Glosten

WASHINGTON DEPARTMENT OF FISH AND WILDLIFE

SIX-YEAR STRATEGIC PLAN: BALLAST WATER MANAGEMENT

PREPARED FOR

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PREPARED

Digitally Signed 27-Jun-2017

ZENZILE Z. MOORE, PhD
MARKETING MANAGER

PREPARED

Digitally Signed 27-Jun-2017

HALEY C. LANE
ENGINEERING WRITER

CHECKED/APPROVED

Digitally Signed 27-Jun-2017

KEVIN J. REYNOLDS, PE
PRINCIPAL-IN-CHARGE

CONTENT/REVIEW/APPROVAL

ALLEN PLEUS
PROGRAM MANAGER, DFW

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Revision History

Section	Rev	Description	Date	Approved
All	-	Report released.	19 June 2017	KJR
All	A	DFW comments incorporated.	27 June 2017	KJR

Foreword

The Washington State Department of Fish and Wildlife (DFW) retained Glosten to develop this six-year ballast water management program strategic plan in May of 2016. At the time, the task was a straightforward assessment of the current program and development of a forward-looking plan in compliance with Washington State administrative code. Inputs were to include historical ballast water discharge data, DFW's current activities, gaps between federal and state requirements, and forecasted ballast management and shipping pattern changes.

This assessment, as of June 2017, has become the subject of unexpected scrutiny and political review as the U.S. Congress considers the *Commercial Vessel Incidental Discharge Act (CVIDA)*. In March 2017, the Washington State Ballast Water Work Group (BWWG) discussed this plan's draft findings mostly in the context of CVIDA. CVIDA has polarized much of the ballast water community:

CVIDA is *"vital in 2017"* and would *"establish a clear and consistent regulatory framework for commercial vessel owners"* -The American Waterways Operators, website accessed 4 April 2017	*"This legislation, currently under consideration in the U.S. Senate, resurrects previous attempts to dismantle federal and state water pollution control laws that protect our vital waterways from the scourge of invasive species discharged by commercial shipping vessels"* -Letter from ten state attorneys general, including Washington, 15 February 2017

We have worked hard to develop this strategic plan independently of the CVIDA debate. A few clarifying points are provided here to inform the reader that may view this plan from one of the polarized perspectives induced by CVIDA:

- DFW, in consultation with BWWG, directed the assessment scope, with Glosten performing the assessment and drafting the recommendations. The final text is the result of joint review by Glosten, DFW, and the BWWG.
- Terminology in the report is taken, to the extent possible, directly from the data sources. The following terms, which can be misleading, are clarified here:

  Raw ballast water is ballast water directly from the source port. Raw ballast water has not been exchanged (flushed with seawater during the voyage) or treated, and is referred to by the USCG as "unmanaged ballast water." Discharge of raw ballast water is not necessarily illegal, as state and federal regulations do not require management of ballast water from certain vessels or for specified coastal and inland voyages.

  Noncompliant discharges include ballast water that was discharged out of compliance with either management requirements (such as performing an exchange in the wrong location) or administrative requirements (such as filing a late report). The relative importance of the various levels of noncompliance is complex.

The passing of CVIDA could have a significant impact on DFW's ballast water program. However, the congressional process is complex and the outcome uncertain. Therefore, we ask that readers view this plan, as written, from the perspective of effectively supporting the current Washington State legislative and administrative framework.

Respectfully,

Kevin J. Reynolds, PE, Glosten (27 June 2017)

Summary

The Washington State Department of Fish and Wildlife (DFW) has a mission to protect the ecological and economic health of Washington State waters. Puget Sound, the Columbia River, and the Northwest Coast are at risk of the introduction of nonindigenous species (NIS) through ballast water pathways. DFW has maintained a special focus on this risk through their Ballast Water Management Program, which was developed following the introduction of specific Washington State legislation in 2000. The requirements of DFW's Ballast Water Management Program are set forth in RCW 77.120 and WAC 220-650. The state shares regulatory responsibility for ballast water activity with the U.S. Coast Guard (USCG) and the U.S. Environmental Protection Agency (EPA), both of which regulate ballast water activity at the federal level.

Measurable and Positive Impact of State Program

In 2015, Washington State received the highest volume of ballast water discharges (15.7M m^3) of all Pacific states (National Ballast Information Clearinghouse, Reference 31). Ballast water discharge is a key driver of NIS invasions. The measurable impact of the DFW program has been to reduce risk of NIS invasion through state involvement.

In order to assess the impact of DFW's Ballast Water Management Program, the risk of NIS invasion is divided into two categories: management risk and compliance risk. Within each category, contributing factors define the risk. Figure 1 presents the approximate ranges of risk level, from low risk to high risk, for the factors of each risk type considered. Each category is defined below and considered in terms of DFW effectiveness at reducing that risk.

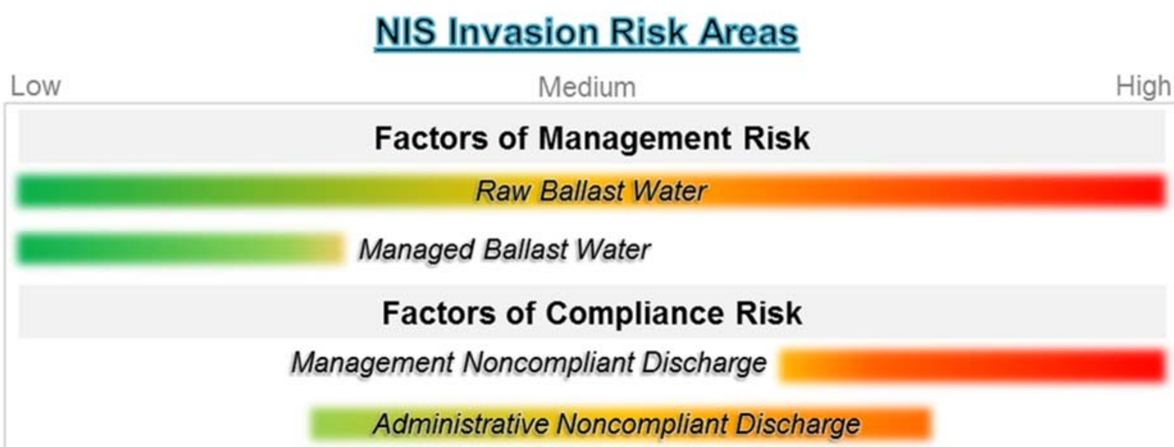


Figure 1 Approximate relative levels of compliance risk and management risk factors

Management Risk refers to the risk of NIS invasion when an arriving vessel has not managed its ballast water prior to discharge. Management options include flushing ballast water tanks with oceanic waters (ballast exchange), using an approved treatment system, discharging to a reception facility, using municipal freshwater, and retaining all ballast water (not discharging). Ballast that has not undergone one of these options is referred to herein as **raw ballast water**.

Importantly, regulations do not require ballast water management in all instances. For example, in Washington State, ballast water sourced and discharged in special "common water" zones is not required to undergo management. Despite this exemption, University of Washington researchers have shown that a common water source does not necessarily indicate a lack of nonindigenous species (Reference 15). Ultimately, most ballast water discharge poses some nonindigenous species risk to the state. Unless the ballast water was either sourced from a potable water source, discharged to a reception facility, or not discharged at all, the water has some potential of discharging nonindigenous species. Thus, an arrival can pose management risk yet be in full compliance with all state and federal regulations.

Higher volumes of raw ballast water correspond to increased invasive species risk. As shown in Figure 1, although managed ballast water tends to be low-risk, raw ballast water presents the full range of risk levels. Washington State raw ballast water discharges, which have the potential to be high-risk, were limited to 14% of the state's total discharge volume in 2015, one-third of the national average of 43% (Reference 55).

Compliance Risk refers to an arriving vessel that does not meet all ballast water regulatory requirements at the state, federal, or both levels. DFW has generally reduced compliance risk through communication and inspection efforts, including real-time ballast report reviews and direct-to-operator communication. These DFW efforts reduced noncompliance rates for vessels that planned to discharge ballast water by half, compared to compliance rates prior to arrival to after the DFW involvement. Inspections, in particular, have typically brought a two-thirds reduction in the size of the initially noncompliant group. Worth note is that state inspectors have typically found that 5% of inspected vessels originally reported as compliant were actually noncompliant.

Compliance risk is composed of two factors as displayed in Figure 1:

- **Administrative noncompliance** refers to discharge activity out of compliance with state administrative regulations. As shown in Figure 1, administrative noncompliant discharge presents a mid-range amount of risk, and a lower degree of risk than management noncompliant discharge activity. Administrative noncompliance can involve a variety of errors, including filing a late form, filing an illegible form, and not filing forms for additional ports.
- **Management noncompliance** refers to vessel ballast water discharge activity out of compliance with management regulations. As shown in Figure 1, management noncompliant discharge activity presents a relatively high level of risk of NIS invasion. Each year, DFW prevents an average of 0.9M m^3 of ballast water from being discharged as management noncompliant. Between 2012 and 2015, DFW recorded an average of 15 management noncompliant discharge events per year, with an average volume of 0.16M m^3 or 1% of the total ballast water discharged into state waters each year.

In summary, state involvement has achieved a high degree of risk reduction in the risk categories described above. DFW has measurably improved vessel compliance with state and federal regulations, and the combination of state and federal legislation and enforcement efforts have resulted in a relatively low annual volume of raw ballast water discharge in state waters.

Continued Risk to Washington State Waters

Despite the positive results of DFW efforts over the last eight years, on average, 1% (0.16M m^3) of ballast water discharges remain noncompliant with management requirements, and a further 17% (2.8M m^3) of planned discharges (by volume) remain noncompliant with recordkeeping requirements. Noncompliance has been compounded by vessel traffic growth (4% between 2008 and 2015), and more importantly, by an increase in ballast water discharge volume of 43% over the same period. This growth is projected to continue over the next six years (Table 1 reprint of Table 20).

Table 1 Summary of trends from historical and forecast data

	2008 – 2015 (Measured)	2016 – 2023 Growth (Forecast, Section 3.2.3)
Vessel Arrivals to Washington's Ports	+ 4%	+ 3%
Ballast Water Discharges	+ 33%	+ 19%
Ballast Water Discharge Volume	+ 43%	+ 27%
Compliance of Arrivals		
Noncompliant, Administrative	17% of discharge volume	---
Noncompliant, Management	1% of discharge volume	---

The practice of flushing ballast water tanks with oceanic waters (ballast exchange) is being phased out as operators must transition to federally required ballast water treatment systems. While ballast water treatment is expected to be more effective than ballast exchange in protecting state waters in the long run, challenges are expected during the phase-in over the next six years. DFW will need to train personnel and develop new inspection procedures in response to this changing environment, and will also need to develop procedures to respond to shipboard operational challenges related to treatment equipment that could result in a vessel arriving in port with raw ballast water.

There continue to be proposals for new bulk export terminals, any of which would significantly increase the volume, number, and frequency of ballast water discharges into state waters beyond what is predicted in Table 1, above. Changes in the economic cycle or shipping patterns can shift these trends.

Six-Year Strategic Plan for the Washington State Department of Fish and Wildlife

DFW efforts to date have had a measurable and positive impact on reducing NIS risk to Washington State waters. It is a remarkable success that management compliance has reached an effectiveness of only 1% noncompliant ballast water discharge into state waters, which is a reflection of combined state, federal, and industry interests to protect those waters.

However, administrative noncompliance remains at 17%, and has the potential to mask management noncompliance. Finally, the number and volume of discharges are forecast to increase significantly, and the implementation of ballast water treatment systems will introduce new demands on the DFW program.

The strategic plan recommendations are made in consideration of the protections currently provided by both USCG and DFW. Both agencies pursue the broad aim of ensuring that all arrivals to Washington State are compliant with state and federal regulations. By employing distinct methods of inspection and enforcement, the agencies collaboratively effect regulatory compliance. Inter-agency cooperation in areas such as data management and inspection prioritization will provide a way to increase the efficiency of each agency in the coming years, minimizing the risk of NIS invasions to Washington State.

It is recommended that DFW strengthen its core ballast water program, develop new methods that address impending challenges with treatment systems and sampling, and renew efforts for cooperation with USCG. Given the significant expected changes over the next six years, the DFW program must be adaptive in nature. This adaptable program should adhere to several recommended objectives:

- **Strengthen program**. Increase state program staffing to five full time equivalent positions, including refilling a vacant Operations Manager position. The increase in staffing includes new data management support roles. An upgrade to the data management infrastructure is also recommended.
- **Evolve methods**. State management methods should evolve with changing technology. The state should restart ballast water exchange sampling, implement an inspection training and protocol system that accounts for the new treatment systems, and research biological sampling. An incentive program for vessel owners and operators should be developed to support information sharing and co-development of inspection and sampling methods.
- **Increase cooperation**. DFW and USCG should enter into formal agreements on data management sharing and vessel inspections, with the objective of increasing effectiveness and avoiding duplication. The Ballast Water Working Group should be reinvigorated, including assuring that ports, industry, regulatory, and environmental groups continue to participate. Education and outreach efforts should be increased. Regional coordination should continue, including with Oregon along the shared waters of the Columbia River and Canada along shared waters of the Puget Sound.

Section 1 Introduction

The Washington State vessel-related ballast water management six-year strategic plan (Plan) was developed at the request of the Washington Department of Fish and Wildlife (DFW) and their stakeholder Ballast Water Work Group (BWWG) through funding by the U.S. Environmental Protection Agency (EPA) Puget Sound Marine and Nearshore Grant Program and legislative proviso funding from the Washington State Aquatic Lands Enhancement Account. This Plan is the culmination of multiple years of effort. It builds off DFW experience and knowledge gained since the program was established in 2000, unmet BWWG recommendations from their 2007 report to the legislature, ballast water data collected between 2008-2015, a regulatory gap analysis report by Reynolds et al. 2016, and U.S. Coast Guard (USCG) ballast data from 2015.

1.1 Purpose

DFW has been tasked by the state legislature since 2000 to ensure that the discharge of ballast water by vessels poses minimal risk of introducing nonindigenous species into state waters. In addition, the legislature directed that state ballast water management be compatible, where practical and appropriate, with the federal government's ballast water requirements. Furthermore, the legislature directed DFW to consult with the regulated industry and other potentially affected partners (stakeholders) to develop and implement regulations that are practical and appropriate in seeking a balance between protection of the state's aquatic resources and shipping-related commerce interests. The stakeholder forum for this consultation was established in 2002 through legislative creation of the BWWG. Authority and requirements for the current Washington State Ballast Water Management Program is found under RCW 77.120 and WAC 220-650.

The purpose of this document is to provide strategic and organizational guidance to the DFW Ballast Water Management Program for the next six state fiscal years – July of 2017 to June of 2023. This guidance is presented through three main parts:

- **Section 2, Background**: Summarizes the environmental, legislative, and economic climate leading up to the development of the Strategic Plan.
- **Section 3, Data Analysis**: Analyzes historic program data and forecasts vessel operations and regulatory changes over the next six years.
- **Section 4, Washington State Ballast Water Management Program Six-Year Strategic Plan**: Presents both an overview and detailed summary of the strategic plan.

The appendices at the end of this report supplement the main information above.

1.2 Ballast Water Work Group

The Ballast Water Work Group was established in 2002 by the legislature under Senate Bill 6538 and is comprised of representatives of shipping interests, ports, shellfish growers, fisheries managers, environmental interests, citizens who have knowledge of the issues, and appropriate governmental representatives including the USCG, EPA, and tribal governments. In 2009, the BWWG was reestablished under WAC 220-650-010 to advise DFW on developing, revising, and implementing chapters RCW 77.120 and WAC 220-650 regarding ballast water and biofouling management. The success of DFW's regulations through several legislative processes, rulemaking, and policymaking actions is due in large part to BWWG consensus and support.

The BWWG assisted in the development of, provided approval for the initial scope of work, and provided recommendations for improving the Plan through two formal 30-day review periods during the document's development. A separate comment log is available from DFW that documents reviewer feedback and how this information was integrated into the document.

1.3 Strategic Plan Development

In order to understand the future needs of DFW, it was important to understand vessel traffic, discharges, and compliance in Washington State. The development and review process of the strategic plan recommendations is shown graphically in Figure 2, below, incorporating the following inputs:

- Data sets relevant to current and forecasted ballast water management practices in Washington State were acquired from DFW and the National Ballast Information Clearinghouse (NBIC). This data was summarized and forecasted to understand trends and predict program resource needs.
    - Glosten conducted a Gap Analysis of differences between Washington state and federal ballast water regulations in early 2016 (Reference 6). The Gap Analysis made recommendations for data analysis on many topics. Analysis recommended in the Gap Analysis was conducted where data was available.
- The data sets were used to develop the strategic plan recommendations, i.e. activities for the DFW to protect waters of the state.
- Review and feedback cycles with DFW and the BWWG provided critical inputs and review of the data sets and recommendations.

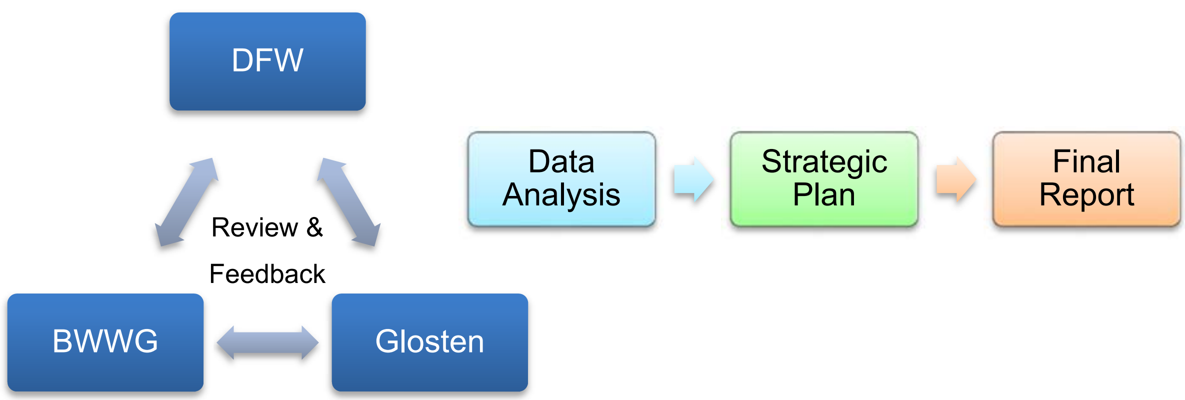


Figure 2 Strategic plan recommendations development and review process

DFW's BWWG played a critical role in developing, shaping, and finalizing this Strategic Plan. Initial development of the strategic plan occurred over several years and formalized with the completion of the BWWG Objectives Subgroup Project Recommendations paper issued in December of 2014. Once funding for the project was secured, these recommendations were incorporated into the project contract's scope of work. In addition, the BWWG advisory role was included to provide two formal reviews to ensure that the scope of work elements were incorporated. Specifically, BWWG review and feedback on this study was solicited through two 30-day comment periods, the first on a rough draft and the second on a final draft. Where BWWG members were not in consensus with the document's results or recommendations, a minority report is provided.

Section 2 Background

2.1 Nonindigenous Species Risks

When a vessel is empty of cargo, it must fill with ballast water to maintain its stability, trim, and structural integrity. When the vessel loads cargo in a distant port, it discharges its ballast water along with any aquatic life it contains. Ballast borne, nonindigenous species invasion represents a significant threat to aquatic ecosystems worldwide and environmental policy is developing rapidly to address this threat. The U.S. Congress, as first published in the *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990*, determined that ballast water discharges from marine vessels posed a significant threat to U.S. waters through the release of nonindigenous species that may disrupt the aquatic and nearshore environments (Reference 3). This aquatic life may out-compete native species and multiply into pest proportions. Problems directly resulting from invasive species include the collapse of entire commercial fisheries, the displacement of native seabed communities, and the red tide contamination absorbed by filter-feeding shellfish, among many others affecting the environment and human health.

The National Academy of Sciences formed an expert team to study the factors that might lead to an invasion, and in 2011 published a study concluding that while reducing propagule pressure reduces the likelihood of species invasions, many other factors influence this likelihood (Reference 11). Propagule pressure can be reduced by decreasing the discharge frequency, the total quantity of viable organisms discharged, and the concentration density of viable organisms.

2.2 Washington State Vessel Traffic Overview

Most vessels that call on Washington's ports are vessels in the following four categories:

- **Bulkers**: Bulk carriers (bulkers) are vessels that transport bulk dry cargoes such as grains and other agricultural products, forest products, steel products, minerals and ores, fertilizers, and cement.
- **Articulated Tug & Barges**: ATBs consist of a barge and a large tug specially designed to operate, for practical purposes, as one vessel.
- **Tankers**: Tankers are purpose-built for seaborne transportation of liquids or gases in bulk.
- **Containerships**: Containerships transport a wide variety of cargo types in standardized 20' and 40' marine shipping containers.

Collectively, bulkers, ATBs, tankers, and containerships comprised 90% of the discharging arrivals and 99% of the discharge volume in Washington State between 2008 and 2015. This study will focus in particular on these four groups of vessels. More information on the above vessel types can be found in Appendix A.

<u>Bulker Traffic</u>

Bulker activity is driven in large part by global market forces; and as such, their routes and cargo profiles change frequently. However, for trans-pacific voyages, it is common for bulkers to carry cargo in one direction only – from the North American West Coast (NAWC) to Asia – as Asian countries have comparatively low bulk export volumes. These vessels arrive in Washington waters in an in-ballast condition, meaning the vessel is empty of cargo, but carrying approximately one-third of its total deadweight capacity in the form of seawater ballast. This is necessary because bulkers are highly ballast-dependent, requiring the water to obtain adequate stability for the ocean transit, and to keep bending and shearing forces on the ship's hull within allowable limits.

According to the NBIC, the majority of bulkers that make calls at Washington ports arrive directly from ports in China, South Korea, and Japan. A smaller percentage of bulkers arrive from other Asian and Latin American countries, as well as from Russia, Canada, and other states in the U.S. (Reference 31).

Articulated Tug & Barge (ATB) Traffic

The past decade has seen a sharp increase in the number of ATBs operating in Washington waters, and elsewhere in the U.S., as illustrated in Section 3.2.1. The increase is attributable to their lower capital and operating costs relative to tankers, and the fact that the design/build timeline for ATBs is shorter than for standard tankers (Reference 5). ATBs are designed for specific operations with smaller cargo loads involved in local or coastal movements.

Almost without exception, ATBs making calls at Washington ports are tug/tank barge combinations designed for petroleum and chemical transportation. Of the six that make regular calls (*Sea Reliance/550-1, Sound Reliance/550-2, Ocean Reliance/550-3, ATB Commitment/650-6, Nancy Peterkin/Kirby 185-01, Bismarck Sea/DBL 106*), all are petroleum carriers operating on dedicated NAWC service routes. As such, they arrive in Washington waters from various west coast ports, such as Valdez, Vancouver, Portland, San Francisco, and Los Angeles (Reference 31). About 10% of 500 average annual ATB arrivals do not come from the U.S.; those come primarily from Canada. With the exception of the *Bismarck Sea/DBL 106*, which transports crude oil out of Valdez, ATBs carry refined petroleum products exclusively. Therefore, similar to product tankers, ATBs generally arrive from out of state in an in-ballast condition, and discharge ballast water as required during cargo load operations.

Tanker Traffic

Tanker operating profiles are similar to bulkers, in that they generally carry cargo in one direction on each voyage, completing the return leg in an in-ballast condition. Tankers are also highly ballast-dependent vessels.

Tankers that make calls at Washington ports are mainly limited to crude oil carriers and refined product carriers less than 125,000 DWT, arriving from other NAWC ports in the U.S. and Canada (Reference 31). Relative to ballast water discharges in Washington waters, the transportation services these two vessel types provide are dissimilar. Generally speaking, crude oil carriers transport cargo from points of production (oilfields) to refineries elsewhere, while product carriers transport petroleum products between refineries, or from refineries to distribution points (direct to market).

Washington State is largely an importer of crude oil, not a producer; and as such, crude oil carriers normally arrive from Alaska, or foreign source, in a loaded or partially loaded condition. As cargo is removed, these vessels take on ballast water to maintain a safe operating condition. Thus, crude oil carriers do not ordinarily discharge ballast in Washington waters. This could change in the future, however, if facilities in Washington are permitted to increase exports of U.S. domestic crude.

Product carriers, by comparison, transport refined petroleum products from Washington refineries to points both within and outside of state waters including Canada. Product carriers coming from out of state generally arrive in-ballast, and must discharge ballast water as cargo is loaded. Washington does export refined petroleum products regularly, and therefore the majority of tank vessel discharges in Washington State are from product carriers. The DFW database analyzed in this study does not distinguish between product tankers and crude tankers, and the difference is only described here to provide background information on the nature of discharges in the state.

Containership Traffic

Most containerships operate on fixed service routes with multiple port calls, sometimes ten or more in a single rotation, and exacting schedules. Cargo operations at each port call are extremely time sensitive in order to maintain overall schedule integrity and ensure on-time delivery of cargo. Containerships that make calls at Washington ports are generally operating on trans-Pacific service routes originating in the Far East, many of which involve eastbound port calls in Prince Rupert or Vancouver, BC prior to arrival in Washington (Reference 31).

Containerships do not usually make large ballast discharges at a single port. This is primarily due to the nature of container trade and container shipping services. Containerships load and unload cargo (generally in a single combined operation) at several ports of call, rather than fully loading or unloading at any one port as bulkers and tankers do. This keeps fluctuation in deadweight between port calls relatively low. As a result, containerships are minimally dependent on ballast, and tend to either not discharge any ballast water or discharge small volumes of ballast water relative to their capacities. In addition, modern containerships have the capability to transfer ballast water internally, between tanks, minimizing the volume of ballast water that must be taken on or discharged during cargo operations.

In Washington, as in other U.S. states, reporting requirements associated with the EPA Vessel General Permit discourage containership operators from discharging ballast water in-state, particularly when it can be avoided through a combination of diligent stowage planning and internal ballast transfers.

Other Vessel Types

Passenger ships large enough to require ballast water reporting when arriving in Washington are usually cruise ships, which arrive in Seattle on a regular schedule and discharge small amounts of ballast water if any. Recreational vessels are mostly super yachts, which almost never discharge ballast water.

General cargo vessels, also known as simply “cargo” vessels, carry both containers and bulk cargo. Cargo vessels average about 250 arrivals a year, similar to ATB arrivals, but only about 25%, about 70 annually, discharge ballast water, and their discharge volumes per vessel are similar to containerships (Reference 31). Vehicle carriers transit between the NAWC and Asia, and almost never discharge ballast water (Reference 31).

Regulated Shipping Vessel Industry

The Washington State Legislature and DFW recognize the importance of maritime commerce to the state’s economy. State ports are national assets, moving needed parts and retail goods into the country, while also providing the gateway for our state’s and nation’s exports to world markets. Washington State has a compelling interest in maintaining the competitiveness of Washington ports and avoiding business loss to other state and Canadian ports. Western states have a compelling interest in maintaining the highest achievable standards to protect their waters against nonindigenous and invasive species and damaging pollutants. As noted previously, the state legislature formally created the BWWG in 2002 to help DFW find practical and appropriate balances between maritime commerce and nonindigenous species risks.

2.3 Governing Legislation

It is important to understand governing legislation for ballast water management within congressional, international, federal, and state levels. Table 2 below provides a timeline of ballast water management (BWM) regulatory actions at congressional, international, federal, and state levels that will be reviewed in more detail in the following subsections.

Table 2 Timeline of ballast water management legislation, statutes, and rules since the 1988 detection of zebra mussels in the Great Lakes by international, state, USCG, EPA, and congressional actions

	1985-89	1990-94	1995-99	2000-04	2005-09	2010-14	2015-19
Congress	1980's: Zebra Mussels, round goby, ruffe in Great Lakes	1990: NANPCA 1991-92: *Vibrio cholerae* in Gulf States	1996: NISA				
IMO BWM Convention		1997: IMO BWM Guidelines		2004: IMO BWM Convention			2017: IMO Convention In Effect Nov
USCG BWM Regulation		1993: USCG BWM Great Lakes (BWE-Vol.)	1999: USCG BWM National (BWE-Vol.)	2004: USCG BWM National (BWE-Req.)		2013: USCG Rules: BWDS/ Timeline (Req.)	2017: 1st BWTS type-approval (anticipated)
EPA VIDM Regulation			1999: Legal Petition filed for EPA BWM	2003: Lawsuit filed against EPA	2008: 1st VGP	2013: 2nd VGP BWDS/ Timeline	2018: VGP (anticipated)
WA State BWM Regulation			1998: ANS Management Plan	2000: BWM program established (BWE-Req.)	2007: WA statue update; 2009: WA rule update		

U.S. Congress

The findings of the 1990 Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) cite the potential environmental and economic harm from zebra mussels, round goby, ruffe, and "thousands of nonindigenous species that have become established" as the basic rationale for the management of large shipping vessels to minimize the risk of nonindigenous species introductions from ballast water. The detection of *Vibrio cholerae* in ballast tanks of ships docked at U.S. gulf coast states in 1991 and 1992 (McCarthy and Khambaty 1994) brought the first evidence that the ballast water pathway has the potential to harm human health.

The need for participation and cooperation between federal and state governments was also clearly outlined throughout NANPCA including the establishment of state aquatic nuisance species (ANS) management plans and appropriation of federal funding for states to implement their plans. Washington State issued its first ANS Management Plan (ANSPC 1998) which was approved by the Governor and submitted to the U.S. Fish and Wildlife Service. The proposed ballast water management strategic plan in this document continues to follow many of those original task recommendations and revisions made in 2001 such as Task 2A2a to establish a sub-committee with maritime cargo vessel representatives and other affected groups to prevent further introductions of ANS (1998), and Task 6A1a to review state laws for gaps and overlaps and compare with other state and federal laws, and recommend changes (2001).

International Maritime Organization

The International Maritime Organization (IMO) adopted the Ballast Convention in 2004. This convention requires management of ballast water using exchange (BWE), moving to treatment on a phase-in schedule related to a vessel's inspection timeline. In response, many new construction vessels have been outfitted with ballast water treatment systems (BWTS) as part of the new construction effort. However, generally these systems have not been used, because an adequate representative shipping tonnage of IMO member states (35%) has only recently ratified the Ballast Convention.

The IMO Convention, ratified in September 2016, is scheduled to enter into force in September 2017. When this takes place, it is expected that the installed BWTS will then be utilized in place of BWE. In addition, an aggressive retrofitting of existing vessels with new BWTS will take place to meet the phase-in requirements in time for scheduled vessel inspections. However, there is a possibility that the date for entry into force of the Convention will be pushed out beyond September 2017. This entry and the delays in USCG type-approval process have created great uncertainties and concerns for the regulated shipping industry.

Washington State

Delays and gaps in federal management of ballast water have been the drivers of the Washington State program. In 2000, the Washington State legislature passed laws making transoceanic BWE mandatory and added mandatory coastal BWE to fill a critical federal regulatory gap. The Washington State legislature in 2007, based on consensus recommendations from the BWWG, reasserted their findings of risk to state waters by unanimous approval in revising the state laws expanding DFW's management authorities and providing permanent funding for two vessel inspectors. In 2009, DFW adopted a new ballast water management rule chapter under WAC 220-650, which implemented the 2007 legislative authorities and formalized the purpose, stakeholder consultation, and cooperative management of the program.

In general, Washington State requires all ballast water discharges into state waters to be managed by either an approved BWE method or an alternative. Empty-refill (ER) is an acceptable BWE method where ballast water in a given tank is pumped to as near empty as practical, and then refilled with deep oceanic seawater. Flow-through (FT) is the other acceptable BWE method where an already full or partially full ballast water tank is overfilled until at least 300% of the tank's capacity is flushed through with deep oceanic seawater. The definition of oceanic seawater varies by port of origin, using 200 nautical miles from nearest land for oceanic voyages, and 50 nautical miles for near coastal voyages.

Washington State also permits alternative methods, which include BWTS that have been approved by USCG or other administrations. These systems use combinations of filters, chemicals, ultraviolet radiation, deoxygenation, and other methods. Alternative methods can also include refraining from discharge, using freshwater from a U.S. Public Water System, or discharging to a land-based treatment facility.

US Federal

Although NANPCA became law in 1990, it was not until 1999 that the USCG issued national voluntary ballast water management guidelines for BWE on transoceanic voyages, which did not include west coast state recommendations for coastal BWE. The USCG first issued mandatory transoceanic BWE requirements in 2004, but did not include coastal BWE provisions or a ballast water discharge standard (BWDS) to drive the evolution of BWE to treatment. The first EPA Vessel General Permit (VGP) was issued in 2008 after a nearly decade legal fight. Ballast water management requirements under the EPA VGP were basically identical to the USCG requirements.

In 2012, the USCG issued final rules establishing a BWDS and implementation timeline consistent with IMO (Table 3), but did not add coastal BWE requirements. EPA issued a new VGP in 2013 which included the same BWDS and timelines, but they included a new requirement for vessels engaged in Pacific nearshore voyages to conduct BWE. Since EPA does not have sufficient enforcement staffing, the USCG agreed to provide enforcement of the VGP requirements in a 2013 Memorandum. A key provision of the USCG and EPA rules is that only U.S. type-approved ballast water management systems (BWMS) are eligible for full grandfathering for life of system or vessel – IMO Flag State-approved treatment systems (termed "Alternative Management Systems" or "AMS" by USCG) may only be used for 5 years due to poor quality control and other foreign type-approval problems.

Federal regulations require the use of a USCG type-approved system and there are a growing number of systems being tested to the stringent type-approval procedures using third-party laboratories. The phase-in of BWTS started for new build vessels in 2013 and existing vessels in 2014, though no U.S. type-approved systems were available at the time so most vessels acquired extensions for installation. The first BWTS achieved U.S. type-approval on December 2, 2016, kicking off installations onboard all required vessels as their extensions expire.

Table 3 USCG approved management system compliance schedule (33 CFR § 151.2035)

	BW Capacity	Date Constructed	Compliance Date
New vessel	All	On or after Dec. 1, 2013	On delivery
Existing vessel	<1,500 m^3	Before Dec. 1, 2013	First scheduled drydocking after Jan. 1, 2016
Existing vessel	1,500-5,000 m^3	Before Dec. 1, 2013	First scheduled drydocking after Jan. 1, 2014
Existing vessel	>5,000 m^3	Before Dec. 1, 2013	First scheduled drydocking after Jan. 1, 2016

Section 3 Data Analysis

In order to understand the future needs of DFW, it was important to understand historical trends in (and develop forecasts from historical trends for) vessel traffic, ballast water management practices, and regulatory compliance in Washington State. This section describes the data used as input to the Strategic Plan.

3.1 Sources and Methods

3.1.1 Washington State Data

Overview

Washington State vessel arrival, discharge, treatment method, and compliance data was collected from the Ballast Water Reporting Database that is operated and maintained by DFW. This database contains information from the ballast water report forms filed by vessels arriving to Washington from 2008 to 2015, as well as additional data logged by DFW staff on reporting accuracy, vessel compliance, and vessel inspections conducted by DFW inspectors. The data used for this study was the most current available data at the time of this study. Pre-2008 ballast water management data was not included in data analysis due to database and quality control issues that have not been addressed due to resource limitations.

Quality Control

The majority of data used for analysis in this document is from DFW's Ballast Water Reporting Database, which is a Microsoft Access database. All data entered into this database undergoes quality control testing on a minimum of 10% of the data entered, based on written protocols in the DFW Ballast Water Database Handbook. The database is comprised of four main parts: vessel information, arrivals, discharge, and inspections. This database is assumed to be the most reliable source on vessel arrivals, inspections, and other ballast water information pertaining to all Washington vessel arrival requirements.

For this analysis, additional quality checks were not performed by Glosten and the data was used as-is. However, the following data processing activities were undertaken to aid in data analysis and to enhance clarity when presenting summary tables and figures:

- Ballast water discharge amounts were converted into a common measure. Cubic meters was selected as the volumetric measure for this report. Recorded data is stored in gallons, long tons, cubic meters, metric tons, and short tons, with conversions between units as noted in Table 4. Specific gravity was infrequently reported in ballast water management reports, so conversion from volumetric to weight units was not straightforward. Specific gravity ranges from approximately 1.000 for fresh water to 1.025 for ocean seawater. For the purposes of this study, one (1) metric ton of ballast was assumed equal to one (1) cubic meter of volume.

Table 4 Ballast water conversion factors

Reported Units	Conversion Factor to m^3
Gallons (gal)	0.00378
Long tons (LT)	1.016
Metric tons (MT)	1.000
Short tons (ST)	0.90718

- Vessel types were described by many different terms. Glosten, in consultation with DFW, consolidated the vessel type descriptions into eleven categories: ATB, Barge, Bulker, Container, General Cargo, Tanker, Passenger, Recreational, Vehicle, and Other. Tank barges were considered to be in the "Barge" category, not "Tanker" category.
- Where possible, spelling errors and alternate formats of recorded arrival and discharge port names were corrected and assigned a single port name to describe the arrival or discharge port via a lookup table, so the underlying data was not altered. For example, "Tacoma / WA," "TACOMA WA," and "Tacoma, WA" were all assigned a common name of "Tacoma."
- Where possible, ballast water source locations were assigned to a country name via a lookup table, so the underlying data was not altered. All source locations recorded as a latitude and longitude were grouped in a single category as "Other Sources".

Although the database contains data from vessels that arrived outside of Washington (Astoria, OR) and from vessels that arrived after 2015, this data is not included in Glosten's analysis. Additional data used for analysis in this document is cited by source where used and qualified with regard to accuracy in situations where confidence in results is suspect.

Approach

Eight years of DFW data were analyzed to understand the vessels that have arrived in Washington State. This included determining what type of vessels were calling, where their ballast water came from, where they arrived, and whether or not they discharged ballast water. This data was extrapolated to forecast the nature of future arrivals to Washington State.

Although analysis includes all vessel arrivals, most results focus on vessels that discharged ballast water in Washington. Vessels report how much ballast water they intended to discharge into Washington State waters via ballast water management reports (BWMR, called ballast water reporting forms (BWRF) prior to February 2016).

In-depth analysis is also conducted on data collected during DFW vessel inspections. As the primary purpose of the DFW program is to minimize NIS risk, DFW prioritizes vessel boarding based on the following indicators of propagule pressure:

- Discharge frequency.
- Total quantity of organisms discharged.
- Concentration densities of viable organisms.

Although DFW does not currently sample for the above indicators prior to boarding, they use the following six measures as logical extensions of these concepts:

- Ballast water compliance history.
- Arrival history and discharge intent.
- Intended discharge volume.
- Cumulative discharge volume history.
- Ballast water source and open sea exchange area.
- Port risk based on cumulative arrival frequency and discharge volume.

Review of these measures will be discussed in Section 3.3.3. DFW research on indicators of organism quantities and concentration densities is provided in Appendix E.

Tools

Data from sources described in this section were sorted, filtered, grouped, and/or linked utilizing Microsoft Access (2013) and Microsoft Excel (2013).

3.1.2 Federal Data

Overview

Vessel arrival and discharge data for Pacific, Gulf, and East coast states was collected from the NBIC, which maintains data from ballast water reporting forms submitted to the USCG. A limited scope of the NBIC data is available to the public for download from http://invasions.si.edu/nbic/ (Reference 31).

This data is included for comparing Washington vessel traffic and ballast water discharge to other states. Additional data analysis was provided by NBIC for raw ballast water, which is not available to the public on their web site. In this report, Washington was compared to four other Pacific states (Oregon, California, Alaska, and Hawaii), five Gulf Coast states, and 14 East Coast states. Additional data on inspection and compliance was obtained through direct correspondence with the USCG (Reference 56).

Quality Control

All data entered into the NBIC database undergoes extensive quality control checks to ensure reporting data field accuracy, but does not otherwise include verification of regulatory compliance. According to the NBIC, their quality assurance measures include direct communication with BWMR submitters. When direct communication results in the need for a corrected form to be submitted, the NBIC replaces the originally submitted data with corrected data in their database.

For this analysis, additional quality checks were not performed by Glosten and the data was used as-is.

Approach

Vessel arrivals and ballast tank detail data were downloaded from the NBIC website in the form of comma-separated values (CSV) files for Washington, Oregon, California, Alaska, and Hawaii for years 2008 to 2015. Raw ballast water discharge data by state for 2015 was provided by NBIC in a Microsoft Excel spreadsheet format through a direct request. USCG national and Puget Sound Sector vessel inspection and enforcement data for the years 2004 through 2013 was provided in text format through a direct request.

Tools

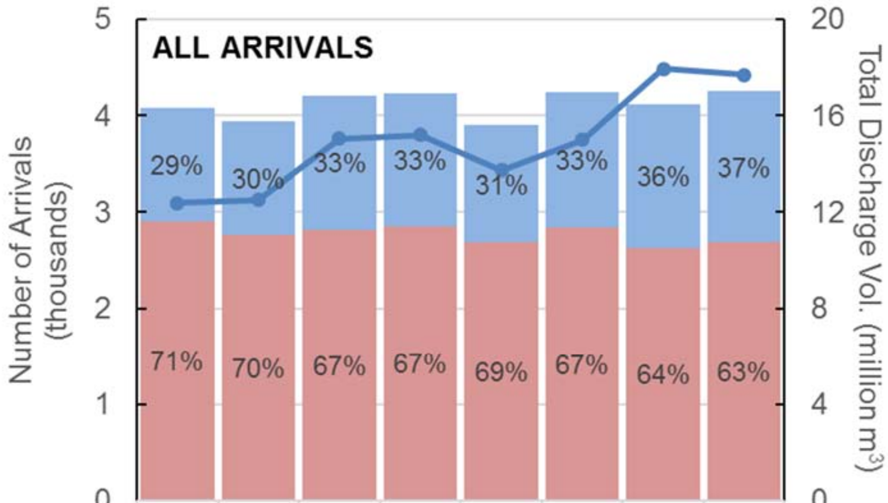
Microsoft Excel (2013) was used to process the NBIC data.

3.2 Washington State Vessel Traffic and Ballast Water Activity

This section reviews vessel traffic and operations in Washington State. The analysis focuses on three key data areas regarding vessel traffic and operations: arrivals, discharges, and ballast water management practices. Section 3.2.1 reviews historical data focused first on arrivals and discharging arrivals. After presenting overall traffic rate, discharge activity is analyzed by vessel type, port of call, voyage type, source port, and frequency (i.e., rate of first-time and repeat dischargers). Section 3.2.2 reviews historical ballast water management practices. Section 3.2.3 uses this historical information to forecast practices over the next six years, and Section 3.2.4 provides a summary.

3.2.1 Arrivals and Discharges

Figure 3 summarizes information on vessel arrivals and ballast water discharges in Washington State between 2008 and 2015. This data was obtained from the DFW reporting database (Section 3.1.1), and does not include arrivals to Columbia River ports in Oregon. All arrivals (common water, coastal, and transoceanic) are included. The number of arrivals that discharged ballast water was obtained by counting the arrivals in the DFW database with nonzero discharge volume.



	2008	2009	2010	2011	2012	2013	2014	2015
Disch. Arrivals	1.2	1.2	1.4	1.4	1.2	1.4	1.5	1.6
Non-Disch. Arrivals	2.9	2.8	2.8	2.9	2.7	2.8	2.6	2.7
Disch. Vol.	12.4	12.5	15.0	15.2	13.7	15.0	17.9	17.7

Figure 3 Washington State arrivals and discharge volume

Discharging arrivals accounted for 10,782 (33%) of the total arrivals from 2008 to 2015 with an average of 1,348 discharging arrivals per year which ranged from a minimum of 1,169 in 2008 to 1,556 in 2015 with the last two years being highest (see Table 8 for summary data). This trend shows that vessel traffic has generally increased by approximately 4% in Washington State from 2008 to 2015.

A majority of the arrivals are to ports in Puget Sound and on the Columbia River. Arrivals to coastal ports made up an average of 3% of the total discharge volume for the years 2008 to 2015. The distribution of arrivals and discharge volumes for Puget Sound ports and the Columbia River ports is shown in Figure 4.

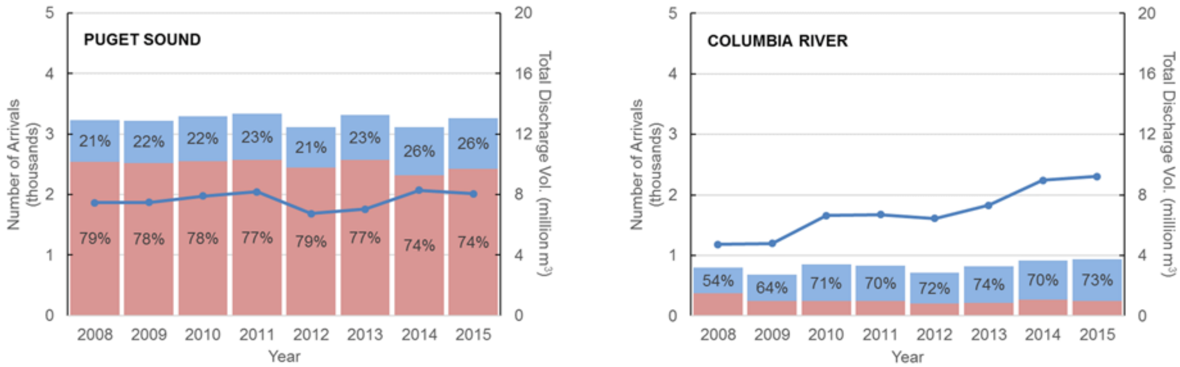


Figure 4 Regional arrivals and discharge volumes

Columbia River ports have seen similar levels of discharge volume to Puget Sound (between about 5M m^3 and 10M m^3 per year), but much fewer arrivals. Columbia River discharge volume has grown steadily since 2008. In 2015, almost three quarters of the vessels arriving at Columbia River ports discharged ballast water.

Vessel Type

This section reviews trends in Washington State vessel arrivals and discharges based on vessel type. Viewing vessel traffic and discharge trends in Washington State by vessel type provides valuable insight into trends. Vessel type links directly with particular industries, so industry-specific changes can affect arrivals and ballast water activities. By looking at data through the vessel type lens, it can been seen if actions, such as tendency to treat ballast water and tendency to uptake "high risk" ballast water, can be associated with a broad category of vessels, which would help DFW focus their enforcement efforts.

Table 5 summarizes discharge activity and arrival activity by vessel type for the years 2008 to 2015 for the four primary vessel types introduced in Section 2.2. Together, bulkers, tankers, ATBs, and containerships represent about 90% of all vessel arrivals that discharge ballast water at Washington ports.

Table 5 Discharge volume, non-discharging arrivals, and discharging arrivals by vessel type, 2008 - 2015

Vessel Type	Discharge Volume (M m^3)		Non-Discharging Arrivals	Discharging Arrivals		Proportion of Arrivals that Discharge Ballast
Bulker	85.1	[71%]	1,285	6,080	[56%]	83%
Tanker	18.8	[16%]	3,034	1,466	[14%]	33%
ATB	9.7	[8%]	839	1,628	[15%]	66%
Containership	1.9	[2%]	8,984	654	[6%]	7%
Other	3.8	[3%]	8,066	954	[9%]	16%
All Types	**120**	**[100%]**	**22,190**	**10,782**	**[100%]**	**33%**

Based on the 2008 to 2015 data, bulkers constitute the largest population of vessels that discharge ballast in Washington waters. On average, 83% of all bulkers that call in Washington State discharge ballast water. Bulkers represent over half (56%) of discharging arrivals, and are responsible for a majority (71%) of the discharge volume in Washington State.

ATBs and tankers are second to bulkers in discharge activity. ATBs represent 15% of all discharging arrivals in Washington State, and 16% of the volume discharged in Washington

State, but more than half (66%) of all ATB arrivals discharge ballast water. About one third (33%) of all tanker arrivals discharge ballast water, and tankers represent 16% of all discharging arrivals, and 14% of the discharge volume in Washington State.

There were 2,273 more containerships arrivals than bulker arrivals from 2008 to 2015. However, the percentage of containership arrivals that discharge ballast water is low (6%).

The following figures review discharge activity on an annual basis for the top four categories (Figure 5 through Figure 7). All available data is presented; no outliers have been removed.

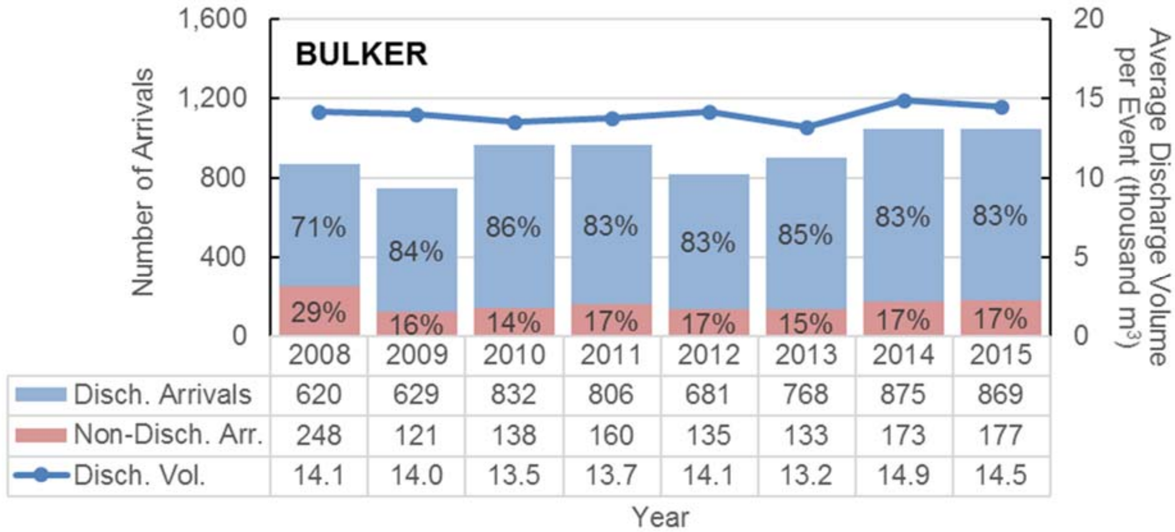


Figure 5 Non-discharging and discharging arrivals, and average discharge volume for bulkers

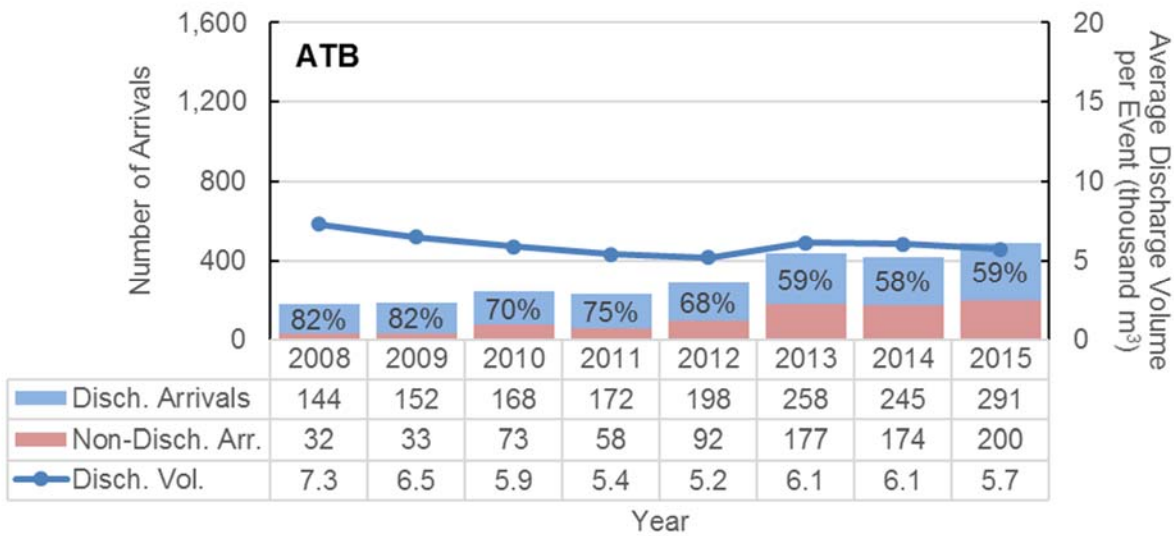


Figure 6 Non-discharging and discharging arrivals, and average discharge volume for ATBs

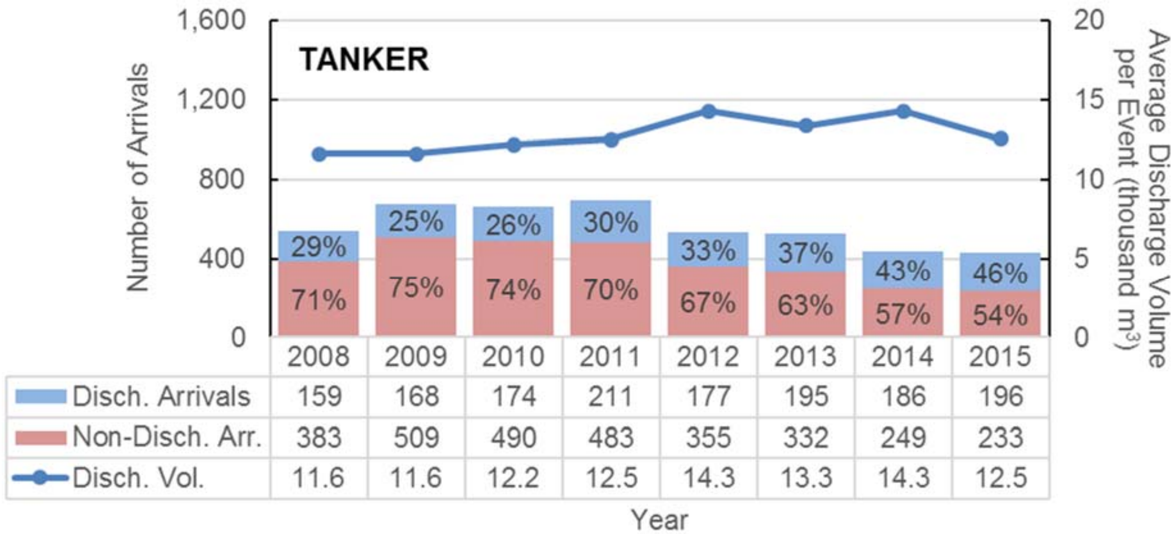


Figure 7 Non-discharging and discharging arrivals, and average discharge volume for tankers

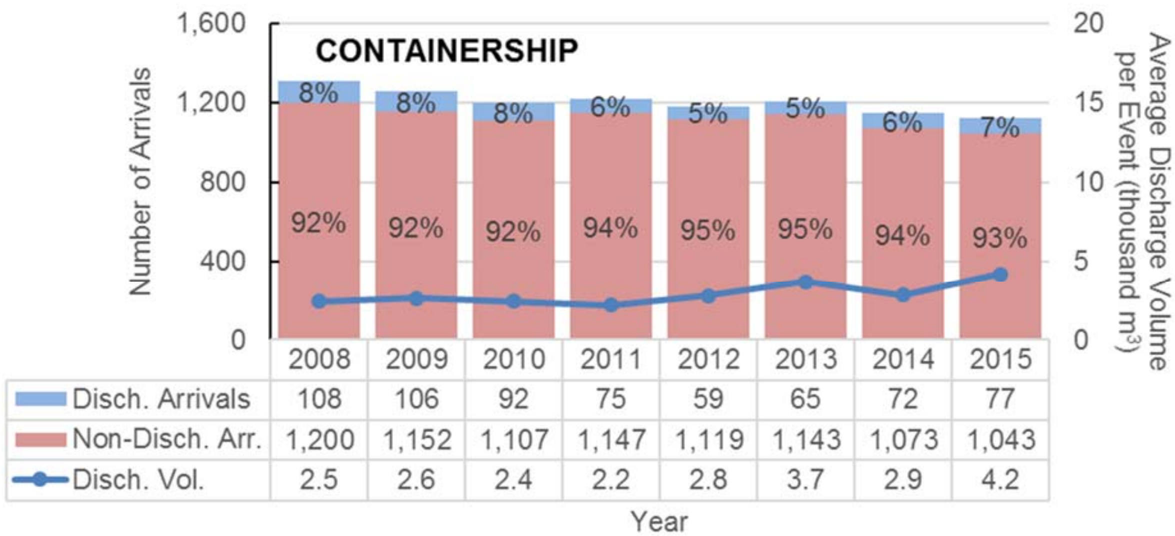


Figure 8 Non-discharging and discharging arrivals, and average discharge volume for containerships

Several trends are apparent in the above figures. Each year, a majority of all bulker arrivals discharge ballast water (range 71%-86%; average 83%). Similarly, each year, a majority of all ATB arrivals discharge ballast water (range 58%-82%; average 66%). In contrast, containerships account for typically less than 100 discharging arrivals each year and less than 5,000 m^3 per discharge event (range 5%-8%; average 7%). Tankers and bulkers have the highest average discharge per event, ranging from 11,600 m^3 to 14,900 m^3 (range 25%-46%; average 33%).

Additionally, an increase in ATB traffic is apparent in Figure 6, but with an overall decrease in proportion and volume of discharges, averaging 6,000 m^3 discharged per event since 2013. Containership traffic has also had a slight decline (Figure 8), potentially due to the recent increase in containership size, which can reduce the number of containerships even as volume of traded cargo increases (Reference 1). An increase in average discharge volume per event is apparent in 2015 for containerships.

Ports of Call

Arriving vessels call at over thirty Washington ports. This section analyzes arrival and discharge activity by port. The distribution of all arrivals to Washington State between 2008 and 2015 by arrival port is depicted in Figure 9.

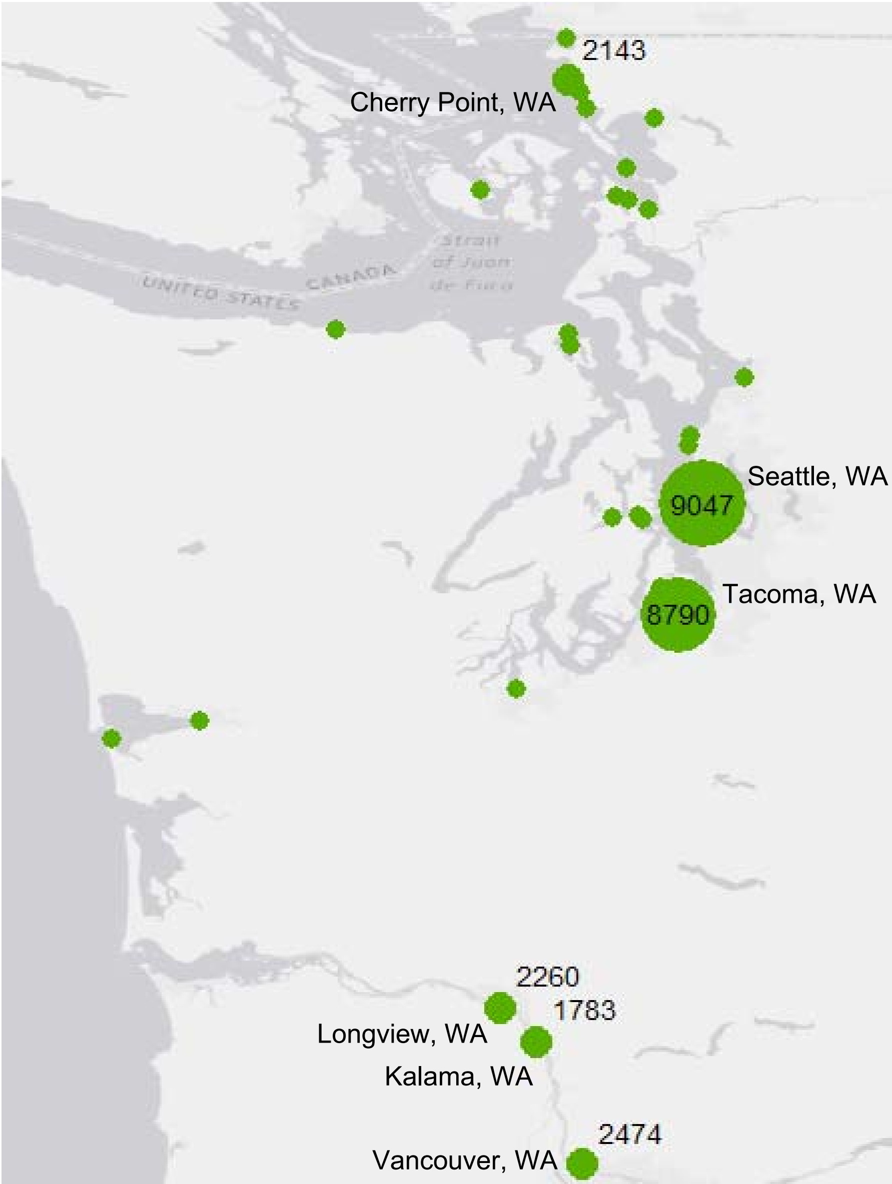


Figure 9 Washington State arrivals by arrival port, 2008-2015

The distribution of arrival port of discharging arrivals is illustrated in Table 6, which summarizes discharge and arrival activity by port for the years 2008 to 2015. (Note that this table is parallel to Table 5, presented in the previous section on Vessel Type.)

Table 6 **Discharge volume, non-discharging arrivals, and discharging arrivals at Washington ports, 2008-2015**

Port	Discharge Volume (M m^3)		Non-Discharging Arrivals	Discharging Arrivals	
Kalama	24.5	[21%]	286	1,497	[14%]
Longview	18.8	[16%]	461	1,799	[17%]
Tacoma	16.1	[14%]	7,488	1,302	[12%]
Cherry Point	13.9	[12%]	1,017	1,126	[10%]
Seattle	12.4	[10%]	7,865	1,182	[11%]
Vancouver	11.3	[9%]	1,280	1,194	[11%]
Anacortes	7.2	[6%]	517	914	[8%]
Other WA Ports	15.2	[3%]	3,275	1,767	[16%]
All Ports	**120**	**[100%]**	**22,190**	**10,782**	**[100%]**

Several trends are evident in Table 6. Kalama and Longview experienced the greatest percentages of discharging arrivals (14% and 17%, respectively) and discharge volume (21% and 16%, respectively) between 2008 and 2015. The four ports with the most discharge volume (Kalama, Longview, Tacoma, and Cherry Point) represent 63% (73.3M m^3) of the total ballast water discharged at Washington ports from 2008-2015, and 53% of the total arrivals.

The spatial distribution of all ballast water discharge volumes from 2008 to 2015 is depicted in Figure 10.

Figure 10 Total Washington ballast water discharge volumes by port, 2008-2015

Source Port

The ballast water discharged in Washington State was sourced from a variety of locations around the world. Most of the ballast water discharged in Washington State is sourced in Asia. Figure 11 describes where vessels performed uptake of ballast water between 2008 and 2015. Figure 12 narrows the focus of where vessels performed uptake of ballast water, by focusing on the top four discharge ports defined in the previous subsection (Longview, Kalama, Tacoma, and Cherry Point). Note that for the data presented in Figure 11 and Figure 12, "Other Sources" refers to all source data that utilized the global coordinate system (latitude/longitude) to describe the source location.

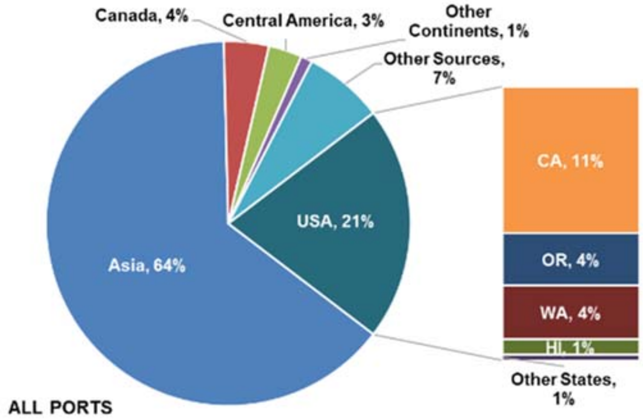


Figure 11 Percentage of total discharge volume into WA ports by ballast water source, 2008-2015

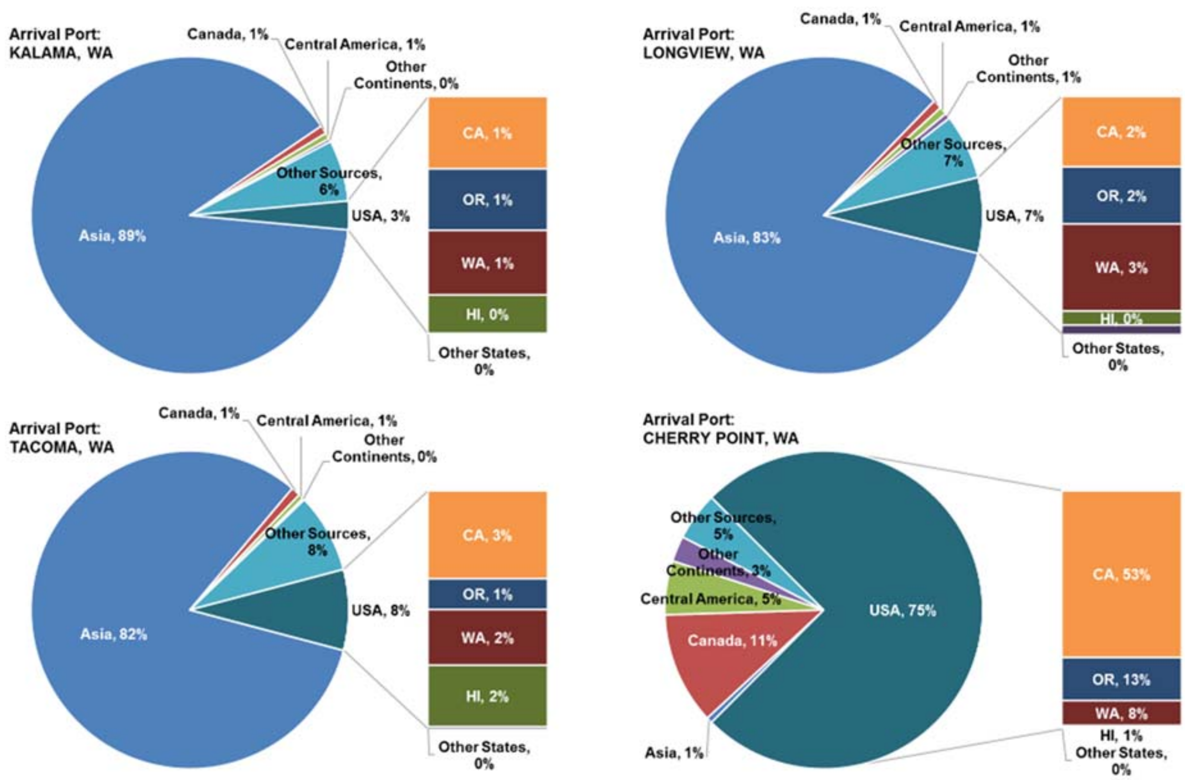


Figure 12 Percentage of total discharge volume into top four ports by volume by ballast water source, 2008-2015

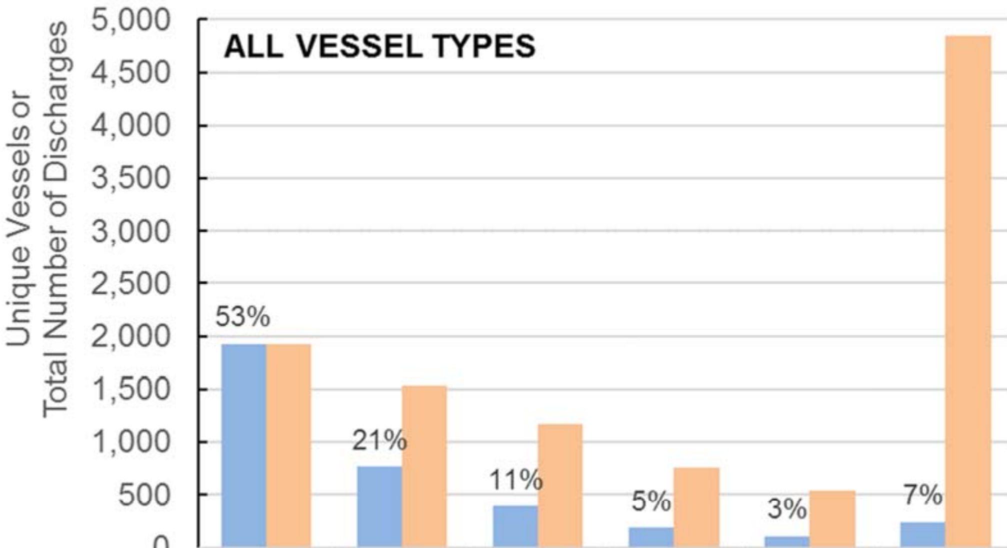
Between 2008 and 2015, a majority of the statewide discharge volume (64%) came from Asia (Japan, China, Taiwan, and South Korea). Twenty-one percent of the discharge volume was sourced from the U.S., with California constituting a major source of ballast water at 11% of the total discharge volume (Figure 11). The majority of ballast water is sourced from Asia at three of the top four ports as well; more than 80% of the ballast water discharged at Kalama, Longview, and Tacoma between 2008 and 2015 was sourced from Asia.

The majority of ballast water discharged at Cherry Point was sourced from the U.S., with California constituting the majority of that source distribution.

Discharge Frequency

Between 2008 and 2015, 3,626 unique vessels performed 10,782 discharge events (Figure 13). Most of the discharges in Washington State came from vessels that were not discharging for the first time.

The 10,782 discharge events are displayed in Figure 13. The proportions (above data bars) and counts (in data table) correspond to the proportions of unique vessels that discharged once, twice, or up to five times in Washington State.



	1	2	3	4	5	>5
Unique Vessels	1,929	768	390	189	108	242
Discharges	1,929	1,536	1,170	756	540	4,851

Number of Discharge Events per Unique Vessel

Figure 13 Distribution of discharge frequency by unique vessels, 2008–2015

The frequency of distribution of discharges by unique vessels shows that the majority of unique vessels (53%) discharged only once, 40% discharged between two and five times, and 7% discharged more than 5 times during that period. As can be seen in Figure 13, a majority of unique vessels discharged once (1,929 vessels, or 53% of the 3,626 unique vessels that call in Washington State) between 2008 and 2015. However, when considering all 10,782 discharge events, a minority of those discharge events come from vessels that discharge only once (1,929 events, or 17% of the total 10,782 discharge events in Washington State). Therefore, most discharge events (83%) can be attributed to a vessel that is discharging for the second, third, or greater time in Washington State.

3.2.2 Ballast Water Management

This section presents a focused analysis of the subset of discharging vessels, to understand how those vessels manage their ballast water: through flow-through exchange (FT), empty/refill exchange (ER), or through alternative management (ALT). Although flow-through and empty/refill are both forms of exchange, they are different techniques that make different demands on vessel operators, and thus are distinguished in this analysis to fully understand management trends. The use of alternative management indicates the use of other management methods such as promising treatment technology approved for experimental purposes by the state, potable water, or a foreign-approved treatment system. Historically, a majority of the ballast water in Washington State has been managed through flow-through ballast water exchange.

Between 2008 and 2015, 120M m^3 of managed ballast water is reported to have been discharged in Washington, through management methods described in Table 7 and illustrated in Figure 14. Note that ballast water that was not required to be managed, such as water from common water sources or public water supplies, is not included in this comparison and therefore are different from the total percent discharge volumes provided in Table 5 and Table 6.

Table 7 Summary table, average over 2008-2015

Vessel Type	Managed Discharge Volume (M m^3)		Average % of Discharge Volume by Management Method 2008-2015		
			FT	ER	ALT
Bulker	80.8	[78%]	70%	30%	<1%
Tanker	14.9	[14%]	45%	55%	<1%
ATB	3.1	[3%]	86%	14%	0%
Containership	1.5	[1%]	11%	89%	<1%
Other	2.3	[2%]	44%	55%	1%
All Types	**103**	**[100%]**	**65%**	**35%**	**<1%**

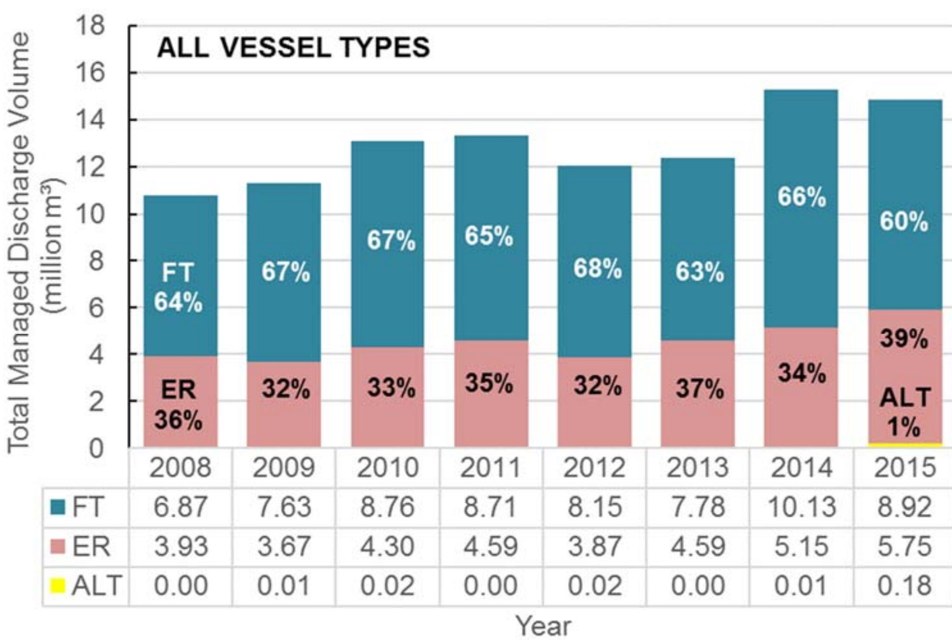


Figure 14 Management method of managed discharge volume

Table 7 shows that 96% of the managed ballast water discharged in Washington State between 2008 and 2015 came from one of four vessel types: bulker, tanker, ATB, or containership. Alternative management was used for less than 1% of the total managed discharge volume.

Appendix D extends the ballast water management analysis across all vessel types. Even within the individual vessel types, a very small portion of the discharge volume was managed through alternative management. ATBs managed ballast almost exclusively through flow-through exchange, and containerships managed almost exclusively through empty/refill exchange.

Due to low use of treatment systems in Washington State, analysis on types of treatment systems being used was not conducted. However, scheduled regulatory changes in the near future will cause the trends in ballast water management methods to change over the next few years.

3.2.3 Forecast

This section uses the historical data described in the previous section to forecast vessel arrival and ballast water discharge activity, and ballast water management practices through 2023. A brief discussion of macroeconomic factors that may affect the forecast is presented. This forecast completes the analysis of vessel traffic and operations in Washington State.

<u>Macroeconomic Considerations</u>

A variety of factors affect the future of vessel traffic in Washington State, including, but not limited to, the general market outlook of marine trade, the effects of the Panama Canal expansion, and the expansion and development of Pacific Northwest ports and railways. Due to uncertainty about the potential market changes and the interactions between these factors, they are presented here for consideration but were not factored into the forecasts given in this section.

Marine Trade

Overall marine trade is predicted to increase at modest rates in the future. The last two years have seen slower than normal rates of growth in marine shipments. Shipments increased by 3.5% in 2014, but accelerated growth is not predicted in the next few years (Reference 41). The recent bankruptcy of Hanjin, a key client of Terminal 46 in Seattle, highlights the overcapacity problem facing the shipping industry, and serves as evidence of slower than normal rates of growth in marine shipments and possibly Washington State vessel arrivals (Reference 53).

The nature of marine trade is predicted to change as vessels get larger, companies consolidate, and shipping routes change. Although the predicted growth in marine trade may increase cargo volumes in Washington State, these factors could result in a reduction in arrival rates (Reference 34). In fact, Puget Sound ports have been seeing fewer arrivals over the past several years and over 800 fewer cargo vessel arrivals than peak years since 1992 (Reference 52).

Panama Canal

The opening of the expanded Panama Canal in 2016 is a large change for global shipping routes. This is expected to reduce the cost of sending larger shipments from Asia to the East Coast, which is predicted to reduce the West Coast's market share of containership traffic by 15% (Reference 49). The magnitude of this reduction will be greatest in California ports, but will be tempered by the overall increase in the size of the container market. The expansion of the Panama Canal is not expected to have a drastic effect on Washington ports, perhaps slowing the expected growth in traffic.

Canada

Container traffic in Prince Rupert and Vancouver, Canada has had a direct impact on container traffic in Washington State. According to Seattle container traffic analysts at Pacific Merchant Shipping Association, Seattle and Tacoma have lost market share directly to these two ports and are now approximately half a million TEU's lower than their peak, dropping them from third to fourth in the U.S. container port gateway rankings. With Canadian container infrastructure expansion, Seattle and Tacoma are in tough competition for the Pacific Northwest market share.

Northwest Ports and Railways

Tanker and ATB traffic activity, which together makes up 29% of Washington State vessel arrivals, may change in the future as Washington may see increased crude delivery by rail. The 2011 Marine Cargo Forecast predicted liquid bulk cargo traffic through Pacific Northwest terminals to increase by only 0.2 – 1.2% a year. Local refineries are predicted to receive a larger proportion of their crude oil by rail, lessening crude imports to marine terminals (Reference 34), and refined product export is not predicted to increase much as refineries are near to their production capacities (Reference 29). Recent U.S. regulation changes allowing export of domestic crude oil have led to questions about whether Pacific Northwest crude exports from Bakken rail transport will increase, but due to low oil prices, they are not predicted to increase drastically at this time (Reference 9). Export of liquid product has a larger effect on ballasting activities in the state than the imports to refineries do - recall from Section 2.2 that exporting liquid cargo leads to ballast water discharges in Washington, whereas importing liquid cargo usually results only in ballast uptake in Washington. However, liquid cargo exports are not likely to have drastic changes in the next few years.

Bulker traffic makes up 56% of Washington arrivals. Dry bulk cargo is experiencing high international demand, and export volumes through Pacific Northwest ports are predicted to increase 7 – 9% a year, although cargo traffic has typically been very cyclical and tied to weather and commodity pricing. Breakbulk cargo traffic is predicted to increase 1-2% per year (Reference 34).

Washington's largest container ports, Seattle and Tacoma, expect to see an annual increase in container volumes of 2.75 - 5.5% (Reference 44). However, containership traffic may decrease even as volumes increase, due to the trend of increasing containership vessel size (Reference 1). In fact, container vessel calls used to average about 1,250 per year but are now down below 1,000. Containerships are responsible for a small percentage of ballast water discharges in the state, so changes in the container market are not anticipated to significantly affect DFW's ballast water operations.

Additional Considerations

Each fleet that discharges ballast water in Washington is subject to fluctuations in the global economy as well as factors specific to the individual market. Global economic factors that may affect vessel traffic in Washington include:

- Federal and state taxes.
- Port fees.
- Growth and stability of world markets.
- Economic growth and income of individual countries.
- Market value of various commodities (supply and demand).
- Spot charter and time charter rates.

- Exchange rates (value of U.S. Dollar against other currencies).
- Oil prices (HFO and LSFO, specifically).
- Environmental forces.
- International development.
- Local (WA, OR, Canada, AK, CA) terminal development.
- East coast and gulf coast terminal development.
- Local rail development.
- Local port call costs (driven by regulations, labor relations, local tariffs, etc.).
- Globalization of world economy.
- Changes in world population.
- International trade agreements / trade protection policies.
- Environmental regulations.
- Other political issues/trends.
- Food supply and security in developing countries.
- Agricultural conditions (e.g. drought, storms, etc.).
- Government support for agriculture (subsidies).
- Waterfront labor issues.

The forecasts on vessel arrivals and ballast water discharges presented in this section should be considered in conjunction with the macroeconomic forces discussed here.

Arrivals and Discharges Forecast

Historical data on arrivals, discharging arrivals, and discharge volume per discharging arrival was used to develop forecasts of discharge activity by vessel type. For each discharge category (arrival, discharging arrival, or discharge volume) and vessel type, eight data points from the years 2008 and 2015 were used to develop a linear forecast. The uncertainty in the forecasts is illustrated by showing the 95% prediction interval about the expected value. Based on the historical data, it is expected that there is a 95% probability that actual value of the future result will be within the prediction interval. An overall forecast is presented in Figure 15 and Figure 16; detailed forecasts by vessel type are provided in Appendix D.

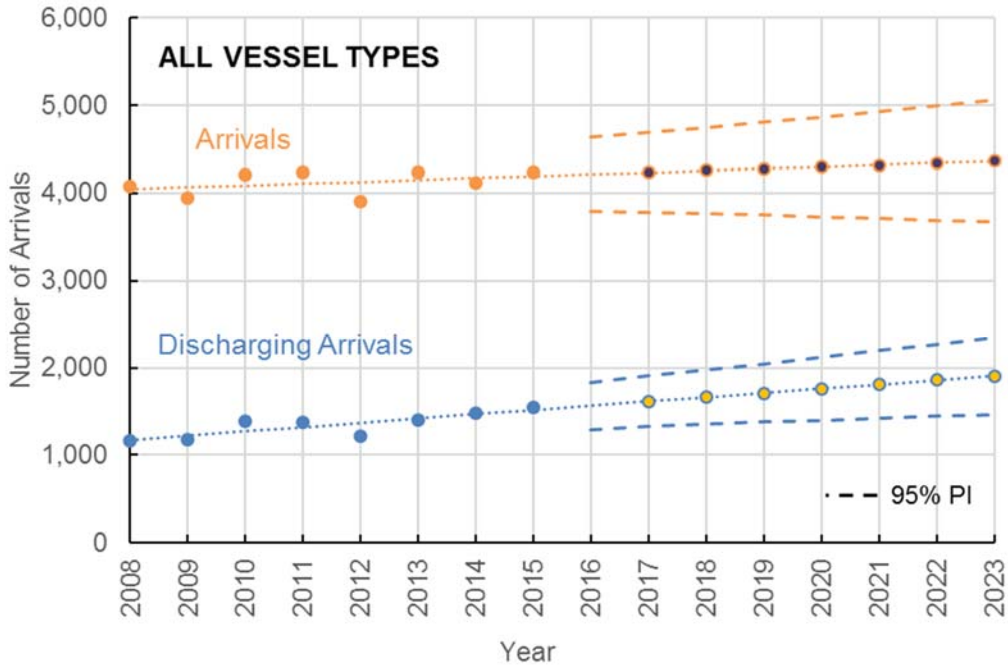


Figure 15 Washington State vessel traffic forecast

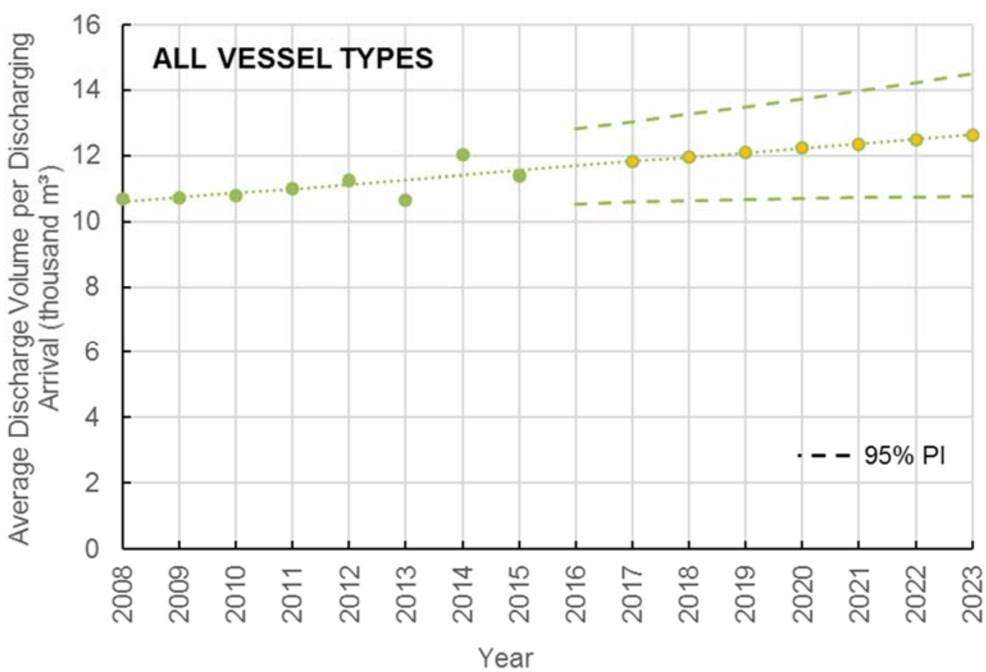


Figure 16 Washington State discharge volume (per discharging arrival) forecast

Ballast water discharges are generally forecasted to increase in discharge event frequency and per event discharge volumes across the four major vessel types. Vessel traffic is forecasted to increase by 3% between 2017 and 2023, and the average volume per discharge is expected to increase by 19%. Taken together, an overall discharge increase of 27%, from 18.9M m^3 in 2017 to 24M m^3 in 2023, is projected.

Ballast Water Management Practices

Currently, all marine vessels are required to exchange near-coastal ballast water from outside of Puget Sound with oceanic water prior to discharging in Puget Sound. This is governed by international (IMO), federal (USCG and EPA), and state guidelines and regulations. Federal and international ballast water management regulations include requirements for management methods to transition from ballast water exchange and foreign-approved alternative management systems to the use of USCG-approved ballast water management systems based on a discharge standard that treats ballast water to render organisms inviable. A majority of vessels will stop performing ballast water exchange, and instead use treatment systems, which are considered more effective at removing nonindigenous invasive species (NIS) and avoid potential vessel stability and hull stress issues associated with ballast water exchange. Vessels could also use potable water or shore-based treatment facilities, but these methods are not expected to be used by a large portion of the industry and therefore not addressed in this report.

While Washington State regulations do not contain discharge standards and implementation timeline requirements, all vessels operating in Washington also fall under USCG authority and are required to comply with the federal requirements as they become implemented. Any vessels making international voyages will also be required to comply with IMO-mandated transitions to treatment systems. Accordingly, although the state does not require vessels to transition from ballast water exchange to treatment, the ballast water management practices of vessels discharging ballast water in Washington will change in the future. However, the lack of a state discharge standard and transition timeline will leave a gap in the State's ability to enforce ballast water management requirements in the future.

Rates and methods of all ballast water management will be affected by the federal regulation changes, and as such further discussion of future ballast water management practices is addressed in Section 3.3.4.

3.2.4 Summary

The key findings of the vessel traffic and operations historical data analysis are:

- Vessel traffic has generally increased in Washington State since 2008.
- Over the eight years between 2008 and 2015, Washington State saw an average of 4,122 annual arrivals, and 1,348 annual discharging arrivals.
- About one third of all arrivals discharged ballast each year, for an average of 14.9M m^3 ballast water annually discharged.
- A majority of ballast water discharge volume is attributed to bulkers (71%), followed by tankers (16%), and ATBs (8%).
- A majority of ballast water is discharged at three ports in Washington State: Kalama (21%), Longview (16%), and Tacoma (14%).
- 64% of the ballast water discharged in Washington State was sourced in Asia.
- 83% of the ballast water discharges in Washington State can be attributed to a vessel that is discharging ballast for the second, third, or greater time in Washington State.
- Less than 1% of vessels managed their ballast water through alternative management.

Vessel traffic and discharge activity may be impacted by regional economic factors but are expected to continue to grow over the next six years. A majority of vessels are expected to stop performing ballast water exchange and instead use treatment systems in the future.

Table 8 summarizes the historical data with regard to vessel arrivals, ballast water discharges, and ballast water management practices.

Table 8 Vessel Traffic and Operations summary table

		2008	2009	2010	2011	2012	2013	2014	2015	Total	Average
3.2.1 Arrivals and Discharges											
Non-Discharging Arrivals		2,905	2,768	2,816	2,855	2,684	2,837	2,631	2,694	22,190	2,774
Discharging Arrivals		1,169	1,175	1,395	1,378	1,218	1,403	1,488	1,556	10,782	1,348
Discharging Arrivals - Returning Dischargers		--	59%	65%	69%	70%	72%	72%	74%	--	69%
Total Arrivals:		4,074	3,943	4,211	4,233	3,902	4,240	4,119	4,250	32,972	4,122
Total Discharge Volume (million m^3):		12.4	12.5	15.0	15.2	13.7	15.0	17.9	17.7	119.5	14.9
Proportion of Total Discharge Volume Attributed to	*Bulkers*	71%	70%	75%	73%	70%	67%	73%	71%	--	71%
	Tankers	15%	16%	14%	17%	18%	17%	15%	14%	--	16%
	ATBs	8%	8%	7%	6%	8%	11%	8%	9%	--	8%
	Other	6%	6%	5%	4%	4%	5%	4%	6%	--	5%
Proportion of Total Discharge Volume Discharged at	*Kalama*	23%	21%	23%	23%	19%	17%	18%	22%	--	21%
	Longview	7%	8%	10%	11%	20%	24%	22%	19%	--	16%
	Tacoma	20%	19%	16%	16%	13%	10%	10%	8%	--	14%
	Other	49%	52%	51%	50%	48%	49%	51%	51%	--	50%
3.2.2 Ballast Water Management Practices											
Proportion of Managed Discharge Volume Managed by	*Alt. Methods*	<1%	<1%	<1%	<1%	<1%	<1%	<1%	1%	--	0.2%
	Empty/Refill	36%	32%	33%	35%	32%	37%	34%	39%	--	35%
	Flow-Through	64%	67%	67%	65%	68%	63%	66%	60%	--	65%

3.3 Washington State Regulatory Management

This section describes the extent to which the state meets the legislative directive of minimizing nonindigenous species risks through regulatory management. DFW began requiring and collecting ballast water reporting information in 2003. In 2004, DFW hired their first vessel inspector and in 2007, a second vessel inspector was hired. DFW efforts to bring vessels into compliance with reporting and ballast water management requirements continually evolve with increased experience and changing resources.

DFW employs two kinds of efforts to bring arrivals into compliance with requirements:

- **Communication efforts**: On a daily basis, office and vessel inspector staff review vessel arrival and BWMR information to determine if all vessel arrivals have submitted their BWMR. DFW protocol (FP/BWMC-ADM 2013) requires department staff to assess all BWMRs (average 4,124 forms per year) for compliance with state regulations. If a vessel is not in compliance with timely submission of their BWMR, DFW staff attempt to contact the vessel or its agent to communicate the state filing requirement. Once a vessel has filed their BWMR, DFW staff assess the report for compliance. If a vessel is not in compliance with BWMR requirements, DFW attempts to contact the vessel or its agent to provide technical assistance to correct any errors.
- **Inspection efforts**: DFW inspects vessels to verify BWMR compliance, and to help crews attain the highest possible level of ballast water management. DFW currently operates with two regional inspectors and one data manager to assist the inspectors from the DFW office. On average, inspectors inspect less than one vessel per day, but also assist with BWMR assessments and data entry.

This section focuses on first on communication efforts (Section 3.3.2), and then on inspection efforts (Section 3.3.3). Section 3.3.4 uses historical data to forecast regulatory management through 2023.

3.3.1 Compliance Risk

In order to assess the impact of DFW's Ballast Water Management Program, the risk of NIS invasion is divided into two categories: compliance risk and management risk. Within each category there are contributing factors that define the risk. Figure 1 presents the approximate ranges of risk level, from low risk to high risk, for the factors of each risk type considered here. Each category is defined below and considered in terms of DFW effectiveness at reducing that risk.

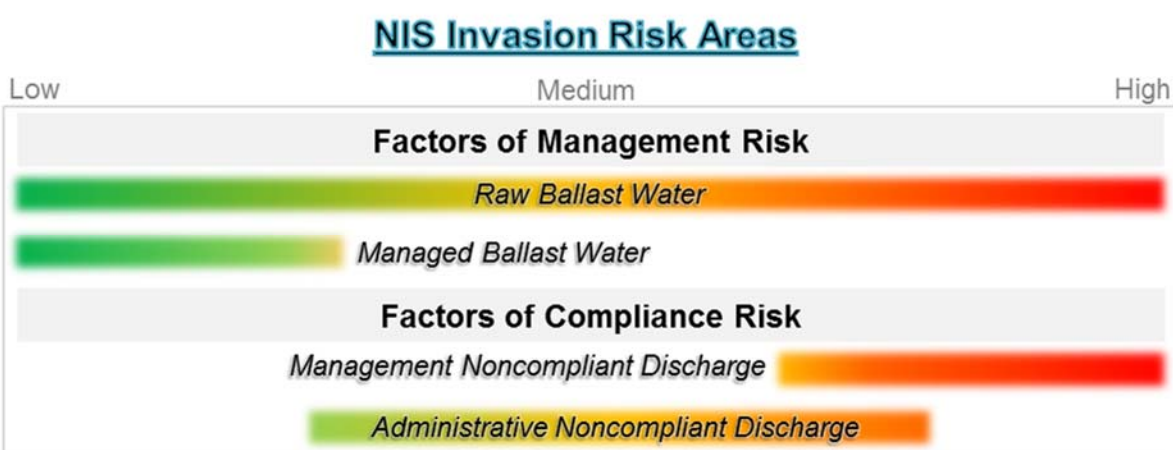


Figure 17 Approximate relative levels of compliance risk and management risk factors

Management risk refers to the risk of NIS invasion due to an arrival's decision not to manage ballast water prior to discharge. Unmanaged ballast water is referred to as raw ballast water; this topic is discussed in Section 3.4. Compliance risk refers to the risk of NIS invasion due to an arrival's failure to follow regulations at the state, federal, or both levels DFW has generally reduced compliance risk through communication and inspection efforts, including real-time ballast report reviews and direct-to-operator communication.

This section will demonstrate how DFW communication and inspection efforts – which DFW strives not to duplicate with USCG efforts – have measurably reduced compliance risk in Washington State. This reduction is made apparent by analyzing the reduction in noncompliance of arrivals, and the low volume of management noncompliant ballast water discharge.

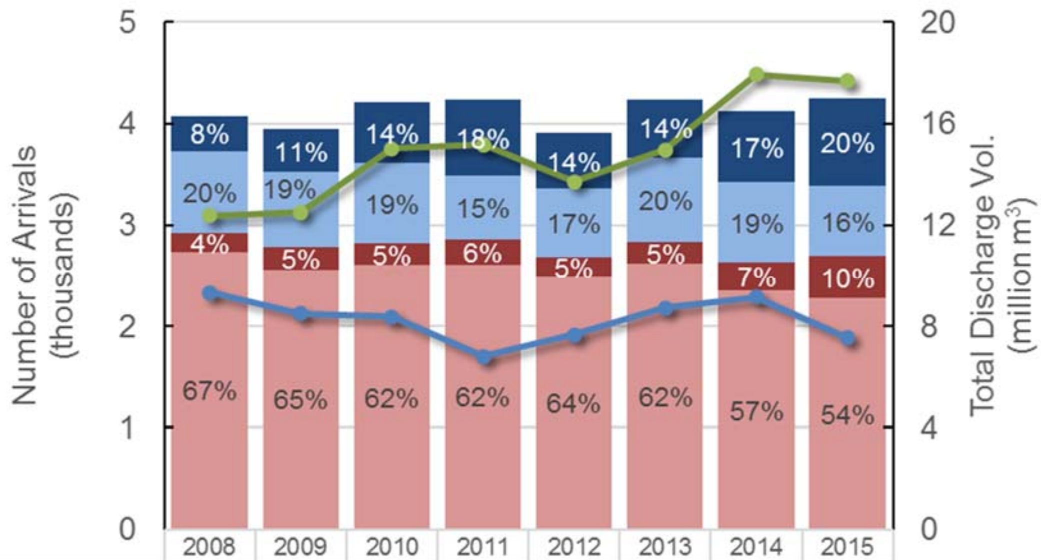
3.3.2 Communication Efforts

This section reviews the results of Washington State's communication efforts in reducing NIS risk from ballast water discharge. It reviews the percentage of BWMR amended each year, then analyzes the noncompliance rates for the last four years. Enforcement and outreach are also discussed.

Amended Forms

This analysis follows a Gap Analysis recommendation of understanding how frequently DFW averts vessel noncompliance prior to arrival (Reference 6). Administrative involvement, whether through phone call or email, is a possible reason that a vessel elected to amend its BWMR. It is important to note that not all amended forms are amended prior to arrival, and that in some instances vessels submit amended forms with no prompting from DFW. Nevertheless, DFW often notifies vessels of their noncompliance prior to arrival, and vessels respond by submitting an amended form.

Figure 18 depicts arrivals that submitted BWMR only once ("Accepted"), and arrivals that refiled one or more times ("Amended") between 2008 and 2015. The figure modifies Figure 3 (Section 3.2.1).



	2008	2009	2010	2011	2012	2013	2014	2015
Amended Disch.	0.3	0.4	0.6	0.7	0.5	0.6	0.7	0.9
Accepted Disch.	0.8	0.7	0.8	0.6	0.7	0.8	0.8	0.7
Amended Nondisch.	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.4
Accepted Nondisch.	2.7	2.6	2.6	2.6	2.5	2.6	2.4	2.3
Amended Disch. Vol.	3.1	4.0	6.7	8.4	6.1	6.3	8.8	10.1
Accepted Disch. Vol.	9.3	8.5	8.4	6.8	7.7	8.7	9.2	7.5

Year

Figure 18 Amendments of BWMR for all arrivals and discharge volume in Washington State

On average, 6% of all arrivals amend forms and do not discharge ballast water ("Amended Nondisch." in Figure 18), whereas 14% of non-discharging arrivals amend forms and discharge ballast water ("Amended Disch." in Figure 18). Thus, discharging arrivals are more than twice as likely to amend their BWMR than non-discharging arrivals.

With the exception of 2008 and 2009, the "Amended Disch Vol" and "Accepted Disch Vol" amounts are roughly equivalent (stacked lines in Figure 18). Thus, just under half of the water discharged in Washington State each year was discharged by a vessel that submitted an amended BWMR. Under current DFW data management practices, the extent of DFW influence on these amended forms is unable to be measured. However, noting the type of influence DFW had on an amended form (phone call, visit, etc.) provides an area to better quantify DFW influence in the future. In addition, comparison to USCG amendment rates for states without a ballast water management program could help to verify and develop this measure.

Enforcement

DFW regularly assesses submitted BWMRs for compliance. When DFW identifies a noncompliant arrival, the agency issues one of three enforcement actions:

- **Warning**. DFW verbally notifies vessel owner or operator that the vessel is out of compliance with state regulations. The verbal notification may include fax or email follow-up. DFW has had the authority to issue warnings since 2012.
- **Notice of Correction (NOC)**. This is a written notification of noncompliance and includes a date and time by which the vessel must attain compliance. NOC's as an enforcement tool became effective with rulemaking in 2009, but are generally only used by DFW when a vessel disregards a Warning.

- **Notice of Penalty (NOP)**. DFW has the authority to issue penalties (NOP's) for up to $5,000 per day of violation prior to 2007 and $27,500 per day of violation since 2007. Penalties increase to maximum authority based on number of days in violation, vessel intent, cooperation, previous violations, and quality/quantity of risk. DFW mails a notice to the vessel owner or operator that informs them of their noncompliance, and issues a penalty. Use of an NOP for enforcement purposes has been limited to vessels that discharge fully noncompliant ballast water.

Table 9 summarizes enforcement actions issued by DFW between 2012 and 2015.

Table 9 Vessel enforcement

Vessel Enforcement	2012	2013	2014	2015
Warnings (All arrivals with noncompliant BWMR)	390	317	639	641
Notice of Correction	6	--	3	3
Notice of Penalty	--	--	3	--

Two observations accompany this data:

- Due to resource limitations, the number of Warnings issued annually correlates with the number of regulatory code violations recorded in the DFW database. Application and database entry of the NOC has also been inconsistent due to resource limitations according to DFW.
- Nine NOP's have been issued since the program began (six in 2005 (not shown in Table 9), three in 2014) and all NOP's were issued for discharges of fully noncompliant ballast water. Noncompliant discharges since 2013 that did not result in penalties were caused by vessels that conducted a ballast water exchange, but not outside the 50 or 200 nm exchange zone base on voyage type. In most cases, these were addressed through the NOC process for future voyages.

Outreach

As seen above, DFW has historically issued a low number of NOP's. Due to the significant resource requirements of issuing NOP's, DFW prefers to improve compliance through education and outreach. DFW primarily conducts education and outreach through:

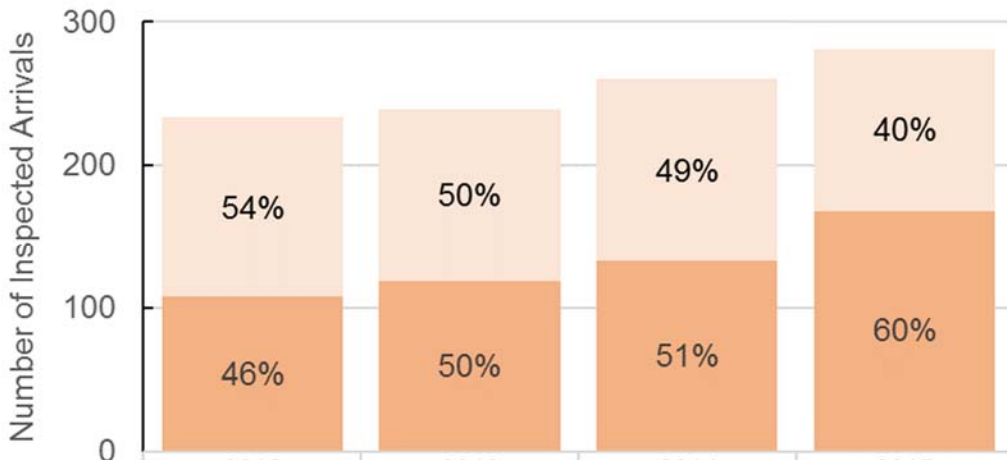
- Offering assistance to vessels during inspections.
- Responding to questions.
- Providing educational materials to agents and operators of vessels entering the state.

DFW spends an estimated two hours each week performing education and outreach.

3.3.3 Inspection Efforts

Inspection Characteristics

DFW typically inspects 7% of all arrivals to Washington State. Between 2012 and 2015, DFW inspected 1,013 vessel arrivals. Figure 19 displays the number of inspections over time, broken down by first-time arrival.



	2012	2013	2014	2015
Returning	125	120	127	113
First Time	108	119	133	168
No Indication				
Total Insp.	233	239	260	281
Total Insp. (%)	6%	6%	6%	7%

Year

Figure 19 Number of inspected vessels

Since 2012, DFW has inspected an average of 6% of vessel arrivals each year. However, the inspection of first-time arrivals has steadily increased since 2012 as DFW placed more emphasis on this risk factor in selecting vessels. DFW inspects a relatively higher proportion of first time arrivals in comparison to arrivals and discharging arrivals, which is consistent with P1 priority ranking due to arrival history factors (discussed below).

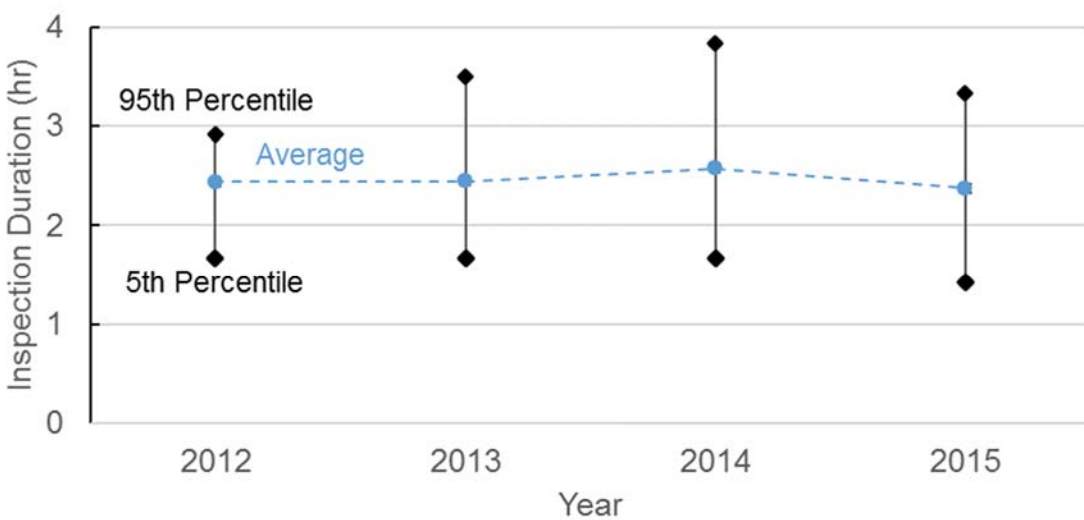


Figure 20 Inspection duration

Typical vessel inspections last about 2.5 hours. Between 2012 and 2015, vessel inspections ranged between 2.3 hours (2015) and 2.6 hours (2014). Higher inspection times are generally attributed to noncompliant factors or complex issues.

DFW focuses the majority of inspections and biological sampling on high-risk vessels. In order to determine which vessels to board and inspect, DFW implements a ranking system called the Vessel Priority Risk Rating, which ranges from low risk (P3) to high risk (P1):

- **Priority 1 (P1)**. High risk for introduction and spread of nonindigenous species. These vessels are prioritized for boarding. In situations where two or more P1 vessels are available for boarding, the inspector will determine which vessel to board unless directed otherwise by supervisor.
- **Priority 2 (P2)**. Moderate risk for introduction and spread of nonindigenous species. If no P1 vessels are available for boarding, P2-designated vessels are prioritized for boarding. In situations where two or more P2 vessels are available for boarding, the inspector will determine which vessel to board unless directed otherwise by supervisor.
- **Priority 3 (P3)**. Low risk for introduction and spread of nonindigenous species. If no P1 or P2 vessels are available for boarding, P3-designated vessels are prioritized for boarding. In situations where two or more P3 vessels are available for boarding, the inspector will determine which vessel to board based on risk or by random selection unless directed otherwise by supervisor.

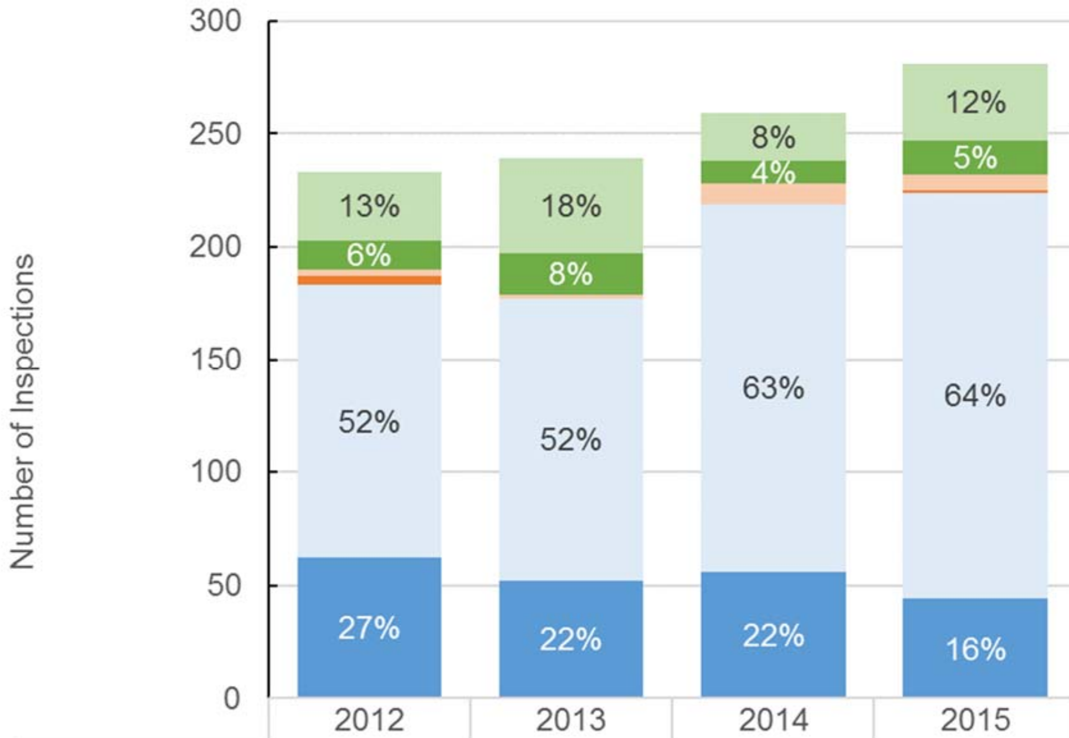
Table 10 summarizes the factors used to rate vessels.

Table 10 Vessel Priority Risk Rating risk factors

No.	Risk Factor
1	Compliance history
2	Arrival history and discharge intent
3	Intended discharge volume at arrival
4	Cumulative discharge volume history
5	Ballast water source and open sea exchange area
6	Port risk based on cumulative arrival frequency and discharge volume history

Although the above risk factors guide DFW's rating, the risk factors are not explicitly provided in the database for all arrivals. Moreover, the risk ratings themselves are not recorded in the DFW database for all arrivals; only for inspected vessels since mid-2011. Recording all risk factors and ratings would allow DFW to develop a better picture of the vessel risk profiles.

DFW pairs Vessel Priority Risk Rating (P1, P2, or P3) with an additional selection technique to form the Boarding Type. The additional selection technique can be random or focused selection, "Random" or "Selection," a ranking process, "Ranking," or a noncompliant BWMR, "Compliance." Boarding type ultimately determines which vessels DFW will inspect (Figure 21).



	2012	2013	2014	2015
TOTAL	233	239	259	281
P3/Selected	30	42	21	34
P3/Random	13	18	10	15
P2/Ranking	3	2	9	7
P2/Compliance	4	0	0	1
P1/Ranking	121	125	163	180
P1/Compliance	62	52	56	44

Year

Figure 21 Number of inspections by boarding type

Figure 21 illustrates the boarding type distribution inspected by DFW from 2012 through 2015. Although DFW inspects vessels of all three boarding types, the majority of inspections correspond to the high risk, P1 boarding type (combined dark and light blue in Figure 21; average 79%). Of those P1 inspected vessels, most submitted a compliant BWMR (P1/Ranking). As illustrated in Appendix D, DFW also tends to take the most biological samples from high-risk vessels.

A greater percentage of inspected arrivals correspond to low risk (P3, or green; average 18%) than moderate risk (P2, or orange; average 3%). Although DFW protocols specify some P1/Compliance vessel arrivals must be inspected (discharge violations; safety exemptions; listed high-risk vessels), DFW protocols do not mandate or recommend a performance target rate for inspections by boarding type.

Since P1 and P2 boarding types correspond to discharging arrivals and P3 corresponds to non-discharging arrivals, this analysis also shows that during the 2012-2015 period, 829 inspections focused on vessel arrivals that discharged, or 14% of all discharging arrivals, and 183 inspections focused on vessel arrivals that did not discharge, or 3% of all non-discharging arrivals.

Although vessel type has not been a factor in determining which vessels to inspect, DFW inspected a representative sample of the four major discharging vessel types (bulk, tanker, container, and ATB), as shown in Figure 22. It should be noted that although containers were responsible for only 2% of the discharge volume between 2008 and 2015, they corresponded to on average 8% of inspections. DFW may want to consider incorporating vessel type into their risk factors.

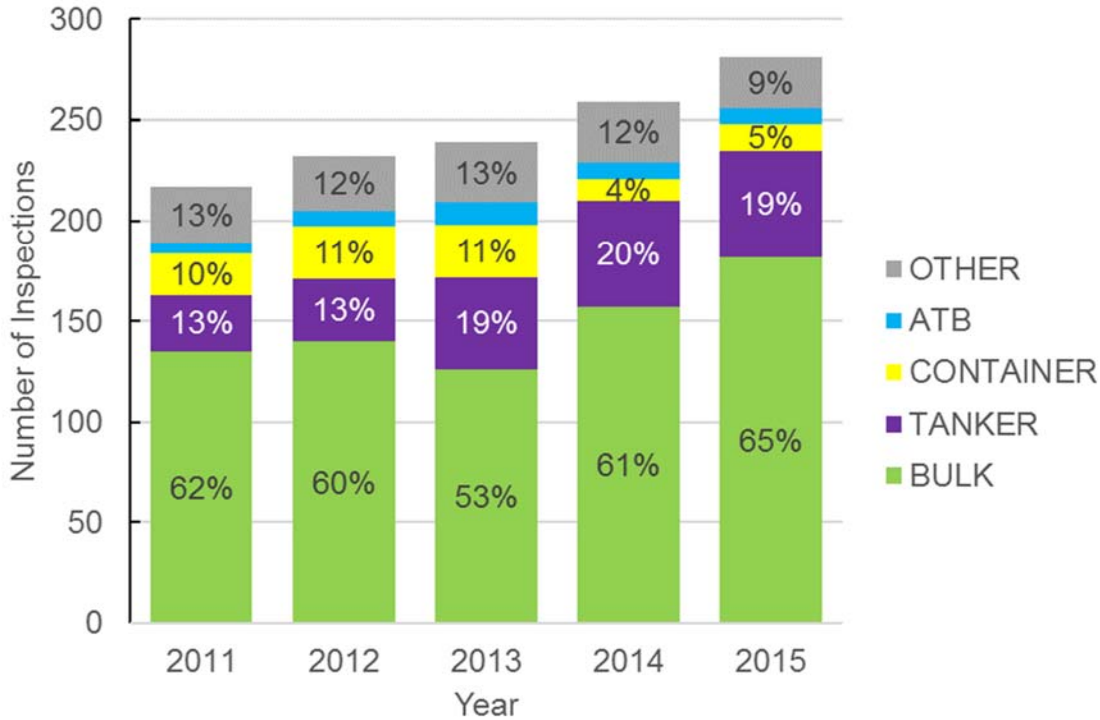


Figure 22 Number of inspections by inspected vessel type

A majority of inspected vessels are bulk vessels (average 60% of all inspected vessels). The second most common vessel type inspected is tankers (average 17% of all inspected vessels), followed by containers (average 8% of all inspected vessels) and ATBs (average 3% of all inspected vessels). Similarly, between 2008 and 2015, bulkers were responsible for over 70% of the ballast water discharge by volume in Washington State, tankers for 16%, and ATBs for 8% (Table 5).

Compliance Change

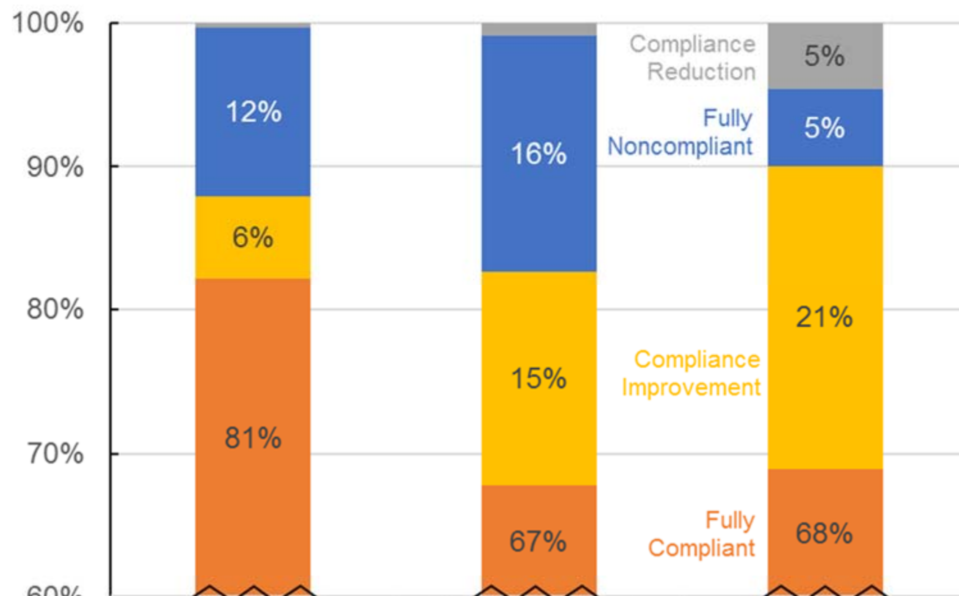
In 2011, DFW began recording compliance with Washington State regulations specific to vessel arrivals and inspections at three points:

- **Pre-arrival**: based on BWMR compliance or violations known prior to boarding vessel.
- **During inspection**: based on vessel inspection confirmation and new noncompliance findings.
- **Post-arrival**: based on final vessel compliance level for vessel-corrected violations.

Compliance change is evaluated as the change in the compliance state of the vessel from the first point, pre-arrival, to the third point, post-arrival. Examples include:

- Pre-arrival full compliance (**Fully Compliant**): an arrival submits a BWMR that meets all regulation code requirements (Table 11 and Table 12).

- Noncompliant to compliant (**Compliance Improvement**): an arrival submits a BWMR with one or more regulation code violations, and is flagged by DFW for inspection. Upon inspection, the inspector helps correct the noncompliant BWMR (such as helping to complete per USCG regulations), and DFW reclassifies the arrival as compliant.
- Post-arrival full noncompliance (**Fully Noncompliant**): an arrival submits a BWMR that has one or more regulation code violations that are not corrected or are not correctable. For example, a late BWMR cannot be corrected; even once the BWMR is turned in, it is still late.
- Compliant to noncompliant (**Compliance Reduction**): a vessel submits a BWRM that is originally marked as compliant, but upon vessel inspection is discovered to have one or more violations to a regulation code previously consider in compliance, and DFW reclassifies the arrival as noncompliant. Figure 23 illustrates compliance change for all arrivals, discharging arrivals, and inspected vessels from 2012 through 2015, combined. Noncompliance is discussed in detail in the following section.



	All Arrivals	Discharging Arrivals	DFW Inspected
Compliance Reduction	50	49	47
Fully Noncompliant	1,937	932	54
Compliance Improvement	951	844	214
Fully Compliant	13,445	3,795	687
No Indication	122	45	12
TOTAL	16,505	5,665	1,014

Figure 23 Compliance change of all arrivals, discharging arrivals, and inspected vessels, 2012 - 2015 combined (note that vertical axis starts at 60%)

The three groups presented in Figure 23 have different population sizes. Both the "Discharging Arrivals" and "DFW Inspected" groups are subpopulations of the "All Arrivals" group and are included in the analysis to assess their different risk profiles.

The "All Arrivals" data includes all vessel arrivals, whether a discharging or non-discharging vessel (16,505 arrivals). DFW efforts directly reduced noncompliance in all arrivals from 18% pre-arrival (combined blue and yellow in Figure 23) to 12% post-arrival (blue in Figure 23). Ultimately, administration and inspection efforts, including real-time ballast report reviews and direct-to-operator communication, reduced noncompliance in all arrivals by 6%, which amounts to a one-third reduction in the size of the initially noncompliant group.

The "Discharging Arrivals" data includes only discharging vessel arrivals (5,665 discharging arrivals). DFW reduced noncompliance in discharging arrivals from 31% pre-arrival to 16% post-arrival. DFW efforts reduced noncompliance in discharging arrivals by 15%, which is a one-half reduction the size of the initially noncompliant group. Given the ballast water risk presented by discharging arrivals, this one-half reduction in noncompliance indicates the positive impact of DFW.

The "DFW Inspected" data focuses only on vessel arrivals boarded and inspected by DFW (1,014 inspected arrivals). DFW efforts directly reduced noncompliance in inspected arrivals from 31% pre-arrival to 10% post-arrival. DFW efforts ultimately reduced noncompliance in inspected arrivals by 21%, or a two-thirds reduction in the size of the initially noncompliant group. Moreover, 5% of inspections are classified as "compliance reduction." This indicates that DFW inspection identifies arrivals that seemed compliant according to BWMR submission, but were actually noncompliant.

This analysis strongly indicates that focusing on discharging vessels and vessel inspections improves the assessment of ballast water risk, can increase a vessel's likelihood of becoming compliant, and can reveal noncompliance that may have otherwise gone undetected if the vessel had not been inspected. Moreover, DFW communication and inspection efforts – which DFW strives not to duplicate with USCG efforts – have measurably reduced compliance risk in Washington State.

Post-Arrival Compliance

Whereas the previous section analyzed the change in compliance from pre- to post-arrival, this section analyzes only final (post-arrival) compliance, as an assessment of the ultimate level of risk to Washington State. Post-arrival compliance can be classified in three ways:

- **Compliant**: vessel is compliant post-arrival.
- **Administrative noncompliance**: vessel is noncompliant with reporting regulations post-arrival; caused by late submissions, incomplete, and incorrectly completed BWMR forms.
- **Management noncompliance**: vessel is noncompliant with management regulations post-arrival; caused by noncompliance with ballast water management requirements, such as meeting exchange method or zone criteria. Unless they are caught early enough to be corrected, management violations may result in the discharge of noncompliant ballast water.

The initial determination of whether an error is due to reporting or to management is often very difficult to make. A violation on the BWMR – such as not filing the form on time – could signify a management risk to the state since the state does not know whether the vessel intends to discharge and what ballast water management practices were applied.

Table 11 and Table 12 present noncompliance violations from 2012 through 2015 for all arrivals. Table 11 focuses on administrative noncompliance and Table 12 focuses on management noncompliance. Each table provides the specific state regulations against which vessel noncompliance is evaluated. Each count represents a single noncompliant violation. Some arrivals have multiple noncompliance violations; in these cases, each compliance code was counted once. For example, for an arrival that earned noncompliance codes I, V, and W, there would be one violation of an "I," one violation of a "V," and one violation of a "W." Compliance codes A and B are excluded as these denote compliant vessels in the DFW database.

Table 11 Administrative post-arrival noncompliance violations, all arrivals

Code	Scenario	Number of Violations			
		2012	2013	2014	2015
C	WAC 220-650-030 2(a) Did not use proper USCG or IMO Form	0	0	5	3
D	WAC 220-650-030 2(b) Did not file 24 hrs prior to arrival	276	269	586	613
E	WAC 220-650-030 2(b)(i) Form had data relating to discharge for outside WA	20	4	9	4
F	WAC 220-650-030 2(b)(ii) Form not completed per USCG Regulations, USCG Form	40	15	47	24
G	WAC 220-650-030 2(b)(iii) Form not completed per USCG Regulations, IMO Form	1	0	0	0
H	WAC 220-650-030 2(c) Did not file new form for each subsequent port	2	0	1	0
I	WAC 220-650-030 2(d) Did not file amended BWMR	60	26	2	0
J	WAC 220-650-030 2(e) BWMR file corrupted, incompatible, or illegible	2	1	0	0
K	WAC 220-650-030 2(a-e) Did not file safety exemption/filed incorrect safety exemption, etc.	0	0	0	0
	Total	**401**	**315**	**650**	**644**

Table 12 Management post-arrival noncompliance violations, all arrivals

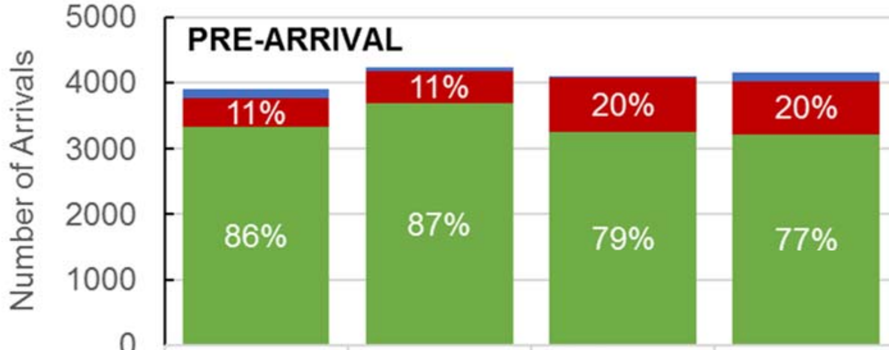
Code	Scenario	Number of Violations			
		2012	2013	2014	2015
L	WAC 220-650-040 (1) Did not exchange ballast water or use approved ALT	1	0	2	0
M	WAC 220-650-040 2(b) Noncompliance with ER exchange method	7	0	1	2
N	WAC 220-650-040 2(c) Noncompliance with FT exchange method	23	10	1	7
O	WAC 220-650-040 3(b) Transoceanic exchange <200nm, <2000m deep	1	0	0	0
P	WAC 220-650-040 3(c) Coastal exchange <50nm, <200m deep	2	0	0	0
Q	WAC 220-650-040 (4) Common water exemption violation	0	0	0	0
	Total	**34**	**10**	**4**	**9**

As evident in Table 11, the most common types of reporting-related noncompliance between 2012 and 2015 are not filing a form 24 hours prior to arrival (D), and not completing the USCG form per USCG regulations (F). The least common type of reporting-related noncompliance is filing an incorrect safety exemption (K); no arrivals committed this form of noncompliance.

As evident in Table 12, the most common type of noncompliance is noncompliance with Flow Through exchange method (N). The least common type of noncompliance is violation of the common water exemption; no arrivals committed this type of noncompliance.

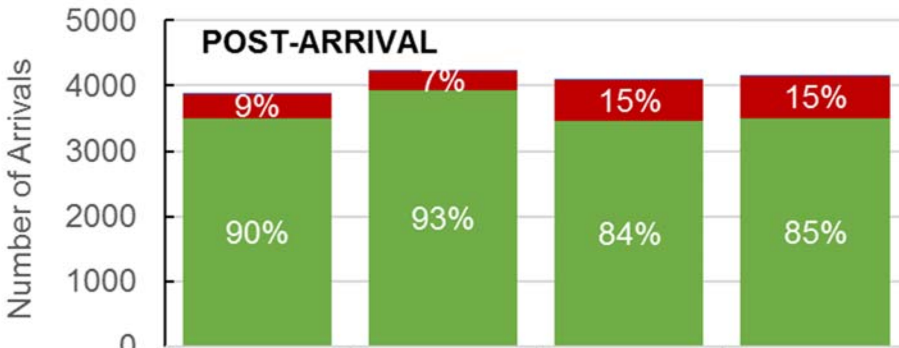
The overall number of management noncompliance instances has reduced since 2012 by a factor of four – from 34 instances in 2012, to only nine instances in 2015. This reduction of management noncompliance over time demonstrates the impact of DFW efforts. It suggests that vessel owners and operators are both learning and adhering to ballast water management regulations.

This reduction in management noncompliance over time has occurred simultaneously with an increase in administrative noncompliance over time – from 401 instances in 2012, to 644 instances in 2015. Figure 24 and Figure 25 illustrate trends in noncompliance over time.



	2012	2013	2014	2015
Management Noncompliant	135	67	14	126
Administrative Noncompliant	427	477	833	810
Compliant	3339	3696	3250	3215

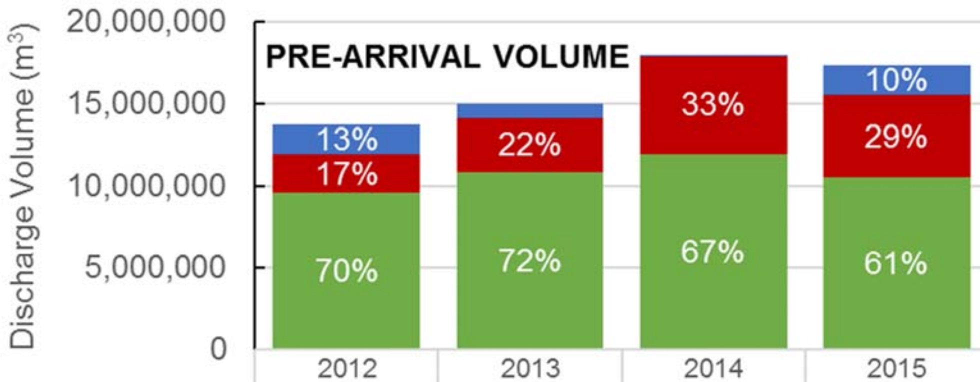
Figure 24 Number of arrivals by pre-arrival compliance



	2012	2013	2014	2015
Management Noncompliant	35	10	4	9
Administrative Noncompliant	355	307	635	632
Compliant	3506	3923	3458	3509

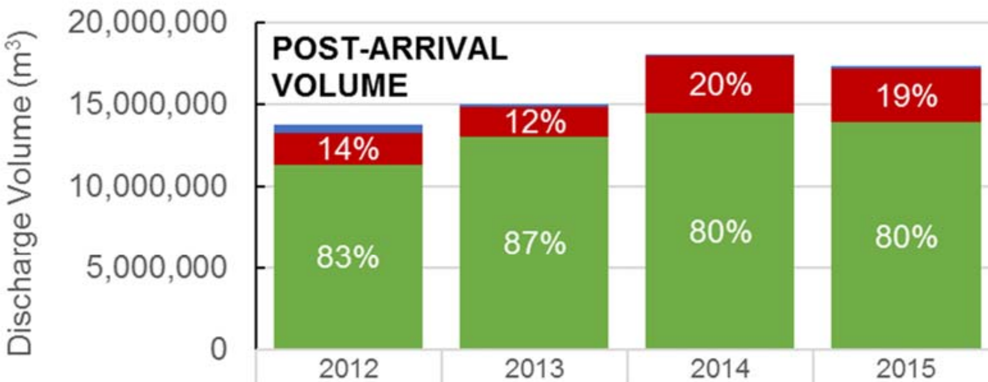
Figure 25 Number of arrivals by post-arrival compliance

The above figures quantify the reduction in administrative noncompliance due to DFW efforts between when a vessel first submits its BWMR (Figure 24) and when the vessel ends its interaction with Washington State (Figure 25). Whereas each year on average 16% of vessels arrive in Washington State with “pre-arrival” administrative noncompliance (red in Figure 24, ranges from 11% to 20% each year), on average 12% of arrivals leave with “post-arrival” administrative noncompliance (red in Figure 25; ranges from 9% to 15% each year). Thus, DFW communication and administration efforts reduce administrative noncompliance (red in Figure 24 and Figure 25) by 4% (156 vessels) on average each year. Moreover, that reduction has increased every year since 2012.



	2012	2013	2014	2015
Management Noncompliant	1,763,419	821,144	99,689	1,736,415
Administrative Noncompliant	2,383,653	3,316,646	5,917,839	5,037,593
Compliant	9,586,262	10,854,217	11,974,437	10,538,303

Figure 26 Discharge volume by pre-arrival compliance



	2012	2013	2014	2015
Management Noncompliant	410,919	124,884	14,776	129,634
Administrative Noncompliant	1,954,894	1,795,699	3,538,056	3,279,982
Compliant	11,367,522	13,071,424	14,439,133	13,902,695

Figure 27 Discharge volume by post-arrival compliance

The above figures quantify the reduction in management noncompliance due to DFW efforts between the time a vessel first submits its BWMR (Figure 26) and the time it ends its interaction with Washington State (Figure 27). Whereas on average 7% of discharge volume (1.1M m^3) is planned by "pre-arrival" management noncompliant vessels (blue in Figure 26), on average only 1% of the realized discharge volume (0.16M m^3) was discharged by "post-arrival" management noncompliant vessels (blue in Figure 27). Thus, by volume, DFW efforts are responsible for reducing management noncompliance by 6%. In other words, on average each year DFW rescues 0.9M m^3 of the pre-arrival 1.1M $m^3$of ballast water each year from being discharged as management noncompliant.

Focusing only on post-arrival noncompliance, as evident in Figure 25 and Figure 27, an average of only 14 vessels each year discharge with a management noncompliance (Figure 25), for an average annual discharge of 0.16M m^3 (Figure 27; 1% of all Washington State discharge) of mismanaged ballast water.

An average of 483 vessels each year discharge with an administrative noncompliance, for an average annual discharge of 2.7M m^3 (17% of all Washington State discharge). However, the discharge volume over time has grown slightly from 14% in 2012, to 19% in 2015.

3.3.4 Forecast

This subsection discusses a forecast of regulatory management through 2023.

Administrative and Inspection Efforts

Performance goals provide one metric for forecasting future administrative and inspection efforts. However, neither the legislature nor DFW have set an inspection or compliance performance measure to assess performance and define "minimal risk." The only formal performance measure established for the program was through the Governor's natural resources office (2008-2012) which had implemented a "Government, Management, Accountability and Performance" program and established an ending compliance target of 95% (GMAP Measure 3.2.a) for all vessel arrivals. State compliance rates currently range from 84% to 93% (Figure 25), indicating that the state is not yet meeting the GMAP goal of 95%.

The changing regulatory climate makes future inspection or compliance rates difficult to forecast based on historic data. Section 4.4.3 presents a methodology for setting future inspection rates based on compliance. It is reasonable to assume that compliance rates will remain similar or increase as long as ballast water management regulations remain the same. However, as discussed below, upcoming changes in federal and international ballast water regulations will have effects on the nature of ballast water management in Washington, which will create new compliance challenges in the future.

Treatment Management Challenges

Ballast water management regulations and technology are in a period of rapid development. Challenges to regulating this technology fall into several categories:

- **Uncertain schedule**. The USCG final rule was issued in March of 2012, with the first treatment system having received USCG type-approval in December of 2016. USCG has employed bridging strategies, such as the USCG AMS program and allowing case-by-case compliance extensions. The result is that the compliance schedule is now on a vessel-by-vessel basis.
- **Evolving monitoring methods**. The methods to perform compliance monitoring audits of ships that will be discharging ballast water are still in development by the administrations of multiple countries, including the U.S. The type-approval process is expected to promulgate specific compliance checking procedures for each type of system approved.
- **System uncertainty**. There is also uncertainty related to the reliability of BWTS due to a lack of operational data from existing marine vessel installations. Most of these systems are in either prototype phases or first-generation development cycles. Further development will generate more reliable data to evaluate the frequency of equipment mechanical failures or predictions on the frequency with which the treatment system process is overwhelmed by the natural conditions of the ballast water. The aim of the type-approval process, although challenging, is to identify verified systems for reliable installation in fleets. This aim should mitigate the uncertainty related to ballast water treatment system reliability.
    - There has been some work on contingency measures in response to reliability concerns. These approaches include the use of a reception facility for treating the ballast water once it is off-loaded from the ship, and the use of mobile equipment that would enable treatment of the ballast water on board the ship itself. The

varying nature of ship types, ports of call, and involved infrastructure present logistical, infrastructure and cost challenges to contingency measure development. Further development and testing of these approaches is required before their utility can be fully evaluated.

- Multiple development phases or cycles are normal for a new system. There is a history of challenges with migrating land-based technology to marine vessels, as evidenced by oily water separator and marine sanitation devices. However, the technologies being migrated, such as ultraviolet irradiation, ozone disinfection, and electro-chlorination, are mature and effective technologies.

More clarity will be gained over the next couple of years as treatment systems are installed on ships and used for ballast water management, and testing is conducted to evaluate compliance with the manufacturer's operational standards, foreign and U.S. type-approval standards, and ballast water discharge standards. It is anticipated that these uncertainties will get resolved over the next several years leading up to 2023, when all vessels are forecast to have installed treatment systems and transitioned to ballast water management using these systems. However, at this point it is impossible to predict the compliance rates of vessels using new, stringently evaluated and approved treatment systems. A further discussion and analysis of treatment system adoption is presented in the next section.

Forecasted Treatment System Adoption and Discharge Volumes in Washington State Waters

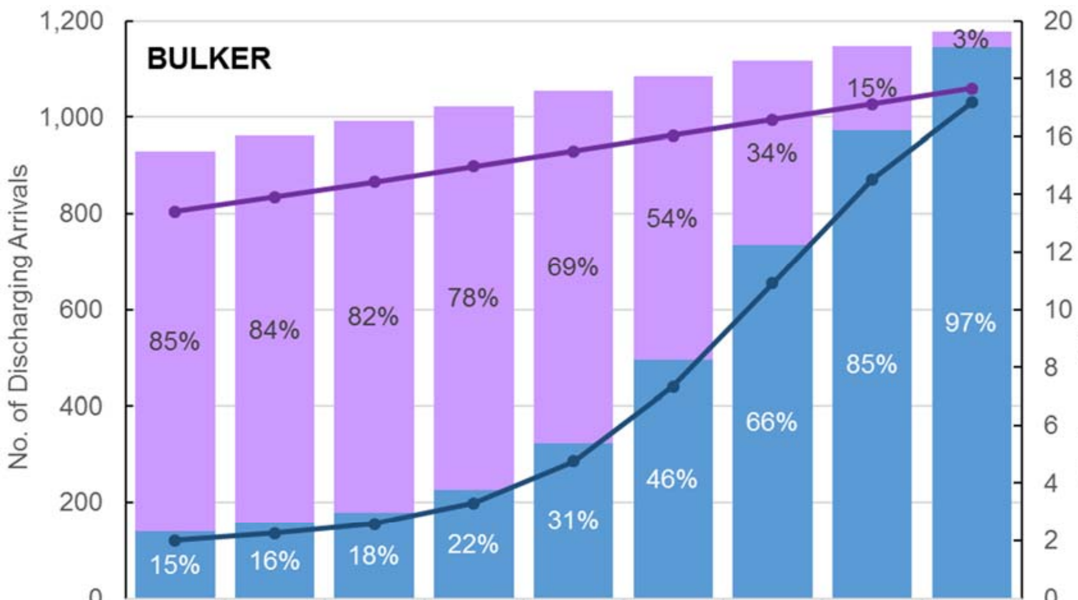
The IMO adopted the Ballast Convention in 2004. This convention requires BWE and ballast water treatment with similar phase-in schedules as USCG and EPA. The IMO Convention was ratified in September 2016, and it is currently expected to enter into force in September 2017. At that time, vessels that travel internationally will be required to install ballast water treatment systems approved by a foreign administration at their next drydocking (most have been accepted as "alternative management systems" or AMS by USCG). It is predicted that an aggressive retrofitting of existing vessels with new BWTS will take place in 2017.

USCG requirements for compliance with ballast water treatment requirements dictate that all vessels should now be installing U.S. type-approved BWMS at their next scheduled drydocking. These requirements were meant to be implemented on a staggered schedule, as indicated in Section 2.3. Although this schedule required the last U.S. vessels to be treating water by their first drydocking after January 1st of 2016, the first BWMS was type-approved by the USCG in December of 2016.

In response to the USCG and IMO new vessel compliance dates, many new construction vessels have been outfitted with BWMS as part of the new construction effort. However, these systems have generally not been used, as the USCG had not approved any systems, and the Ballast Convention was only recently ratified by an adequate representative tonnage (35%) of IMO member states. Now that the IMO Convention has been ratified, it is expected that the installed BWMS will then be utilized in place of ballast water exchange, and existing vessels will begin installing BWMS in greater numbers in 2017.

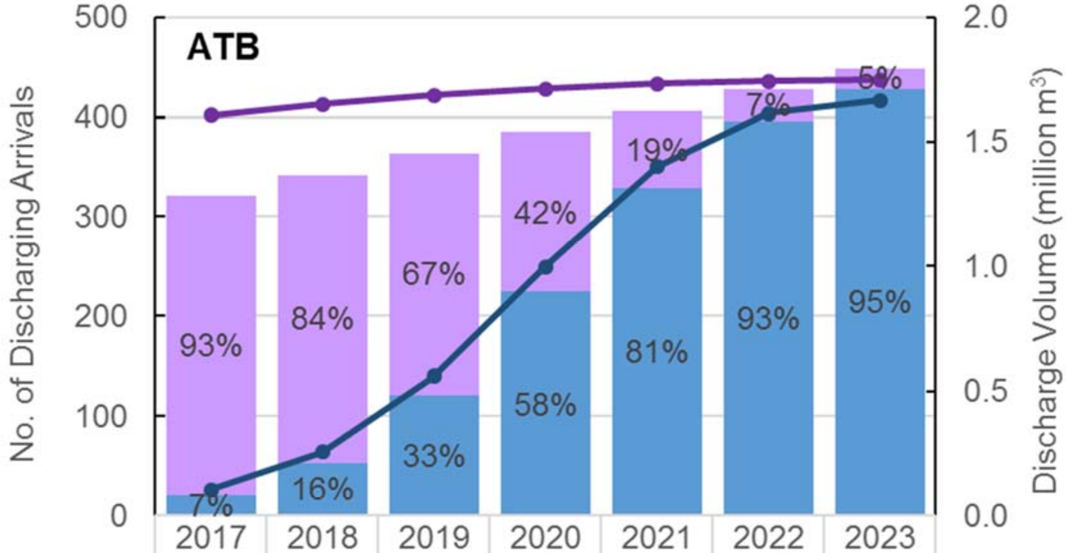
During the delay of U.S. type-approved BWMS available for installation, the USCG issued extensions to the management compliance dates. The USCG also allowed vessels to use AMS found to be acceptable by the USCG to treat their ballast water, instead of conducting BWE. AMS are treatment systems that have been type-approved by a foreign administration, and then submitted to USCG for AMS acceptance. AMS use explains how some vessels are already reporting ballast water management by treatment system although type-approved systems are not available. The USCG enforces the use of AMS or exchange prior to discharge, as documented in the widely-publicized *Vega Mars* discharge violation in early 2017 (Reference 28).

The first system received U.S. type-approval on December 2, 2016, and vessels have begun to install BWTS as their extensions expire. A majority of vessels are expected to install within the next five years, which is a typical vessel dry-docking schedule. However, some vessels can be expected to obtain additional extensions or otherwise be behind the curve, as notionally illustrated by vessel type in Figure 28 through Figure 31. This is the typical pattern of adoption of new technology.



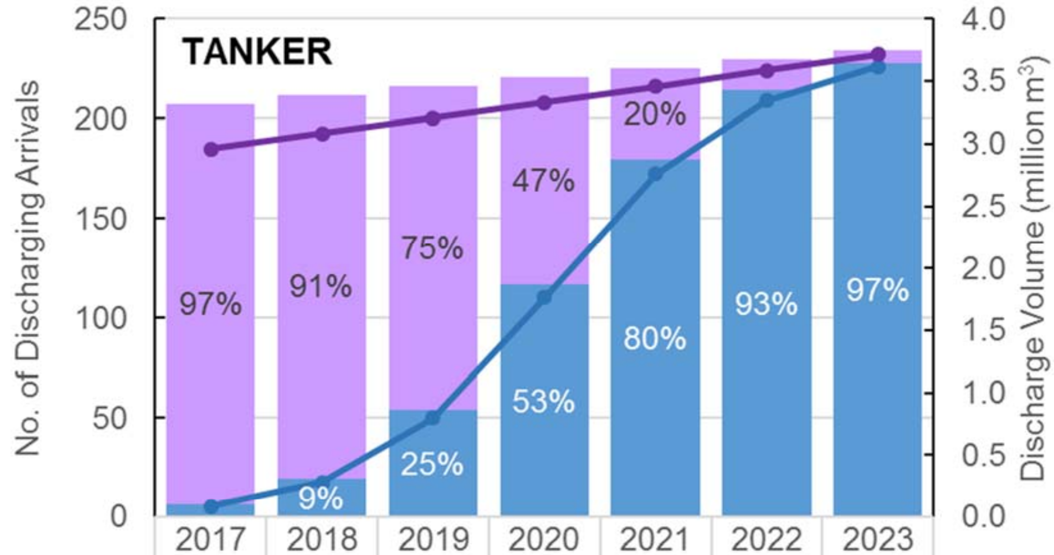
	2017	2018	2019	2020	2021	2022	2023	2024	2025
LM Exchange	790	805	814	797	731	589	381	174	32
LM Treatment	139	156	178	226	323	496	735	974	1,146
Exch Vol	11.4	11.7	11.9	11.7	10.7	8.7	5.7	2.6	0.5
Treatment Vol	2.0	2.3	2.6	3.3	4.8	7.3	10.9	14.5	17.2

Figure 28 Forecast treatment system adoption and treated volume, bulkers



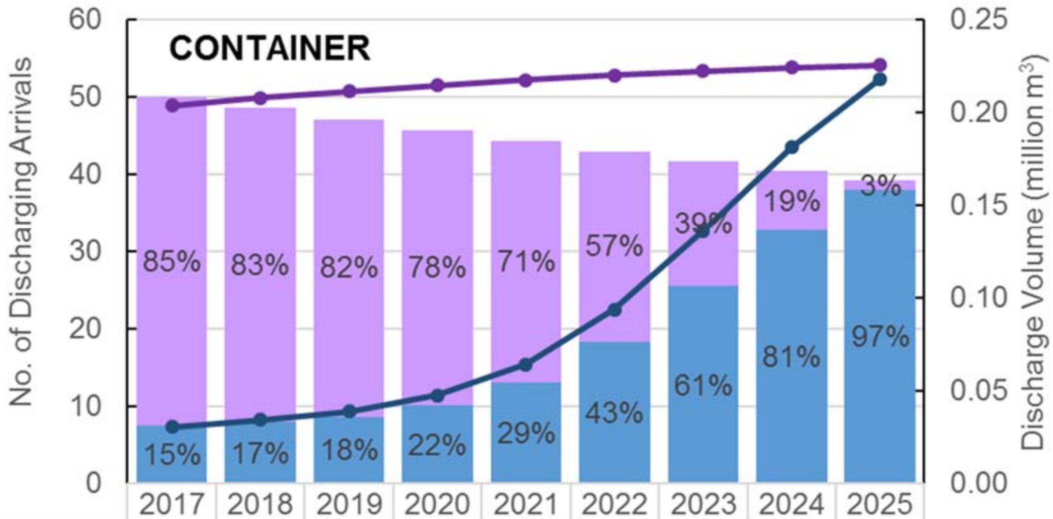
	2017	2018	2019	2020	2021	2022	2023
LM Exchange	299	288	243	160	78	32	21
LM Treatment	21	54	121	225	328	395	428
Exch Vol	1.5	1.4	1.1	0.7	0.3	0.1	0.1
Treatment Vol	0.1	0.3	0.6	1.0	1.4	1.6	1.7

Figure 29 Forecast treatment system adoption and treated volume, ATBs



	2017	2018	2019	2020	2021	2022	2023
LM Exchange	201	193	162	104	45	15	6
LM Treatment	6	19	54	117	180	215	228
Exch Vol	2.9	2.8	2.4	1.6	0.7	0.2	0.1
Treatment Vol	0.1	0.3	0.8	1.8	2.8	3.3	3.6

Figure 30 Forecast treatment system adoption and treated volume, tankers



	2017	2018	2019	2020	2021	2022	2023	2024	2025
LM Exchange	43	41	38	36	31	25	16	8	1
LM Treatment	8	8	9	10	13	18	26	33	38
Exch Vol	0.17	0.17	0.17	0.17	0.15	0.13	0.09	0.04	0.01
Treatment Vol	0.03	0.03	0.04	0.05	0.06	0.09	0.14	0.18	0.22

Figure 31 Forecast treatment system adoption and treated volume, containers

The above figures forecast treatment system adoption through the implementation of the logistic function, a common mathematical model of adoption behavior. In a variety of fields, the adoption of innovations often follows the shape of an s-shaped sigmoid curve, with a slow rate of adoption at first, followed by a period of rapid adoption, and then a slow rate of adoption towards the end as adoption nears 100%. A simple logistic function can be described by the maximum number of adopters, the rate of adoption, and the midpoint of the curve.

For the vessel types above, the logistic function was applied to the forecasts of discharging arrivals by vessel type (Appendix D; a modified forecast was used for containerships due to their low numbers) with selected logistic function parameters to estimate treatment system adoption by vessel type. Widespread adoption of treatment systems is generally expected close to 2023, with the exception of bulkers, who have a longer phase-out cycle and may generally adopt closer to 2030.

Although Figure 28 through Figure 31 provide a possible picture of treatment system behavior, many uncertainties surround vessel use of treatment systems to manage ballast water. USCG type-approval of systems is widely recognized to be a rigorous process, and systems that have achieved type-approval will be equipped with a host of self-monitoring capabilities to ensure proper function.

By contrast, IMO type-approval involves less specific requirements for the testing of a treatment system. Type-approval has been inconsistently implemented, and leaves uncertainty as to whether vessels using such systems will be able to comply with the international standard. A recent study for the IMO on the implementation of the D2 standard for BWMS performance concluded that there is a lack of transparency on the methods that have been used to approve systems, and that systems are irregularly monitored for ability to properly disable entrained species and for toxic contents of discharged water (Reference 22).

3.3.5 Summary

The efforts of DFW have been directly responsible for improving compliance rates. DFW works to ensure its communication and inspection efforts do not duplicate USCG efforts. Communication efforts have measurably affected discharge activity:

- On average, just under one-half of the ballast water discharged in Washington State each year was discharged by a vessel that amended its BWMR. Direct communication with a vessel, whether through phone call or email from DFW, may be the reason for a vessel amending its BWMR.
- On average for administrative noncompliance discharge risk, DFW efforts resulted in an average reduction from 4.1M m3 (26% of total discharge volume) to 2.6M m3 (17% of total volume).
- On average for management noncompliance discharge risk, DFW efforts resulted in an average reduction from 1.1M m3 (7% of total discharge volume) to 0.2M m3 (1% of total volume).

DFW typically inspects 7% of all arrivals to Washington State. The inspections last about 2.5 hours, and focus on high-risk vessels and a diverse sample of vessel types. Inspection efforts have also measurably affected discharge activity:

- Communication and inspection efforts, including real-time ballast report reviews and direct-to-operator communication, reduced noncompliance in discharging arrivals by 15%, which is a one-half reduction in the size of the initially noncompliant group. Given the ballast water risk presented by discharging arrivals, this one-half reduction in noncompliance indicates the positive impact of DFW.
- DFW efforts ultimately reduced noncompliance in inspected arrivals by 21%, or a two-thirds reduction in the size of the initially noncompliant group. Moreover, 5% of inspections are classified as "compliance reduction." This indicates that DFW inspection identifies arrivals that seemed compliant according to BWMR submission, but were actually noncompliant.

Due to administrative and inspection efforts, on average, only 15 arrivals each year pose a management noncompliance by discharging with ballast water management violations (0.2M m^3, or 1% of all ballast water discharged in Washington State). However, the discharge volume over time has grown slightly from 14% in 2012, to 19% in 2015.

Federal ballast water management regulations and technology are in a period of rapid development, which introduces uncertainty regarding whether technology can consistently meet discharge performance standards. There is also uncertainty related to the reliability of ballast water treatment systems due to a lack of operational data from existing marine vessel installations. At this point, it is impossible to predict the compliance rates of vessels using new, stringently evaluated and approved treatment systems.

Many owners of new vessels outfitted their ships with AMS as part of the new construction, and then left these systems unused while they waited for the USCG to approve new ballast water management systems and the IMO to ratify the Ballast Water Convention. Since IMO ratified the convention in September of 2016 and the USCG has started issuing U.S. type-approvals for BWMS in December of 2016 (three total at time of this report), it is expected that existing vessels will begin installing both BWMS and AMS in greater numbers in 2017. Uncertainties in IMO BW convention entering into force as predicted in September of 2017 and potential delays in the commercial availability of USCG type-approved BWMS makes the timeline of full

BWMS implementation difficult to predict. With the exception of bulkers, general widespread use of treatment systems is expected by 2023 for the top discharging vessel types in Washington State (tankers, ATBs, and containers). Widespread use of treatment systems by bulkers is expected closer to 2030.

Table 13 summarizes the historical data with regard to DFW inspection efforts.

Table 13 Regulatory management summary table; post-arrival compliance is shown

		2008	2009	2010	2011	2012	2013	2014	2015	Total	Average
Total Arrivals:		4,074	3,943	4,211	4,233	3,902	4,240	4,119	4,250	32,972	4,122
Total Discharge Volume (million m^3):		12.4	12.5	15.0	15.2	13.7	15.0	17.9	17.7	119.5	14.9
3.3.2 Inspection Efforts											
Inspected Arrivals (Number)		--	--	--	--	233	239	260	281	2,332	292
Inspected Arrivals (Proportion of Total Arrivals)		--	--	--	--	6%	6%	6%	7%	--	6%
Number and Proportion of Total Arrivals with Post-arrival Status of	*Compliant*	--	--	--	--	3,506	3,923	3,458	3,509	14,396	3,599
		--	--	--	--	90%	93%	84%	83%	--	88%
	Administrative Noncompliant	--	--	--	--	355	307	635	632	1,929	483
		--	--	--	--	9%	7%	15%	15%	--	12%
	Management Noncompliant	--	--	--	--	35	10	4	9	58	15
		--	--	--	--	0.9%	0.2%	0.1%	0.2%	--	0.3%
Amount and Proportion of Total Discharge Volume (million m^3) with Post-arrival Status of	*Compliant*	--	--	--	--	11.3	13.0	14.3	13.9	52.7	13.2
		--	--	--	--	83%	87%	80%	80%	--	82%
	Administrative Noncompliant					2.0	1.8	3.5	3.3	10.6	2.6
		--	--	--	--	14%	12%	20%	19%	--	17%
	Management Noncompliant					0.4	0.1	0.01	0.1	0.7	0.2
		--	--	--	--	3%	1%	0.1%	1%	--	1%
Compliance Improvement	*All Arrivals*									6%	--
	Discharging Arrivals									15%	--
	DFW Inspected Arrivals									21%	--

3.4 Ballast Water Activity in Other States

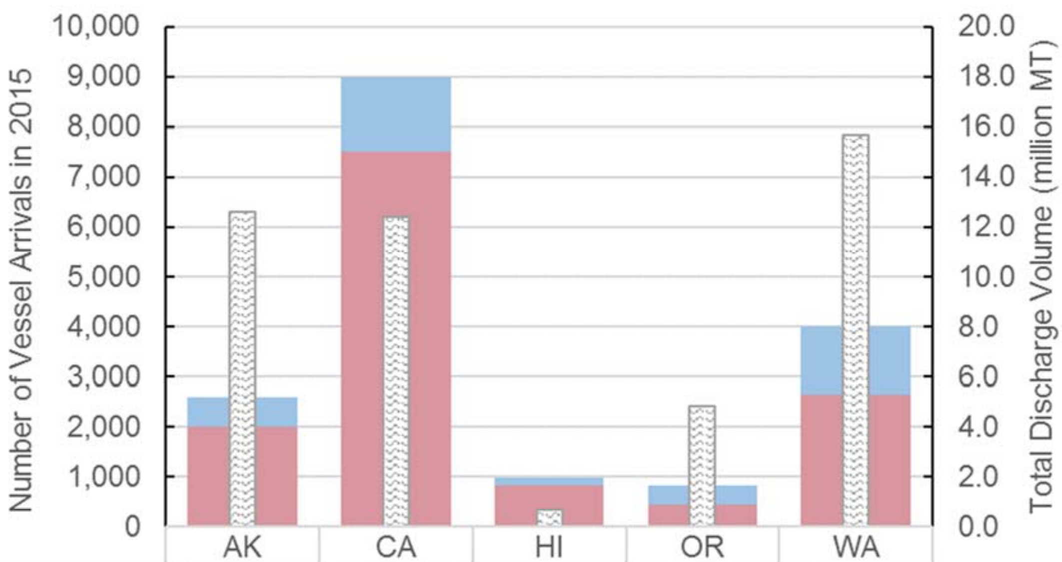
This section compares ballast water activity among the Pacific coast states, including Washington State, as well as East and Gulf coast states based on data from the NBIC.

The NBIC classifies ballast water as either originating overseas or from coastal waters. These types are defined as follows:

- **Overseas** ballast water was entrained from a location that requires transiting beyond the combined U.S. and Canadian Exclusive Economic Zones (EEZ).
- **Coastal** or **coastwise** ballast water was entrained within 200 nm of any shore. Coastwise ballast water does not require transiting beyond the combined U.S. and Canadian EEZ.

3.4.1 Arrivals and Discharges

Washington State had more discharge than other West Coast states in 2015 (15.7M m^3). NBIC data and DFW data show strong agreement for arrivals and discharges (Appendix D). The NBIC database was used to compare vessel traffic and ballast water discharges in Washington with other Pacific states (Oregon, California, Alaska, and Hawaii). Comparisons were made based on year 2015 only. Figure 32 compares the number of discharging arrivals, non-discharging arrivals, and discharge volume for Washington in 2015 with other Pacific states.



	AK	CA	HI	OR	WA
Disch.	578	1,478	169	373	1,351
Non-Disch.	2,010	7,513	817	450	2,653
Disch. Vol.	12.6	12.4	0.7	4.8	15.7

Arrival Port State

Figure 32 Number of non-discharging arrivals, discharging arrivals, and total discharge volume for Pacific states, 2015

In 2015, California had the most arrivals and the most discharging arrivals. However, Washington is the state with the highest discharge volume at 15.7M m^3. Alaska has the second highest discharge volume (12.6M m^3), and California the third highest (12.4M m^3). Washington State's bulk export sector (refined petroleum, grain, logs, etc.) may partially justify this trend.

3.4.2 Ballast Water Management

To evaluate the effectiveness of Washington State's ballast water program in comparison to other states with and without state ballast water management programs, 2015 data on ballast water management status and trends was compared between Washington State, other West coast states, and the Gulf and East coast states. This comparison reveals that in 2015 the West coast states with ballast water management programs (Washington, California, Oregon, and Hawaii) were substantially more effective at limiting the discharge of raw ballast water. Washington State raw ballast water discharges were limited to 14% of the total discharges in 2015, which is only one-third of the national average of 43%. Unlike Washington State, which has a dedicated ballast water management program, the vast majority of states rely solely on federal requirements and enforcement.

Importantly, managing ballast water is not required by regulations in all instances. For example, in Washington State, ballast water entrained and discharged in special "common water" zones is not required to undergo exchange. Thus, before ballast water treatment systems were federally required, an arrival could discharge raw ballast water from common water zones and still be in full compliance with all state and federal regulations.

In general, USCG ballast water management regulations allow for higher volumes of raw coastwise discharges. There are no management requirements for:

- Voyages within a single COTPZ (33 CFR § 151.2015).
- Voyages where a vessel invokes the "deviation from planned voyage" exemption (33 CFR § 151.2055).
- Voyages or where a vessel files a safety exemption due to weather or vessel design limitations (33 CFR § 151.2040).

<u>NBIC Special Data</u>

The data for this comparison was requested from the NBIC for state-specific data for Pacific coast, East coast, and Gulf coast states. Although the NBIC provides a web-based database portal to access most of the data used by the public for most analyses needs, data by coastwise and overseas categories were provided by the USCG.

NBIC notes that these data should be considered conservative. The dataset omits data under a number of conditions:

- Lacks sufficient information to identify source locations as overseas or coastwise (0.06% of data).
- Lacks sufficient information to determine whether a tank underwent exchange (1% of data).

NBIC also notes that these problems were some of the main reasons for implementing their new reporting form requiring vessels to enter this key data before submitting. As noted before, NBIC data does not reflect or evaluate compliance with either USCG or EPA VGP ballast water management requirements.

Pacific Coast Comparison

All Pacific coast states except Alaska have ballast water management programs that include inspection of vessels and enforcement of both state and federal requirements. Table 14 provides the NBIC data for Pacific Coast states, and puts Washington State ballast water management practices in a regional context.

Table 14 Pacific Coast ballast water discharge by source, 2015

State	Total Discharge (MT)	Total Raw Discharge (MT)		Total Safety Exempt Discharge (MT)		Source	Raw Discharge by Source (MT)	Safety Exempt Discharge by Source (MT)
AK	12,605,683	5,315,498	42%	3,219,470	26%	Coastwise	5,129,917	3,059,752
						Overseas	185,581	159,718
CA	12,417,333	1,857,806	15%	46,974	<1%	Coastwise	1,670,566	46,974
						Overseas	187,240	0
HI	700,932	55,403	8%	0	0%	Coastwise	28,392	0
						Overseas	27,011	0
OR	4,848,783	191,313	4%	159	<1%	Coastwise	182,669	159
						Overseas	8,644	0
WA	15,655,505	2,226,725	14%	1,763	<1%	Coastwise	2,197,260	1,763
						Overseas	29,465	0

Pacific Coast states with ballast water management programs (California (CA), Hawaii (HI), Oregon (OR), and Washington (WA)), have raw discharge at percentages ranging from 4% to 15%, which is far below the national average (43%, weighted average of Total Raw Discharge across Pacific Coast, East, and Gulf Coast states). Those states have assessed their raw coastwise ballast water discharge volumes and know that these volumes generally comply with state requirements where the ballast water was sourced and discharged within an allowed geographic region and to a much smaller extent (<1% of total raw discharge), where a vessel has filed a valid safety exemption due to weather or vessel design limitations (as compared to national average of 0.2%). As noted in Section 3.3.3, ballast water management noncompliance constitutes less than 1% of total discharges in Washington State. The NBIC data also shows that except for Hawaii, coastwise water makes up over 90% of all raw ballast water. Two factors of note are that WA, CA, OR, and HI do not have the "deviation from planned voyage" exemption allowed under USCG rules and that each state evaluates safety exemptions for validity.

Alaska (AK), which does not have its own ballast water program, has a raw discharge rate consistent with the national average (42% and 43% respectively), but far exceeds the national average for raw ballast water volume due to safety exemptions (26% and 0.2% respectively). Of note is that prior to the EPA VGP Pacific nearshore voyage requirement in 2008, Alaska's ratio of raw ballast water was 81% with an incremental improvement post-implementation to 62% by 2013 (Reference 48).

Additionally, Pacific coast states are afforded greater federal protections through their Vessels Carrying Ballast Water Engaged in Pacific Nearshore Voyages provisions which require those vessels to conduct ballast water exchange at least 50 nm from any shore.

East and Gulf Coasts Comparison

Pacific Coast ballast water management practices were compared with practices on the East Coast (Table 15) and Gulf Coast (Table 16). Safety exemptions were not available from the NBIC for this data.

Table 15 East Coast ballast water discharge by source, 2015

State	Total Discharge (MT)	Total Raw Discharge (MT)		Source	Raw Discharge by Source (MT)
CT	113,084	100,096	89%	Coastwise	100,096
				Overseas	0
DE	979,248	735,471	75%	Coastwise	733,803
				Overseas	1,668
GA	1,938,952	685,438	35%	Coastwise	631,084
				Overseas	54,354
MA	439,902	231,685	53%	Coastwise	230,627
				Overseas	1,058
MD	6,729,974	633,136	9%	Coastwise	611,128
				Overseas	22,008
ME	366,468	51,112	14%	Coastwise	51,112
				Overseas	0
NC	631,940	195,590	31%	Coastwise	190,380
				Overseas	5,209
NH	82,476	6,024	7%	Coastwise	6,024
				Overseas	0
NJ	1,917,909	1,552,880	81%	Coastwise	1,551,120
				Overseas	1,761
NY	6,899,054	5,660,420	82%	Coastwise	5,568,468
				Overseas	91,952
PA	2,412,140	1,548,892	64%	Coastwise	1,542,722
				Overseas	6,170
RI	242,751	125,202	52%	Coastwise	125,202
				Overseas	0
SC	483,558	152,936	32%	Coastwise	142,820
				Overseas	10,116
VA	10,502,111	2,204,234	21%	Coastwise	2,173,968
				Overseas	30,267

Table 16 Gulf Coast ballast water discharge by source, 2015

State	Total Discharge (MT)	Total Raw Discharge (MT)		Source	Raw Discharge by Source (MT)
AL	4,696,614	1,645,660	35%	Coastwise	1,443,539
				Overseas	202,121
FL	4,940,498	2,953,850	60%	Coastwise	2,183,053
				Overseas	770,797
LA	54,347,189	26,319,675	48%	Coastwise	23,518,302
				Overseas	2,801,373
MS	5,550,622	3,092,139	56%	Coastwise	2,667,398
				Overseas	424,742
TX	81,671,820	42,881,310	53%	Coastwise	34,209,223
				Overseas	8,672,088

As illustrated in Table 15 and Table 16, most vessels arriving at East Coast and the Gulf Coast states discharge a significantly higher percentage of raw ballast water than vessels on the Pacific Coast. Sixteen of the nineteen East and Gulf Coast states have raw percentages higher than the four Pacific Coast states with ballast water programs. In fact, 11 of the 19 states have raw percentages higher than the national average, Connecticut (CT) being the highest at 89% followed closely by New Jersey (NJ) and New York (NY) at over 80%.

There are geographic constraints, particularly on the Gulf coast, that are significantly different than on the West coast. For vessels transiting north-south voyages, it is nearly impossible to get 200 nm from any shore to conduct a ballast water exchange. None of the 19 East or Gulf coast states have their own ballast water management or enforcement programs. Therefore, these states rely solely on the USCG to enforce federal requirements. The EPA VGP does not require nearshore ballast water exchanges for these states.

3.4.3 Summary

Table 17 summarizes the ballast water activities of Alaska, California, Hawaii, Oregon, and Washington during 2015.

Table 17 Summary of ballast water activities across Pacific Coast states, 2015

		AK	CA	HI	OR	WA	Avg
3.4.1 Arrivals and Discharges							
Total Arrivals in 2015:		2,588	8,991	986	823	4,004	3,478
Total Discharge (million MT):		12.6	12.4	0.7	4.8	15.7	9.2
Proportion of Managed Discharge Managed by	*Alt. Methods*	1%	0.3%	2%	1%	1%	1%
	Empty/Refill	41%	53%	50%	35%	38%	43%
	Flow-Through	58%	46%	45%	64%	62%	55%
3.4.1 Ballast Water Management							
Total Raw Discharge (million MT)		5.3	1.9	0.6	0.2	2.2	2.4
As a Percent of total discharge		42%	15%	8%	4%	14%	--

3.5 State and Federal Regulatory Management: Opportunity for Cooperation

By administrative rule under WAC 220-650-010(3), "[DFW] communicates and cooperates with the USCG and other federal and state agencies to standardize regulations to the extent practical and appropriate, minimize duplication of efforts, and share information." The USCG and DFW both pursue the broad aim of ensuring all arrivals to Washington State are compliant with state and federal regulations. Both agencies support the ongoing implementation of ballast water risk management efforts including the development and implementation of international and federal discharge standards and treatment technology installations.

This section reviews the two major techniques each agency uses to provide this support: inspection and enforcement. The data presented in this section informs the extent to which DFW duplicates efforts performed by other agencies.

3.5.1 U.S. Coast Guard

The USCG has a broad mission to "protect the public, the environment, and U.S. economic interests – in the nation's ports and waterways" (Reference 47). This protection extends to guarding against the risks posed by the introduction nonindigenous species to Washington's marine ecosystems.

Inspections. USCG conducts Port State Control inspections that cover a range of security, safety, and environmental compliance aspects using safety and environmental protection compliance targeting matrix (Reference 37). Key matrix elements include ship management; flag state; recognized organizations; vessel history, and ship particulars (Figure 33).

The USCG asserts that several aspects of their comprehensive Port State Control inspection are used to assess compliance with federal ballast water regulations:

- Vessels with repeated deficiencies, including ballast water deficiencies, experience increased targeting priority for inspections.
- Every Port State Control inspection includes a ballast water compliance examination. USCG examiners utilize a 141-item Port State Control checklist to ensure totality and consistency with every inspection (Reference 38). Most items examined onboard are interconnected with other examination tasks. Although the term "ballast water" explicitly appears in only one item, 11 of the items involve examination of a vessel's ballast water program.
    - An example would be Item 55, Examine Logbook entries. For this item, examiners compare ballast water management documents with ballast water logs (Item 49, Verify transfer personnel, procedures, equipment, and records) and the navigation entries in the ship's log.
- USCG inspectors have the option of completing an "expanded" ballast water management exam under NVIC 07-04, Change 1 (Reference 10); however, data on frequency of application is not available.
- USCG data on vessel inspections is publicly available on their Port State Information Exchange web page (Reference 39) on an individual vessel search basis.

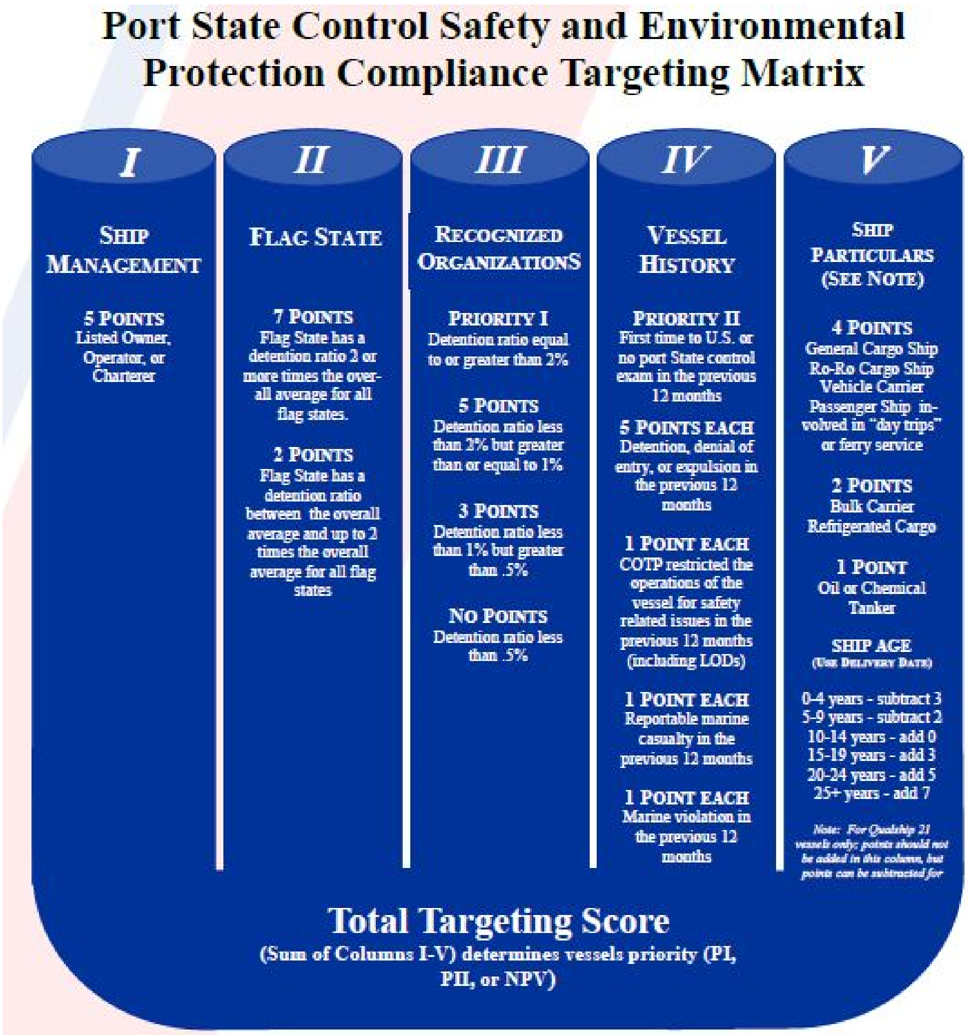


Figure 33 Port State Control safety and environmental protection compliance targeting matrix

Enforcement. Enforcement can form a secondary stage to inspection. The enforcement actions of USCG Sector Puget Sound are compared to those of USCG National in Table 18.

Table 18 USCG enforcement actions, 2004 – 2013; inspection data from 2006 – 2013

	USCG National	USCG Sector Puget Sound
Inspections (Since 2006)	~68,000	2,175
Deficiencies	969	11
Citations	96	0
Citations: Warnings	61	0
Penalties	35 (~$114k)	0
Penalties ≥ $10,000	1	0
Penalties ≥ $5,000 and < $10,000	1	0
Penalties ≥ $1,000 and < $5,000	27	0
Penalties ≥ $1 and < $1,000	6	0

Table 18 presents information obtained by DFW through direct dialogue with the USCG (Reference 56). The USCG data covers all inspections and enforcement actions under 33 CFR § 151 Part D, which includes non-ballast water requirements such as ballast tank cleaning, anchor chain washing, and removing fouling organisms from the vessel's hull. The data does not separate out enforcement due solely to ballast water management.

As illustrated in Table 18, USCG Sector Puget Sound identified 11 deficiencies out of the total 2,175 inspections. Those deficiencies account for about 1% of all 969 deficiencies identified by the USCG between 2004 and 2013.

The level and type of enforcement actions at the federal level over the next six years will be an important factor in vessel compliance rates, especially as treatment systems come online in increasing numbers.

3.5.2 Washington Department of Fish and Wildlife

DFW regulatory management practices were discussed in detail in Section 3.3. The information here is a subset of the information previously discussed.

Inspections. Each day, DFW selects its vessels for boarding from those vessels that are not inspected that day by USCG. DFW makes this selection in conjunction with assigned vessel priority risk ratings (Section 3.3.3). On the rare occasions where DFW and USCG inspections overlap, DFW delays boarding until USCG completes inspection, unless there is a high probability the vessel will discharge non-compliant ballast water under state regulations.

DFW employs a comprehensive boarding checklist of 23 items with expanded elements for safety exemptions, biological sampling, and treatment system (in development) compliance reviews.

Enforcement. The enforcement actions of DFW between 2012 and 2015 are provided in Table 19.

Table 19 DFW enforcement actions for Puget Sound arrivals

Vessel Enforcement	2012	2013	2014	2015	TOTAL
Inspections	233	239	260	281	2,332
Warnings (All Arrivals with Noncompliant BWMR)	390	317	639	641	1,987
Notice of Correction	6	--	3	3	12
Notice of Penalty	--	--	3	--	3

In Table 19, it is important to note that a vessel does not have to be inspected to receive a warning; DFW issues warnings to all arrivals with noncompliant BWMR.

Between 2012 and 2015, DFW issued warnings to 1,987 vessels, and distributed penalties to three vessels. The level and type of enforcement actions at the state level over the next six years will be important to continue to monitor.

3.5.3 Cooperation between DFW and USCG

Both DFW and NBIC collect information on the same BWMR form. USCG BWMR data is not publicly available until weeks after the vessel arrival. As such, this does not support DFW intervention efforts for potential noncompliant discharges prior to the planned discharge event. DFW thus receives the BWMR form independently to perform real-time review, including identifying potential errors in the reported information, such as the raw discharge described in Section 3.4.1. Looking forward, there is an opportunity for inter-agency cooperation over the next six years through real-time sharing of BWMR data between USCG and DFW.

Because USCG and DFW both perform inspection roles, communication and collaboration in this area is vital. Ideally, a cooperative agreement between the two agencies would help each agency understand the inspection prioritization scheme and inspection methods utilized by the other. A shared prioritization scheme between the two agencies would ensure that any vessels inspected by USCG were inspected to standards that preserved protection of state waters, and if not, would ensure that DFW could take additional steps to ensure that was the case.

3.5.4 Summary

There are several differences to note between state and federal levels:

- **Vessel traffic and operations; ballast water management.** Washington State had more discharge than other Pacific coast states in 2015. In the same year, Washington and other Pacific coast states, except Alaska, were substantially more effective at limiting the discharge of raw ballast water, and therefore minimizing management risk, than the vast majority of states that rely solely on federal requirements and enforcement.
- **Regulatory management.** The USCG conducts more vessel inspections, but DFW finds significantly more noncompliance. DFW and USCG utilize different methods to determine which vessels to inspect. Ideally, a cooperative agreement between the two agencies would help each agency understand the inspection prioritization scheme and inspection methods utilized by the other.

3.6 Discussion

Table 20 summarizes highlights from this historical and forecast analysis.

Table 20 Summary of trends from historical and forecast data

	2008 – 2015 (Measured)	2016 – 2023 Growth (Forecast, Section 3.2.3)
Vessel Arrivals to Washington's Ports	+ 4%	+ 3%
Ballast Water Discharges	+ 33%	+ 19%
Ballast Water Discharge Volume	+ 43%	+ 27%
Compliance of Arrivals		
Noncompliant, Administrative	17% of discharge volume	---
Noncompliant, Management	1% of discharge volume	---

Several observations stem from this analysis. These observations form the foundation of the six-year Strategic Plan presented in the next section.

- **Lack of real-time federal data availability at the state level.** Vessels are required to submit the same BWMR at the state and federal levels, and the NBIC database and the DFW database agree on the data they contain. However, the available NBIC data currently does not offer enough information to allow DFW to use it instead of collecting their own parallel information. Without a close working partnership with the NBIC, DFW cannot rely on the data collected by NBIC, and needs to receive this data independently and control their own database. We recommend that DFW continue to maintain their own database on vessel arrivals and discharges. Additionally, the federal regulations do not require submittal of ballast water reports early enough to allow intervention with noncompliant vessels before they discharge raw ballast water. This is one of the key ways that DFW fulfills their mission and offers value to the state. We recommend that DFW continue to require advance submittal of BWMR forms.
- **Lack of federal inspection data availability at the state level.** Federal, USCG, inspection data is not readily available to DFW on a real-time basis. This lack of information sharing prevents DFW from understanding if high-risk vessels are going to be inspected, have been inspected, or what the findings were. We recommend that DFW continue to inspect vessels for reporting and management compliance until they can establish a close working partnership with the federal program to ensure that high-risk vessels are identified in real-time, and inspections are being performed on those vessels. When such a cooperative program is established, DFW can consider reducing its inspection program based on information sharing, and resulting compliance rates.
- **Need to track DFW administrative efforts.** DFW interacts with vessels upon submission of their BWMR to help vessels improve their compliance, and conducts outreach primarily through offering technical assistance to vessels arriving to the state. These interactions are not recorded and quantifiable in the DFW database. Better recording of this data would help DFW quantify and ultimately refine its efforts around interactions that improve vessel compliance, and thereby reduce the risk to state waters of invasive species.
- **Need to standardize DFW inspection efforts.** DFW does not currently have a protocol or the resources to inspect every P1 (high risk) vessel that arrives in Washington. Instead, they conduct inspections based on the availability of their inspectors, and select the highest risk vessel arriving at a time when an inspector is available. This allows them

to conduct a percentage of inspections on P2 and P3 vessels when no P1 vessels are present, which helps test the risk ranking protocol. It is recommended that DFW continue to apply their method of selecting highest risk vessels when inspectors are available. DFW should collect data on the risk metrics of all vessels. Current and additional data that could enhance vessel risk and vessel criteria includes:

  - Vessel type.
  - Whether or not an arrival is a first-time caller.
  - Whether or not a vessel filed a safety exemption.
  - Measure of invasive species density at source port.
  - Ballast water age.
  - Ballast water management method.
  - BWMS/AMS type.
  - BWDS and BWE biological sampling results.
  - Which vessels DFW determined not to inspect due to planned USCG inspection.

  Although DFW currently collects data on the above elements, incorporating this data into the assessment of Vessel Priority Risk Rating could more effectively use state resources to better protect state waters. These factors would help DFW refine their efforts on the most high risk arrivals.

- **Degree of uncertainty in ballast water treatment future.** Vessels have started phasing in treatment systems for managing ballast water. Although those systems that achieve USCG type-approval will have been rigorously tested and be required to include certain monitoring parameters, there is a lack of certainty on operational reliability. While treatment equipment approvals are the sole purview of USCG, DFW will need to train personnel and develop new inspection procedures. Procedures will also be needed to handle operational challenges related to treatment equipment that could result in a vessel arriving in port with raw ballast water. DFW should develop or adopt suitable methods for determining compliance of ballast water treatment systems. The inspections methods should consider a tiered approach including: certificate and ballast water record book review, equipment inspection, indicative sampling methods, and if needed numerical sampling. There should be consideration of examining possible residual toxicity in the treated effluent. The inspection regime should be adaptive, responding to experience from inspection efforts and open to cooperation with federal agencies.

Section 4 Washington Ballast Water Management Program: Six-Year Strategic Plan

4.1 Strategic Theme: Adaptation

Marine vessel ballast water management practices are expected to shift away from ballast water exchange and be completely replaced with ballast water treatment systems over the next eight to ten years. These new treatment systems use filters, chemicals, irradiation lamps, and other technologies, and will require ballast water management regulators to develop new methods of outreach and monitoring. The near future will likely be turbulent for both vessel operators and regulators, as they learn to operate and regulate new systems and standards.

In this shifting future, **adaptivity** will be a key quality of the DFW. By being flexible and responsive, the program will achieve its perennial goal of minimizing risk to state waters of NIS introduction, while minimizing gaps in protection by state and federal agencies.

This section lays out the strategic plan that will help DFW to adaptively pursue its goal of minimizing risk to state waters of NIS invasion. First, overarching objectives are reviewed in Section 4.2, and then the full program is presented in Section 4.3. All program elements are fully explained in Section 4.4.

4.2 Strategic Objectives

Over the next six years, Washington State's adaptable ballast water management program should adhere to several recommended objectives:

1. **Strengthen program**. As identified in Section 3, DFW has measurably reduced risk of NIS invasions. However, DFW needs additional resources to continue to provide protection in the face of increased regulatory demand from the introduction of treatment systems. There are several steps DFW can take to internally strengthen the program. This will include enhancing state program staffing, and improving the state data management infrastructure. These steps will increase DFW's ability to protect state waters from risk of NIS introduction.
2. **Evolve methods**. State management methods must evolve with changing technology. Notably, the adoption of treatment systems represents a change with which DFW has minimal experience. As noted in Section 3.3.4, the introduction of ballast water treatment systems presents uncertainty on equipment reliability and methods of inspection. The state must evolve its methods to adequately monitor the risk of NIS invasion from vessels that utilize treatment systems. Independent of the impact of new treatment systems, DFW should improve its tracking of its administrative efforts, and standardize inspection efforts. The state should restart ballast water exchange sampling, implement inspection training and protocols that account for treatment system effects (treatment effluents, electrical safety, chemical exposures, etc.), and research biological sampling. An incentive program for vessel owners and operators should be developed to support the information sharing and co-development of inspection and sampling methods.
3. **Increase cooperation**. Increased cooperation between the state and federal (USCG and EPA) agencies will result in more efficient and effective protection of state waters. This can result in more effective vessel inspections, clearer communications to the regulated community, and less resource demands on the state. This will require further sharing of

data and alignment/coordination of inspection routines to the extent possible, see Section 3.5.3.

The existing cooperation between Pacific states remains important in aligning methods to the extent possible, sharing lessons learned, and shared research. Regional coordination should continue, especially with Oregon along the shared waters of the Columbia River and Canada along shared waters of the Puget Sound. Outreach and engagement with the regulated community (vessel owners and operators) and their agents should continue. Efforts with the BWWG, including environmental advocates, fisheries interests, ports, should remain a core part of the state program.

Achievement of all three identified objectives will ensure DFW continues to maintain an adaptive program that adequately protects state waters despite inevitable changes in regulations, compliance, and the broader industry. The agency will be best equipped to achieve its legislative mandate of protecting state waters as a flexible and responsive agency that is ready to change, increase, or reduce its legislative efforts in a rapidly changing industry.

4.3 Strategic Plan Action Items

Over the next six years, DFW can execute specific actions to attain the above objectives. Table 21, Table 22, and Table 23 present these action items, sorted by fiscal year and all elements are considered in addition to DFW's current baseline ballast water program.

Table 21 Strategic plan action items (FY 2017 - 2019)

No.	Element	Strategic Objective	Detail
1	Increase state program staffing	Strengthen Program	• 1 FTE operations manager • 0.5 FTE data management technician
2	Improve state program data management infrastructure	Strengthen Program	• Upgrade database for effective tracking • Add automated GIS tracking for BWE compliance
3	Enhance vessel risk/selection process	Evolve Methods	• Implement a Risk Matrix for inspection selection • Apply an Adaptive Inspection rate
4	Restart ballast water exchange sampling for regulatory management	Evolve Methods	• Provides insight into management effectiveness over time, as treatment is phased in.
5	Develop training and protocols that account for treatment system installations	Evolve Methods	• Research treated ballast water biological sampling equipment and protocols • Link with Compliance Plan/Alternative strategy rules to work with 3rd party experts
6	Continue regional and national coordination	Increase Cooperation	Develop MOA/MOU with USCG and EPA for cooperative management
7	Increase outreach to / education of industry	Increase Cooperation	Outline an incentive program to encourage industry information sharing and methods development.
8	Establish performance measures and adapt authorities	Increase Cooperation	• Establish performance measures in consultation with BWWG • Adopt rules establishing a state BWD standard consistent with national standard and provide general rule updates as necessary • Propose legislation, in consultation with BWWG, to adjust revenues to meet program performance measure needs for one or both 2018 and 2019 legislative sessions.

Table 22 Strategic plan action items (FY 2019 - 2021)

No.	Element	Strategic Objective	Detail
9	Monitor state program resource needs	Strengthen Program	Add additional staff and implement new projects as needed/funded
10	Establish treatment system protocols	Evolve Methods	• Implement BWT biological sampling full time • Develop and implement BWT contingency measures
11	Increase outreach to / education of industry	Increase Cooperation	Implement the incentive program outlined in FY 2017 – 2019 (Table 21)
12	Communicate with the public	Increase Cooperation	Write interim report on strategic plan accomplishments/status of performance measures
13	Adapt authorities	Increase Cooperation	Propose legislation as needed, in consultation with BWWG, to adjust authorities and revenues to meet program performance measure needs

Table 23 Strategic plan action items (FY 2021 - 2023)

No.	Element	Strategic Objective	Detail
14	Monitor state program resource needs	Strengthen Program	Adjust staff and programs to suit changes in the needs to regulate ballast water
15	Monitor state program methods	Evolve Methods	• Continue management and implementation of unfinished plan elements • Implement ambient monitoring
16	Communicate with the public	Increase Cooperation	Evaluate and report on this strategic plan's accomplishments; and develop the next six-year plan
17	Adapt authorities	Increase Cooperation	Propose legislation as needed, in consultation with BWWG, to adjust authorities and revenues to meet program performance measure needs

The first three years of the strategic plan, 2017 through 2019 (Table 21), are foundational years where DFW is recommended to execute a majority of action items. The final three years (Table 22 and Table 23) are maintenance years, where DFW is recommended to monitor its performance and prepare for its next six-year strategic plan.

4.4 Action Item Detail

This section provides discussion related to the action items listed in Table 21, Table 22, and Table 23.

4.4.1 Increase State Program Staffing

DFW should make staffing increases (Table 21, No.1). DFW has been effective in protecting state waters for the last eight years, but this effectiveness reflects data available through 2015. Moreover, future regulatory changes mean DFW will need to increase its actions, and therefore needs resources to not only catch up with data management, but also respond to a new regulatory environment. Forecast growth in vessel traffic, forecast growth in discharge activity (Section 3.2.3), and the increasing adoption of new treatment technology (Section 3.3.4) all indicate the need to strengthen DFW with more staffing resources.

The DFW Ballast Water Program's staffing level is below a baseline threshold of full time equivalent (FTE) permanent positions required to meet the Washington State legislature's directive to minimize the risk of NIS, both currently and as projected into the next six years. A long-term vacancy in the Operations Manager position and data management staff have required shifting other staff resources to focus only on day-to-day critical functions, maintaining a low volume of noncompliant ballast water discharge at the cost of creating a six-month and growing data entry backlog and many other necessary program functions. DFW asserts that continued program vacancies will result in the state program failing to meet its objectives.

Once a baseline staffing level has been realized and program functions normalize, DFW, in consultation with Ballast Water Work Group, will need to assess whether new staffing resources are warranted based on opportunities for federal and state cooperative agreements, meeting the challenges in the transition from ballast water exchange to treatment, an need for adapting to forecast growth in vessel traffic, forecast growth in discharge activity.

Table 24 provides the current staffing structure.

Table 24 Current DFW staffing

Role	Staff	Focus
Program Manager	0.25 FTE	Policy and regulatory oversight
Vessel Inspectors	2.0 FTE	Board vessels to determine compliance
Data Management Specialist	1.0 FTE	Data management and entry

Program Manager

The Program Manager duties for DFW's Ballast Water Program are generally expected to require 0.25 of their FTE workload within the broader NIS Unit. Over the last biennium, the workload has actually ranged towards 0.75 of this position's FTE. The Program Manager's regular duties for the program are to provide higher-level functions including:

- Setting program goals and objectives, and ensuring objectives are met.
- Providing program oversight.
- Developing and monitoring of state and federal legislative policy and budget.
- Leading state rulemaking processes.
- Leading consultation with the stakeholder Ballast Water Work Group.
- Working to develop and maintain state/federal cooperative agreements.

Vessel Inspector

Given the success DFW has found in increasing compliance and identifying instances of noncompliance (Section 3.3), DFW should continue to conduct inspections at a similar level to their current inspection rates, with the addition of an adaptive management scheme (Section 4.4.2). Two inspectors are recommended for the short term of the program, with the possibility to increase or decrease this number based on future arrival and compliance numbers.

Data Management Specialist

The Data Management Specialist reviews daily BWMRs for noncompliance, supports vessel inspectors with vessel risk assessments; provides administrative outreach to vessels and agents on understanding state requirements and bring vessels into compliance, maintains the day-to-day operations of the state database, conducts data entry of BWMR information, and performs quality control actions as resources and time allows. With relief from new data entry staff below, they could add and maintain GIS capabilities.

Table 25 presents the recommended new staffing additions.

Table 25 Recommended new DFW staffing, 2017 – 2023

Role	Recommended Staff	Focus
Operations Manager	1 FTE	Day-to-day program management
Data Entry Specialist	0.5 FTE	Data entry

<u>Operations Manager</u>

The Operations Manager position has been vacant since 2011 due to reduced state funding. This position's duties are generally expected to require a full permanent 1.0 FTE. Responsibilities of this role include:

- Supervising program staff and managing the program budget.
- Supporting the Program Manager in their duties as needed.
- Managing the state database.
- Tracking and analyzing vessel activity and compliance metrics.
- Providing rapid response and back-up vessel inspection capacity.
- Writing and presenting reports on vessel compliance and program accomplishments.
- Coordinating the BWWG.
- Performing outreach duties.
- Communicating with the federal and regional agencies.

<u>Data Entry</u>

Current data management staffing does not adequately meet the needs of real-time noncompliance correction, reports for use by staff and the community, and quality control. It is recommended that DFW add additional resources to support the current Data Management Specialist position. This additional resource would aid in entry of further metrics data related to vessel risk, help DFW maintain current data input levels, and clean up/enter backlogged and pre-2008 data.

4.4.2 Improve State Program Data Management Infrastructure

DFW should improve its methods for recording data in the state database in order to easily monitor state compliance goals and program success (Table 21, No. 2). Data management helps DFW track its effectiveness through such parameters as the volume of noncompliant ballast water discharged each year, and the effectiveness of inspections in improving a vessel's compliance state (Section 3.3.3). Especially in light of the added burden of now tracking treatment systems, DFW should automate data collection in order to reduce the data management burden.

Automation could best be accomplished through alignment with the federally collected NBIC database, which would minimize data collection burden on the state program. However, the current delayed availability of NBIC data is not sufficient to allow DFW to track compliance (Section 3.4). Cooperation (such as through an MOU, detailed below in Section 4.4.6) will be necessary to efficiently combine the state and federal data collection process while still providing useful information on a timely basis.

DFW could immediately provide vessels the option to enter their BWMR form data into an online submittal interface, which would reduce burden on data management staff and perhaps offer a more efficient reporting method for vessels. Additionally, the implementation of an electronic method for recording inspection data would allow efficient collection of data during inspections, including the additional characteristics recommended to be collected for BWMS's. Entry of data into a form using a tablet or similar device that automatically populates the DFW database would reduce burden for inspectors, vessels, and data managers alike.

In addition to automation, the following improvements could be made to DFW data management practices:

- Record interactions with vessels (technical assistance, inspections, etc.) in addition to compliance changes, for analysis of program influence on compliance (Section 3.3.2).
- Improve database links between inspections/arrivals/discharges.
- Create super categories for the two compliance types (reporting and management).
- Create a database link between inspection data and vessel arrival data.
- Include the Vessel Risk Priority Rating for all arrivals.
- Record the use of BWTS, including make, model, governing mechanism, details of use, and sampling results. This data should be analyzed at regular intervals to determine whether treatment system characteristics can inform targeted outreach efforts and improved risk identification criteria.
- Utilize geographic information system (GIS) software to record ballast water uptake and discharge locations. The recommended updates to location reporting (below) will assist in accurate mapping of uptake and location data. The use of GIS software will assist implementation of the risk matrix for inspection selection recommended above.

4.4.3 Enhance Vessel Risk/Selection Process

DFW should prioritize vessels for inspection based on vessel risk assumptions, or "risk indicators" (Table 21, No. 3). As detailed in Section 3.3.3, a number of factors have historically linked with increased risk of NIS invasion, including vessel type, ballast water source, first-time arrival status, and discharge volume. These risk indicators have historically not been applied in a trackable and measurable fashion. A proposed Risk Matrix, a formulaic process for applying risk indicators to arrivals, is fully detailed in the Risk Matrix Appendix B.

These risk indicators should be monitored regularly to account for new research or ballast management methods, and to ensure that the best available risk indicators are being utilized. Additionally, the risk indicators could provide a basis for a focused inspection auditing program. Rather than broadly conduct inspections across all discharging arrivals, the state could employ an auditing program to focus inspections only on high risk vessels.

Washington State could also employ an adaptive inspection rate to modulate (increase, decrease, or maintain) inspection levels. A sample adaptive inspection rate derived from the International Organization for Standardization is provided in Appendix C.

4.4.4 Restart Ballast Water Exchange Sampling for Effectiveness Monitoring and Regulatory Management

DFW should restart sampling of exchanged ballast water to monitor effectiveness of reducing risk to state waters and for new application as a tool for regulatory management as recommended by Cordell et al (Reference 14; Appendix E) (Table 21, No. 4). Collection of exchange samples provides critical information on trends in overall effectiveness of exchange over time, identification of potential invasive species to guide ambient monitoring actions in state waters, and for vessel-specific measures of exchange effectiveness that can identify noncompliance or the need for alternative management strategies to improve effectiveness due to ballast tank design limitations.

For regulatory applications, DFW could adopt a tiered approach similar to that currently used by the USCG (Reference 10) to test for compliance with the IMO Ballast Water Performance Standard (Regulation D-2, Reference 23). Specifically, DFW should utilize the testing techniques outlined in Regulation D-2 for Level Two and Level Three inspections, and update their methods to match those used by the IMO as further developments are made. The inspection routine would include:

- **Level One - Inspection.** This is performed for all vessels identified for inspection. This is a visual inspection of the equipment, review of approval paperwork, and review of ballast water management log including maintenance and repair.
- **Level Two – Indicative Sampling.** This is for vessels that raise concerns during the Level One inspection, risk-based identification process, or otherwise at DFW discretion. This level consists of taking one or more regular ballast water tank samples using a plankton net, to assess indicative measures such as percent coastal species and densities. These measures provide a gross indication on how well the exchange process is working.
- **Level Three – Intensive Sampling/Compliance Plans and Alternative Strategies.** This is for vessels that raise concern during indicative sampling. Thresholds developed in the Cordell et al. report should be refined and utilized to identify and prioritize vessels for additional evaluation, sampling, and when it is practical and appropriate, requiring temporary compliance plans or alternative strategies under WAC 220-650-037 to improve ballast water exchange effectiveness until those vessels convert to ballast water treatment systems. The department should work with the Ballast Water Work Group to identify and recommend threshold(s) for determining when there is sufficient evidence for listing (or delisting) a vessel under WAC 220-650-035, and determine if there is a gross exceedance threshold that can establish noncompliance.

The DFW Operations Manager should remain abreast of research on exchange sampling procedures presented to IMO, and should implement any new promising or accepted testing procedures. A list of the current potential methods for indication of compliance with the IMO D-1 standard for exchange (which contains the same requirements as the Washington state and U.S. federal exchange requirements) is available in BWM.2/Circ.42, Reference 24.

4.4.5 Develop Treatment System Inspection Regime

Ballast water treatment systems represent a new knowledge area for DFW (Table 21, No. 5). Although DFW has worked with treatment systems to some extent over the last eight years, less than 1% of all ballast water has been discharged by treatment systems in the last eight years (Table 8). The oncoming widespread adoption means DFW will interact with treatment systems at a much greater level than in years past. While it is not DFW purview to inspect or approve the treatment systems, these systems will impact the inspection routines. For example, the ballast water will now be expected to meet treatment system efficacy limits that are much more stringent that ballast water exchange, some effluents will have a risk of chemical residues that inspectors should understand, and although not directly inspecting the equipment they should be aware of electrical and chemical hazard associations with the equipment.

The Operations Manager position identified in Action Item (1) (Section 4.4.1) should lead the development of new inspection protocol in the era of treatment system use, and should collaborate with the Data Management Specialist to determine how to monitor compliance. DFW should consider linking treatment system acceptance for use as a management technique with the existing Compliance Plan/Alternative strategy rules.

4.4.6 Continue Regional and National Coordination

DFW should develop a cooperative management program that minimizes gaps and overlaps in the protections provided at the state and federal levels (Table 21, No. 6). Due to a lack of real-time data availability at the federal and state levels, DFW and the USCG independently track similar parameters. Minimizing the gaps and overlaps in protection between the state and federal program will be key over the next six years, especially as new treatment technologies enter industrial use. Addressing those gaps is best accomplished through a state and federal cooperative management program.

It is possible that a robust federal inspection routine could eventually reduce, or even replace, the state inspection routine. The same could possibly apply to the state reporting requirements. However, at present the state's efforts have a clear, demonstrated effect on ballast water management practices. Such a reduction, or replacement, would require setting acceptable performance levels, sharing data to demonstrate that level of performance, and continued monitoring. Alternatively, a cooperative federal/state program could be developed. For example, real-time sharing of NBIC data (Section 4.4.2) would reduce the administrative burden on both DFW and vessel operators themselves.

A Memorandum of Agreement (MOA) would lay a solid foundation for the recommended cooperative management program. The MOA would establish a clear set of roles and responsibilities between the agencies to build upon strengths and to minimize duplication of efforts.

4.4.7 Increase Outreach to / Education of Industry

DFW should employ increased outreach and education (Table 21, No. 7; Table 21, No. 11). Outreach can be a cost-effective manner to decrease inspection needs and increase compliance rates. Outreach would be especially effective in Washington State, as most of the discharge events come from vessels that are not making their first discharge in Washington State (Section 3.2.1). Outreach has a multiplicative effect in Washington; educating one vessel would improve compliance on multiple discharge events.

Examples of measureable success resulting from outreach efforts can be found in multiple case studies:

- A study conducted in Wisconsin found that an educational outreach program on preventing the spread of nonindigenous plant species effected a measurable increase in compliance rates, and that in-person educational visits had more of an impact on compliance than mailed information (Reference 33).

- Similarly, police agencies whose officers conduct community outreach visits separately from patrol work see higher rates of community satisfaction with police work (Reference 35). Police agencies who engage community stakeholders in problem-solving processes see decreased crime and increased community satisfaction (Reference 20, 26).
- An inspection program conducted in California found that when auto shops agreed to a voluntary educational inspection for environmental compliance, the program had decreased costs and paperwork burdens associated with follow-up inspections, and the inspected shops were very satisfied with the inspection program (Reference 42). This same inspection program utilized cooperation of multiple regulatory agencies to simplify requirements for the regulated community and to minimize inspection costs for each agency.
- These cases indicate that outreach conducted during and outside of inspections are effective methods with benefits to the regulated community and the regulatory agencies, reducing burden and increasing monetary benefit.

Outreach effectiveness could be gauged by asking vessels to report whether they have received any educational materials, outreach efforts, or technical assistance from DFW in the past. This question could be easily implemented if DFW utilized an optional alternative vessel reporting method.

DFW should also explore incentivizing vessel owners and operators to comply with regulations through contingency measures. Currently, there is a minimal motivation for vessel owners and operators to exchange/treat ballast water properly before discharge. If an owner/operator has not followed the proper pre-discharge protocol, they have several options:

- Not discharge (and likely harm cargo operations).
- Discharge and be subjected to enforcement.
- Sail to the proper area to conduct a ballast water exchange.

4.4.8 Consultation with BWWG

DFW should ensure the BWWG is informed of and can provide feedback on changing DFW practices (Table 21, No. 8; Table 22, No. 13; Table 23, No. 17). The BWWG has continued to be a valuable resource to DFW since its inception. It provides the needed perspectives of many ballast water management and NIS risk stakeholders: the DFW, the USCG, states, ports, environmental advocates, fisheries, and vessel owner/operators themselves.

4.4.9 Monitor State Resource Needs; Monitor State Program Methods

DFW should continuously monitor its practices and resource needs (Table 22, No. 9; Table 23, No. 14 and 15). The Operations Manager (Section 4.4.1) will have chief responsibility for this action. At any given time, the Operations Manager should understand the general risk to Washington State waters of NIS invasion. This understanding can be achieved by reviewing available data on vessel traffic and operations, compliance, and effectiveness, such as the analyses presented in Section 3. Increased risk would indicate the need to adjust practices or increase resources. Communications with the BWWG through regular meetings, and the general public through reports and eventually a new strategic plan will provide the opportunity to perform clear assessments of state practices and resource needs.

In the FY 2021-23 biennium, DFW should begin implementing ambient monitoring. Ambient monitoring will provide a metric for assessing how widespread and established treatment system use is becoming. Ambient monitoring will provide information on existing invasions to monitor and prevent species spread and to allow evaluation of regulatory program effectiveness. A recent study of nonindigenous species populations provides the baseline for future monitoring activity (Reference 15). Periodic reassessment of the status of nonindigenous populations is recommended in the future. Assessment of species introductions at the organism DNA level is also recommended, to create a more robust baseline of introduced species traceable to their sources.

4.4.10 Establish Treatment System Protocols

Depending on how treatment system protocols have developed (see Action Item 5), DFW may need to develop an inspection and sampling routine focused on ballast water treatment systems (Table 22, No. 10). Each newly adopted ballast water treatment system will have undergone rigorous type-approval testing under international guidelines and gained the approval of the administration of the marine vessel where the system is installed. However, there remains risk as to whether the systems will be installed, commissioned, and operated in accordance with the design intention. A rigorous inspection regime will identify such short falls, especially as installation routines do not currently require a biological sampling and assessment component. This inspection regime should consider several features:

- **Safety.** Special care should be paid to the safety of those near the system, and the environment. Treatment systems may contain technologies that threaten human welfare or the environment. Inspectors must be trained to protect the safety of themselves and those around them.
- **Treatment requirement.** In order to inspect ballast water treatment systems, DFW should consider new regulations that require their use.
- **Performance standard.** DFW regulations differ from federal and regional requirements on treatment system phase-in period and discharges standards. Washington does not have any specific requirements for the performance of BWMS used to manage ballast water discharged in Washington. Without this requirement, DFW is unable to inspect vessels for compliant discharge of water managed by a treatment system.
- **Compliance monitoring.** Treatment system sampling will inform not only vessel compliance and inspection risk criteria, but also whether the state program is effectively protecting state waters as management by treatment system becomes standard. This monitoring will also indicate the species and quantities of organisms that may still be discharged into state waters after ballast water treatment.

To adapt to widespread treatment system adoption, it may at some point become necessary for DFW to add a new program position for an expert in treatment systems. Their expertise would span the use and technology behind treatment systems, and they would be responsible for ensuring DFW develops sufficient protocols for monitoring treatment system use from human safety, environmental safety, and NIS risk perspectives. They would also serve as a liaison with third party experts, such as marine engineers.

The IMO uses the term “contingency measures” when considering how to handle vessels that arrive with raw ballast water. DFW should also consider such contingency measures. DFW should support the continued development of contingency measures as an alternative for owner/operators who have not followed proper pre-discharge protocol. One possible contingency measure is having vessels pump ballast water to shore-based facilities through a ballast system connection located on the main deck of the vessel. However, not many vessels are outfitted with such a connection, the shore-based infrastructure to receive the ballast water does not yet exist, and there are challenges to implementing this option. Another method is to send working crews aboard the vessels themselves using portable equipment to treat the ballast water in-situ. The cost of a contingency program provides an alternative to the three options outlined above, and could incentivize owners and operators to install and operate treatment systems, which would ultimately protect the environment better than exchange. Development efforts on this approach are ongoing. The DFW Operations Manager should remain abreast of developments in this field and consider acquiring portable equipment for emergency ballast treatment if it becomes available.

4.4.11 Communicate with the Public

DFW must continue to communicate with the public about its efforts and the need for protecting state waters (Table 21, No. 12; Table 23, No. 16). An increase in the general public's understanding of the risks facing the waters around their homes and the challenges involved with mitigating those risks can lend support to DFW in the fight against NIS invasion. The education provided through DFW reports and media will help shipping companies and the state understand the value of the significant efforts required to prevent NIS invasion.

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Appendix A Glossary of Terms

AMS: Alternative management system, a ballast water management system (BWMS) that has been approved by a foreign administration pursuant to the standards set forth in the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004, and is deemed acceptable by the USCG.

BWDS: Ballast Water Discharge Standard.

BWE: Ballast Water Exchange.

BWMS: Ballast water management system (essentially synonymous with BWTS).

BWMR: Ballast water management report (formerly Ballast Water Reporting Form, BWRF).

BWRF: Ballast water reporting form; this term is superseded by BWMR.

BWTS: Ballast water treatment system (essentially synonymous with BWMS).

CFR: Code of Federal Regulations.

DFW: Washington State Department of Fish and Wildlife.

IMO: International Maritime Organization.

NAWC: North American West Coast.

NBIC: National Ballast Information Clearinghouse.

USCG: United States Coast Guard.

WAC: Washington Administrative Code

Ballast water means any water and matter taken on board a vessel to control or maintain trim, draft, stability, or stresses of the vessel, without regard to the manner in which it is carried. This includes matter suspended in such water per USCG regulations under 33 CFR § 151.1504 (from WAC 220-650-020(3)).

Ballast water management method means a system used by an applicable vessel to comply with applicable ballast water management regulations. The following are acceptable methods for compliance with Washington State ballast water management requirements:

1. Conduct ballast water exchange (BWE), meaning replace the water in a ballast tank using either flow through exchange, empty/refill exchange, or other exchange methodology recommended or required under 33 CFR § 151.2035. Vessels traveling within the common waters area (see below) who have already managed their ballast water or are only carrying water from within the common waters area are exempt from conducting exchange.
   The Washington common waters area consists of the waters of Washington state, the Oregon portions of the Columbia River system, and the internal waters of British Columbia south of latitude fifty degrees north, including the waters of the Straits of Georgia and Juan de Fuca.
2. Use an exchange alternative, meaning manage ballast water using an alternative that meets or exceeds the standards provided under Regulation D-2 of the International Convention for the Control and Management of Ships' Ballast Water and Sediment as signed on February 13, 2004 (Reference 23).
3. Do not discharge, meaning that a vessel does not release any water from their ballast tanks while within waters of the state.

The following are acceptable methods for complying with USCG ballast water management methods:

1. Use an approved Ballast Water Management System or BWMS, meaning a system for treating ballast water that has been approved by the Coast Guard under 46 CFR § 162.
2. Use an Alternative Management System or AMS, see above.
3. Conduct ballast water exchange, meaning to replace the water in a ballast tank using flow-through exchange or empty/refill exchange, unless the vessel is required to employ an approved BWMS per the schedule found in 33 CFR § 151.2035(b).
   a. Flow-through exchange consists of pumping ocean water into the bottom of the ballast tank until the tank has overflowed three full tank volumes of water.
   b. Empty/refill exchange is exchange where the ballast tanks are drained and refilled with ocean water.
4. Use another management means, including using only water from a U.S. public water system (PWS), not discharging ballast water into waters of the United States, or discharging to a facility onshore or to another vessel for purposes of treatment.

Biofouling means the community of marine organisms that adheres to wetted surfaces of vessels including sessile species that attach directly to surfaces and mobile species that can inhabit a matrix of sessile biofouling (Reference 16).

DFW Ballast Management Regions: DFW breaks vessel arrivals data into three regions. The Puget Sound ballast water management region consists of all ports east of the mouth of the Straits of Juan de Fuca. The Columbia River management region consists of all ports east of the mouth of the Columbia River. The Coastal management region includes all calls along the west coast of Washington, mainly consisting of calls to the ports in Grays Harbor.

Nonindigenous species means any species or other viable biological material that enters an ecosystem beyond its natural range. This also includes the seeds, eggs, spores, and other biological material capable of reproducing that species, or any other viable biological material that enters an ecosystem beyond its natural range (WAC 220-650-020(16)).

Vessel Types: For the purpose of Washington State ballast water regulations, **Vessel** means a ship, boat, barge, or other floating craft of three hundred gross tons or more, United States and foreign, carrying, or capable of carrying, ballast water into the coastal waters of the state after operating outside of the coastal waters of the state, except those vessels described in RCW 77.120.020 (WAC 220-650-020(24)). For the purpose of federal (USCG) ballast water regulations, applicable vessels are all non-recreational vessels, U.S. and foreign, that are equipped with ballast tanks and operate in the waters of the United States, except those vessels described in 33 CFR §151.2015 or 36 CFR §151.2020.

The following vessels are some of the common callers in Washington State:

Bulk Carriers: Bulk carriers (bulkers) are vessels that transport bulk dry cargoes such as grains and other agricultural products, forest products, steel products, minerals and ores, fertilizers, and cement.

Figure 34 Bulker image from (http://gcaptain.com/shipping-rates-rising-threefold/)

ATB (Articulated Tug and Barge): ATBs consist of a barge and a large tug specially designed to operate, for practical purposes, as one vessel. The design offers better handling and efficiency than a tug and barge, with similar crew required to operate. Tank barges are most common, but other barge types are also operated as ATBs. For all types, the barge features a reinforced “notch” in the stern, shaped to accommodate the bow of the tug. This enables the tug to propel and maneuver the barge in a pushing configuration from this position.

Figure 35 ATB image from (http://www.crowley.com/About-Us/EcoStewardship/Technology/Crowley-is-building-and-operating-the-industry-s-newest-and-most-environmentally-friendly-Articulated-Tug-Barges-ATBs)

The ATB features an articulated coupling between the tug and barge. This affords the tug some freedom of movement within the notch, as well as the ability to detach from the barge relatively quickly and operate independently as a standard towing vessel. ATBs can carry a variety of liquid cargoes. Although the USCG lumps this vessel type with tankers, Washington State considers them a separate vessel type based on vessel information in the USCG Port State Information Exchange.

Tankers: Tankers are purpose-built for seaborne transportation of liquids or gases in bulk. This class of vessels includes crude oil and refined (petroleum) product carriers, chemical carriers, and liquefied gas carriers (e.g. LNG ships), among others. Tankers tend to discharge ballast water in large volumes.

Figure 36 Tanker image from (http://worldmaritimenews.com/wp-content/uploads/2012/09/South-Korea-DSME-Holds-Naming-Ceremony-for-New-SCF-Tanker.jpg)

Containerships: Containerships transport a wide variety of cargo types in standardized 20' and 40' marine shipping containers. These vessels travel between Asia and the US, and discharge ballast water irregularly, usually in small amounts.

Figure 37 Containership image from (http://maritime-connector.com/ship/cosco-france-9516416/)

Appendix B Risk Matrix for Inspection Selection

Risk Indicators

Vessels should be prioritized for inspection based on the following assumptions about vessel risk, applied in a formulaic process as described in Section 4:

A. A vessel that has not had a recent inspection is at higher risk for noncompliance. Allowing vessels to undergo inspections by independent inspectors instead of USCG or DFW reduces burden on agencies to conduct inspections and on vessels to undergo inspections. There is precedent for this between the USCG and class societies, as the USCG holds MOUs with various societies allowing them to independently inspect vessels for compliance with USCG regulations.

B. Vessels with history of noncompliance are a higher risk for repeat noncompliance.

C. Vessels that have not been to Washington before are higher risk of noncompliant reporting or discharge as they are less likely to be familiar and in compliance with state regulations.

D. A vessel claiming a safety exemption is intending to discharge untreated ballast water and therefore is a high risk to state waters.

E. Ballast water that comes from a port with similar environmental characteristics to the intended discharge location is a higher risk to state waters, as the entrained species are more likely to be able to survive and establish in the discharge location. The IMO suggests that environmental matching criteria be applied for vessels traveling between different marine ecoregions, and a species-specific approach be used for vessels remaining within one marine ecoregion (Reference 54). Marine ecoregions can be determined using the Marine Ecoregions of the World database.

   - For vessels that are coming from other marine ecoregions, environmental similarity should be determined using the method described by Ware et al. (Reference 18) to compare source environment and discharge environment seawater temperature and salinity.
   - For vessels that are coming from the same marine ecoregion, the NEMESIS nonindigenous species database should be use to provide a base-level assessment of the number of introduced species present in the source environment (Reference 32). High/medium/low categories should be developed for levels of introduced species from common source ports. It should be noted that this method will supersede the exemption of vessels coming from within the common water zone, which was noted by University of Washington researchers as unlikely to represent a "safe" zone of ballast source water (Reference 15).

F. Invasive species richness in BW source environment

   - Using Nature Conservancy database of global marine invasive species, and counting species only from the "ballast water and sediments" pathway

G. A vessel intending to discharge at a port that routinely sees high discharge volumes is a higher priority for inspection because a port that repeatedly receives nonindigenous species introductions is more likely to become invaded.

H. A vessel intending to discharge a high volume of ballast water is a higher risk to the state because higher discharges bring higher risks of species introductions, and of multiple organisms being discharged simultaneously, again providing cumulative introductions which are more likely to lead to species establishment.

I. Repeated discharges from the same source port are more likely to bring repeated introductions of a given nonindigenous species, and are therefore a higher risk to the state.

J. A vessel intending to discharge that has only recently taken up ballast water is a higher priority for inspections because the entrained organisms have not had time to die in ballast water. University of Washington researchers found that older ballast water contained lower populations of nonindigenous species (Reference 15).

K. Ballast water exchange is not as effective as ballast water treatment. A treatment system that has been type-approved by the USCG has been held to a more rigorous standard than a system type-approved by a foreign administration and accepted for use by the IMO (Reference 22).

L. An arriving vessel that is going to be inspected by a USCG or independent inspector does not need to also be inspected by DFW.

<u>Risk Matrix</u>

Vessel inspection profile criteria should be applied by a prescribed, formulaic process when determining a vessel's risk rating and inspection priority. It is recommended that a matrix be developed to guide the process of assigning vessel risk criteria. A proposed matrix is included below.

	Risk Area	**High Risk (3)**	**Med Risk (2)**	**Low Risk (1)**	**Very Low Risk (0)**
A	Last inspection (by DFW, USCG, or independent inspector)		Never	>365 days ago	<365 days ago
B	Previous noncompliance		Management noncompliance in past 24 months	Reporting noncompliance in past 24 months	No past noncompliance
C	First-time arrival to state	Yes			No
D	Safety exemption claimed for this arrival	Yes			No
E	Similarity of BW source environment				
	Sourced from different Marine Ecoregion	Similar temp and salinity to source environment (Exact value range TBD, use method from Reference 18)	Somewhat similar temp and salinity to source environment (Exact value range TBD, use method from Reference 18)	Different temp and salinity from source environment (Exact value range TBD, use method from Reference 18)	
	Source and discharge from same Marine Ecoregion	TBD # of species in source port (use NEMESIS)	TBD # of species in source port (use NEMESIS)	TBD # of species in source port (use NEMESIS)	

	Risk Area	High Risk (3)	Med Risk (2)	Low Risk (1)	Very Low Risk (0)
F	Invasive species richness in BW source environment	≥20 species	10 - 19 species	<10 species	
G	At-risk intended discharge port		Kalama/ Longview	Cherry Point /Seattle /Vancouver	Other ports
H	Intended discharge volume	>20,000 m^3	10,000 - 20,000 m^3	<10,000 m^3	
I	Cumulative discharge volume		≥3 prior discharges same source/discharge port in past 724 months	1 – 2 prior discharges same source/discharge port in past 24 months	No prior discharges same source /discharge port in past 24 months
J	Time since BW uptake		<5 days	6-10 days	11+ days
K	Management type	Exchange	Foreign-approved system	USCG type-approved system	
L	Planned inspection by USCG or independent inspector	If yes, DFW should not inspect			
Other information to be noted:		- Manufacturer/model of BWTS - Approval method for BWTS - Treatment mechanism - Sample results, if sampled			

It is recommended that DFW discontinue their vessel risk ranking system, record each matrix value for every vessel arrival to Washington, and choose vessels for inspection based on those highest on the risk matrix when an inspector is available.

In addition to selecting vessels for inspection using a formulaic process, a plan should be developed for regular re-examination of the inspection selection process, to account for new research or ballast management methods, and insure that the best available risk indicators are being utilized. Ongoing comparison of DFW ballast water sampling data results with the state's prioritization criteria should be conducted to verify that the criteria can accurately predict vessels with a higher risk for introducing nonindigenous species.

Appendix C Adaptive Inspection Rate

Generally, vessel arrivals, discharge frequency, and discharge volumes are predicted to moderately increase. However, by utilizing a risk-based approach, these increases do not necessarily require an increase in vessel inspections and other DFW resource demands. The long-term goal of the DFW ballast water management program is to adapt inspection rates to meet the current compliance rates, and to reduce inspections to zero through shared inspection responsibility and increased vessel compliance rates. This section proposes an adaptive inspection methodology to apply to Washington State vessel arrivals in the coming years.

Background

As discussed in Section 3.3.3, DFW currently inspects about 6% of vessel arrivals to Washington (233 – 281 inspections per year in the last four years). Under those inspection levels, vessel compliance has ranged from 83 – 93% in the last four years according to DFW data collection. However, the shift from ballast water exchange to ballast water treatment system use is likely to significantly shift compliance rates. Shifting of requirements and transition to new technology does not happen smoothly. The adoption of new technology is subject to logistic growth, with a portion of the population resisting change and lagging behind the majority. Additionally, studies of BWTS approval methods and early implementation show that systems have been held to ranging levels of standards and monitoring for performance or compliance with discharge standards is inconsistent. In the face of uncertainty about the adoption compliance and functional compliance of BWTS, continued inspection will be key to protecting state waters for the near future.

Literature Review of Inspection Standards

Examples of inspection standards can be found in the literature. Two main standards are reviewed here: the International Organization for Standardization (ISO), and the U.S. Military.

It should be noted that both the ISO standard and the U.S. Military standard recommend selecting elements for the sample with a random method. Rather than employ a random method, DFW has selected vessels for inspection based on risk to state waters, and coordination of inspection efforts with USCG. The use of a risk-based method for ballast water management regulations is recommended in the literature, and increases efficiency of the program (Reference 54).

International Organization for Standardization

ISO International Standard 2859-1 recommends sampling procedures for inspection by certain population attributes (Reference 50). This standard focuses on the Acceptable Quality Level (AQL), which corresponds to the maximum number of nonconforming elements deemed acceptable by the responsible authority. The standard presents schemes for determining under what circumstances inspection rates should move from a normal level to an increased, "tightened" level with increased inspection rates, or from a normal level to a reduced level with lower inspection rates. The standard also presents a number of sampling schemes for the responsible authority to choose from, such as a single sampling scheme, or a scheme for re-sampling the population after defects are found.

The Single Sampling Plan presented in ISO 2859-1 could be applied to the number of arrivals to Washington State each year. Under this Single Sampling Plan, at the sample size of 200 vessels, DFW can choose from a variety of acceptable quality levels, ranging from 6.5 defects per 100 units at the most stringent level to 650 defects per 100 units (assuming that a single unit can have more than one defect).

U.S. Military

MIL-STD-1916 was developed to aid the federal government in selecting acceptable product, by helping contractors to employ a satisfactory process control scheme for determining which goods are acceptable to offer to the Department of Defense (DOD). Rather than employ the AQL-based strategy described above, the standard was intended to institute a prevention-based strategy. The standard focuses not just on criteria for accepting or rejecting lots, but encourages contractors to modify their entire process when an unacceptable number of defects are found.

ISO Method

Washington typically sees around 4,000 arrivals per year, or 1,000 arrivals per quarter. The "Single Sampling Method" described in ISO International Standard 2859-1 (Reference 50) can be applied to this quarterly arrival rate (Table 26).

Table 26 ISO 2859-1 Single Sampling Plan application to Washington State vessel inspection

Inspection Scenario	Circumstances*	Reversion Circumstances*	Inspection Level (arrivals/quarter)	Maximum Accepted Noncompliance Instances	
				Reporting (AQL 15)	Management (AQL 1.0)
Normal	Recommended	---	80	21	2
Tightened	2 fails (out of 5)	5 passes	125	21	3
Reduced	10 passes	1 fail	50	14	1

*Apply to consecutive quarters

The ISO method focuses on tracking defects, such as the defects that may occur in a product produced on a manufacturing line. To apply the ISO method to Washington State, a defect is assumed to be a single noncompliance instance recorded for a BWMR (Section 3.3.2). Noncompliance instances are recorded by DFW using the letters C through K to denote paperwork noncompliance, and letters L through Q to denote management noncompliance. A single vessel can have multiple noncompliance instances for each arrival.

Under the ISO method, a lot size of 1,000 corresponds to a commonly used inspection level of 80 elements per lot, or 80 vessels per quarter. DFW alone currently inspects an average of 68 vessels per quarter. To adhere to the ISO method, it is recommended that DFW inspect at least 80 vessels each quarter.

The ISO method includes a protocol for adapting the inspection level. This protocol focuses on recording whether consecutive quarters "pass" or "fail." A quarter passes when the number of noncompliance instances do not exceed the values in Table 26. This inspection regime can be further tightened or reduced under the following circumstances:

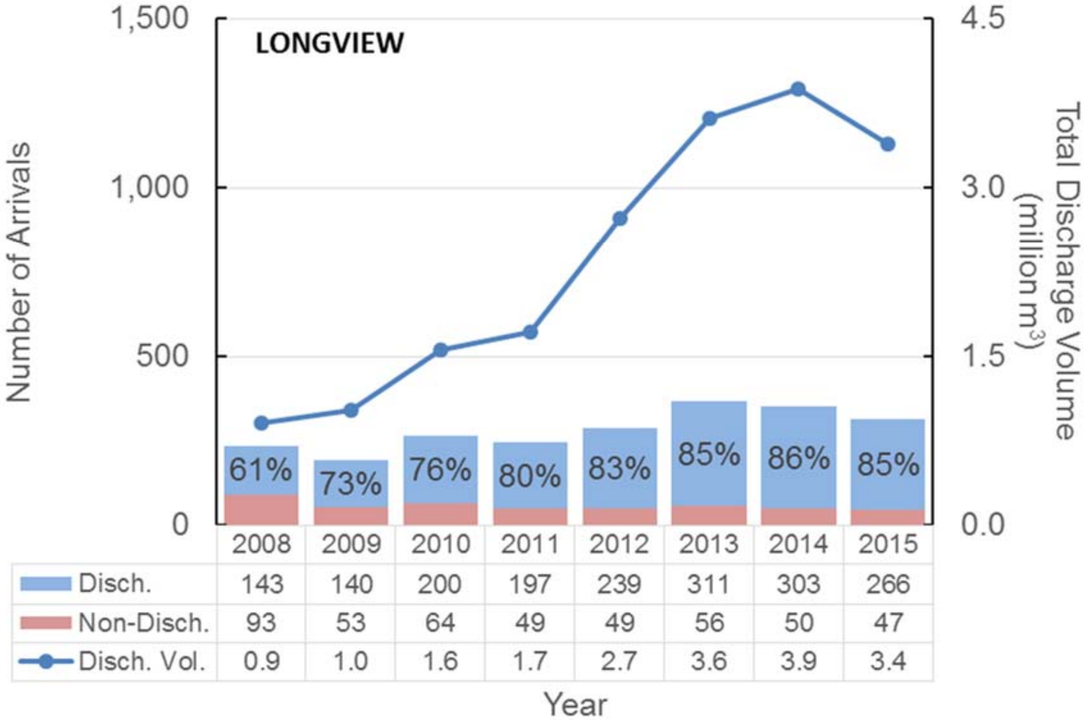
- **Tightened.** If two out of five consecutive quarters fail, vessel arrivals must be inspected more stringently. Thus, more arrivals should be inspected (125 arrivals). The inspection level can revert to Normal after five consecutive quarters pass.
- **Reduced.** If under the Normal regime ten consecutive quarters pass, vessel arrivals may be inspected less stringently. Thus, few arrivals can be inspected (50 arrivals). The inspection level should revert to Normal after a single quarter fails.

This recommended inspection regime will become increasingly difficult to adhere to as new technologies become adopted by vessel owners and operators. As new treatment-system-specific inspection methods will require new skills, tools, and practices, inspection resources may need to be increased temporarily to meet these goals.

Appendix D Detailed Analysis

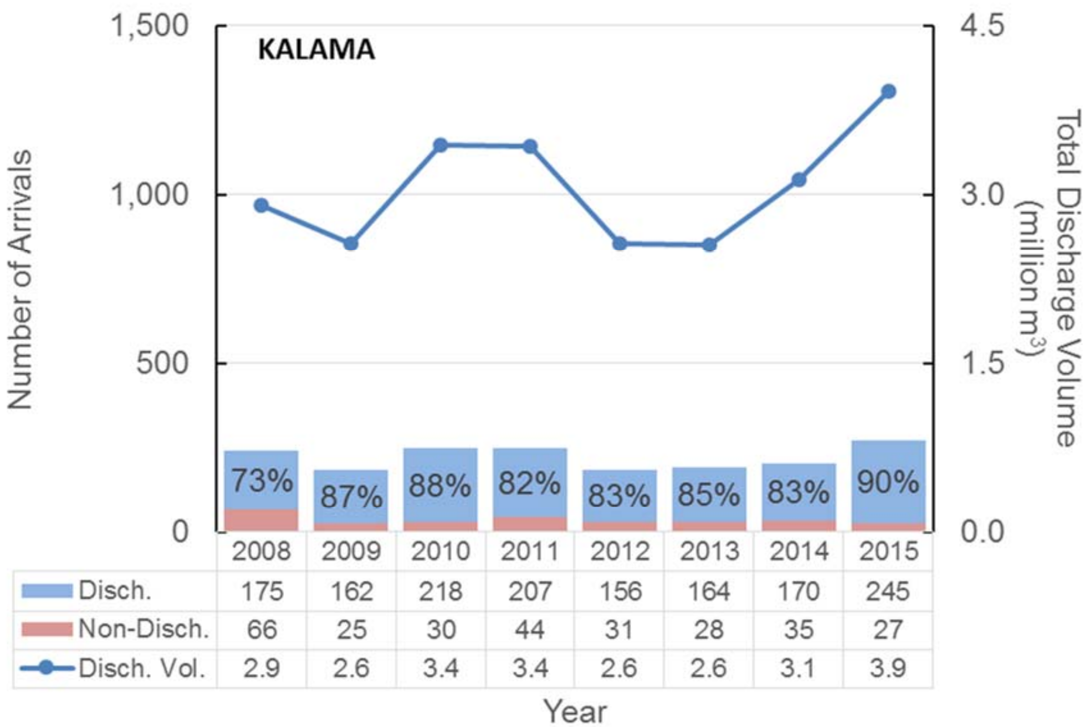
Port of Call

The discharge activity at these top four ports is described in Figure 38, Figure 39, Figure 40, and Figure 41.



	2008	2009	2010	2011	2012	2013	2014	2015
Disch.	143	140	200	197	239	311	303	266
Non-Disch.	93	53	64	49	49	56	50	47
Disch. Vol.	0.9	1.0	1.6	1.7	2.7	3.6	3.9	3.4

Figure 38 Non-discharging arrivals, discharging arrivals, and total discharge volume at Longview



	2008	2009	2010	2011	2012	2013	2014	2015
Disch.	175	162	218	207	156	164	170	245
Non-Disch.	66	25	30	44	31	28	35	27
Disch. Vol.	2.9	2.6	3.4	3.4	2.6	2.6	3.1	3.9

Figure 39 Non-discharging arrivals, discharging arrivals, and total discharge volume at Kalama

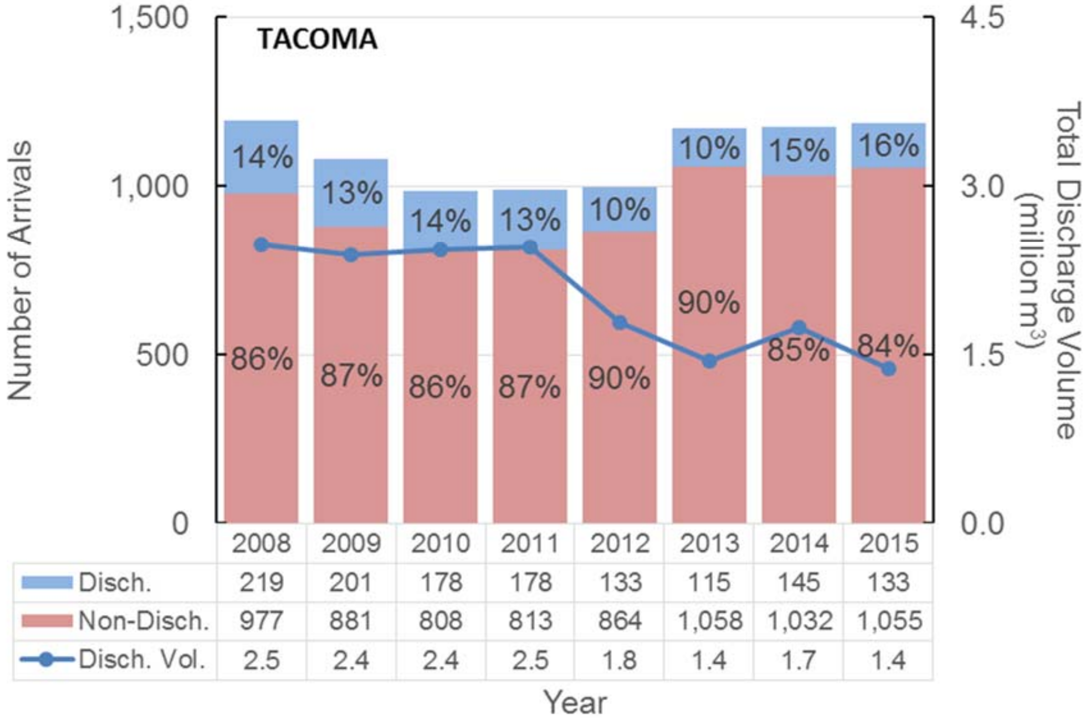


Figure 40 Non-discharging arrivals, discharging arrivals, and total discharge volume at Tacoma

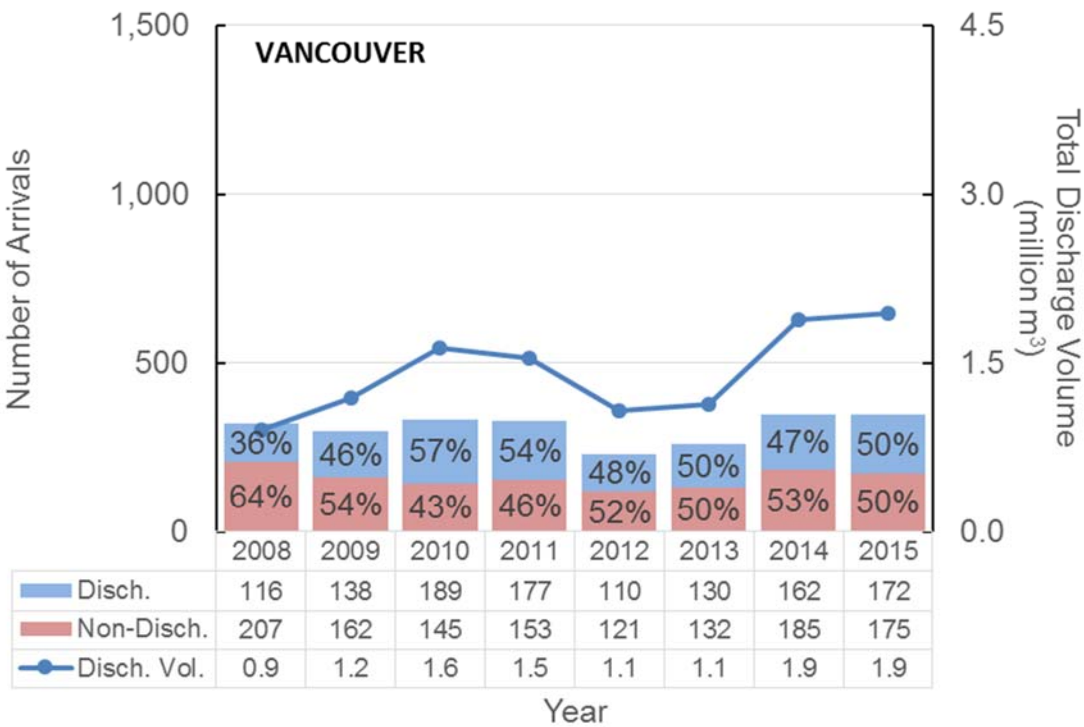
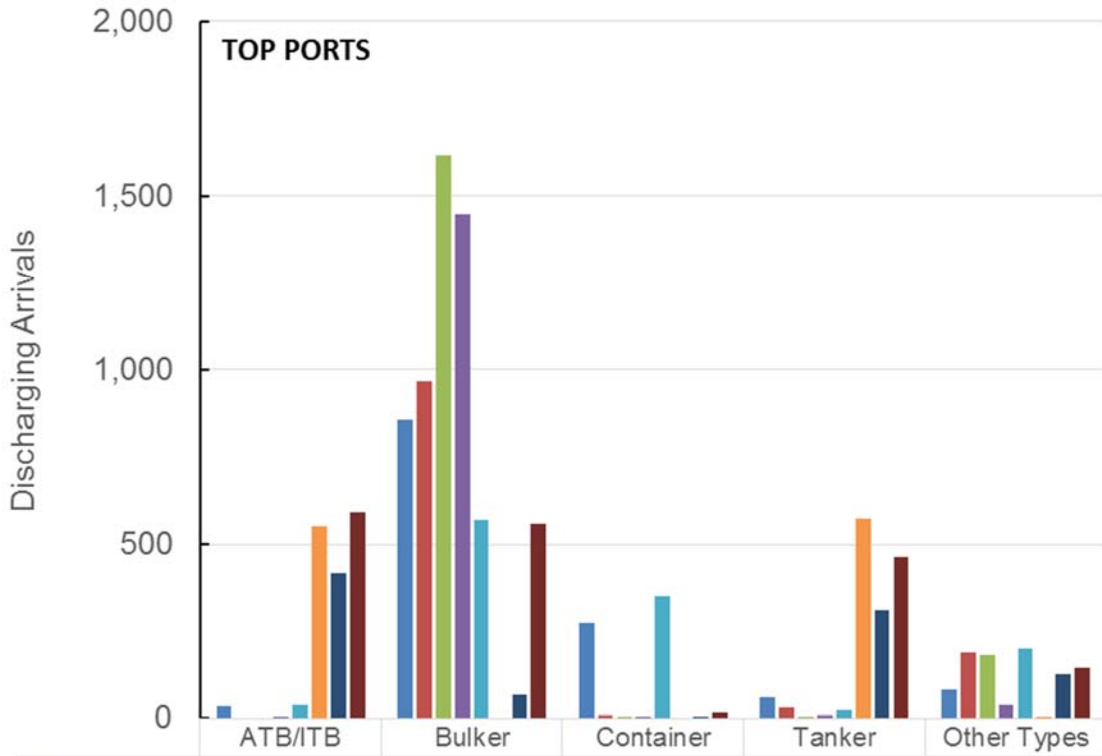


Figure 41 Non-discharging arrivals, discharging arrivals, and total discharge volume at Vancouver

Several trends are evident from the above figures. Each port in the set experienced between 1,100 and 1,800 discharging arrivals over the eight-year period. Although Tacoma has experienced the most arrivals of the set (over 1,000 arrivals annually), only 10-16% of those arrivals also discharged ballast water. Kalama and Longview have experienced the highest cumulative discharge volume (dark blue line) over the eight-year period, at 25M m^3 and 19M m^3 respectively.

Port of Call by Vessel Type

The ports of call of discharging vessels can be further analyzed in combination with vessel type. Figure 42 depicts the distribution of vessel types that call at the top four ports before discharging, and Table 27 summarizes the primary vessel types across major ports.



	ATB/ITB	Bulker	Container	Tanker	Other Types
Tacoma	33	855	272	60	82
Vancouver		967	9	29	189
Longview		1,616	2	2	179
Kalama	1	1,448	4	7	37
Seattle	38	570	351	24	199
Cherry Point	551			574	1
Anacortes	414	66	1	308	125
Other Ports	591	558	15	462	142

Vessel Type

Figure 42 Discharging arrivals by port of call and vessel type, 2008 – 2015

Table 27 Primary vessel types of discharging arrivals by port, 2008-2015

Arrival Port	Primary Vessel Types of Discharging Arrivals (2008-2015)
Seattle, WA	Bulker, Containership
Tacoma, WA	Bulker, Containership
Vancouver, WA	Bulker, General Cargo
Longview, WA	Bulker

Arrival Port	Primary Vessel Types of Discharging Arrivals (2008-2015)
Kalama, WA	Bulker
Anacortes/March Point, WA	Tanker, ATB, Barge
Cherry Point, WA	Tanker, ATB

As evidenced in the above figure and table, bulkers constitute a large portion of discharging arrivals across most of the ports. Containerships represent a very small portion of discharging arrivals at the ports. Although only a very small portion of the discharging arrivals at Longview, Kalama, Tacoma, and Vancouver are ATBs or tankers, those two vessel types constitute a large portion of the discharging arrivals at other ports.

<u>Port of Call – Forecast</u>

The trends in discharging arrivals at top Washington ports are summarized in Table 28, and Figure 43 through Figure 46. Forecasting trendlines were not calulcated for this data, but general trends based on visual observation of the data are noted in Table 28.

Table 28 Trend in number of discharging arrivals by vessel type at top Washington ports, based on 2008-2015 data

Arrival Port	Trend in Number of Discharging Arrivals by Vessel Type			
	Bulker	Tanker	ATB	Container
Seattle, WA	↓	-	-	↓
Tacoma, WA	↓	-	-	↑
Vancouver, WA	↑	-	-	-
Longview, WA	↑	-	-	-
Kalama, WA	↑	-	-	-
Anacortes/March Point, WA	-	Level	↑	-
Cherry Point, WA	-	Level	↑	-

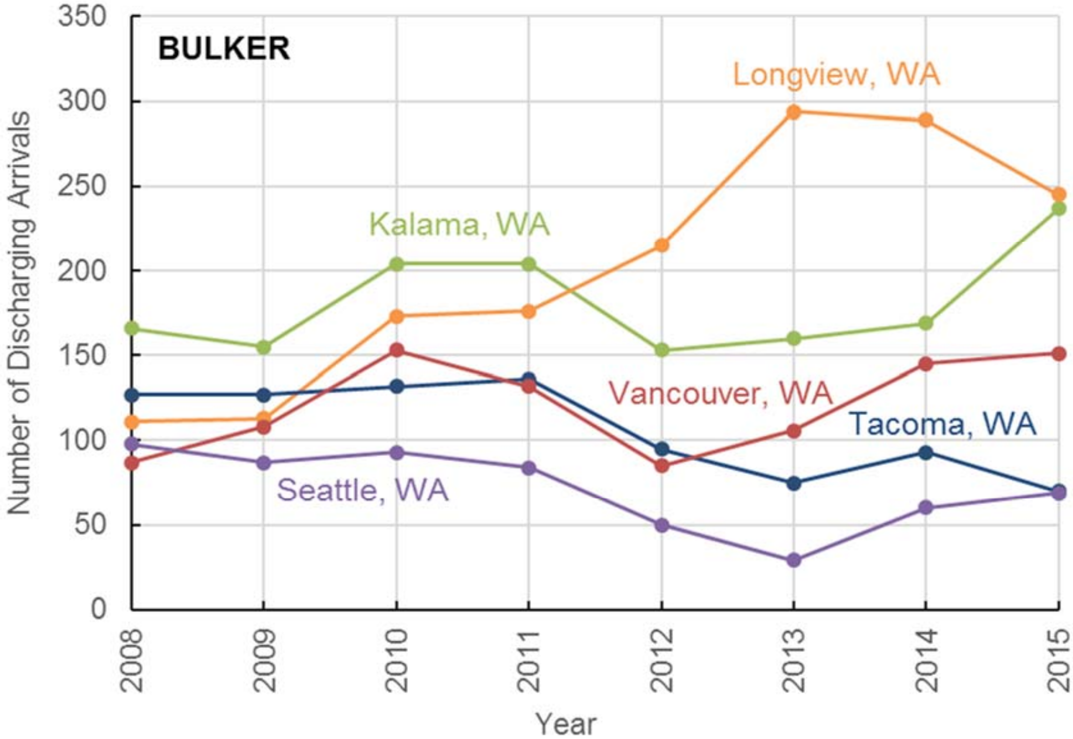


Figure 43 Discharging arrivals by port, bulkers

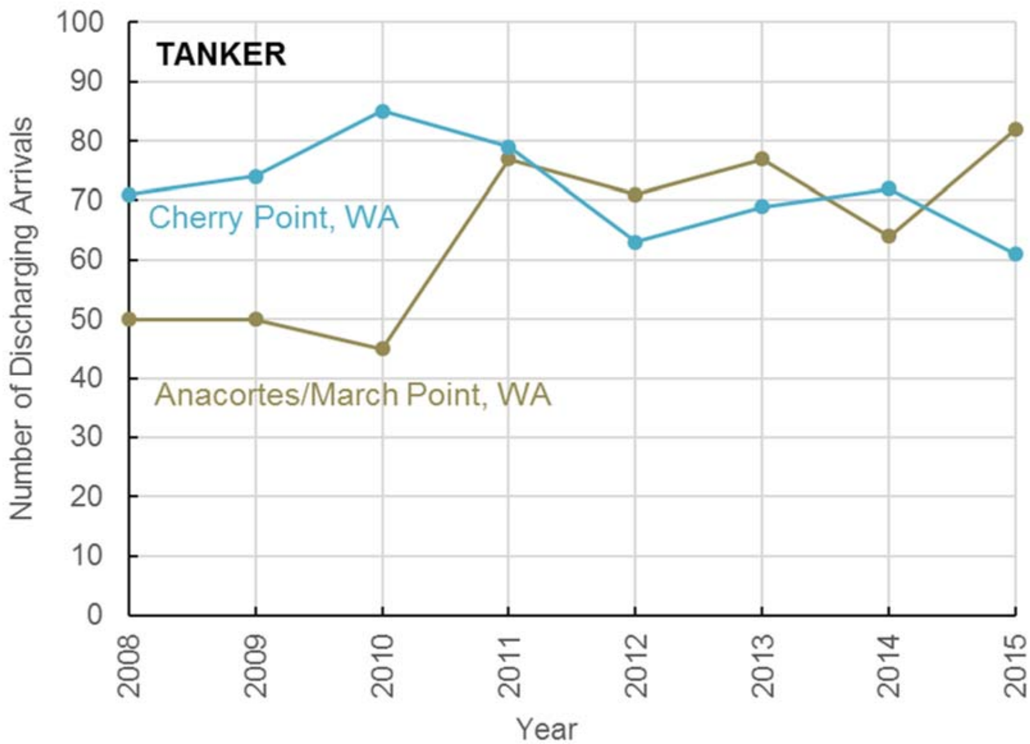


Figure 44 Discharging arrivals by port, tankers

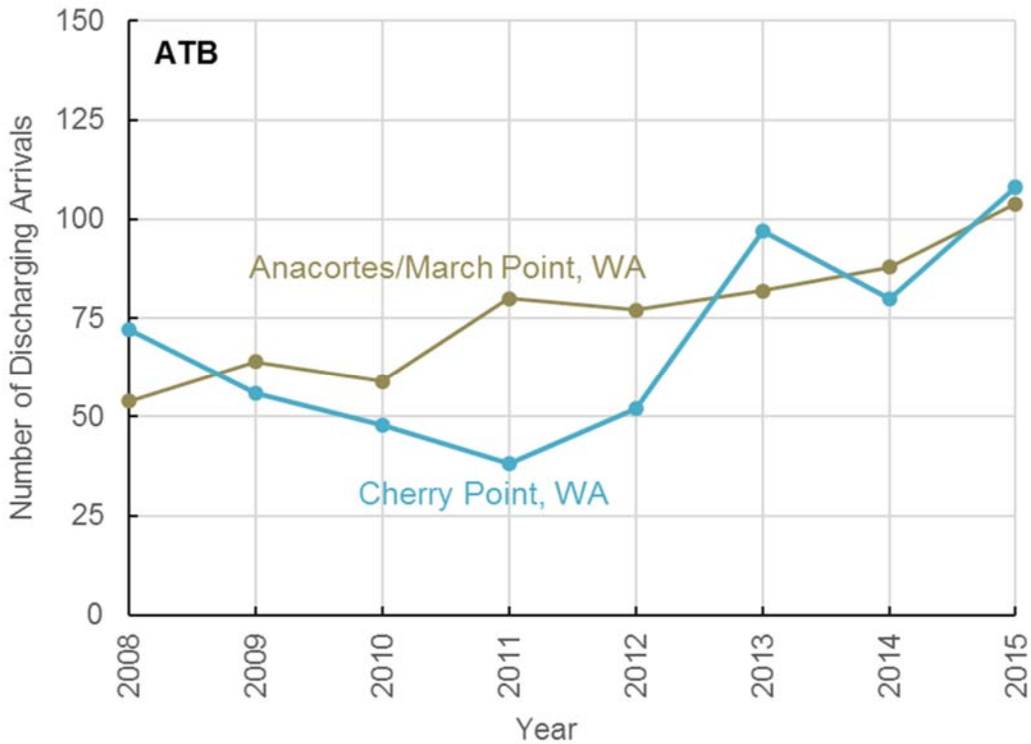


Figure 45 Discharging arrivals by port, ATB

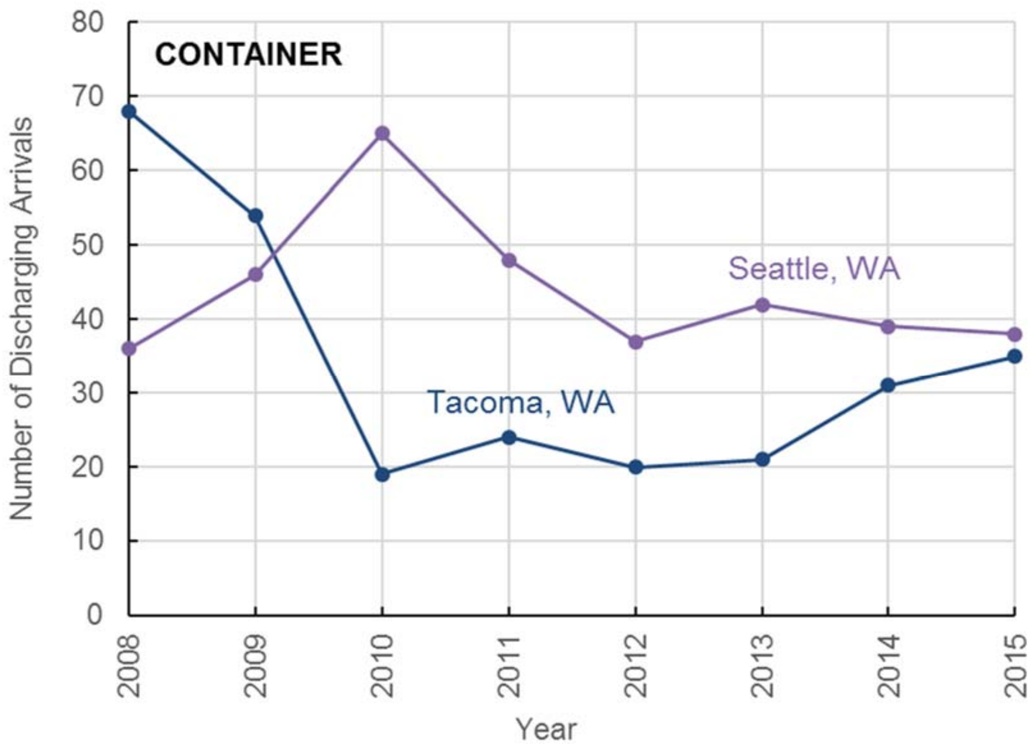


Figure 46 Discharging arrivals by port, container

Ballast Water Management Practices by Vessel Type

Figure 47 through Figure 51 break down ballast water management practices by vessel type across the most common vessel types to discharge in Washington: bulkers, ATBs, tankers, and containerships.

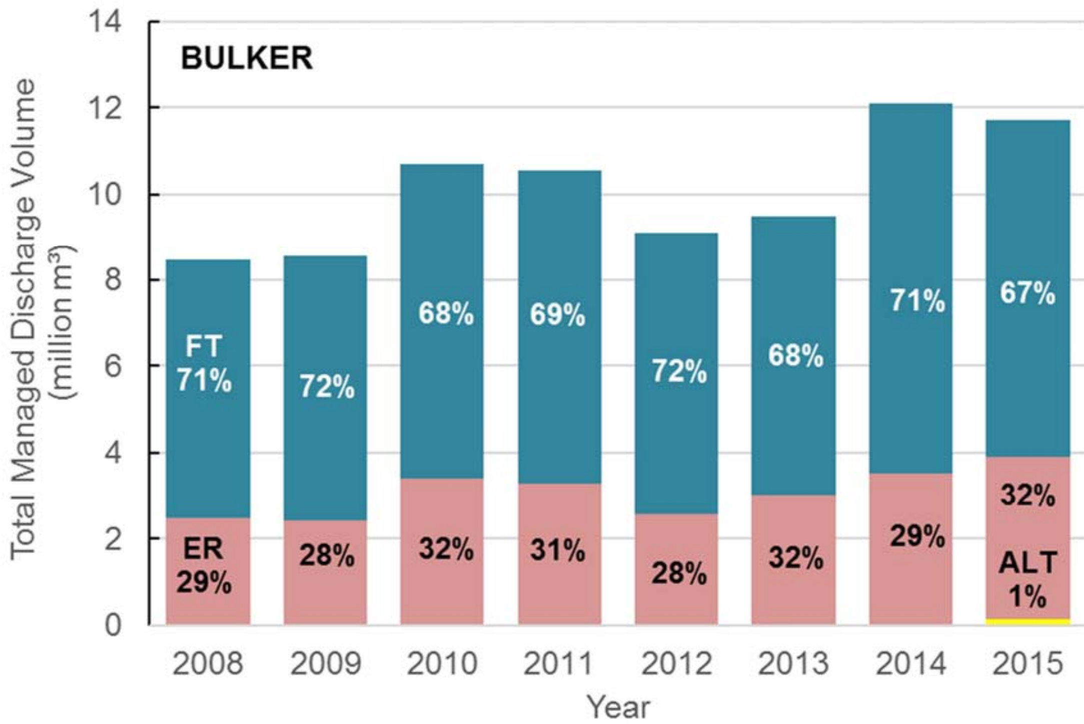


Figure 47 Management method of managed discharge volume for bulkers

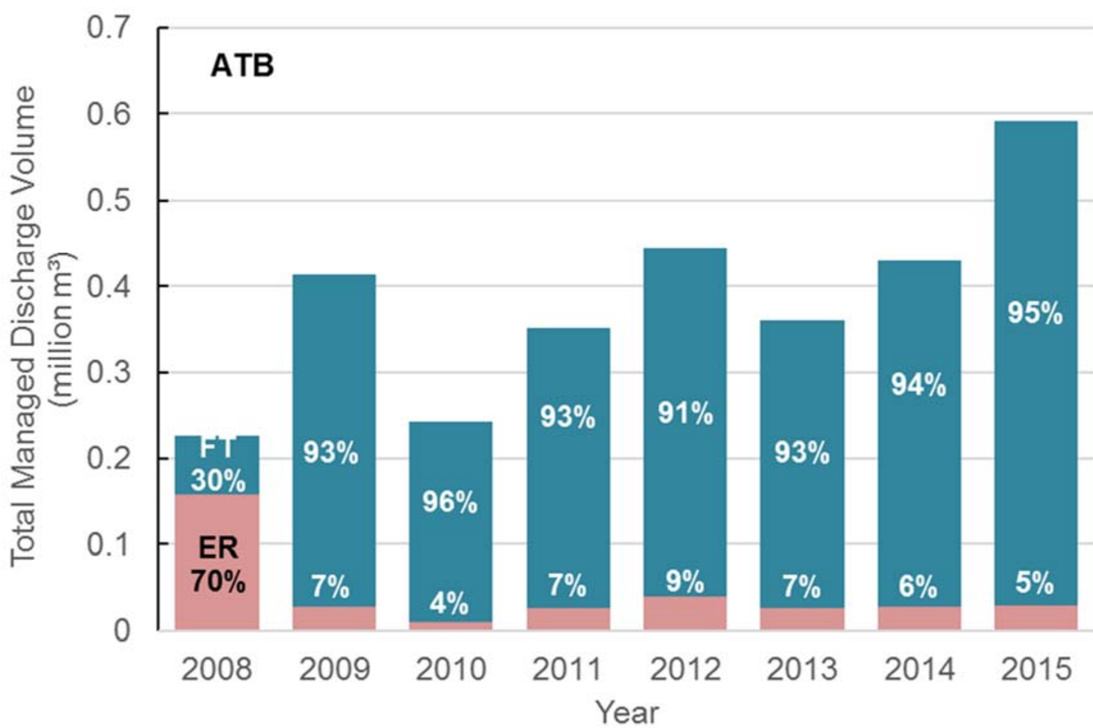


Figure 48 Management method of managed discharge volume for ATBs

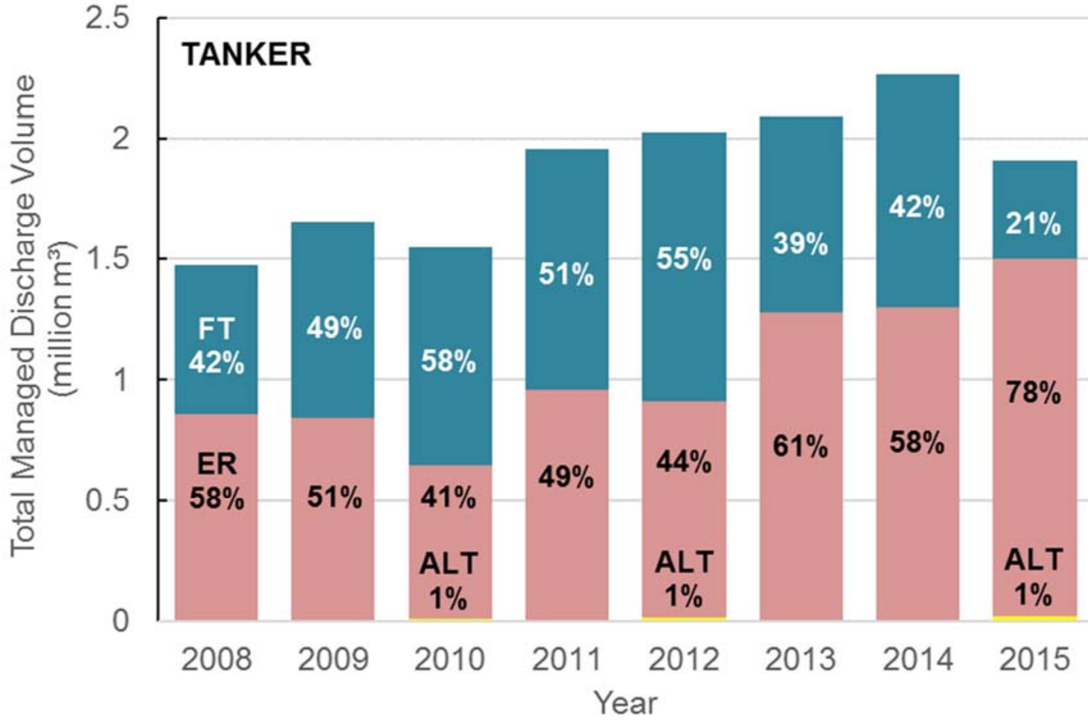


Figure 49 Management method of managed discharge volume (m^3) for tankers, 2008 – 2015

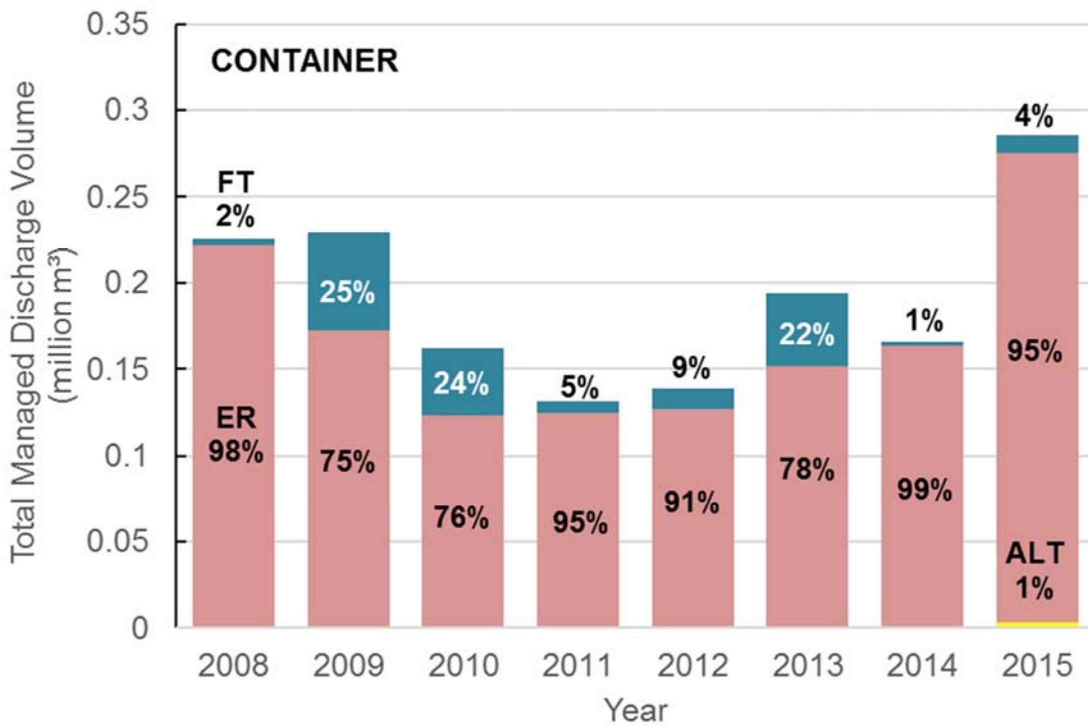


Figure 50 Management method of managed discharge volume (m^3) for containerships, 2008 – 2015

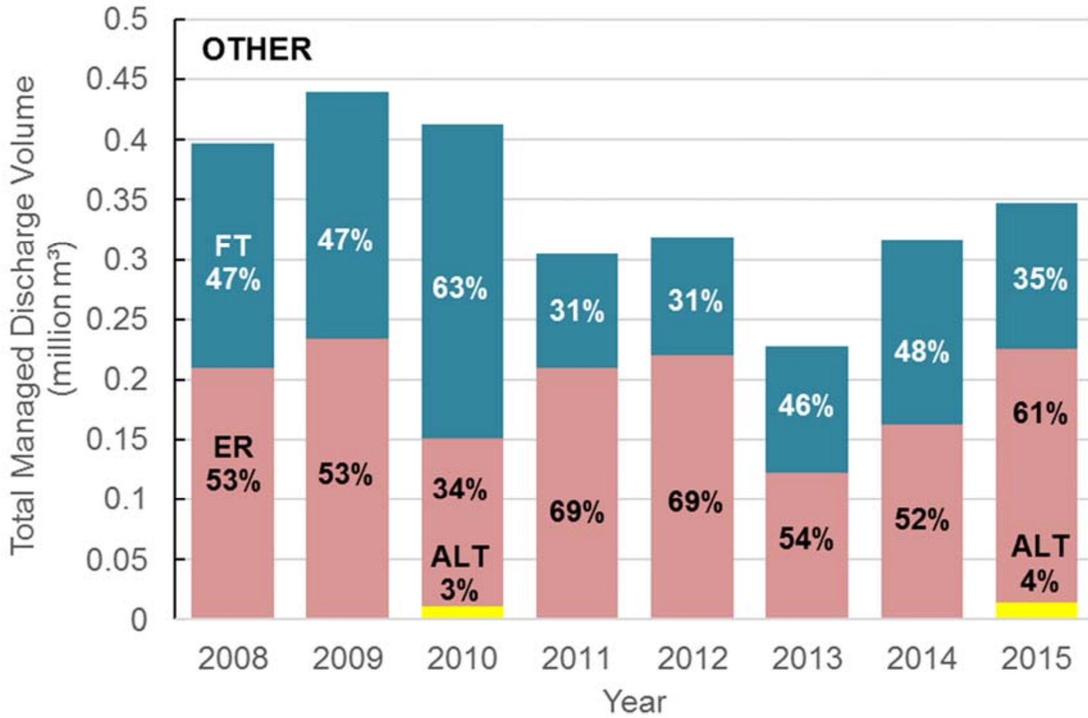


Figure 51 Management method of managed discharge volume (m^3) for other vessel types, 2008 – 2015

Several trends are evident in the above figures. Appendix B extends the ballast water management analysis across all vessel types. Across all vessel types, a very small portion of the discharge volume was managed through alternative management. ATBs tended to manage ballast almost exclusively through flow-through exchange, and containerships have tended to manage almost exclusively through empty/refill exchange.

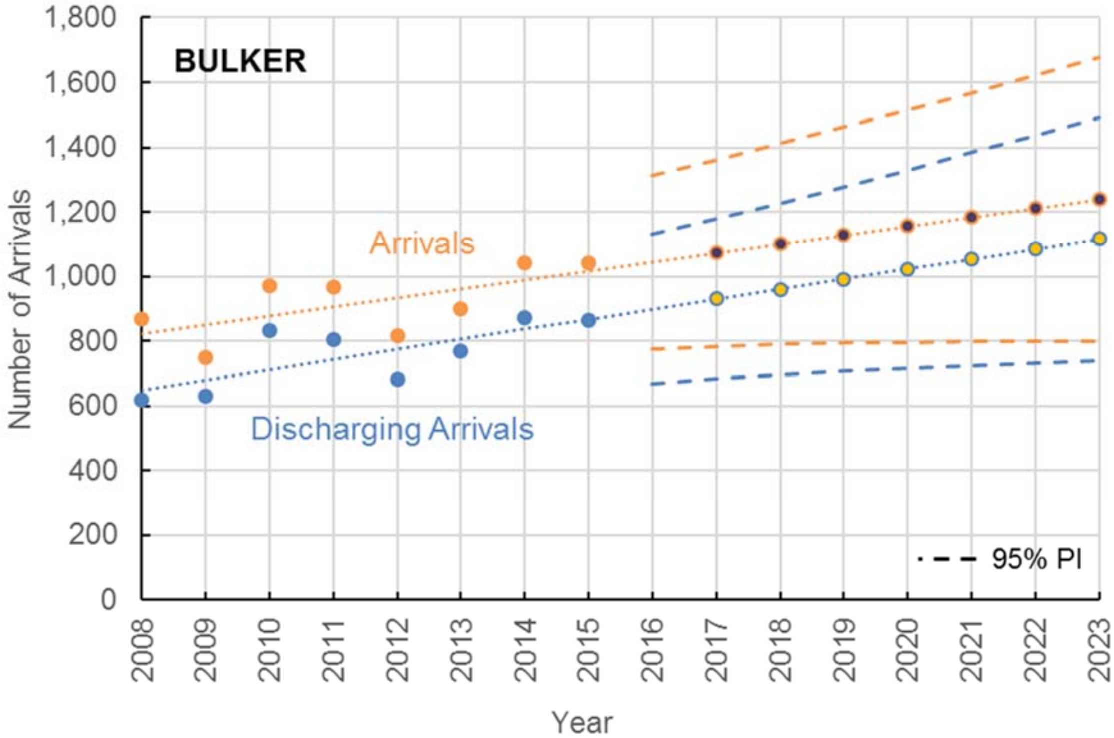


Figure 52 Forecast number of arrivals and discharging arrivals, bulker

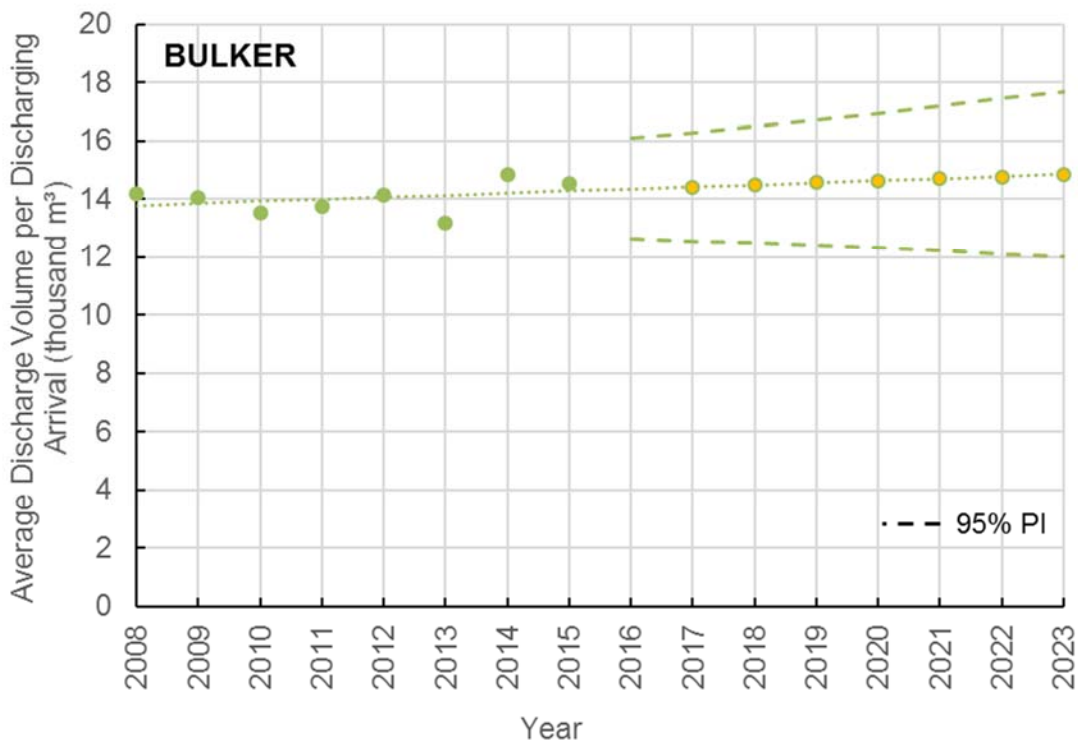


Figure 53 Forecast discharge volume per discharging arrival, bulker

Bulker arrivals and discharging arrivals are forecast to increase, and average discharge volume per arrival is also forecast to increase for bulkers.

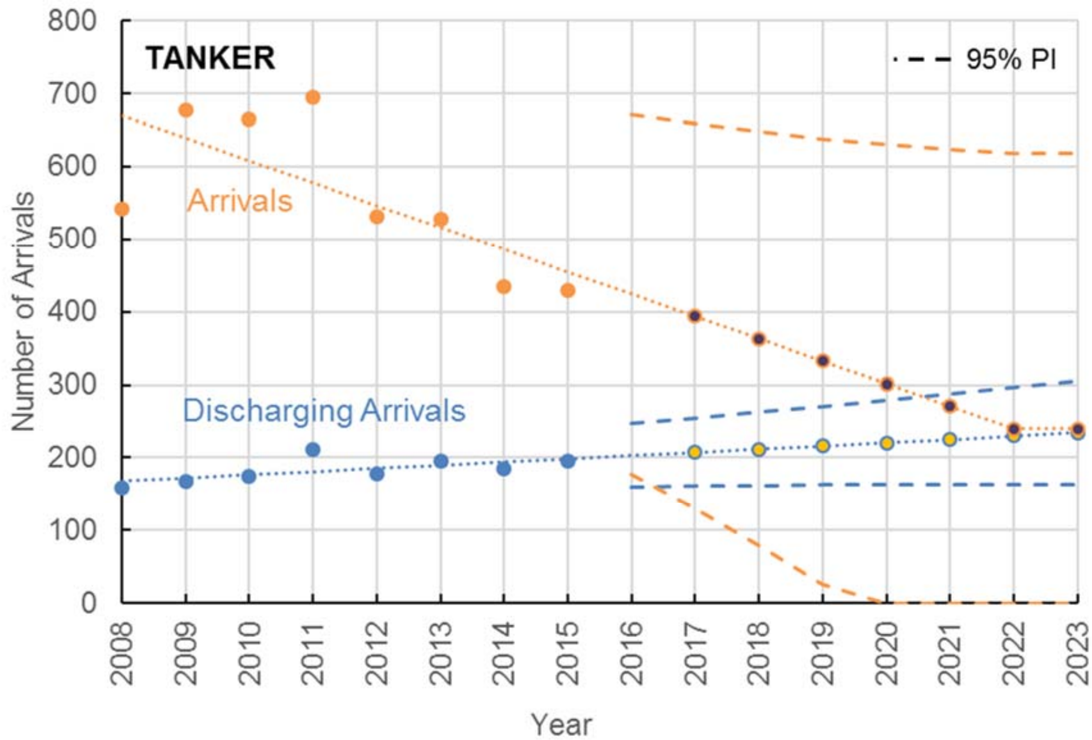


Figure 54 Forecast number of arrivals and discharging arrivals, tanker

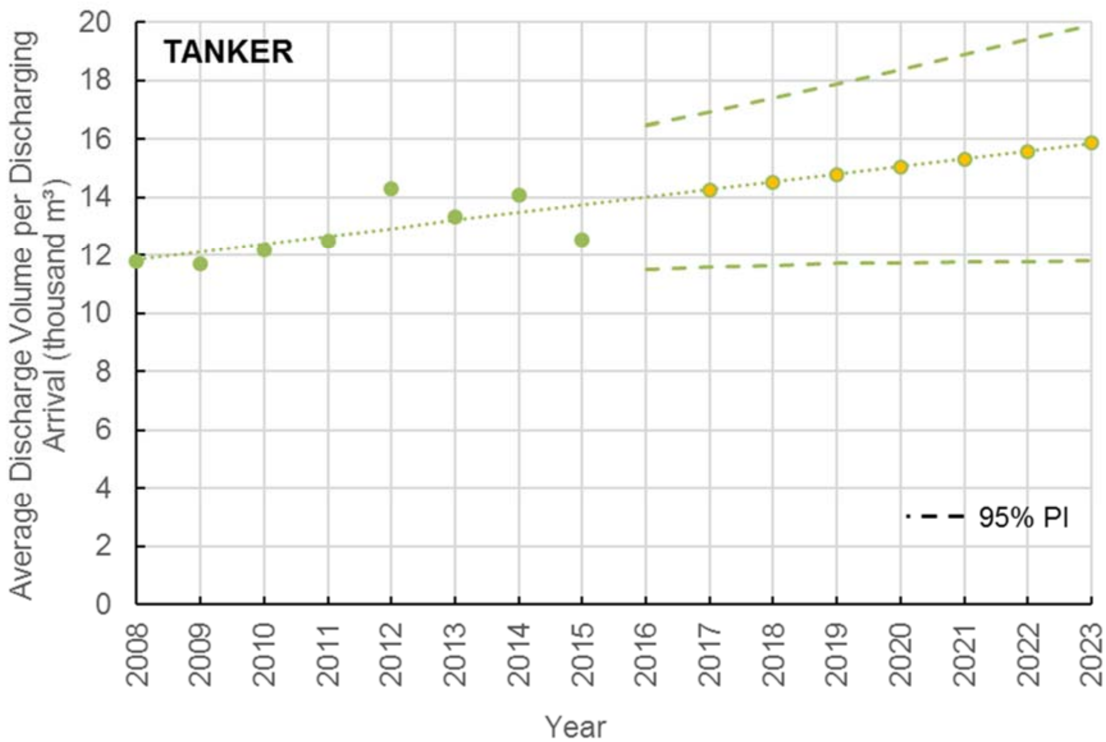


Figure 55 Forecast discharge volume per discharging arrival, tanker

Tankers show a remarkable contrast in forecasted arrivals, discharging arrivals, and discharge volume. Although arrivals are forecast to decrease, both discharging arrivals and discharge volume per arrival are forecast to grow. The wide prediction intervals on the arrivals forecast should be noted.

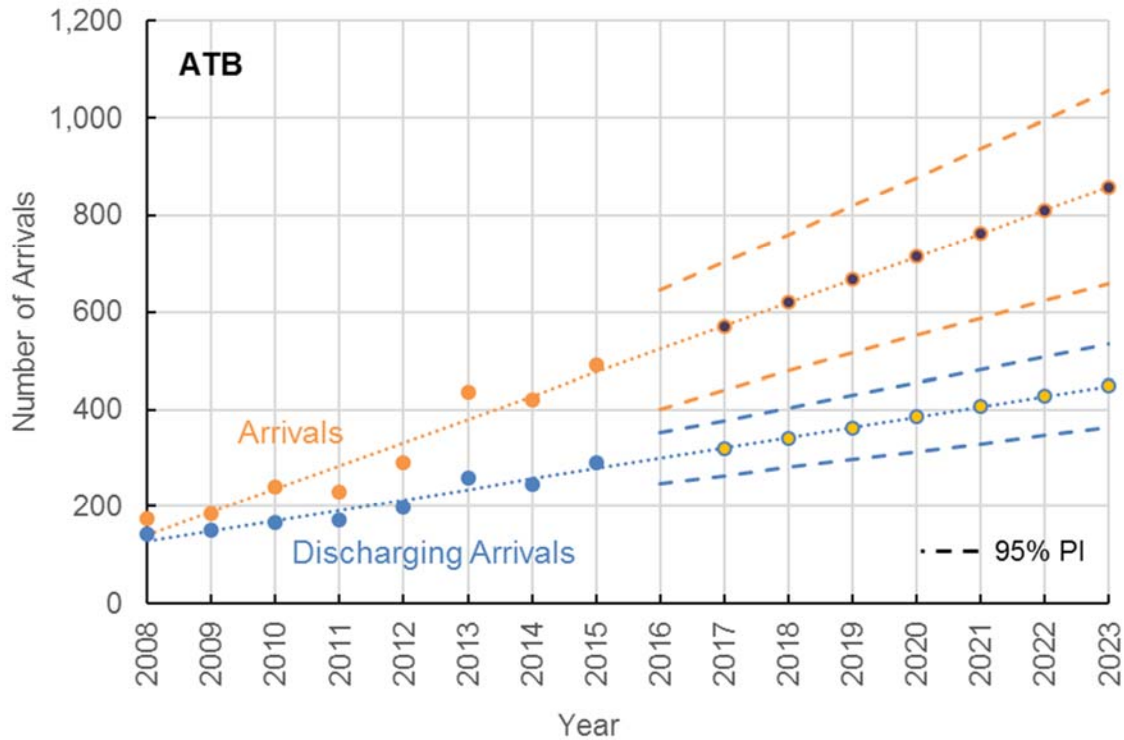


Figure 56 Forecast number of arrivals and discharging arrivals, ATB

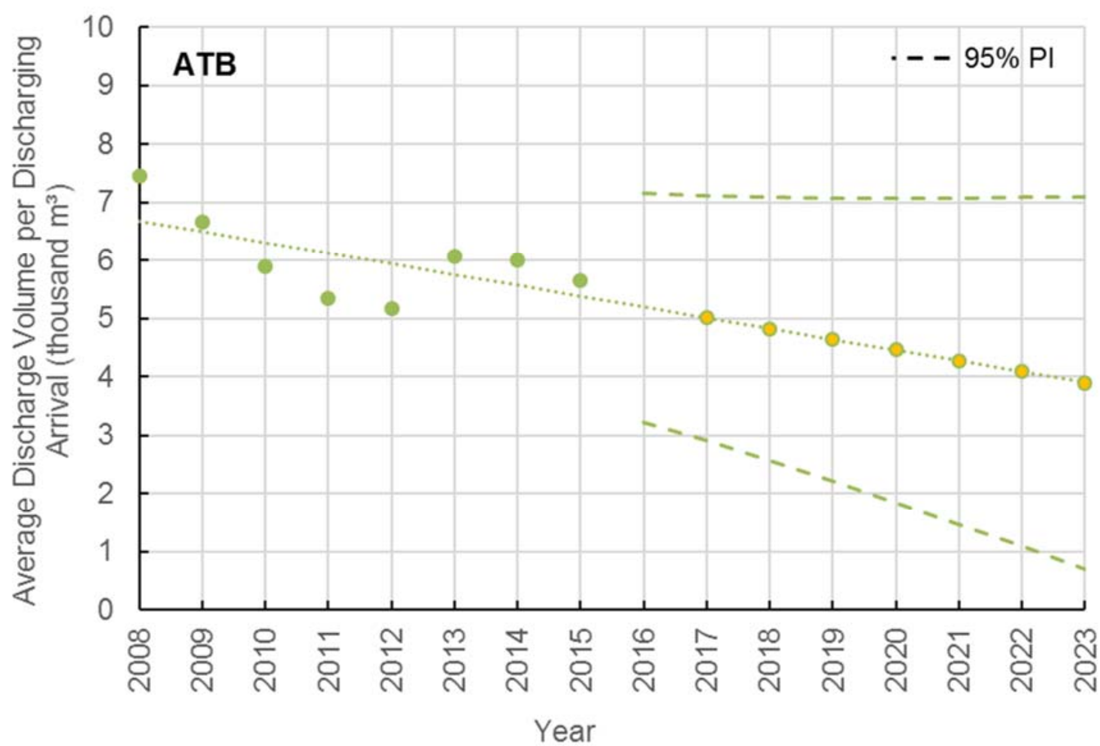


Figure 57 Forecast discharge volume per discharging arrival, ATB, 2008 - 2023

ATB numbers are growing (Section 2.2, and supported by Figure 56), but discharge volumes per arrival are forecast to decrease through 2023.

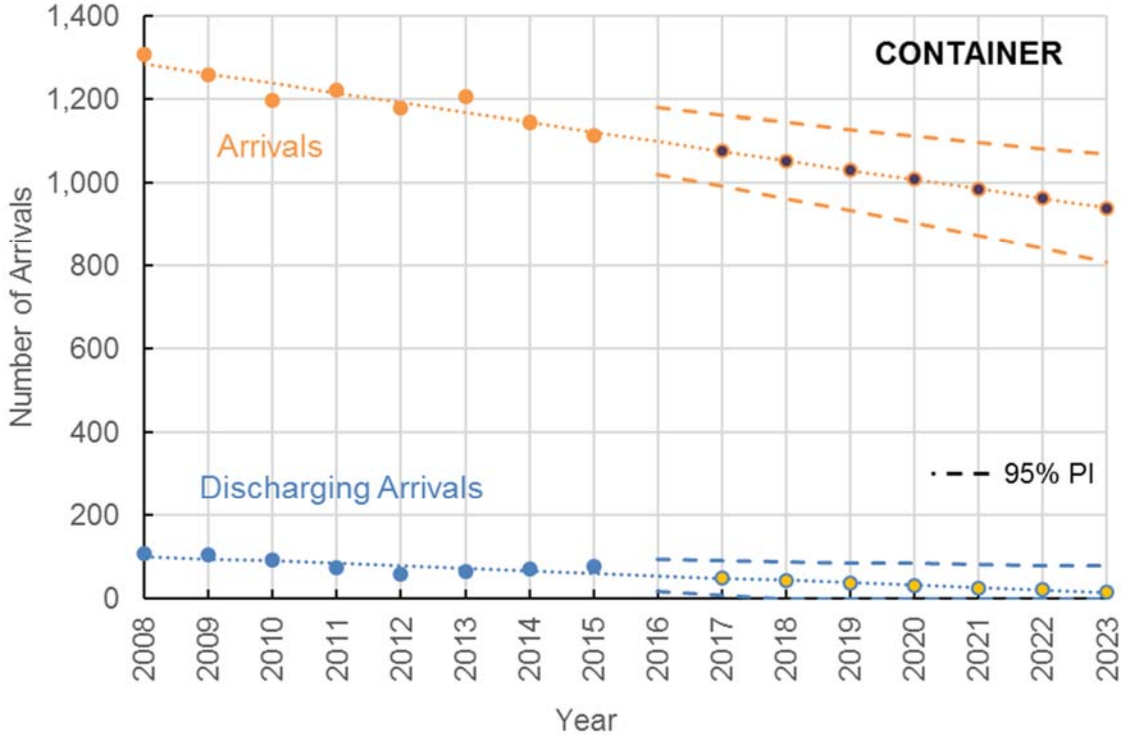


Figure 58 Forecast number of arrivals and discharging arrivals, container

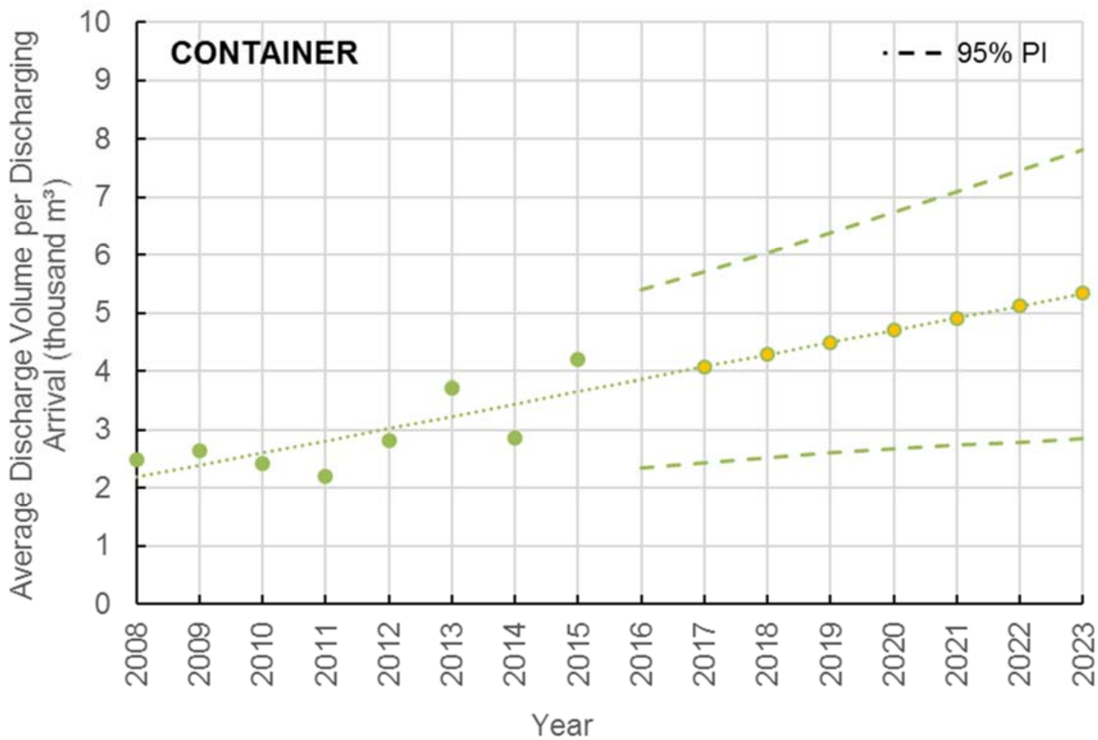


Figure 59 Forecast discharge volume per discharging arrival, container

Containership arrivals and discharging arrivals are forecast to decrease, but discharge volume per arrival is forecast to increase. This trend would align with the trend of the consolidation of container shipping into fewer, larger vessels. This trend may be affected by whether or not Washington is the first port of call for the containerships. If not, their discharge volume may not necessarily grow as indicated in Figure 59.

Table 29, Summary of Vessel Discharge Trends 2015 to 2023

	Discharging Arrivals			Discharge Vol per Arrival (thousand m^3)			Total Discharge Vol (million m^3)		
Vessel Type	2015	2023	Change	2015	2023	Change	2015	2023	Change
Bulker	869	1120	28.9%	14.5	14.6	0.7%	12.6	16.4	29.8%
Tanker	196	230	17.3%	12.5	15.8	26.4%	2.5	3.6	48.3%
ATB	291	425	46.0%	5.7	3.9	-31.6%	1.7	1.7	-0.1%
Containership	77	10	-87.0%	4.2	5.3	26.2%	0.3	0.1	-83.6%
Total	**1433**	**1785**	**24.6%**	**11.9**	**12.2**	**2.3%**	**17.0**	**21.7**	**27.4%**

Biological Sampling

The University of Washington (UW), in coordination with DFW, began biological sampling of ballast tanks to research BWE effectiveness in 2001. In 2004, DFW continued the research (non-regulatory) with regular sampling and contracted with UW to analyze the samples for zooplankton analysis. Vessels sampled were assumed to comply with BWE operational requirements, but considered high risk due to discharge volumes and source ports. Additional samples were also collected from raw ballast tanks (non-compliant and non-discharging vessels) to round-out the sample design and research assumptions. The proportion of inspected vessels whose ballast water was sampled in the last five years is depicted in Figure 60. In the last five years, the percentage of total arrivals to Washington that DFW has sampled ranged from less than 1% of annual arrivals to just over 2%.

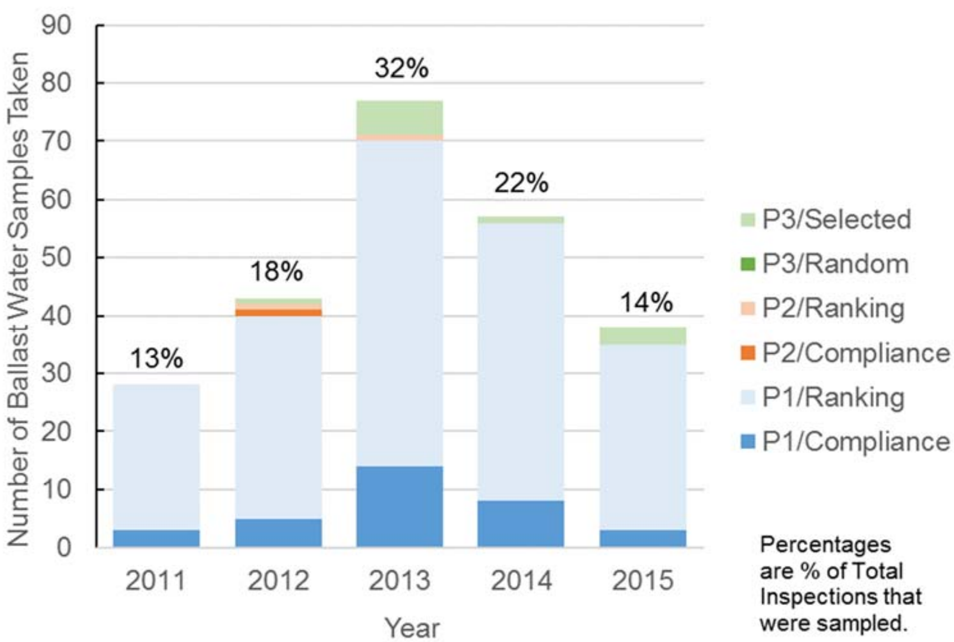


Figure 60 Number of ballast water samples taken by boarding type[1]

This figure indicates that 2013 was the year with the highest number and greatest proportion (32%) of ballast water samples taken from inspected vessels. Across the last five years, P1/Ranking and P1/Compliance are the most common boarding type to be sampled. Thus, DFW samples the greatest proportion of "high" Vessel Priority Risk Rating vessels.

[1] 2011 data was dispersed across multiple DFW databases; this percentage includes only the biological sampling data in the main database focused on for this report.

Ballast Water Age

The age of ballast water is depicted for ballast water sourced from China and Japan in Figure 61, and for ballast water sourced from California in Figure 62. Only discharge data that included dates for all three activities (uptake, management, and discharge) are included.

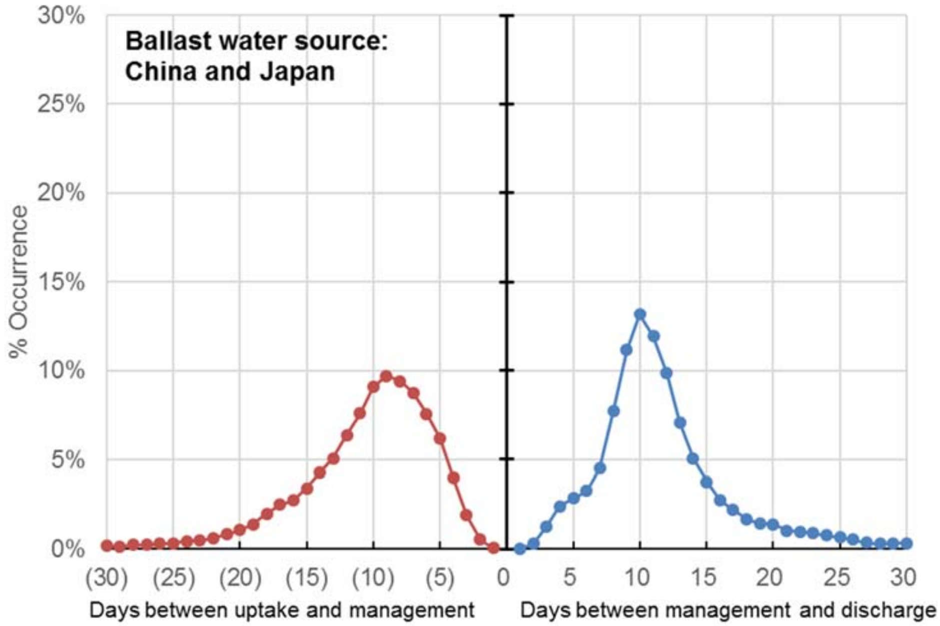


Figure 61 Age of ballast water sourced from China and Japan, 2011 to 2015 combined

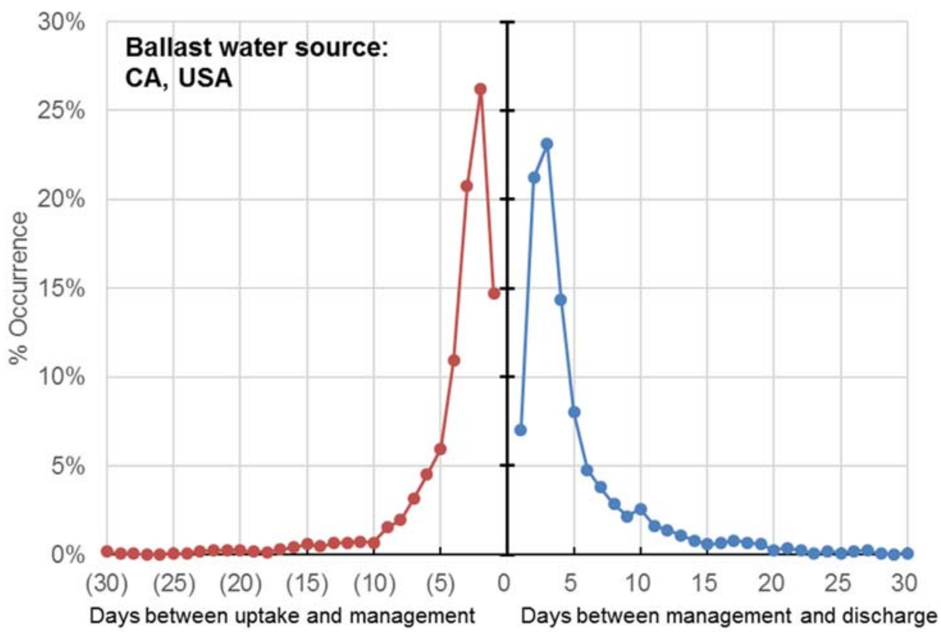


Figure 62 Age of ballast water sourced from California, USA, 2011 to 2015 combined

From the above figures, it is evident that ballast water from California is younger than water from China and Japan. Whereas the majority (between 20 and 25%) of ballast water from California takes between 0 and 5 days for uptake/management and management/discharge, the majority of ballast water from China and Japan takes just under 10 days for the uptake/management segment and 10 more days for the management/discharge segment.

Ballast Water Origin

The 2015 UW study found that ballast water that came from California had high densities of coastal zooplankton, and high levels of diversity with species known to be invasive. Ballast water from Washington's "common water" zone, which is not required to be managed, also contained high levels of coastal and invasive zooplankton. This is corroborated by data on multiple recent invasions into the Columbia River ecosystems that can likely be traced to California invasions (Reference 11).

Vessel Type

DFW ballast water sampling has been concentrated on the ships that discharge the most ballast water in Puget Sound, including tankers, bulkers, and ATBs. From the data analyzed in this strategic plan, bulkers made up about 56% of the total ballast discharges from 2008 – 2015, tankers made up about 14%, and ATBs made up about 15%. The 2015 UW study found that the water discharged by bulkers, which mostly originates in Asia, contains relatively low numbers of viable coastal zooplankton. This is tied to the age of the ballast water as described above. Tankers and ATBs conducting coastal voyages discharge young ballast water from California, with high levels of coastal zooplankton. Though bulkers have discharged more total ballast water than tankers over the years of the study, in almost every year tankers were responsible for the discharge of larger volumes of zooplankton.

Biological Sampling for Ballast Water Treatment Effectiveness

Because there are no type-approved BWMS available yet, none are in use on ships and there is no historical data on sampling of ballast water treated by these systems. Collection of this type of data in the future will be critical to assessing the effectiveness of these systems in treating ballast water and preventing the spread of nonindigenous species. The USCG type-approval process will include type specific compliance monitoring processes that will be the subject of great interest with respect to overall risk management when treatment systems are in use.

UW Biological Sampling Study

In 2014, DFW contracted with UW to conduct a comprehensive study of 2001-2014 ballast water exchange samples (Reference 12). Multiple published papers have been generated from this data set with the primary findings including data on the differences in ballast water risk between coastal and transoceanic voyages, ballast water from specific source ports, ballast water hold time, different vessel types, and other conclusions.

The results of this study included:

Ballast Water Exchange Trends over Time

Analysis of the density of coastal zooplankton in the ballast water of sampled vessels shows that vessels on West Coast voyages reporting to have exchanged their ballast water often show lower plankton densities (Figure 63). Analysis was also conducted for vessels on transoceanic voyages, but sample sizes were too small to be conclusive.

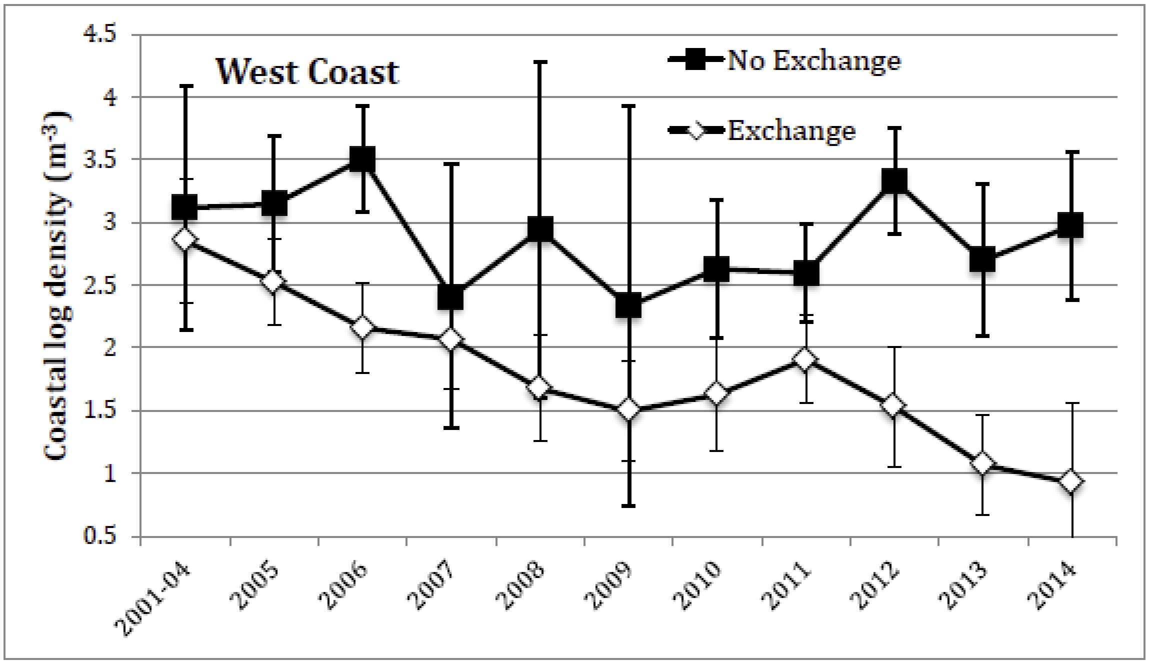


Figure 63 Average log 10 transformed densities of coastal zooplankton in ballast tanks for West Coast (California) sub-region sources.

In Figure 63, error bars indicate 95% confidence intervals. Wide confidence intervals for un-exchanged Trans-Pacific log density in 2007 were attributed to using a small sample size (n = 2). Years without confidence intervals had sample sizes of n = 1. This figure compares exchanged and unexchanged ballast water.

Ballast Water Age

The study, and others by the University of Washington, also found strong correlation between ballast water age and density of zooplankton (References 15, 14). From 2001 through 2014, ballast water discharged to Puget Sound that had originated on the West Coast was most frequently discharged five or less days after the date of exchange (or source date for un-exchanged ballast water), and contained the highest densities of coastal zooplankton. Ballast water originating from Trans-Pacific locations was most frequently 16 – 20 days old, and contained much lower densities of coastal zooplankton. However, the study also noted that ballast water originating in Trans-Pacific locations contained larger organism diversity, which brings its own risks for species invasion (Reference 15).

In general, the study found that ballast water older than 30 days was a highly effective indicator of risk reduction that would likely meet the USCG discharge standard for treatment systems in the ≥ 50 micrometer size class (< 10 organisms per cubic meter).

Figure 64 is reproduced from Reference 15 and shows the ballast water ages and zooplankton densities found by the UW researchers.

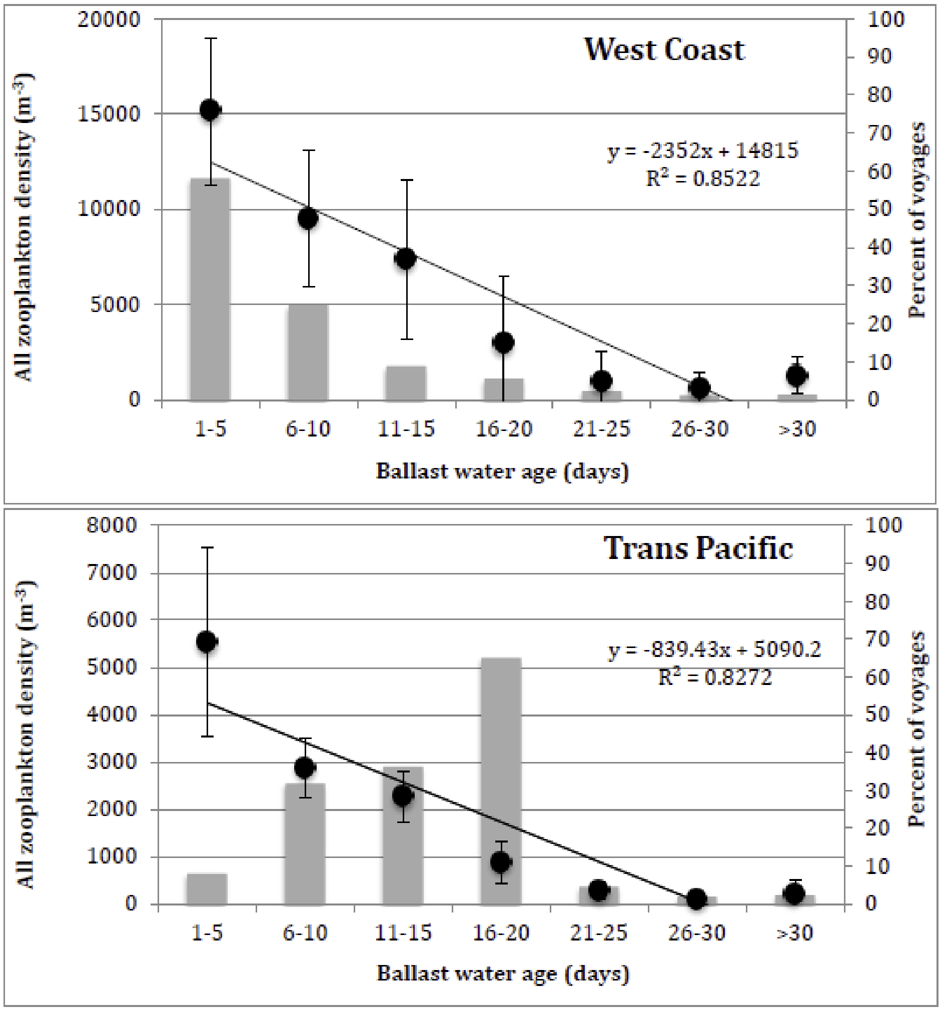


Figure 64 Average density of all zooplankton (coastal and oceanic) per cubic meter (m^3) (filled circles) and percent of samples by ballast water age bins for West Coast (top) and Trans-Pacific (bottom) regional sources (grey bars); error bars indicate 95% confidence intervals for zooplankton densities (Reference 15)

For ballast water discharges reported to DFW, age of ballast water can be derived from the differences between uptake date, management date, and discharge date. This age can be divided into two segments: the number of days between uptake and management, and the number of days between management and discharge.

Nonindigenous Species in Puget Sound

Sampling conducted by the UW researchers gave insight into the discharge history of an invasive species (*Oithona davisae*) known to be established in San Francisco Bay and recently discovered in Puget Sound. The average number of this species discharged to Puget Sound dropped off after 2007, though it is still being discharged at lower levels. Researchers concluded that ballast water exchange has likely had positive effect for Puget Sound, but also that more sampling for research is needed to indicate the effectiveness of exchange and the risk of new species establishment.

Ballast Water Exchange Sampling As a Management Tool

UW researchers used the results of their ballast water sampling to develop proposed risk threshold criteria identifying high, medium, and low risk vessels based on coastal species composition and density, and ballast water age. Using the categories they developed, researchers estimated that 17% of discharging arrivals to Puget Sound would meet the proposed high-risk threshold. Of the vessels that were actually sampled by the study, 16 out of 49 met this high risk threshold, consisting of 7 bulk carriers, 5 ATBs, and 4 tankers. Further development of ballast water exchange sampling as a management tool was recommended.

Biological Sampling for Ambient Monitoring

The UW study of ballast water samples found that new invasive species populations have turned up in northern Puget Sound as well as the Columbia River. The quantities of species found in the Columbia River led the researchers to question whether the exemption of vessels traveling within the common water zone is sufficiently protecting the state from invasions. The researchers also found that the species present in northern Puget Sound had not been noted by previous studies, highlighting the need for regular monitoring conducted on the ambient environment in Washington, not just on ballast water. This corroborates conclusions from a recent study by researchers at Portland State University examining nonindigenous species introductions to Washington State from 1926 to 2011 (Reference 16). The study found that there are 94 nonindigenous species established in Washington between the Pacific coast and Puget Sound. They emphasized that the lack of long-term regional data on species populations hinders better understanding of how species invade.

The Portland State study found that of the 94 established species, 35 in Puget Sound and 32 on the Washington coast were new in the last 20 years, and that the rate of species introduction has greatly increased in last 100 years. The study used a database called NEMESIS created by the Smithsonian Environmental Research Center that maintains bay-level lists of known invasive species populations and the vectors that could have brought them (Reference 32). While not all of the nonindigenous species introductions in Washington can be attributed to ballast water discharges, the findings of this study and the database established during its research give a baseline species inventory that can be used as a resource for further study of invasive population change over time.

Agreement between DFW and NBIC Datasets

Data from the DFW database and the NBIC database for Washington only were compared to show the differences between the data available from each source (Table 30). The numbers reported here should be considered approximate, since the underlying data was used as is. An actual comparison by vessel arrival date and discharge volume would require access to NBIC's raw data files and is outside the scope and resources of this report

Table 30 Comparison between DFW and NBIC databases, 2015 only

Source	2015 Arrivals to Washington Ports	2015 Arrivals with Ballast Water Discharge in Washington Ports	2015 Discharge Volume
DFW Database	4,246	1,535	17.7M m^3
NBIC Database	4,004	1,368	15.7M mt
Difference between NBIC and DFW (% DFW)	-9%	-5%	+11%

The values in Table 30 reflect the following assumptions:

- The recorded arrival port was used to determine whether an arrival was to a Washington port; the recorded discharge port was used to determine whether ballast water was discharged at a Washington port.

- An arrival with discharge was only counted if the discharge port was explicitly recorded as a port in Washington. Blank entries (less than five in each database), latitude/longitude entries (less than 24), and ports outside of Washington accounted for a small portion of the data set and were not included.

The additional discharge volume accounted for in the DFW data is possibly attributed to state BWMR filing requirements within same COTPZ.

Figure 65 compares the recorded discharge volume at Washington ports for the DFW database with the NBIC database. A strong agreement between the databases is apparent.

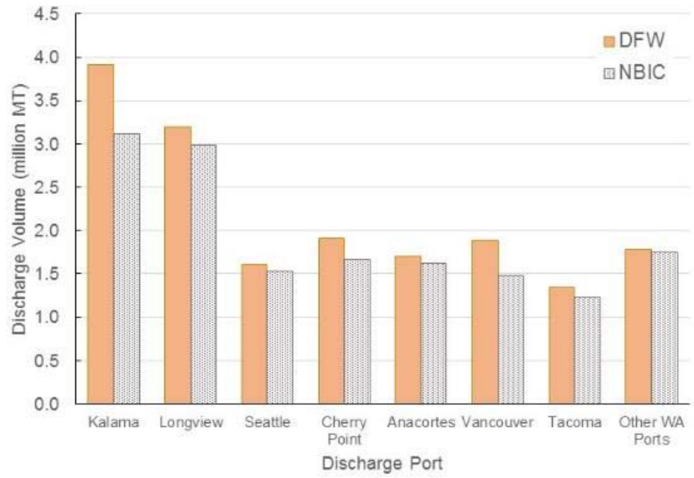


Figure 65 Comparison of discharge volumes recorded in the DFW and NBIC databases for 2015

National Ballast Water Management Trends

Nationally, approximately 70% of all 2015 arrivals did not discharge ballast water. Of the 30% that did, they discharged 282.2 million metric tons (M MT) of ballast water, of which 117.4M MT (42%) were of overseas origin and 164.9M MT (58%) were of coastwise origin (Minton et al 2016). The amount of ballast water treated using an Alternative Management System (AMS) represented only 1% of all discharge by volume. Raw ballast water nationally accounted for 121.2M MT (43%) of the volume, but varied significantly by geographic origin with 24.1M MT (15%) of overseas and 97.1M MT (83%) of coastwise ballast water. The volume of raw ballast water discharged under a safety exemption was 0.2 M MT (0.2%). Figure 66 provides a breakdown of ballast water discharges by managed (BWE) and raw (No BWE) over a three-year period as reported in Minton et al (2016).

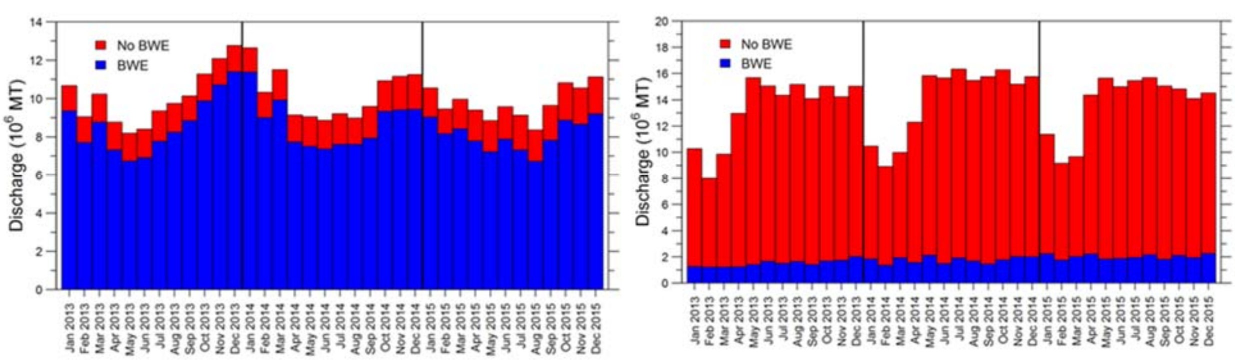


Figure 66 Monthly reported discharge of ballast water that originated from overseas (left graph) and coastwise (right graph) by management status: "No BWE" (no ballast water exchange) means raw and "BWE" means managed ballast water discharges, 2013-2015.