State of Oregon
Department of Environmental Quality

Managing Aquatic Invasive Species Risks from Shipping Transport Pathways

A report prepared by The Oregon Task Force on
the Shipping Transport of Aquatic Invasive Species

for the 2009 Oregon State Legislature

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EXECUTIVE SUMMARY

The Oregon Shipping Transport of Aquatic Invasive Species Task Force, pursuant to SB 643 (2007) and ORS 783.625, prepared this report to the 2009 Legislature. The Task Force, similar to the Oregon Ballast Water Task Force of 2002, 2004, and 2006, was established for the purpose of studying and making recommendations aimed at combating the introduction of non-indigenous species associated with shipping related transport in our state. Members of the Task Force represent a diverse range of academic, maritime, regulatory and environmental perspectives, as well as two advisory members from the Legislative Assembly.

Commercial shipping activities constitute an important and vital economic engine for the state of Oregon. An unintentional consequence of trade, however, is the transport and introduction of species to ecosystems outside their historic ranges. These aquatic invasive species (AIS), freed of the natural controls of their native range, can proliferate in Oregon's waterways, displace native species, and degrade ecosystem services critical to human economies and health. A sustainable economy requires effective management to prevent the introduction of AIS via shipping related pathways such as ballast water discharge and vessel biofouling.

This report provides information and analysis on i) current ballast water regulations at international, federal, and regional levels; ii) shipping and ballast water discharge trends in Oregon waters; iii) shipping industry compliance with Oregon Law; iv) threats and possible management options for non-ballast water pathways of introduction such as hull-fouling; and v) emerging issues that may impact Oregon's efforts to reduce invasive species threats associated with shipping transport. The report also provides program development suggestions for the Department of Environmental Quality and legislative recommendations for strengthening invasive species prevention in Oregon's waterways.

The final chapter identifies four general themes (program resources, ballast water treatment, biofouling, and regional cooperation) that deserve increased attention and concludes with specific recommendations aimed at better protecting our waterways from invasive species threats. These recommendations include:

- ❖ Amend statutory language to provide ODEQ, or its agents, with explicit legal authority to board and inspect regulated vessels, audit ballast water bookkeeping records, and collect samples from ballast tanks for ballast exchange verification purposes.
- ❖ Provide supplemental funding needed for ballast program incidental expenses including: BWE verification and sampling equipment, laboratory analyses of water quality samples, consultation fees for database developments that may streamline data processing, and out of state travel for regional coordination meetings and workshops.
- ❖ Authorize ODEQ to develop rules defining ballast water treatment technology standards to be as consistent as possible with administrative rules adopted in other west coast states if:
    - The federal government has failed to adopt satisfactory ballast water treatment standards by January 2009; and
    - The states of Washington and California have adopted comparable ballast water treatment standards. If Washington and California adopt comparable treatment standards, ODEQ will adopt a common west coast treatment standard.
- ❖ Authorize ODEQ to develop rules providing for emergency use, when necessary, for applying biocides to high-risk ballast tanks, i.e. proposed illegal discharge of ballast water in Oregon waters. For purposes of this recommendation, "high risk" discharge means unmanaged ballast water discharge from ports designated by ODEQ as high-risk ports for introduction of invasive aquatic species.
- ❖ Provide for the continuation of the Shipping Transport of Aquatic Invasive Species Task Force through 2010 in order to assist ODEQ and the State in developing risk-reduction management options.

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List of Abbreviations

ABRPI	Aquatic Bioinvasion Research and Policy Institute (PSU)
ABWEA	Alternative Ballast Water Exchange Areas
AIS	Aquatic Invasive Species
ANS	Aquatic Nuisance Species
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWRF	Ballast Water Reporting Form
BWT	Ballast Water Treatment
COTP	Captain of the Port
CRB	Columbia River Basin
CRE	Columbia River Estuary
CSLC	California State Lands Commission
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
ETV	Environmental Technology Verification
IMO	International Maritime Organization
MARAD	Maritime Administration (US Dept of Transportation)
MT	Metric Tons
NANPCA	National Aquatic Nuisance Prevention and Control Act
NBIC	National Ballast Information Clearinghouse
NIS	Non-indigenous Species
NISA	National Invasive Species Act
NGO	Non-Governmental Organization
NM	Nautical Miles
NOAA	National Oceanographic and Atmospheric Association
ODEQ	Oregon Department of Environmental Quality
PBWG	Pacific Ballast Water Group
PDXMEX	Portland Merchants Exchange
PSMFC	Pacific States Marine Fisheries Commission
PSU	Portland State University
PSAT	Puget Sound Action Team
SERC	Smithsonian Environmental Research Center
STAIS	Shipping Transport of Aquatic Invasive Species Task Force
STEP	Shipboard Technology Evaluation Program
USCG	United States Coast Guard
UW	University of Washington
WCBOP	West Coast Ballast Outreach Project
WDFW	Washington Department of Fish and Wildlife
WSA	Wetted Surface Area (of a vessel hull)

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I. INTRODUCTION

Non-native or non-indigenous species (NIS) are organisms that have been inadvertently transported outside of their naturally occurring historic range. Only a small fraction of these organisms establish viable reproducing populations upon arrival, and even fewer become 'invasive', crowding out native species and potentially altering key ecosystem processes. Yet, biological invasions have been globally implicated as a potent force for ecological and evolutionary change, ranking along with habitat loss, pollution, and climate change as the greatest threats to native biodiversity (Vitousek et al. 1997, Mack et al. 2000, Grosholz 2002, ISAB 2008). In addition to substantial ecological impacts, biological invasions represent a major economic threat to Oregon taxpayers and industries.

Commercial shipping activities constitute an important and vital economic engine for the state of Oregon. However, incidental vessel operations have caused this industry to be identified as one of the leading sources of NIS introductions along the west coast (Sytsma et al. 2004, Molnar et al. 2008). In response to the threats posed by aquatic invasive species (AIS), and to minimize the risks posed by ballast discharge from shipping operations, the 2001 Oregon Legislature created the Oregon Ballast Water Management Program (ORS 783.620 – 783.640; Appendix A). In the absence of a federally mandated program, this statute established ballast management reporting requirements for all transoceanic and coastal arrivals to Oregon waters. In addition, the statute established the Oregon Ballast Water Task Force for the purposes of studying and making recommendations for future adjustments to the ballast water regulations (Vingograd and Sytsma 2002, Flynn and Sytsma 2004, Simkanin and Sytsma 2006).

The 2007 Legislature renamed the Task Force (to the Shipping Transport of Aquatic Invasive Species (STAIS) Task Force) to reflect a broader range of concerns, in addition to ballast water operations, that may increase shipping related AIS risks (SB 643). The newly created task force (consisting of various state, federal, academic, industry, NGO and academic representatives) was directed to study and make recommendations:

- ❖ For combating the introduction of aquatic non-indigenous species associated with shipping-related transport into the waters of this state; and

❖ On changes to the ballast water program established in ORS.625 to 783.640, including but not limited to the following considerations:
    - Shipping industry compliance with ORS 783.625 to 783.640;
    - Practicable and cost-effective ballast water treatment technologies;
    - Appropriate standards for discharge of treated ballast water into waters of this state;
    - The compatibility of 783.625 to 783.640 with new laws enacted by the United States Congress, regulations promulgated by the United States Coast Guard and ballast water management programs established by the States of Alaska, California and Washington and the Province of British Columbia;
    - Practicable and cost-effective techniques to combat the introduction of aquatic non-indigenous species associated with shipping related transport into the waters of this state; and
    - Appropriate regulations and standards to combat the introduction of aquatic non-indigenous species associated with shipping related transport into the waters of this state.

The STAIS Task Force was formed in January 2008 for the primary purpose of producing this report, including a final section on conclusions and recommendations directed at program development and possible legislative action.

<u>A. Non-indigenous Species and Their Potential Impacts</u>

Over 50,000 non-indigenous species have become established in the United States as the result human commerce, trade and movement (Pimentel et al. 2005). While some have been intentionally introduced for food crops, livestock, pets, aquaculture, recreational fisheries, and ornamental plants; an ever-increasing number are being unintentionally introduced as a consequence of increased global trade and human travel (Carlton 1985, di Castri 1989, Vermeij 1991). A vast majority of NIS introduced to habitats outside their historic range are not well adapted to the new environment and are unable to establish a reproducing population. Some NIS may become established after introduction, but cause no detectable impact on the local environment, either because they easily co-exist with similar native species or their population numbers remain low. In some cases, however, NIS become 'invasive species' whose introduction and spread threaten native biodiversity, ecosystem processes and often have indirect impacts on socio-cultural, economic and/or human health (Mack et al. 2000, Carlton 2001, US Ocean Commission 2004)

The processes by which living organisms are introduced into new ecosystems, outside of their historic range, are referred to as 'vectors' or 'pathways.' Whether intentional (e.g. aquaculture, recreational fisheries, pet trade) or unintentional (e.g. ballast water discharge, fouling organisms, etc.), modern NIS pathways are typically the direct result of global and regional trade, transport of goods and people, and the cultural needs associated with human behavior (Cusack and Harte 2008). Because of increased global trade during the past 100 years, the establishment of new NIS (and the impacts of AIS) is on the rise (Ruiz et al. 2000, Ruiz and Carlton 2003).

Once established, NIS are capable of inflicting a cascade of direct and indirect effects upon the receiving environment. In some cases, the absence of a natural suite of predators and/or parasites enables NIS to achieve densities far greater than observed in their historical range. In doing so, NIS often out compete native species for critical resources such as food or space. In some cases, NIS may themselves introduce disease and/or parasites for which native species are ill-adapted (ISAB 2008). As a result of their introduction, NIS may impart a broader impact on the ecosystem by altering food web dynamics and disrupting biogeochemical cycling processes (Grosholz 2002). Specific examples of well-studied biological invasions include: mudflat conversion by cord grass, *Spartina altinoflora* (Daehler and Strong 1996); degredation of water quality caused by hydrilla, *Hydrilla verticillata* (Langeland 1996); alteration of plankton production dynamics by Asian clam, *Potamocorbula amurensis* (Kimmerer et al. 1994, Cloern 1996); and declines in native fisheries production resulting from the comb jelly, *Mnemiopsis leidyi* (Shiganova 1998). While the impacts of such well-documented case studies are clear, there are an unknown number of NIS for which the impacts have not been sufficiently documented (Parker et al. 1999, Lodge et al. 2007).

The rapid expansion of Eurasian freshwater mussels of the Dreissenid family in North America serves as a stark example of why NIS prevention efforts are critical to protecting Oregon's waterways. Zebra mussels (*Dreissena polymorpha*) and the closely related quagga mussel (*Dreissena rostriformis bugensis*) were introduced to the Great Lakes in the late 1980's, most likely via ballast discharge from ships arriving from Europe (Mills et al. 1994). As a result of their high fecundity (up to 1 million eggs/female/year) and rapid dispersal (planktonic larvae that persist for 8-240 days in the water column before settling onto hard substrate), both species expanded their range throughout the Great Lakes, Ohio River and Mississippi River regions during the 1990's. An immediate economic consequence of their extraordinarily high densities (up to 700,000 individuals per m2) was the cost of combating biofouling of industrial and municipal water intake pipes. Currently, it is estimated that annual costs for control efforts and damage to infrastructure has reached $1.1 billion (Pimentel et al. 2005). Additionally, these mussels have been implicated as the catalyst for a cascade of impacts to water quality and fisheries production, including disrupted ecosystem processes and altered food web dynamics that contribute to outbreaks of *E. coli* and botulism (MacIsaac 1996). In total, the direct and indirect economic losses resulting from invasive species in the Midwest Region has been estimated at $1 billion per year (Pimentel et al. 2005).

In an effort to confine the infestation, the 100th Meridian Project was established to educate recreational boaters and reduce the risk of an expanded Dreissenid invasion throughout Western States. Despite these efforts, Quagga mussels were identified in deep waters of Lake Mead, Nevada. While some speculated that the mussels would not survive well in the warm surface waters of the southwest, the Quagga has since demonstrated its ability to reproduce throughout most of the year (they only reproduce seasonally in the cooler waters of the Midwest), colonizing surfaces throughout the lake. Since its first detection in early 2007, the Quagga has been identified in 16 reservoirs associated with the lower Colorado Aqueduct system in Arizona, Nevada and California. More recently in February 2008, Zebra mussels were identified for the first time west of the Continental Divide in a small reservoir east of Monterey Bay, California.

Although dreissenids were first introduced to North America from ballast water discharge, the transport of recreational vessels between waterbodies in western states is considered the greatest threat for their introduction to Oregon waterways. In fact, Dreissenid mussels have been identified on the hulls of numerous recreational vessels being transported on trailers coming into the Pacific Northwest (pers. comm. Jim Gores, ODFW and Allen Pleus, WDFW). Nonetheless, it is mentioned in this report as one example to illustrate the broader potential consequences that are at stake from biological invasions. For example, a report by Phillips et al. (2005) investigated the potential control and maintenance costs that would be incurred upon 13 hydropower facilities on the Columbia River in the event of a Zebra mussel infestation. These specific costs alone were estimated at $27 million per year. Although it is difficult to quantify the economic costs inflicted by the combined impact of all terrestrial and aquatic NIS, the most comprehensive assessments have estimated US annual losses to be near $140 billion per year (Pimentel et al. 2005, Cuscack and Harte 2008).

In addition to the ecological and economic harm caused by AIS, there has been growing concern that human health risks may be elevated due to the dispersal of AIS (Ruiz et al. 1997). Some phytoplankton produce toxic compounds and form dense algal blooms that may become incorporated into the tissue of fish and shellfish that may be harvested for human consumption (Van Dolah et al. 2001). Other organisms act as intermediate hosts to human pathogens, such as the Asian inter-tidal snail, *Assiminea parasitologica*, which can host the parasitic human lung fluke and was first detected in Coos Bay in July 2007 (pers. comm. John Chapman OSU, 2008). Furthermore, the intake and subsequent discharge of substantial volumes of ballast water for normal shipping operations have been implicated as a major factor resulting in the global spread of microbial communities (Hallegraff 1998, Drake et al. 2001, Drake et al. 2007), including the potential dispersal of pathogenic bacteria and viruses such as cholera (Ruiz et al. 2000, McCarthy et al. 1994). Compared to impacts of larger sized NIS, the impacts and extent to which microorganisms have been globally distributed by human activities is poorly understood.

B. Shipping Mediated Pathways of Aquatic Invasive Species (AIS)

Shipping operations have contributed to the introduction of AIS to new habitats by two primary pathways: ballast water discharge and biofouling. Ship operators manage changes in cargo load by transferring ambient waters from the vessel's surroundings into ballast tanks or cargo holds, thereby increasing stability, efficiency and safety during a vessel's voyage. The process of pumping large volumes of water into ballast tanks while unloading cargo at one port, and then discharging the ballast upon loading cargo at a distant port provides a mechanism by which aquatic organisms (typically plankton and other small organisms that easily become entrained by the flow of intake pumps) may 'hitchike' to regions outside their historic range. While many planktonic organisms spend their entire life-cycle free-floating in the water column (i.e., holoplankton), others are only planktonic for days to months as larvae prior to settling into benthic habitats for the adult portion of their life-cycle (i.e., meroplankton). Because sediment tends to accumulate at the bottom of ballast tanks, organisms may also settle out within the tanks to establish reproducing populations that travel within the vessel and may be capable of repeatedly replenishing the tanks waters with meroplanktonic larvae (Carlton 1985, Carlton and Geller 1993). In a different manner, ships may act as an invasion pathway for organisms which colonize (or 'foul') hard substrate surfaces of the vessel (e.g., hull, sea chests, anchors, and piping) for the adult portion of their life-cycle. These biofouling organisms may result in the introduction of AIS to a new region if they release reproductive offspring or become dislodged from the vessel and fall into the surrounding waters (Gollasch 2002, Fofonoff et al. 2003).

Ballast Water Discharge - Ballast water exchange (BWE), or tank flushing, has been the predominant ballast management strategy practiced worldwide. As defined in USCG regulations (33 CFR 151.2025), 'exchange' may be completed by one of two accepted methods. Most regulations accept the use of either the '*empty/refill'* method (i.e., pump out as much of ballast as is possible; then re-fill with mid-ocean water) or the *'flow through'* method (i.e., flush out the tank by pumping in mid-ocean water at the bottom of the tank; continuously overflowing the tank from the top until the equivalent of three full-tank volumes have been pumped into the tank). Both methods aim to replace at least 95 percent of the original ballast volume contents, but tank configuration (e.g., height of pump intakes from the bottom of the tank and 'dead space' that may not flush as easily) may limit this goal, especially for vessels that are unable to use the empty/refill method.

Three major problems have challenged the usefulness of BWE as a long-term solution to AIS prevention. The first problem concerns operational challenges and safety concerns involved with ballast exchange. Secondly, BWE efficacy is highly variable, largely dependent on vessel type, voyage duration and environmental characteristics of source and discharge locations. Lastly, there has been a lack of effective regulatory tools for verifying ballast exchange compliance.

When ballast water exchange is properly implemented in oceanic environments, it can be an important management practice for protecting Oregon's waterways from aquatic invasive species. This is particularly true for freshwater conditions like the Columbia River, where recent studies demonstrated that BWE and in-tank mortality removed more than 99.5% of high-risk organisms sourced from the freshwater port of Sacramento (Noble 2007). That said, for each voyage, a bulk carrier may intake as much as 40,000 m^3 of ballast water that consequently entrains approximately 400 million individual zooplankton Even a highly successful BWE resulting in a 99.5% reduction of coastal taxa will result in the discharge of millions of potential invaders at the destination port**.** Furthermore, ballast exchange leaves standing water and sediments in tanks that typically harbor a high number of organisms that are not removed from the tank. Table 1 shows results from a recent study in which vessel type was indicated as a probable reason for the wide range in efficacy values for BWE removal of zooplankton and phytoplankton taxa (Ruiz and Reid 2007). Oceanic BWE may be responsible for an order of magnitude decrease in planktonic species (Minton et al. 2005), and may be particularly effective at reducing the delivery of AIS to freshwater ports (Noble 2007). However, even under optimal BWE implementation, a de-ballasting vessel may still discharge millions of viable organisms into ports along its shipping route. For these reasons, BWE has long been recognized as an interim solution to reducing the risk of AIS introduction via ballast water discharge

Table 1. Plankton removal efficacy by mid-ocean ballast water exchange practices (from Ruiz and Reid 2007). The results of this study suggest that although the effectiveness of ballast water exchange can be relatively high under some conditions (e.g. bulk carrier vessels), the variability of its effectiveness (see range values) is cause for concern.

Vessel Type		**Zooplankton Removal**	**Phytoplankton Removal**
Container Ships (n=8)	*mean*	80.1	74.8
	median	84.0	86.0
	mode	98.0	95.0
	sd	21.4	26.5
	range	16 – 100	2 – 100
	# samples	41	23
USN Oiler (n=9)	*mean*	92.1	92.8
	median	97.0	95.5
	mode	97.0	100.0
	sd	13.3	8.6
	range	37 – 100	69 – 100
	# samples	46	48
Crude Oil Tankers (n=9)	*mean*	90.2	Not measured
	median	97.9	
	mode	100.0	
	sd	17.2	
	range	20 – 100	
	# samples	68	
Bulk Carrier (n=1)	*mean*	94.9	Not measured
	median	97.5	
	mode	100.0	
	sd	6.0	
	range	84 – 100	
	# samples	10	

Ultimately, treatment technologies are necessary eliminate ballast discharge as a source of biological invasions. While current federal law allows the USCG to approve the use of ballast treatment technology (BWT) with efficacy greater than or equal to ballast water exchange, high variability in vessel type and voyage characteristics have complicated and delayed the development and federal implementation of BWT. In response to a lack of progress at the federal level, California has enacted ballast treatment legislation, while multiple other states are actively pursuing similar measures (e.g. Michigan and Washington State). In order to further diminish ballast water related invasions, Oregon and other states throughout the region must promote the development of ballast treatment technologies that are suitable to industry operations and are sufficiently protective of the environment.

***Biofouling* –** Whereas ballast water transfer has become a relatively new shipping related pathway for AIS in the past 50 years, ship surfaces subject to fouling and wood boring organism have been a probable AIS vector for thousands of years. However, since the advent of steel-hulled ships and particularly the application of anti-fouling paints, fouling mediated introduction of AIS has been less of a focus compared to ballast water transfer. Since January 2003, the application of organotin-based anti-fouling paint systems has been banned by the IMO due to the harmful impacts of its active compounds on the marine environment. The IMO ban on applying or reapplying organotin-based anti-fouling paint systems began in January 2003. Since January 2008, ships may not bear any organotin compounds on their hulls or surfaces, or must have covered the non-complying organotin layer with a coating to prevent the toxic compounds from leaching into the environment. As new anti-fouling coatings are developed and vessels shift to different coatings with potentially lower efficacies at preventing biofouling, there are concerns that the risk of fouling mediated transport of AIS may increase (Nehring 2001). This concern has been evident at various international maritime and scientific conferences and has become a prominent topic of discussion for international, national, and state regulations.

C. Regional Considerations

Estuaries, in particular, appear to be vulnerable to bioinvasion likely due to concentrated human settlements and the high degree of shipping activity that often centers around these bays and harbors (Ruiz et al. 1997). Along the west coast, all major ports have been colonized by a significant number of marine and estuarine NIS, none more so than San Francisco (Figure 1). Cohen and Carlton (1998) identified the SF Bay as the most highly invaded estuary in the world, an ominous title that was further confirmed by a recent worldwide assessment of marine NIS (Molnar et al. 2008). While other ports have lower numbers of NIS than SF Bay at this time, coastal shipping traffic and close proximity between ports may increase the risk of secondary invasions of SF Bay NIS taxa to other waters throughout the Pacific Coast Region.

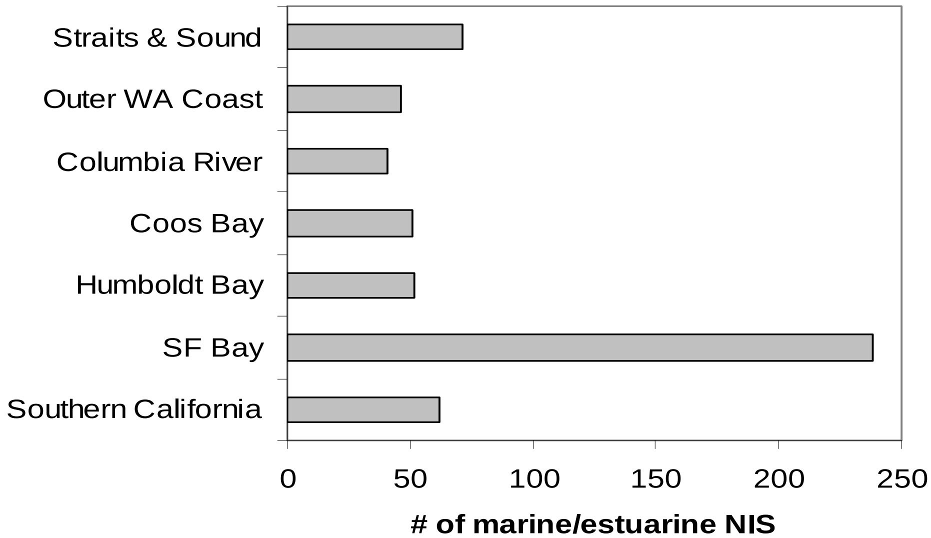

Figure 1. Number of non-indigenous species identified in seven coastal regions of the US West Coast (courtesy of Ian Davidson; based on USGS NIS database; Cohen and Carlton 1998; Wonham and Carlton 2005).

Despite substantially fewer vessel arrivals than other major ports along the west coast (e.g., Puget Sound, SF Bay, LA/Long Beach), the Columbia River is the recipient of a greater volume of annually discharged ballast than any other port on the west coast (Figure 2). As a result of a greater proportion of export commodities (e.g., grain, ore, and forest products) being shipped from ports in our region, many vessels calling upon the Columbia River arrive empty of cargo, but carry large volumes of ballast that are subsequently discharged in port during loading operations. The consequences of these actions along with other potential AIS pathways (e.g., aquaculture, recreational fisheries) were most recently documented in a 2001 survey of the lower Columbia River (Sytsma et al. 2004). Analyses of survey results reveal an apparent exponential rise in invertebrate NIS over the past 50 years, largely attributable to increased shipping traffic (Figure 3a-b).

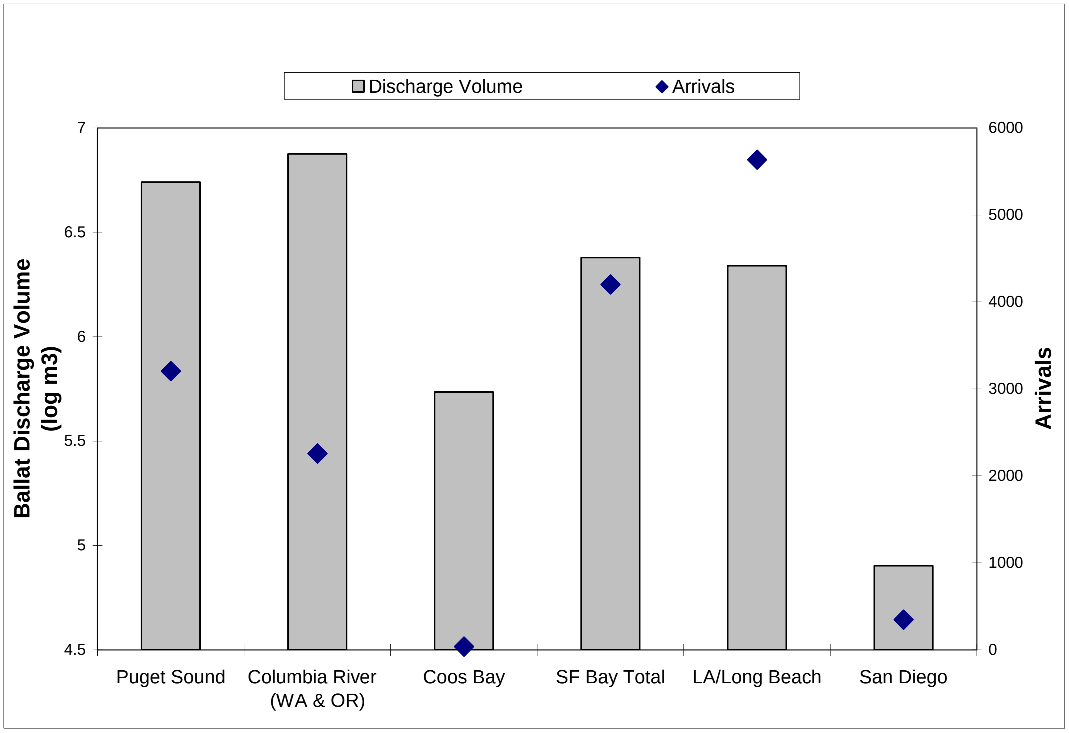

Figure 2. Comparison of vessel arrival and ballast discharge for six west coast ports in 2006 (Arrival data from MARAD; CA discharge data from CSLC 2007, and WA discharge data from PSAT 2007). Note that each integer on the log scale represents an order of magnitude increase, such that 5.0 corresponds to 100,000 m^3 and 6.5 represents 5,000,000 m^3.

While shipping transport and AIS have received modest attention in the Lower Columbia River since the Oregon Ballast Water Program began in 2002, even less attention has been paid to this issue in Coos Bay due to limited funding. Coos Bay receives a smaller fraction of total arrivals than the Columbia River, but multiple studies have implicated shipping transport as the probable pathway for numerous AIS established within the Coos Bay region (Carlton and Hodder 1996, Wonham and Carlton 2005, pers. comm. J. Chapman 2008). Like the Columbia River, Coos Bay receives significant volumes of ballast discharge despite its low number of arrivals relative to other west coast ports (Figure 2). Whereas Coos Bay receives roughly one tenth as many arrivals as San Diego (37 versus 346, respectively, in 2006), over six times as much ballast water is discharged in the Coos Bay Estuary. Unlike the Columbia River, however, Coos Bay is vulnerable to a different suite of AIS risk factors because its port facilities are primarily located in an estuarine environment rather than in freshwater habitats. A systematic survey of the Coos Bay environment, similar to the Sytsma et al. 2004 study of the lower Columbia River, would help address critical information gaps regarding the extent of biological invasions and the contributing factors.

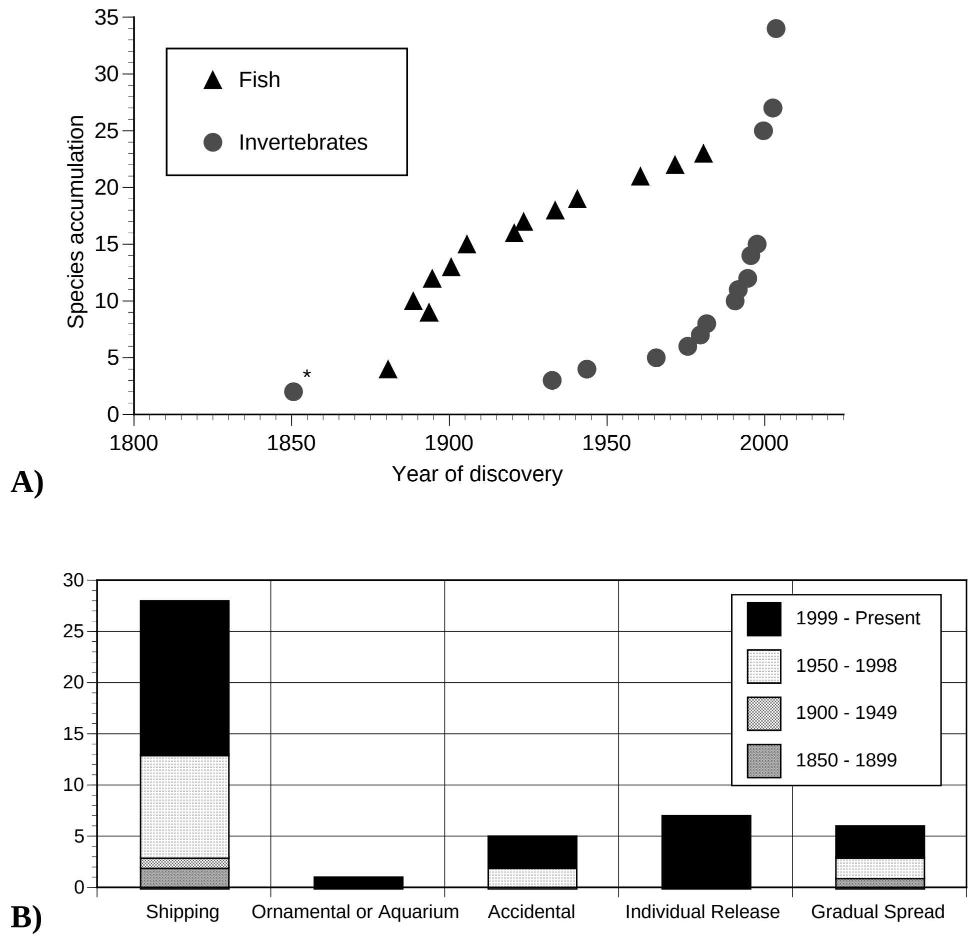

Figure 3. Non-indigenous species identified in the Lower Columbia River: a) Cumulative number of non-indigenous species by year of discovery, and b) Changes in invertebrate introduction vectors over time (courtesy of Sytsma et al. 2004).

II. PERTINENT LAWS & REGULATIONS

Vessels operating in west coast waters are subject to a combination of international, national, and state ballast water management regimes. Increasingly, regulations share several similarities at the international, US Federal, and state management levels (Figure 4) that are critical for creating a manageable regulatory environment for an industry with such widespread operations. For example, all jurisdictions currently allow oceanic exchange as an acceptable method of ballast water management, and most programs provide a safety clause exemption if a vessel and its crew are at risk from a proposed ballast exchange operation. While various new regulatory amendments are pending (see section 5c – Emerging Issues), regional efforts in recent years have aimed to eliminate programmatic differences that would otherwise create a regulatory patchwork, which ultimately create a barrier to industry compliance.

A. International

The International Maritime Organization (IMO) and member countries adopted the *International Convention for the Control and Management of Ships' Ballast Water and Sediments* in February of 2004. This convention requires all vessels to implement a ballast water and sediment management plan and identifies standards for treatment and exchange effectiveness. The standards specify strict limits on the number of organisms or microbe colonies permissible per unit of ballast water, whether discharged after undergoing exchange or alternative treatment. An implementation timeline is based upon vessel size and construction date, where ultimately all vessels will be required to meet the standards by 2016. The convention will go into effect 12 months after the convention is ratified by 30 countries representing 35% of the world's shipping tonnage (IMO 2006). As of June 2008, 14 countries representing 3.6% of the world shipping tonnage had ratified the convention.

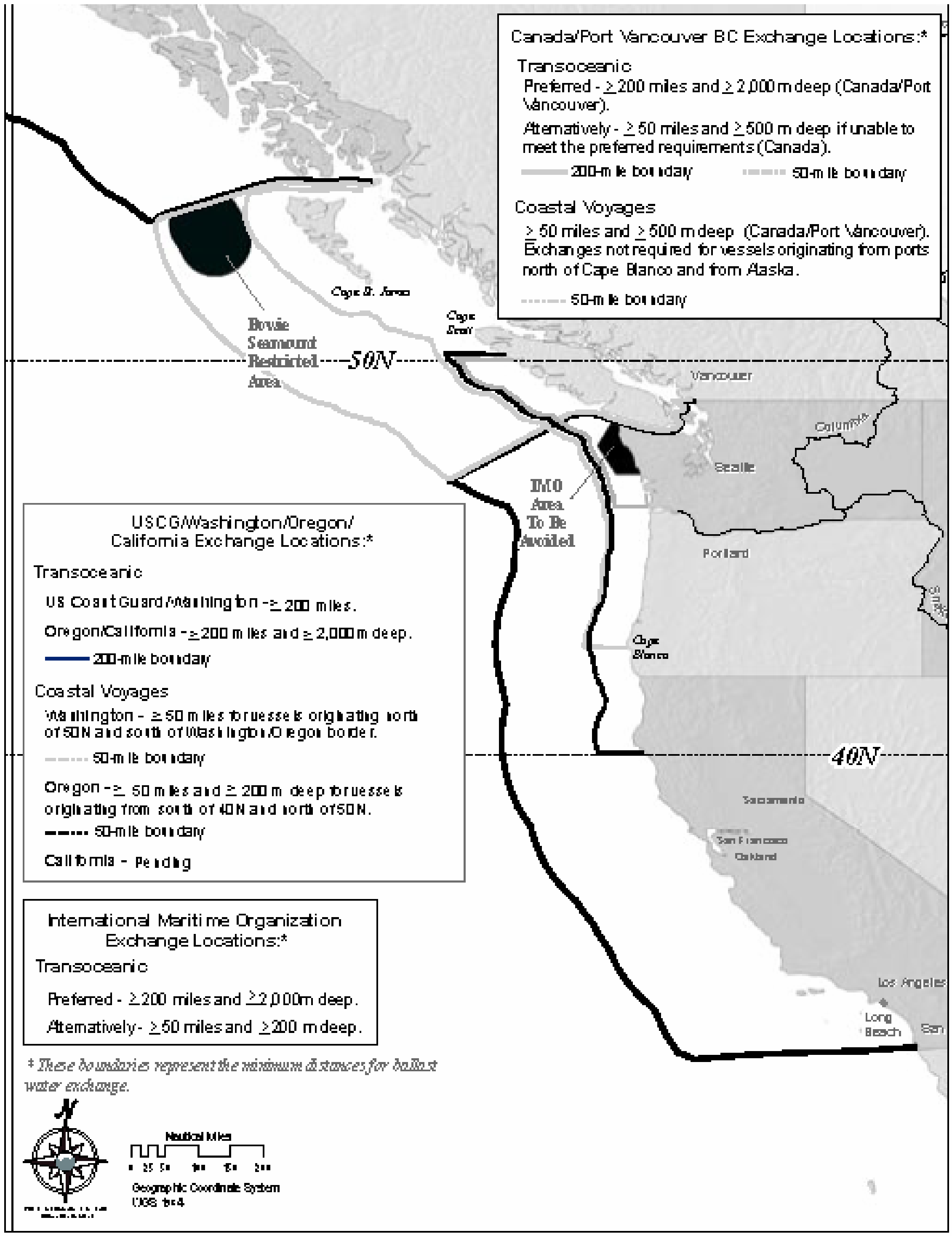

Figure 4. Map of Pacific Coast Region (courtesy of PSAT 2007. *Ballast Water Management In Washington State: Recommendations for Improvement.* March 2007. Puget Sound Action Team).

B. Canadian

Effective June 2006, the Canada Shipping Act implemented mandatory ballast water practices. The regulations require that all vessels arriving to Canadian ports with ballast water originating from outside of Canadian waters conduct open-ocean ballast exchange at least 200 nautical miles (nm) from shore where the depth is at least 2000 meters (m). Vessels discharging waters sourced from within the Economic Exclusion Zone (EEZ) must exchange ballast water at least 50 nm from shore where the depth is at least 500 m. These regulations allow for safety exemptions and require that all arrivals submit a ballast management report after completing exchange. The Act also adopts ballast water discharge standards identical to those proposed by the IMO Convention.

Beginning in 2008, Transport Canada, the Canadian government's agency responsible for ballast water management, dramatically increased its inspection and enforcement program. The Canadian government's investment of roughly $4.5 million over the next five years is aimed at protecting Canadian waters from ship-sourced biological pollution.

The province of British Columbia supports the federally mandated BWM program and has not established regulatory measures specific to the Pacific Coast region of Canada.

C. US Federal

The National Aquatic Nuisance Prevention and Control Act (NANPCA) was established in 1990 to reduce invasive species risks in the Great Lakes. NANPCA was later revised and expanded under the National Invasive Species Act (NISA) of 1996. In 2004, after five years of a voluntary ballast management program, the US Coast Guard established mandatory regulations governing ballast discharge from vessels entering the US waters from outside the US EEZ. For these vessels, ship operators are required to conduct mid-ocean ballast water exchanges at least 200 nm from shore where the depth is at least 200 m. There is no exchange requirement for vessels traveling 'coastally', or only within the 200 nm EEZ. Federal provisions do not require vessels to alter their voyage plan solely for performing a mid-ocean ballast exchange (e.g., vessels transiting from Mexican or other Central American locations may conduct their ballast exchange < 200 nm from shore if their voyage plan does not involve sailing outside the required range). The US Federal ballast regulations also allow for safety exemptions if weather or extraordinary equipment limitations put the crew or vessel at risk from conducting ballast exchange.

Vessel operators must submit federal ballast water management reports (Appendix B) to the National Ballast Information Clearinghouse (NBIC) located at the Smithsonian Environmental Research Center (SERC) in Edgewater, Maryland. Ballast Water reporting forms (BWRF) are required from all vessels arriving to a U.S. port or place from outside the U.S. EEZ and vessels traveling from one Captain of the Port (COTP) Zone (a USCG delineation for port systems in the U.S.) to another. There are five COTP Zones on the west coast: San Diego, Los Angeles/Long Beach, San Francisco Bay, Portland, and Puget Sound. The Portland COTP Zone encompasses all of Oregon and the Columbia River. Reports may be submitted electronically and must be received by the NBIC at least 24 hours prior to arrival

The USCG is responsible for enforcing ballast management regulations and regularly boards vessels to inspect various compliance measures, including ballast operations. USCG inspectors review ballast reporting forms to ensure that they were properly filled out, submitted and accurately reflects the vessel's ballast configuration. If inspectors suspect that a proper mid-ocean ballast exchange has not occurred, they may perform an expanded BWM examination where a salinity measurement is taken from a ballast water sample. The salinity readings may be used as indicator of noncompliance. Under the national program, the USCG can assess civil penalties up to $27,500 per violation as well as criminal penalties.

In recognition that ballast water exchange represents an incomplete solution to the challenges of ballast water management, the development of federal treatment standards and an implementation timeline for treatment technology have been anticipated since 2006. However, delays in this process have continued over the past two years and at the time this report was published, no further progress has been noted.

D. State Programs

Many states have adopted ballast water management regulations more comprehensive than federal requirements. In order to reduce industry concerns that a patchwork of regulations could ensue, some states have attempted to coordinate ballast water regulations on a regional basis. Specifically, the US mainland Pacific States (with the exception of Alaska) presently have uniform regulations with only minor variations (Appendix C) that require vessel operators of coast-wide/domestic voyages to conduct ballast exchange operations at least 50 nm offshore and report all ballast management practices to the state prior to arrival. This effort has largely been successful due to the organization of the Pacific Ballast Water Workgroup (PBWG) and support from the Pacific States Marine Fisheries Commission (PSMFC). In the absence of a more robust Federal Program, regional coordination may continue to be critical as states pursue more environmentally protective ballast management solutions, including the implementation of mandatory ballast treatment technology as an alternative to ballast water exchange.

The following describes ballast water management efforts by individual states, within the Pacific Coast Region and elsewhere, that may have implications for the Oregon program or may be impacted by possible changes to the federal program.

Washington **–** The Aquatic Nuisance Species Unit of the Washington Department of Fish and Wildlife (WDFW) administers the Washington State ballast water program. Since its onset in 2000, the Washington State program has required ballast management for both foreign and domestic/coastal voyage arrivals. The regulations require ballast exchange to occur at least 200 nm offshore for foreign arrivals and at least 50 nm offshore for coastal voyages. Note, that unlike the international and federal regulations, no depth requirements are established under the Washington regulations. Vessel operators may be exempt from BWE requirements for safety considerations, or if ballast contents solely originate from state waters, the Columbia River system, or internal waters of British Columbia south of 50N (PSAT 2007).

The WDFW ballast program receives state general funds that support 3.0 FTE dedicated to program management, vessel report tracking and vessel inspection efforts, as well as supplemental funds to support ballast sample analyses and ancillary AIS research and monitoring activities. Two vessel inspectors (one in Puget Sound and another in SW/Columbia River region) target high-risk vessels for boarding and ballast sampling. To verify proper BWE and to further research ballast water ecology, inspectors collect zooplankton samples that are later assessed for composition of coastal species. Washington has recently raised its penalties such that ships illegally discharging may be fined up to $27,500 per violation (PSAT 2007).

In response to delays in the development of federal ballast treatment standards, Washington was the first state to adopt standards and an implementation timeline that would provide vessels the option of using ballast treatment technology as an alternative to BWE prior to discharging into state waters (PSAT 2006). The Washington standards are based on percent reduction, and are therefore significantly different from standards that have been proposed by federal and international initiatives and those recently adopted in California (i.e., based on number of organisms per unit volume). The original target implementation date for the treatment option was July 1, 2003, but this has been postponed multiple times. Most recently, Washington's Ballast Water Work Group has determined that the discharge standard is not feasible for enforcement purposes since it requires knowing the original density of organisms prior to treatment. The Washington Ballast Water Work Group is currently working to revise its treatment standards so that they are based on the number of organisms per unit volume, and thus more readily enforceable and consistent with efforts by other jurisdictions (pers. comm. Allen Pleus, 2008).

***California* –** The California State Lands Commission administers the state's Marine Invasive Species Program, which was the first program on the west coast to implement mandatory ballast water regulations (2000). Originally, the program only required ballast water management for vessels arriving to California from outside the US EEZ. Effective in 2006, however, BWE is also required of vessels arriving to California ports from within the Pacific Coastal Region (approximately Cook Inlet, AK to Baja, Mexico). California and Oregon have identical definitions for coastal ballast exchange: 50 nm from land in waters at least 200 m deep. Vessel operators are exempt from BWE requirements if they are operating within common water zones of the state (Falkner et al. 2007).

The California Marine Invasive Species Act specifies that at least 25% of all arriving vessels be inspected for ballast management compliance. To achieve this goal, the program supports the activities of 13 vessel inspectors throughout the state. The entire program (including policy development, data management, vessel inspections, outreach, and support for various research initiatives) consists of 21 FTE and is supported by fees imposed on each vessel arriving from outside of state waters. Effective August 1, 2008, the fee has been raised from $400 to $625 USD per arrival. Violation of California ballast management regulations may result in civil penalties up to $27,500 per occurrence (Falkner et al. 2007).

In response to the need for effective ballast treatment (BWT) options, CSLC with the aid of its advisory panel, including industry, regulatory and research representatives, developed recommendations for BWT standards (Falkner et al. 2006). The ballast water standards determined by the advisory panel were submitted to the California legislature as majority recommendations with minority objections attached. The panel established a set of performance standards based on organism size class to be executed with a phased implementation schedule (similar to the IMO timeline) based on vessel size class and construction date (Appendix D). In addition, the panel established a final performance standard goal of zero detectable living organisms for all size classes to be achieved by 2020; a goal that may not be technological feasible. These standards were incorporated into the Coastal Ecosystems Protection Act of 2006 (SB 497) which was passed by the California Legislature and went into effect in October 2007.

In accordance with the Coastal Ecosystems Protection Act, CSLC has developed performance standards for the discharge of ballast water incorporating both interim and final performance standards that will be implemented on a graduated time schedule beginning January 2010 (Appendix D). The interim performance standards establish limits for the number of organisms for different functional groups (i.e., specific pathogenic bacteria and viruses) per unit volume that are permitted in discharged waters. The initial implementation date of January 2010 applies to newly constructed vessels less than 1500 metric tons. According to the graduated implementation schedule (Appendix

D), all vessels discharging ballast into California waters must meet performance standards by January 2016. Although ballast retention and discharge to reception facilities would be allowable under the CA law, most vessels intent on discharging ballast will need to implement on-board treatment technology in order to comply with the new standards.

***Hawaii* –** In October 2007, the Department of Land and Natural Resources adopted new rules to manage ballast discharge from vessels operating in Hawaiian waters. The regulations require a vessel specific management plan, advance reporting to the state, and mid-ocean BWE for any ballast originating from outside state waters.

***Alaska* –** Alaska does not have a formal program for the management of aquatic nuisance species in ballast water discharges. It relies on the U.S. Coast Guard to enforce national standards. The only Alaskan laws that deal specifically with ballast water discharges refer only to ballast water that contains chemical contaminants or sewage organisms. Alaska does have laws that regulate movement of biological organisms into and around the state but the ballast discharge pathway has not been specifically addressed.

***Great Lakes Region*–** In 2006, representatives from the St. Lawrence Seaway Development Corporation, Transport Canada, and the US Coast Guard Ninth Circuit formed the Great Lakes Ballast Water Working Group. As a result of their cooperation, new regulations were established in 2008 that require all 'NOBOB' ships (vessels declaring NO Ballast On Board) to engage in salt-water flushing of their ballast tanks prior to entering the Seaway. This regulation addresses concerns that 'NOBOB' ships still contain residual waters and sediment in their ballast tanks and represent a loophole in ballast regulations that increase the risk of introducing new NIS. Another result of the cooperative agreement has been increased inspection and ballast exchange verification where >95% of arrivals are inspected.

Beginning January 2007, the state of Michigan began a general permit issuance program to cover maritime operations and the discharge of ballast into state waters. The general permit requires ballast treatment systems for all ocean-going vessels intending to discharge in Michigan waters. The state has approved four treatments for use under the general permit, including sodium hypochlorite, chlorine dioxide, ultraviolet light, and de-oxygenation. Vessel operators may propose alternative ballast treatment options that may be cover under an individual permit. Although industry groups are challenging the Michigan regulations in US Court of Appeals for the Sixth Circuit, there is broad support amongst other states of the Great Lakes region, including Minnesota, Wisconsin, and New York, who are currently considering similar state ballast regulations.

III. OREGON BALLAST WATER PROGRAM

A. Background

In response to AIS threats posed by shipping activities, the 2001 Oregon Legislature passed SB 895 that authorized the Oregon Department of Environmental Quality (ODEQ) to implement and enforce ballast water regulations under the Oregon Ballast Water Program. The Oregon program evolved from meetings of the Pacific Ballast Water Group, an ad hoc organization of environmental groups, academic scientists, regulators and shipping industry representatives who began discussions in 1997 concerning west coast ballast management solutions. Modifications to the Oregon Ballast Water Program were made in 2003 (HB 3620), 2005 (HB2170), and 2007 (SB 643, 644). These modifications were primarily driven by the implementation of the Oregon Aquatic Nuisance Species Management Plan (ANSMP) and efforts of the Oregon Ballast Water Task Force (Vingograd and Sytsma 2002, Flynn and Sytsma 2004, Simkanin and Sytsma 2006).

Prior to late 2007, ODEQ had received no direct funding to manage and enforce the ballast water program. In response to the lack of funding at ODEQ, other interested parties contributed to data gathering and compliance monitoring for ballast operations in Oregon waters from 2002 - 2007. Specifically, the program was maintained by a Columbia River Steamship Operators grant to PSU (2002); WDFW data collection and monitoring efforts of Columbia River arrivals (2003 & 2004); and USCG pilot study funding to ABRPI/SERC (Jan 2005 to Apr 2007). During the 2007 legislative session, however, SB 644 was passed to provide 1.0 FTE general fund support to ODEQ for ballast program activities, resulting in the hire of a ballast program manager in October 2007. This newly created position is responsible for program development, policy analysis, vessel arrivals and report compliance monitoring, vessel inspections and ballast exchange verification sampling, enforcement actions, outreach and coordination, and providing staff support to the STAIS Task Force.

B. Rules and Regulations

Oregon's initial legislation, SB 895, addressed the ballast water invasion pathway at a time when national regulations for foreign vessel arrivals were voluntary. The states mandatory regulations require mid-ocean ballast exchange (200 nm offshore; 2000 m deep) for all vessels arriving from outside the US EEZ. Furthermore, the legislation established the first regulations aimed at reducing the risk of intra-coastal transfer of invasive species. As a result, domestic voyages within the US EEZ are required to exchange ballast at least 50 nm offshore in waters at least 200 m deep prior to discharge in Oregon waters. Similar coastal exchange requirements have since been adopted by Washington State and California.

The Oregon statute requires that all vessels submit a ballast water reporting form (BWRF, Appendix B) declaring their ballast management intentions at least 24 hours prior to arriving in state waters. The report is required whether or not the owner or operator plans to discharge ballast into the waters of the state. Since 2007 (SB 643), the regulations apply to all vessels greater than 300 gross tons equipped with ballast tanks (including barges), but does not apply to commercial fishing vessels. Vessel operators may submit their BWRF to the Portland Merchants Exchange who already receives various other reporting forms from vessel arrivals, and compiles BWRF's for delivery to ODEQ on a daily basis. If a vessel operator alters their ballast management practices for any reason after reporting its ballast management intentions to the state, the owner or operator must immediately submit an amended ballast water report. Civil penalties for a violation of reporting requirements may be up to $500 per occurrence.

Unexchanged ballast may only be discharged into state waters if extraordinary conditions (e.g. adverse weather, equipment failure, etc.) threaten the safety of the vessel or its crew, the vessel operator declares a safety exemption, or if the contents of the ballast solely originated from within 'common waters' of Oregon. Common waters for the state of Oregon are defined as coastal waters between 40N and 50N latitude. A vessel is also exempt from Oregon's BWE requirements if "discharged ballast water has been treated to remove organisms in a manner approved by the USCG" (ORS 783.630; Appendix A) However, no treatment standards or systems have yet established for use under the federal program. Current civil penalties for failure to comply with ballast discharge regulations may result in fines up to $5,000 for each violation.

The 2006 Ballast Water Task Force acknowledged that the development of ballast treatment systems is critical for developing management practices more protective than

BWE regulations currently provide (Simkanin and Sytsma 2006). However, due to substantial differences in standards adopted in Washington and California and the expectation that Federal standards would be released in 2006 or 2007, the Task Force did not recommend that the 2007 legislature pursue treatment standards for the state of Oregon. If sufficiently protective Federal standards were not in place by 2009, however, the Task Force recommended pursuing an Oregon standard that is complementary to neighboring states. This report reconfirms that recommendation.

C. Commercial Shipping Traffic in State Waters

Based on the information submitted by vessels in the required ballast water reporting forms, ODEQ is able to assess patterns of vessel traffic and ballast management practices. Approximately 2,250 vessel calls (arrivals) per year arrive at the six ports of the Columbia River (MARAD, 2002-2007; Figure 5a). Portland Harbor receives about 58% of the arrivals while Vancouver (WA), Longview (WA), Kalama (WA), Astoria, and Rainier receive the remaining 17%, 12%, 10%, 2%, and 1%, respectively (Figure 5b). With the exception of a moderate decline observed in 2003, vessel traffic in the Columbia River has been generally stable over the past six years (Figure 5a). In terms of seasonality, a greater number of vessels tend to arrive during the autumn months, corresponding with the export of seasonal products like grain whereas fewer vessels tend to arrive in the winter (Noble 2007).

Coos Bay, Oregon's second largest port, received an average of 47 vessels per year during the 2002-2007 time period (MARAD). Due to economic changes in the south coast region, a 40% decline in vessel arrivals was observed at this port during this six-year time period (Figure 5a).

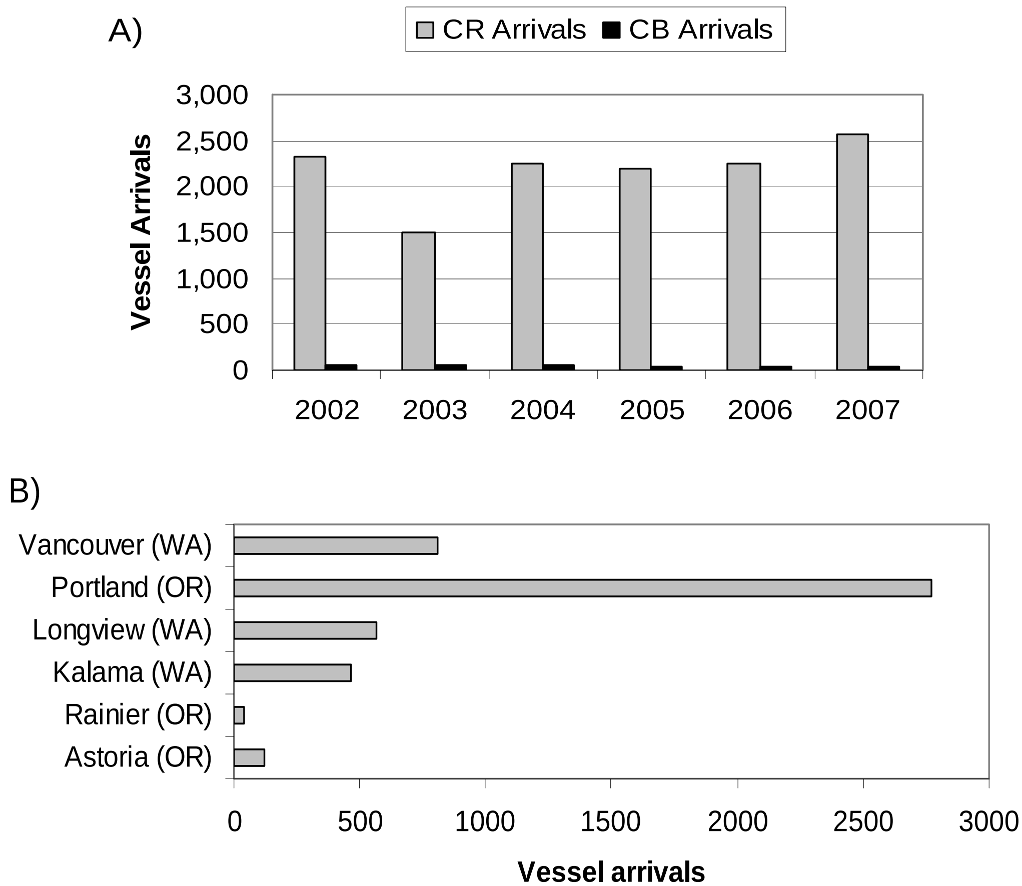

Figure 5. Vessel arrivals to Oregon waterways: A) 2002-2007 (CR; Oregon and Washington ports) and Coos Bay (CB) and B) Total arrivals to specific ports on the Columbia River from 2005-2007.

Fifty percent of the arrivals to Oregon waters are bulk carrier vessels, which routinely transport our region's exports to other regions around the globe. This type of vessel traffic, in particular, is of great concern for our AIS prevention efforts since they typically discharge substantial volumes of ballast water during cargo loading operations (see section D: Discharge Patterns in State Waters). In the Columbia River, other significant contributors to shipping traffic include vehicle carriers (18%), general cargo (11%), container (9%), and tankers (8%) (Figure 6a-b). Wood chip carriers, which are a specific type of bulk carrier, are the dominant vessel type arriving to Coos Bay (Figure 6c).

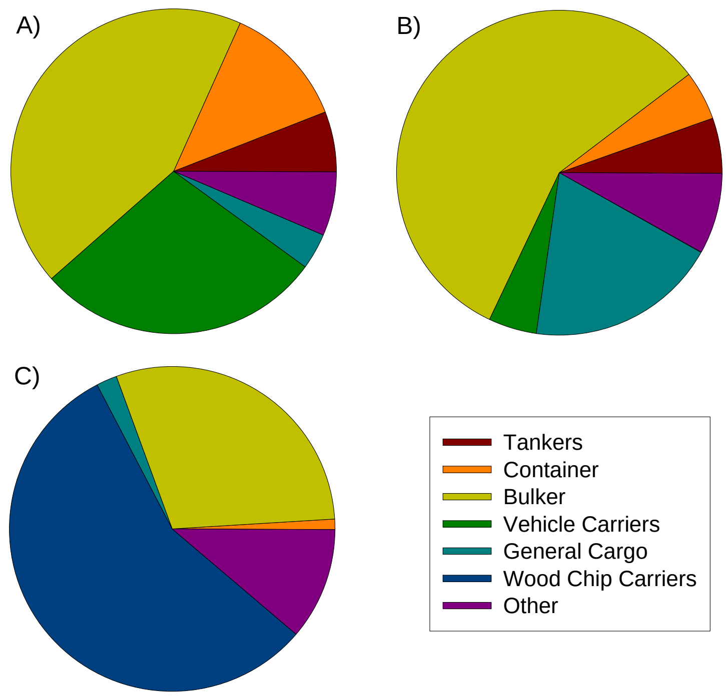

Figure 6. Proportion of arrivals by vessel type to: a) Oregon ports on the Columbia River, b) Washington ports on the Columbia River, and c) Coos Bay (2005-2007 average).

Analysis of ballast water reports received by the state and the NBIC from 2005-2007 reveal that nearly 52% of arrivals to Oregon waters are transoceanic voyages while 48% are coast wide traffic (Figure 7a-c). A vast majority of the transoceanic arrivals made their last port call in Asian countries such as Japan, South Korea, and China (together comprise 50% of all arrivals) whereas coastal voyages were primarily from California (16%), British Columbia (15%), Washington State (9%) and Latin America (5%) (Figure 8). In Coos Bay, a greater proportion of the arrivals are transoceanic (79%) compared to coast wide traffic (21%) (Figure 7c).

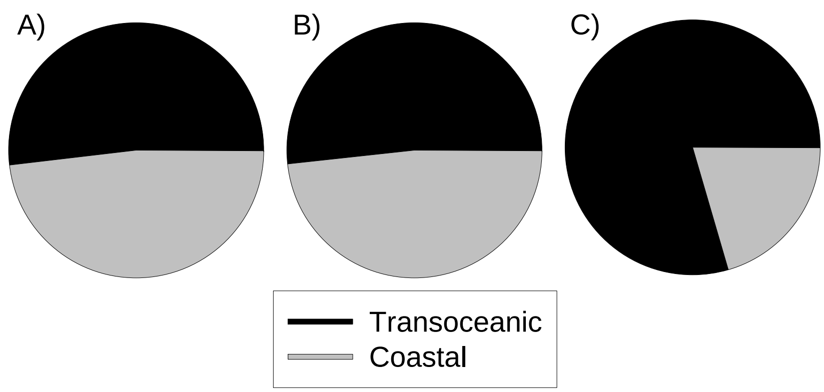

Figure 7. Voyage type (transoceanic or coast wide) for vessel arrivals to: a) Oregon ports on the Columbia River, b) Washington ports on the Columbia River, and c) Coos Bay (2005-2007 average).

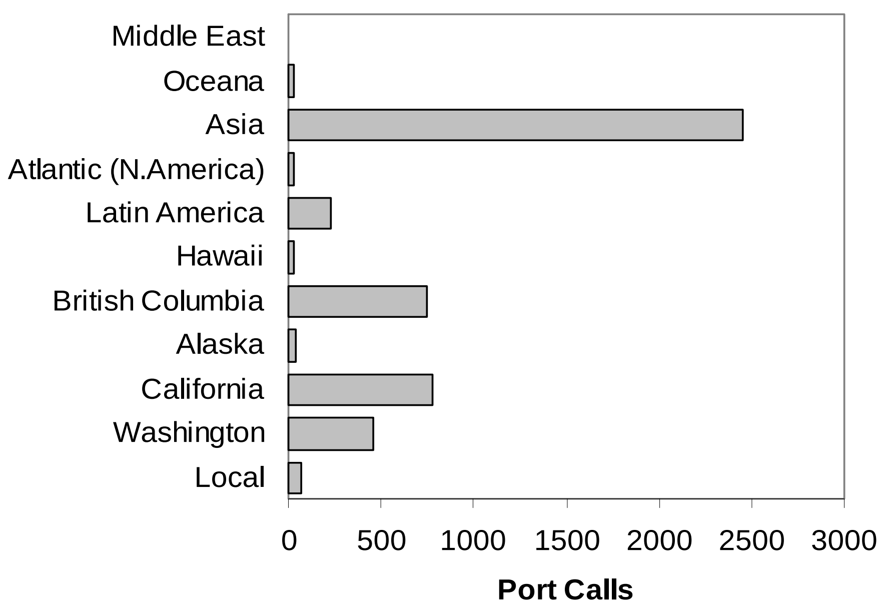

Figure 8. Last port of call for Columbia River arrivals (2005-2007).

D. Discharge Patterns in State Waters

The risk of NIS becoming established is influenced by various factors, including propagule pressure (i.e., quantity of NIS being released), condition of the propagules upon release, timing of inoculation, the health/stability of the receiving ecosystem, and the presence or absence of suitable resources to support colonization by specific taxa (Elton 1958, Ruiz et al. 2000, Kolar and Lodge 2001). The discharge of ballast water is a considerable AIS risk because not only may it release an abundance of NIS individuals into the receiving environment, but it also results in the transfer of entire ecological communities, including viruses, bacteria, phytoplankton, zooplankton, fish, and macrophytes (Carlton and Geller 1993, Ruiz et al. 2000). For these reasons, regulatory management of ballast discharge has focused on pathway management rather than a species-specific approach to managing individual AIS of greatest concern (Ruiz and Carlton 2003).

Retention of ballast water, or any operational practice that eliminates the need to discharge ballast into state waters, represents the most environmental protective management strategy available. In the Columbia River, roughly 50% of the vessel arrivals during the 2005-2007 time period operated without discharging ballast water while in port. However, ballast retention may not be feasible for many vessel arrivals due to cargo loading constraints and/or vessel design limitations. At Washington ports on the Columbia River, for example, a greater proportion of the arrivals tend to discharge compared to vessel activity on the Oregon side of the river (Figure 9a-b). In Coos Bay, the proportion of vessels discharging is even greater, making up approximately 78% of all arrivals (Figure 9c).

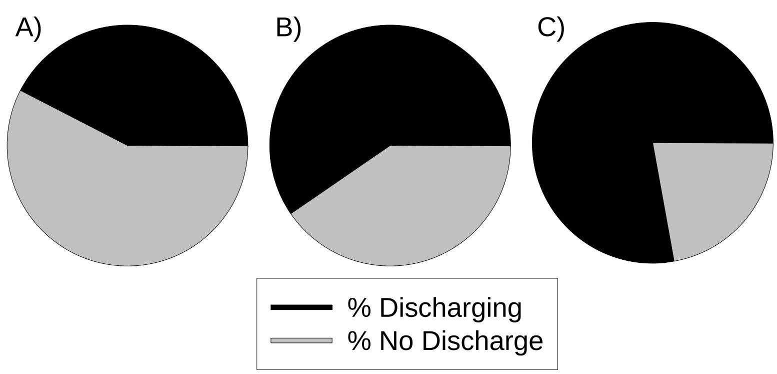

Figure 9. Discharge behavior (% vessel arrivals discharging vs. retaining ballast water) for arrivals to: a) Oregon ports on the Columbia River, b) Washington ports on the Columbia River, and c) Coos Bay (2005-2007 average).

Ballast water exchange (BWE) aims to reduce not only the absolute quantity of organisms being released, but also specific types of coastal and freshwater species more likely to survive upon discharge in a port environment. BWE is estimated to reduce the quantity of coastal zooplankton discharged by one order of magnitude (Minton et al.

2005). Theoretically, most of the organisms present in tanks after BWE are accustomed to higher salinity or open ocean conditions rather than the environments more commonly observed in ports, and therefore have a lower probability of survival upon discharge. However, even after an order of magnitude reduction in propagules following BWE (Minton et al. 2005, Ruiz and Reid 2007), approximately two million zooplankton (and approximately 200 billion phytoplankton) may still be released from a typical bulk carrier that discharges 40,000 m3.

Over the course of the Oregon Ballast Water Program's six year history, the reported volume of ballast water discharged into the Columbia River has increased from about 5.5 to nearly 8.0 million metric tones (MT, Figure 10a). Because the total number of arrivals in Oregon have remained relatively constant (Vinograd and Sytsma 2002, Simkanin & Sytsma 2006), the progressive increase in declared ballast discharge may be attributed to increased compliance and greater accuracy of ballast management reporting. In Coos Bay, data were only available since 2005; despite a decrease in vessel arrivals (Figure 5a), reported discharge has remained relatively stable (Figure 10b).

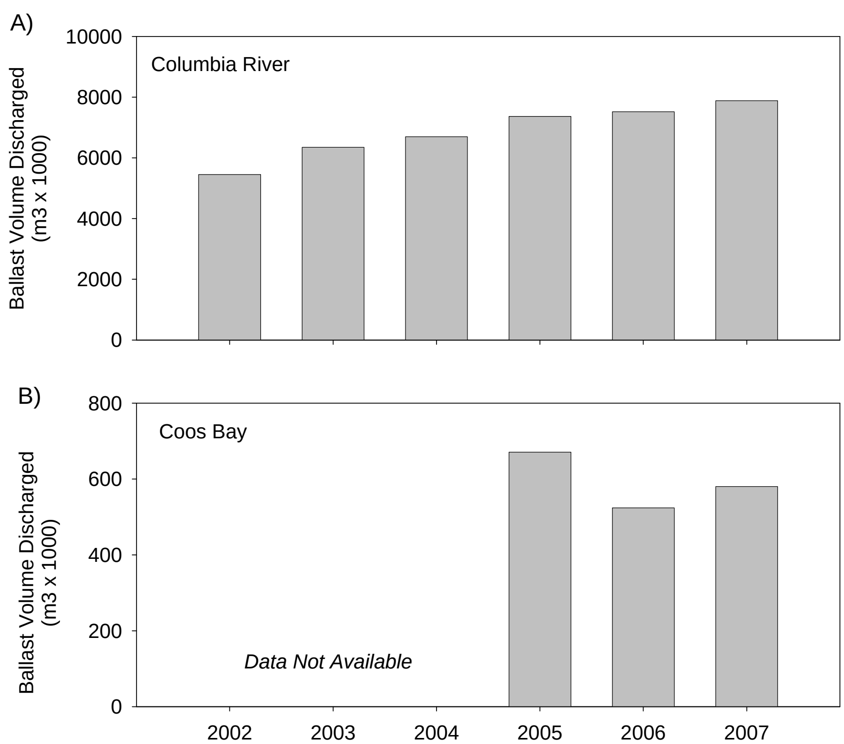

Figure 10. Annual ballast discharge from vessel arrivals to: a) Columbia River (OR and WA ports combined) and b) Coos Bay. (Note the order of magnitude difference on scale bars between the two figures).

Figure 11 shows the average discharge per arrival for six vessel type categories arriving to Oregon waters during the 2005-2007 time period. An average bulk carrier operating in Oregon waters discharges over 9,000 m^3 per voyage arrival, roughly equivalent to the volume of 3.5 Olympic sized swimming pools (Figure 11). While some bulk carrier arrivals may discharge little or no ballast, others often result in the discharge of more than 20,000 m^3. This class of vessels was the source for 92% of all ballast water discharged into the Columbia River from 2005-2007 (Figure 12a).

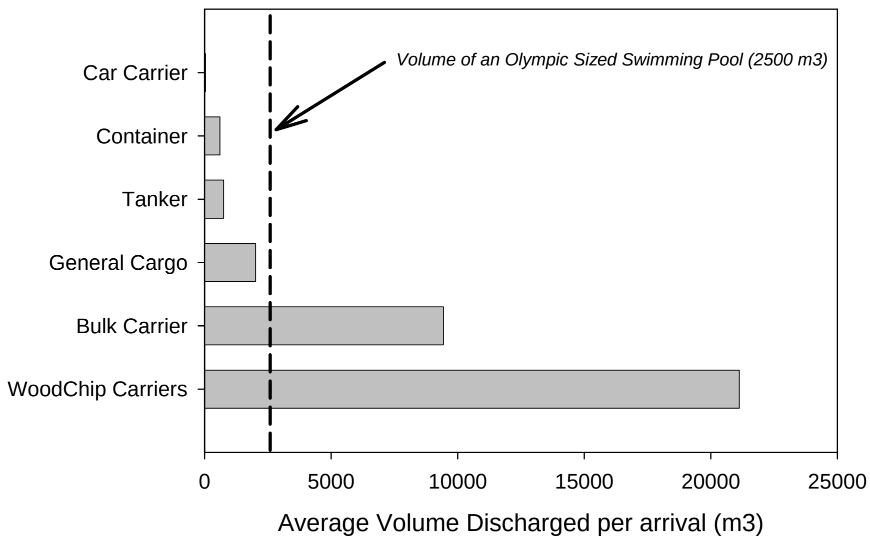

Figure 11. Average discharge per vessel type for vessels entering state waters (2005-2007).

Relative to a comparatively small number of vessel arrivals, Coos Bay is the recipient of a significant volume of discharged ballast water (Figures 2, 9). This risk pattern is largely attributed to the dominance of woodchip vessels, a specific type of bulk carrier that regularly provides services to the natural resource export sector of the south coast economy. The average woodchip carriers calling on Coos Bay port discharges 21,000 m^3 of ballast water (Figure 11). Due to the large ballast discharge demands of operating these vessels, over two-thirds (67.2%) of the ballast discharged into Coos Bay comes from woodchip carrier operations (Figure 12b).

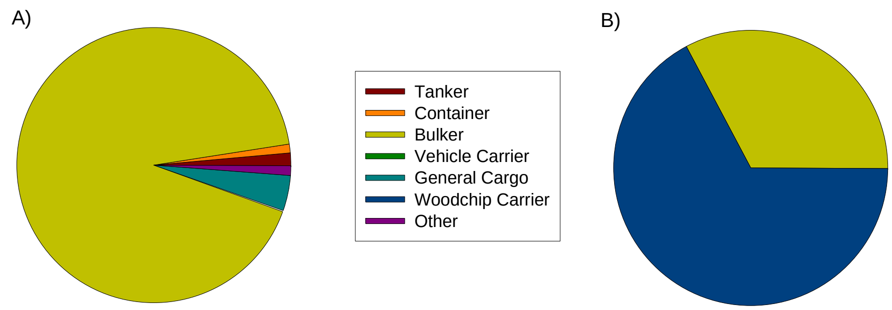

Figure 12. Proportion of total ballast discharged by vessel type in: a) Columbia River (OR and WA ports combined) and b) Coos Bay (2005-2007).

Figure 13a demonstrates the hypothetical origin of over 24.5 million m^3 of ballast water that would have been discharged into Oregon waters between 2005 and 2007 if BWE practices were not implemented. Since a single cubic meter, or one MT, of coastal marine water contains approximately 4,000 – 40,000 living animals (not including single celled bacteria and viruses), ballast discharge constitutes a considerable environmental threat. In the case of the Columbia River, over 75% of this 'hypothetical' discharge would have been sourced from Asian coastal waters (Figure 13a). Analyses by Noble (2007) further suggest that 75% of ballast discharged into the Columbia River was originally taken on at marine ports, 17% was from ports in estuarine conditions, 5% was from a riverine ports, and 3% came from unknown locations. However, based on BWRF data received by the state between 2005 and 2007, the implementation of ballast regulations, along with shipping industry efforts, have resulted in a 96.6% reduction in discharge of coastally derived ballast water (Fig 13b). Instead of ballast waters sourced from ports outside of our region, 23.8 million m^3 of ballast discharged into Oregon waters had undergone oceanic exchange (or flushing) management practices. Although mid-ocean exchange clearly represents a reduction in risk, ballast tank design does not allow for 100% removal or exchange of the high risk waters, and represents a significant operational expense for vessel operators. Thus, BWT remains an important goal for vessel operators and for the sake of environmental protection.

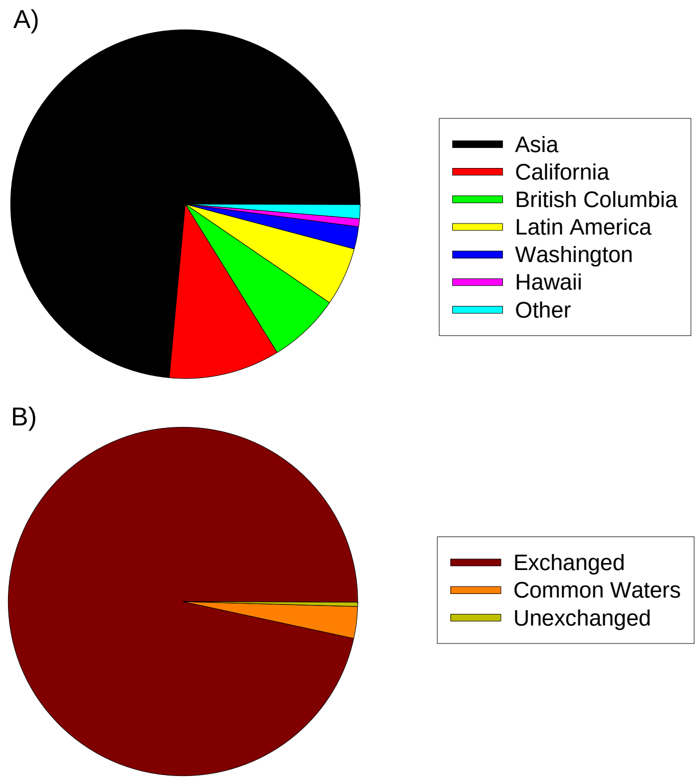

Figure 13. Comparison of discharged ballast characteristics in the presence and absence of ballast management practices. a) hypothetical source of discharged ballast based on last port of call (in the absence of ballast management practices) and b) management practices imposed upon ballast contents prior to discharge according to ballast reporting forms submitted to the state.

Of the 765,221 m^3 of 'unexchanged' ballast water discharged into state waters from 2005-2007, 87.7% was from a 'common water' source along the Pacific Coast (between 40N and 50N), and thus was not required by Oregon law to undergo BWE (Figure 13b). Of the remaining 94,122 m^3 discharged, 85% was from ports in California, 9% from northern British Columbia and Alaska, 4% from the Gulf/Atlantic region, and only 4% from foreign ports.

E. Compliance

Since the beginning of the program in 2002, reporting compliance has been largely dependent upon the resources devoted to local follow-up efforts with local shipping agents. Initially, monitoring efforts by a PSU graduate student showed 98.5% compliance for Columbia River arrivals during the first 10 months after implementation of the states requirements (Vinograd and Sytsma 2002). However, during 2003-2004 no funding was available to support local follow-up efforts directed at contacting local shipping agents when reports were missing. As a result, dramatically reduced compliance (78%) was observed from 2003-2004 (Simkanin and Sytsma 2006). Resources were re-dedicated to compliance monitoring beginning in May 2005, as part of a joint reporting pilot study between ABRPI and NBIC. In addition to identifying opportunities to streamline monitoring efforts and reduce duplication of effort in data processing, the local follow-up resulting from the pilot studies helped reduce the missing report rate for Columbia River arrivals to 6.2% for May 2005 to Apr 2007 (Figure 14; Simkanin & Sytsma 2006). Following the termination of the pilot study in April 2007, reporting compliance declined once again (Figure 14). However, beginning in November 2007, funding commenced for ODEQ staff to support ballast water program management activities and during 2008, the percentage of reports missing for arrivals to Oregon ports has been reduced to <5% (Figure 15a-b).

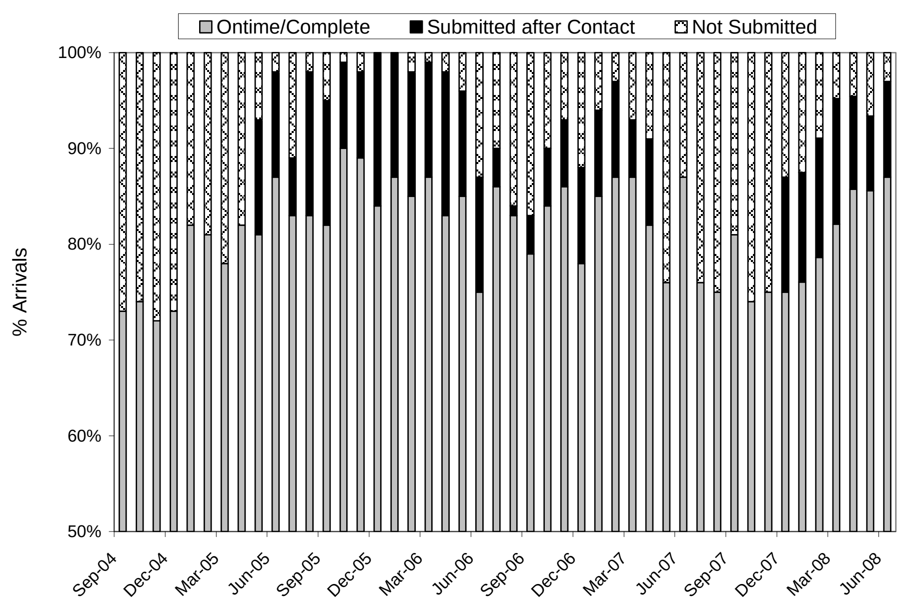

Figure 14. Monthly reporting compliance rates for vessel arrivals to the Columbia River (all ports - OR and WA combined).

Currently, ballast management reports for ships arriving to Oregon waters must be submitted to the Portland Merchants Exchange at least 24 hours prior to arrival, as well as the National Ballast Information Clearinghouse (NBIC). The Merchants Exchange forwards BWRF's to Oregon DEQ where arrival information is entered into a database and compared with vessel arrival schedules for Columbia River and Coos Bay ports. Vessels arriving to Washington ports on the Columbia River may submit their reports to the state by sending them to the Portland Merchants Exchange (PDXMEX) or directly to Washington Department of Fish and Wildlife. This difference in reporting requirements may complicate our ability to track reporting compliance in the Columbia River since ODEQ may not receive notice when vessel operators send reports exclusively to WDFW. In other words, recent reporting compliance estimates for the Columbia River may be conservative since some of the 'missing' reports may pertain to arrivals at Washington ports for which vessel operators submitted directly to WDFW rather than the PDXMEX, which acts as a 3rd party conduit between Washington and Oregon (Figures 14, 15a). In addition, interstate vessel traffic between ports on the Columbia further complicates monitoring of vessel compliance in a bi-state environment.

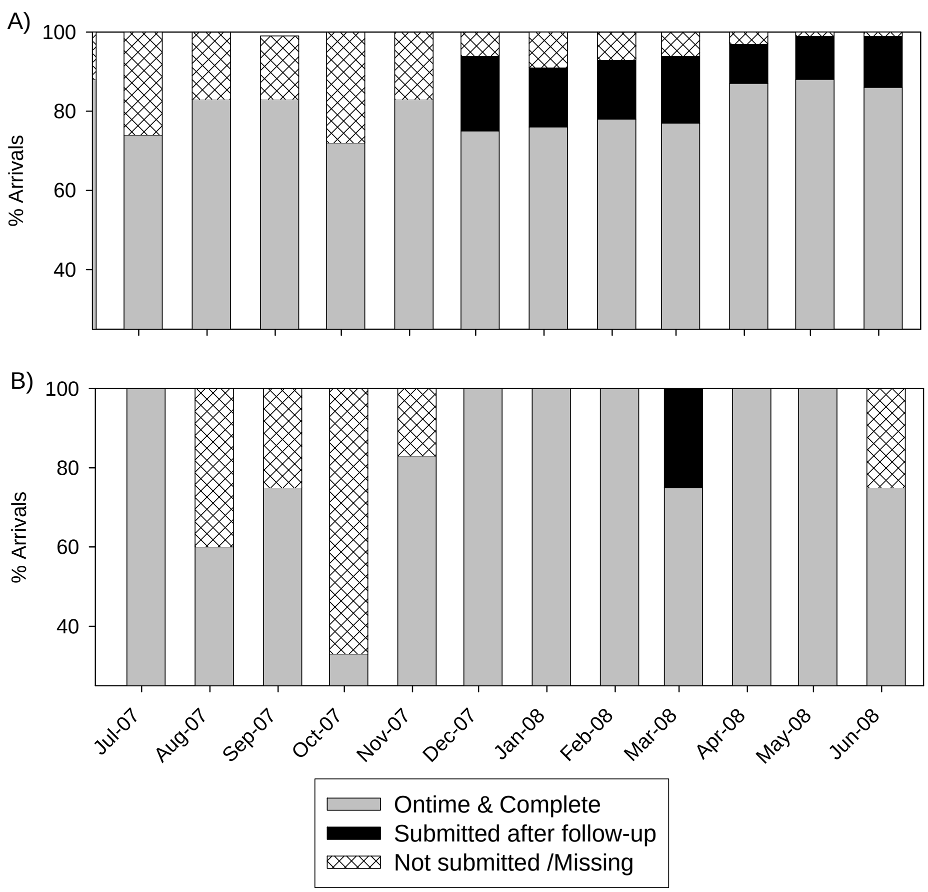

Figure 15. Monthly reporting compliance rates for vessel arrivals to: A) OR ports on the Columbia River and B) Coos Bay.

Between December 2007 and June 2008, the percentage of arrivals at Oregon ports on the Columbia River that were submitted on time and complete averaged 81%. In contrast, the percentage of arrivals that failed to submit reports was 4.7%, but was further reduced to 1% during May and June (Figure 15a). For the remainder of arrivals, reports were received by the state only after local follow-up efforts were pursued with local shipping agents and/or vessel operators. Coos Bay monthly reporting compliance during the same time period was typically 100% on time and complete, with the exception of one report submitted late after follow-up in March 2008, and one report missing for June 2008 (Figure 15b).

F. Inspection & Enforcement Actions

The recent increases in reporting compliance are largely attributed to local follow-up and outreach with shipping agents via phone or email when ballast water reports have not been received by ODEQ. Figure 16 identifies the number of follow-up contacts pursued each month since the program has been implemented by ODEQ in November 2007. Due to increased reporting compliance observed since April 2008, the number of follow-up cases per month has predictably declined.

In order to increase regulatory compliance and further prevent AIS from entering our waterways, additional outreach and enforcement efforts have recently been implemented (Figure 16). Periodic ODEQ inspection of ballast water reports (2-3 times per month) identifies the intent of vessel operators to perform non-compliant discharge while in Oregon waters. In some cases, a BWE had occurred but at an insufficient distance from shore (i.e., < 200 nm for an oceanic voyage) or a vessel operator may have erroneously filled out the BWRF. In any of these instances, ODEQ establishes contact with the local shipping agent and vessel operator (if possible) to communicate the problem and seek resolution. Non-compliant discharge was identified in four cases since March 2008, and warning letters were subsequently issued to vessel owners (Figure 16).

In 2008, ODEQ staff initiated vessel boarding and inspection efforts to facilitate greater understanding of our ballast management regulations and to assist vessel operators in achieving greater compliance and transparency in their ballast operations and bookkeeping. Inspections typically target vessels that have failed to submit BWRF prior to arrival or have submitted suspect data on the form. In addition, ODEQ staff are developing criteria to prioritize high-risk arrivals for boarding and inspection (e.g., last port of call characteristics and similarity to environmental characteristics at location of anticipated discharge). Inspection protocols are focused on an audit of bookkeeping records to ensure that various shipboard logbooks (i.e., ballast logbook, deck logbook) catalog ballast management practices that are consistent with one another and with the information submitted to the state on the BWRF. During the first half of 2008, 17 vessels were boarded by ODEQ for ballast water inspections, representing 2.5% of the 703 arrivals to Oregon ports. The monthly inspection rate was greatest in May 2008 when 5.8% (n=6) of the Oregon arrivals were inspected (Figure 16).

Beginning in autumn 2008, the inspection protocols will include sampling ballast tanks for verifying ballast exchange practices (Appendix E). Since ODEQ began inspection efforts in early 2008 there have been no incidents where vessel operators have resisted inspection efforts. However, ORS 783.640 does not articulate explicit authority for ODEQ boardings and inspections. In light of future plans for ballast verification sampling, an amendment to the statute is advised.

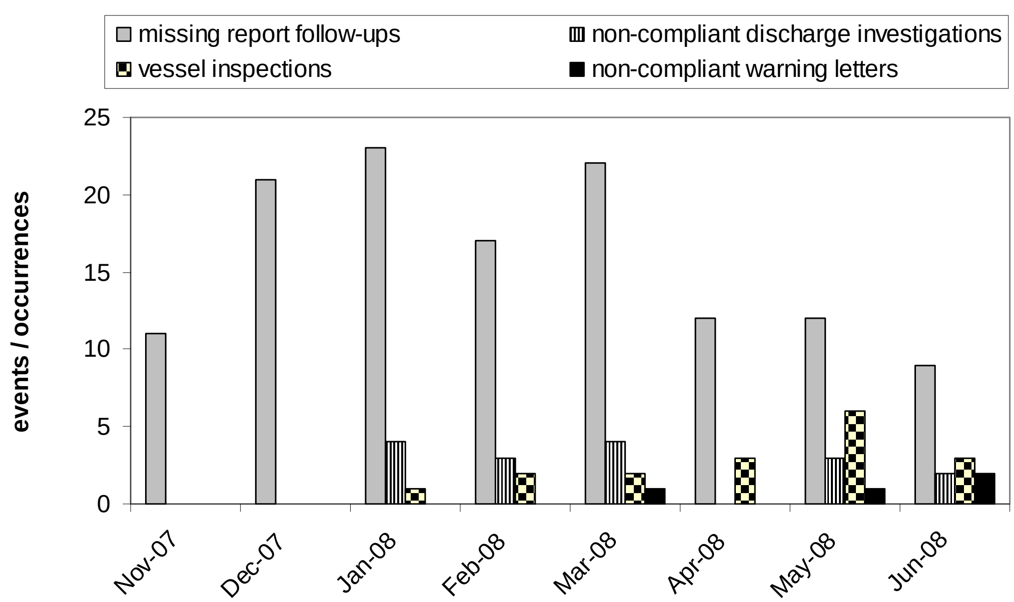

Figure 16. Summary of monthly enforcement efforts and activities by the ODEQ Ballast Water Program.

IV. NON-BALLAST PATHWAYS & MANAGEMENT OPTIONS

A. Background

Although recent decades have seen considerable progress in AIS risk reduction associated with ballast water transfer from shipping operations, far less attention has been directed at biofouling, which is a shipping related AIS vector of long-standing historic importance. Fouling is the process by which sessile, or non-motile, macrophytes and invertebrates attach to submerged objects, both naturally occurring and manmade. As individuals from various taxonomic groups accumulate on submerged ship hulls, the vessel surface becomes a thriving biological community that travels with the ship. Individual organisms may break loose from the ship's surface or release reproductive offspring into a suitable environment, enabling a new population to establish itself outside of the species' historic range.

The potential for hull fouling as a dispersal vector of marine species has been recognized since the mid-1800's (Darwin 1854). Presumably, ships have carried organisms on and in their wooden hulls for as long as shipping navigation has been active (Carlton and Hodder 1996). In the late-1800's, iron hulled ships began replacing most wooden ships and generally resulted in less opportunity for certain types of fouling organisms (e.g., wood boring mollusks and annelids), but biofouling remained a noticeable problem for mariners (Ostenfeld 1908). Ship operators have long been aware of the negative impacts of biofouling on vessel performance, particularly fuel efficiency, and will periodically have their hull cleaned to lessen the drag from accumulated organisms. To further lessen hull-fouling and of the need for cleaning operations, biocidal anti-fouling paints have been applied to the bottoms of ships for many decades. Traditionally, these paints slowly leach toxic compounds into the water, killing any living organisms that attempt to colonize the ship's hull. Increased evidence documenting the harmful indirect and cumulative effects of these persistent compounds in the marine environment have resulted in recent bans on the use of the most effective anti-fouling paints (e.g., tributyltin or TBT). In the wake of a ban on these paints, there has been a renewed concern about increased biofouling and a growing need to identify replacement paints that can effectively kill fouling organisms without introducing more harmful compounds to the environment. Due to this growing concern for a potential increase in hull-fouling mediated AIS introductions, the 2007 Oregon Legislature expanded the scope of the formerly named Ballast Water Task Force, by directing the current STAIS Task Force to study and make recommendations for combating not just ballast water but any shipping related vector that may increase the risk of AIS in Oregon waterways.

B. Factors influencing hull-mediated invasion risk

In general, there are four reasons why hull-fouling mediated AIS introductions have decreased since the mid 1900's (Coutts 1999, Ruiz et al. 2004, Davidson et al. 2006). First, wooden ships have become far less common, reducing the complexity of vessel substrate, which contributes to greater biofouling opportunities. Second, average ship speeds have increased. The increased laminar velocity flow is both a deterrent to settlement and discourages the persistence and longevity of organisms as they grow and differentiate. Third, harbor residence times have decreased, which limits the ship's exposure to the diverse array of fouling organisms that thrive in coastal regions. And last, highly effective anti-fouling paints have routinely been applied to ship hulls. On the other hand, some research suggests that faster voyages between ports, improved water quality in harbors, infrastructure alterations to harbor design, and recent regulatory changes in antifouling paint use have all combined in a manner that could potentially increase the likelihood of NIS establishment (Nehring 2001, Floerl and Inglis 2003, Minchin and Gollasch 2003).

A complex suite of factors influences biofouling mediated transfer of AIS. These factors include, but are not limited to: hull surface area and complexity, environmental characteristics of voyage routes and ports-of-call, vessel speed, voyage duration, harbor residence times, methods and regularity of hull maintenance, and implementation of preventative measures (e.g., antifouling paints) (Coutts 1999, Ruiz et al. 2004, Davidson et al. 2006). Combined, these factors determine the probability of whether an organism may colonize a ship's surface, survive translocation from its native habitat to a recipient location, and then 'successfully' establish a viable reproducing population in a distant port. Since data are not available to quantify many of these variables, the most commonly used metric to assess biofouling risk from shipping related transport is 'wetted surface area' (WSA), which simply represents the calculated area of a ship's exterior hull that could be colonized by fouling organisms.

C. Existing management initiatives related to vessel fouling

Table 2 summarizes various regulations, management actions and guidelines that seek to minimize AIS introduction through biofouling in various jurisdictions (adapted from Takata et al. 2006). Currently, no country has adopted national regulations that explicitly aim to prevent biofouling introductions from commercial shipping transport. However, various state/provincial jurisdictions, as well as international organizations, have developed (or proposed) measures to decrease risk of transferring AIS via biofouling.

The IMO produced the International Convention on the Control of Harmful Anti-fouling Systems in 2001, which aims to ban the use of ship hull anti fouling systems that are environmentally damaging (IMO 2004). In addition to the ban on organotin based anti-fouling paints, which began in January 2008, all internationally sailing ships over 400 gross tons must keep onboard a 'Declaration on Anti-fouling Systems' that identifies vessel specific methods and materials that are being used. The IMO and its participating countries have devoted considerable attention to this topic in recent years, including the sponsorship of conferences and symposia dedicated to biofouling concerns (e.g., International Conference on Biofouling and Ballast Management in Goa, India, February 2008).

Although Australia has not established national regulations related to biofouling on vessels larger than 25 m, all of the country's states and territories have implemented regulations that prohibit in-water cleaning of commercial vessels. Most of these regulations are direct variants of codes of practice that were developed by the Australian and New Zealand Environmental Conservation Council (ANZECC 1997). New Zealand regulates ship-mediated transfer of AIS under its 1993 Biosecurity Act. Presently, government regulators are accumulating more information on hull-husbandry practices from questions added to their ballast water declaration reporting forms, while voluntary codes of practice are encouraged amongst the shipping fleet.

In the US, federal ballast regulations require vessels to rinse anchor chains and anchors at place of origin. Additionally, vessels are directed to remove fouling from hulls, piping and tanks on a 'regular basis.' The only states that have statutes addressing hull-fouling concerns are California and Hawaii.

Statutory language in California is nearly identical to federal regulations in requiring 'regular cleaning' of hulls and vessel niche areas (e.g. sea chests) where biofouling may accumulate. However, Assembly Bill 740 was signed into law in October 2007, requiring the CSLC to develop and adopt regulations explicit to hull fouling management by 2012. In addition to supporting various biofouling research studies, CSLC has also implemented a mandatory annual hull-husbandry reporting requirement for all commercial vessels. The information acquired from the survey forms will assist the commission in developing management practices that will likely include a more explicit definition of 'regular' hull cleaning intervals (Takata et al. 2006, Falkner et al. 2007).

Hawaii has implemented a framework for targeting high-risk vessels that is currently under consideration for legislative approval. If approved, the management guidelines would establish pro-active measures for monitoring and detection, re-active measures to respond to high-risk events/arrivals, and post-event measures that may include vessel quarantines and mandatory out-of-water cleaning.

In 2007, the Oregon State legislature passed legislation that prohibits performing shipbreaking activities in a manner that would allow fouling organisms that are in or on the ship to enter the waters of the state (ORS 783.400). This initiative was primarily motivated by a proposal aimed at towing obsolete ships from the Naval Reserve Fleet in Suisun Bay, CA to Oregon waters for shipbreaking operations. Also, the presence of anti-fouling paints containing heavy metals may prohibit a vessel's ability to conduct in-water cleanings within Oregon waterways unless an NPDES permit has been issued under provisions of the Clean Water Act (pers. comm. Larry Knudsen, OR DOJ).

Table 2. Summary of Current Management Frameworks for Vessel Fouling. Various regulations, proposed management actions, recommendations, guidelines, and codes of practice aimed towards preventing vessel mediate introductions of biofouling NIS (Modified from Takata et al. 2006).

Jurisdiction or Organization	Management Strategy	Details
U.S. Federal	Embedded in ballast water regulation	Rinse anchor chains and anchors at place of origin Remove fouling from hull, piping and tanks on a regular basis. Dispose wastes in accordance with local, state, and federal law.
California	Embedded in ballast water statute	Rinse anchor chains and anchors at place of origin Remove fouling from hull, piping and tanks on a regular basis. Dispose wastes in accordance with local, state, and federal law.
	Survey & Research Develop Rules (AB 740)	Conduct mandatory hull-husbandry vessel survey and conduct other biofouling research to inform future rulemaking and implementation of AB 740
Hawaii	Information Framework Targeting High Risk Vessels (Proposed)	Pro-active measures: Education/outreach, vessel arrival monitoring, evaluation for high-risk arrivals (See Figure VI.1.) Re-active measures: Rapid response/investigation of high risk event Post-event measures: Long term regulations for high-risk events • Limit time in port • Vessel quarantine • Out of water cleaning
New Zealand	Survey (On Ballast Water Declaration Form)	1. When and where was the vessel last dry-docked and cleaned? 2. Has the vessel been laid-up for 3 months or more since it was last dry-docked and cleaned? If YES, state when and where. (Also requests start and end date laid up) 3. Do you intend to clean the hull of the vessel in New Zealand? If YES, state when and where
	Voluntary Codes of Practice (Fishing Industry)	Chartered foreign owned or sourced fishing vessels must be substantially free from plant or animal growth prior to entering New Zealand's EEZ. If no assurance, vessel inspected and cleaned before departure. Otherwise inspected in NZ and if necessary, fouling removed so no foreign organisms enter the marine environment

Table 2 (cont.). Summary of Current Management Frameworks for Vessel Fouling. Various regulations, proposed management actions, recommendations, guidelines, and codes of practice aimed towards preventing vessel mediate introductions of biofouling NIS (Modified from CSLC 2006).

Country or Organization	Management Strategy	Details
Australia	Prohibition (States/Territories/ Ports)	States & territories prohibit in-water cleaning. Many require containment and disposal regulations of fouling debris removed during out-of-water cleaning.
Australia and New Zealand Environmental Conservation Council (ANZECC)	Codes of Practice	In-water hull cleaning prohibited, except under extraordinary circumstances. Sea-chests, sea suction grids, other hull apertures may be allowed under permit, if debris not allowed to pass to water column or sea bed. Polishing propellers may be allowed under permit.
Merchant Classification Societies	Requirements (Applies to majority of merchant fleet)	Dry dock requirements vary somewhat depending on classification society. Generally: o Dry dock every 5 years. Cleaning and painting is usually conducted, but is at the discretion of the company. o Interim in-water cleanings: Periodicity at the discretion of the company. Typically dependent on results of fuel consumption tests.

D. Hull-fouling risk in Oregon

The findings from twelve studies investigating possible hull-mediated transfer of AIS are highlighted in Table 3, including three studies that involved transit in Oregon waters (Carlton & Hodder 1995, Brock et al. 1999, Davidson et al. 2006). All three studies documented ship-mediated biofouling concerns, in some cases identifying individual hulls that had greater than 80% biofouling coverage and were transporting as many as 117 different fouling species (Table 3, Figure 17).

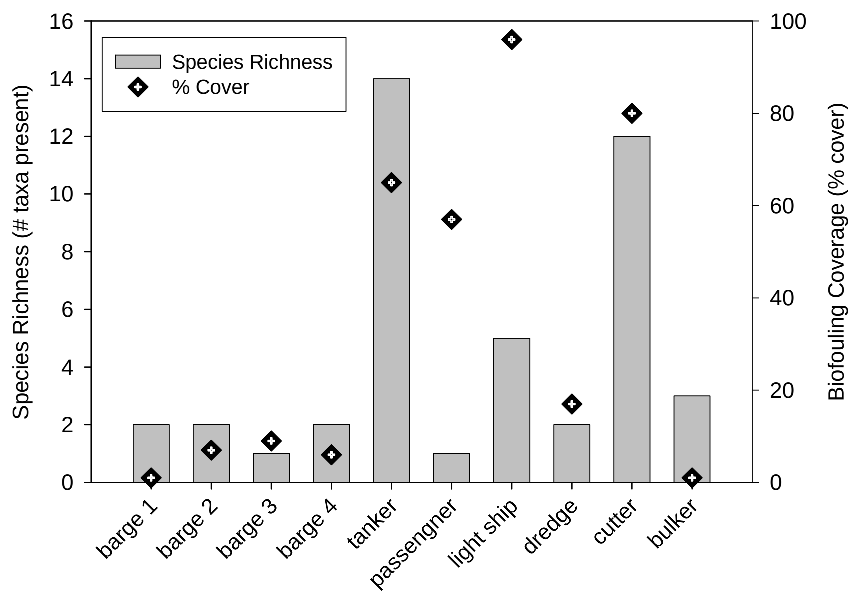

Figure 17. Extent of biofouling on vessels arriving to Portland Harbor as a function of species richness (# of unique taxa identified) and percentage of hull covered by fouling organisms (Data courtesy of Davidson et al. 2006).

Table 3. Literature review of studies documenting biofouling on 'non-traditional' maritime vessels and/or routes (modified from I. Davidson presentation to STAIS Task Force, April 2008).

Study	Vessel Type	Route	Fouling Metric	Study Result	# NIS
Doty (1961)	Barge	Guam > Hawaii	Descriptive	'heavily fouled'	Several NIS; 5 specifically documented
Foster & Willan (1979)	Oil platform	Japan > New Zealand	Barnacle species richness	12 barnacle species identified	6 NIS to New Zealand
Carlton & Hodder (1995)	16th Century replica vessel	US Pacific coast voyage	Species richness & organism densities	46 spp	All established West Coast taxa
Hay & Dodgshun (1997)	Fishing trawler	Black Sea > New Zealand	Wet biomass; qualitative	90 tonnes of marine growth; 100% cover	Non-indigenous mussels were dominant
Brock et al. (1999)	Battleship 'USS Missouri'	Puget Sound > HI (via Col. River)	Species richness	117 species	> 65 NIS to Hawaii
DeFelice (1999)	Floating dock 'USS Machinist'	Philippines > Hawaii > Guam	Species richness	113 spp.	46 NIS to Hawaii
Godwin (2003)	Floating dry dock	California > Hawaii	Species richness	56 species	35 NIS to Hawaii
Coutts (2002)	Barge	New Zealand (domestic)	Species richness & wet biomass	76 species	> 15 NIS to Marlborough Sound
Lewis et al. (2003)	3 research vessels	Tasmania > Antarctica	Species richness (qualitative)	15 functional groups	At least 4 NIS to Antarctica
Lewis et al. (2006)	Supply barge	Tasmania > sub-Antarctica	Species richness & organism densities	20 spp.	>8 NIS to sub-Antarctica
Drake & Lodge (2007)	Bulker	Algiers > Peru > Great Lakes	Species richness	74 species	8 NIS to Great Lakes
Davidson et al. (2008)	Transoceanic Transfer of MARAD Reserve Fleet for shipbreaking.	SF Bay > Texas (via Panama Canal)	Species richness & percent cover	22 spp. (pre-transit); 57 species (post-transit). Species-specific variability in % cover changes.	5 NIS to Gulf of Mexico (two confirmed alive).

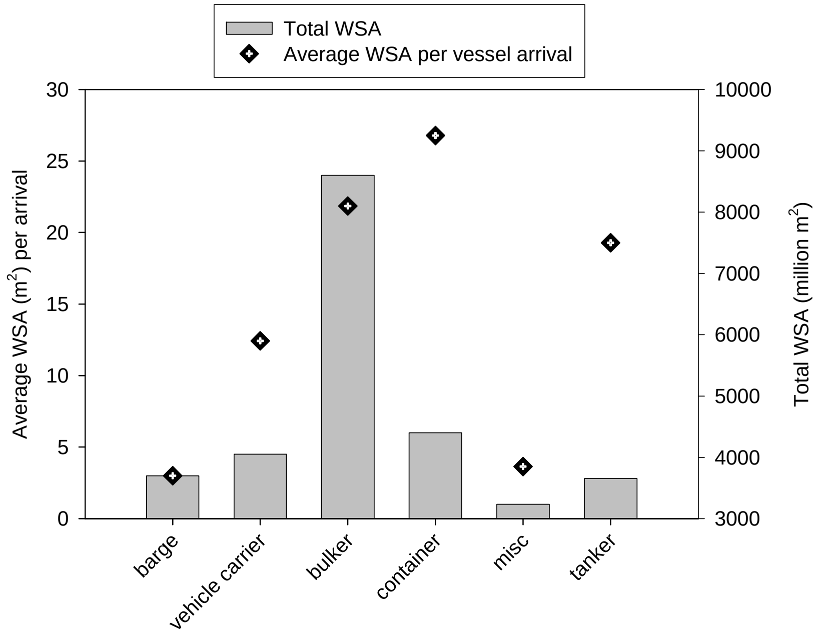

Figure 18. Biofouling mediated invasion risk to the lower Columbia River as a function of wetted-surface-area (WSA) from July 2002-June 2005 vessel arrivals. Total WSA per vessel type (bars), as well as average WSA per arrival (diamonds) are reported (data modified from Davidson et al. 2006).

In a recent study, Davidson et al. (2006) showed that container ships tend to introduce more WSA upon arrival than any other vessel type. However, due to the disproportionate number of arrivals per vessel type in Oregon waters (Figure 5), bulk carrier traffic represents a greater overall source of WSA to the Columbia compared to other vessel types (Figure 18). This contrasts with shipping patterns from our neighboring states, where container and tanker vessels contribute the greatest amount of WSA. Due to the frequency and composition of vessel traffic to our neighboring states, Washington and California receive approximately 2 times and 7 times more WSA, respectively, than the approximately 13.5 million m^2 arriving in Oregon waters (Figure 19).

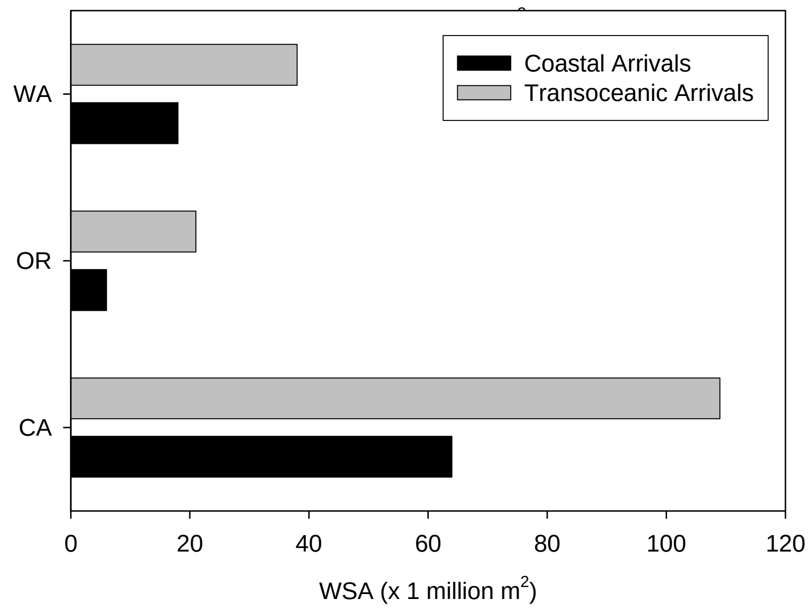

Figure 19. Comparative biofouling mediated invasion risk, per state on the west coast, as a function of vessel wetted-surface area (WSA) arriving over a two-year period. Data courtesy of Ian Davidson, PSU/ABRPI.

Barges represent relatively less WSA than other vessel classes (Figure 18), but may represent a higher risk for biofouling transport due to their slower transit speeds and in some cases, longer residence times while in port. The lower velocity transit speed increases probability of biofouling accumulation, while extended residence times result in greater probability that fouling organisms will reproduce and release gametes or detach into the surrounding waters (Gollasch 2002, Minchin and Gollasch 2003, Coutts and Taylor 2004, Coutts 2005, Davidson et al. 2006). Figure 20 shows recent barge arrival traffic to the Columbia River. Since current regulatory statutes do not apply to vessels under 300 gross tons or those vessels not equipped with ballast tanks (i.e., most barges), data are currently lacking on last port of call and voyage characteristics for barge arrivals to Oregon waterways.

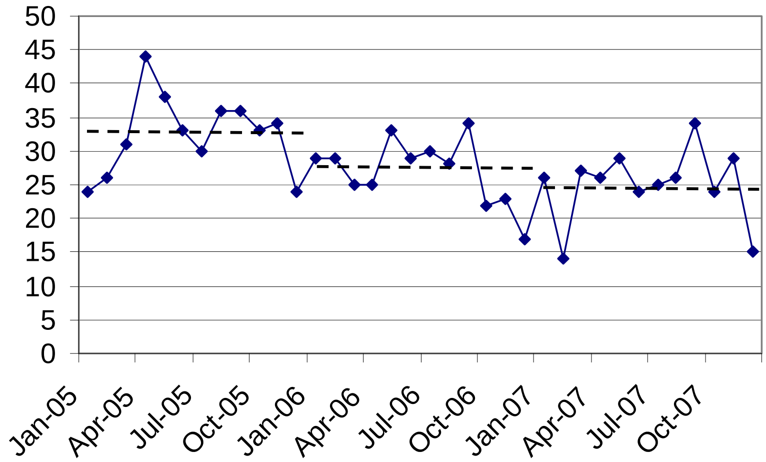

Figure 20. Monthly barge arrivals to the Columbia River, 2005-2007. Dashed lines represent average monthly arrivals for each of the three calendar years (Data courtesy of Portland Merchants Exchange).

The greatest asset to protecting Oregon from biofouling mediated AIS introductions is the environmental characteristics of its most frequently visited ports (i.e. Columbia River ports upriver from Astoria). Unlike other major ports on the west coast, vessels calling on the Columbia River subject their hulls to freshwater immersion, which acts as a natural biocide for most fouling organisms that thrive in marine and estuarine conditions. For this reason, vessels that regularly visit the Columbia River (or any other freshwater water port) tend to accumulate fewer viable fouling organisms (Davidson et al. 2006). Despite this reduced risk for our most active port locations, the lower Columbia River Estuary and Coos Bay remain vulnerable to marine AIS introductions. While most fouling organisms are marine and estuarine species, there are freshwater fouling organisms (extremely rare in the Western Hemisphere) that pose a significant risk to the Columbia Basin and other Oregon waterways. The most notable concern in this category are freshwater mussels that possess byssal threads, which are specialized adaptations that enable attachment to hard substrate). Freshwater mussels of the genus *Dreissenid* sp. (e.g., quagga and zebra mussels) and *Limnoperna* sp. (golden mussels) have successfully invaded regions of North America and the Amazon Basin, respectively, causing considerable economic and environmental impacts (Karatayev et al. 2007). Shipping mediated transfer of these freshwater biofouling organisms, however, is minimized by extended voyage in oceanic waters.

Various factors (such as vessel operator incentive to maintain hulls free of fouling organisms for the sake of fuel efficiency) have dramatically reduced the threat of biofouling from shipping related operations. Yet, we remain concerned that the absence of regulations addressing this introduction pathway leaves our ecosystems vulnerable to the minority of vessels that are ill- maintained (Table 3). This concern was highlighted in a recent Davidson et al. (2008) publication which investigated hull-fouling on obsolete ships that were being transferred to ship-breaking facilities in Texas after residing unmaintained in the SF Bay for over a decade. Their results highlight concern over rare and unusual vessels that may be categorized as high density biofouling vectors, and thus represent a higher risk for AIS introductions than a majority of the commercial fleet. In another study, Drake and Lodge (2007) found extensive fouling on a bulker ship that transited from Algeria to Chile prior to arriving in the freshwater port of Lake Ontario. The ship had experienced a prolonged stay in Algiers prior to its voyage, and samples revealed that it was transporting at least 74 distinct freshwater and marine taxa into Lake Ontario; eight of which had never been observed in the Great Lakes. Although voyage circumstances such as these may be unusual for a majority of the commercial fleet, they represent a considerable threat to our aquatic ecosystems.

E. Conclusions

As an incidental NIS pathway resulting from shipping transport, biofouling is recognized as a potent vector for transporting a wide variety of taxonomic groups between coastal marine and estuarine regions (Ruiz et al. 2000, Fofonoff et al. 2003, Hewitt 2004). Safeguards resulting from anti-fouling paint application during the past 50 years resulted in less regulatory concern for this NIS pathway, compared to ballast water management. In a post-tributyltin anti-fouling paint regulatory environment, however, greater attention to biofouling risks is warranted.

The relative threat of NIS introduction from hull fouling is probably lower for the Columbia River than for other Pacific coastal ports (Davidson et al. 2006). While marine fouling species are unlikely to survive the acute reduction in salinity upon arrival to CR ports, freshwater fouling organisms from other ports will not survive a transit that subjects them to long term submersion in oceanic waters. Despite this potential safeguard for the freshwater habitats of the Columbia River system, the lower Columbia Estuary and other coastal ports (i.e. Coos Bay) remain vulnerable to the introduction of biofouling AIS.

Based on the high degree of inter-port connectedness along the North American Pacific Coast, the most effective strategy may require a broader regional framework for investigating and managing biofouling risk reduction. Since invasive species do not recognize geopolitical boundaries and may easily be transferred along our coasts once established, management and prevention efforts may only be as effective as the 'weakest link' amongst the region's ports (Cusack and Harte 2008).

Future research is required to ascertain whether biofouling regulatory actions are required, and if so, the nature of the recommendations. In order to contribute to the information gathering needs and work cooperatively with efforts underway in neighboring states, ODEQ staff will solicit survey data from local vessel operators (Appendix F). The data will help identify current hull-maintenance and biofouling management practices employed by our shipping fleet. While this effort will hopefully provide a better understanding of general fleet operations, it will be important to develop monitoring and detection capabilities for identifying 'non-traditional' vessel arrivals that may pose a higher biofouling risk.

V. EMERGING ISSUES

There is extensive activity underway in the areas of research, policy development, and technological advancement that will have significant impacts on the management of shipping related pathways for NIS. The following is a collection of some of those issues that may be important to Oregon policymakers and stakeholders as we consider how best to protect our aquatic ecosystems from future introductions.

A. Ballast water exchange (BWE) verification

Although efforts are underway to implement on-board ballast treatment systems that will address the efficacy limitations of BWE (see below), full implementation of such technologies by the majority of the commercial fleet is unlikely for many years. Thus, inspection and enforcement efforts that sample ballast tanks for verification of mid-ocean BWE are critical for limiting the risk of AIS introduction from ballast discharge.

The primary BWE verification method that has been employed by shipboard inspectors is the measurement of salinity. In general, open ocean waters (i.e., areas greater than 200 nm offshore) tend to have salinity values in the 33-35 parts per thousand (ppt) range, which is considerably higher than nearshore coastal zones where salinity is usually less than 33 ppt. However, coastal oceanographic dynamics can produce considerable deviations from this generalized salinity pattern (Hickey 1998, Barth et al. 2000). Such variability may complicate the use of salinity as an indicator of source waters, thereby limiting its value for compliance and enforcement purposes (Murphy et al. 2005). Recent research has supported the development of sampling tools that measure chromophoric dissolved organic matter (CDOM) as a key indicator of oceanic waters proximity to land, and thus may function as a valuable BWE verification tool. CDOM refers to the fraction of dissolved organic matter that absorbs light and fluoresces in the ultra-violet and visible light regions of the spectrum (Murphy et al. 2006), and is consistently higher in near-shore regions compared to open ocean environments. Portable, hand-held CDOM instrumentation has been developed (BEAM 100, Dakota Technologies, Inc.) and undergone testing by the joint EPA/USCG Environmental Technology Verification (ETV) Program. Based on some technical difficulties identified by the ETV testing program in January 2007, the manufacturer made some design modifications and has recently loaned 16 units to the USCG for field testing purposes. Following field-testing, the product was released in April 2007 with a retail price of $9,000 USD.

In addition to the ETV testing program, a joint research initiative of CSLC/SERC will investigate the applicability of CDOM for BWE verification purposes at west coast ports. Samples gathered by ballast water inspectors in California, Oregon and Washington will help determine the value of this tool for ballast program management along the west coast (pers. comm. G. Ruiz 2008).

B. Pending changes to federal regulations

Although the USCG may approve the use of ballast water technology that has efficacy greater than or equal to ballast water exchange, the lack of federally established treatment performance standards has contributed to a significant delay in technology development. Efforts at various levels of state and federal policymaking, including legislative proposals and pending adjustments to federal programs, are underway that may have dramatic implications on the shipping related management of AIS.

Clean Water Act enforcement of vessel discharge by EPA – In October 2006, the 9th Circuit Federal Court ruled in favor of a Northwest Environmental Advocates lawsuit against EPA, requiring that vessel discharges be regulated under the Clean Water Act (CWA). Enacted in 1972, the CWA requires that the U.S. EPA regulate any pollutants discharged into navigable waters from a point source. As a result of the court's ruling, EPA has been ordered to develop an NPDES permit program for regulating discharge incidental to vessel operations by September 30, 2008. Although the administration may be seeking legislative resolutions that could effectively negate the courts ruling, a draft NPDES permit program was released for public comment in June 2008.

The EPA has drafted two general permits; the first aims at regulating 27 specific discharge pathways (including ballast water) from vessels greater than 79 ft in length while the second recommends best management practices for vessels less than 79 ft. However, SB 3298 has removed recreational boats from consideration under the CWA, and established a moratorium for all fishing vessels and any commercial vessels less than

79 ft under CWA provisions. The bill was signed by the President and passed into law on July 31, 2008.

Congressional Legislation – Multiple bills with ballast management implications have been introduced in Congress over the past four years, though none has yet been passed. Some of these proposals are comprehensive legislative packages that address a broad range of invasive species management issues, including prevention measures for multiple NIS pathways, rapid response emergency funding, and research and outreach components (e.g., SB 770, SB 1224, and HR 5030). Other proposals are specific to the Great Lakes region: vessels are not required to conduct BWE if they declare that no pumpable ballast is in their tanks, but still present an environment risk since 'empty' tanks typically contain remnant ballast water that could introduce AIS if ballasting/de-ballasting operations ensue within the Great Lakes system. The type of legislation that may have the greatest potential for passage, however, appears to be legislation that specifically addresses ballast water management for all vessel traffic in US waters, and would set discharge standards and implementation timelines for phasing out BWE in favor of ballast treatment technologies. In particular, one piece of legislation has received considerable attention in recent months and is highlighted below.

> ***HR 2830*** - On April 14, 2008, the US House of Representatives passed the Coast Guard Reauthorization Act which includes Section V: Ballast Water Management Act of 2007. The Act proposes ballast water performance standards that would be implemented on a graduated timeline, similar to the timeline proposed by IMO and California. The performance standards are more stringent than the IMO proposed standards but less environmentally protective California's standards. The Act would allow state programs to petition the Secretary of Homeland Security for inspection and enforcement authority, but otherwise would preempt state regulations aimed at reducing the threat of AIS from shipping related transport.

At the present time, it is difficult to predict how the Senate will take up the Coast Guard Reauthorization measures and whether it would include the ballast water management language from HR 2830, alternate versions being considered within the

Senate, or develop new versions in congressional conference between the two legislative branches.

C. Alternative Ballast Water Exchange Areas (ABWEA)

The National Invasive Species Act (NISA) contains provisions for establishing alternative ballast water exchange areas (ABWEA's) within the US EEZ that may be used in instances when safety, mechanical or other reasons have limited an international arrival from conducting a proper mid-ocean exchange in waters greater than 200 nm offshore. Further, federal ballast management statutes provide clear authority for regional USCG Captain of the Port authorities to designate areas where vessels can and cannot discharge ballast water if they fail to conduct an open ocean exchange. Various concerns for how to assess ecological vulnerability of receiving waters and logistical ramifications of designating ABWEA's prompted a 2006 workshop on this topic that was sponsored by PSMFC.

At this workshop, a working group of research and regulatory specialists presented diverse perspectives on west coast oceanography, estuarine dynamics, plankton ecology, and industry constraints that may dictate the development of ABWEA's throughout the Pacific Coastal Region. A paper outlining the workshop's recommendations and findings was published in 2007. Specific recommendations include:

- ABWEA's should not be established closer than 50 nm to shore or in waters less than 1000 m depth.
- The need for a bilaterial coordination workshop with Mexican officials and scientists to help reduce the number of NIS introduced to both US and Mexican waters.
- ABWEA establishment should avoid major estuary and oceanic river plumes, subsurface physical features (e.g., seamounts) and critical fish habitats.

In addition, the working group developed a map of potential areas possessing important physical and/or biological attributes that are important to consider in identifying Pacific Coast ABWEA's (Appendix G). Importantly, substantial portion of

Oregon offshore areas were highlighted in consideration of Columbia River Plume dynamics (Hickey et al. 2005).

D. Availability of Ballast Water Treatment (BWT) Technology

As international, federal and state entities consider the issue of performance standards for ballast water discharges, substantial interest is being dedicated to the development and testing of ballast water treatment systems. The availability, reliability, effectiveness and cost of treatment options are likely to be critical to their eventual successful integration into ballast management practices. For example, to assess the availability of treatment systems that could meet the performance standards established under California law, the CSLC produced a report reviewing the developmental status of ballast treatment systems (Dobroski et al. 2007).

The CSLC report reviewed 28 different treatment systems; most of which use a chemical or combined physical-chemical treatment methodology (Appendix H). The absence of standardized methods for evaluating system performance limited CSLC from assessing whether many of the 28 systems are capable of meeting or exceeding the established performance standards. Of those that were compared with CSLC discharge standards, none were able to meet more than 4 of the 7 performance criteria. Another important finding from the report was the need for further development and testing for most of the systems, particularly at the shipboard scale.

Based on the results of the technology assessment report, CSLC has recommended that the California Legislature delay its implementation timeline by one-year. In order to determine if technology availability will be a limiting factor for future implementation schedules, CSLC staff will conduct annual reviews of available technology.

Although CSLC will not be approving specific technologies systems for shipboard use, they are currently producing treatment technology testing guidelines that will provide technology developers with recommended protocols for verifying system compliance with California standards and water quality parameters (due late 2008; N. Dobroski pers comm.). These guidelines aim to complement verification protocols that are being proposed by both international and federal entities. The IMO has developed testing and performance specifications for evaluating ballast management systems relative to the IMO performance standards (MEPC 2005). In the US, a federal partnership between the EPA and USCG has proposed an Environmental Technology Verification (ETV) Program for assessing ballast treatment systems (EPA 2004).

The USCG implemented the Shipboard Technology Evaluation Program (STEP) in 2004 in anticipation of federal regulations that may set specific limits on the number of live organisms allowable in ballast water discharge. STEP aims to support the development and implementation of experimental shipboard treatment systems that would replace ballast water exchange management practices. As such, STEP could play an important role in advancing the development and testing of ballast treatment systems. Under this program, vendors and vessel operators are encouraged to apply for and implement the use of experimental treatment systems on board vessels. As of July 2008, three applicants have sought participation in the program, including Princess Cruise Lines *Coral Princess*, Atlantic Container Lines' *Atlantic Compass*, and Matson Shipping's *Moku Pahu*. Draft environmental assessments have been prepared for each proposal and are currently under review for possible environmental impacts. If 'no significant impact' is identified, the ship(s) will begin to use experimental treatment systems for managing all their ballast water. Although the STEP program does not approve specific treatment systems, the applicants identified above have proposed using a chlorine dioxide based system (EcoChlor), a combined ultraviolet radiation and filtration system (Hyde Marine), and a deoxygenation system (NEI Treatment), respectively. (pers. comm. LCDR Brian Moore, USCG).

A treatment technology testing facility, supported by NOAA, has been established at the Pacific Northwest National Laboratory in Sequim, WA. As one of four national facilities dedicated to ballast treatment testing (only one on the west coast), PNNL and regional partners (including PSU) will play an important role in furthering the development and assessment of effective treatment technology that will be suitable for shipboard operation.

E. LNG proposals and ballast operations

At least three liquid natural gas (LNG) transfer facilities have been proposed in Oregon, and are currently under consideration by state and federal authorities. Due to the offloading operations anticipated at these LNG facilities, minimal ballast discharge into Oregon waters is expected. Although the large size of the LNG vessels represents a measurable increase in the annual wetted-surface-area (a surrogate measure of hull-fouling introduction risk) arriving to Oregon waters, we do not perceive any substantial AIS risk as a result of the proposed LNG facilities.

In their review of the proposed activities, however, NOAA Fisheries (NMFS) has identified the *intake* of ballast water as a source of concern for ESA-listed juvenile salmonids; as ballast water is brought into a ship, juvenile salmon are likely to be brought in as well. Whereas most water intake sources in navigable waters of the PNW are strictly regulated for flow rate and screen size, commercial vessels calling upon our ports have not been regulated for such concerns. Due to the substantial volume required for ballast (up to 65,000 m^3 per vessel visit; compare with Figure 10) and engine cooling operations of LNG tankers, NMFS has indicated that significant numbers of endangered salmon may be impacted by facilities proposed in Oregon waterways and ballast water intake (pers. comm., Cathy Tortorrici, NOAA Fisheries). Estuaries, including the lower Columbia and Coos Bay, are considered critical nursery ground habitat for several salmonid stocks listed under the Endangered Species Act. In order to comply with NMFS operational requirements aimed at protecting listed species, LNG vessels operating in Oregon (and/or land based facilities) may require specific pumping operations and intake screen equipment.

F. Climate Change & AIS

Although climate change and invasive species are recognized as two of the leading threats to native biodiversity, their interactive and cumulative effects on ecosystems are not well understood. Each factor may independently result in considerable ecological harm, yet only recently have studies begun to assess the manner in which changing climate may alter the likelihood of future biological invasions (Kolar and Lodge 2000, Stachowicz et al. 2002, US EPA 2008, Rahel and Olden 2008).

Anticipated changes to fresh- and saltwater ecosystems that are associated with projected climate variability include altered stream flow patterns such as magnitude and timing, increased stream and ocean temperatures, increased saltwater intrusion to estuaries, and altered timing and magnitude of disturbance events (storms, floods, etc.) (Poff et al. 2002, Lodge et al. 2006, Rahel and Olden 2008). Disruptive changes such as these will likely facilitate the establishment of non-native species. Similarly, the likelihood that an established NIS will have competitive or predatory impacts on native species will be largely determined by factors subject to climate change (Taniguchi et al. 1998, Peterson and Kitchell 2001). Climatic warming may also increase the presence and virulence of non-native parasites and pathogens. For example, the pathogen that causes whirling disease in salmonids, *Myxobolus cerbralis*, achieves greater virulence and higher densities under increased stream temperatures. This pathogen has been introduced in the Columbia River Basin, and its impacts on native salmonids may be greater under projected climate change scenarios. In general, scientific evidence suggests that ecosystems will become increasingly vulnerable to the establishment and negative impacts of invasive species as a result of the altered environmental conditions and disturbance regimes associated with climate change.

Climate change presents a new challenge for the prevention and control of invasive species. In a recent review of the complex interaction between climate change and AIS, the US EPA identified multiple research and management activities that may help AIS management programs adapt to the poorly understood environmental changes that are projected to occur. Since biological responses to changing climate conditions will likely be species-specific (e.g., ranges of some native species will expand while others contract; some non-native species will benefit while others do not) the report emphasized the importance of comprehensive monitoring programs to provide early AIS detection. The report also highlighted the need for states to coordinate and share information on species of concern and probable pathways; this data sharing would eventually aid in future data collection efforts and prevention activities (EPA 2008).

VI. REGIONAL COLLABORATION

Given the inter-jurisdictional nature of shipping industry operations, regulatory coordination at the regional (if not national) level is critical for the establishment of environmentally protective measures. To help facilitate greater cooperation and coordination, program staff from ODEQ participate in a variety of regional workgroup activities, including; the Pacific Ballast Water Group, Washington's Ballast Water Work Group, California's Technical Advisory Group West Coast Ballast Outreach Project's Advisory Committee, and the Oregon Invasive Species Council Advisory Committee. Due to the high degree of international and interstate voyages by many shipping carriers, it is important that vessel operators are not faced with a patchwork of regulations that are dramatically different or contradictory from one another. In particular, the various entities and partnerships listed below may help facilitate regulatory uniformity at the west coast regional level.

Pacific Ballast Water Group (PBWG)

The Pacific Ballast Water Group (PBWG) began in 1997 as an ad hoc forum for regulators, industry, and academic representatives to address regional issues related to ballast water management on the west coast. In recent years, the Pacific States Marine Fisheries Commission has facilitated activities of the workgroup that now includes industry representatives, state and federal agencies, environmental organizations and others interested in developing a regional approach to ballast management. The group has been instrumental in minimizing regulatory differences among west coast states that would otherwise cause challenges for vessel operators. Although current regulations are mostly similar along the west coast, ongoing efforts to implement ballast treatment standards will necessitate continued support for PBWG's work.

The PBWG most recently convened December 4-5, 2007 in Portland, Oregon, where discussion focused on the various challenges presented by the transition away from BWE in favor of ballast treatment systems. While the development of ballast treatment guidelines remain uncertain at the federal level, Washington state is revising its performance standards in a manner that may or may not conform with California's standards (WA rulemaking is currently underway). If Washington and Oregon choose not to adopt BWT standards similar to those adopted by California in 2007, there will be considerable differences in ballast management regulations for west coast operators in the near future.

West Coast Ballast Outreach Project (WCBOP)

In 1999, California Sea Grant established the West Coast Ballast Outreach project to conduct outreach aimed at improving industry knowledge of ballast water regulations. Generally, the project promotes an information exchange between industry, researchers and regulators to ensure that advances in AIS prevention adequately balance economic and environmental considerations.

The project has been supported by National Sea Grant and CALFED Bay Delta Program funds, and is entering its final year of funding. During its final year, WCBOP will focus on wrapping up various educational initiatives, including publication of its final semi-annual newsletter, *Ballast Exchange*. In addition, they are updating outreach materials highlighting similarities and differences amongst AIS prevention regulations for the Pacific States (Appendix C).

West Coast Governor's Agreement on Ocean Health (WCGAOH)

Motivated by the findings of the Pew Oceans Commission and the US Commission on Ocean Policy, Governors from the three Pacific Coastal States have forged an agreement aimed at greater regional coordination of marine resource management. The agreement and subsequent management plans were developed to address critical marine resource issues facing all three states and the importance of cooperation in addressing challenges that transcend political boundaries.

The Governors action plan was released in July 2008 and identifies the protection and restoration of ocean and coastal habitats (including the prevention of marine invasive species) as one of seven priority areas. Specifically, the plan acknowledges the interdependency of the three states in invasive species prevention due to interstate vessel traffic and ocean currents that may disperse AIS across jurisdictions. The plan also calls for the three states to "cooperatively reduce pathways of introduction such as ballast water, vessel hulls of commercial ships and recreational boats, and boat trailers traveling across state boundaries" (WCGAOH 2008). The plan identifies the need to support ongoing efforts by the PBWG as the logical venue for achieving these goals.

Bi-state Coordination on the Columbia River

The shared waters of the Columbia River require special consideration for implementation of effective ballast management strategies. Currently, few differences in regulations exist between Oregon and Washington; however, the transition from BWE to ballast treatment technology management poses a new challenge for establishing regulatory uniformity on a shared water body of significant importance.

Given the considerable stake that each state has in protecting the integrity of the lower Columbia River ecosystem, controls on (biological) pollutants require coordinated efforts. Evaluating the efficacy of the current regulatory measures requires that the states maintain data collection protocols that enable data sharing. Both states use the same BW reporting form (Appendix B) for data collection, but differences on how vessels may submit their reports can lead to uncertainty for the compliance of some arrivals. In addition, there are a significant number of vessels that change their specific port of call after submitting a report and arriving in the Columbia River system, or others that make multiple port calls within a single arrival to the system. Each month, approximately 39 vessels make their initial port of call at a Washington port and then subsequently move to a second port of call on the Oregon shore, while approximately 47 vessels per month make inter-port moves from Oregon to Washington (Figure 21). Although state laws require that a new BWRF be submitted by vessels moving between ports of different states, vessel operator confusion about these requirements within a single USCG COPT zone often results in non-compliance that requires more systematic monitoring and coordination between ODEQ and WDFW.

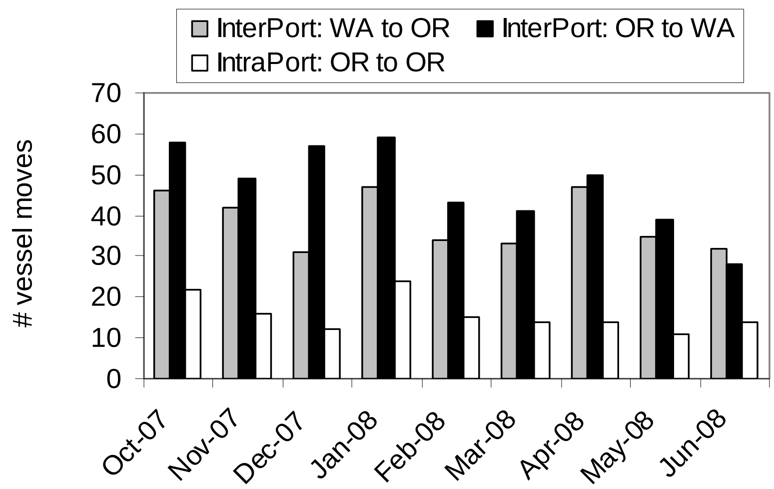

Figure 21. Monthly vessel moves between ports on the Columbia River; October 2007 – June 2008.

In addition to routine vessel inspections by USCG, ships arriving to the Columbia River may also be boarded by WDFW ballast inspectors, Washington Department of Ecology inspectors, or ODEQ personnel. Inter-agency coordination should be maximized in order to reduce multiple boardings where appropriate; particularly for vessels that have made inter-port moves across the river. No memoranda of agreement are currently in place, but may be helpful for increasing the efficiency of ship inspectors and reducing burdens on ship operators.

Under Washington law, vessels may use Washington approved treatment technologies in lieu of ballast water exchange whereas Oregon only authorizes the use of technology that has been approved by the USCG. As of July 2008, no treatment technologies have been approved by Washington State or the USCG. Nonetheless, variation in discharge standards, evaluation, and approval procedures could result in ballast discharge to the Columbia River that is authorized by one state but not the other. Given the considerable degree of inter-harbor traffic at Columbia River ports (Figure 21), the regulatory differences impose both operational and natural resource management challenges.

In a 2006 report commissioned by the Puget Sound Action Team and the Washington Ballast Water Workgroup, researchers from PSU/ABRPI analyzed ballast management challenges and strategies in the bi-state jurisdictional environment of the Columbia River (Larson & Sytsma 2006). The primary recommendation from the report was to establish a bi-state commission to foster interstate cooperation and seek regulatory uniformity. The authors recommended that the commission be co-chaired by governor's representatives from each state, and that the workgroup seek to secure a memorandum of agreement between the governors regarding cooperation and joint management efforts on the Columbia. To date, officials in Oregon and Washington have favored the use of existing regional workgroups (e.g. PBWG) as a forum for addressing these challenges, rather than the creation of a new commission.

VII. CONCLUSIONS and RECOMMENDATIONS

Ballast water discharge and biofouling from shipping activities are inadvertent but substantial pathways for introducing aquatic invasive species into Oregon waterways. Together, they are responsible for the introduction of over 50% of the 54 non-indigenous species (NIS) in the lower Columbia River as of 2001 (Sytsma et al. 2004), and are likely to have played an equal or greater role in the introduction of 52 NIS to Coos Bay (Wonham and Carlton 2005, Molnar et al. 2008). Important strides in toward reducing the threat of invasive species have been made through stakeholder initiative and legislation, but opportunities remain for further reducing shipping related risks that may increase the likelihood of biological invasions in our waterways.

In 2007, the Oregon legislature adopted a number of recommendations put forth by the Oregon Ballast Water Task Force. Most critically, the Legislature made funding available (1.0 FTE) to support ballast water data collection, report compliance monitoring and enforcement efforts at ODEQ, and to provide staff support for Task Force activities. In addition, a revised definition of vessels covered by the statute was adopted and the Task Force was reconvened (and renamed) to address various shipping related concerns with respect to invasive species, in addition to ballast water (e.g. biofouling).

The remainder of this section discusses the status of prior recommendations presented by the previous Ballast Water Task Force workgroups, as well as the specific programmatic and legislative recommendations from the 2008 Task Force on Shipping Transport of Aquatic Invasive Species. Our conclusions are generally summarized by the following four themes:

Funding and Staff Resources: Previous task force reports had recommended that a core Ballast Management Program be funded with 2.49 FTE to achieve desired objectives including field-based vessel inspections (ballast exchange verification sampling) for 25% of Oregon port calls. Although critical aspects of program development have been underway since hiring a ballast project manager in autumn 2007, certain program objectives such as vessel inspections, ballast water and aquatic invasive species research efforts, and participation in a wide range of state and regional issues will be limited without additional funding.

To achieve program development objectives, the 2008 Task Force suggested that efforts be undertaken by ODEQ and the 2009-2010 Task Force to evaluate potential supplemental sources of revenue (in addition to the 1.0 FTE from general funds) to support our vessel inspection goals and other resource limited AIS prevention activities at ODEQ. Consistent with revenue generation by programs in our neighboring states, these funds could also be used as seed money and/or matching funds to support gaps in AIS research and monitoring. Ideally, sources of revenue would be directed at aquatic invasive species pathways of greatest concern. However, in recognition that some revenue source options (e.g. shipping container fees) could result in negative economic impacts to our ports, there is consensus agreement amongst Task Force members that the implementation of any fee based program must not impact the competitive advantage between ports within our region.

Ballast Water Treatment: The 2006 Task Force recommended that the Oregon Legislature should authorize development of ballast discharge standards that are complementary to neighboring states if a federal ballast treatment program had not been established by the end of 2008. As of September 2008, federal standards have not been developed and at present it is not clear whether such standards will be promulgated before the end of the year. Due to the pending activities from introduced federal legislation and possible rulemaking amendments at the USCG, the 2008 Task Force is not recommending any specific action at this time. However, if federal efforts to establish protective ballast treatment discharge standards remain incomplete by January 2009, the legislature should authorize ODEQ to develop treatment standards that would protect the environment and help achieve regulatory uniformity along the west coast.

Biofouling: Due to the recent prohibition of highly effective (yet environmentally toxic) anti-fouling paints, biofouling has re-emerged as a leading biological invasions threat. As previously indicated, the 2006 Ballast Water Task Force recommended expanding the scope of the 2008 Task Force to address non-ballast water pathways of introduction, including hull fouling. The 2008 Task Force has recommended that ODEQ prepare and administer a voluntary hull-husbandry survey of commercial vessel operators in order to better characterize biofouling risk in Oregon waters. The results of the survey will provide critical information on fleet management practices that will contribute to greater understanding of biofouling risks associated with shipping transport along the west coast.

Coordination with Local, State, Regional and Federal Partners: The Task Force supports State efforts to further engage in invasive species prevention efforts, including implementation of action plans outlined in the West Coast Governors Agreement on Ocean Health, as well as participation in coordination efforts through the Pacific Ballast Work Group and the Columbia Basin Rapid Response Team. These efforts are critical in our attempts to protect Oregon's natural resources from threats that do not recognize political boundaries.

Based on our review of invasive species risks posed by shipping related activities and an assessment of the Oregon Ballast Water Program, the Task Force supports the following initiatives ***<u>for program development at ODEQ:</u>***

- ❖ In conjunction with local partners, identify and evaluate potential options for additional funding for consideration by the 2011 Legislative Assembly to support program development for aquatic invasive species prevention. Specifically, additional funds would help support greater inspection presence at our ports, and currently unfulfilled research and monitoring needs.
- ❖ Continue to explore more efficient options for industry to report required ballast water information and for the Department to manage ballast water reporting forms. Specifically, ODEQ should implement changes that would enhance vessel compliance efforts and reduce data entry duplication.
- ❖ Pursue rulemaking in 2009 to make Oregon Administrative Rules consistent with recent and pending changes to Oregon Revised Statutes (Appendix A and B). Specifically, conflicts between the statute and rules, such as different definitions for vessels that are subject to ORS 783.640, should be addressed since these conflicts are confusing for all parties and have complicated outreach to the shipping industry.
- ❖ Improve the vessel inspection program by developing criteria for prioritizing boardings based on high-risk arrivals.

- Develop and implement a voluntary hull-husbandry survey for commercial vessels operating in Oregon waters.
- Work with the Oregon Invasive Species Council to clarify inter-agency uncertainties regarding hull-fouling responsibilities and jurisdiction.
- Use existing forums (e.g. STAIS Task Force, Washington's BWWG, and/or PBWG) to work with Washington partners for developing more efficient and coordinated management of inter-port vessel operations on the Columbia River.

<u>Recommendations to the Governor and the 2009 Oregon State Legislature:</u>

To promote a more effective invasive species prevention strategy for Oregon and the Pacific Coast region, the Task Force recommends the following actions, including suggested amendments to the Oregon Ballast Water Statute, ORS 783.620 et seq.:

- Amend statutory language to provide ODEQ, or its agents, with explicit legal authority to board and inspect regulated vessels, audit ballast water bookkeeping records, and collect samples from ballast tanks for ballast exchange verification purposes.
- Update ballast water noncompliance civil penalties (ORS 783.990), establishing greater consistency with other ballast water programs along the west coast. Specifically, raise maximum fines for noncompliant discharge from $5,000 to $27,500 to be consistent with current penalties in neighboring states (CA and WA), and raise the maximum penalties for failure to submit ballast water reports from $500 to $2,000. In addition, allow ODEQ to develop rule based criteria for assessing penalties below the maximum amounts.
- Provide supplemental funding needed for ballast program incidental expenses including: BWE verification and sampling equipment, laboratory analyses of water quality samples, consultation fees for database developments that may streamline data processing, and out of state travel for regional coordination meetings and workshops. Costs for this supplemental funding during the 2009-2011 biennium are estimated at approximately $35,000.
- Support for future funding requests to conduct invasive species monitoring of ambient conditions in Oregon waters. For example, assessing the effectiveness of

Oregon's ballast management program requires periodic monitoring efforts in the lower Columbia River, yet a systematic survey has not been completed since 2001. Specifically, Oregon Legislative action, and the assistance of the Governor's Office, is requested in the form of:

- A Legislative Resolution, or Governor's Office request, for U.S. Congressional delegation support for federal funding to support invasive species monitoring efforts; and
- During the 2009-11 biennium, if ODEQ or other state agencies are able to obtain partial funding for invasive species monitoring efforts from federal agencies, the State of Washington, or other sources, the Emergency Board and/or Legislative Assembly will consider an appropriation of state funds as needed to provide matching state funds for monitoring programs.

❖ Authorize ODEQ to develop rules defining ballast water treatment technology standards to be as consistent as possible with administrative rules adopted in other west coast states if:

- The federal government has failed to adopt satisfactory ballast water treatment standards by January 2009; and
- The states of Washington and California have adopted comparable ballast water treatment standards.

❖ Authorize ODEQ to develop rules providing for emergency use, if necessary, for applying biocides to high-risk ballast tanks, i.e. proposed illegal discharge of ballast water in Oregon waters. For purposes of this recommendation, "high risk" discharge means unmanaged ballast water discharge from ports designated by ODEQ as high risk ports for introduction of invasive aquatic species.

❖ Amend ORS 561.687 to make ODEQ an ex-officio member of the Oregon Invasive Species Council. Adopt other legislative proposals as required to support statewide coordination on invasive species prevention and rapid response/early detection capabilities.

❖ Amend law as necessary to provide for the continuation of the Shipping Transport of Aquatic Invasive Species Task Force through the 2009-2011 biennium. The

Task Force should be charged with advising the Department, and the 2011 Legislative Assembly, regarding the following issues:

- Potential revenue sources to support ballast program activities and objectives.
- The development of discharge standards and the implementation of ballast treatment technology for review and adoption by the Environmental Quality Commission, as discussed above;
- Development of rules that may be used for the management of unmanaged ballast discharge (vessels not otherwise complying with Oregon's ballast water requirements) under emergency situations that are considered high risk for introduction of invasive species;
- Further study and exploration of potential prevention measures that would address non-ballast water pathways (e.g. biofouling).

VIII. REFERENCES

Australian and New Zealand Environment Conservation Council (ANZECC). 1997. Code of practice for antifouling and in-water hull cleaning and maintenance. 12 pgs.

Brock, R., J.H. Bailey-Brock, J. Goody. 1999. A case study of efficacy of freshwater immersion in controlling introduction of alien marine fouling communities: The USS Missouri. *Pacific Science*. 53: 223-231.

Carlton, J.T. 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. *Oceanography & Marine Biology Annual Review*, 23: 313-371.

Carlton, J.T. & Geller, J.B. (1993). Ecological roulette: the global transport of nonindigenous marine organisms. *Science*, 261: 78-82.

Carlton, J.T. and J. Hodder. 1995. Biogeography and dispersal of coastal marine organisms: experimental studies on a replica of a 16th-century sailing vessel. *Marine Biology*. 121: 721-730.

Carlton, J.T. 2001. Introduced species in US coastal waters: environmental impacts and management priorities. Arlington, VA: Pew Oceans Commission.

Cloern J.E. 1996. Phytoplankton bloom dynamics in coastal ecosystems: A review with some general lessons from sustained investigation of San Francisco Bay, California. *Rev Geophys* 34:127-168.

Cohen, A. N. & Carlton, J.T. 1998. Accelerating invasion rate in a highly invaded estuary. *Science*, 279: 555-558.

Coutts, A.D.M. 1999. Hull fouling as a modern vector for marine biological invasions: Investigation of merchant vessels visiting northern Tasmania. Thesis. Australian Maritime College. 283 pgs.

Coutts, A.D.M. 2002. A biosecurity investigation of a barge in the Marlborough Sounds. Cawthron Report No. 744, New Zealand.

Coutts, A.D.M. and M.D. Taylor. 2004. A preliminary investigation of biosecurity risks associated with biofouling on merchant vessels in New Zealand. *New Zealand Journal of Marine and Freshwater Research*. 38: 215-229.

Coutts, A.D.M. 2005. Slow-moving barge introduces biosecurity risk to the Marlborough Sounds, New Zealand. Pp. 29-35. *In* Hull fouling as a mechanism for marine invasive species introductions. *Proceedings of a workshop on current issues and potential management strategies.* L.S. Godwin (ed.) Honolulu, HI. February 12-13, 2003.

Cusack, C. and M.Harte. 2008. The economics of invasive species. Prepared for the Oregon Invasive Species Council, July 2008. Oregon State University.

Darwin C. 1854. A monograph of the sub-class Cirripedia, with figures of all the species. The Balanidae (or Sessile Cirripedes); the Verrucidae, etx. The Ray Society, London, 684 pp.

Daehler C.C. and D.R. Strong. 1996. Status, prediction and prevention of introduced cordgrass Spartina spp. Invasions in Pacific estuaries, USA. *Biological Conservation*, 78:1-58.

Davidson, I., Sytsma, M. & Ruiz, G. 2006. Preliminary Investigations of Biofouling of Ships' Hulls: Non-indigenous Species Investigations in the Columbia River. Produced for the U.S. Coast Guard Research and Development Center.

Davidson I.C., L.D. McCann, P.W. Fofonoff, M.D.Sytsma, and G.M. Ruiz. 2008. The potential for hull-mediated species transfers by obsolete ships on their final voyages. *Diversity Distrib*. 24:518-529.

di Castri, F. 1989. History of biological invasions with special emphasis on the Old World. P 1-30 in Drake, J.A., H.A. Mooney, F. di Castri, R.H. Groves, F. J. Kruger, M. Rejmanek, and M. Williamson (eds.). Biological Invasions: a Global Perspective. Scope 37. Wiley, Chichester.

DeFelice R. C. 1999. Fouling marine invertebrates on the floating dry dock USS Marchinist in Pearl Harbor to its move to Apra Harbor, Guam. Hawaii Biological Survey, Bishop Museum Honolulu, Hawaii. Contribution No. 1999-013 to the Hawaii Biological Survey.

Dobroski N., L. Takata, C. Scianni, and M. Falkner. 2007. Assessment of the efficacy, availability and environmental impacts of ballast water treatment systems for use in California waters. Prepared for the California Sate Legislature by the California State Lands Commission.

Doty M.S. 1961. *Acanthophora*, a possible invader of marine flora of Hawaii. *Pacific Science*, 15:547-552.

Drake, L.A.. 2001. Global redistribution of bacterio-plankton and virioplankton communities. *Biol. Invasions*, 3:193-199.

Drake J.M. and D.M. Lodge. 2007. Hull fouling is a risk factor for intercontinental species exchange in aquatic ecosystems. *Aquatic Invasions*, 2:121-131.

Drake, L.A., M.A. Doblin, and F.C. Dobbs. 2007. Potential microbial bioinvasions: evaluating options for ballast water management. *Mar. Poll. Bull.* 55:333-341.

EPA 2004. Draft generic protocol for the verification of ballast water treatment technologies. July 2004.

EPA 2008. Effects of climate change for aquatic invasive species and implications for management and research. National Center for Environmental Assessment, Washington, DC; EPA/600/R-08/014. http://www.epa.gov/ncea.

Falkner, M., L. Takata, S. Gilmore. 2006. California State Lands Commission Report on Performance Standards for Ballast Water Discharges in California Waters. Prepared for the California State Legislature.

Falkner, M., L. Takata, S.Gilmore, and N. Dobroski. 2007. Report on the California Marine Invasive Species Program. Prepared for the California Sate Legislature by the California State Lands Commission.

Floerl, O. and G.J. Inglis. 2003. Boat harbour design can exacerbate hull fouling. *Austral Ecology*. 28: 116-127.

Flynn, K and Sytsma, M. 2004. Report on the Oregon Ballast Water Management Program in 2004. Prepared in cooperation with the Oregon Ballast Water Task Force. September 2004.

Fofonoff, P.W., Ruiz, G.M., Steves, B. and Carlton, J.T. 2003. In ships or on ships? Mechanisms of transfer and invasion for nonnative species to the coasts of North America. In: Invasive species: vectors and management strategies Ruiz, G.M. & Carlton, J.T. (eds). Washington DC: Island Press. p. 152-182.

Foster, B.A. and R.C. Willan. 1979. Foreign barnacles transported to New Zealand on an oil platform. *New Zealand Journal of Marine and Freshwater Research*. 13: 143-149.

Godwin, L.S. 2003. Hull fouling of maritime vessels as a pathway for marine species invasions to the Hawaiian Islands. *Biofouling*.19 (Supplement): 123-131.

Gollasch, S. 2002. The importance of ship vessel fouling as a vector of species introductions into the North Sea. *Biofouling*, 18(2): 105-121.

Grosholz, E. 2002. Ecological and evolutionary consequences of coastal invasions. *Trends Ecol Evol.*, 17:22-27.

Hay, C. and Dodgshun, T., 1997. Ecosystem Transplant? The case of the Yefim Gorbenko. *Seafood N.Z.* May 1997: 13-14

Hallegraff G.M. 1998. Transport of toxic dinoflagellates via ships ballast water: bioeconomic risk assessment and efficacy of possible ballast water management strategies. *Mar. Ecol. Prog. Ser*. 168:297-309.

Hewitt, C.L., Campbell, M.L., Thresher, R.E., Martin, R.B., Boyd, S., Cohen, B.F., Currie, D.R., Gomon, M.F., Keough, M.J., Lewis, J.A., Lockett, M.M., Mays, N., MacArthur, M.A., O'Hara, T.D., Poore, G.C.B., Ross, D.J., Storey, M.J., Watson, J.E., Wilson, R.S. 2004. Introduced and cryptogenic species in Port Philip Bay, Victoria, Australia. *Marine Biology*. 144: 183-202.

International Maritime Organization. 2006. Global Ballast Water Management Program-The New Convention. Accessed 8/2/06. http://globalast.imo/index.asp

Independent Scientific Advisory Board (ISAB). 2008. Non-native species impacts on native salmonids in the Columbia River Basin. ISAB 2008-4. Northwest Power and Conservation Council, Portland, Oregon.

Karatayev, A.Y., D. Boltovskoy, D.K. Padilla, and L.E. Bulakova. 2007. The invasive bivalves, *Dreissena polymorpha* and *Limnoperna fortunei*: parallels, contrasts, potential spread and invasion impact. *Journal of Shellfisheries Research,* 26:205-213.

Kimmerer, W., E. Gartside, and J.J. Orsi. 1994. Predation by an introduced clam as the likely cause of substantial declines in zooplankton of San Francisco Bay. *Marine Ecology Progress Series*, 113:81-93.

Kolar C.S. and D.M. Lodge. 2000. Progress in invasion biology: predicting invaders. Trends in Ecology and Evolution 16:199-204.

Kolar C.S. and D.M. Lodge. 2001. Freshwater nonindigenous species: interactions with other global changes. in Invasive species in a changing world, H.A. Mooney and R. J. Hobbs, (eds.) Island Press, Washington, D.C.

Langeland, K.A. 1996. *Hydrilla verticullata* (L.F.) Royle (Hydrocharitaceae), "The perfect aquatic weed". *Castanea* 61:293-304.

Lavoie, D.M., Smith, L.D. & Ruiz, G.M. (1999). The potential for intracoastal transfer of non-indigenous species in the ballast water of ships. *Estuarine, Coastal and Shelf Science,* 48: 551-564.

Lewis, J. 2002. Hull fouling as a vector for the translocation of marine organisms, Phase 3: The significance of the prospective ban on tributyltin antifouling paints on the introduction and translocation of marine pests in Australia. Department of Agriculture, Fisheries and Forestry – Australia. Report No. 2. 133 pgs.

Lewis P.N. C.L. Hewitt, M. Riddle, and A. McMinn. 2003. Marine introductions in the Southern Ocean: an unrecognized hazard to biodiversity. *Marine Pollution Bulletin*, 46:213-223.

Lewis, P.N., D.M. Bergstrom, and J. Whinam. 2006. Bargin in: a termperate marine community travels to the subantarctic. *Biological Invasions*, 8:787-795.

Lodge, D.M., and 12 coauthors. 2006. Biological invasions: recommendations for US policy and management. *Ecological Applications*, 16:2035-2054.

Maritime Administration (MARAD) 2008. US Port Calls by Port and Vessel Type, 2002-2007. http://www.marad.dot.gov/marad_statistics/index.html accessed August 7th, 2008.

MacIsaac, H.J. 1996. Potential abiotic and biotic impacts of zebra mussels on the inland waters of North America. *American Zoologist*, 36:287-299.

Mack, R.N., Simberloff, D., Lonsdale, W.M., Evans, H., Clout, M. & Bazzaz, F.A. 2000. Biotic invasions: causes, epidemiology, global consequences, and control. *Ecological Applications*, 10(3): 689-710.

MEPC 2005. Draft guidelines for ballast water sampling for port state control (G2). Marine Environment Protection Committee (MEPC) 53/2/7.

Michin, D. and S. Gollasch. 2003. Fouling and ship's hulls: How changing circumstances and spawning events may result in the spread of exotic species. *Biofouling*. 19: 111-122.

Minton M.S., E. Verling, A.W. Miller, and G.Ruiz. 2005. Reducing propagule supply and coastal invasions via ships: effects of emerging strategies. *Frontiers in Ecology and Environment*, 3:304-308.

Molnar J.L., R. Gamboa, C. Revenga, and M. Spalding. 2008. Assessing the global threat of invasive species to marine biodiversity. *Frontiers in Ecology*. 6:doi:10.1890/070064.

Murphy, K., J. Boehme, P. Coble, J. Cullen, P. Field, W. Moore, E. Perry, R. Sherrell, and G. Ruiz. 2004. Verification of mid-ocean ballast water exchange using naturally occurring coastal tracers. *Mar. Poll. Bull.*, 48:711-730.

Murphy K.R, G. Ruiz, W. Dunsmuir, and T. Waite. 2006. Optimized parameters for fluorescence-based verification of ballast water exchange by ships. *Environ. Sci. Technol.* 40:2357-2362.

Nehring, S. 2001. After the TBT Era: Alternative anti-fouling paints and their ecological risks. *Senckenbergiana maritima*. 31(2): 341-351.

Noble, M. 2007. Evaluating the risk of invasions associated with low salinity ballast water arriving to the Columbia River. Masters Thesis. Portland State University, Portland, Oregon. pp. 43.

Parker IM, Simberloff D, Lonsdale WM, Goodell K, Wonham M, Kareiva PM, Williamson MH, Von Holle B, Moyle PB, Byers JE, Goldwasser L. 1999. Impact: toward a framework for understanding the ecological effects of invaders. *Biol Invasions* 1:3-19.

Peterson, J.H., and J.F. Kitchell. 2001. Climate regimes and water temperature changes in the Columbia River: bioenergetic implications for predators of juvenile salmon. *Canadian J. Fish. Aquat. Sciences*, 58:1831-1841.

Phillips, S., Darland, T., & Sytsma, M. 2005. Potential Economic Impacts of Zebra Mussels on the Hydropower Facilities in the Columbia River Basin. Prepared for the Bonneville Power Administration.

Pimentel, D., Rodolfo, Z. & Morrison, D. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. *Ecological Economics*, 52: 273-288.

Poff, N.L., M.M. Brinson, and J.W. Day Jr. 2002. Aquatic ecosystems and global climate change: potential impacts on inland freshwater and coastal wetland ecosystems in the United States. Pew Center on Global Climate Change, Arlington, Virginia.

Puget Sound Action Team (PSAT). 2006. Mid-term Report: Ballast Water Management in Washington State. Prepared for the Washington State Ballast Water Work Group.

Puget Sound Action Team (PSAT). 2007. Ballast water management in Washington State: A report of the state ballast water work group to the 2007 Regular session of the Washington State Legislature.

Rahel, F.J., J.D. Olden. 2008. Assessing the effects of climate change on aquatic invasive species. *Conservation Biology*, 22:521-533.

Ruiz, G.M., Carlton, J.T., Grosholz, E.D. & Hines, A.H. 1997. Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent and consequences. *American Zoologist*, 37: 621-632.

Ruiz, G.M., Fofonoff, P.W., Carlton, J.T., Wonham, M.J. & Hines, A.H. 2000. Invasion of coastal marine communities in North America: apparent patterns, processes, and biases. *Annual Review of Ecology and Systematics*, 31: 481-531.

Ruiz G.M. and J.T. Carlton. 2003. Invasion vectors: a conceptual framework for management. Invasive species: vectors and management strategies (ed. by G.M. Ruiz and J.T. Carlton), pp. 459-504, Island Press, Washington, D.C.

Ruiz, G.M.and D.F. Reid (eds). 2007. Current state of understanding about the effectiveness of ballast water exchange (BWE) in reducing aquatic non-indigenous species introductions to the Great Lakes Basin and Chesapeake Bay, USA: Synthesis and Analysis of Existing Information. NOAA Technical Memorandum GLERL-142. US Department of Commerce, September 2007.

Ruiz G.M. and G. Smith. eds. 2004. Biological studies containerships arriving to the Port of Oakland, California. Smithsonian Environmental Research Center, Edgewater, Maryland.

Shiganova, T.A. 1998. Invasion of the Black Sea by the ctenophore *Mnemiopsis leidyi* and recent changes in pelagic community structure. *Fisheries Oceanography*, 7: 305-310.

Simkanin C., and M. Sytsma 2006. Report on the Oregon Ballast Water Management Program in 2006. Prepared for the Oregon State Legislature in cooperation with the Oregon Ballast Water Task Force. September 2006.

Stachowicz J.J., J.R. Terwin, R.B. Whitlatch, and R.W. Osman. 2002. Linking climate change and biological invasions: ocean warming faciliatates nonindigenous species invasions. *Proceedings of the National Academy of Sciences of the United States of America*, 24:15497-15500.

Sytsma, M.D., Cordell, J.R., Chapman, J.W. & Draheim, R.C. 2004. Lower Columbia River Aquatic Non-indigenous Species Survey 2001-2004. United States Coast Guard and United States Fish and Wildlife Service.

Takata, L., Falkner, M. & Gilmore, S. 2006. Commercial Vessel Fouling in California: Analysis, Evaluation, and Recommendations to Reduce Nonindigenous Species Release From the Non-Ballast Water Vector. Prepared for the California State Legislature.

Taniguchi, Y., F.J. Rahel, D.C. Novinger, and K.G. Gerow. 1998. Temperature mediation of competitive interactions among three fish species that replace each other along longitudinal stream gradients. *Can J. Fish. Aquat. Sciences*, 55:1894-1901.

Van Dolah, F, D. Roelke, and R. Greene. 2001. Health and ecological impacts of harmful algal blooms: risk assessment needs. Human and Ecological Risk Assessment 7(5):1329-1345.

Vermeij, G.J. 1991. Wne biotas meet: understanding biotic interchange. *Science* 253:1099-1104.

Vinograd, J. & Sytsma, M. 2002. Report on the Oregon ballast water management program in 2002. Prepared in cooperation with the Oregon Ballast Water Task Force. December 2002.

Vitousek, P.M., Antonio, C.M.D., Loope, L.L., Rejmanek, M. & Westbrooks, R. 1997. Introduced species: A significant component of human-caused global change. *New Zealand Journal of Ecology*, 21(1): 1-16.

WCGAOH. 2008. West Coast Governors Agreement on Ocean Health Action Plan. http://westcoastoceans.gov/docs/WCGA_ActionPlan_lowest-resolution.pdf Accessed on August 7th, 2008.

Wonham M.J., and J.T. Carlton. 2005. Trends in marine biological invasions at local and regional scales: the Northeast Pacific Ocean as a model system. *Biological Invasions*, 7:369-392.

Appendix A: Oregon Ballast Management Statute (ORS 783.625-640)

BALLAST WATER

783.620 Discharge of ballast in navigable waters. Except as provided in ORS 783.635, a person may not discharge the ballast of any vessel into the navigable portions or channels of any of the bays, harbors or rivers of this state, or within the jurisdiction of this state, so as to injuriously affect such portions or channels of such bays, harbors or rivers, or to obstruct navigation thereof. [Formerly 783.600]

783.625 Definitions for ORS 783.625 to 783.640. As used in ORS 783.625 to 783.640, unless the context requires otherwise:

(1) "Ballast water" means any water used to manipulate the trim and stability of a vessel.

(2) "Cargo vessel" means a ship in commerce that is equipped with ballast tanks, other than a tank vessel or a vessel used solely for commercial fish harvesting, of 300 gross tons or more.

(3) "Coastal exchange" means exchanging the ballast water taken onboard at a North American coastal port at a distance of at least 50 nautical miles from land and at a depth of at least 200 meters.

(4) "Department" means the Department of Environmental Quality.

(5) "Oil" means oil, gasoline, crude oil, fuel oil, diesel oil, lubricating oil, oil sludge, oil refuse and any other petroleum related product.

(6) "Open sea exchange" means a replacement of ballast water that occurs in an area no less than 200 nautical miles from any shore.

(7) "Passenger vessel" means a ship of 300 gross tons or more carrying passengers for compensation.

(8) "Sediment" means any matter that settles out of ballast water.

(9) "Ship" means any boat, ship, vessel, barge or other floating craft of any kind.

(10) "Tank vessel" means a ship that is constructed or adapted to carry oil in bulk as cargo or cargo residue other than:

(a) A vessel carrying oil in drums, barrels or other packages;

(b) A vessel carrying oil as fuel or stores for that vessel; or

(c) An oil spill response barge or vessel.

(11) "Vessel" means a tank vessel, cargo vessel or passenger vessel.

(12) "Voyage" means any transit by a vessel destined for any Oregon port.

(13) "Waters of this state" means natural waterways including all tidal and nontidal bays, intermittent streams, constantly flowing streams, lakes, wetlands and other bodies of water in this state, navigable and nonnavigable, including that portion of the Pacific Ocean that is in the boundaries of Oregon. [2001 c.722 §1; 2003 c.692 §1; 2005 c.62 §2; 2007 c.816 §2]

783.630 Application; exclusions. (1) ORS 783.625 to 783.640 apply to all vessels carrying ballast water into the waters of this state from a voyage, except a vessel that:

(a) Discharges ballast water only at the location where the ballast water originated, if the ballast water is not mixed with ballast water from areas other than open sea waters;

(b) Does not discharge ballast water in waters of this state;

(c) Traverses only the internal waters of this state;

(d) Traverses only the territorial sea of the United States and does not enter or depart an Oregon port or navigate the waters of this state;

(e) Discharges ballast water that originated solely from waters located between the parallel 40 degrees north latitude and the parallel 50 degrees north latitude on the west coast of North America; or

(f) Discharges ballast water that has been treated to remove organisms in a manner that is approved by the United States Coast Guard.

(2) ORS 783.625 to 783.640 do not authorize the discharge of oil or noxious liquid substances in a manner prohibited by state, federal or international laws or regulations. Ballast water containing oil or noxious liquid substances shall be discharged in accordance with the requirements applicable to those substances.

(3) Nothing in this section:

(a) Requires an open sea or coastal exchange if the owner or operator in charge of a vessel determines that performing an open sea or coastal exchange would threaten the safety or stability of the vessel or the safety of the vessel's crew or passengers because of any extraordinary condition, including but not limited to adverse weather, vessel design limitations or equipment failure.

(b) Exempts the owner or operator in charge of a vessel from the reporting requirements under ORS 783.640, whether or not ballast water is carried or discharged in the waters of this state. [2001 c.722 §2; 2003 c.692 §2; 2005 c.62 §5]

783.635 Discharge of ballast water prohibited; exemption. (1) Except as authorized by this section, the discharge of ballast water in the waters of this state is prohibited.

(2) An owner or operator of a vessel may discharge ballast water in the waters of this state:

(a) If the owner or operator has conducted a complete open sea or coastal exchange of ballast water prior to entering the waters of this state. The open sea or coastal exchange must be performed using either of the following methods:

(A) Flow-through exchange. A flow-through exchange occurs when an amount of ocean water equal to or exceeding three times the capacity of the vessel's ballast water tank is pumped into an opening in the ballast water tank while the existing ballast water is discharged through another opening.

(B) An empty and refill exchange. An empty and refill exchange occurs when a ballast water tank is pumped empty to the point that the pump loses suction and then is refilled with ocean water.

(b) Without performing an open sea exchange or a coastal exchange of ballast water if:

(A)(i) The owner or operator reasonably believes that an exchange would threaten the safety of the vessel; or

(ii) The exchange is not feasible due to vessel design limitations or equipment failure; and

(B) The vessel discharges only the amount of ballast water that is operationally necessary.

(3) An owner or operator who discharges ballast water in the waters of this state under subsection (2)(b) of this section is subject to the reporting requirements under ORS 783.640. [2001 c.722 §3; 2005 c.62 §3]

783.640 Reporting of ballast water management. (1) Owners or operators of vessels regulated under ORS 783.625 to 783.640 must report ballast water management information to the Department of Environmental Quality:

(a) For voyages greater than 24 hours in length, at least 24 hours prior to entering the waters of this state; or

(b) For voyages less than 24 hours in length, prior to departing the port or place of departure.

(2) The department may work with maritime associations and any national ballast information clearinghouse to establish the manner and form of the reporting required under this section.

(3) The department may verify compliance with ORS 783.625 to 783.640 by relying on tests conducted by the United States Coast Guard or on other tests determined to be appropriate by the department. [2001 c.722 §4; 2005 c.62 §4]

Note: Sections 1 and 4, chapter 816, Oregon Laws 2007, provide:

Sec. 1. Shipping Transport of Aquatic Invasive Species Task Force (1)(a) There is created the Shipping Transport of Aquatic Invasive Species Task Force.

(b) The President of the Senate and the Speaker of the House of Representatives shall appoint two members from among members of the Legislative Assembly to serve in an advisory capacity to the task force.

(c) The Director of the Department of Environmental Quality may appoint members to the task force who represent the interests of this state and federal, State of Washington, maritime, environmental and academic interests.

(2) The purpose of the task force is to study and make recommendations:

(a) For combatting the introduction of aquatic nonindigenous species associated with shipping-related transport into the waters of this state; and

(b) On changes to the ballast water program established in ORS 783.625 to 783.640, including but not limited to the following considerations:

(A) Shipping industry compliance with ORS 783.625 to 783.640;

(B) Practicable and cost-effective ballast water treatment technologies;

(C) Appropriate standards for discharge of treated ballast water into waters of this state;

(D) The compatibility of ORS 783.625 to 783.640 with new laws enacted by the United States Congress, regulations promulgated by the United States Coast Guard and ballast water management programs established by the States of Alaska, California and Washington and the Province of British Columbia;

(E) Practicable and cost-effective techniques to combat the introduction of aquatic nonindigenous species associated with shipping-related transport into the waters of this state; and

(F) Appropriate regulations and standards to combat the introduction of aquatic nonindigenous species associated with shipping-related transport into the waters of this state.

(3) Portland State University may provide staff support or coordination assistance to the task force, subject to available funding from gifts, grants or donations.

(4) All agencies of state government, as defined in ORS 174.111, are directed to assist the task force in the performance of its duties and, to the extent permitted by laws relating to confidentiality, to furnish such information and advice as the members of the task force consider necessary to perform their duties.

(5) A majority of the members of the task force constitutes a quorum for the transaction of business.

(6) Official action by the task force requires the approval of a majority of the members of the task force.

(7) The task force shall elect one of its members to serve as chairperson.

(8) The task force shall submit a report, including recommendations for legislation, to an interim committee related to natural resources no later than October 1, 2008.

(9) Notwithstanding ORS 171.072, members of the task force who are members of the Legislative Assembly are not entitled to mileage expenses or a per diem and serve as volunteers on the task force. Other members of the task force are not entitled to compensation or reimbursement for expenses and serve as volunteers on the task force.

(10) As used in this section:

(a) “Aquatic nonindigenous species” means any species or other viable biological material that enters an ecosystem beyond its historic range.

(b) “Waters of this state” has the meaning given in ORS 783.625. [2007 c.816 §1]

Sec. 4. Section 1 of this 2007 Act is repealed on the date of the convening of the next regular biennial legislative session. [2007 c.816 §4]

PENALTIES

783.990 Penalties. (1) Violation of ORS 783.510 is punishable, upon conviction, in a justice or circuit court, by a fine of not less than $50 nor more than $200, or by imprisonment in the county jail for not less than one nor more than six months, or both.

(2) Violation of ORS 783.520 is punishable, upon conviction, in a justice or circuit court, by a fine of not less than $50 nor more than $250, or by imprisonment in the county jail for not less than 60 days nor more than six months.

(3) Violation of ORS 783.530 is punishable, upon conviction, in a justice or circuit court, by a fine of not less than $20 nor more than $200, or by imprisonment in the county jail for not less than 10 nor more than 100 days.

(4) Violation of ORS 783.550 is punishable, upon conviction, in a justice or circuit court, by a fine of not less than $20 nor more than $100 or by imprisonment in the county jail for not less than 10 nor more than 100 days, or both.

(5) Violation of ORS 783.560 by any officer is a Class D violation.

(6) Violation of ORS 783.580 is punishable, upon conviction, by a fine of not less than $100 nor more than $250, and by imprisonment in the county jail not less than 10 nor more than 25 days. Justices of the peace have jurisdiction of violations of ORS 783.580.

(7) Violation of ORS 783.590 and injury or damage of any bridge across the Willamette River for want of the appliances described in ORS 783.590 is a Class A violation.

(8) Violation of ORS 783.620 is punishable, upon conviction, by a fine of not less than $100 nor more than $500, or by imprisonment in the county jail for not less than three months nor more than one year.

(9) Violation of ORS 783.610 is punishable, upon conviction, by a fine of not less than $100 nor more than $200, or by imprisonment in the county jail not less than one nor more than six months, or both. [Amended by 1953 c.113 §2; 1997 c.249 §224; 1999 c.1051 §227]

783.992 Civil penalties. (1) Except as provided in subsection (2) of this section, the Director of the Department of Environmental Quality may impose a civil penalty on the owner or operator of a vessel for failure to comply with the requirements of ORS 783.625 to 783.640. The penalty imposed under this section may not exceed $5,000 for each violation. In determining the penalty imposed, the director shall consider whether the violation was intentional, negligent or without any fault and shall consider the quality and nature of risks created by the violation. The owner or operator of a vessel subject to such a penalty may contest the determination by requesting a hearing under ORS 183.413 to 183.470.

(2) The civil penalty for a violation of the reporting requirements of ORS 783.640 may not exceed $500 per violation. [2001 c.722 §7; 2005 c.62 §6]

Appendix B: Ballast Water Reporting Form (BWRF; OMB 1625-0069)

OMB Control Number 1625-0069

BALLAST WATER REPORTING FORM

IS THIS AN AMENDED BALLAST REPORTING FORM? YES☐ NO☑

1. VESSEL INFORMATION	2. VOYAGE INFORMATION		3. BALLAST WATER USAGE AND CAPACITY
Vessel Name:	Arrival Port:		*Specify Units Below (m^3, MT, LT, ST)*
IMO Number:	Arrival Date (D/M/YYYY):		Total Ballast Water on Board:
Owner:	Agent:		Volume / Units / No. of Tanks in Ballast
Type:	Last Port:	Country of Last Port:	m3
GT:			Total Ballast Water Capacity:
Call Sign:	Next Port:	Country of Next Port:	Volume / Units / Total No. of Tanks on Ship
Flag:			m3

4. BALLAST WATER MANAGEMENT Total No. Ballast Water Tanks to be discharged: ☐

Of tanks to be discharged, how many: Underwent Exchange: ☐ Underwent Alternative Management: ☐

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

If no ballast treatment conducted, state reason why not: ☐

Ballast management plan on board? YES☐ NO☐ Management plan implemented? YES☐ NO☐

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

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

Tanks/ Holds	BW SOURCE				BW MANAGEMENT PRACTICES						BW DISCHARGE			
List multiple sources/tanks separately	DATE D/M/YYYY	PORT or LAT. LONG.	VOLUME (units)	TEMP (units)	DATE D/M/YYYY	ENDPOINT LAT. LONG.	VOLUME (units)	% Exch	METHOD (ER/FT/ ALT)	SEA HT. (m)	DATE D/M/YYYY	PORT or LAT. LONG.	VOLUME (units)	SALINITY (units)
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg

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

6. RESPONSIBLE OFFICER'S NAME AND TITLE, PRINTED AND SIGNATURE: ☐

Released 12-01-2006 Send form by e-mail **OR** Submit form on-line **OR** Save as text file NBICReportingForm-1.6.pd

Appendix C: Regulations Comparison table (courtesy of WCBOP)

Managing Ballast Water and Vessel Fouling. Various regulations, proposed management actions, recommendations, guidelines, and codes of practice aimed towards preventing AIS introductions through ballast water and vessel fouling are summarized below.

	IMO Convention	U.S. National Program (NISA)	State Programs (CA, WA, OR, HI)
Proactive measures: education/outreach, vessel arrival monitoring, evaluation for high-risk arrivals	x		CA, WA, OR, HI
BALLAST WATER MANAGEMENT			
Requires ballast water management plan	x	x	CA, WA, HI
Requires reporting at each port of call		x	CA, WA, OR, HI
Requires mandatory open ocean exchange (with safety and other exemptions allowed)	x	x	CA, WA, OR, HI
Requirements apply to domestic coastal voyages			CA, WA, OR
Boarding of vessels to verify management compliance		x	CA, WA, OR, HI
Penalty for non-reporting and non-compliance		x	CA, WA, OR, HI
Allows alternative treatment methods, if approved	x	x	CA, WA, OR, HI
Offers incentives for alternative treatment	x	x	CA
Includes an approval process for vendors with ballast water treatment systems	x	Due 2008	
Includes implementation schedule for ballast water discharge performance standards.	x	Due 2008	CA
Includes fees to support program			CA
VESSEL FOULING MANAGEMENT			
Requires rinsing of anchor chains and anchors at place of origin		x	CA
Requires removal and disposal of fouling from hull, piping and tanks, in accordance with applicable laws		x	CA
Vessel owner/operator/agent are required to submit annually hull husbandry/management information			CA

Appendix D: Ballast Water Treatment (BWT) Performance Standards from IMO and California (modified from Falkner et al. 2006).

Organism Size Class	IMO Regulation D-2[1]	California[1,2]
Organisms greater than 50 µm[3] in minimum dimension	< 10 viable organisms per cubic meter	No detectable living organisms
Organisms 10 – 50 µm[3] in minimum dimension	< 10 viable organisms per ml[4]	< 0.01 living organisms per ml[4]
Organisms less than 10 µm[3] in minimum dimension		$< 10^3$ bacteria/100 ml[4] $< 10^4$ viruses/100 ml[4]
Escherichia coli	< 250 cfu[5]/100 ml[4]	< 126 cfu[5]/100 ml[4]
Intestinal enterococci	< 100 cfu[5]/100 ml[4]	< 33 cfu[5]/100 ml[4]
Toxicogenic *Vibrio cholerae* (01 & 0139)	< 1 cfu[5]/100 ml[4] or < 1 cfu[[5]/gram wet weight zooplankton samples	< 1 cfu[5]/100 ml[4] or < 1 cfu[5]/gram wet weight zoological samples

[1] See Implementation Schedule (below) for dates by which vessels must meet California Interim Performance Standards and IMO Ballast Water Performance Standard
[2] Final discharge standard for California, beginning January 1, 2020, is zero detectable living organisms for all organism size classes
[3] Micrometer – one-millionth of a meter
[4] Milliliter – one-thousandth of a liter
[5] Colony-forming-unit – a measure of viable bacterial numbers

Appendix D (cont): Ballast Water Treatment (BWT) Performance Standards implementation (modified from Falkner et al. 2006).

Ballast Water Capacity of Vessel	Standards apply to new vessels in this size class constructed on or after	Standards apply to all other vessels in this size class beginning in
< 1500 metric tons	2009	2016
1500 – 5000 metric tons	2009	2014
> 5000 metric tons	2012	2016

Appendix E: Vessel Inspection Survey Form (ODEQ)

State of Oregon
Department of Environmental Quality

Oregon Ballast Water Program

811 SW 6th Avenue
Portland, OR 97204
Ph: (503) 229-6865
Fax: (503) 229-6954
Email: ballast.water@deq.state.or.us
http://www.deq.state.or.us/lq/cu/emergency/ballast.htm

VESSEL INSPECTION COMPLIANCE REPORT

Arrival Information:		*Inspection Details:*	
Vessel Name:		**Inspection Date:**	
IMO #:		**Port:**	
Last Port:		**Berth:**	
Arrival Date:		**Inspector:**	
Ballast Onboard:	LT/MT/M3	**Ship Personnel Encountered:**	
Discharging?	**Yes / No**		

Reporting Requirements:

Was the ballast water reporting form accurate, complete, legible, and submitted 24 hours prior to arrival?

- ☐ BWRF submitted to State 24 hours prior to arrival. (5 pts)
- ☐ BWRF submitted to NBIC 24 hours prior to arrival. (5 pts)
- ☐ BWRF was legible. (5 pts)
- ☐ BWRF was filled out properly. (10 pts) Score: ______(25)

Ballast Water Management Implementation & Recordkeeping:

How well does the BWR and ships' log records correspond to ballast management regulations?

- ☐ Updated and clearly organized ballast log book. (5 pts)
- ☐ Ballast exchange declaration corresponds with Deck/Position log and/or Engine Room log. (10 pts)
- ☐ Discharged ballast was exchanged fully and at sufficient distance from shore (or treated using approved technology). (10 pts)
- ☐ Vessel will not discharge during port call; No records audit performed. Score: ______(25)

Ballast Water Exchange Verification:

Do water sample collections verify that ballast water exchange was conducted properly?

*Tank*_____ *Tank*_____ *Tank*_____ *Tank*_____ *Tank*_____

- ☐ Salinity
- ☐ CDOM
- ☐ No samples were collected Score: ______(25)

Non-ballast vector management:

Was the ballast water reporting form accurate, complete, legible, and submitted 24 hours prior to arrival?

- ☐ Ballast Water Management Plan (10 pts)
- ☐ Demonstrated awareness of sediment management and other BMP's (5 pts)
- ☐ Approved anti-fouling regime certification. (5 pts)
- ☐ Hull cleaning (______ yrs ago). (5 pts) Score: ______(25)

TOTAL SCORE: ___________

This inspection was conducted to assess vessel compliance with State of Oregon ballast water management regulations and to further efforts at preventing the introduction of aquatic invasive species to Oregon waterways. Violations will be referred to the DEQ Enforcement Division for further action. Further, any violations of Federal or International rules will be reported to the United States Coast Guard as part of our cooperative inspection program.

________________________________ Inspector, OR DEQ

Appendix F: ODEQ hull-husbandry voluntary survey form (adapted from CSLC)

Submit Form

DEQ
State of Oregon Department of Environmental Quality

State of Oregon
Department of Environmental Quality
Aquatic Invasive Species Prevention Program

Survey of Hull-husbandry & Maintenance Practices

Vessel Reporting Form

Vessel Name:____________________ Official / IMO Number:__________________
Date Submitted (Day/Month/Year): ____
Responsible Officer's Name and Title: ______________________________________

Hull Husbandry Information

1. Since delivery, has this vessel ever been removed from the water for maintenance?
   Yes ☐ No ☐

   a. If Yes, enter the date and location of the most recent out-of-water maintenance:
      Last date out of water (Day/Month/Year): __________________________
      Port or Position: ____________________ Country: ____________________

   b. If No, enter the delivery date and location where the vessel was built:
      Delivery date (Day/Month/Year): ________________________________
      Port or Position: ____________________ Country: ____________________

2. Were the submerged portions of the vessel coated with an anti-fouling treatment/coating during the **out-of-water** maintenance or shipbuilding process listed above?
   Yes, full coat applied ☐ Yes, partial coat only ☐
   No coat applied ☐

   a. If 'Yes, partial coat applied' or 'No coat applied' was checked, when did the submerged portion of the vessel last undergo a **full coat** of anti-fouling treatment?
      Date of treatment completion (Day/Month/Year):______________________

3. For the most recent full coat application of anti-fouling treatment, what type of anti-fouling treatment was applied and to what specific **sections** of the submerged portions of the vessel was it applied?

   Manufacturer/Company: ____
   Product name: ____
   Applied on **(Check all that apply)**: Hull Sides ☐ Hull Bottom ☐ Sea Chests ☐
   Sea Chest Gratings ☐ Propeller ☐ Rope Guard/Propeller Shaft ☐
   Previous Docking Blocks ☐ Thrusters ☐ Rudder ☐ Bilge Keels ☐

Appendix F (cont.) ODEQ hull-husbandry voluntary survey form (adapted from CSLC)

Official/IMO Number: ________________

Manufacturer/Company: ____
Product name: ____
Applied on **(Check all that apply)**: Hull Sides ☐ Hull Bottom ☐ Sea Chests ☐
Sea Chest Gratings ☐ Propeller ☐ Rope Guard/Propeller Shaft ☐
Previous Docking Blocks ☐ Thrusters ☐ Rudder ☐ Bilge Keels ☐

Manufacturer/Company: ____
Product name: ____
Applied on **(Check all that apply)**: Hull Sides ☐ Hull Bottom ☐ Sea Chests ☐
Sea Chest Gratings ☐ Propeller ☐ Rope Guard/Propeller Shaft ☐
Previous Docking Blocks ☐ Thrusters ☐ Rudder ☐ Bilge Keels ☐

4. Were the sea chests inspected and/or cleaned during the **out-of-water** maintenance listed above? If no out-of-water maintenance since delivery, select Not Applicable. **Check all that apply**.

   Yes, sea chests inspected ☐ Yes, sea chests cleaned ☐
   No, sea chests not inspected or cleaned ☐ Not Applicable ☐

   a. Are Marine Growth Protection Systems (MGPS) installed in the sea chests? Yes ☐ No ☐

   b. If MGPS is installed, specify manufacturer and model:
   Manufacturer: ______________________ Model: ____________________

5. Has the vessel undergone **in-water** cleaning to the submerged portions of the vessel since the last out-of-water maintenance period? Yes ☐ No ☐

   a. If Yes, when and where did the vessel most recently undergo **in-water** cleaning (Do not include cleaning performed during out-of-water maintenance period)?

   Date (Day/Month/Year): ____
   Port or Position: ____________________ Country: ________________________
   Section(s) cleaned (**Check all that apply**):
   Hull Sides ☐ Hull Bottom ☐ Propeller ☐ Sea Chest Grating ☐
   Sea Chest ☐ Bilge Keels ☐ Rudder ☐ Docking Blocks ☐
   Thrusters ☐ Unknown ☐

   Cleaning method: Divers ☐ Robotic ☐ Both ☐
   Vendor providing cleaning service: ____________________________________

6. Has the propeller been polished since the last **out-of-water** maintenance or **in-water** cleaning? Yes ☐ No ☐
   If Yes, indicate date (Day/Month/Year): ________________________________

7. Are the anchor and anchor chains rinsed during retrieval? Yes ☐ No ☐

Appendix F (cont.) ODEQ hull-husbandry voluntary survey form (adapted from CSLC)

Official/IMO Number: ______________

Voyage Information

8. List the following information for this vessel averaged over the last four months:
   a. Average Voyage Speed (knots): ______________
   b. Average Port Residency Time (hours or days): ______**Hours** or ______**Days**

9. Since the hull was last cleaned (**out-of-water** or **in-water**), has the vessel visited:
   a. Fresh water ports (Specific gravity of less than 1.005)? Yes ☐ No ☐
      If Yes, how many?______________

   b. Tropical ports (between 23.5° S and 23.5° N latitude)? Yes ☐ No ☐
      If Yes, how many?______________

   c. Panama Canal? Yes ☐ No ☐ If Yes, how many times? ______________

   d. List the previous 10 ports visited by this vessel in the order they were visited (start with most recent). Note: If the vessel visits the same ports on a regular route, check here ☐ and list the route once (you do not have to use all 10 spaces if the route involves less than 10 ports; add more lines if regular route involves more than 10 ports). **List dates as (Day/Month/Year)**.

Port or Position: ______________ Country: ______________
Arrival date: ______________ Departure date: ______________

Port or Position: ______________ Country: ______________
Arrival date: ______________ Departure date: ______________

Port or Position: ______________ Country: ______________
Arrival date: ______________ Departure date: ______________

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Arrival date: ______________ Departure date: ______________

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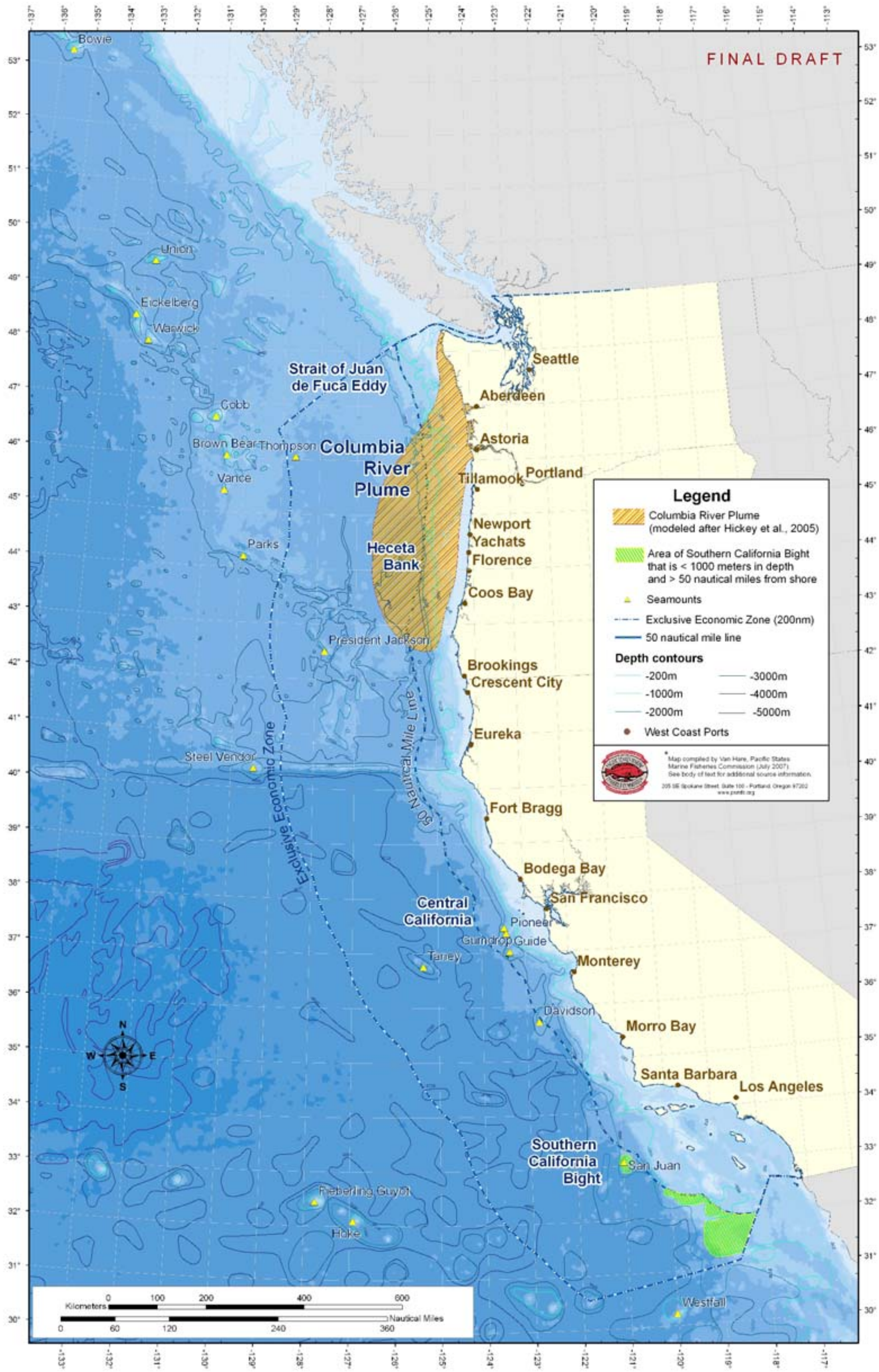
Appendix G: Map identifying oceanographic features of the Pacific Coast region that should be considered in developing Alternative Ballast Water Exchange Areas (ABWEA's) (courtesy of PSMFC).



Appendix H. Treatment Technologies Assessement (courtesy of Doboski et al. 2007)

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Alfa Laval	Sweden	PureBallast	combination	filtration + advanced oxidation technology (hydroxyl radicals)	IMO Basic and Final
Degussa AG	Germany	Peraclean Ocean	chemical	biocide (peracetic acid and hydrogen peroxide)	IMO Basic
Ecochlor	USA	Ecopod	chemical	biocide (chlorine dioxide)	
Electrichlor	USA	Model EL 1-3 B	chemical	biocide (sodium hypochlorite)	
Environmental Technologies Inc.	USA	BWDTS	combination	ozone + sonic energy	
Ferrate Treatment Technologies	USA		chemical	ferrate	
Greenship	Netherlands	Sedimentor + chlorination	combination	hydrocyclone + electrolytic chlorination	
Hamann AG	Germany	SEDNA System	combination	hydrocyclone + filtration + biocide (Peraclean Ocean)	IMO Basic (Peraclean)
Hi Tech Marine	Australia		physical	heat treatment	
Hitachi	Japan		physical (?)	coagulation + magnetic separation + filtration	
Hyde Marine	USA	Hyde Guardian, HBWTS	combination	filtration + UV	WA Conditional
Japan Assoc. Of Marine Safety	Japan	Special Pipe	combination	mechanical treatment + ozone	IMO Basic
JFE Engineering Corp.	Japan	JFE BWMS	combination	filtration + biocide (sodium chlorine) + cavitation	
L. Meyer GMBH	Germany		combination	filtration + disinfection liquid	

Appendix H (Continued). Treatment Technologies Assessement (courtesy of Doboski et al. 2007)

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
MARENCO	USA		combination	filtration + UV	WA General Approval
Maritime Solutions Inc.	USA		combination	centrifugal separation + UV or biocide (Seakleen)	
MH Systems	USA	BW treatment system	combination	deoxygenation + carbonation	
Mitsubishi Heavy Industries	Japan	Hybrid System	combination	filtration + electrolytic chlorination	
NEI	USA	Venturi Oxygen Stripping (VOS)	combination	deoxygenation	Type Approval (Liberia)
NKO	Korea		chemical	ozone	IMO Basic
Nutech 03 Inc.	USA	SCX 2000, Mark III	chemical	ozone	
OceanSaver	Norway	OceanSaver	combination	filtration + nitrogen saturation + cavitation	
OptiMarin	Norway	OptiMar	combination	hydrocyclone + UV	
Resource Ballast Technologies	South Africa	RBT Reactor	combination	cavitation + ozone + sodium hypochlorite	
RWO Marine Water Technology	Germany	CleanBallast!	combination	filtration + advanced electrolysis (EctoSys)	IMO Basic (EctoSys)
SeaKleen	USA	SeaKleen	chemical	biocide (menadione)	
Severn Trent DeNora	USA	BalPure	chemical	electrolytic generation of sodium hypochlorite	
Techcross Inc.	Korea	Electro-Clean	combination	electrochemical oxidation	IMO Basic