which vessels reported no exchange of discharged ballast water. Between July and August of 1999, the number of vessels reporting no exchange of discharged water jumped by almost 70%. Afterward, there was a slight decreasing trend in the number of vessels reporting no exchange until February 2000, followed by an increasing trend to the end of the first year of the program. Across all regions, there was little difference in the relative amounts of discharged ballast water that had been unexchanged, exchanged incompletely, or exchanged completely, over the first 12 months of the program (Fig. 8c).

The regional pattern of compliance with the reporting requirement suggests that reporting along the West Coast was significantly spurred by implementation of California ballast water legislation, with authorization for penalties, requiring submission of the USCG form to the state. Similar increases in reporting were not obvious for the East Coast following passage of a similar law in Maryland. While the reporting compliance increased in California following passage of ballast water legislation, there was no indication of a parallel increase in the rate of compliance with the voluntary ballast water management guidelines for mid-ocean exchange.

Significant problems exist with implementation of the USCG verification surveys. Too few boardings are being reported and, of these, an even smaller number are actually usable for their intended purpose. Factors that reduce or prevent the usage of submitted reports include a high rate of clerical mistakes, boardings that are not part of the official randomized schedule, and continued use of an outdated and flawed reporting form.

The low level of reporting creates a significant problem in interpreting (a) compliance with voluntary guidelines and (b) tracking the delivery and management patterns of ballast water arriving to the U.S. This gap in information increases the importance of the USCG Verification Surveys, which were intended to both verify voluntary compliance and serve as an independent source of data to characterize these traffic patterns. This underscores an urgent need to improve the quality and quantity of the USCG surveys.



Figure 1. Captain of the Port Zone designations for all coastal marine ports of the United States.

Monthly Reporting Rates by Coast

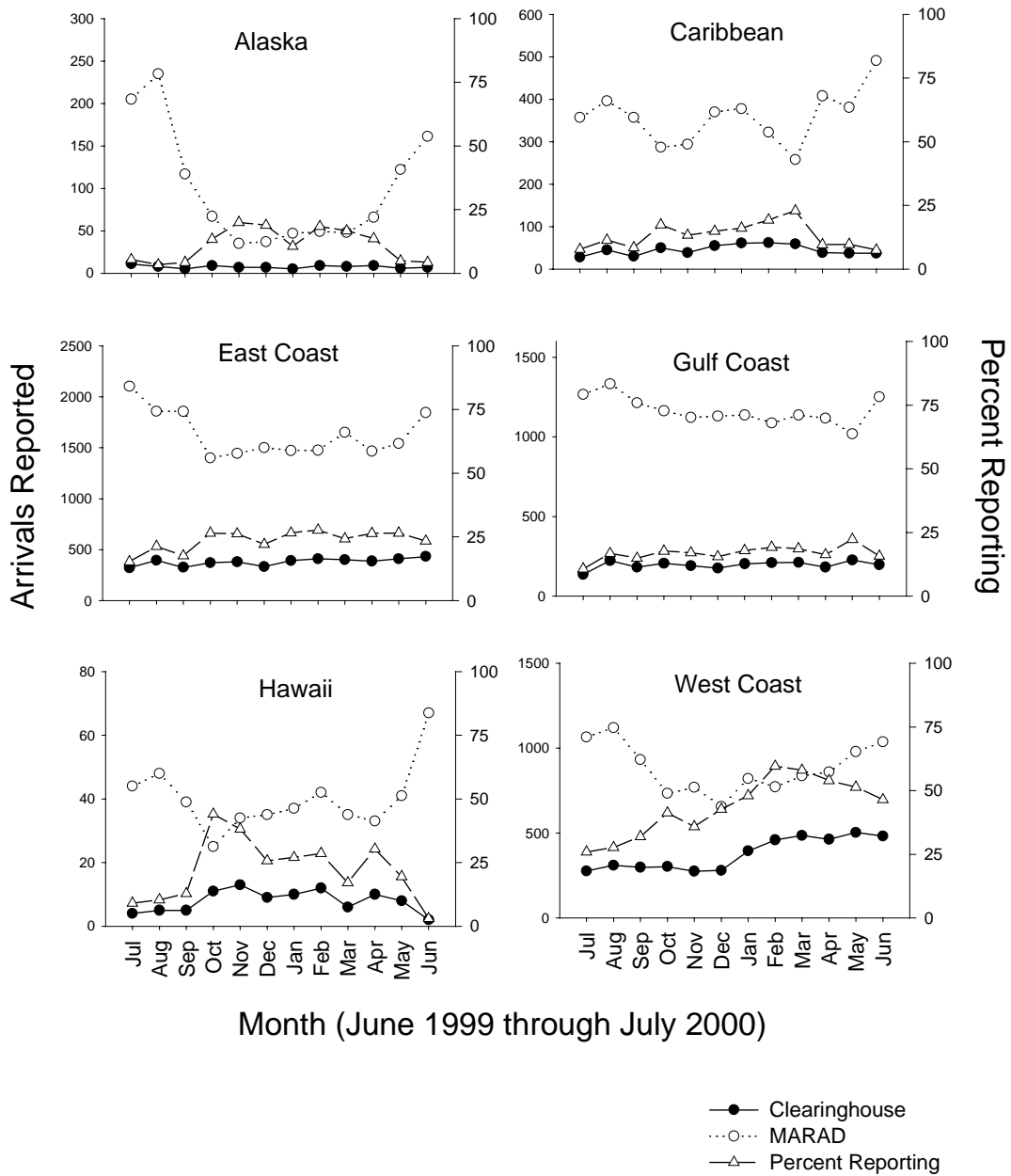


Figure 2. Monthly foreign arrivals to the United States by coastal region (number of arrivals and % reporting rate) for June 1999 to June 2000. Data are from National Ballast Survey and Maritime Administration databases.

West Coast Reporting by State

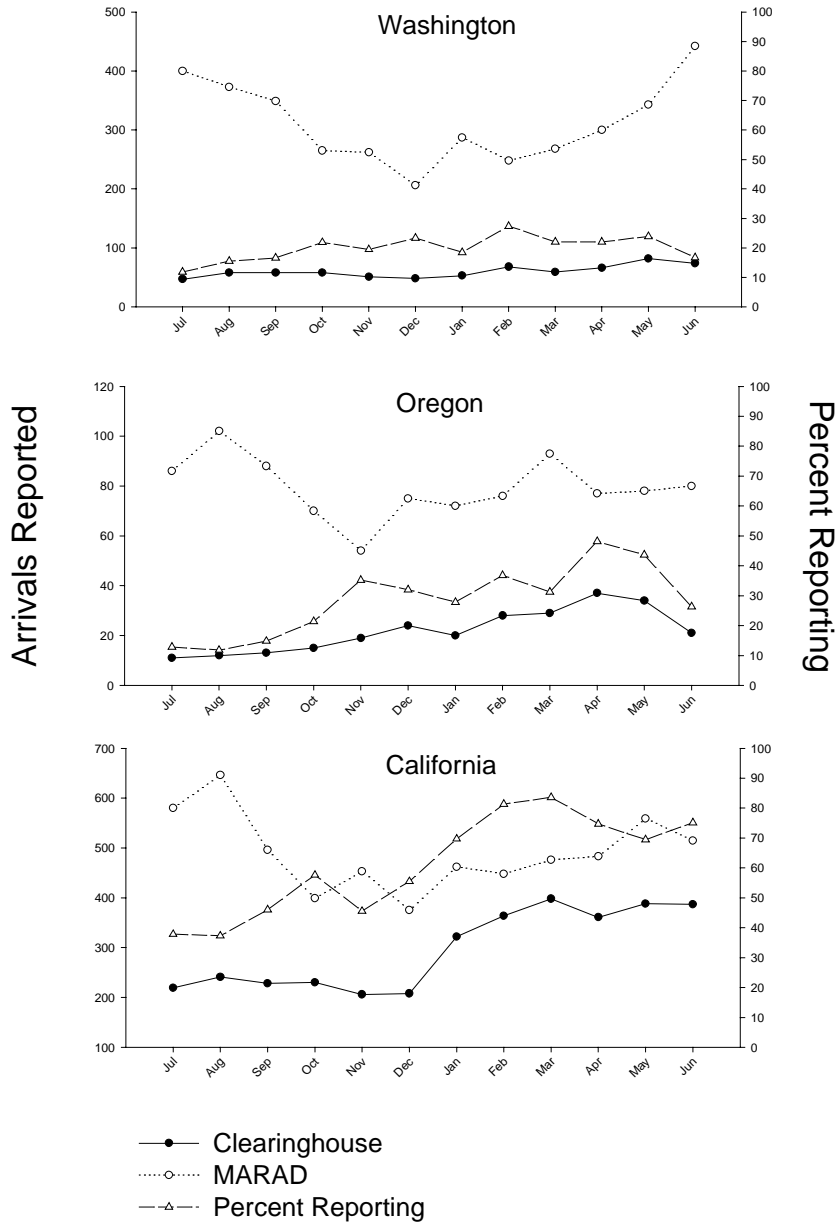


Figure 3. Monthly foreign arrivals to the West Coast states (number of arrivals and % reporting rate) for June 1999 to June 2000. Data are from National Ballast Survey and Maritime Administration databases.

Discharge and Exchange Patterns by Coast

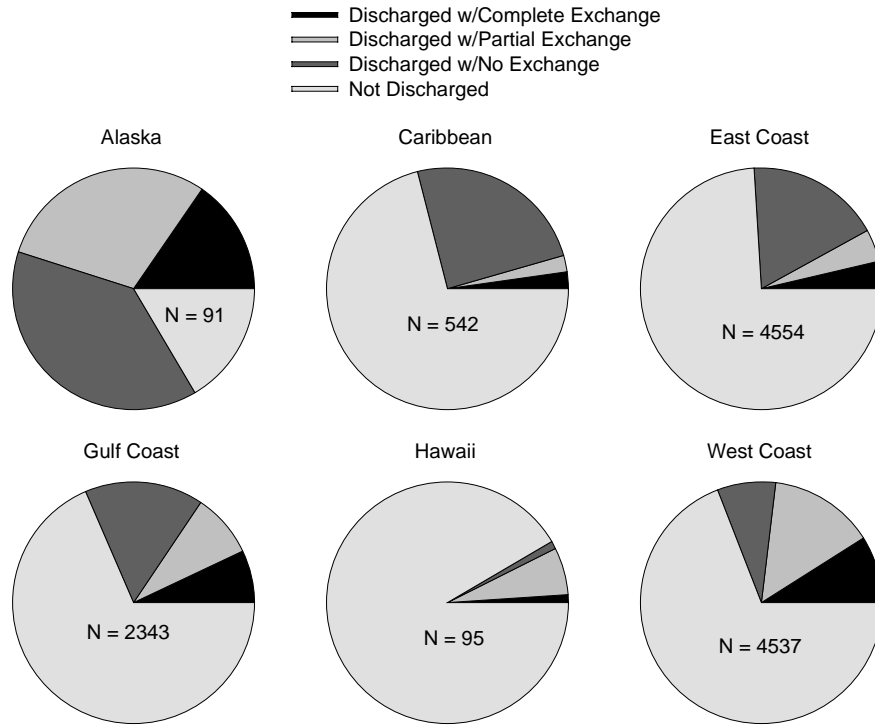


Figure 4. Discharge and ballast water exchange patterns by coastal region. Complete exchange is defined as $\geq 100\%$ exchange by volume.

California Exchange Practices

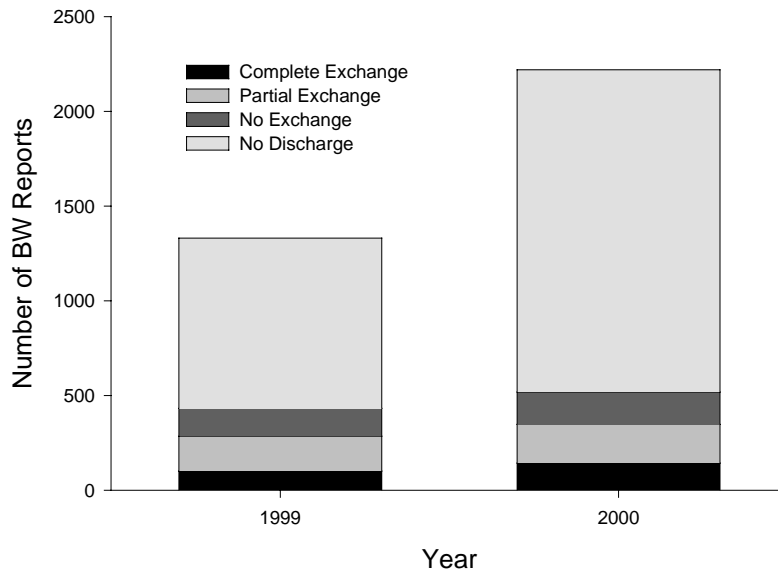


Figure 5. California ballast water exchange practices between July 1999 and June 2000. Data are from National Ballast Survey database and represent the number of reports from foreign arrivals to Californian ports.

Volume of Exchange Patterns by Coast

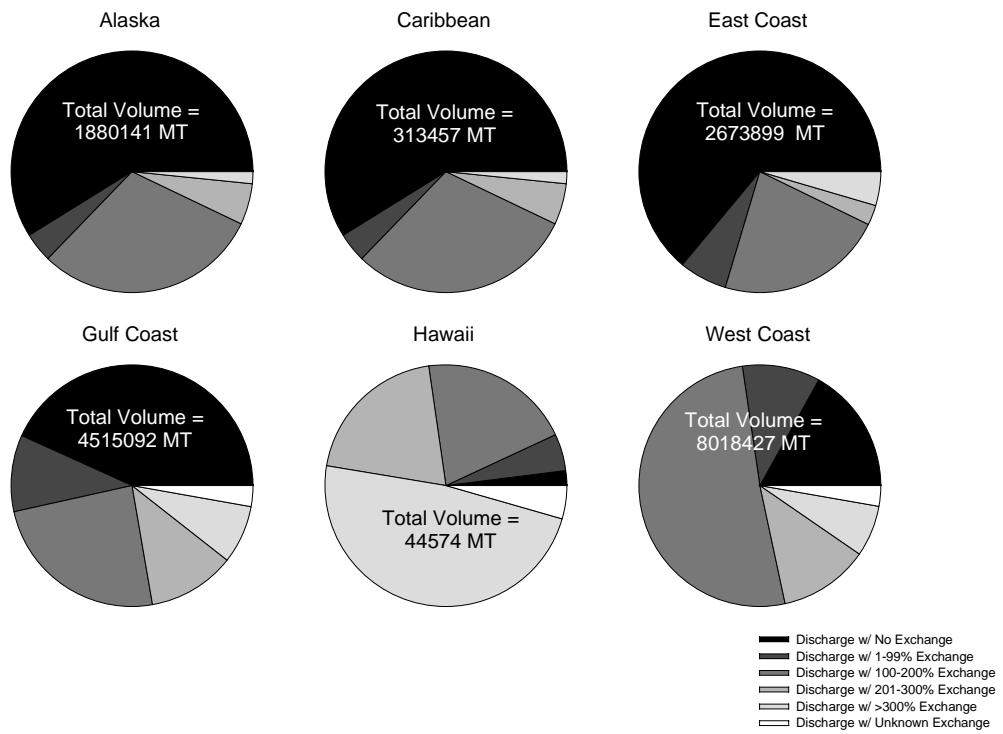


Figure 6. Exchange patterns by volume for coastal regions of the United States.

Density of Exchange July 1, 1999 to June 30, 2000

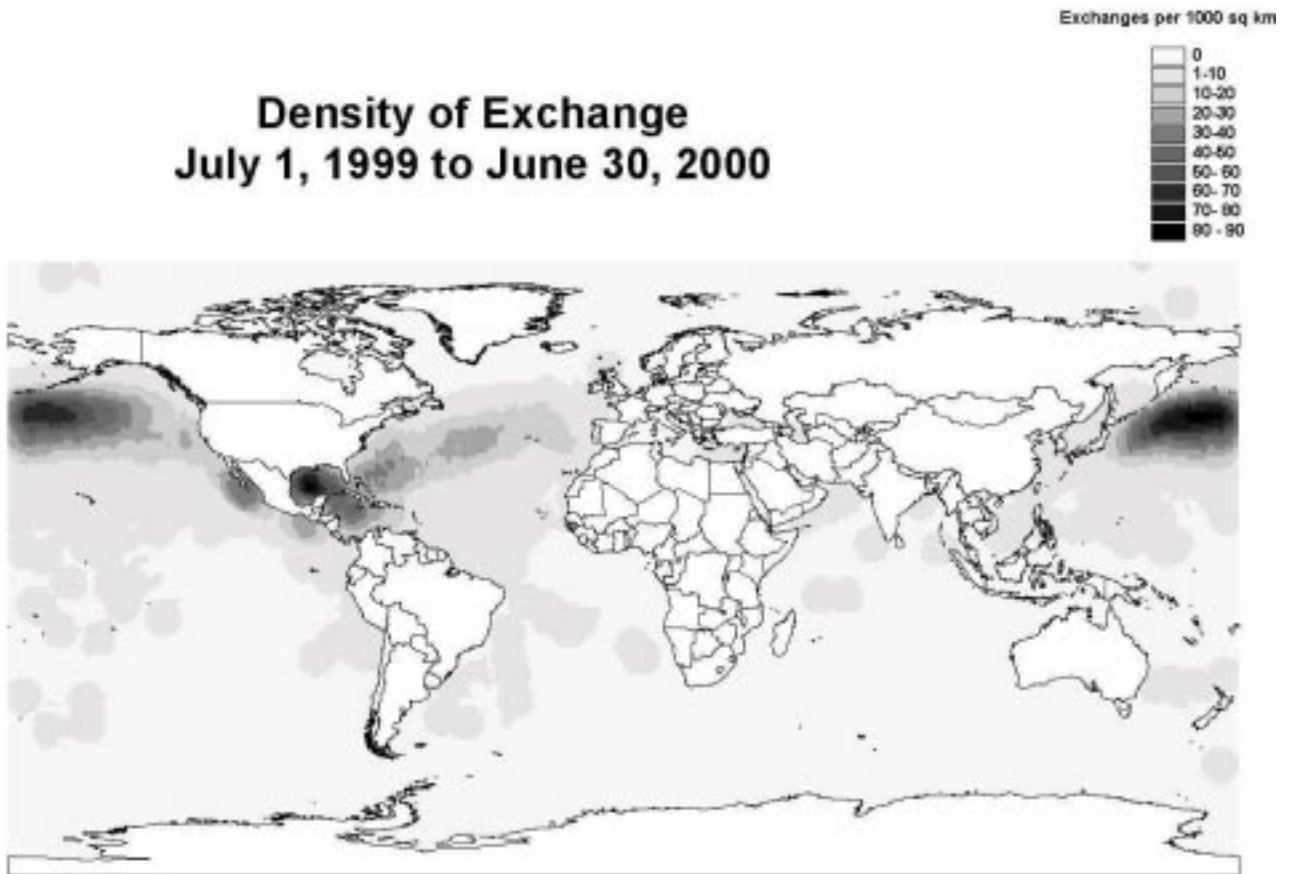


Figure 7. Density of open-ocean ballast water exchange in terms of volume (MT) of ballast water exchanged per 1000 km².

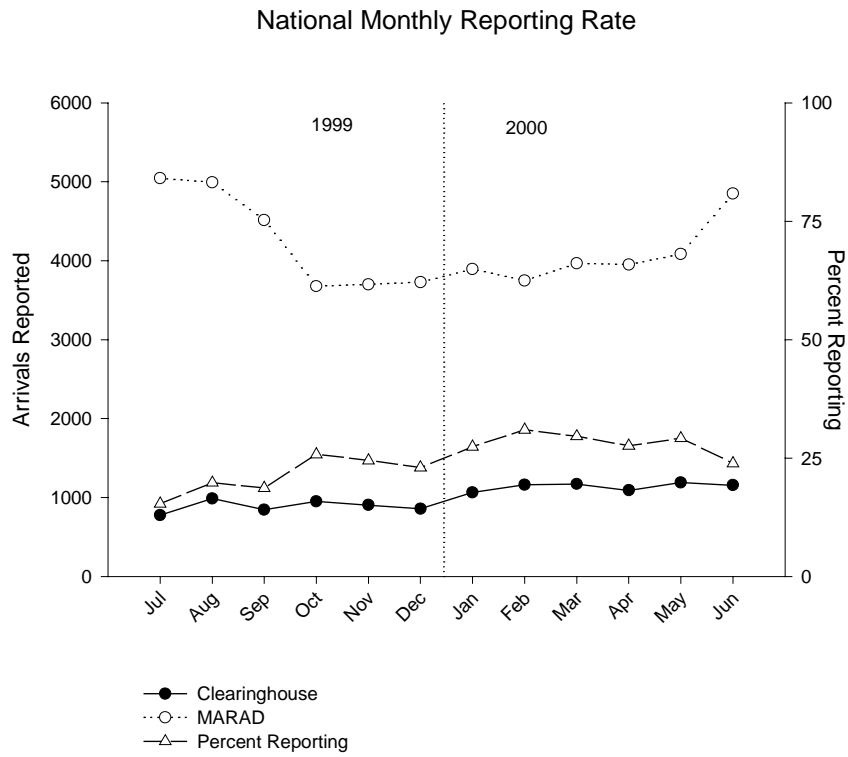


Figure 8a. Overall monthly foreign arrivals to the United States (number of arrivals and % reporting rate) for June 1999 to June 2000. Data are from National Ballast Survey and Maritime Administration databases.

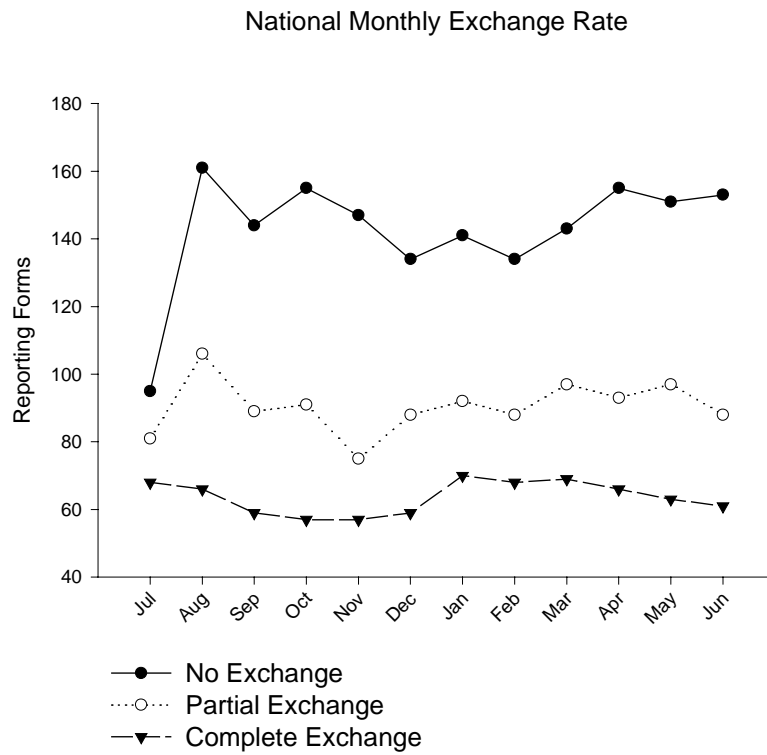


Figure 8b. Ballast water exchange rates for the United States between July 1999 and June 2000. Complete exchange is defined as $\geq 100\%$ exchange by volume. Data are from National Ballast Survey and Maritime Administration databases.

National Patterns of Exchange by Volume and Month

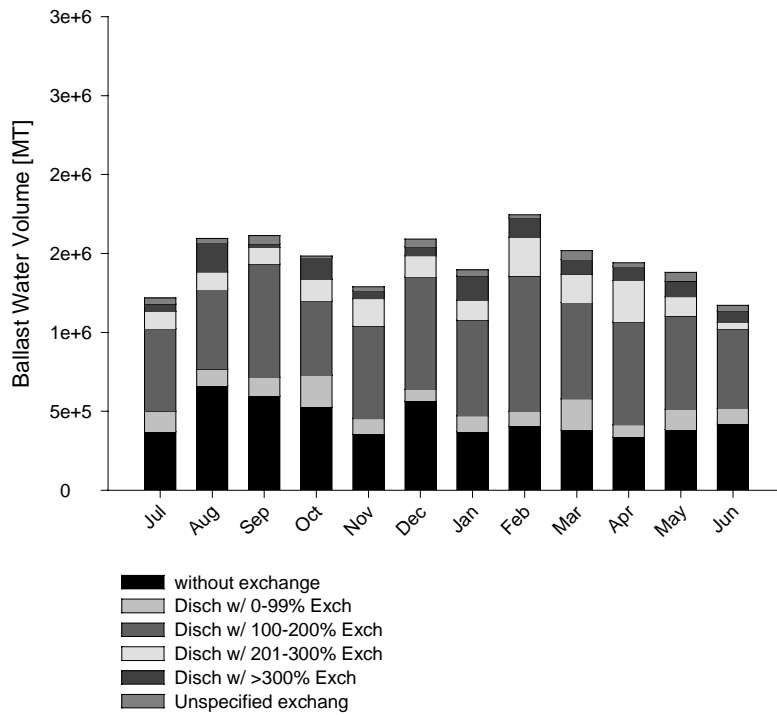


Figure 8c. National monthly patterns of ballast water exchange by volume between July 1999 and June 2000. Data are from National Ballast Survey database.

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

Port	Year	No. Foreign Arrivals	
		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%)

Table 2. Number of ballast water reporting forms received by the Clearinghouse during the first 12 months following implementation of the reporting requirement. The percent reporting rate was calculated as the number of ballast water reporting (BWR) forms received divided by the number of vessels recorded by MARAD.

U. S. Coast	COTPZ	BWR Forms [#]	MARAD Arrivals [#]	Percent Reporting Rate
Alaska	ANCMS	67	608	11.0%
	JUNMS	9	1018	0.9%
	VALMS	15	24	62.5%
	Subtotal	91	1650	5.5%
Caribbean	SJPMS	542	5152	10.5%
	Subtotal	542	5152	10.5%
East Coast	BOSMS	98	596	16.4%
	LISCP	19	69	27.5%
	NYCCP	764	2952	25.9%
	POMMS	187	1183	15.8%
	PROMS	11	236	4.7%
	BALMS	152	695	21.9%
	HMRMS	130	578	22.5%
	PHIMS	806	1656	48.7%
	WNCMS	36	889	4.0%
	CHAMS	274	929	29.5%
	JACMS	364	1910	19.1%
	MIAMS	1543	9580	16.1%
	SAVMS	170	685	24.8%
	Subtotal	4554	21958	20.7%
Gulf of Mexico	TAMMS	353	914	38.6%
	CORMS	211	1147	18.4%
	HOUCP	752	5754	13.1%
	MOBMS	181	1696	10.7%
	NEWMS	708	6226	11.4%
	PATMS	138	1107	12.5%
	Subtotal	2343	16844	13.9%
Pacific Islands	HONMS	95	526	18.1%
	GUAD	8	N/A	N/A
	Subtotal	103	526	19.6%
West Coast	LOSMS	2899	4692	61.8%
	SDCMS	143	720	19.9%
	SFCMS	510	809	63.0%
	PORMS	434	1583	27.4%
	SEAMS	551	4687	11.8%
	Subtotal	4537	12491	36.3%
	Grand Total	12170	58621	20.8%

Table 3. Compliance, by ship, with the voluntary ballast water management guidelines. Columns 3, 4, 6, 8, 10, and 12 are numbers of ships; columns 5, 7, 9, and 11 are the percent of column 3 represented by the preceding columns. Column 13 is the percent of the number of vessels discharging ballast water (sum of columns 6, 8, and 10) that had completely exchanged the water (column 10).

U. S. Coast	COTPZ	BWR Forms [#]	Zero Discharge [#]	% Zero Discharge	Zero Exchange [#]	% Zero Exchange	Partial Exchange [#]	% Partial Exchange	Complete Exchange [#]	% Complete Exchange	Discharge [#]	% Dischargers with Complete Exchange	
Alaska	ANCMS	67	10	14.9%	33	49.3%	15	22.4%	9	13.4%	57	15.8%	
	JUNMS	9	2	22.2%	0	0.0%	3	33.3%	4	44.4%	7	57.1%	
	VALMS	15	3	20.0%	2	13.3%	9	60.0%	1	6.7%	12	8.3%	
	Subtotal	91	15	16.5%	35	38.5%	27	29.7%	14	15.4%	76	18.4%	
Caribbean	SJPMS	542	385	71.0%	133	24.5%	12	2.2%	12	2.2%	157	7.6%	
	Subtotal	542	385	71.0%	133	24.5%	12	2.2%	12	2.2%	157	7.6%	
East Coast	BOSMS	98	72	73.5%	22	22.4%	1	1.0%	3	3.1%	26	11.5%	
	LISCP	19	16	84.2%	2	10.5%	1	5.3%	0	0.0%	3	0.0%	
	NYCCP	764	616	80.6%	68	8.9%	23	3.0%	57	7.5%	148	38.5%	
	POMMS	187	173	92.5%	5	2.7%	5	2.7%	4	2.1%	14	28.6%	
	PROMS	11	10	90.9%	1	9.1%	0	0.0%	0	0.0%	1	0.0%	
	BALMS	152	134	88.2%	3	2.0%	7	4.6%	8	5.3%	18	44.4%	
	HMRMS	130	79	60.8%	16	12.3%	21	16.2%	14	10.8%	51	27.5%	
	PHIMS	806	746	92.6%	16	2.0%	18	2.2%	26	3.2%	60	43.3%	
	WNCMS	36	25	69.4%	4	11.1%	3	8.3%	4	11.1%	11	36.4%	
	CHAMS	274	204	74.5%	32	11.7%	20	7.3%	18	6.6%	70	25.7%	
	JACMS	364	232	63.7%	120	33.0%	8	2.2%	4	1.1%	132	3.0%	
	MIAMS	1543	932	60.4%	520	33.7%	73	4.7%	18	1.2%	611	2.9%	
	SAVMS	170	135	79.4%	8	4.7%	17	10.0%	10	5.9%	35	28.6%	
	Subtotal	4554	3374	74.1%	817	17.9%	197	4.3%	166	3.6%	1180	14.1%	
	Gulf of Mexico	TAMMS	353	237	67.1%	79	22.4%	22	6.2%	15	4.2%	116	12.9%
		CORMS	211	167	79.1%	19	9.0%	18	8.5%	7	3.3%	44	15.9%
		HOUCP	752	516	68.6%	119	15.8%	54	7.2%	63	8.4%	236	26.7%
MOBMS		181	145	80.1%	8	4.4%	18	9.9%	10	5.5%	36	27.8%	
NEWMS		708	432	61.0%	137	19.4%	75	10.6%	64	9.0%	276	23.2%	
PATMS		138	109	79.0%	10	7.2%	14	10.1%	5	3.6%	29	17.2%	
Subtotal	2343	1606	68.5%	372	15.9%	201	8.6%	164	7.0%	737	22.3%		
Pacific Islands	HONMS	95	87	91.6%	1	1.1%	6	6.3%	1	1.1%	8	12.5%	
	GUAD	8	7	87.5%	0	0.0%	1	12.5%	0	0.0%	1	0.0%	
Subtotal	103	94	91.3%	1	1.0%	7	6.8%	1	1.0%	9	11.1%		
West Coast	LOSMS	2899	2103	72.5%	289	10.0%	315	10.9%	192	6.6%	796	24.1%	
	SDCMS	143	116	81.1%	6	4.2%	17	11.9%	4	2.8%	27	14.8%	
	SFCMS	510	380	74.5%	23	4.5%	56	11.0%	51	10.0%	130	39.2%	
	PORMS	434	180	41.5%	20	4.6%	145	33.4%	89	20.5%	254	35.0%	
	SEAMS	551	357	64.8%	16	2.9%	108	19.6%	70	12.7%	194	36.1%	
Subtotal	4537	3136	69.1%	354	7.8%	641	14.1%	406	8.9%	1401	29.0%		
Grand Total	12170	8610	70.7%	1712	14.1%	1085	8.9%	763	6.3%	3560	21.4%		

Table 4. 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.

Excuse Provided	BWR Forms [#]	%
Unspecified/Undecipherable	199	17.2%
Clean Water Tank	75	6.5%
Itinerary	389	33.7%
N/A	234	20.3%
No Ballast Plan	7	0.6%
Safety	202	17.5%
Ship's Design	37	3.2%
Alternative Management Method	12	1.0%
Total	1155	100.0%

Table 6. U.S. Coast Guard ground-truthing reports for June and July 2000. Reports summarized according to the medium of data collection. National target boarding rate per vessel type = 60 boardings/month.

June 2000	Electronic	Hard Copy (New)	Hard Copy (Old)	Total	% of Target
Boardings:					
Official Boardings	5	16	51	72	24.0%
# Dischargers	2	3	16	21	
# Non-Dischargers	3	12	35	50	
# Unspecified	0	1	0	1	
Vessel Types:					
# Bulk Carriers	1	6	17	24	40.0%
# Containers	1	0	8	9	15.0%
# Tankers	2	4	7	13	21.7%
# General Cargos	0	3	6	9	15.0%
# Others	1	3	13	17	28.3%
Salinity Measured:					
#Dischargers	0	1	8	9	42.9%
#Non-Dischargers	1	0	0	1	
Additional Boardings (invalid)	0	8	33	41	

July 2000	Electronic	Hard Copy (New)	Hard Copy (Old)	Total	% of Target
Boardings:					
Official Boardings	3	9	22	34	11.3%
# Dischargers	0	2	4	6	
# Non-Discharger	3	7	18	28	
# Unspecified	0	0	0	0	
Vessel Types:					
# Bulk Carriers	0	2	5	7	11.7%
# Containers	1	2	7	10	16.7%
# Tankers	2	1	6	9	15.0%
# General Cargos	0	2	3	5	8.3%
# Others	0	2	1	3	5.0%
Salinity Measured:					
#Dischargers	0	2	4	6	37.5%
#Non-Dischargers	0	2	0	2	
Additional Boardings (invalid)	11	7	16	34	