2011 BIENNIAL REPORT ON THE CALIFORNIA MARINE INVASIVE SPECIES PROGRAM

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EXECUTIVE SUMMARY

California's Marine Invasive Species Act of 2003 renewed and expanded the Ballast Water Management for Control of Nonindigenous Species Act of 1999, to address the threat of noninidenous species (NIS) introductions. The law charged the California State Lands Commission (Commission) with oversight and administration of the state's program to prevent or minimize the release of NIS from commercial vessels. To advance this goal, the Commission's Marine Invasive Species Program (MISP) utilizes an inclusive, multi-faceted approach to: Develop sound, science-based policies in consultation with technical experts and stakeholders; Track and analyze ballast water and vessel fouling management practices of the California commercial fleet; Enforce laws and regulations to prevent introductions; and, Facilitate outreach to promote information exchange amongst scientists, legislators, regulators, and other stakeholders. This report fulfills the reporting mandate set forth in Public Resources Code (PRC) Section 71212 and summarizes the activities of the MISP in each of these areas from July 2008 through June 2010.

Vessel Arrival Statistics and Compliance with Ballast Water Management Requirements

Commercial vessels are required to submit a Ballast Water Reporting Form upon departure from each port or place of call in California. These forms provide specific information about vessel capacity, voyage particulars, and the origin and management of ballast water that is discharged in the state. Data from the forms are used to examine trends in the quantity and geography of arrivals, ballast water management and discharge, and patterns of compliance and noncompliance in the state. Compliance with the requirement to submit reporting forms is consistently very high. Since 2004, compliance has remained above 93%, and has been even higher in recent years. From July 2008 through June 2010, 98% of forms were submitted as required, and 87% were submitted on time.

Arrival statistics from July 2008 through June 2010 appear to reflect the global economic downturn that has depressed international trade. The overall number of arrivals to California began decreasing in late 2006, a pattern that continues throughout the time period of focus for this report. Over 6,000 arrivals were observed during the first six months of 2006, declining to a low of 4488 arrivals during the first six months of 2010. Aside from LA-LB, many ports saw a decrease in the proportion of arrivals from places outside of the Pacific Coast Region ("foreign arrivals"). Since the last biennial report (Falkner et al. 2009), Oakland and San Diego's foreign arrivals have declined 5% and Hueneme's foreign arrivals have declined 6%. Nearly 50% of all arrivals to California came from other ports within the Pacific Coast region.

Compliance with ballast water management requirements in California remains extremely high. Of the more than 120 million metric tons (MMT) of vessel-reported ballast water carried into State waters between July 2008 and June 2010, over 98% was managed in compliance with California law. Approximately 84% of arrivals comply with California's requirements by retaining ballast water on board, which is considered the most protective management strategy. Of the 20.9 MMT of ballast water discharged, 88% was appropriately managed through legal ballast water exchange and was compliant with California law. While ballast water exchange at legal distances offshore is most protective, some attempt at ballast water exchange is, in most cases, more beneficial than no exchange at all. The vast majority of ballast water in violation of management requirements (over 76%) had been exchanged prior to discharge, but in a location not acceptable under California law. Further, the proportion of ballast water discharged in the state that is compliant with state law has been steadily improving since the latter half of 2006, even though total discharges have been on the rise.

Commission Marine Safety personnel verify vessel-reported ballast water management practices through onboard inspections of vessel logbooks and sampling ballast water to be discharged. Between July 2008 and June 2010, 4310 ballast water inspections (22.5% of arrivals) were conducted by Commission staff. Approximately 1.1% of arrivals were found to be in violation with operational aspects of the law, which includes improper ballast water management.

Hull Husbandry Reporting Form Data Analysis: Trends in Vessel Fouling-Related Practices and Behaviors

Commission staff has also been moving forward with data collection and the development of management requirements to prevent introductions via the vessel fouling vector. Beginning in 2008, vessels operating in California waters are required to submit a Hull Husbandry Reporting Form (HHRF) once annually. This form requests information on certain voyage behaviors and maintenance practices that influence the amount of fouling that accumulates on the wetted surfaces of vessels, influencing the risk for NIS introduction. Data from the HHRF forms will be used in concert with targeted biological research funded by the Commission to better understand how husbandry practices and voyage characteristics affect the quantity and quality of fouling organisms arriving in California on commercial ships. These two data streams, in addition to consultation with a multi-disciplinary technical advisory group during 2010 and 2011, will be used to develop management requirements by January 1, 2012 to reduce introductions through the vessel fouling vector.

The rate of submission for the HHRF has improved dramatically, from 74.4% during 2008 (the first year the form was required), to nearly 93% in 2009, and data indicates that most vessels are taking various steps to minimize fouling growth. Overall, 83% of all vessels have been out of water (either newly built or dry docked) and painted with fresh antifouling coatings within the past three years (99% within the past five years). Because of the relatively young age of these coatings, the physical removal of organisms while the vessels remain in water does not appear to be a major tool used fleet-wide, as less than 10% of all vessels conduct in-water cleaning of the hull and other submerged surfaces. The application of antifouling coatings to deter fouling growth is conducted on a regular basis, typically during either the shipbuilding process or the last out-of-water dry dock. The majority (86.1%) of the vessels operating in California are utilizing biocide-based coatings, while 3.8% utilize biocide-free coatings, and 3.7% utilize a combination of antifouling coating types. A little over half of the fleet (50.1 – 65.7%) has installed marine growth prevention systems (MGPSs) to prevent fouling organisms from accumulating within sea chests and internal piping networks. However, more investigation will be needed to determine how often vessels with installed MGPSs actually utilize them.

Voyage characteristics examined from the HHRFs suggest a gradient of risk associated with different vessel types. Elevated traveling speed and shorter sedentary periods are associated with lower levels of fouling accumulation. Auto carriers, container vessels, and passenger vessels that visit California travel at elevated speeds in excess of 16 knots and spend a day or less in port. In comparison, bulk vessels and the "other" vessel type category travel at slower speeds and typically spend over three days in port. In addition, a dramatic increase in frequency and duration of extended layups (immobile periods) between 2008 and 2009 appear to be a consequence of the global economic recession. Per capita, the 2009 California fleet saw a 21.6 % increase in the total number of layups since each vessel's most recent dry docking or delivery. Large increases in the duration of layups was also observed, with layups of 60-99 days and 500 days or greater experiencing the largest increases. In the absence of drydocking or in-water cleaning, extended sedentary periods have the potential to result in the accumulation of heavy fouling, raising concerns for the potential of NIS transfer from vessels that have experienced extended layups.

Implementation of Performance Standards for Ballast Water Discharge

The Commission has been moving forward with several projects for the implementation of California's performance standards for ballast water discharge. Since December of 2007, the Commission has produced three legislatively mandated reviews of ballast water treatment systems and one additional update. These reports evaluate whether systems will be available to meet the performance standards on new vessels for which construction began on or after January 1, 2010 or 2012 (applicable effective date depends on vessel's ballast water capacity). Multiple systems have demonstrated that they have the potential to meet California's performance standards, and systems should be available by the time the construction of affected vessels nears a phase where treatment systems must be installed. However, recent discussions within expert scientific panels convened by other state groups (Great Lakes Collaborative) and the federal Environmental Protection Agency have raised questions about technology availability and the ability of scientists to verify system performance for standards as strict as California's. This information is being weighed by Commission staff and may require changes to the Commission's plans for implementing California's performance standards.

Regardless of how performance standards are implemented, once vessels begin to use ballast water treatment systems in California, information on their installation and use will be needed to monitor compliance. In addition, compliance inspections will require Commission staff to take samples of treated ballast water from discharge piping. Assembly Bill 248 of 2009 provided the Commission with the authority to request ballast water treatment information on forms to be developed by the Commission. Two forms were adopted in October of 2010 to collect the needed information – the "Ballast Water Treatment Technology Annual Reporting Form" and the "Ballast Water Treatment Supplemental Reporting Form." In the fall of 2009, the Commission adopted regulations that require vessels to install sampling ports (i.e. sampling facilities) as near to the point of discharge as practicable. The regulations are based on the International Maritime Organization's Guideline G2, establishing design specifications for in-line sampling facilities, and requirements for where the sampling facilities should be installed on the discharge line. Sampling facilities must be installed on vessels by the same year that they must comply with California's performance standards.

Marine Invasive Species Program Involvement at the State, Federal, and International Levels

Commission staff continues to play an active role in several organizations that address ship-born NIS issues at the state, federal and international levels. Because California's MISP is often a leader in the development and implementation of preventative measures for reducing NIS release from ships, staff has received recent invitations to speak or participate on committees/panels, including (but not limited to): the federal Aquatic Nuisance Species (ANS) Task Force (Washington D.C.), the National Invasive Species Council (Washington D.C.), the North Sea Ballast Water Opportunity Workgroup (Germany and Sweden), the State of Washington's Ballast Water Working Group, the Shipping Transport of Aquatic Invasive Species Task Force (Oregon), the Minnesota Invasive Species Conference, and the Great Lakes Ballast Water Collaborative. Commission staff members have also given programmatic presentations at numerous local, state, national and international science and management conferences, including the International Conference on Marine Bioinvasions, the International Conference on Aquatic Invasive Species, the California and the World Oceans Conference, and the CSLC's Prevention First Symposium.

Looking Forward

In the coming years Commission staff intends to: (1) improve compliance with current ballast water management requirements by targeting outreach and enforcement on arrivals with comparatively lower compliance rates; (2) develop a revised course of action for the implementation of California's performance standards for ballast water discharge in consultation with scientific experts; (3) pursue an amendment to PRC Section 71204.7 to extend the grandfathering of vessels engaged in the testing of experimental ballast water treatment systems through the United States Coast Guard Shipboard Technology Evaluation Program (STEP); (4) develop regulations to reduce NIS discharge via the vessel fouling vector; (5) develop Memoranda of Agreement (MOAs) with international agencies working in parallel with the Commission in developing fouling management strategies; and, (6) support research promoting ballast water treatment technology development, in-water hull cleaning technology development, and fouling prevention in the sheltered nooks and crannies of the wetted surfaces of vessels (niche areas). As a part of all of these activities, the Commission will continue to use current resources to work proactively with the regulated industry, scientific community, and state, national and international regulatory agencies to reduce the risks of biological invasions to California waters.

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ABBREVIATIONS AND ACRONYMS

AB	Assembly Bill
ABRPI	Aquatic Bioinvasions Research and Policy Institute
Act	Marine Invasive Species Act (Chapter 491, Statutes of 1999)
AFS	Antifouling Systems on Ships
APL	American Presidential Line
Ba	Barium
BEAM	Ballast Exchange Assurance Meter
BOE	Board of Equalization
BW	Ballast Water
BWE	Ballast Water Exchange
BWM	Ballast Water Management
BWT	Ballast Water Treatment
CA	California
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDOM	Chromophoric Dissolved Organic Matter
CFU	Colony-Forming Unit
Commission	California State Lands Commission
CWA	Clean Water Act
DEQ	Department of Environmental Quality (Michigan)
EA	Environmental Assessment
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
HHRF	Hull Husbandry Reporting Form
IMO	International Maritime Organization
l	Liter
LA-LB	Los Angeles-Long Beach port complex
m	Meters
ml	Milliliter

MAF	Ministry of Agriculture and Forestry (New Zealand)
MARAD	Maritime Administration
MEPC	Marine Environment Protection Committee (IMO)
MGPS	Marine Growth Prevention System
MISP	Marine Invasive Species Program
MLML	Moss Landing Marine Laboratories
MMT	Million Metric Tons
Mn	Manganese
MOA	Memoranda of Agreement
MPCA	Minnesota Pollution Control Agency
MPPS	Massively Parallel Pyrosequencing
MT	Metric Tons
NAS	National Academy of Sciences, National Research Council
NIS	Nonindigenous Species
nm	Nautical Miles
NOAA	National Oceanic and Atmospheric Administration
NOBOB	No Ballast On Board
NPDES	National Pollution Discharge Elimination System
ODEQ	Oregon Department of Environmental Quality
OR	Oregon
P	Phosphorous
PCR	Pacific Coast Region
PPT	Parts Per Thousand
PRC	Public Resources Code
QV	Qualifying Voyage
SAB	Science Advisory Board
SB	Senate Bill
SD	Standard Deviation
SERC	Smithsonian Environmental Research Center
STEP	Shipboard Technology Evaluation Program
TAG	Technical Advisory Group

TBT	Tributyltin
µm	Micrometer
U.S.	United States
USCG	United States Coast Guard
VGP	Vessel General Permit (Clean Water Act)
WA	Washington
Water Board	State Water Resources Control Board (California)
WDFW	Washington Department of Fish and Wildlife
WDNR	Wisconsin Department of Natural Resources

I. PURPOSE

This report was prepared for the California State Legislature pursuant to Public Resources Code (PRC) Section 71212. According to statute, the California State Lands Commission (Commission) shall prepare and update biennially, a report that includes an analysis of ballast water and vessel fouling management practices reported by the industry, summarizes recent research addressing the release of nonindigenous species (NIS) by vessels, evaluates the effectiveness of California's Marine Invasive Species Program (MISP), and puts forth recommendations to improve the effectiveness of the program.

Since the inception of the MISP in 2000, four biennial reports have been completed. Activities from the first two and one half years of the program are detailed in the first biennial report to the Legislature (Falkner 2003). MISP activities from January 2003 through December 2004 are covered in Falkner et al. (2005), Falkner et al. (2007) covers the period from January 2004 through June 2006, and Falkner et al. (2009) summarizes activities from July 2006 through June 2008. This document constitutes the fifth MISP biennial report reviewing program activities, administration, research, and data analyses from July 2008 through June 2010.

II. INTRODUCTION

Nonindigenous Species and Vehicles of Introduction – "Shipping Vectors"

Also known as "introduced," "invasive," "exotic," "alien," or "aquatic nuisance species," nonindigenous species (NIS) in marine, estuarine and freshwater environments may be transported to new regions through numerous human activities. Aquaculture, live bait release, intentional sportfishing introductions, release of aquarium pet and live seafood specimens, transfer via leisure watercraft, and accidental release from research institutions are just a few of the mechanisms, or "vectors," by which organisms are introduced into United State (U.S.) waters (Weigel et al. 2005, Minchin et al. 2009). In coastal environments, commercial shipping is the most important vector for invasion, accounting for or contributing to 79.5% of introductions to North America (Fofonoff et al. 2003).

Commercial ships transport organisms through two primary mechanisms - ballast water and vessel fouling. Ballast water is necessary for many functions related to the trim, stability, maneuverability, and propulsion of large seagoing vessels (National Research Council 1996). Vessels may take on, discharge, or redistribute water during cargo loading and unloading, as they encounter rough seas, or as they transit through shallow coastal waterways. Typically, a vessel takes on ballast water as cargo is unloaded in one port to compensate for the weight imbalance, and will later discharge water when cargo is loaded in another. This transfer of ballast water from "source" to "destination" ports results in the movement of many organisms from one region to the next. In this fashion, it is estimated that more than 7000 species are moved around the world on a daily basis (Carlton 1999). Moreover, each ballast water discharge event has the potential to release over 21.2 million individual planktonic animals (Minton et al. 2005).

Fouling organisms are aquatic species attached to or associated with submerged hard surfaces. These include organisms such as barnacles, algae, and mussels that physically attach to vessel surfaces, and mobile organisms such as worms, crabs, and amphipods (small shrimp-like animals) that associate with the attached fouling community. When vessels move from port to port, fouling communities are transported along with their “host” structure. Fouling organisms are introduced to new environments when they spawn (reproduce) or drop off their transport vector (i.e. vessels). Thus vessel fouling has been identified as one of the most important mechanism for marine NIS introductions in several regions, including Australia, North America, Hawaii and the North Sea (Ruiz et al. 2000a, Eldredge and Carlton 2002, Gollasch 2002).

NIS Impacts

The rate, and thus the risk, of species invasions has increased significantly during recent decades. In North America, the rate of reported invasions in marine and estuarine waters has increased exponentially over the last 200 years (Ruiz et al. 2000a). Prior to the implementation of ballast water regulations, a new species was believed to become established every 14 weeks in the San Francisco Estuary (Cohen and Carlton 1998). One of the primary factors leading to this increase has been the vast expansion of global trade during the past 50 years, which in turn has lead to significantly more ballast water, fouled hulls, and associated organisms moving around the world. The increased speed of global trade has allowed many more potentially invasive organisms entrained in ballast tanks to survive under shorter transit times (Ruiz and Carlton 2003). Organisms that arrive “healthy” in recipient regions are more likely to thrive and reproduce in their new habitats.

Once established, NIS can have severe ecological, economic, and human health impacts in the receiving environment. One of the most infamous examples is the zebra mussel (*Dreissena polymorpha*) which was introduced to the Great Lakes from the Black Sea in the mid-1980s. Zebra mussels attach to hard surfaces in dense populations (as many as 700,000 per square meter) that clog municipal water systems and electric generating plants, resulting in costs of approximately a billion dollars a year (Pimentel et al. 2005). In such high densities, zebra mussels filter vast amounts of tiny floating plants and animals (plankton) from the water. Plankton support the foundations of aquatic food webs, and disruptions to this base appear to reverberate throughout the ecosystem. By dramatically reducing plankton concentrations and crowding out other species, zebra mussels have altered ecological communities, causing localized extirpation of native species (Martel et al. 2001) and declines in recreationally valuable fish species (Cohen and Weinstein 1998). In 2007, a cousin of the zebra mussel, the quagga mussel (*Dreissena rostriformis bugensis*), was discovered in the Colorado River Aqueduct System that serves southern California, and in 2008 the zebra mussel was discovered in San Justo Reservoir (California Department of Fish and Game 2008). Impacts to California's waterways and conveyance structures are only beginning to be calculated.

In San Francisco Bay, the overbite clam (*Corbula amurensi*s) spread throughout the region's waterways within two years of being detected in 1986. The clam accounts for up to 95% of the living biomass in some shallow portions of the bay floor (Nichols et al. 1990). It is believed to be a major contributor to the decline of several pelagic fish species in the Sacramento-San Joaquin River Delta, including the threatened delta smelt, by reducing the plankton food base of the ecosystem (Feyrer et al. 2003, Sommer et al. 2007).

In addition to impacting ecosystems and native species, NIS may also pose a risk to human health. Vessels and port areas have been connected to the spread of epidemic human cholera in a number of instances (Takahashi et al. 2008, Ruiz et al. 2000b), including the transport of the toxogenic *Vibrio cholerae* serotype O1 from Latin America to Mobile Bay, Alabama in 1991, which lead to the closure of nearly all Mobile oyster beds that summer and fall (Lovell and Drake 2009). In addition to cholera, microbes that have been found in ships include the microorganisms that cause paralytic shellfish poisoning (Hallegraeff 1998), coral pathogens (Aguirre-Macedo et al. 2008), human intestinal parasites (*Giardia lamblia, Cryptosporidium parvum, Enterocytozoon bieneusi)* and the microbial indicators for fecal contamination (*E. coli* and intestinal enterococci) (Reid et al. 2007).

Prevention Through Vector Management

Attempts to eradicate NIS after they have become widely distributed are often unsuccessful and costly (Carlton 2001). Between 2000 and 2006, over $7 million was spent to eradicate the Mediterranean green seaweed (*Caulerpa taxifolia)* from two small embayments (Agua Hedionda Lagoon and Huntington Harbour) in southern California (Woodfield 2006). Control is likewise extremely expensive. By the end of 2010, over $12 million will have been spent in San Francisco Bay to control the Atlantic cordgrass (*Spartina alterniflora*) (M. Spellman, pers. comm. 2010). Prevention of species introductions through vector management is therefore considered the most desirable way to address the NIS issue.

Ballast Water Management

The vast majority of commercial vessels use ballast exchange as the primary method of ballast water management. Exchange has been the best compromise of efficacy, environmental safety, and economic practicality. Most vessels are capable of conducting exchange, and the management practice does not require any special structural modification to most vessels in operation. During exchange, the biologically rich water that is loaded while a vessel is in port, or near the coast, is exchanged with the comparatively species-poor waters of the open ocean. Coastal organisms adapted to the conditions of bays, estuaries and shallow coasts are not expected to survive or be able to reproduce in the open ocean due to differences in biology and oceanography (Cohen 1998). Open ocean organisms are likewise not expected to survive in coastal waters.

Ballast water exchange (BWE) is an interim ballast water management tool, however, because of its variable efficiency and several operational limitations. Scientific research indicates that ballast water exchange typically eliminates between 70% and 99% of the organisms originally taken into a tank while the vessel is in or near port (MacIsaac et al. 2002, Wonham et al. 2001, USCG 2001, Zhang and Dickman 1999, Parsons 1998, Cohen 1998), however the percentage of ballast water exchanged does not necessarily correlate with a proportional decrease in organism abundance (Choi et al. 2005, Ruiz and Reid 2007). A proper exchange can take many hours to complete, and in some circumstances, may not be possible without compromising safety due to adverse sea conditions or antiquated vessel design. Some vessels are regularly routed on short voyages, or voyages that remain within 50 nautical miles (nm) of shore. In such cases, the exchange process may create a delay or require a vessel to deviate from the most direct route.

Because of the aforementioned limitations on exchange, regulatory agencies and the commercial shipping industry have looked toward the development of effective ballast water treatment technologies as a promising management option. For regulators, ballast water treatment can provide NIS prevention including in situations where exchange may be unsafe or impossible. Technologies that eliminate organisms more effectively than exchange will provide a consistently higher level of protection to coastal ecosystems from NIS. For the shipping industry, the use of effective ballast water treatment systems will allow voyages to proceed along the shortest routes, in all operational scenarios, thereby saving time and money, and avoiding the safety issues related to BWE.

Until recently, financial investment in the research and development of ballast water treatment systems was limited and the advancement of ballast water treatment technologies slow. Many barriers have hindered the development of technologies including equipment design limitations, the cost of technology development, and the lack of guidelines for testing and evaluating performance. However, some shipping industry representatives, technology developers and investors considered the absence of a specific set of ballast water performance standards as a primary deterrent to progress. Performance standards would set benchmark levels for organism discharge that a technology would be required to achieve for it to be deemed acceptable for use in California. Developers requested these targets so they could design technologies to meet these standards (MEPC 2003). Without standards, investors were reluctant to devote financial resources towards conceptual or prototype systems because they had no indication that their investments might ultimately meet future regulations. For the same reason, vessel owners were hesitant to allow installation and testing of prototype systems onboard operational vessels. It was argued that the adoption of performance standards would address these fears, and accelerate the advancement of ballast treatment technologies. Thus in response to the slow progress of ballast water treatment technology development and the need for effective ballast water treatment options, state, federal and international regulatory agencies have adopted or are in the process of developing performance standards for ballast water discharge. California adopted performance standards regulations in October of 2007 and is preparing for the implementation of those standards when the ships that must meet them begin arriving to the state in 2011 (See Section IV for more details).

Vessel Fouling Management

Mariners have long been aware of fouling (the attachment or association of aquatic organisms to the underwater areas of vessels) as a nuisance to vessel operations as it relates to vessel performance and fuel efficiency. Fouling on the hull can create drag, increasing fuel consumption and can cause engine strain. In pipes, fouling can block inflowing seawater meant to cool machinery. To prevent such problems, common industry fouling management strategies include cleaning of underwater vessel surfaces and the use of antifouling coatings and systems.

Antifouling coatings, either biocide-containing or biocide-free, function to reduce the extent to which organisms can attach to submerged portions of vessels. Biocidal antifouling coatings are applied during dry dock and deter the attachment of fouling organisms by leaching toxic compounds, such as tributyltin (TBT), copper, and zinc. However, these compounds are also detrimental to non-target organisms in the surrounding environment, and many regions have adopted or are considering restrictions on their use. TBT is a highly effective antifouling agent that has been restricted by many nations in line with the 2001 International Maritime Organization (IMO) Convention on the Control of Antifouling Systems on Ships (IMO 2001), which bans the use of all organotin compounds in antifouling coatings as of September 17, 2008. Most non-TBT coatings available utilize copper compounds as biocides, though they are generally less effective and their longevity is shorter than TBT (Lewis 2002). In addition, bans and restrictions on copper-based paints are being considered in a number of places. Biocide-free silicon-based coatings are available, but are more costly to apply and are currently only practically effective for active, swift vessels (those that cruise over 15 knots) (Lewis 2002, International Marine Coatings 2006). These coatings produce a slippery surface making it difficult for many fouling organisms to remain attached once the vessel is underway. As new coatings are developed and vessels shift to different antifouling coatings with lower toxic effects and potentially lower efficacies, there are concerns that the risk posed by fouling as a transport mechanism for NIS may increase (Nehring 2001).

In addition to the use of antifouling coatings, vessels also regularly clean underwater portions of their vessels to manage fouling growth. The frequency with which most vessels clean their hull is usually based on the maintenance rules of their classification society (organization that establishes and applies technical standards for ship design, construction and survey). Vessel-specific programs may include a five-year cycle of annual in-water surveys and special out-of-water (dry dock) surveys. Most vessel owners take advantage of required dry dockings to clean vessel hulls of fouling organisms and apply a fresh coat of antifouling paint. Because fouling continues to accumulate between required dry dockings, vessel owners also conduct interim in-water cleanings of the vessel hull. Out-of-water cleanings during dry dock allow for the containment of materials, including fouling organisms that are removed from the vessel hull. In-water cleanings, however, may allow organisms and paint debris to enter the water column. In-water cleaning, therefore, has increasingly come under scrutiny due to concerns about water quality and NIS introductions. As part of the California Clean Water Act (CWA) Section 401 Water Quality Certification of the U.S. EPA Vessel General Permit (VGP), the California State Water Board has prohibited in-water cleaning in water bodies that have been included in California's Clean Water Act Section 303(d) list as "impaired". These include California's major shipping ports.

Despite the efforts of the maritime industry to minimize vessel fouling by employing hull cleaning and antifouling coatings, recent studies indicate that fouling is still an important mechanism by which NIS can be transported to new regions (see Takata et al. 2006). Vessels that move at slow speeds, spend long periods in port, or are repainted infrequently, tend to accumulate more organisms (Coutts 1999). Though much of the outer surface of vessel hulls are treated with antifouling paints, certain locations, particularly those that are not exposed to shear forces, have been found to be more prone to fouling. These “niche” areas, including dry docking support strips, waterlines, propellers, rudders, sea chests, and worn or unpainted areas (Coutts et al. 2003, Minchin and Gollasch 2003, Coutts and Taylor 2004, Davidson et al. 2009a), have the potential to harbor diverse assemblages of NIS. Although the vessel fouling vector can have a high level of NIS introduction risk associated with it, managers and policy makers have only recently been focusing attention and resources toward it (See Section IV for more details).

III. REGULATORY OVERVIEW: BALLAST WATER

International, U.S. federal and state regulations governing the management of ballast water share many similar components. Nearly all allow ballast water exchange as an acceptable method of ballast water management, and many programs provide some type of exemption should a vessel or its crew become endangered by the exchange process. Many accept approved alternative ballast water treatments in anticipation of the development of effective technologies. Many also require the onboard maintenance of ballast water logs and management plans, and require the submission of forms detailing ballast management and discharge practices.

The International Maritime Organization (IMO)

The IMO adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) in February of 2004, which becomes effective one year after ratification by 30 countries representing 35% of the world shipping tonnage (IMO 2005). As of September 30, 2010, 27 countries representing 25.32% of the world shipping tonnage, had signed the BWM Convention (IMO 2010). The United States is not a signatory to the convention, and as of the writing of this report, the BWM Convention lacked the required number of signatories and had not entered into force.

The BWM Convention requires vessels to conduct exchange at least 50 nautical miles (nm) from shore in waters at least 200 meters (m) deep, though it is preferred that exchange be conducted 200 nm offshore (IMO 2005). It also imposes performance standards for the discharge of ballast water (Regulation D-2) with an associated implementation schedule based on vessel ballast water capacity and year of construction (Tables III.1 and III.2).

Until the BWM Convention is ratified, it cannot be enforced upon any ships (IMO 2007). By 2007, insufficient time remained to ratify the BWM Convention and have it enter into

Table III.1. Ballast Water Treatment Performance Standards

Organism Size Class	IMO BWM Convention, Regulation D-2 Performance Standards[1]	California (CA)[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 in minimum dimension	< 10 viable organisms per ml[4]	< 0.01 living organisms per ml
Living organisms less than 10 µm in minimum dimension		< 10^3 bacteria/100 ml < 10^4 viruses/100 ml
Escherichia coli	< 250 cfu[5]/100 ml	< 126 cfu/100 ml
Intestinal enterococci	< 100 cfu/100 ml	< 33 cfu/100 ml
Toxicogenic *Vibrio cholerae* (O1 & O139)	< 1 cfu/100 ml or < 1 cfu/gram wet weight zooplankton samples	< 1 cfu/100 ml or < 1 cfu/gram wet weight zoological samples

[1] See Implementation Schedule (Table III.2) for dates by which vessels must meet California Interim Performance Standards and IMO Ballast Water Performance Standards.
[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 (cfu) – a measure of viable bacterial numbers

Table III.2. Implementation Schedule for Performance Standards

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[1]
< 1500 metric tons	2009 (IMO)[2] /2010 (CA)	2016
1500 – 5000 metric tons	2009 (IMO)[2] /2010 (CA)	2014
> 5000 metric tons	2012	2016

[1] In California the standard applies to vessels in this size class as of January 1 of the year of compliance. The IMO Convention applies to vessels in this size class not later than the first intermediate or renewal survey, whichever occurs first, after the anniversary date of delivery of the ship in the year of compliance (IMO 2005)
[2] IMO has pushed back the initial implementation of the performance standards for vessels constructed in 2009 in this size class until the vessel's second annual survey, but no later than December 31, 2011 (IMO 2007).

force before the original first date of performance standards implementation in 2009. Consequently, the IMO General Assembly adopted Resolution A.1005(25), on November 29, 2007. The Resolution delayed the date by which vessels with keels laid in 2009, and with a ballast water capacity of less than 5000 MT must comply with Regulation D-2, from 2009 until the vessel's second annual survey, but no later than December 31, 2011 (IMO 2007). For now, the implementation dates for all other vessel size classes remain the same as originally proposed (Table III.2).

National Regulations Outside of the United States

Over a dozen countries outside of the United States have ballast water management requirements. Nearly all include ballast water exchange at varying distances from shore as a primary management tool, and some also allow approved ballast water treatment as an option. Many require that vessels maintain a ballast water management plan, ballast water log, or both, and some require reporting of ballast water activities to the arrival region or country. Some have regulations that apply to only a subset of ports or areas, or apply in addition to requirements in effect nationally. Table III-3 summarizes general ballast water management requirements that apply in countries outside of the United States. Some areas have ballast water treatment requirements for human health purposes (e.g. addition of chemicals to prevent Cholera outbreak), and these are included in the table since they function to reduce NIS release as well.

United States Federal Regulations

The authority to regulate ballast water discharges in the United States recently shifted to include the U.S. Environmental Protection Agency (EPA) in addition to the U.S. Coast Guard (USCG). As of February 6, 2009, the EPA must regulate ballast water, and other discharges incidental to normal vessel operations, under the Clean Water Act (CWA). This requirement stems from a 2003 lawsuit filed by Northwest Environmental Advocates et al. challenging the U.S. EPA regulation which excluded discharges incidental to the normal operation of ships from regulation under the CWA National Pollution Discharge Elimination System (NPDES) permit system (see See Northwest Envtl. Advocates v. United States EPA, (N.D. Cal. Sept. 18, 2006, No. C 03-05760 SI) 2006 U.S. Dist. LEXIS 69476)), On March 30, 2005, the U.S. District Court concluded

Table III-3: National Ballast Water Management Requirements for Countries Outside of the U.S.

Country	Arrivals Affected	General Requirements	Special/Local Provisions	Paperwork Required	Reference
Argentina	All arrivals to River Plate Basin, and River Parana	BWE in open sea following IMO methods. BWT allowed if IMO or Argentine approved.	Port of Buenos Aires has additional treatment requirements for cholera prevention.	Management Plan Log	Prefectura Naval Argentina, 1998
Australia	Overseas arrivals with “high risk” ballast	BWE more than 12 nm from shore in waters 200 m deep. “High risk” = Salt water from outside of Australia’s territorial sea (12 nm).	State of Victoria has additional requirements for ballast water from inside Australia’s territorial sea.	Management Plan Log Reporting	Australian Quarantine and Inspection Service, 2008
Brazil	All arrivals	BWE at least 200 nm from shore in waters at least 200 m deep.	If 200 nm BWE not possible, BWE 50 nm from shore in waters at least 200 m deep. Arrivals to the Amazon and Para rivers must conduct a 2nd exchange in specified areas to reduce salinity before discharge.	Management Plan Reporting	Brazil Maritime Authority, 2005
Canada	From outside the Canadian EEZ	BWE at least 200 nm from shore in waters 2000 m deep.	BWE not required for specified common waters arrivals. BWT allowed if IMO D-2 Standards are met.	Management Plan Reporting	Canadian Minister of Justice, 2006.
	From within the Canadian EEZ	BWE at least 50 nm from shore in waters 500 m deep.			
Chile	Arrivals from abroad	BWE more than 12 nm from the Chilean coast.	If BWE not possible, addition of 100 grams (g) sodium hypochlorite and 14 g calcium hypochlorite per ton of ballast water.	Management Plan Log Reporting	DIRECTEMAR A-51/002; Globallast 2010

EEZ = Exclusive Economic Zone. The sea zone over which a nation has jurisdiction over use of marine resources, stretching out to 200 nautical miles from its coast; BW=Ballast Water; BWE=Ballast Water Exchange; BWT=Ballast Water Treatment

Table III-3 (Continued): National Ballast Water Management Requirements for Non-U.S. Countries

Country	Arrivals Affected	General Requirements	Special Provisions	Paperwork Required	Reference
Georgia	Arrivals with BW from outside the Black Sea	BWE in the Black Sea.		Management Plan	Lloyd's Register, 2009
Israel	Arrivals with BW not from open ocean	BWE in open ocean beyond continental shelf or fresh water current effect.	Ships bound for Eilat must exchange outside of the Red Sea. Ships bound for Mediterranean ports must exchange in Atlantic Ocean.	Reporting	Lloyd's Register, 2009
New Zealand		BWE at least 200 nm from shore and in waters over 200 m deep. Discharge of fresh ballast water may be allowed.	Permission must be granted for any discharge. Except in emergency, no discharge granted for "high risk" ballast water from Tasmania or Port Phillip Bay, Australia.	Log Reporting	Biosecurity New Zealand, 2005
Panama	Panama Canal arrivals	No ballast discharge.			Panama Canal Authority, 2010
Peru	All arrivals	BWE 12 nm from Peru before discharging, even if ballast water was taken up in a Peruvian port.	If BWE not undertaken, harbormaster will designate an alternative exchange area.	Management Plan Reporting	Lloyd's Register, 2009

EEZ = Exclusive Economic Zone. The sea zone over which a nation has jurisdiction over use of marine resources, stretching out to 200 nautical miles from its coast; BW=Ballast Water; BWE=Ballast Water Exchange; BWT=Ballast Water Treatment

Table III-3 (Continued): National Ballast Water Management Requirements for Non-U.S. Countries

Country	Arrivals Affected	General Requirements	Special Provisions	Paperwork Required	Reference
Persian Gulf: Regional Organization for the Protection of the Marine Environment (ROMPE)	Arrivals from outside the ROMPE area (Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Sudi Arabia & United Arab Emirates)	BWE 200 nm from land in waters at least 200 m deep.	If 200 nm BWE not possible due to safety reasons, BWE must occur at least 50 nm from shore in waters at least 200 m deep. BWT allowed if system is approved in accordance with the IMO BWM Convention performance standards.		MEPC 59/INF.3, 2009
Russia	Arrivals to Novorossiysk	BWE in the Black Sea			Lloyd's Register, 2009
Ukraine	Arrivals to Odessa and Yuzhnyy	BWE in the Black Sea		Log Reporting (if discharging)	Lloyd's Register, 2009
United Kingdom, Orkney Islands	Arrivals to the Orkney Islands	Ships wishing to discharge at the Flotta Terminal.	Discharge to shore reception facility. Liquified gas tankers may discharge into Scapa Flow if ballast water has been taken onboard within 24 hours and at least 12 miles from shore.	Reporting	Lloyd's Register, 2009

EEZ = Exclusive Economic Zone. The sea zone over which a nation has jurisdiction over use of marine resources, stretching out to 200 nautical miles from its coast; BW=Ballast Water; BWE=Ballast Water Exchange; BWT=Ballast Water Treatment

that the EPA had exceeded its authority under the CWA and vacated the regulation in question. On July 23, 2008, the appellate court affirmed the decision of the district court. A motion filed by the EPA for an extension of the CWA vacature until December 19, 2008 was granted in September of 2008. In December, 2008, EPA issued the NPDES Vessel General Permit for discharges incidental to the normal operation of vessels. The implementation of the permit was subsequently delayed until February 6, 2009 to provide the regulated community with additional time to comply.

In large part, the NPDES Vessel General Permit delegates the management of ballast water discharges to existing USCG regulations found in 33 Code of Federal Regulations Part 151. The USCG regulations, developed under authority of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, revised and reauthorized as the National Invasive Species Act of 1996, require ballast water management (i.e. ballast water exchange) for vessels entering U.S. waters from outside of the 200 nm Exclusive Economic Zone (EEZ) of the U.S. The EEZ is the sea zone over which a nation has jurisdiction over use of marine resources, stretching out to 200 nautical miles from its coast. Vessels that experience undue delay, however, are exempted from the ballast water management requirements. The NPDES Vessel General Permit includes provisions for ballast water management of vessels transiting between Captain of the Port Zones (USCG designated geographic regions that partition U.S. waters, defined in CFR 33 Part 3) along the Pacific Coast of the U.S. These vessels are required to conduct ballast water exchange 50 nm from shore in waters at least 200 m deep. There is no management requirement, however, for vessels traveling “coastally” or wholly within the 200 nm EEZ bound for U.S. ports on the Gulf or Atlantic coasts.

Vessels may use onboard treatment systems to meet the current ballast water management requirements if that system is approved by the Commandant of the USCG. However, as of November 2010, no approval process has been implemented. On August 28, 2009, the USCG issued a notice of proposed rulemaking for federal ballast water performance standards and for a U.S. type approval process for ballast water treatment systems. The proposed rule would implement two different standards in two phases. The “phase-one standards” are the same as the IMO BWM Convention (Table III-2), and would be implemented in a staggered fashion depending on a vessel’s ballast water capacity and build date. All vessels built on or after January 1, 2012 would be required to comply upon delivery. Vessels built before January 1, 2012 would be required to comply by their first scheduled drydocking after specified dates based on ballast water capacity, with the latest implementation date proposed for January 1, 2016. A “phase two” standard would be 1000 times more stringent than the IMO BWM Convention standards, and vessels would be required to meet them beginning in 2016, however, the implementation of the phase two standard is contingent upon a review of the availability of technologies to meet that standard. The public comment period for the proposed rule closed on December 4, 2009, and the USCG received thousands of comments on the contents of the proposed regulations. It is possible that the proposed regulation could undergo substantial change and delay before a final rule is issued. At this time, no date has been set for the release of the final regulation.

The current NPDES Vessel General Permit does not include performance standards for the discharge of ballast water, though standards will likely be included in the next iteration of the permit (in 2013) based on the outcome of the USCG rulemaking, and if treatment technologies are determined to be commercially available and economically achievable to meet those standards. The U.S. EPA, in conjunction with the U.S. Coast Guard, is currently gathering information from two panels consisting of leading scientific experts to inform the selection of ballast water discharge standards and to assess the availability of ballast water treatment technologies. The first panel, convened through the National Academy of Sciences, National Research Council (NAS) Water Science and Technology Board is evaluating numeric limits for living organisms in ballast water. More specifically, the NAS committee is evaluating the risk of species introductions given certain concentration of living organisms in ballast water discharges (The National Academies 2010). A final report on the committee’s recommendations is due in June 2011. The second panel has been convened through the U.S. EPA Science Advisory Board (SAB) Ecological Processes and Effect Committee which has been augmented with panel members with expertise in ballast water management in order to assess the availability of ballast water treatment technologies. The SAB has met several times in 2010 and has been gathering and reviewing available data about ballast water treatment system performance, operation, and a host of other statistical and methodological analyses. A final report of the SAB findings is expected to be complete in mid-2011. The NAS and SAB reports will be used by U.S. EPA to guide the selection of ballast water standards for the next iteration of the NPDES Vessel General Permit, and by the USCG in the development of the final discharge standard rulemaking.

U.S. State Programs

States have taken two approaches to the implementation of ballast water management. Some states have specific authority granted by state legislation to establish ballast water management requirements either by regulation or permit. Other states have added specific provisions to the Vessel General Permit through the CWA Section 401 certification process. The following is a summary of ballast water management requirements by state and how each has approached implementation.

Ballast Water CWA Section 401 Certifications Under the Vessel General Permit (VGP)

Section 401 of the Clean Water Act allows states to add requirements above and beyond those present in a federal permit. Eight states established ballast water management requirements in 2009 through the VGP, five of which specifically included the establishment of performance standards. Illinois, Indiana and Ohio require vessels to comply with the IMO BWM Convention standard (see Table III-2) by 2012 for newly built vessels or 2016 for existing vessels. Pennsylvania established a two-phase standard that requires vessels built prior to 2012 to install treatment systems that meet the IMO BWM Convention standard by 2012, and vessels built on or after 2012 to meet California's performance standards (roughly equivalent to1000 times the IMO standard). New York will require all vessels to install treatment systems that meet a standard roughly equivalent to 100 times the IMO BWM Convention standard by 2012. Vessels constructed on or after 2013 must install systems that meet California's performance standards.

The states of Connecticut, Iowa, Massachusetts, New York and Pennsylvania included general (non-performance standard) ballast water management conditions in their 401 certifications. In Connecticut, vessels are required to utilize ballast water treatment systems before discharging, if they have a system installed to meet the requirements of any other jurisdiction. Iowa requires that vessels perform open sea exchange so any ballast water discharged in the state meets certain water quality standards set by state law (IDNR in 567~ 61.3 (455B)), including standards for pH, turbidity, and other chemical constituents. Massachusetts, New York and Pennsylvania require vessels arriving from within the U.S. EEZ with ballast on board to conduct exchange in waters at least 50 nm from shore and at least 200 m deep. New York and Pennsylvania also require that vessels with only residual amounts of ballast water perform a saltwater flush at least 50 nm from shore in waters at least 200 m deep. These provisions apply until New York and Pennsylvania begin implementing their respective performance standards in 2012.

Other State Ballast Water Programs (Non- Federal VGP)

Great Lakes Region

In 2008, regulations were established requiring all 'NOBOB' vessels (vessels declaring No Ballast On Board) to conduct a salt-water flush of their ballast tanks prior to entering the St. Lawrence Seaway. This regulation closed a loophole in prior regulations and addresses the residual ballast water and sediments in otherwise empty ballast tanks.

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 (greater than 200 nm from any coast) BWE for any ballast originating from outside state waters.

Michigan

Michigan passed legislation in June 2005 (Act 33, Public Acts of 2005) requiring a permit for the discharge of any ballast water from oceangoing vessels into the waters of the state beginning January 2007. Through the general permit (Permit No. MIG140000) developed by Michigan Department of Environmental Quality (DEQ), any ballast water discharged must first be treated by one of four methods (hypochlorite, chlorine dioxide, ultraviolet radiation preceded by suspended solids removal, or deoxygenation) that have been deemed environmentally sound and effective in preventing the discharge of NIS. In state waters, vessels must use treatment technologies in compliance with applicable requirements and conditions of use as specified by Michigan DEQ. Vessels using technologies not listed under the Michigan general permit may apply for individual permits if the treatment technology used is deemed, "environmentally sound and its treatment effectiveness is equal to or better at preventing the discharge of aquatic nuisance species as the ballast water treatment methods contained in [the general] permit," (Michigan DEQ 2006).

Minnesota

Effective July 1, 2008 Minnesota state law requires vessels operating in state water to have both a ballast water record book and a ballast water management plan approved by the Minnesota Pollution Control Agency (MPCA 2008). Additionally, the MPCA has issued a State Disposal System general permit for ballast water discharges into Lake Superior and associated waterways. Under the permit, all vessels are required to comply immediately with approved best management practices. No later than January 1, 2012, new vessels will be required to comply with the IMO BWM Convention performance standards for the discharge of ballast water (see Table III-1), and existing vessels will be required to comply with those standards no later than January 1, 2016 (MPCA 2008).

Oregon

Oregon began requiring ballast water management in 2002. Vessels arriving from outside the EEZ are required to conduct exchange at least 200 nm offshore in waters at least 2000 m deep. Oregon's legislation also established the first U.S. regulations designed to reduce the risk of intra-coastal transport of NIS. Domestic voyages traveling within 200 nm of shore must conduct exchange at least 50 nm from shore in at least 200 m of water (Hooff 2010). Exchange is not required for ballast water originating from within the common waters of Oregon, between 40^{o} N and 50^{o} N latitude. Based on recommendations in a 2008 legislative report prepared by the Oregon Task Force on the Shipping Transport of Aquatic Invasive Species, the Oregon Department of Environmental Quality (ODEQ) was given rulemaking authority for ballast water discharge performance standards and the development of emergency ballast water management protocols. ODEQ anticipates a notice of proposed rulemaking in late 2010, which may include provisions for these standards and protocols (Hooff 2010).

Washington

The Washington Department of Fish and Wildlife (WDFW), in consultation with their stakeholder Ballast Water Work Group, completed a comprehensive rewrite of the state's ballast water management regulations, which became effective on July 26, 2009. Washington requires open sea exchange (in waters at least 200 nm from shore and 2000 m deep) for voyages originating from outside the U.S. EEZ. Vessels that do not travel outside the EEZ must exchange in waters at least 50 nm from shore and 200 m deep. In June of 2009, WDFW initiated a new rulemaking to adopt permanent concentration-based performance standards for ballast water discharge. A priority for WDFW is to adopt standards that help bring the national and/or U.S. Pacific coast states into greater management consistency. The WDFW no longer independently approves treatment systems for use in state waters and now relies on regional, national or international approvals. Systems previously approved under the interim regulations will remain approved for their original period of use. WDFW staff expects the new standards to be adopted in early 2011 (Pleus, A., pers. comm. 2010).

Wisconsin

As of February 1, 2010, vessels that discharge ballast in Wisconsin waters must comply with the General Permit to Discharge under the Wisconsin Pollutant Discharge

Elimination System. The permit was established by the Wisconsin Department of Natural Resources (WDNR) under authority provided by Chapter 283, Wisconsin Statutes. Among its provisions, the permit sets ballast water performance standards roughly 100 times more restrictive than the IMO BWM Convention standard. All vessels constructed on or after 2012 must meet the Wisconsin Standard set forth in the permit. Existing vessels have until 2014 to comply. Prior to the implementation of the standards, WDNR will conduct an assessment of the availability of treatment systems to meet the Wisconsin standards. If the WDNR determines that treatment technologies which meet the Wisconsin standard are commercially unavailable, the permit requires vessels to comply with the IMO BWM Convention standard in place of the Wisconsin Standard. The existing implementation schedule remains the same.

IV. REGULATORY OVERVIEW: VESSEL FOULING

While ballast water management has progressed substantially over the past decade, comparatively little attention has been directed towards managing NIS introductions via vessel fouling. Currently, no country has adopted mandatory national regulations that specifically address NIS introductions from commercial vessel fouling, though Australia and New Zealand have voluntary guidelines. Some regions have implemented restrictions on the use and cleaning of antifouling coatings applied to submerged portions of vessels, because many antifouling coatings discourage organism attachment by slowly releasing toxic substances. Though such regulations were established to address water quality concerns and not NIS, they have the potential to affect NIS introductions through the fouling vector.

The International Maritime Organization

On September 17, 2008, the IMO International Convention on the Control of Harmful Antifouling Systems on Ships (AFS Convention) (IMO 2001) entered into force, twelve months after ratification by 25 member states representing 25% of the world ship tonnage. The AFS Convention calls for the prohibition of organotin compounds (including tributyltin, or TBT) in antifouling coatings applied to ships. Though such coatings are highly effective at preventing fouling growth, they are highly toxic, persist in the aquatic environment, and bioaccumulate in the tissues of organisms, including marine mammals. Under the AFS Convention, ships must either remove organotin antifouling coatings, or must coat over them so that they do not leach into the water. Vessels engaged in international voyages must carry a Declaration of Antifouling Systems signed by the owner or authorized agent (IMO 2001).

In 2009, the federal Clean Hull Act (H.R. 3618) was introduced in the Congress in order for the U.S. to sign on and implement the AFS Convention. In November 2009, the bill had passed the House and was referred to the Senate for consideration. The Senate has not taken any action on the bill. Hence, as of the writing of this report, the United States is not a party to the AFS Convention, and U.S. flagged vessels are not subject to its requirements, unless they enter a port of a member state that is a party to the AFS Convention.

National Programs Outside of the United States

Australia

Australia has developed guidance documents with voluntary measures that vessels may follow to minimize the transport of NIS through fouling. The guidelines encourage vessels to utilize antifouling coatings in accordance with the AFS Convention, and ensure they are utilized in “niche” areas (sheltered from strong, shear water forces) where fouling tends to accumulate more rapidly in comparison to exposed surfaces. Areas that are not coated with antifouling paint for operational reasons (e.g. cathodic anodes, propellers, propeller shafts, internal seawater pipes) should be inspected and cleaned frequently. The installation and regular operation of marine growth protection systems (MGPS) are encouraged for internal seawater systems and sea chests (underwater compartments through which external sea water is drawn in or discharged for operational purposes) (Commonwealth of Australia, 2009a). More extensive guidance is provided for the management of fouling on non-trading vessels, which include vessel classes used for construction and tow, research, inshore patrol, defense, and local transport (e.g. ferries and water taxis). In addition to recommendations provided for trading commercial vessels, guidance for non-trading vessels includes advice on ship design and construction, specified management measures for over a dozen vessel classes, and guidelines for maintaining a biofouling record book (Commonwealth of Australia 2009b). In order to prevent the release of NIS, most Australian states/territories do not allow in-water cleaning of vessel hulls. Propeller polishing or sea chest cleaning may be allowed in some places, but specific permission must be requested in advance.

New Zealand

Biosecurity New Zealand, a division within the country’s Ministry of Agriculture and Forestry (MAF), is currently developing measures to reduce the risk for invasions via the fouling vector. Background and consultation documents were distributed in mid-2010 describing recent research on the invasion risk posed by fouling on vessels and the pros and cons of three general management options: 1) Await an international solution; 2) Develop voluntary measures and rely primarily on education and outreach for implementation; or 3) Implement mandatory regulations through an import health standard requiring a “clean hull” for arriving vessels. The division prefers the implementation of an import health standard as it would provide the highest level of protection and benefit for the country (Biosecurity New Zealand 2010). MAF Biosecurity New Zealand anticipates implementing requirements soon after reviewing input received on these consultation documents.

United States Federal – Fouling Related Provisions of the Vessel General Permit

In addition to the regulation of ballast water, the EPA’s Vessel General Permit (VGP) also limits discharges originating from antifouling hull coatings, underwater ship husbandry, and seawater piping fouling protection. Antifouling hull coatings and chemicals used for seawater piping fouling protection must be either registered according to the Federal Insecticide, Fungicide, and Rodenticide Act or must not contain biocides or toxic materials banned for use in the U.S. The use of TBT antifouling coatings are explicitly prohibited under the VGP and, as in the AFS Convention, vessels must remove such coatings or paint over them to prevent toxic leaching. Under the VGP, underwater ship husbandry must be conducted in a manner that minimizes the discharge of fouling organisms and antifouling hull coatings, and the cleaning of copper-based antifouling coatings must not produce a visible plume of paint.

U.S. State Programs – Hull Cleaning CWA Section 401 Certifications Under the Vessel General Permit (VGP)

Three states included requirements related to hull cleaning and maintenance as part of their CWA 401 certifications to the EPA Vessel General Permit. Massachusetts and Maine both prohibit in-water cleaning and fouling removal. The rationale for implementing these restrictions differed between the two states, however. Maine did so for water quality reasons, and Massachusetts did so to prevent NIS spread. With the exception of propeller polishing, the California State Water Resources Control Board

(Water Board) prohibits in-water cleaning on all vessels except those using biocide-free antifouling coatings. The Water Board deemed biocide-free antifouling coatings a “best available technology”, and vessels utilizing such coatings may conduct in-water cleaning in California waters (EPA 2009).

V. CALIFORNIA'S MARINE INVASIVE SPECIES PROGRAM

Programmatic Origins and Overview

The Marine Invasive Species Program's enabling legislation, Assembly Bill (AB) 703 (Chapter 849, Statutes of 1999), addressed the ballast water invasion threat at a time when national regulations were not mandatory. This legislation, named the Ballast Water Management for Control of Nonindigenous Species Act, established a statewide multi-agency program to prevent and control aquatic NIS introductions from commercial vessels. In addition to the Commission, the California Department of Fish and Game (CDFG), the State Water Resources Control Board (Water Board) and the Board of Equalization (BOE) were charged to direct research, monitor vessel arrivals and species introductions in California waters, develop policy and regulations, and to cooperatively consult with one another to address the NIS problem (Falkner 2003). Chapter 849 required that vessels entering California from outside the U.S. EEZ manage ballast before discharging into state waters. Vessels were required to exchange ballast water 200 nm offshore or treat ballast water with an approved shipboard or shore-based treatment system. There was, however, no management requirement for vessels transiting between ports wholly within the U.S. EEZ, despite evidence that "intra-coastal" transfer may facilitate the spread of NIS from one port to the next (Lavoie et al. 1999, Cohen and Carlton 1995). The Legislature, sensitive to the uncertainties surrounding the development of an effective ballast water management program for the State, included a sunset date of January 1, 2004 in Chapter 849.

In 2003 the Marine Invasive Species Act (Act) (Chapter 491, Statutes of 2003) was passed, reauthorizing and enhancing the 1999 legislation to include many of the recommendations of the program's first biennial report to the Legislature (see Falkner 2003). The Act reauthorized, enhanced, and renamed the State's ballast water management program, creating the Marine Invasive Species Program, and applies to all U.S. and foreign vessels over 300 gross registered tons that arrive at a California port or place. The Act requires all vessels to have a ballast water management plan and ballast tank logbook specific to the vessel. A ballast water reporting form detailing the ballast water management practices must be submitted to the Commission by each vessel upon departure from each port call in California.

The Act also directed the Commission to adopt regulations for vessels transiting within the Pacific Coast Region (PCR). The PCR is defined as coastal waters of the Pacific Coast of North America east of 154 degrees West longitude and north of 25 degrees North latitude, exclusive of the Gulf of California (Figure V.1). The coastal regulations (California Code of Regulations Title 2, Division 3, Chapter 1, Article 4.6; 2 CCR § 2280 *et seq*.), which were finalized in March 2006, require vessels arriving to California (CA) ports after operating within the PCR to conduct ballast water exchange 50 nm from shore in waters at least 200 m deep prior to discharging into California waters.

Performance Standards for Ballast Water Discharge

The Marine Invasive Species Act (Act) further directed the Commission, in consultation with the Water Board, the USCG and a technical advisory panel, to recommend performance standards for the discharge of ballast water to the State Legislature (see PRC Section 71204.9). The Commission convened the technical advisory panel in 2005, and after several meetings submitted the recommended standards and information on the rationale behind its selection in a report to the State Legislature in January of 2006 (Falkner et al. 2006). By the fall of that same year, the Legislature passed the Coastal Ecosystems Protection Act (Chapter 292, Statutes of 2006), directing the Commission to adopt the recommended standards and implementation schedule through the California rulemaking process by January 1, 2008. The Commission completed that rulemaking in October 2007 (2 California Code of Regulations (CCR) Section 2291 *et seq*. (see Tables III.1 and III.2)).

Chapter 292 also directed the Commission to review the efficacy, availability and environmental impacts of currently available ballast water treatment systems by January 1, 2008. The review and resultant report was approved by the Commission in December 2007 (see Dobroski et al. 2007). Additional reviews must be completed

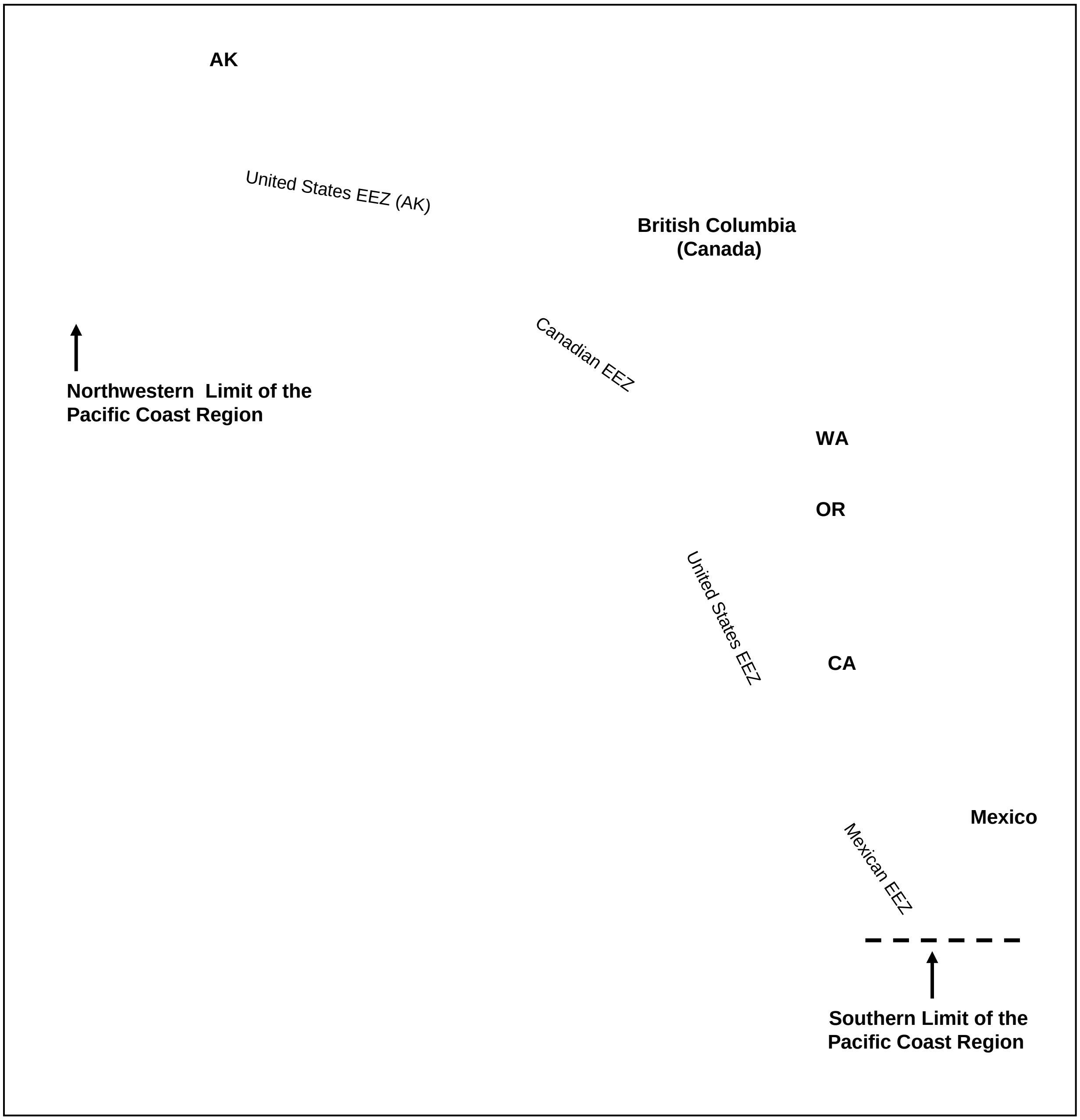

Figure V.1. Exclusive Economic Zones of Pacific North America (200 nm), and the Pacific Coast Region (PCR). The PCR extends from approximately Cooks Inlet, AK (154° west longitude) to ¾ down the Baja Peninsula (25° north latitude) and 200 nm offshore.

18 months prior to the implementation dates for all other vessel classes and 18 months before the implementation of the final discharge standard on January 1, 2020 (see Table III.2 for full implementation schedule, and Table V.1 for a list of completed and future reviews). During any of these reviews, if it is determined that existing technologies are unable to meet the discharge standards, the report must describe why they are not available.

The first technology assessment report (Dobroski et al. 2007) determined that technologies would not be available to meet California's discharge standards for new build vessels with a ballast water capacity less than or equal to 5000 MT by the original 2009 implementation date. In response, the Legislature passed Senate Bill (SB) 1781 in 2008 (Chapter 696, Statutes of 2008). Chapter 696 amended PRC Section 71205.3(a)(2) and delayed the implementation of the interim performance standards for new vessels with a ballast water capacity of less than or equal to 5000 MT from January 1, 2009 to January 1, 2010. Chapter 696 also required an additional assessment of available ballast water treatment technologies by January 1, 2009 (see Dobroski et al. 2009) prior to the new 2010 implementation date. The 2009 assessment report (Dobroski et al. 2009) determined that technologies were available that had demonstrated the potential to meet California's performance standards. The report recommended that the Commission proceed with the initial implementation of the performance standards on January 1, 2010.

As of January 1, 2010, newly built vessels (vessels for which construction began on or after January 1, 2010) with a ballast water capacity of less than 5000 MT that discharge ballast in California waters must comply with California's performance standards. Vessel construction often takes a year or more, and it is anticipated that the first vessels that must meet the performance standards will not begin to arrive in California until sometime during 2011. Commission staff is in the process of preparing protocols to assess compliance with the performance standards and will be ready to begin inspections once new build vessels that fall under the 2010 implementation date arrive in California waters.

Table V.1. Assessments of Ballast Water Treatment Systems

Assessment Completion	Applies To	Compliance Date	Conclusion
Dec. 2007	New vessels** with ballast water capacity ≤ 5000 MT	Jan. 1, 2009 (delayed to 2010)	Technologies not available
Jan. 2009	New vessels** with ballast water capacity ≤ 5000 MT	Jan. 1, 2010	Technologies available that show potential to meet CA standards
Oct. 2009 (Update)*	New vessels** with ballast water capacity >5000 MT	Jan. 1, 2012	Technologies available that show potential to meet CA standards.
Aug. 2010	New vessels** with ballast water capacity > 5000 MT	Jan. 1, 2012	Technologies available that show potential to meet CA standards.
Sep. 1, 2011 (Update)	New vessels** with ballast water capacity > 5000 MT (Update)	Jan. 1, 2012	To be determined
Jul. 1, 2012	Existing vessels built before Jan. 1, 2012, with ballast water capacity of 1500-5000 MT	Jan. 1, 2014	To be determined
Jul. 1, 2014	Existing vessels built before Jan. 1, 2012, with ballast water capacity <1500 MT and >5000 MT	Jan. 1, 2016	To be determined
Jul. 1, 2018	Assessment of all vessels to meet final discharge standard of no detectable living organisms for all organism size classes.	Jan. 1, 2020	To be determined

* Updates are not legislatively mandated reports.
**"New Vessels" refer to those for which construction was initiated on or before the compliance date (3rd column).

The most recent technology assessment report was approved by the Commission in August 2010 (see California State Lands Commission 2010) and addresses the availability of ballast water treatment systems for new build vessels with a ballast water capacity of greater than 5000 metric tons (MT). These vessels must comply with California's performance standards beginning January 1, 2012. The report concluded that, based on the data currently available, multiple treatment systems have demonstrated the potential to meet California's performance standards. Vessels for which construction is initiated on or after January 1, 2012 will not be expected to meet the standards until construction is complete and the vessels are commissioned, likely sometime in 2014 at the earliest. The lead time available for further technology development and refinement is sufficient to indicate that technologies will be available by the time these vessels are operational and are required to meet California's standards. Commission staff will prepare an update to the August 2010 assessment by September 1, 2011, in order to ensure that technology development and availability is progressing on schedule to allow for the implementation of the standards beginning January 1, 2012. The next legislatively mandated technology assessment report is due July 1, 2012 in advance of the implementation of the standards for existing vessels, those built before January 1, 2010, with a ballast water capacity between 1500 and 5000 MT (Table V.1).

Commission staff has already begun gathering information in preparation for the September 2011 update. Recent discussions from several international, federal and state panels have begun to inform the conclusions for this updated report. The Great Lakes Collaborative, a panel of Great Lakes states and associated stakeholders (on which the Commission participates) completed a report summarizing issues around determining whether treatment technologies are available to meet the Wisconsin ballast water discharge standards which are 100 times more stringent than the IMO BWM Convention standard (see Table III-1) (Great Lakes Ballast Water Collaborative 2010). The Great Lakes Ballast Water Collaborative concluded that there are no available protocols or techniques to verify system performance to the Wisconsin standard – a standard weaker than California's standards. Additional discussion about technology availability and the ability of scientists to verify system performance have also taken place at the federal level through the EPA's Science Advisory Board (see Section III. Regulatory Overview – Ballast Water). The SAB committee of scientific and engineering experts on ballast water have not completed their deliberations yet, but based on information presented at public meetings to date, the committee believes that technologies will not be available to meet standards of 100x or 1000x IMO (approximately representing the Wisconsin and California standards, respectively) within the next 10 years. This information is being weighed by Commission staff and may require changes (possibly through legislative or rulemaking action, see Section VIII. Conclusions) to the Commission's plans for implementing California's performance standards.

Implementing California's Performance Standards

As discussed in California State Lands Commission (2010), the Commission does not have the practical ability to test and approve ballast water treatment systems for use in California waters. Therefore, Commission staff will focus on dockside inspection of vessels for verification of compliance with the performance standards (in accordance with PRC Section 71206). Vessel inspections will consist of both an administrative review of applicable ballast water management plans and reporting documents as well as the collection of ballast water samples for analysis.

Vessels must currently keep an up-to-date ballast water management plan on board as well as copies of all ballast water reporting forms submitted to the Commission within the past two years. However, once vessels begin to use ballast water treatment systems, information on the installation and use of systems will be needed to monitor compliance with the performance standards. Based on recommendations in Dobroski et al. (2009), Assembly Bill 248 (Chapter 317, Statutes of 2009) was passed in the fall of 2009, which provided the Commission with the authority to request ballast water treatment information on forms to be developed by the Commission. In 2009, Commission staff convened a technical advisory panel to discuss the development of two forms – the "Ballast Water Treatment Technology Annual Reporting Form" and the "Ballast Water Treatment Supplemental Reporting Form." Forms were adopted through the California rulemaking process in October 2010.

During an inspection, once Commission staff has reviewed applicable vessel paperwork, a ballast water sample will be drawn from vessels intending to discharge in California waters. Because California's performance standards are a discharge standard, samples must be drawn from the vessel's ballast water discharge piping. Most vessels do not have the equipment necessary to enable the Commission's Marine Safety personnel to take samples of ballast water from the discharge line. Therefore, the Commission developed regulations in the fall of 2009 that require vessels to install sampling ports (i.e. sampling facilities) as near to the point of discharge as practicable (2 CCR § 2297). In order to maintain international uniformity, the regulations are based on the IMO Guideline G2 for ballast water sampling with additional input provided by the USCG. The regulations establish design specifications for in-line sampling facilities and set requirements for where the sampling facilities should be installed on the discharge line (i.e. the sampling point). Sampling facilities must be installed on vessels by the same year that they must comply with California's performance standards.

Vessel Fouling

The 2003 Marine Invasive Species Act (Act) directed the Commission to analyze and evaluate the risk of NIS release from commercial vessel vectors other than ballast water (essentially vessel fouling) in a report to the Legislature, developed in consultation with a technical advisory group. The report (see Takata et al. 2006) was approved by the Commission and submitted to the Legislature in April 2006. It summarized the analysis, evaluation, and consultations conducted by the Commission in accordance with the Act, and offered recommendations to reduce the discharge of NIS from vessel fouling.

In October 2007, the Governor signed Assembly Bill 740 (Chapter 370, Statutes of 2007) which incorporated the recommendations in Takata et al. (2006), and further amended the Act to include provisions requiring the removal of fouling organisms from vessel hulls, piping, propellers, sea chests and other submerged portions of vessels on a regular basis. Additional recommendations adopted in Chapter 370 were intended to position the Commission to develop science-based management actions to reduce the release of NIS from vessel fouling in the future, following the fulfillment of key information gaps. The Commission was given authority to collect hull husbandry (e.g. drydocking, in-water cleaning) and other fouling-related information from vessels operating in California. This data was identified in the 2006 report to the Legislature as a critical need to help inform the development of any future management action(s). In consultation with a fouling-specific technical advisory group, the Commission developed and adopted the Hull Husbandry Reporting Form (HHRF) and has been collecting this detailed information annually from the California fleet since January 2008 (see Section VI for summaries of HHRF data).

The mandatory Hull Husbandry Reporting Forms are being collected as part of a larger effort to inform the development of management strategies to better prevent introductions via commercial vessel fouling in California. HHRF data will be used in conjunction with results from MISP-funded biological research on the occurrence and ecology of fouling organisms on ships (see Section VII), other emerging research on commercial hull fouling, and consultation with a technical advisory group to develop regulations by January 1, 2010, as directed by Chapter 370. Technical advisory group meetings began in August of 2010 and it is anticipated that they will be completed in early 2011, when Commission staff will initiate the rulemaking process.

Structure and Function of the Commission's Marine Invasive Species Program

The Marine Facilities Division of the California State Lands Commission administers the Marine Invasive Species Program. To carry out the requirements of the Act and to ensure effective management, the MISP is separated into three primary functional components: 1) Data Management, 2) Field Operations, and 3) Program Administration (Figure V.2). All program components contribute to outreach activities in the form of technical advisory groups, dispersal of educational materials, and public outreach at state, national and international events.

MISP Data Management

MISP data management staff tracks ballast water management, compliance and enforcement of more than 900 vessel arrivals every month. This involves tracking all vessel arrivals, reviewing ballast water management reports to identify and clarify inconsistencies, and issuing delinquency notices to owners or operators. In order to verify that vessels on qualifying voyages submit Ballast Water Reporting Forms, received forms are matched with arrival data from the Northern and Southern California Marine Exchanges. Late and missing form notifications are sent to agents representing

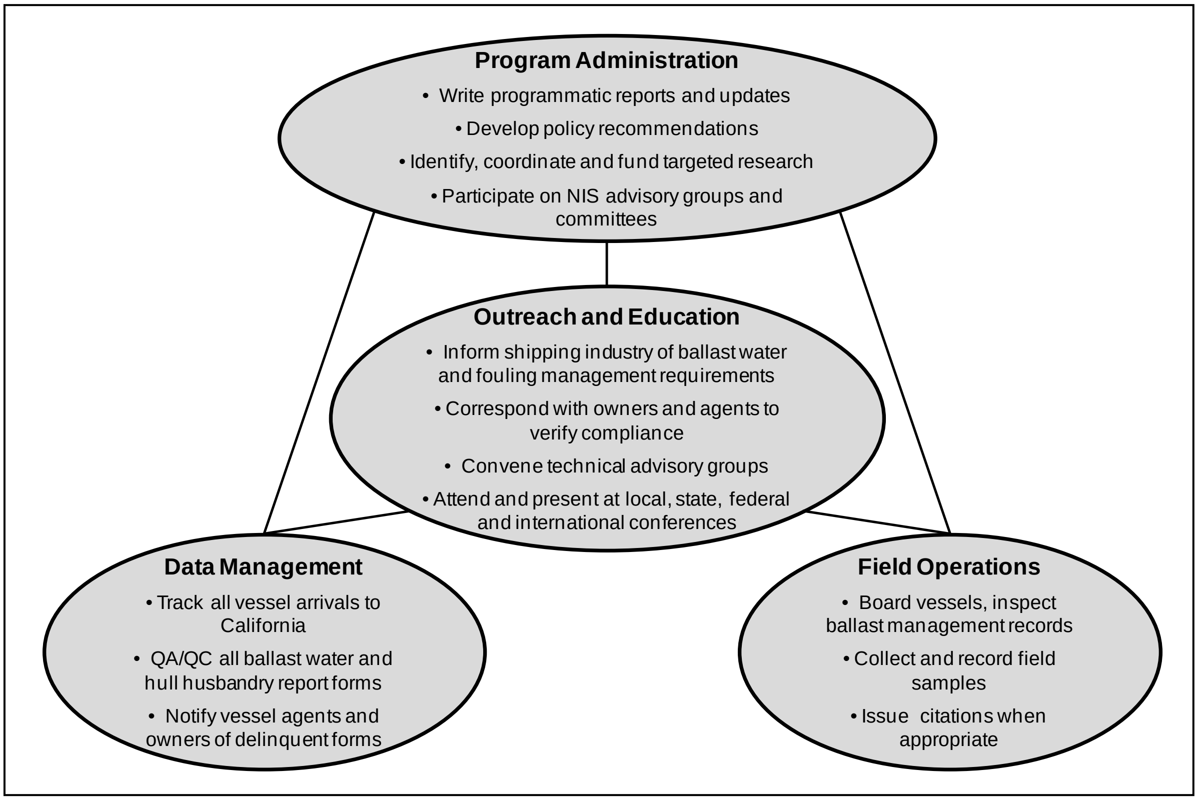

Figure V.2. MISP Components and Associated Functions

vessels that neglect to submit forms. Between July 2008 and June 2010, over 18,000 ballast water reporting forms were received, reviewed, entered into a database, and reconciled with actual port arrival data. Vessels that submit forms with inconsistent, incorrect or questionable data are flagged in the database for follow-up during an inspection boarding. Data management staff is continual contact with ship officers and agents, relaying information about MISP requirements. Staff coordinates information requests with field operations staff, so inspectors can ensure that crew receive needed information when boarding vessels.

MISP data management staff also tracks Hull Husbandry Reporting Form (HHRF) submission and compliance. Submitted forms are reviewed for inconsistencies and are then entered into the MISP database. MISP administrative staff reconciles received HHRF against vessel arrival data to determine if the once-annual reporting requirement has been met. Notices are sent to agents representing vessels with outstanding HHRFs.

MISP Field Operations (Inspections)

MISP field operations are based out of offices located in Northern and Southern California. Commission Marine Safety personnel at these field offices implement an extensive vessel boarding, monitoring, and outreach program to ensure compliance with the Act. Though the central role of inspectors/inspections is to enforce laws that vessels must obey in order to reduce the release of problematic organisms in California waters, MISP inspectors do much more. They are the primary conduit providing regulatory information to vessel personnel. Inspectors help crew understand their complicated and ever-changing legal obligations, how to properly complete and maintain paperwork, and which agencies to submit paperwork to. Education and outreach is considered one of the key drivers for the high compliance rates observed with the MISP program.

All vessels are required to submit to compliance inspections, which include sample collection of ballast water, examination of ballast water logbooks, engine books, report forms, and any additional inquiries as needed. The Marine Invasive Species Act specifies that at least 25% of arriving vessels are to be inspected, with enforcement administered through the imposition of administrative, civil, and criminal penalties. During vessel boardings, Marine Safety personnel verbally explain paperwork, reporting, and ballast management obligations, and point out where a vessel may be falling short of compliance. Staff also samples ballast tanks when discharge is intended. The samples are analyzed for salinity (a measure of the salt concentration in water), which is currently the best available method to indicate if ballast water has been exchanged. Salinity levels are expected to indicate whether ballast water originated from coastal or mid-ocean areas because coastal regions tend to have more freshwater runoff. Coastal regions often exhibit lower salinities than open ocean water, which maintains an approximate reading of 35 PPT (parts per thousand). When a violation is found, a citation is given to the vessel crew and a hard copy is retained in Commission files. A copy of the violation and enforcement letter is also sent to the vessel owner. The vessel is then targeted for re-inspection upon its next visit to California waters. The Commission finds that working with vessel owners in this way creates a positive working relationship with the industry that results in higher compliance rates.

In addition to verifying compliance with the management requirements of the Act, the inspection program plays a key role in MISP activities by providing vessel access for researchers collecting data that are used to improve the future management of NIS. Such assistance has become particularly important as heightened security levels at ports would otherwise hinder or block ship access. Assistance may involve simply escorting scientists onboard vessels so they may obtain samples, or may involve the inspector(s) collecting the samples directly. In the past, MISP inspectors have worked with researchers who are noted experts in their field, including staff from the Smithsonian Institution, San Francisco State University, and Portland State University. Most recently, Commission Marine Safety personnel assisted the Smithsonian Environmental Research Center (SERC) on a project designed to validate a prototype hand held device – the Ballast Exchange Assurance Meter (BEAM). The BEAM takes measurements of key chemical tracer elements in ballast water to determine whether ballast water exchange occurred offshore or not. Commission Marine Safety personnel boarded approximately 40 vessels to collect samples for this project (see Research, Ballast Water Exchange Verification for more details).

MISP Administration & Policy Development

MISP administrative staff works closely with staff within the other two MISP program components, the data management and field staff teams, in order to assess vessel compliance with the requirements of the Act, develop regulations and policy recommendations for the Legislature, and coordinate research to reduce the spread of NIS from vessel vectors. Administrative staff regularly consults with a wide array of scientists, state and federal regulators, non-government organizations and the maritime industry to evaluate current knowledge and guide policy recommendations. The administrative component of the MISP also directs and funds targeted, applied research that advances the development of strategies for NIS prevention from the commercial ballast water and vessel fouling vectors.

In addition to the regulatory directives, the Act included mandates to address management gaps to improve the Commission's ability to prevent NIS introductions from commercial vessel vectors. MISP administrative staff frequently assembles Technical Advisory Groups (TAGs) to discuss policy and regulatory matters related to general NIS management, specific directives of legislation and/or regulations, and the implementation of legislative mandates. TAGs include representatives from the maritime industry, ports, state, federal, and international agencies, environmental organizations, and research institutions. They serve as a forum through which information and ideas are exchanged and discussed to ensure that policy recommendations and rulemaking actions consider the best available science, as well as concerns of affected stakeholders, while also fulfilling legislative mandates. The technical advisory group process also functions as an effective outreach tool, as TAG members relay information to their respective constituencies, keeping them abreast of Commission actions and activities. The MISP administrative program has assembled technical advisory groups to discuss regulations for ballast water management within the Pacific Coast Region, the setting of performance standards for ballast water discharge, potential changes to the MISP fee, the development of several forms to collect vessel fouling and ballast water treatment technology data, the development of recommendations to reduce NIS introductions via vessel fouling, and for assessments of ballast water treatment technologies.

Administrative staff also represents the MISP at state, national and international conferences, advisory panels, and committees related to invasive species science and management. Such participation is particularly important given the global nature of shipping and the transport of NIS. Communication with other regulatory jurisdictions (states, federal, international) serves to increase efficiency, consistency, and effectiveness by sharing successes and failures amongst programs. Because California's MISP is often a leader in the development and implementation of preventative measures for reducing NIS release from ships, staff has received invitations to speak or participate on committees/panels, including (but not limited to) the federal Aquatic Nuisance Species (ANS) Task Force (Washington D.C.), the National Invasive Species Council (Washington D.C.), the North Sea Ballast Water Opportunity Workgroup (Germany, Sweden), the State of Washington's Ballast Water Working Group, the Shipping Transport of Aquatic Invasive Species Task Force (Oregon), The Minnesota Invasive Species Conference, and the Great Lakes Ballast Water Collaborative. Administrative staff has also given programmatic presentations at numerous local, state, national and international science and management conferences, including (but not limited to): the International Conference on Marine Bioinvasions, the International Conference on Aquatic Invasive Species, the California and the World Oceans Conference, the CalFED Science Conference, the Ocean Sciences Conference, the Coastal Zone Management Conference, and the California State Lands Commission's Prevention First Symposium.

The Shared Role of Outreach

One of the key components for the success of the MISP continues to be the close communication, coordination, and outreach between the Commission, the maritime industry, and other state, federal and international agencies. Outreach is a role shared by all parts of the MISP, with each component of the program exchanging information with various external stakeholder groups (Figure V.3). Program administration staff interacts primarily with science, policy, and decision making representatives to coordinate and develop improved management policies. Data management staff consults with shipping agents and owners on a daily to weekly basis over paperwork submission requirements and general questions about California rules. Field inspectors are the primary conduit for information to ship officers and crew, educating them on state requirements and supplying outreach materials. Inspectors also facilitate access to vessels for researchers working on studies that will inform future management decisions.

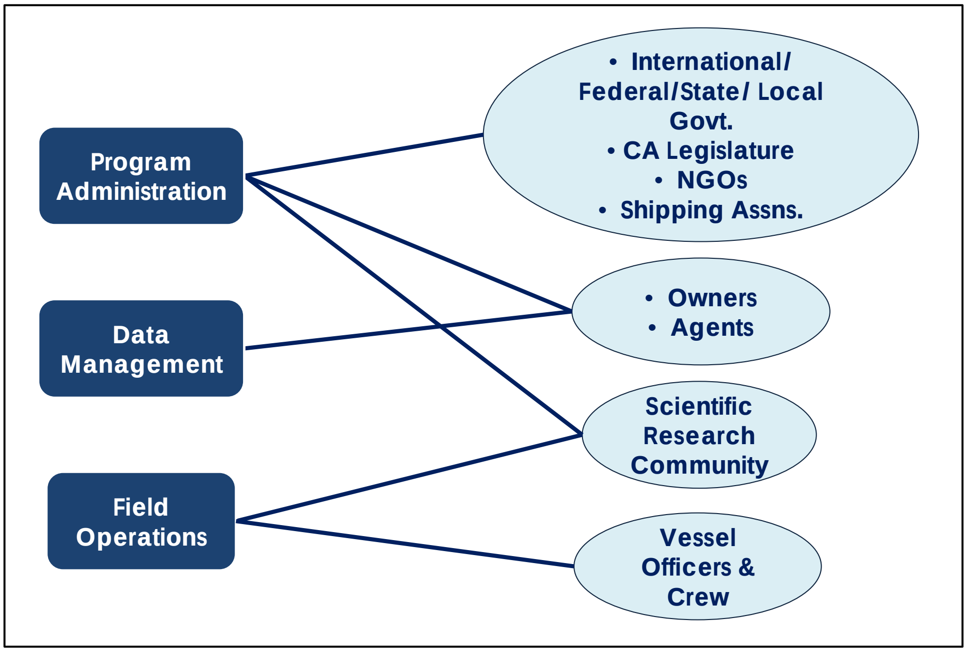

Figure V.3. MISP Information Exchange with Stakeholders

In general, outreach activities coordinate information exchange among scientists, legislators, the regulated industry, non-governmental organizations and regulating agencies. By establishing and maintaining relationships with the diverse groups that play a role in the transport of NIS via commercial ships' ballast water and vessel fouling, MISP staff helps ensure improved compliance amongst the regulated community, the development of well-informed policy decisions, and the utilization of management tools/strategies based on the best available science.

VI. DATA ANALYSIS

Trends in Statewide Vessel Traffic

Ballast Water Reporting Requirements

Under the Marine Invasive Species Act (Act), the master, owner, operator, agent, or person in charge of a vessel is required to submit the “Ballast Water Reporting Form” upon departure from each port or place of call in California. A qualifying voyage (QV) for the purposes of reporting and fee submittal refers to all vessels greater than 300 gross registered tons operating in California waters. The Commission is required to compile the information obtained from submitted forms to assess shipping patterns and compliance with the requirements of the Act. Utilizing a state database created under AB 703 (Chapter 849, Statutes of 1999), and modified pursuant to the Act (Chapter 491, Statutes of 2003), the Commission can assess: (1) rates of compliance with mandatory reporting requirements (see *Ballast Water Reporting Compliance*, this section); (2) QV traffic patterns (see *Vessel Traffic Patterns*, this section); (3) patterns of ballast water discharge and management according to vessel class and geographic area (see *Ballast Water Discharge Patterns*, this section); and (4) rates of compliance with ballast water management requirements (see *Ballast Water Management Compliance*, this section).

Commission staff supplements the ballast water information reported by vessels on the Ballast Water Reporting Form with: (1) transportation statistics collected from the two California Marine Exchanges, individual ports, and shipping agents; and (2) verification inspections of vessels operating in California waters conducted statewide by Commission Marine Safety personnel. These three primary sources of data enable Commission staff to assess vessel compliance and efficacy use of various ballast water management practices. This information is assessed for both coastal (within the Pacific Coast Region, or PCR) and foreign (arriving from outside of the PCR) vessel traffic to California ports. The PCR extends from approximately Cooks Inlet, Alaska (154° west longitude) to ¾ down the Baja Peninsula (25° north latitude) and 200 nm offshore (see Figure V.1). Reporting and ballast water management requirements are also assessed at two geographic scales: statewide and local port system. Through the original legislation (Chapter 849, Statutes of 1999) and as implemented by regulations, the Commission has identified 19 port zones, including Humboldt Bay, Sacramento, Stockton, Carquinez, Richmond, San Francisco, Oakland, Redwood, Moss Landing, Monterey, Morro Bay, Santa Barbara, Carpinteria, Port Hueneme, El Segundo, Los Angeles-Long Beach (LA-LB), Avalon/Catalina, Camp Pendleton, and San Diego (Figure VI.1).

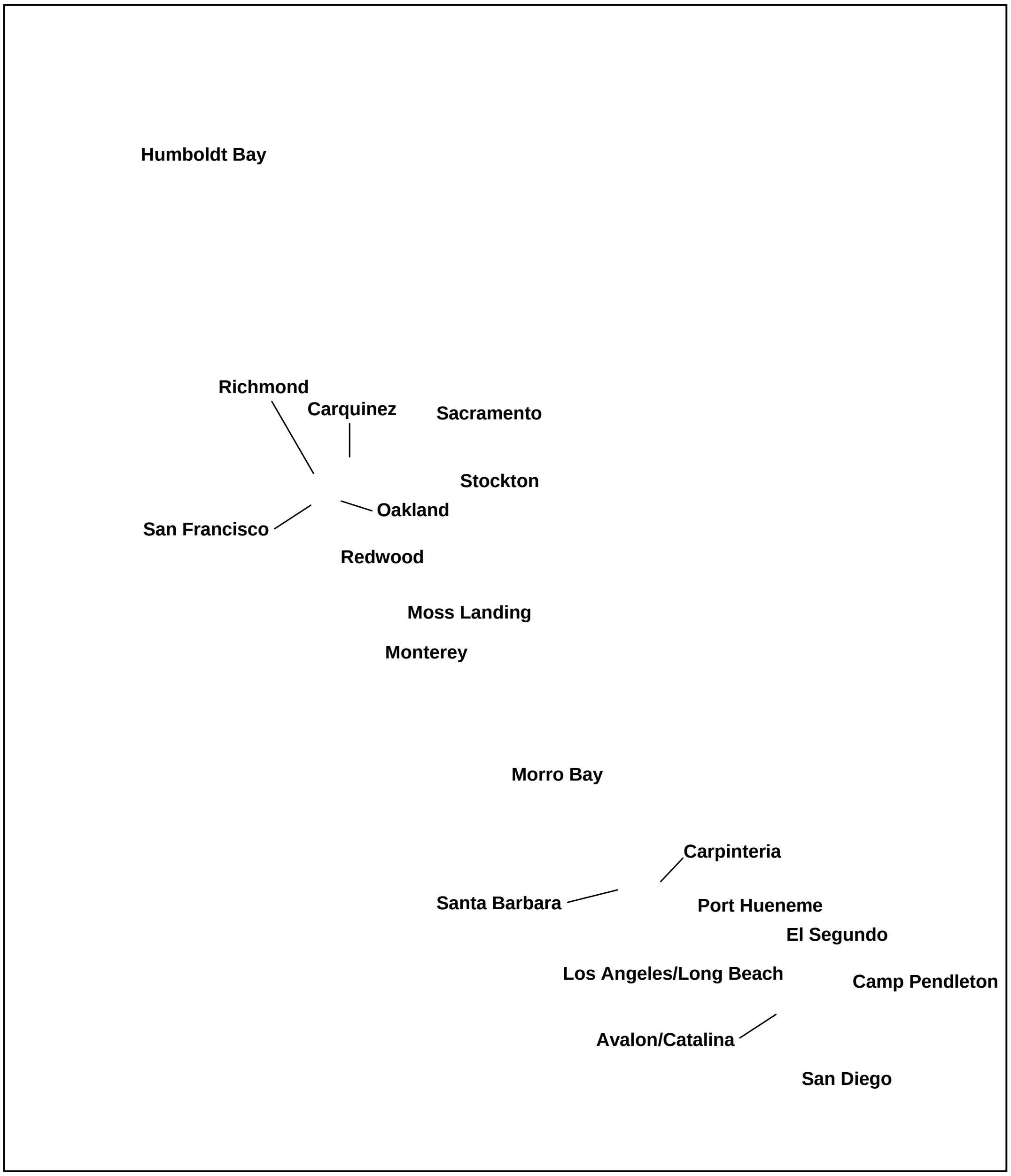

Figure VI.1. California Port Zones

Ballast Water Reporting Compliance

In late 2000, the Commission initiated an electronic procedure to notify ship agents and owners of missing Ballast Water Reporting Forms. This electronic notification process, coupled with education and outreach to the shipping industry, has resulted in high compliance with ballast water reporting requirements. The ballast water reporting requirements changed in 2004 as a result of the passage of the Act (Chapter 491, Statutes of 2003). Therefore, for this report, all time series data and graphs are presented from January 2004 forward, with a specific focus on the period from July 2008 through June 2010. For purposes of data analysis and reporting, the six-month period from January through June will be indicated as “a” and the period from July through December will be indicated as “b”. Between 2008b-2010a, 98% of QVs to California ports or places were compliant with reporting requirements, and 87% of QVs were both compliant and submitted forms on time (Figure VI.2).

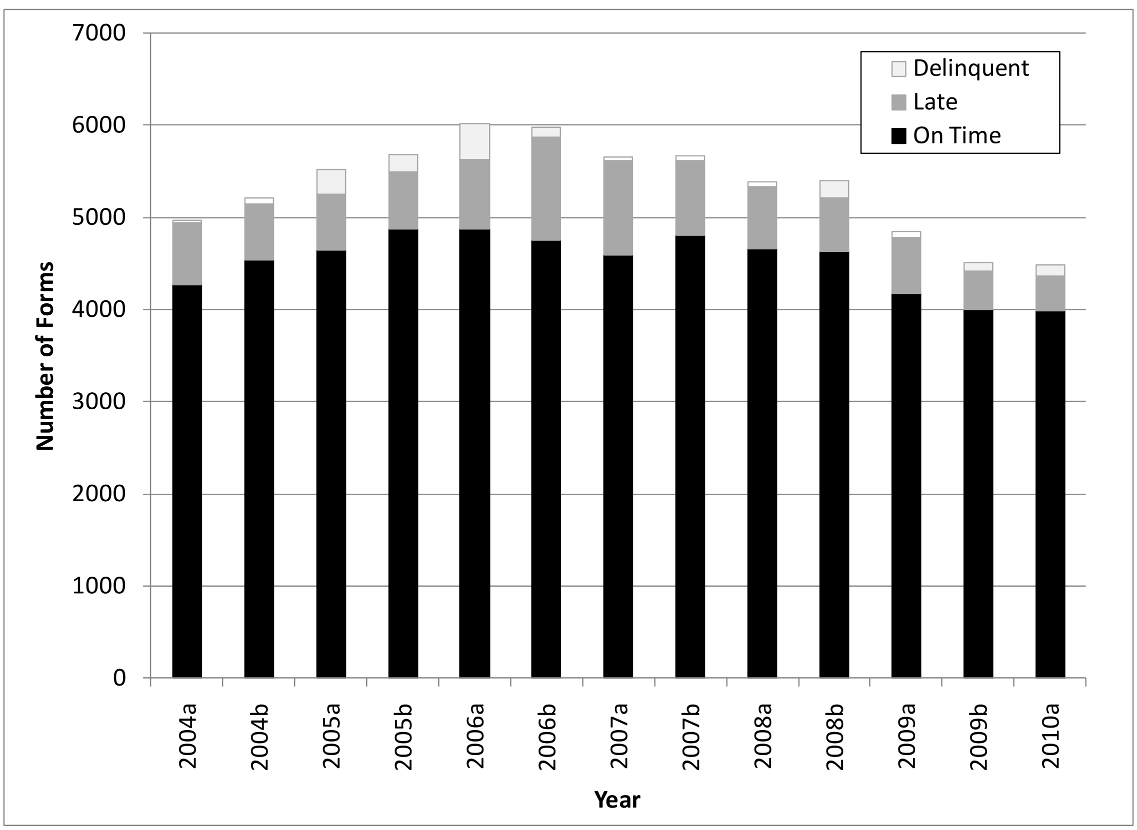

Figure VI.2. Compliance with requirement to submit the Ballast Water Reporting Form (a = January to June, b = July to December)

Vessel Traffic Patterns

Based upon the information provided by vessels on the Ballast Water Reporting Forms, Commission staff assesses patterns of vessel traffic and ballast water management. Vessel traffic to California ports has decreased in recent years from a high of 6025 QV arrivals per six month period in 2006a (Figure VI.3) to a low of 4488 QV arrivals during the first six months of 2010. The recent downturn in the economy has likely contributed to the decline in vessel arrivals seen since late-2006.

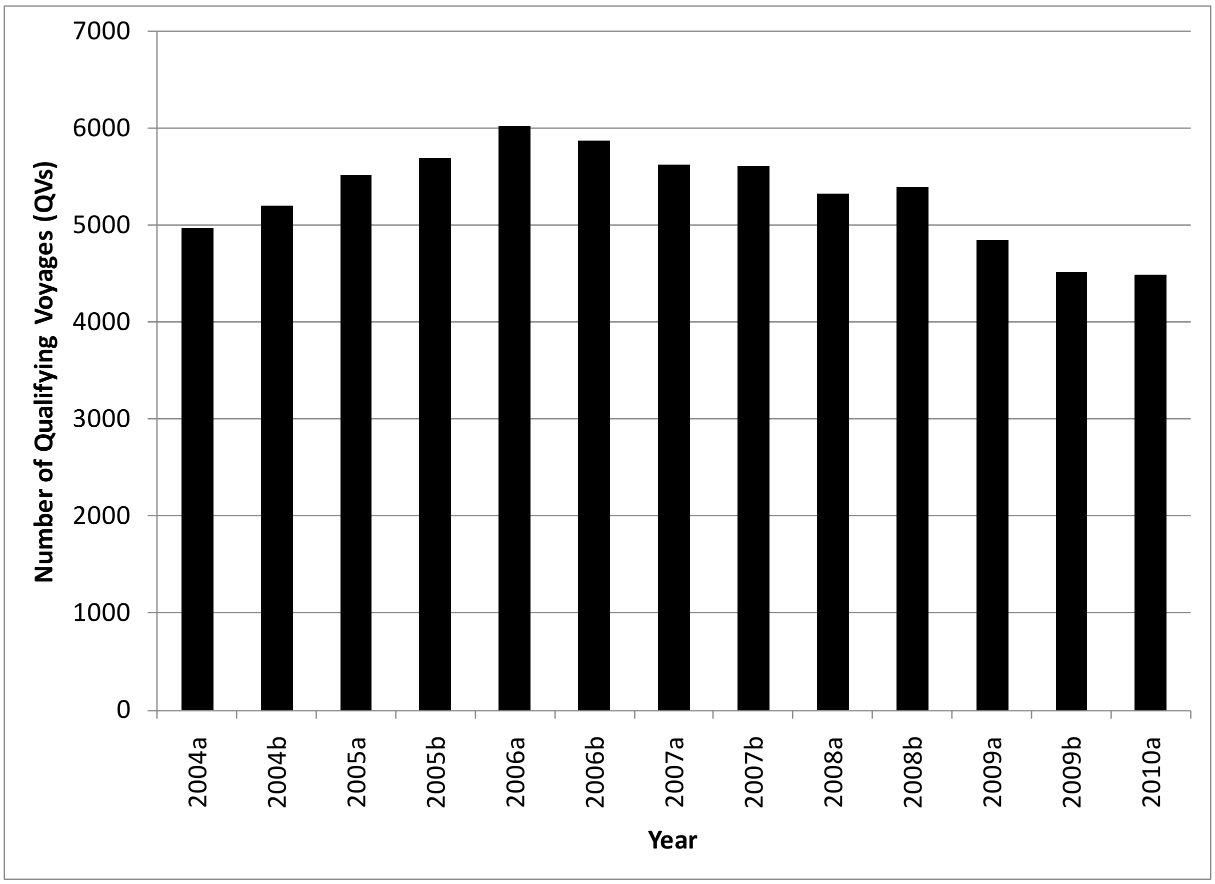

Figure VI.3. Number of qualifying voyage (QV) arrivals to California ports (a = January to June, b = July to December)

While the total number of QV arrivals is down, the distribution of QV arrivals by port has remained consistent with previous reports (Figure VI.4, see Falkner et al. (2007, 2009)). There has, however, been some recent change in the ratio of coastal to foreign vessel traffic for each port. As with previous years, the LA-LB Port Complex leads the state in

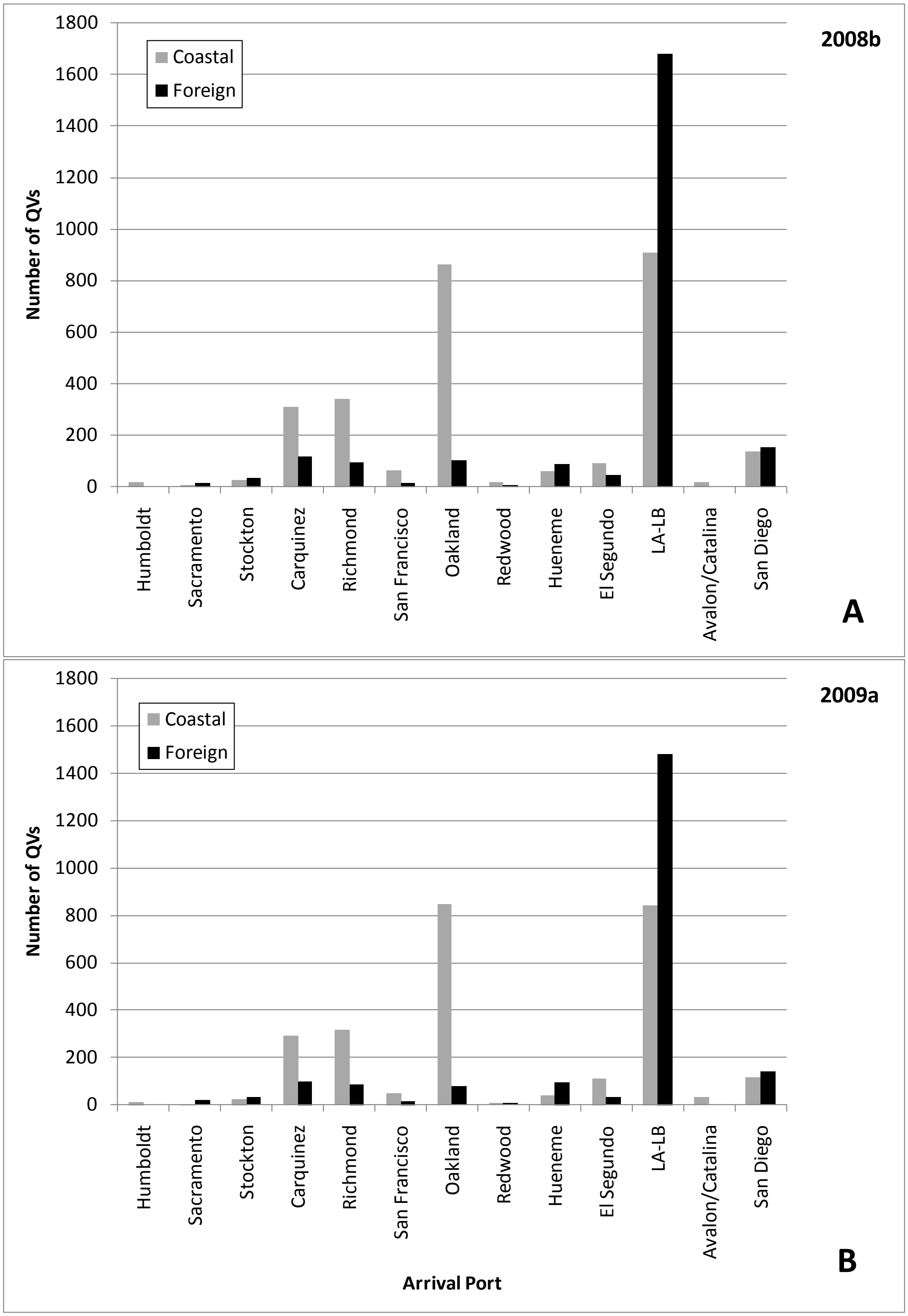

Figure VI.4. Distribution of qualifying voyage (QV) arrivals by port. Coastal voyages originate from Pacific Coast Region (PCR) ports, foreign voyages originate from non-PCR ports (see Figure V.1 for map of PCR).

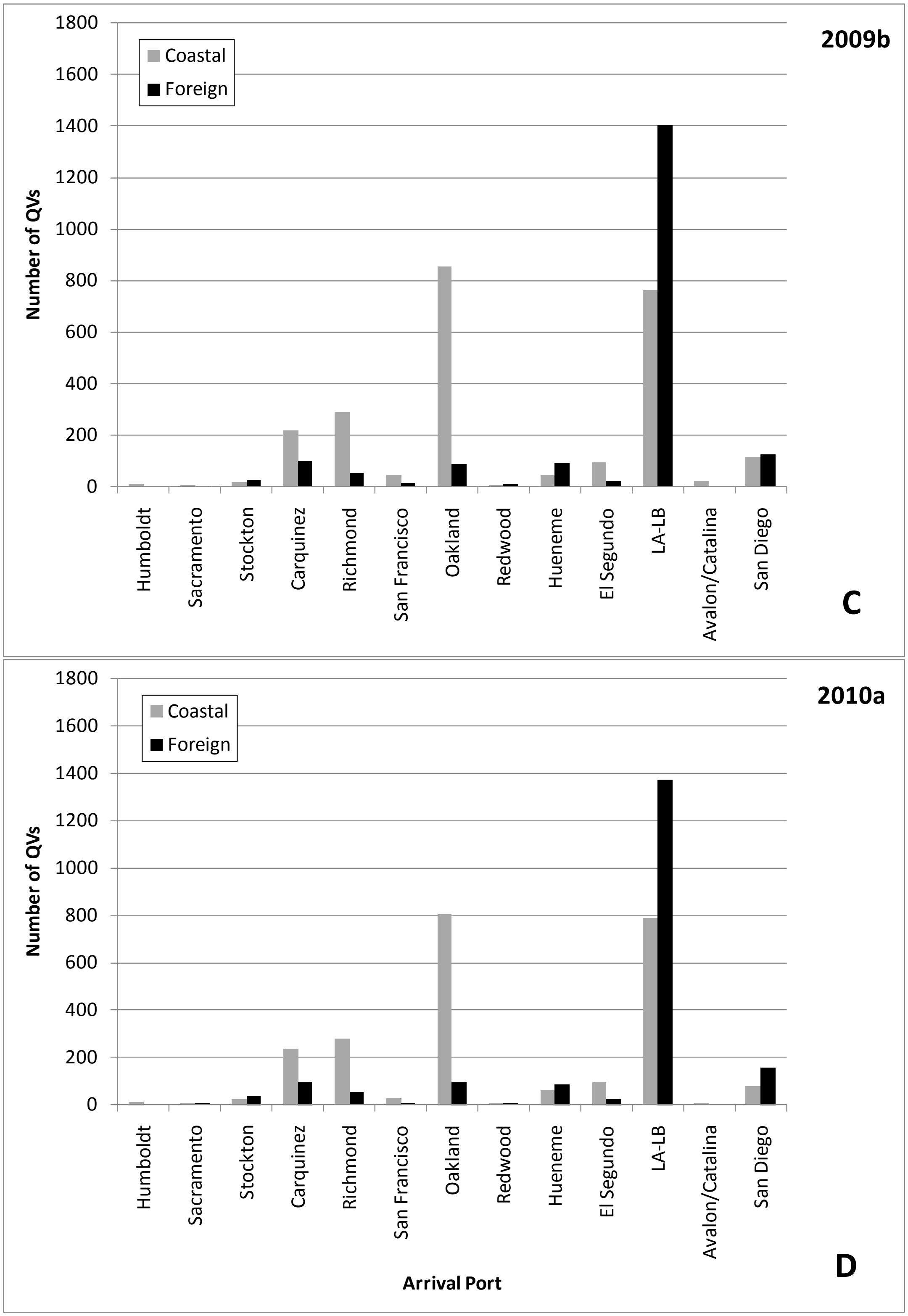

Figure VI.4 (contined). Distribution of qualifying voyage (QV) arrivals by port. Coastal voyages originate from Pacific Coast Region (PCR) ports, foreign voyages originate from non-PCR ports (see Figure V.I for map of PCR).

arrivals, receiving 49% of all QVs to California ports between 2008b and 2010a. During this time, LA-LB received more foreign arrivals than any other port in California (a total of 5359 foreign QVs between 2008b and 2010a), and was a close second (3301) behind the Port of Oakland (3369) for the total number of coastal arrivals. Foreign arrivals accounted for two-thirds (64%) of vessel traffic to LA-LB (Figure VI.4 A-D). While Oakland received comparable numbers of coastal arrivals as LA-LB, Oakland received barely 6% of LA-LB's total number of foreign arrivals (Oakland = 364 total for 2008b-2010a) (Figure VI.4 A-D). Between 2008b and 2010a only ten percent of QVs to Oakland were of foreign origin, this is a decrease of five percent over previous reports (see Falkner et al. 2009); between 2006b and 2008a, 15% of arrivals to Oakland were foreign in origin.

Several other California ports also saw a drop off in the relative proportion of foreign vessel traffic from 2008b to 2010a as compared to the previous report (see Falkner et al. 2009). Foreign arrivals at the Port of Hueneme declined from 70% during 2006b-2008a, to 64% of arrivals during 2008b-2010a. San Diego experienced a similar 5% decline in the proportion of foreign traffic arriving to the port. These decreases in foreign vessel arrivals can likely be attributed to decreased demand for foreign consumer goods, including automobiles.

The types of vessels calling on each of California's ports varies as a function of local industry, demand, and port infrastructure (e.g. the presence of container cranes) (Figure VI.5). The Ports of LA-LB and Oakland combined received 99% of all container vessel traffic to California ports. The ports of Los Angeles and Long Beach, on average, received the majority of bulk (56%) and passenger (52%) vessel arrivals to California (Figure VI.6A). The majority of the remaining passenger vessels (33% on average) calling on California arrive to the Port of San Diego. Forty-one percent of all tank vessels, on average, arrive to LA-LB with the remainder largely divided between the Ports of Richmond (23%), Carquinez (19%), and El Segundo (12%) (Figure VI.6B). Auto

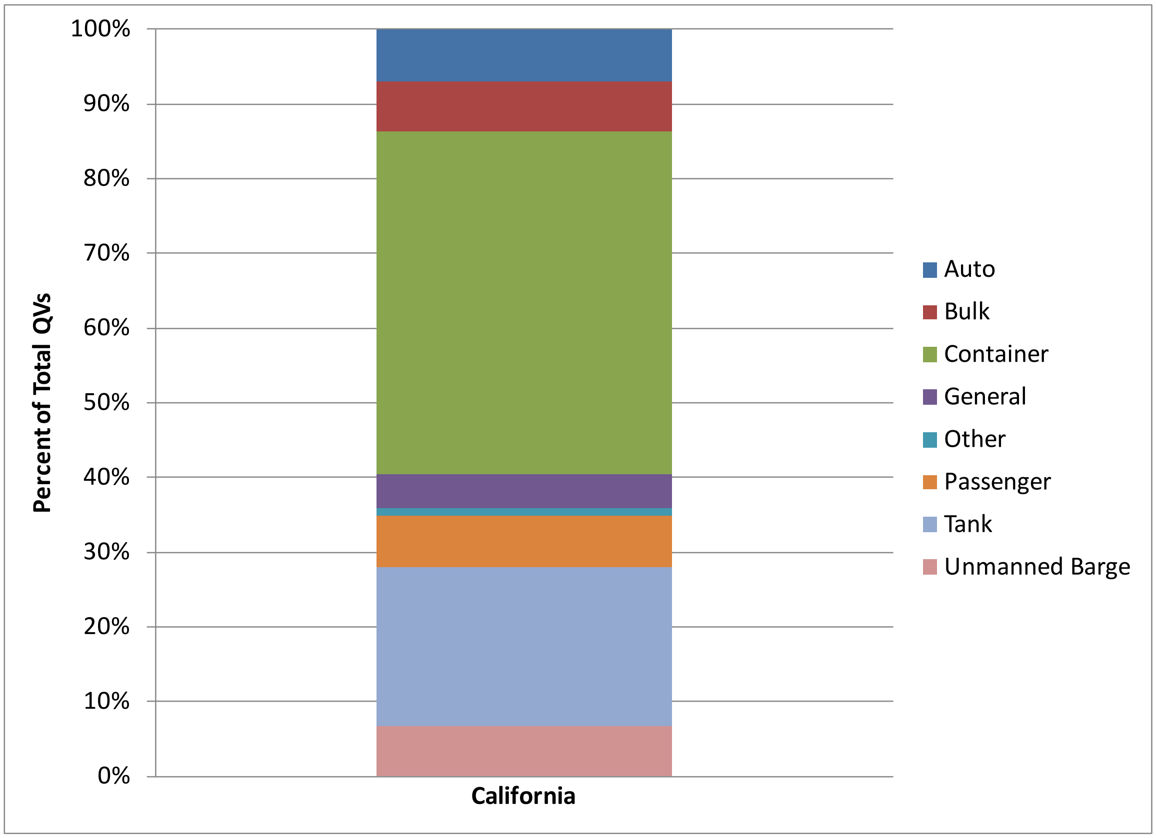

Figure VI.5. Percent of QV Arrivals to California by Vessel Type (2008b – 2010a)

carriers primarily arrive to LA-LB (34% on average), San Diego (27%), Hueneme (23%), and Carquinez (12%). Unmanned barges, on average, predominately arrive to LA-LB (31%), Richmond, (30%) and Carquinez (29%).

Since July 2008, almost 50% of all arrivals to California originated from within the Pacific Coast Region (Figure VI.7, see Figure V.1 for map of PCR). Thirty-six percent of vessel calls to California ports came from other California ports, 7% originated in Washington State (up 2% since the previous report), 4% in coastal Mexican ports (i.e. within the PCR), 2% in Oregon, 4% in coastal Canadian ports, and less than 1% from Alaska. The majority of foreign (non-PCR) arrivals to California came from Asian ports (China, Japan, Korea, and all other Asian countries (“Other Asia”) account for 22% of all QVs), followed by approximately 8% from foreign (non-PCR) Mexican ports, and 6% from Central America (Figure VI.7).

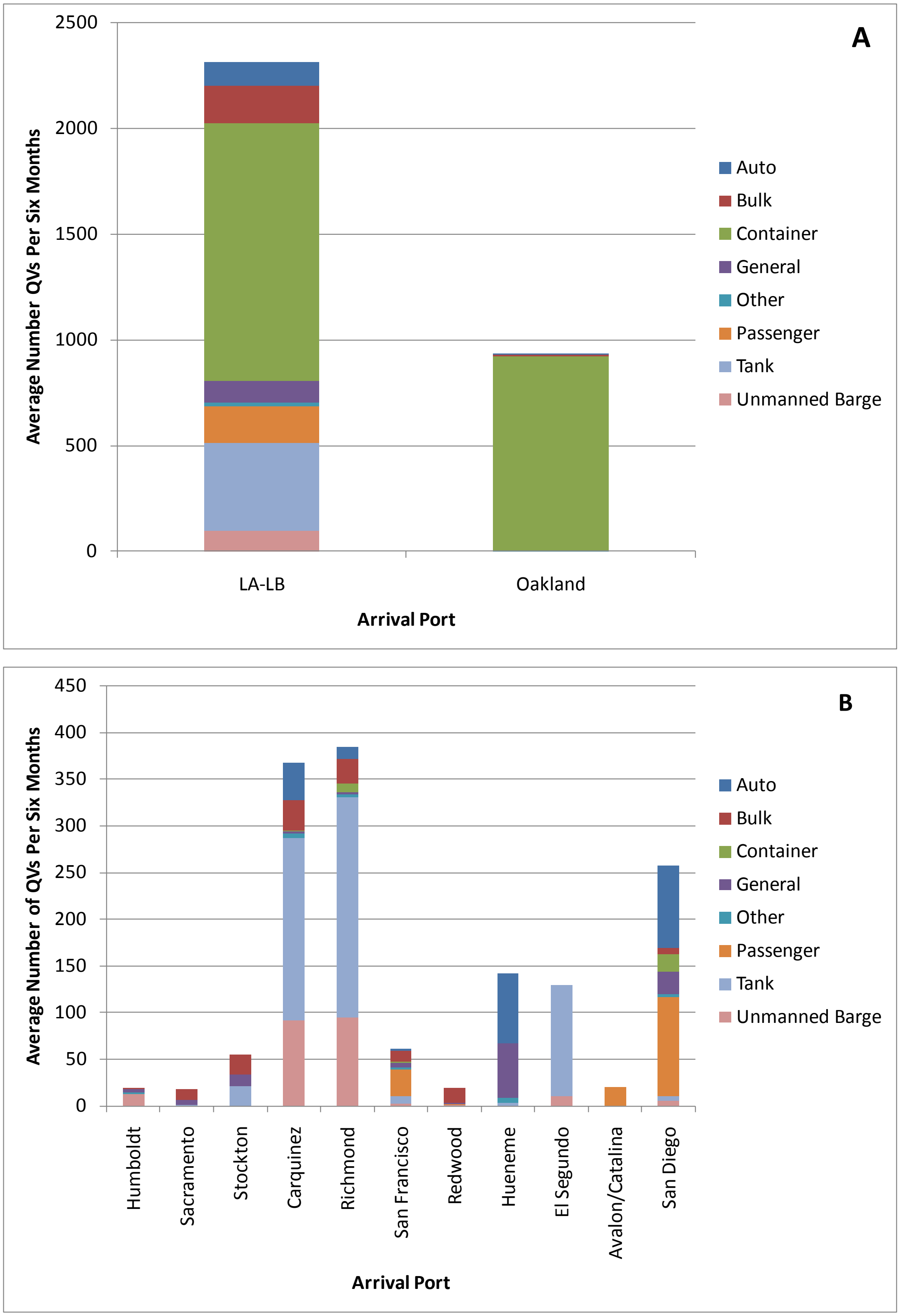

Figure VI.6. Average Number of Arrivals per Six-Month Period by Vessel Type and Port (2008b –2010a) for Oakland and LA-LB (A) and the Remaining California Ports (B). Note that the scales are not the same across panels.

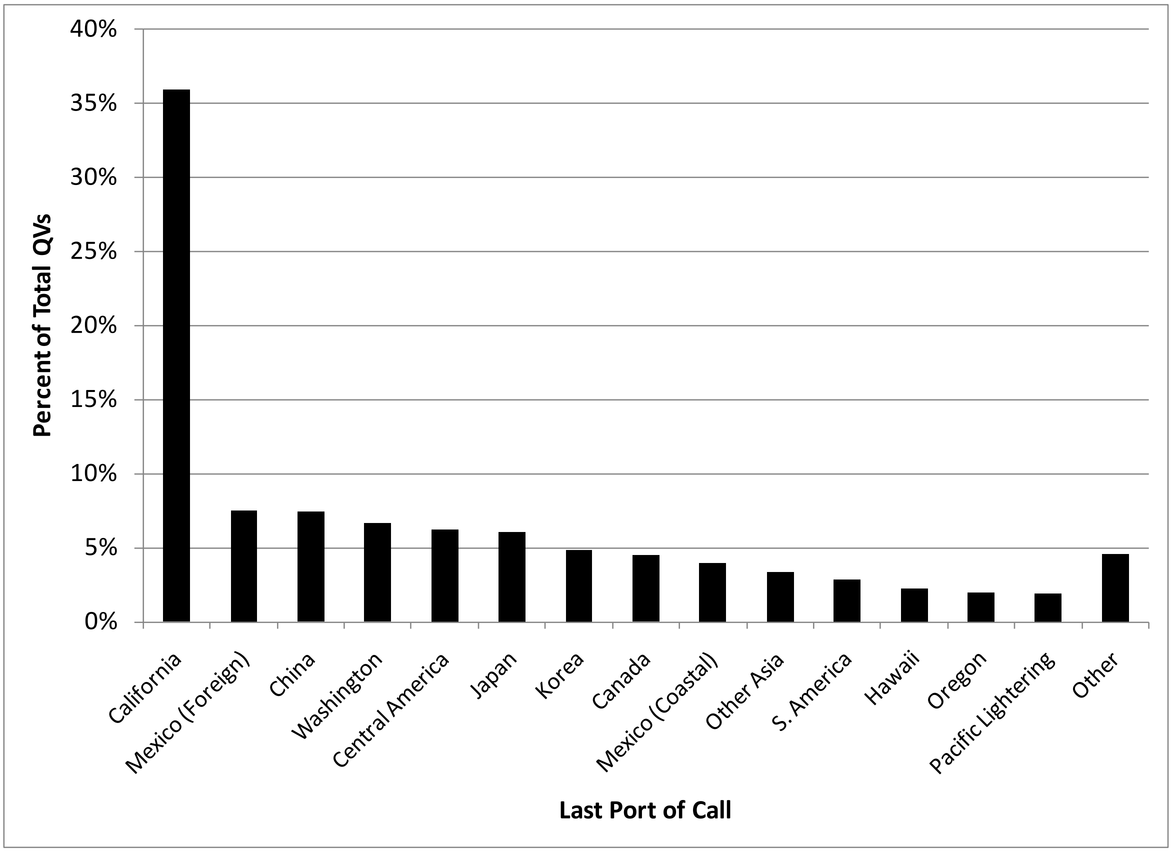

Figure VI.7. Last Port of Call for Qualifying Voyages (QVs) to California Ports (2008b – 2010a)

Ballast Water Discharge, Management and Compliance

Ballast Water Discharge Patterns

The risk for NIS introductions through ballast water is based on many factors, including (but not limited to) the source, age, and volume of ballast water discharged, environmental similarities between the source and recipient port waters, and time of year (i.e. season). Therefore, an examination of geographic and volumetric patterns of ballast water retention and discharge provides valuable background that may be used to frame relative trends and risk of species introductions in the State.

Vessels that do not discharge any ballast water within the state pose no risk for NIS introductions through the ballast water vector (see Section II for discussion of NIS introduction risks due to vessel fouling), and retention is currently the most protective management strategy available. Since reporting requirements were implemented in 2000, the percent of QVs retaining all ballast water on board while in state waters (i.e. not discharging) increased to a high of 86% in 2007, and since 2008 has leveled off at 84% (Figure VI.8).

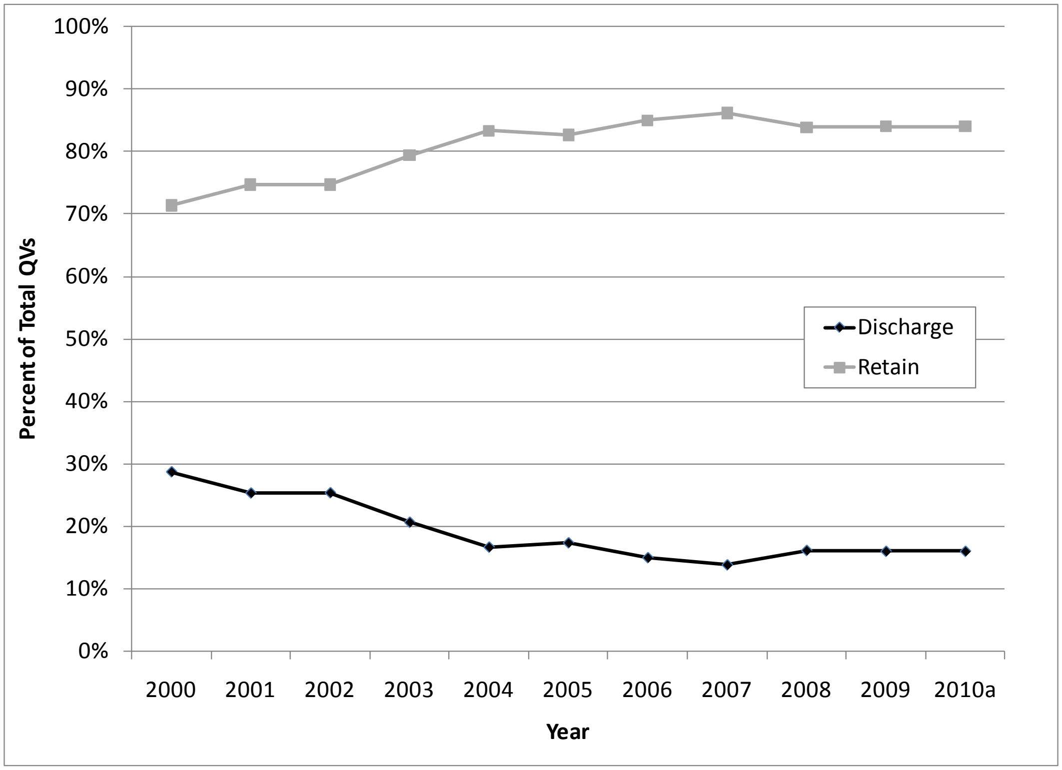

Figure VI.8. Reported Ballast Water Management (a = January to June)

The percent of QVs discharging ballast in California water has remained static since 2008 (Figure VI.8), however the total volume of ballast water discharged by all QVs and the average volume of ballast water discharged per QV over that same time period has continued to increase (Figures VI.9 and VI.10 respectively). More ballast water was discharged into California waters during the first six months of 2009 (5.65 million metric tons, MMT) than in any similar time period since the inception of the Marine Invasive Species Program (Figure VI.9). In addition, the highest average per voyage volume of ballast water discharge in the history of the program was observed in 2009a (Figure VI.10).

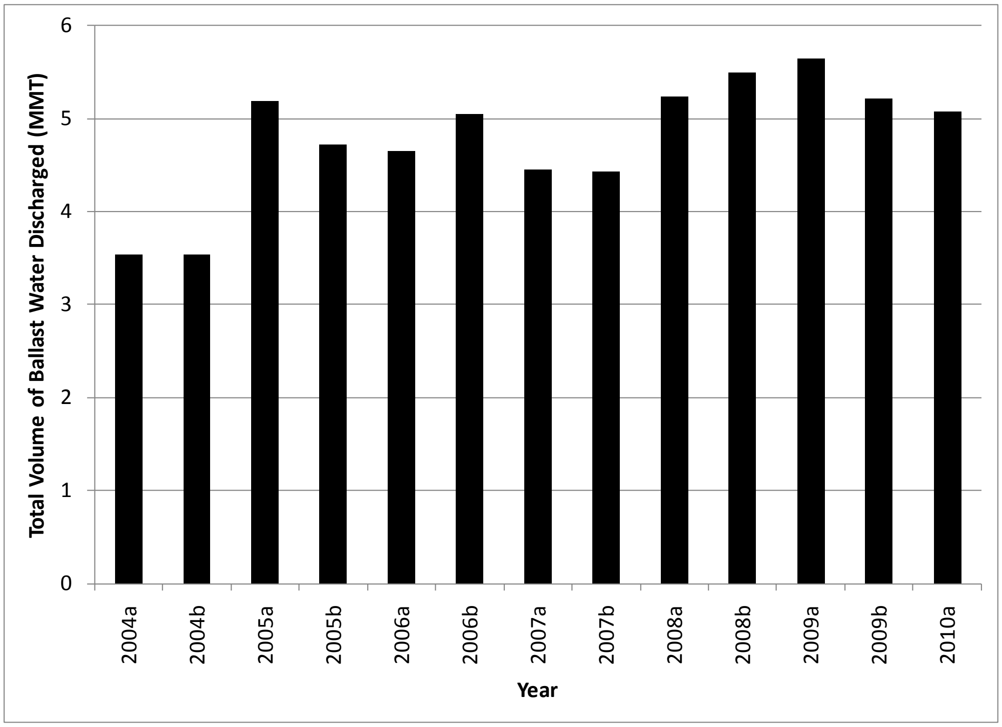

Figure VI.9. Total Volume Ballast Water Discharged (metric tons; MT) (a = January to June, b = July to December)

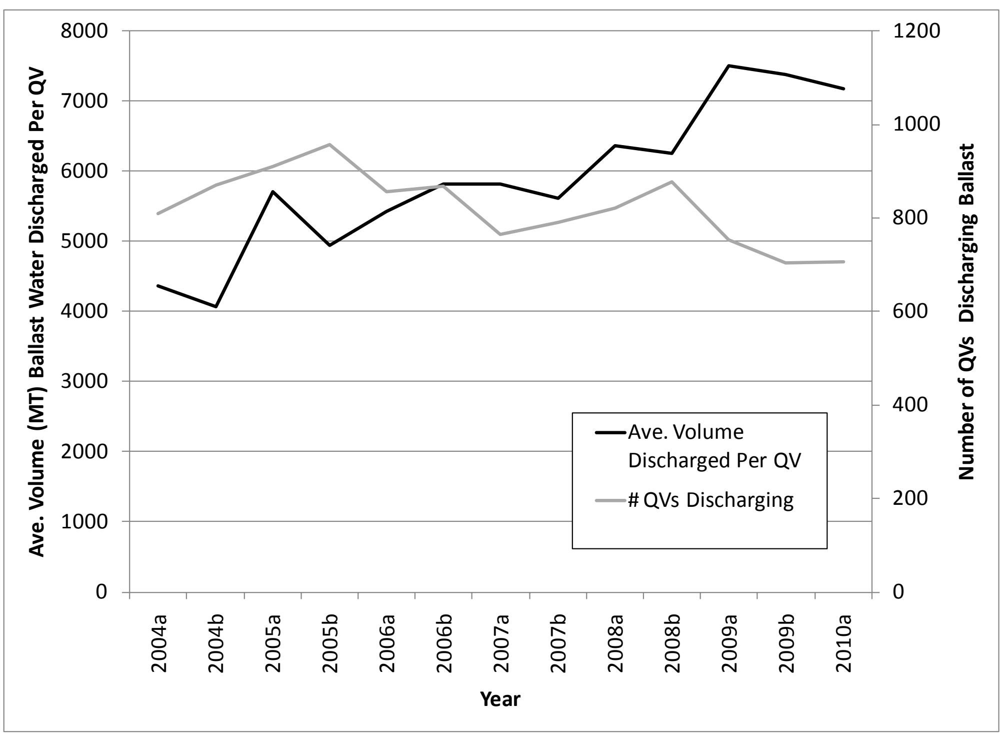

Figure VI.10. Average volume (MT) of Ballast Water Discharged per Qualifying Voyage (QV). Average calculated using the number of vessels discharging not the total number QVs.

In 2009 and early 2010, the number of QVs discharging ballast water in the state declined (Figure VI.10), yet the total volume of ballast water discharge reached an all time high. The increase in the total volume and average per voyage volume of ballast water discharged was driven, in large part, by bulk and tank vessels. Bulk and tank vessels carry more ballast water, on average, than any other ship type. The average ballast water capacity of a bulk vessel operating in California waters is 22,132 metric tons (MT). The average tank vessel's capacity in California is 31,643 MT. By comparison, container vessels operating in California, which account for almost half of the total arriving vessel population (see Figure VI.5), carry an average of only 14,408 MT of ballast water - less than half the capacity of tank vessels. Due to the nature of their cargo operations, bulk and tank vessels often cannot retain all ballast water on board. When these vessel types load cargo they frequently need to discharge the entire capacity of their ballast tanks and have very little operational leeway to eliminate the need to deballast. Thus, an average of 51% of arriving bulk vessels discharge in California waters, and 25% of arriving tankers discharge while in California (Table VI.1). Container vessels, on the other hand, are better able to adjust cargo operations so they may reduce discharge volumes or to eliminate the need to discharge completely. On average, only of 8% of containerships that arrive to California discharge ballast.

Table VI.1. Average Distribution of QVs and Discharge Patterns by Vessel Type (2008b – 2010a).

Vessel Type	Average Number of QVs Per 6 Month Period	Average Number Discharging Per 6 Month Period	Percent Discharging
Auto	329	5	2%
Bulk	313	158	51%
Container	2159	168	8%
General	214	37	17%
Other	42	7	17%
Passenger	325	53	16%
Tank	1002	247	25%
Unmanned Barge	316	86	27%

A closer look at the actual number of discharging bulk and tank vessels (Table VI.1) and the volume of ballast water discharged by these vessel types (Figure VI.11) highlights the role that bulk and tank vessels play in driving the total volume of ballast water discharged in the state.

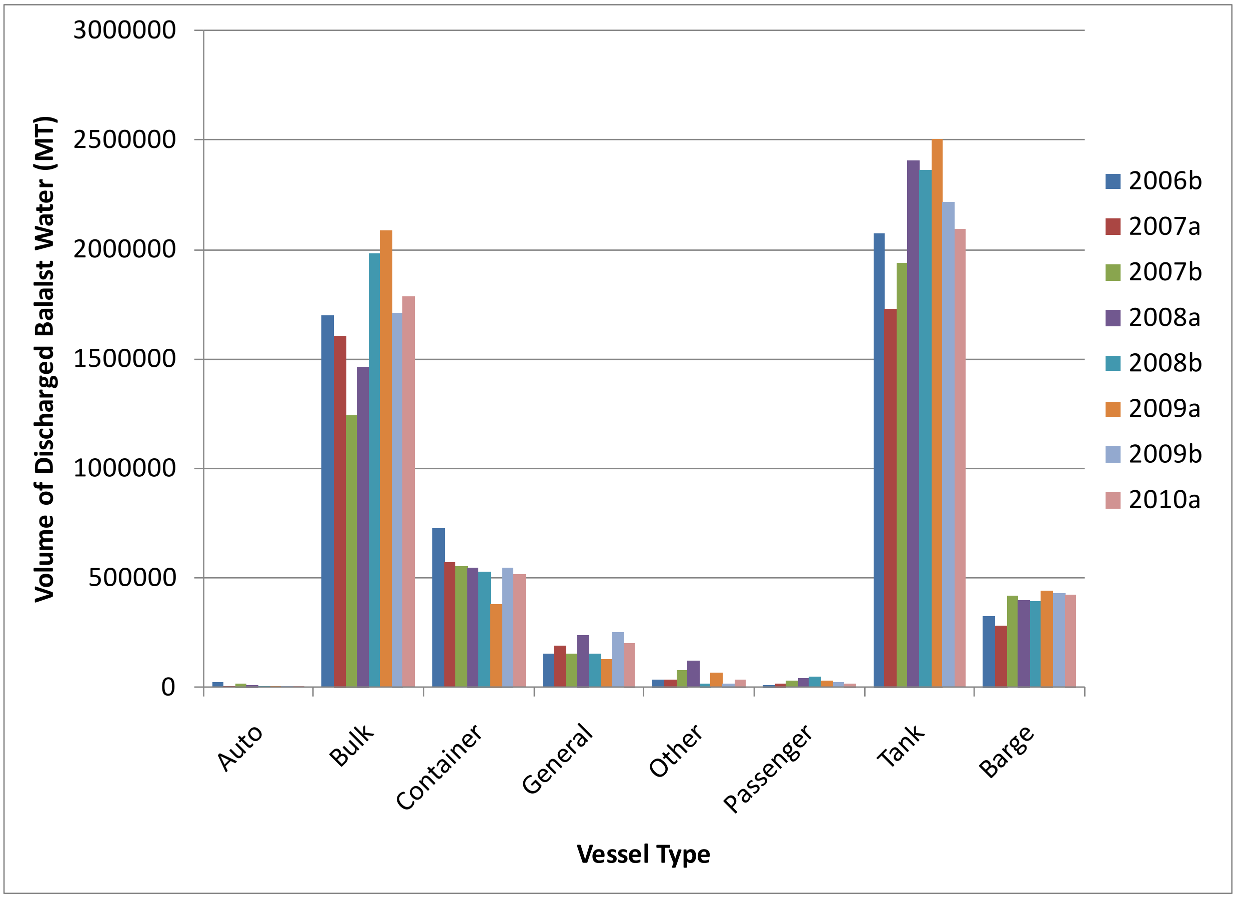

Figure VI.11. Total Volume of Ballast Water (metric tons; MT) Discharged per Six-Month Period as a Function of Vessel Type. (a = January to June, b = July to December)

The data collected on the Ballast Water Reporting Forms not only allow for analysis of discharge patterns by vessel type, but also by arrival port. A close examination of the number of QVs discharging by port highlights the regional nature of vessel discharge patterns (Table VI.2). As might be expected based on the numbers of QV arrivals (see Figure VI.4), the greatest discharge volumes occur in the ports of LA-LB, Carquinez, Richmond, and Oakland. The ports of Los Angeles and Long Beach receive large numbers of discharging vessels from both coastal and foreign origin, while the majority of arrivals discharging in the San Francisco Bay ports of Oakland, Carquinez, and Richmond are of coastal origin.

Table VI.2. Number of Qualifying Voyages that Discharged Ballast by Port, Six-Month Period, and Origin of Voyage (2008b-2010a; a = January to June, b = July to December). Coastal voyages originated from ports within the PCR. Foreign voyages originated from ports outside of the PCR.

Discharge Port	2008b		2009a		2009b		2010a	
	Coastal	Foreign	Coastal	Foreign	Coastal	Foreign	Coastal	Foreign
Humboldt	5	0	0	0	0	0	0	0
Sacramento	2	5	4	14	2	3	6	9
Stockton	6	7	10	10	4	7	2	18
Carquinez	115	31	110	28	86	22	113	23
Richmond	107	16	83	22	81	19	77	16
San Francisco	10	4	2	4	7	8	4	0
Oakland	51	10	31	9	59	7	49	14
Redwood	4	5	2	6	0	10	1	6
Hueneme	0	2	1	3	0	1	1	3
El Segundo	19	8	29	9	26	5	24	3
LA-LB	200	241	174	180	126	200	125	187
Avalon/Catalina	0	0	0	0	0	0	0	0
San Diego	18	12	14	8	16	14	14	11
TOTAL	**537**	**341**	**460**	**293**	**407**	**296**	**416**	**290**

The number of QVs discharging at each port (Table VI.2) is one indicator of potential risk of introduction, however the volume of ballast water released at these ports is perhaps a better gauge of invasion pressure (Table VI.3). The Ports of Richmond and Carquinez received less than one-half as many QVs, on average, as Oakland (see Figure VI.4), but these ports received, on average, approximately 5 times more ballast water than Oakland per six-month period (Table VI.3). The average volume of ballast water discharged from coastal voyages per six-month period was greater for Carquinez than LA-LB, even though LA-LB had approximately 65% more coastal vessels discharging, on average, than Carquinez. This pattern can be explained by the high volume of tank vessel traffic to Carquinez.

Overall, 54% of the volume of ballast water discharged in California between 2008b and 2010a came from vessels whose last port of call was within the PCR (Table VI.3). Thus coastal ballast water plays an equal, if not more important, role in the transport of nonindigenous species as does foreign ballast water. Given the combination of the quantity of arriving coastal vessels and the large volumes of ballast water discharged by such transits (Tables VI.2 and VI.3), these data demonstrate the high potential for intraregional transport of introduced species across several recipient ports. In examining these statistics, it is important to note that several factors influence invasion risk in addition to the volume of ballast water released. This includes the age of the ballast water discharged (species often survive better when held for a short period of time), the degree of repeated inoculation (frequency with which ballast is discharged in a given area), and similarity between donor and recipient regions (biological, chemical, and physical characteristics at each port) (Carlton 1996, Ruiz and Carlton 2003). The coastal regulations implemented in early 2006 require vessels to manage their ballast water when moving between ports in the PCR. The regulations are proving to be an important tool to help reduce the risk of new species introductions into California's ports.

Table VI.3. Discharge Volume (metric tons = MT) by Port, Six-Month Period, and Source of Voyage. (2008b-2010a; a = January to June, b = July to December)

Discharge port	2008b			2009a			2009b			2010a		
	Percent foreign discharges	Percent coastal discharges	Total volume discharged (MT)	Percent foreign discharges	Percent coastal discharges	Total volume discharged (MT)	Percent foreign discharges	Percent coastal discharges	Total volume discharged (MT)	Percent foreign discharges	Percent coastal discharges	Total volume discharged (MT)
Humboldt	0%	100%	17107	0%	0%	0	0%	0%	0	0%	0%	0
Sacramento	98%	2%	42150	85%	15%	154,236	75%	25%	40,465	67%	33%	138,703
Stockton	54%	46%	100,990	62%	38%	215,500	83%	15%	97,192	98%	2%	190,136
Carquinez	29%	71%	1,363,209	24%	76%	1,336,988	26%	74%	1,178,798	24%	76%	1,290,097
Richmond	9%	91%	1,056,739	22%	78%	902,955	15%	85%	912,057	19%	81%	923,387
San Francisco	49%	51%	60,473	43%	57%	54,811	27%	73%	52,801	0%	100%	4,382
Oakland	37%	63%	258,339	59%	41%	217,683	43%	57%	204,333	43%	57%	296,633
Redwood	44%	56%	84,744	98%	2%	71,102	100%	0%	108,508	0%	100%	77,051
Hueneme	100%	0%	672	82%	18%	4,490	0%	100%	241	32%	68%	2,257
El Segundo	10%	90%	216,598	43%	57%	427,142	16%	84%	340,068	10%	90%	185,755
LA-LB	69%	31%	2,272,484	67%	33%	2,228,566	69%	31%	2,252,241	71%	29%	1,943,051
San Diego	42%	58%	21,505	69%	31%	32,706	50%	50%	19,710	21%	79%	15,285
TOTAL	**43%**	**57%**	**5,495,012**	**48%**	**52%**	**5,646,181**	**46%**	**54%**	**5,206,411**	47%	53%	**5,066,737**

Ballast Water Management Compliance

Ballast water management requirements for vessels that must discharge ballast water in California depend on where a vessel arrives from, and the origin of ballast water intended for discharge. California Code of Regulations Article 4.6 (Title 2, Division 3, Chapter 1) requires that the master, operator, or person in charge of a vessel arriving to a California port or place from another port or place <u>within</u> the Pacific Coast Region with ballast water from within the PCR, manage ballast water in at least one of the following ways:

- Exchange the vessel's ballast water in near-coastal waters (more than 50 nm from land and at least 200 meters [m] deep) before entering the waters of the State, if that ballast water has been taken on in a port or place within the PCR.
- Retain all ballast water on board the vessel.
- Use an alternative, environmentally sound, Commission or USCG-approved method of treatment
- Discharge the ballast water to an approved reception facility (currently there are no such facilities in California).

California PRC Section 71204.3 requires that the master, operator, or person in charge of a vessel arriving to a California port or place from a port or place <u>outside</u> of the Pacific Coast Region, or with ballast water from outside the PCR, shall manage ballast water in at least one of the five following ways:

- Exchange ballast water in areas at least 200 nm from any shore and in waters at least 2000 m deep (mid-ocean waters) before discharging in California waters
- Retain all ballast water on board the vessel.
- Discharge ballast water at the same location where it was taken on, provided that the ballast water has not been mixed with water taken on in an area other than mid-ocean waters.
- Use an alternative, environmentally sound, Commission or USCG-approved method of treatment.

- Discharge the ballast water to an approved reception facility (currently there are no such facilities in California).

If ballast water that will be discharged in California originates from outside the PCR, that ballast water must be managed according to the requirements in California PRC Section 71204.3, regardless of the vessel's last port of call.

Of the more than 120 MMT of vessel-reported ballast water carried into State waters between July 2008 and June 2010, over 98% or 118 MMT was managed in compliance with California law. The majority of vessels operating in California achieve compliance with California's requirements by retaining their ballast water on board. Between July 1, 2008 and June 30, 2010, approximately 84% of the QVs arriving to the State, an average of 3938 arrivals during each six-month period did not discharge ballast water (Figure VI.8), and were therefore compliant with California law.

Of the 20.9 MMT of ballast water discharged into California from July 2008 through June 2010, 88% was appropriately managed through legal ballast water exchange and was compliant with California law (Figure VI.12). When examined over a longer temporal scale, an interesting trend emerges. Although the total volume of ballast water discharged into California has exhibited an increasing trend since the last half of 2006, the volume of noncompliant ballast water has exhibited a decreasing trend (Figure VI.12). Noncompliant ballast water has accounted for a smaller and smaller proportion of all ballast water discharges through the years, from 24% in the latter half of 2006, to 9.8% in the latter half of 2010.

Approximately 2.5 MMT of noncompliant ballast water was discharged in to California waters from July 2008 and June 2010. This noncompliant ballast water generally fell into one of three categories:

- Ballast water exchange was conducted, but the location of exchange was not in mid-ocean or in near-coastal waters as required by PRC Section 71204.3 or by 2 CCR § 2280 *et seq*.

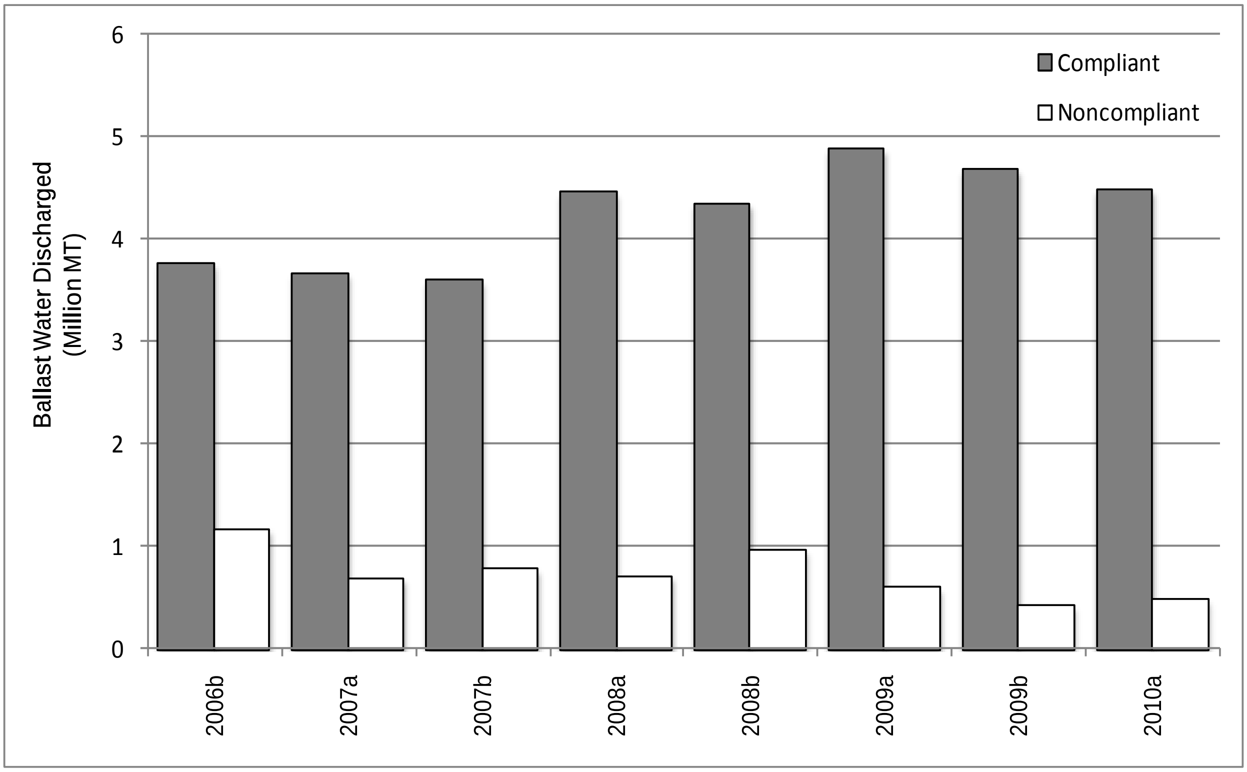

Figure VI.12. Volume (million metric tons, MMT) of Compliant and Noncompliant Ballast Water (BW) Discharged by Six-Month Period Since July 2006. Includes only compliance of discharging vessels and does not include data for vessels that comply by retaining ballast water (a = January to June, b = July to December).

- Ballast water was not exchanged.
- Vessel reported exchanging ballast water, but the location of exchange was unknown or unspecified.

While ballast water exchange at legal distances offshore is clearly most protective, some attempt at ballast water exchange is, in most cases, more beneficial than no exchange at all. Most vessels in violation of management requirements attempted to exchange before discharging in California, but did so in a location not acceptable by California law. The percentage of voyages falling into this category was relatively stable over the past 2 years, and accounted for 72.6% of noncompliant ballast water by volume in 2008b (144 qualifying voyages), 75% in 2009a (96 QVs), 80.8% in 2009b (83QVs) and 77% in 2010a (97 QVs) (Figure VI.13).

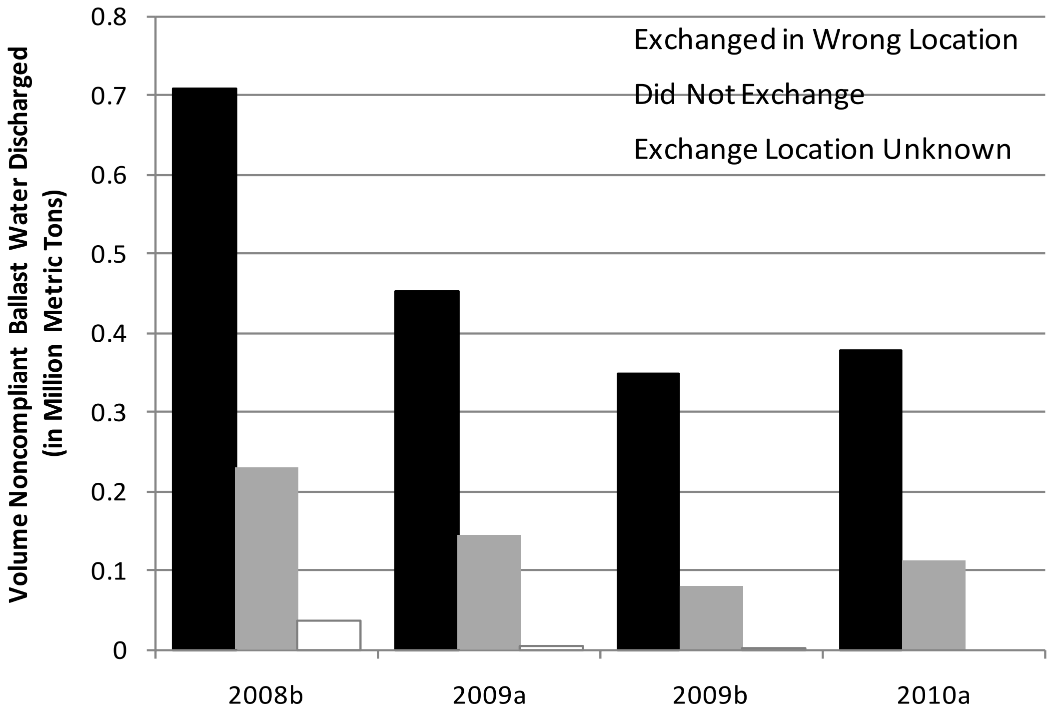

Figure VI.13. Volume (million metric tons; MMT) of Noncompliant Ballast Water (BW) Discharged by Violation Type (a = January to June, b = July to December).

Of the noncompliant ballast water exchanged in the wrong location between 2008b and 2010a, 11.8% (0.214 MMT from 89 QVs) was exchanged within five percent of the required offshore distance (e.g. within 10 nm of the 200 nm boundary for mid-ocean waters or within 2.5 nm of the 50 nm boundary for near coastal waters). This subgroup serves as an example of vessels that are attempting to comply with California law but failed to extend fully to the required distance offshore.

Across the time period examined, the largest proportions of noncompliant ballast water can be attributed to tank vessels, followed by bulk vessels. These two vessel types were responsible for the vast majority of all noncompliant ballast water discharged into California from July 2008 through June 2010, accounting for approximately 88.6%. The relative contribution of both bulk and tank vessels were fairly consistent over this time span. Tankers accounted for between 51.3%-61.3% of noncompliant discharges. Excluding 2010a, bulkers accounted for between 32.8%-35.8% of noncompliant discharges. During the 2010a time period, bulkers accounted for a smaller proportion of noncompliant discharges, approximately 18.9% (Figure VI.14). Despite the high proportion of noncompliant ballast water attributable to bulk and tank vessels, the overall volume of noncompliant ballast water discharged by these vessel types has exhibited a decreasing trend from 0.89 MMT in 2008b to 0.39 MMT in 2010b. This mirrors the general pattern of overall reductions in illegal ballast water discharge across all vessel types during the last 4 years (Figure VI.12).

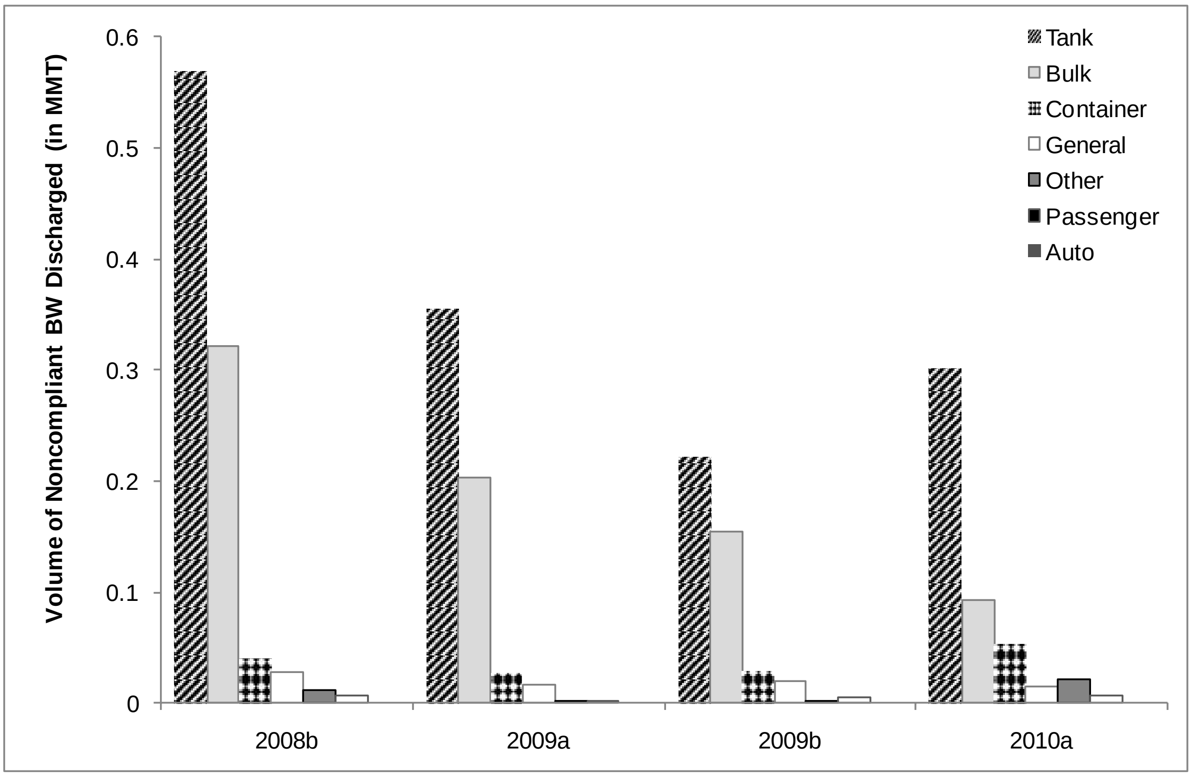

Figure VI.14. Volumes of Noncompliant Ballast Water (BW) by Vessel Type (a = January to June, b = July to December)

Over the past six and a half years, container vessels have continually accounted for the greatest proportion of QVs to California (Figure IV.5) - 45% between January 2004 and June 2006 (Falkner et al. 2007), 44% between July 2006 and June 2008, and 46% from July 2008 to June 2010. While the percentage of qualifying arrivals attributed to container vessels has consistently dominated other vessel types, the total volume and proportion of noncompliant ballast water discharged from container vessels was comparatively low during the 2 year focus of this report, accounting for between 4.1%

(2008b) to 10.8% (2010a). Over a longer time scale, this proportion had been decreasing until recently, from 31.7% of all noncompliant ballast water discharges in 2004a (Falkner et al. 2007), to a low of 4.1% in 2008a (Figure VI.14). During more recent time periods however, the proportion of noncompliant ballast water discharged by containers has been slowly increasing, from 4.5% in 2008b to 10.8% in 2010a.

Due to safety concerns associated with transferring personnel to an unmanned barge to conduct ballast water exchange, barges may utilize a safety exemption in California as per PRC section 71203. In such cases, vessels are not compelled to exchange ballast water intended for discharge, because the process would pose a safety risk to the vessel or crew. However, if barges are examined as if they did not utilize the safety exemption, vessel type would represent the 3rd largest source of ballast water that was not appropriately exchanged prior to discharge (Figure VI.15). Between July of 2008 and June of 2010, barges would have accounted for 14.2% (2010a) to 20.5% (2009a) of such discharges by volume, despite the fact that barges account for only 7% of arrivals. Seventy-seven percent of this ballast water, or 0.35 MMT, was exchanged but at distances from land that would not be considered adequate (Figure VI.16). In addition, the proportion of total barge discharges that would have been considered noncompliant was much higher than for tankers or bulkers: approximately 27.0% of barge discharges were noncompliant, versus 15.7% and 10.1% for bulkers and tankers respectively. This notable amount of noncompliant ballast water attests to the need for moving forward with the implementation of performance standards, where ballast water would undergo treatment before discharge. Because many ballast water treatment systems treat on uptake and/or discharge when a vessel is likely to be in the sheltered waters of a port, the use of technologies should allow barges to reduce the risk of NIS introduction with significantly less concern for vessel and/or crew safety.

In addition to discharge volumes and vessel types, the source of the discharged water can relay important information for the risk of NIS introductions, particularly since risk may relate to chemical, physical, and biological similarities between source and receiving waters. The majority of noncompliant ballast water discharged in California

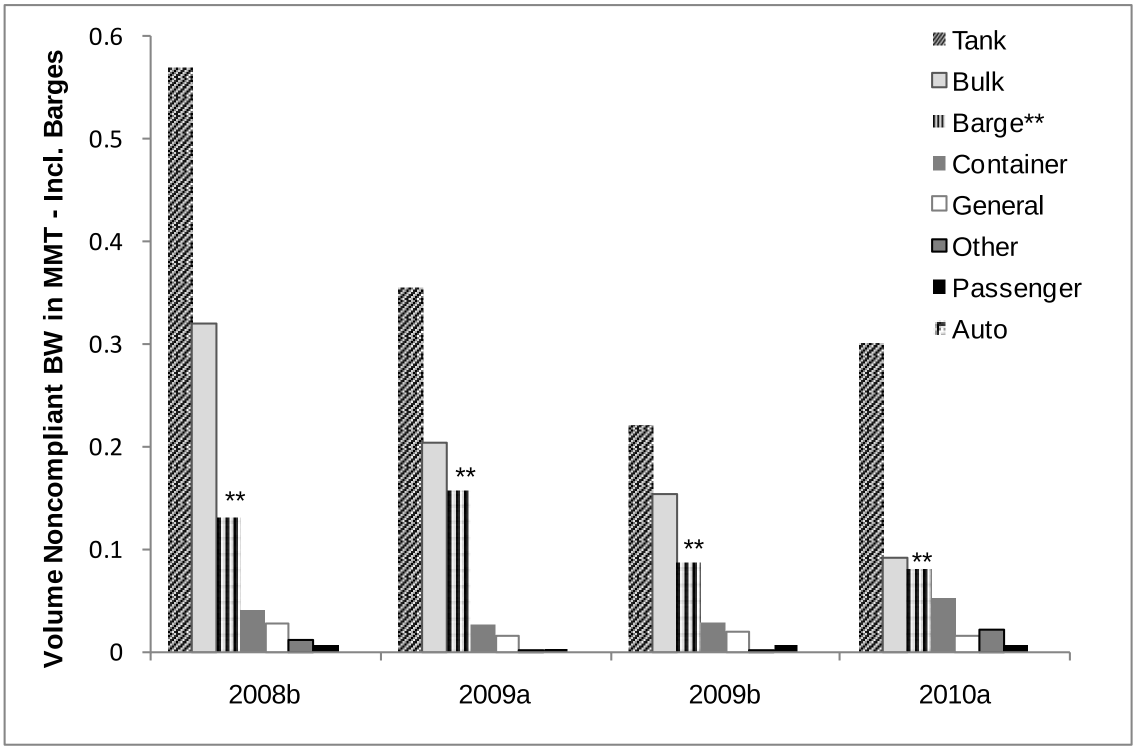

Figure VI.15. Volumes of Noncompliant BW by Vessel Type, Inclusive of Unmanned Barges Which Generally Utilize a Safety Exemption for Ballast Water Exchange (a = January to June, b = July to December)

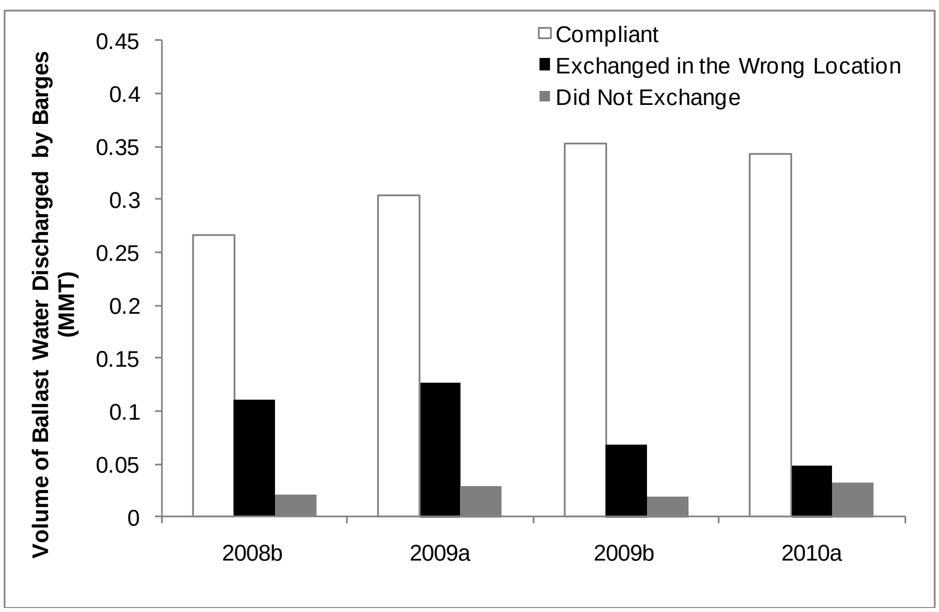

Figure VI.16. Volumes (million metric tons, MMT) of All Ballast Water Discharged by Unmanned Barges (a = January to June, b = July to December). Black and grey bars denote ballast water that would be considered non-compliant, if the safety exemption was not utilized.

from July 2008 through June 2010 originated from within the United States West Coast Exclusive Economic Zone (EEZ) (200 nm or closer to California, Oregon or Washington) and the Mexican EEZ. This proportion ranged from 61.3% (2009b) to 73.6% (2009a) of all ballast discharged. The relative dominance of these two sources was not consistent through all 6 month intervals. Mexico was clearly the largest source in 2008b (42.5% vs. 22.5% from the U.S. West Coast), while the U.S. West Coast was clearly dominant during 2009b (38.7% vs. 22.6% from Mexico). During 2009a and 2010a, the two sources contributed similarly to noncompliant discharges, with Mexico accounting for 38.0% and 39.8% respectively, and the U.S. West Coast accounting for 35.6% and 33.6% respectively (Figures VI.17 – VI.20). The majority of noncompliant ballast water from both of these sources was discharged by tank vessels, which accounted for 74.3% by volume between July 2008 and June 2010.

With the exception of 2009b, Asia is the third largest source of noncompliant ballast water, fluctuating between 10.9% (2009b) and 14.2% (2009a), with no obvious increasing or decreasing trend during the examination period. In contrast to noncompliant ballast water originating from the U.S. West Coast or Mexico, noncompliant ballast water sourced from Asia was not dominated by tanker vessels. Rather, bulkers accounted for between 72.5% to 96.9% of these discharges. Other than an 8.5% contribution in 2008b, tank vessels did not contribute to noncompliant discharges originating from Asia.

Prior to the implementation of California's coastal regulations requiring ballast water management of vessels transiting within the PCR (2 CCR § 2280 *et seq*., implemented March 22, 2006), vessels arriving from the west coast of Canada were required to exchange their ballast water at a distance greater than 200 nm from shore. During this time, noncompliant ballast water discharged from vessels arriving from Canada accounted for 2.6% (11 vessels) of the total volume of noncompliant ballast water in 2004 and 4.2 % (14 vessels) in 2005 (Falkner et al. 2007). However, during the first six months of 2006 (i.e. when coastal regulation was implemented), noncompliant ballast water arriving from Canada accounted for only 0.7% (1 vessel) of the total volume of

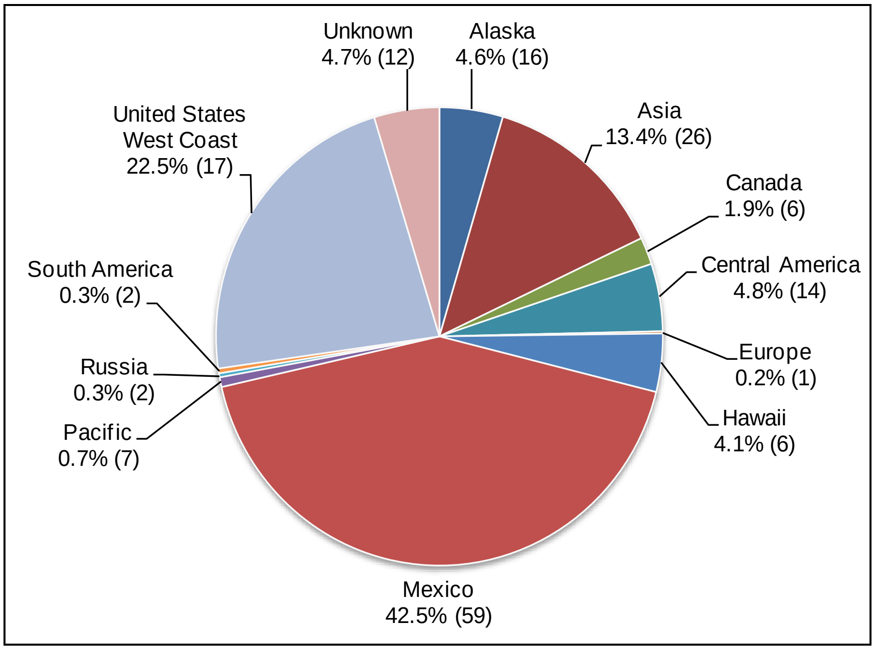

Figure VI.17. Source of Noncompliant Ballast Water (2008b; July-December 2008). Numerals in parentheses denote number of vessels.

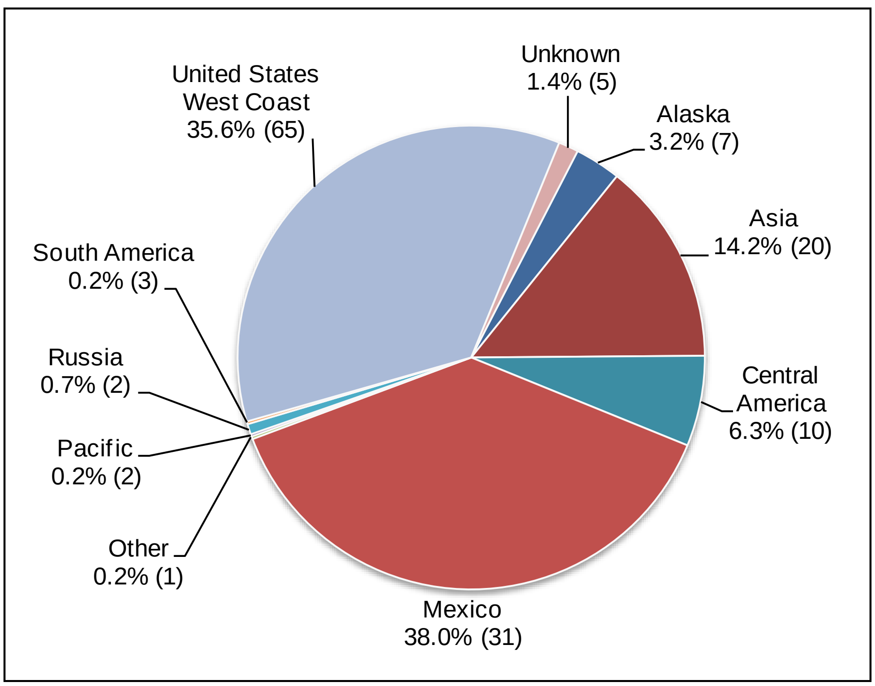

Figure VI.18. Source of Noncompliant Ballast Water (2009a; January-June 2009). Numerals in parentheses denote number of vessels.

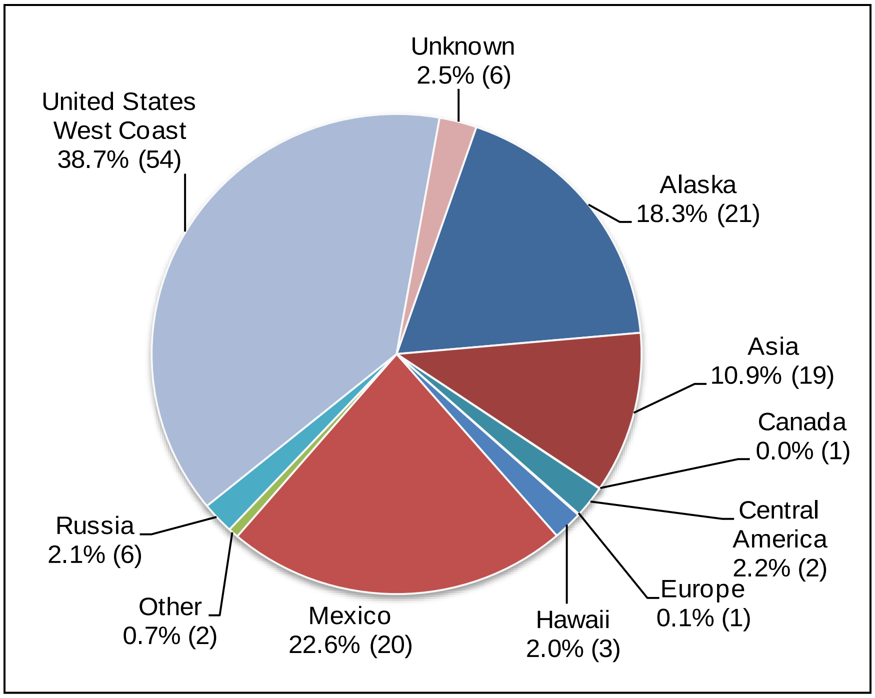

Figure VI.19. Source of Noncompliant Ballast Water (2009b; July-December 2009). Numerals in parentheses denote number of vessels.

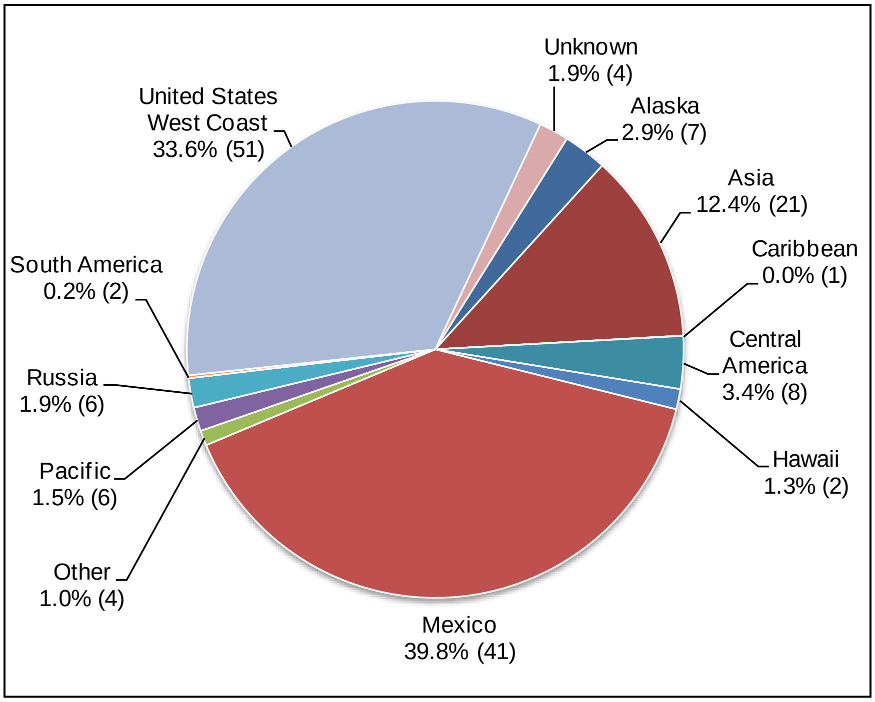

Figure VI.20. Source of Noncompliant Ballast Water (2009a; January-June 2010). Numerals in parentheses denote number of vessels noncompliant discharge. Excluding the second half of 2008 when 1.9% (6 vessels) of noncompliant discharges originated from Canada, less than 1% of the total volume of noncompliant discharges into California originated from this region. This consistently low proportion of noncompliant discharge from vessels arriving from Canada may be attributable to the fact that vessels now only have to exchange their ballast water 50 nm from shore, rather than 200 nm, in order to be compliant with California law.

Ballast water that is not exchanged composes a much smaller proportion of noncompliant discharges in comparison to ballast water that was exchanged at inadequate distances from shore. Examination of this smaller subset of noncompliant ballast water exhibits slightly different source pattern. The U.S. West Coast accounted for the majority of such ballast water during 2008a, approximately 57.8%. During more recent time periods, this source accounts for over two thirds of unexchanged ballast water discharged in California, 77.7% in 2009a, 74.2% in 2009b, and 64.0% in 2010a. During 2008a - 2010b, vessel types responsible for unexchanged discharges were tankers (57.8%), containers (18.3%), and bulkers (13.8%). Other sources of unexchanged ballast water were Asia (13.0%) and Mexico (11.9%) (Figure VI.21). Though unexchanged ballast water represents only 22.3% of noncompliant discharges, and only 2.7% of all discharges (compliant + noncompliant) by volume, this sub-portion may represent a higher risk for introduction to the State because there has be no attempt at ballast water management. In addition, because such a large proportion of this ballast water originates from other U.S West Coast areas, it indicates that there may be notable potential for NIS spread to California from other ports in other West Coast states.

While the ability to determine the origin of noncompliant ballast water and types of vessels that discharge illegal water is important in assessing the risk of NIS introductions into California, it is important to remember that the overall volume of noncompliant ballast water discharged into California waters is relatively small and has been decreasing through time. Since July of 2006, noncompliant ballast water

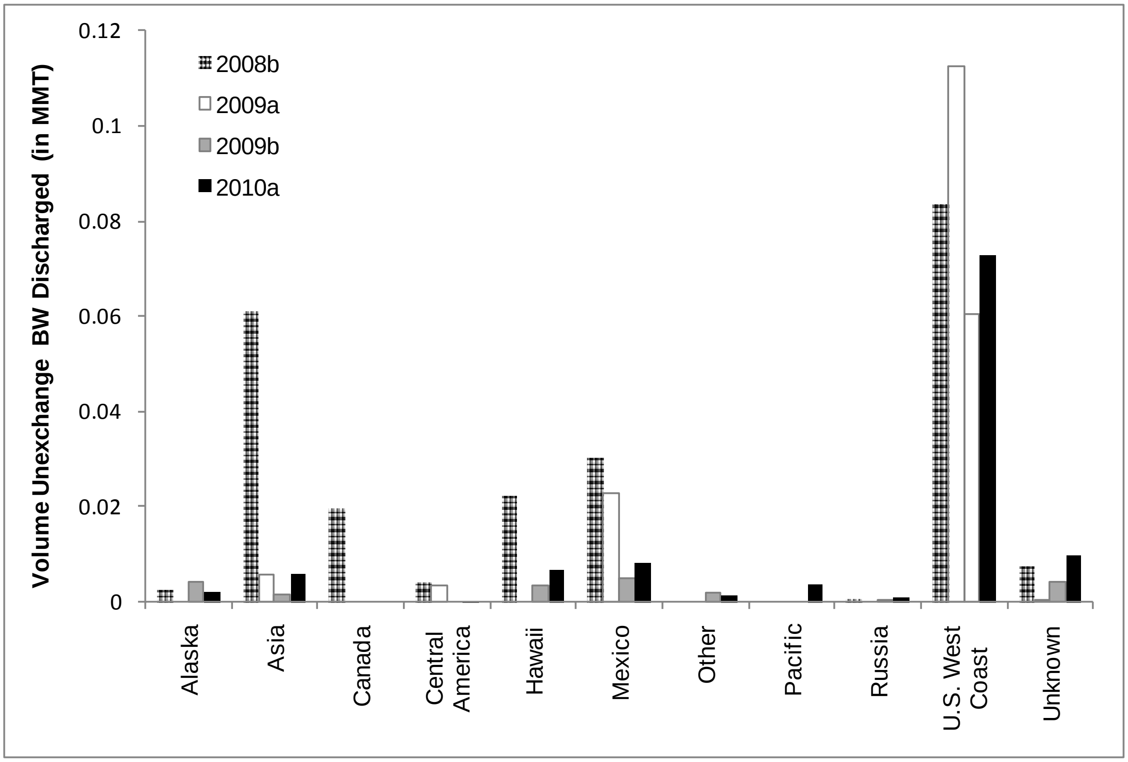

Figure VI.21. Sources of Noncompliant, Unexchanged Ballast Water (BW) Discharged in California. (MMT=million metric tons, a = January to June, b = July to December)

discharges have decreased 52% from 1,009,232 MT (2006b) to 490,416 MT (2010a), even though overall discharges have exhibited a fluctuating, but generally increasing trend. During the two-year focus of this report, only 2% of the 120 MMT of ballast water carried into California did not properly comply with the State's management requirements. Furthermore, the vast majority of the noncompliant ballast water discharged in State waters underwent some type of exchange, likely reducing the risk of NIS introductions.

Similar to the trend of decreasing volumes of noncompliant ballast water discharge in California, the number of vessel arrivals in violation of ballast water management requirements has remained small and has experienced a modest decrease over the 2 year focus of this report, from 202 vessels (3.9% of all QVs) in 2008b to 144 vessels (3.2% of all QVs) in 2010a. This decreasing trend is a continuation of the same pattern evident on the longer timescale that begins after the coastal regulations went into effect in March of 2006 (Figure VI.22). Though the number of qualifying voyages has also decreased since 2006a, the fact that the proportion of arrivals out of compliance continues to decrease demonstrates that compliance on a vessel-by-vessel basis has continually improved.

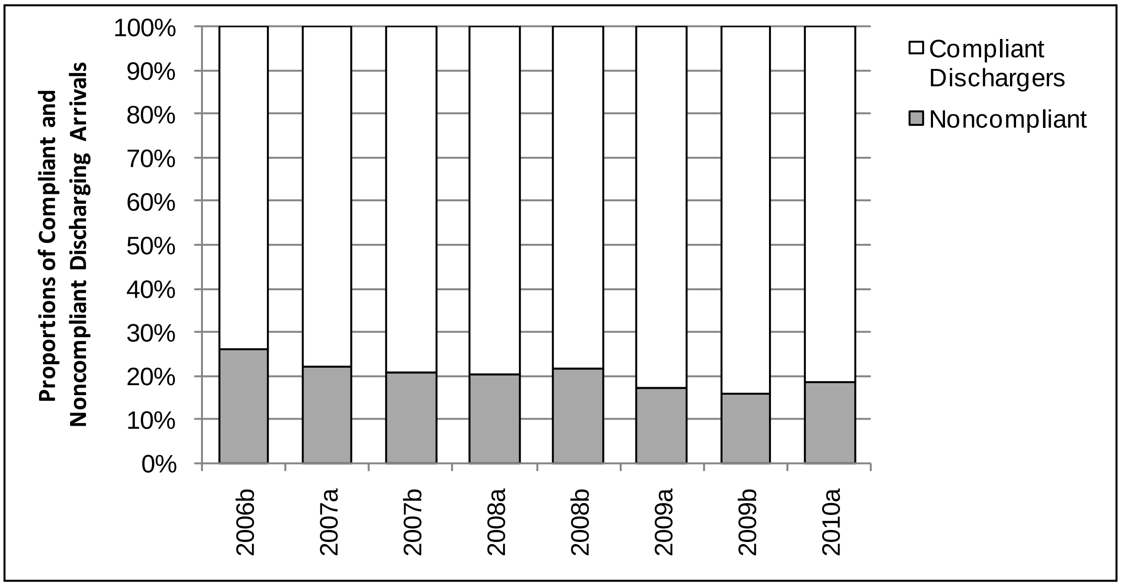

Figure VI.22. Proportions of Compliant and Noncompliant Discharging Arrivals Since Pacific Coast Region Requirements Went Into Effect (a = January to June, b = July to December)

Compliance through Field Inspections

Under PRC Section 71206, the Commission assesses compliance of any vessel subject to the Act through a vessel inspection program. The Commission has two field offices, one in Southern California, and the other in Northern California. Statewide, Marine Safety Inspectors boarded and inspected 22.5% (4340) qualifying voyages between July 1, 2008 and June 30, 2010. (Table VI.4).

During the inspection process, inspectors interview crew and review paperwork, including but not limited to Ballast Water Reporting Forms, ballast water logbooks and engine logbooks. If these items are not in order as required, the vessel is cited for an administrative violation. A salinity sample is taken at the top, middle and bottom of a subset of tanks intended for discharge in California. Any tank with a salinity reading

Table VI.4. Vessel Inspections and Violations

	2006b	2007a	2007b	2008a	2008b	2009a	2009b	2010a
No. Qualifying Voyages	5645	5463	5541	5382	5253	4857	4579	4606
No. Inspections Conducted	818	897	969	1108	1053	1225	1061	1001
Total No. Violations Cited	148	114	82	66	59	50	20	22
No. Administrative	123	86	59	53	41	34	13	16
No. Operational	25	28	23	13	18	16	7	6

below 29 PPT (parts per thousand) serves as a flag for a potential violation and the Inspector more closely scrutinizes paperwork and re-interviews vessel officer(s).

The majority of vessels inspected are found to comply with the Act. The majority of noted violations are associated with administrative components of the law (incomplete ballast water management plan, inaccurate ballast report forms, incomplete ballast tank logs, etc.). All inspected vessels found in violation of California law are cited. A copy of the citation is given to the vessel crew and a copy is retained by the Commission. In addition, a copy of the violation and an enforcement letter is sent to the vessel owner. The vessel is then targeted for re-inspection upon its next visit to California waters.

Trends in Vessel Fouling-Related Practices and Patterns

As illustrated in Figure VI.8, about 84% of the qualifying voyages into California manage their ballast water retaining all ballast on board, and therefore pose ‘zero’ risk of introducing NIS through the ballast water vector. However, through vessel fouling, every vessel represents some level of risk. This is because all vessels have submerged surfaces that are susceptible to accumulating fouling organisms and fouling organisms cannot be completely contained or retained in port as they can be within an enclosed ballast tank. In an effort to evaluate the risk of introducing NIS into California through vessel fouling, the Commission produced and presented a report titled “Commercial Vessel Fouling in California” (see Takata et al. 2006) to the State Legislature in April 2006. This report revealed large information gaps in our knowledge of the biology of fouling organisms associated with commercial ships, as well as the husbandry and voyage characteristics of the fleet operating along the U.S. West Coast. In response to some of the recommendations made in that report, the State Legislature developed and passed Assembly Bill 740 (Chapter 370, Statutes of 2007), which was signed into law in October 2007. This legislation requires the master, owner, operator, agent, or person in charge of a vessel arriving to a California port or place to submit, on an annual basis starting January 2008, fouling-related information via a reporting form to be developed by the Commission.

The Commission's Hull Husbandry Reporting Form (HHRF) was developed in consultation with a technical advisory group consisting of representatives from the shipping industry, scientific community, and local, state, federal, and international agencies. The form was distributed to the commercial fleet operating in California via shipping agents in January 2008. The HHRF is an eleven question survey that is divided into two sections: one addressing hull husbandry practices relating to submerged vessel surfaces, and the other relates to voyage characteristics that are thought to influence fouling accumulation and complexity.

Title 2, Section 2298 of the California Code of Regulations (2 CCR § 2298) requires annual submission of the HHRF from every vessel carrying, or capable of carrying, ballast water into the coastal waters of the state. During 2008, the first year of this reporting requirement, 74.4% of the vessels that operated in California submitted the form as required, with only five of the eight vessel types recording over 70% compliance (Figure VI. 23). During the following year, the Commission utilized the monthly notification system already in place for delinquent ballast water reporting forms and was able to increase the overall HHRF submission compliance rate to 92.9%, with seven of the eight vessel classes recording compliance rates above 90%.

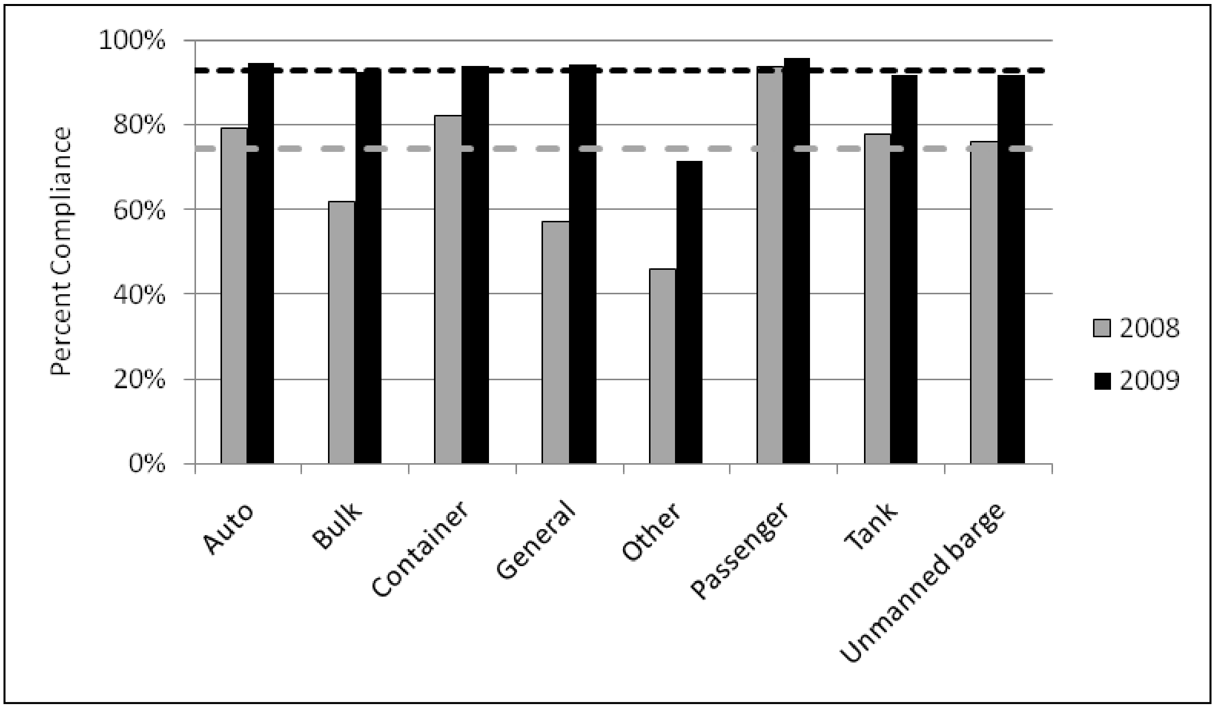

Figure VI.23. Percent Compliance for Hull Husbandry Reporting Form Commission By Vessel Type during 2008 and 2009. Dashed lines represent overall percent compliance for California fleet.

Overall, 1362 vessels in 2008 and 1722 vessels in 2009 submitted HHRFs. The population breakdown by vessel type was similar during both years; with containerships (30.2 – 32.8% of the fleet) accounting for about a third of the unique vessels, followed by tankers (23.8 – 25.1%), bulkers (15.4 – 20.1%), auto carriers (11.1 – 14.1%), general cargo ships (7.2 – 9.1%), passenger vessels (2.8 – 3.4%), unmanned barges (1.2 – 1.4%), and 'other' vessels (0.8 – 1.5%; Figures VI. 24 a and b).

Because vessels are only required to submit the HHRF once each year they operate in California waters, the data collected in 2008 and 2009 represent two snapshots of vessel practices and voyage characteristics for the California fleet. Differences between 2008 and 2009 were minimal, as reflected in the population breakdown (Figure VI.24 a, b), and the 2009 dataset was much more complete and representative of the fleet as a whole due to much higher submission compliance rates. For these reasons, most of the remaining data presented in this section will represent the 2009 dataset. However, both

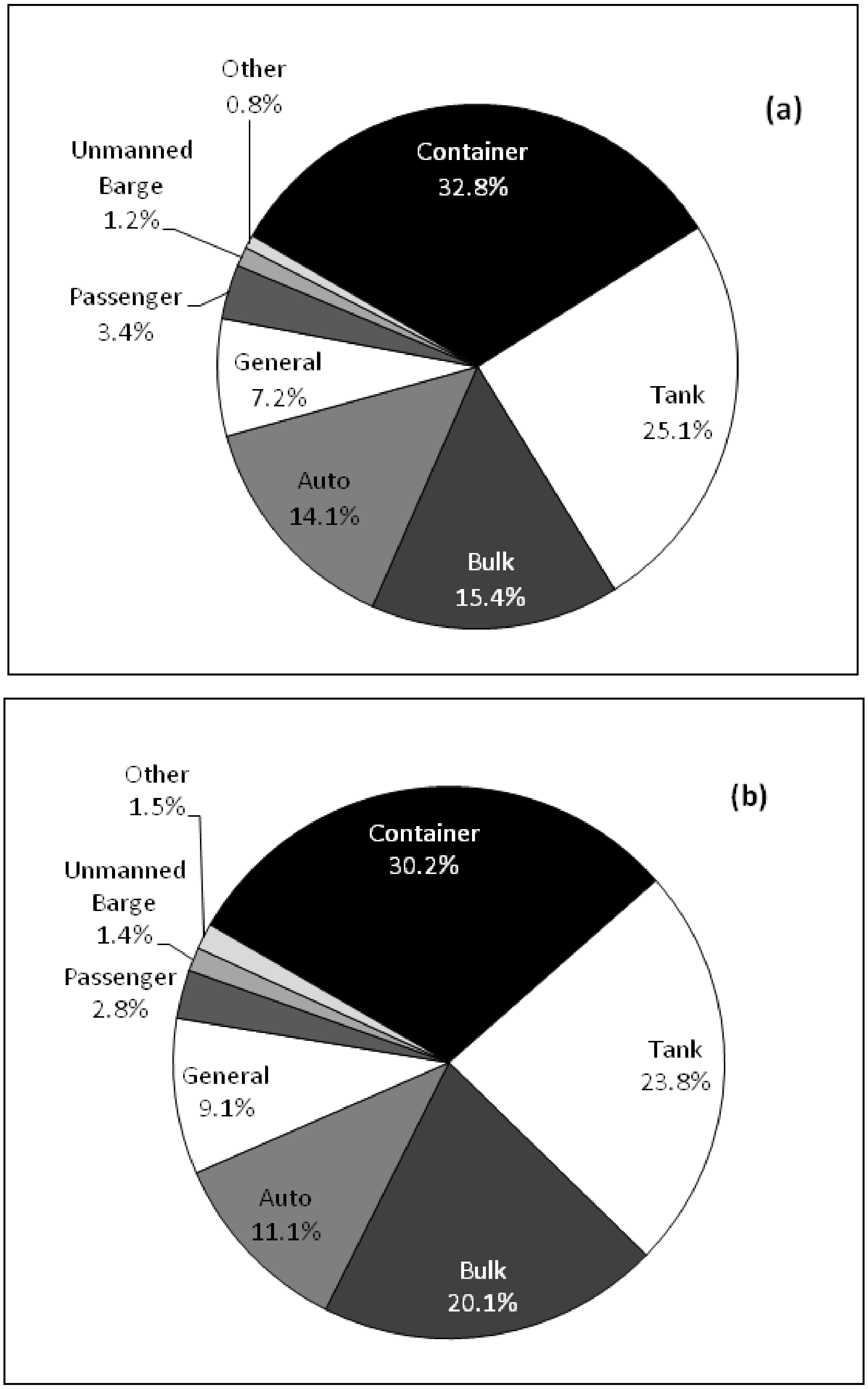

Figure VI.24. Population Breakdown of Unique Vessels Submitting Hull Husbandry Reporting Forms in (a) 2008 and (b) 2009.

datasets will be presented when large differences between the two reporting years occurred.

Husbandry Practices of the Commercial Fleet in California

One of the most common ways of reducing the amount of fouling organisms on the submerged surfaces of a vessel is to physically remove them. This usually occurs during a vessel's out-of-water dry dock, which is required at every 5-7.5 years by most classification societies. California law (PRC 71204(f)) also requires vessels to have fouling organisms removed from their submerged surfaces on a regular basis, with regular basis defined as no longer than 60 months since the vessel completed its last out-of-water dry docking. As such, nearly the entire fleet (99.2%) has been either dry docked (and cleaned and treated with an antifouling coating) or delivered as new within the past five years (Figure VI.25), with most (83.5%) dry docked even more recently within the last 3 years. Because of the young age of the antifouling coatings and reduced time for heavy colonization and succession, vessels which have been newly built (i.e. vessels built within past five years and which have not been dry docked,

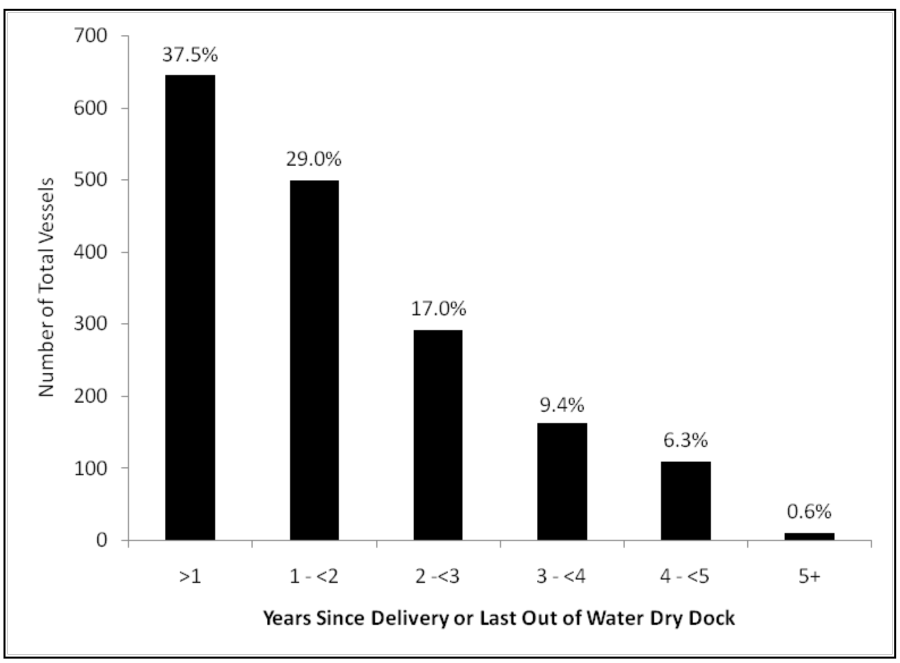

Figure VI.25. Total Number of Vessels (and Percent of Entire Fleet) Delivered as New or Cleaned and Coated During Dry Dock Within Each of the Past Five Years.

approximately 33.1% of the fleet) or dry docked within the past two to three years are more likely to have fresher, more effective anti-fouling coatings and may pose a lower risk for NIS introduction.

While nearly all of the vessels evaluated have been newly delivered or dry docked within the past five years, evaluating the average (+ Standard Deviation; SD) time since each type of vessel has been out of water (either during ship building or dry docking) provides more useful information on the practices among ship types. Although standard deviation was high among all groups, four vessel types (unmanned barges, auto carriers, bulkers, and ‘other’ vessels) averaged less than 1.5 years since their underwater surfaces were last cleaned of fouling organisms, and none of the vessel types evaluated averaged more than 2.1 years since the last out of water cleaning or delivery. The overall average for the fleet was 1.7 years (Figure VI.26).

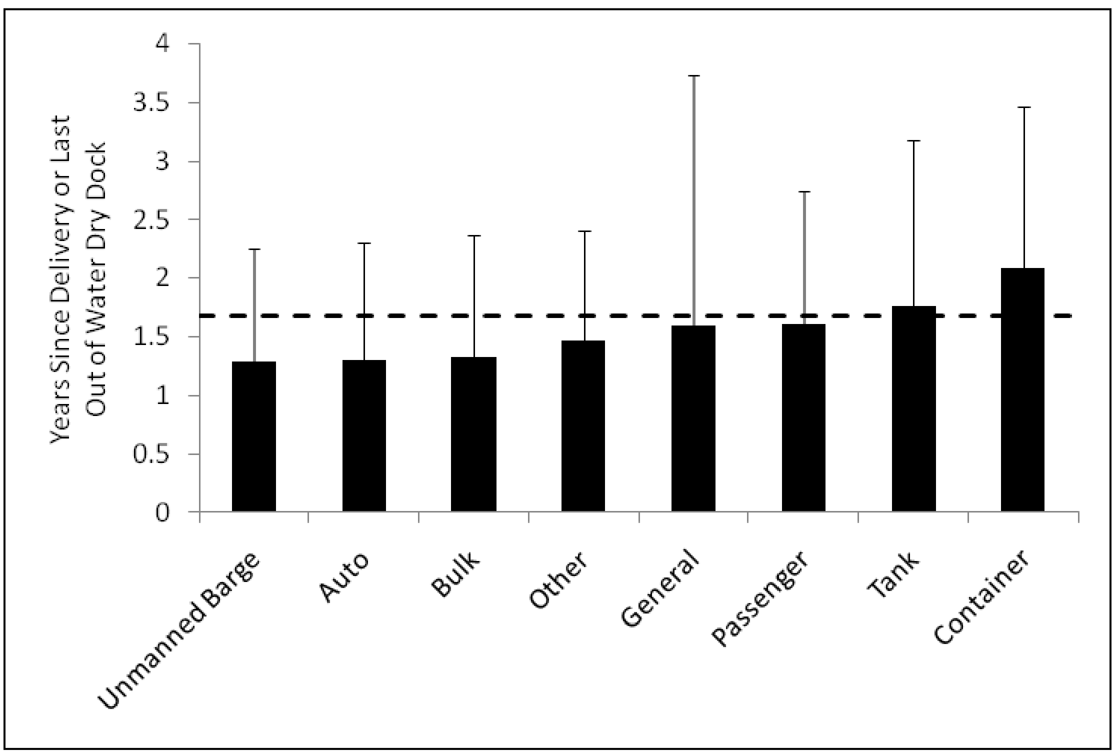

Figure VI.26. Average (+ standard deviation) Number of Years Since Vessels’ (by type) Delivery (New) or Dry Dock. Dotted line represents overall average.

Physical removal of fouling organisms from submerged vessel surfaces can also take place while the vessel is in the water. In-water cleaning is an option many vessel owners and operators utilize to remove fouling organisms during the time between dry dock cleanings (i.e. inter-dry dock period) if fouling levels become elevated and noticeable drag is experienced. In-water cleaning can include cleaning of many underwater areas on a vessel, or it can simply involve the cleaning of the propeller (i.e. propeller polishing). Overall, 19.1% of the fleet has conducted some sort of in-water cleaning since delivery or dry dock, and about half of these have conducted propeller polishing only. Considering that nearly 84% of the fleet has been dry docked or delivered within the past three years, it is not surprising that only 9.2% of the fleet has undergone in-water cleaning to the hull and other submerged surfaces recently. Although there were many more individual tankers and containerships reporting in-water cleaning, the only vessel class that had more than 15% percent of their fleet undergoing this type of treatment were the passenger vessels (24.5%; Figure VI.27).

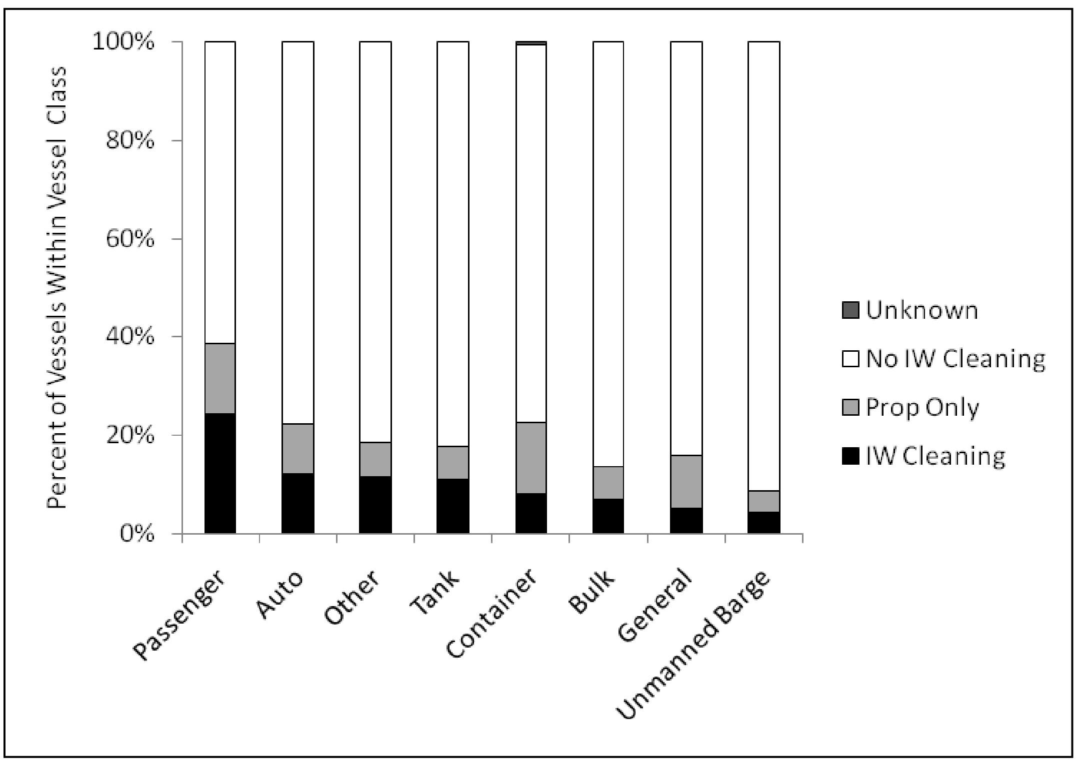

Figure VI.27. Percent of Vessels That Have Conducted In-Water Cleaning on Submerged Surfaces Since Delivery or Last Dry Docking. IW=In-Water

About a quarter of the vessels undergoing in-water cleaning are doing so within the United States (26.4% of total; Figure VI.28), a trend not seen for dry docking (5.5% conducted within the U.S.). Of those vessels undergoing in-water cleaning in the U.S., 57% have been cleaned in California, nearly all within the Los Angeles and Long Beach harbors.

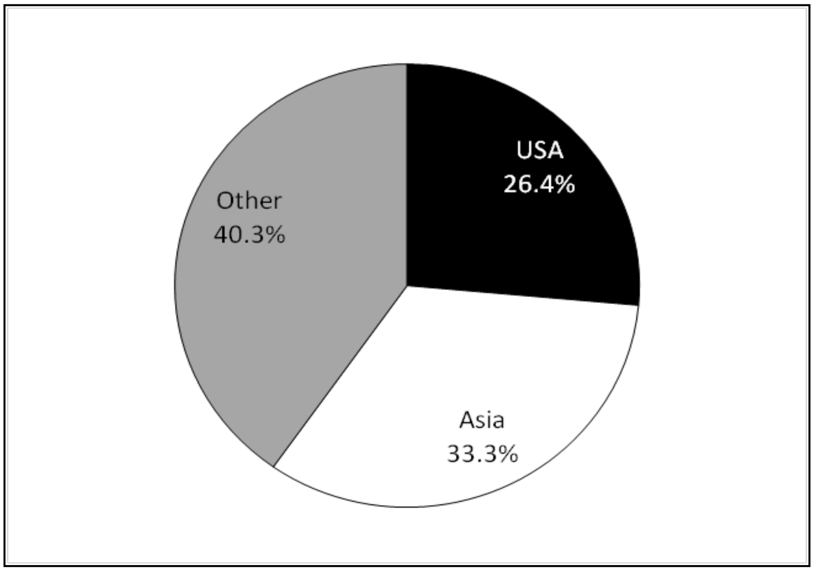

Figure VI.28. Proportion of Vessels Cleaned In-Water by Geographic Region.

Aside from physical removal of fouling organisms from vessels, vessel owners and operators also utilize preventative measures to keep levels of fouling to a minimum between required dry dockings. One of these preventative measures is the use of antifouling systems, with antifouling coatings as the most common type. Except in the rare case of dry docking for emergency repair, antifouling coatings are typically applied while in dry dock or during the shipbuilding process. Therefore, the ages of these antifouling coatings applied to the commercial fleet in California mirror the amount of time since these vessels were last out of water. Antifouling coatings generally fall into one of two categories - those containing biocides and those that are biocide-free. Biocide-based coatings usually contain toxic metals and are most frequently copper-based. Over 86% of all coatings used in California during 2009 were biocide-based. Biocide-free coatings are typically silicon or fluoropolymer-based and rely on a fouling-release mechanism. Organisms are not expected to adhere tightly to these surfaces and therefore ‘release’ or fall off as the vessel is in transit. The majority of these biocide-free fouling-release coatings are designed to be used with vessels that travel at speeds of 15 knots and above, although several recently introduced products claim to work on vessels transiting as slow as 8 knots.

The majority of the vessels operating in California utilize the biocide-based antifouling strategy, with 86.1% using strictly biocide-containing coatings (Figure VI.29), while only 3.8% are using strictly biocide-free coatings. Another 3.7% are combining strategies, with most typically covering the sides of the hull (where high flow velocities are more likely) with biocide-free treatments and using biocide-containing coatings along the bottom of the hull and other niche areas (where flow velocities are likely to be reduced).

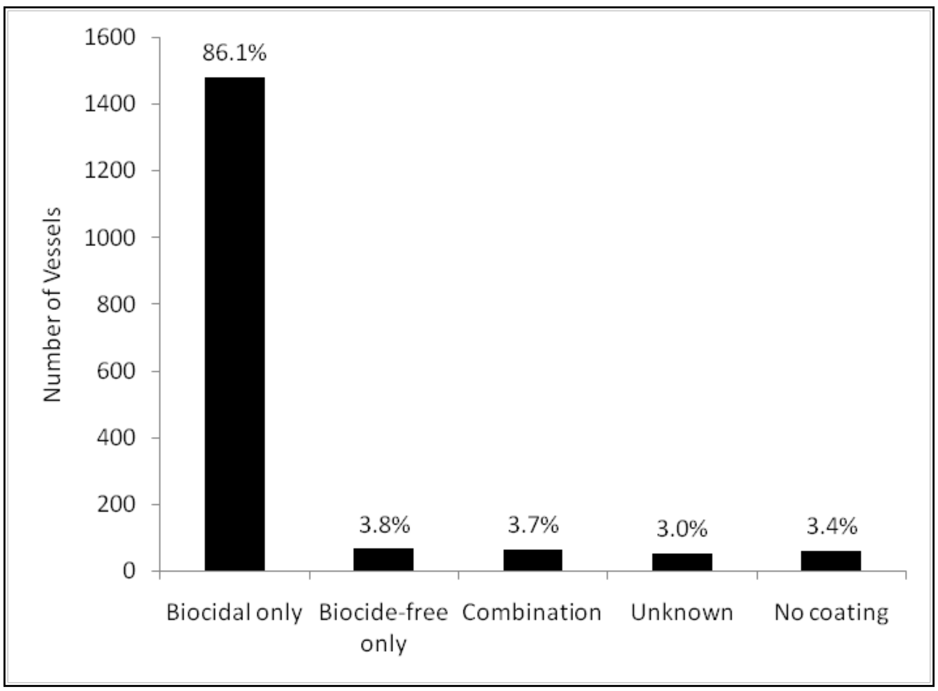

Figure VI.29. Number and Percent of Vessels Using Various Antifouling Coating Strategies. “Combination” refers to application of both biocide-based and biocide-free coatings to different areas on the same vessel.

Another type of antifouling system in use on the majority of vessels operating in California is a Marine Growth Prevention System (MGPS). This type of system is placed within a vessels’ sea chest to prevent fouling organisms from accumulating within the sea chests and internal pipe network. Marine Growth Protection Systems typically operate by dispensing small doses of copper ions or hypochlorite into the sea chest, thereby inhibiting the growth of fouling organisms. From an operational point of view, the vessel requires large volumes of water to flow through the sea chests for normal operations, thus keeping them free of fouling organisms is a priority. Sea chests have been recognized as a very important transport mechanism (Coutts and Dodgshun 2007) and potential source for new invasion, even when the exposed hull of a vessel may be relatively free of organisms. MGPSs were installed on 50.6 – 65.7% of the fleet operating in California during 2009. The lack of specificity for this figure is due to the vague answers received on HHRF for this question, which limited the ability of Commission staff to verify the use of these systems for 15.1% of the fleet (white portion of the bars in Figure VI.30). When considering only those vessels that reported verified MGPSs, only the auto carriers, container vessels, and tankers had this type of system installed in at least 50% of their fleet (Figure VI.30).

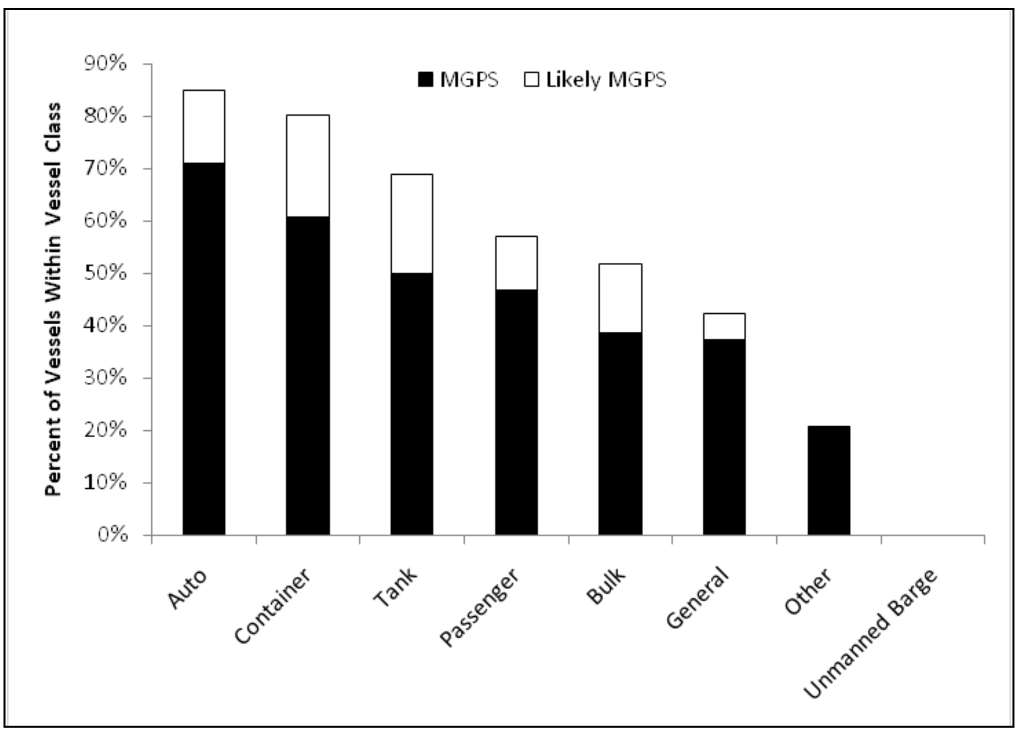

Figure VI.30. Percent of Vessels That Have a Marine Growth Prevention System (MGPS) Installed Within the Sea Chest(s). "Likely MGPS" represents vessels reporting the installation of a MGPS but did not provide enough information on the manufacturer and model for verification.

Fouling-Related Voyage Characteristics of the Commercial Fleet in California

In addition to hull-husbandry practices, certain voyage characteristics are believed to influence the extent and diversity of vessel fouling. One of these characteristics is the speed at which a vessel travels, as slower moving vessels are thought to be more susceptible to accumulating and retaining fouling organisms because the force and stress placed on these organisms is reduced in comparison to forces experienced at elevated speeds. Overall, the average (±SD) traveling speed of the commercial fleet operating in California during 2009 was 16.1 ± 3.5 knots (Figure VI.31). However, only three vessel types travel at speeds greater than 15 knots, on average: container vessels (20.2 ± 1.8 knots), auto carriers (17.2 ± 1.3 knots) and passenger vessels (16.8 ± 2.7

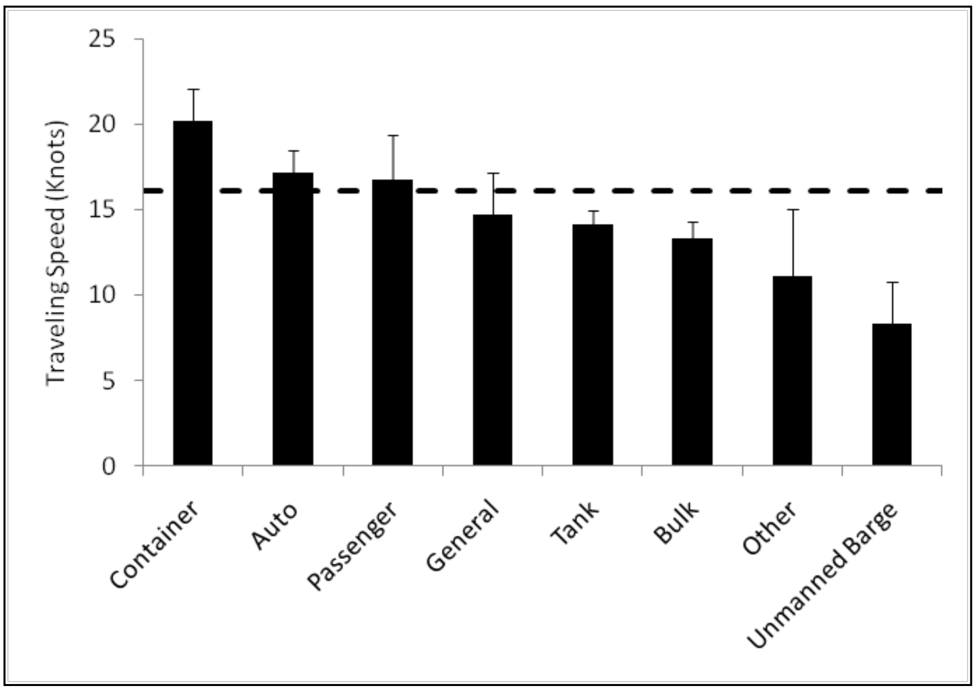

Figure VI.31. Average (± standard deviation) Traveling Speed for Each Vessel Type. Dotted line represents the average speed of the California fleet as a whole (16.1 knots).

knots). Three other vessel types travel at much slower speeds: bulk vessels (13.3 ± 1.0 knots), 'other' vessels (11.1 ± 3.9 knots), and the unmanned barges (8.4 ± 2.4 knots).

The amount of time that a vessel spends in port is also thought to influence fouling levels, as vessels that remain in port for extended periods of time may have more of an opportunity to accumulate fouling organisms. As a whole, the California fleet averaged 2.3 (± 3.0 standard deviation) days in port per vessel, within the four months prior to submission of the HHRF (Figure VI.32). However, individual vessel types exhibited widely varying average days in port. Three vessel types average about a day or less in port: auto carriers (1.06 ± 2.29 days), container vessels (0.94 ± 0.87 days), and passenger vessels (0.51 ± 0.48 days). Three vessel types averaged much longer amounts of time in port, over three days: bulk vessels (4.60 ± 4.51 days), other vessels (3.24 ± 3.70 days), and general cargo vessels (3.20 ± 3.37 days).

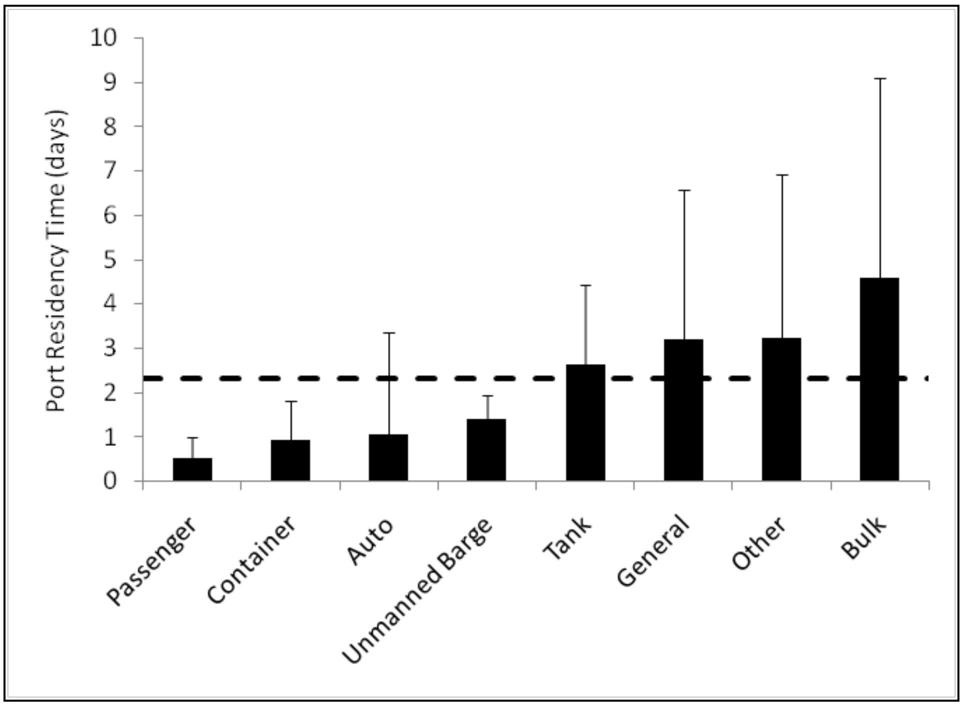

Figure VI.32. Average (± standard deviation) Port Residency Time for Each Vessel Type. Data was reported for four-month period prior to submission of the Hull Husbandry Reporting Form. Dotted line represents overall average (2.3 days).

Although average vessel port stays ranged between a day and nearly 5 days in port depending on type, there may be infrequent occurrences when vessels remain in port for more extended periods of time. This has been especially true over recent years as the worldwide economic contraction has had a significant deleterious effect on maritime trade, at one point forcing 10.6% of the worldwide containership fleet into extended layup (anchor) (Pacific Maritime Magazine 2009). Extended layups are important because longer and more frequent idle periods represent a higher potential for fouling organisms to colonize submerged vessel surfaces.

The occurrence of extended layups was dramatically different between the 2008 and 2009 HHRF datasets. During the 2008 reporting year, 34.9% of the California fleet reported experiencing at least one layup of ten or more days since their most recent dry docking or delivery (if newly built). That number jumped to 43.4% of the fleet during the 2009 reporting year. Several individual ships have also reported more than one extended layup during this time, therefore the total number of extended layups experienced by the fleet increased dramatically as well, by 21.6% on a per capita basis (i.e. number of layups normalized to number of vessels reporting). By vessel type, three vessel types were disproportionately affected by extended layups: auto carriers (359% increase in layups reported on a per capita basis), unmanned barges (150% increase), and container vessels (84% increase; Figure VI.33). The remaining five vessel types either remained neutral or had declines in the number of layups reported.

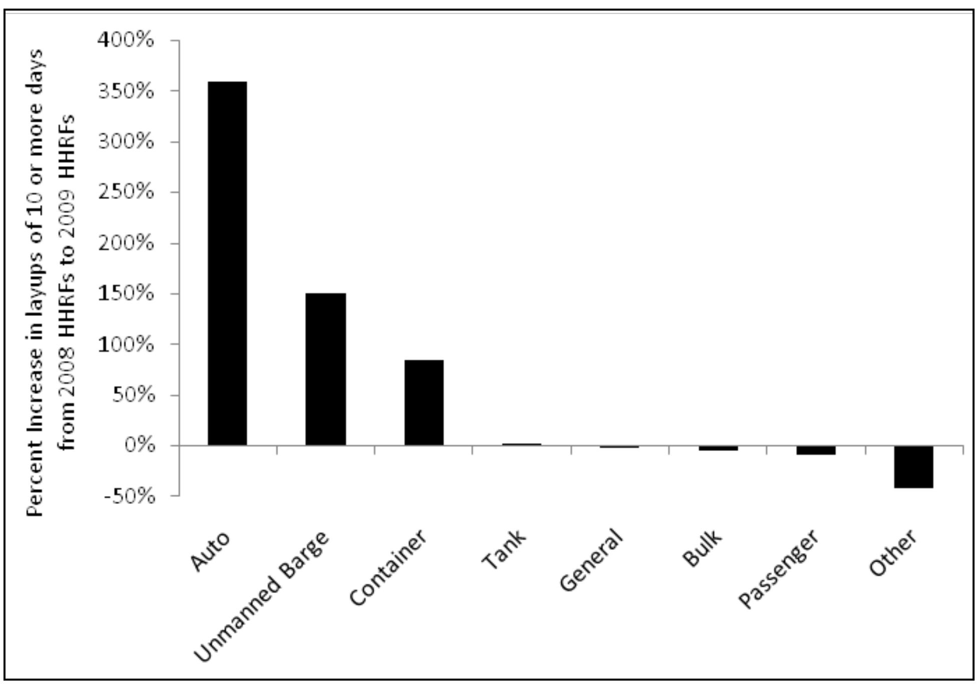

Figure VI.33. Per Capita Percent Increase from 2008-2009 in Number of Extended Layups of 10 or More Days by Vessel Type. Layups may have occurred any time since the vessels most recent dry docking or delivery if newly built.

Not only did the total number of extended layups increase during 2009 reporting, but the duration of the layups increased as well. The occurrence of layups spanning months and even over a year increased dramatically. The largest increases, on a per capita basis, were observed for layups spanning 500 days or more (216% increase), 70-99 days (200% increase), and 60-69 days (177% increase; Figure VI.34).

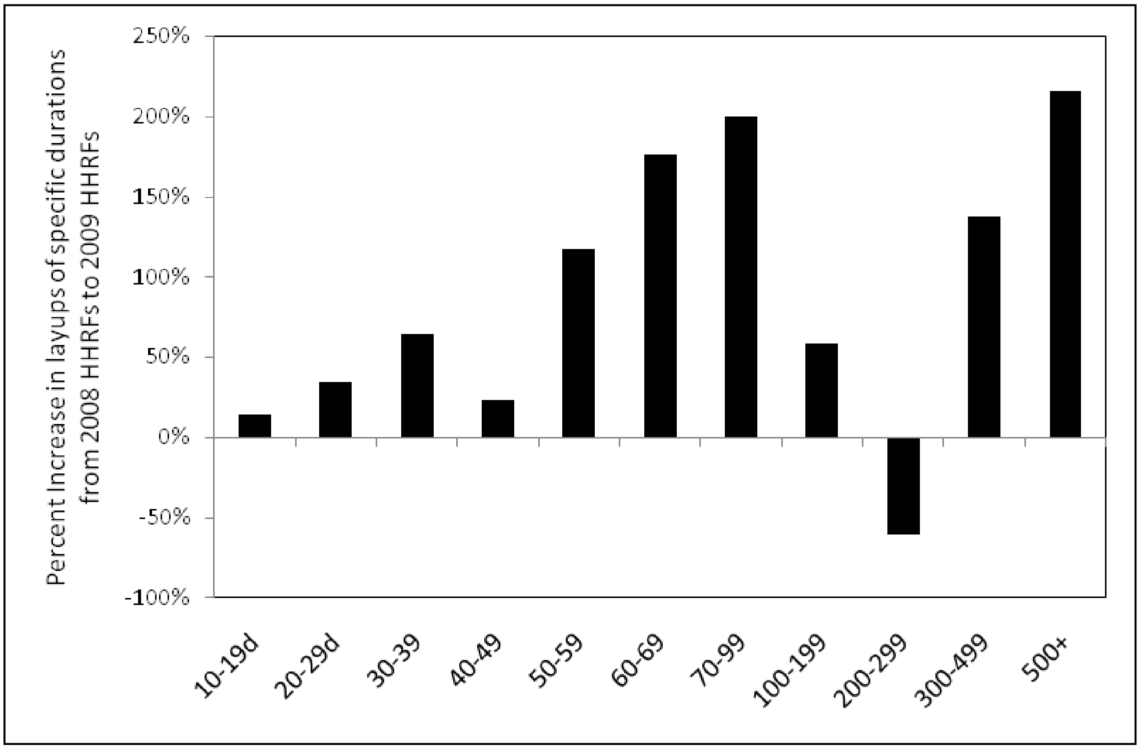

Figure VI.34. Per Capita Percent Increase in Number of Extended Layups from 2008 to 2009. Layups may have occurred any time since the vessels most recent dry docking or delivery if newly built.

The hull husbandry practices employed by the fleet of commercial vessels operating in California indicates that vessels are complying with current California law and are attempting to limit the amount of fouling organisms that can accumulate. The data presented suggest that the fleet is relatively young. One third of the California fleet in 2009 were newly built and delivered within the past five years, and over 70% of these new builds were delivered within the past three years. Therefore the majority have had comparatively less time to accumulate fouling organisms. The remainder of the vessels (66.9% of the fleet) appears to be physically removing fouling organisms regularly.

Overall, 83% of all vessels have been out of water (either newly built or dry docked) and coated with antifouling treatments within the past three years (99% within the past five years). Because of the relatively young age of these coatings and short amounts of time since dry docking or delivery, the physical removal of organisms while the vessels remain in water does not appear to be a major tool used fleet-wide, as less than 10% of all vessels conduct in-water cleaning of the hull and other submerged surfaces. The application of antifouling coatings as a preventative measure is being conducted on a regular basis, typically during either the shipbuilding process or the last out-of-water dry dock. The majority (86.1%) of the vessels operating in California are utilizing the biocide-based antifouling coating strategy, while 7.5% of the fleet are using biocide-free antifouling coatings, either by themselves or in combination with biocide-based paints. In addition to antifouling coatings, a large fraction of the fleet (50.1 – 65.7%) has installed marine growth prevention systems to prevent fouling organisms from attaching and accumulating on the surfaces of sea chests and internal piping.

Unlike the ballast water vector, all vessels pose some level of risk through the fouling vector. However, because fouling organisms are external, they are exposed to many more varying environmental conditions than sheltered ballast water organisms. These environmental conditions and voyage patterns are likely to influence the amount, complexity, and viability of fouling biota on the submerged surfaces of the commercial fleet. The normal operational voyage characteristics evaluated in this section (i.e. traveling speed and port residency time) suggest a gradient of risk associated with the different vessel types. Auto carriers, container vessels, and passenger vessels exhibited behaviors that are thought to result in lower potential for fouling accumulation, at least for the exposed hull (i.e. not necessarily for certain 'niche areas' that are protected from certain environmental variables). They all travel at elevated speeds in excess of 16 knots and they all spend an average of about a day or less in port. On the other hand, bulk vessels and the 'other' vessel type both exhibited behaviors that are thought to result in greater potential for fouling accumulation. They both travel at slower speeds, 13.3 knots and below) and they both spend an average of at least 3.2 days in port.

In addition to the characteristics associated with normal operations, the occurrence of extended layups is also thought to influence fouling levels on the commercial fleet. The fleet experienced a 21.6 % increase in the total number of layups reported on their 2009 reporting forms, on a per capita basis. The vessel types that were most affected by these layups were the auto carriers, the container vessels, and the unmanned barges. Thus, even though the auto carriers and the container vessels exhibited lower risk behaviors for the normal operational characteristics (i.e. traveling speed and port residency time), the drastic increase in the occurrence of layups of ten days or more points towards greater potential for fouling accumulation on these vessels, at least in the short term. Not only was there an increase in the total number of extended layups reported during 2009, but also large increases in the duration of these layups, with layups of 60-99 days and 500 days or greater experiencing the largest increase.

The information presented in this section along with other data that will be collected via the HHRF over the next few years will provide the Commission with valuable insight into the fouling-related practices of the fleet as a whole. These data will be used in conjunction with biological data collected through fouling-related research currently funded through the MISP (see Section VII) to get a fuller picture on how the husbandry practices and voyage characteristics described in this section affect the quantity and quality of fouling biota associating with vessels operating in California. Both sets of information will guide and inform the development of regulations to manage fouling for vessels operating in California, mandated by January 1, 2012.

Fee Submission

Under PRC Section 71215, the Board of Equalization (BOE) collects a fee from the owner or operator of each vessel that arrives at a California port or place from a port of place outside of California. The Fees collected are deposited in the Marine Invasive Species Control Fund to support the State's Marine Invasive Species Program.

BOE receives daily reports from the Los Angeles/Long Beach Marine Exchange and San Francisco Marine Exchange listing all arrivals to California ports. An electronic record of this information is maintained for reference and use by the BOE staff. The reports are reviewed to determine which arrivals are qualifying voyages and subject to the Fee. Vessel accounts are billed based on arrival information. Additional analysis is necessary to assign the correct account numbers to these arrivals.

There are currently 3,131 ballast accounts representing 8,561 vessels registered with the BOE. On average, 65 new vessel accounts are added per month. In addition, an average of 150 account maintenance items (address changes, adding vessels to existing accounts, etc.) are processed per month. Approximately six vessel accounts are closed out each month, and an average of 500 vessel billings are mailed per month. Compliance rate for fee submission exceeds 98% (Table VI.5).

Table VI.5. Summary of Marine Invasive Species Fee Program.

Year	Voyages Billed	Voyages Reported[1]	Total Voyages	Fees Billed	Fees Reported[1]	Total Fees	Payments Recd. for Period[2]
2000	5,870		5,870	2,735,134		2,735,134	2,724,072
2001	5,263	510	5,773	2,105,200	204,000	2,309,200	2,307,593
2002	4,599	921	5,520	1,376,600	277,200	1,653,800	1,645,350
2003	4,668	1,013	5,681	933,600	202,600	1,136,200	1,134,962
2004	5,858	1,123	6,981	2,788,000	535,100	3,323,100	3,296,523
2005	6,161	1,157	7,318	2,873,800	535,200	3,409,000	3,374,372
2006	6,247	1,161	7,408	2,498,800	464,400	2,963,200	2,956,348
2007	5,997	1,199	7,196	2,398,800	479,600	2,878,400	2,863,459
2008	5,578	1,133	6,711	2,753,750	557,825	3,311,575	3,273,822
2009	5,023	866	5,889	3,324,325	574,100	3,898,425	3,856,119
Through June 2010[3]	2,475	280	2,755	2,103,750	238,000	2,341,750	2,072,397
TOTAL	**57,739**	**11,558**	**64,627**	**23,790,764**	**5,933,775**	**27,856,034**	**29,774,370**

[1]Returns are due at the end of the month following the period of activity. [2]Actual cash received may exceed amount billed due to penalty and interest charges. [3]Amounts may be understated until return processing is complete.

VII. RESEARCH

Funded and Collaborative Research

PRC Section 71201 declares that the purpose of the Marine Invasive Species Program is, "to move the state expeditiously toward elimination of the discharge of nonindigenous species into the waters of the state." The MISP advances this goal through a comprehensive multi-pronged approach to vessel vector management including funding and coordination of targeted, applied research that advances the development of strategies to prevent the introduction of NIS from ballast water and vessel fouling. Specifically, PRC Section 71213 mandates the Commission to:

> *" . . .. identify and conduct any other research determined necessary to carry out the requirements of this division. The research may relate to the transport and release of nonindigenous species by vessels, the methods of sampling and monitoring of the nonindigenous species transported or released by vessels, the rate or risk of release or establishment of nonindigenous species in the waters of the state and resulting impacts, and the means by which to reduce or eliminate a release or establishment . . .."*

In an effort to advance the goals of the MISP, the Commission has funded specific research addressing many of the NIS-related issues for which information has been limited or lacking, including research related to emerging technologies which may strengthen the Commission's ability to reduce or prevent the occurrence of NIS introductions into California waters. This section summarizes the research that the Commission has funded and collaborated on during the previous two years.

Vessel Fouling Research

The Commission has been actively evaluating the risk of NIS introductions into California through both the ballast water and vessel fouling vectors over the past two years. As part of the evaluation of vessel fouling the MISP has funded research aimed at evaluating and understanding this vector more completely. This research is being conducted by the Aquatic Bioinvasions Research and Policy Institute (ABRPI), a joint collaboration between SERC and Portland State University. This research includes a variety of inter-related projects, some of which have been completed and some of which are currently being investigated. A brief discussion of each of these studies is presented below.

Recently Completed Fouling-Related Research

Ship Fouling: A Review of an Enduring Worldwide Vector of Nonindigenous Species (Davidson et al. 2009d)

The aim of this review was to provide a broad overview of the available literature on ship fouling, highlighting the diversity and numbers of organisms found on ships and identifying information gaps. The literature search revealed 36 papers and reports (grey literature) that had surveyed ships' submerged surfaces. Although there was a lot of variability in the data, the higher numbers of fouling species were found with longer durations since dry-docking. The authors also examined the relative contribution vessel fouling played in invasions at eight temperate locations where invasions have been well documented. Ship fouling was the sole or a possible vector for 73% of the 553 species across these eight locations, and was considered the most important vector at the Ports of Los Angeles and Long Beach. This review also highlighted, the fact that the condition, viability, and reproductive status of fouling organisms that arrive on ships' hulls have received little attention. Thus, future analyses of fouling communities on ships should strive to address knowledge gaps associated with organism condition as well as numbers arriving to specific locations.

An Experimental Analysis of Salinity Shock on Biofouling Communities: A Pilot Study (Davidson et al. 2009c)

The review on ship fouling conducted by Davidson et al. (2009a) highlighted the limited amount of data available on how the conditions experienced by fouling organisms during vessel movement from one place to another (i.e. salinity and temperature changes, shear forces, voyage duration, etc.) may affect them. This pilot study was designed to determine how abrupt and severe changes in salinity (salinity shock) affect marine fouling organisms, and whether immersion in freshwater for an amount of time that mimics passage through the Panama Canal might prevent or reduce invasion risk. Organisms accustomed to marine ‘salty’ waters have problems regulating water concentration in their cells with sudden freshwater exposure. This may result in organism death, and thus exposure of marine fouling organisms to freshwater (as would be experienced during a vessel passage through the Panama Canal) is considered one stressor that may affect the development of fouling organisms on vessels.

Davidson et al. (2009b) performed an experiment to determine the effects of freshwater exposure on marine fouling organisms. Researchers collected fouling communities on settling plates from two sites along the Pacific coast of Panama, and placed into aquaria with either freshwater (treatment) or marine water (control) for 12 hours. Total numbers of organisms decreased two-fold and the numbers of species (diversity) decreased eight-fold after treatment with freshwater. Although not 100% effective, freshwater immersion for 12 hours was lethal to most species groups and did disrupt fouling communities. However, there were also a few instances where certain species responded to the freshwater treatment by releasing eggs or larvae. The major conclusions from this pilot study were that salinity shock can be a potential management option for treating many marine fouling organisms on commercial vessels, and that passage through the Panama Canal may alter their abundance and diversity.

Biofouling as a Vector of Marine Organisms on the U.S. West Coast: A Preliminary Evaluation of Barges and Cruise Ships (Davidson et al. 2009a)

In an attempt to characterize vessel fouling patterns (organism abundance and species composition) on vessels travelling on short coastal voyages within the U.S. Pacific West Coast (coastwise), the ABRPI conducted a number of SCUBA and dry dock surveys of several vessel types. They sampled seven barges and three tugs involved in Pacific coastwise trade, and five cruise ships also engaged in coastwise transits but some with previous ports-of-call elsewhere (e.g. Hawaii). An additional long ranging USCG cutter was also sampled in dry dock. As with previous studies, they found that fouling was unevenly distributed across vessel submerged surfaces, with areas sheltered from strong shear forces and areas lacking antifouling paint (‘niche’ areas), acting as hotspots for organism accumulation.

Barges, had hotspots of fouling in ladder holes and on dock block areas. Dock blocks are supports on which a vessel sits during dry docking. Fresh coats of antifouling paint cannot be applied to these areas, and fouling tends to accumulate more rapidly in these locations. Cruise ships had considerable accumulations at thruster and stabilizer areas as well as in recesses behind specialized propellers called ‘azipods’. There were also almost three times as many species in the sea chests of two vessels compared to the outer submerged surfaces of the same vessels. In contrast, exposed hull surfaces were generally free of fouling and cover was generally low (<10% of the surface area covered). This was not the case, however, for the USCG Cutter which had extensive fouling across all hull surfaces (80% cover). This was probably related to extended lay-up periods the vessel spent in the warm waters of Hawaii, where fouling is thought to accumulate more quickly.

The main findings from this report pointed towards two problematic areas: the heavily-fouled vessels encountered in many studies, but composing a small minority of all vessels sampled in the literature, and fouling accumulation within certain protected ‘niche’ areas. In some cases, fouling in niche areas results in tens of thousands of organisms being transferred on a regular basis. The authors noted that policies which promote additional or more frequent maintenance attention to niche areas are likely to be effective in reducing organism delivery via vessel fouling.

<u>Ongoing Fouling-Related Research</u>

Published, peer reviewed journal articles on the vessel fouling vector is dominated by studies measuring the identity and quantity of organisms. However, studies on the condition, and reproductive status of organisms has been largely absent even though it is an important indicator for the chances of a successful invasion. Many fouling species are attached physically to vessel surfaces, and are generally unable to detach at will.

The ability of fouling organisms to release eggs or young in a recipient port is therefore an important way that fouling organisms may be introduced in new locations.

This study will evaluate organism condition (viability) more closely while also providing measures of organism diversity and abundance on commercial vessels arriving to the U.S. West Coast. Specifically, the ABRPI will be conducting ship sampling with an added focus on the condition of organisms, their reproductive status, and their parasite/pathogen loads.

Ballast Water Exchange Verification Research (Recently Completed)
Verifying Ballast Water Exchange at Sea: A Full-Scale Demonstration of its Application by Regulatory Agencies
Currently the only practical method for determining if a vessel has conducted ballast water exchange is to examine the salinity of the water to be discharged. High salinities (over 30 par parts per thousand (PPT)) are indicative of oceanic waters, and lower salinities are sometimes indicative of estuarine port waters. However many ports of the world are in waters where the salinity is above 30 PPT, and thus this approach to determining vessel compliance is problematic.

This study was aimed at evaluating a technique to verify that ballast water exchange has been conducted by vessels. Four aquatic chemical tracers that are expected to decline in concentration with increasing distance from land were examined in ballast water: chromophoric dissolved organic matter (CDOM), barium (Ba), phosphorous (P), and manganese (Mn). Additionally, a commercially-available handheld instrument (ballast exchange assurance meter; BEAM) developed by Dakota Technologies was tested by Commission staff onboard operating vessels during ballast water inspections. This device was designed to conduct rapid, on-site measurements of CDOM concentrations to provide real-time determinations of ballast water exchange.

Inspectors from California (Commission Marine Safety Inspectors), Oregon, and Washington collected CDOM, Ba, P and Mn data from 73 vessels. In addition, Commission staff conducted field trials with the BEAM on 47 vessels in LA/Long Beach and San Francisco. Generally, the Ba, P, and Mn tests performed poorly, either being unable to discriminate between exchanged and unexchanged tanks or prone to contamination. Laboratory-determined CDOM measurements generally agreed with BEAM measurements conducted onboard, indicating the potential for this device to be used as a quick verification tool during ballast water inspections.

Alternative Treatment Technology Pilot Projects

In addition to the mandate in PRC Section 71213 to conduct research necessary to carry out the requirements of the division, PRC Section 71210 specifically addresses the management of ballast water using alternative treatment technologies and requires the Commission to:

> *"…sponsor pilot programs for the purpose of evaluating alternatives for treating and otherwise managing ballast water. The goal of this effort shall be the reduction or elimination of the discharge of nonindigenous species into the coastal waters of the state…Priority shall be given to projects to test and evaluate treatment technologies that can be used to prevent the introduction and spread of nonindigenous aquatic species into coastal waters of the state by ship-mediated vectors."*

To fulfill this mandate, Commission staff has worked with the maritime industry and ballast water treatment technology vendors over the last several years to help identify vessels and test platforms for the purpose of treatment system development and evaluation. It is a challenge to find companies willing to commit to costly vessel retrofits in support of shipboard experimental testing of ballast water treatment systems. Identifying appropriate shipboard platforms for treatment system evaluations requires a unique combination of owner willingness, available funding, and engineering compatibilities.

The Commission has funded the following projects in recent years in order to gather much needed information about the design, development, installation and evaluation of ballast water treatment technologies.

Matson - Ecochlor

In 2005, a portion of MISP funds was allocated to support the shipboard installation and biological evaluation of an experimental ballast water treatment technology onboard the Integrated Tug/Barge *Moku Pahu,* operated by Matson Navigation Inc. The funds were provided to assist in the installation and evaluation of a chlorine dioxide treatment system designed by Ecochlor Inc. Initial studies have shown this technology to effectively treat zooplankton, phytoplankton, and some microorganisms (Oviatt et al. 2002). The Commission finalized a funding contract and project timeline with Matson Navigation Inc. which required system evaluation according to the USCG's Shipboard Technology Evaluation Program (STEP). The Ecochlor system was installed on the *Moku Pahu* in 2005, and during the summer of 2006, Matson Navigation Inc. submitted an application to the STEP for the *Moku Pahu*. Following a very lengthy USCG review of the STEP application the USCG released the draft Environmental Assessment (EA) necessary to evaluate the *Moku Pahu* for enrollment into STEP in 2008. Matson and Ecochlor worked with USCG to address the comments received in response to the draft EA, and the vessel was accepted into STEP in November, 2008 – over two years after the application was submitted.

After being accepted into STEP, biological performance (efficacy) testing of the Ecochlor system on the *Moku Pahu* was delayed by the USCG as the STEP application procedures and protocols for conducting vessel performance verification testing were revised. While the biological testing was delayed, the vessel and system manufacturer continued to treat ballast and conduct modifications of the system to optimize performance. Ecochlor added a filtration unit to the system in 2009 based on the results of land-based system testing conducted at the Royal Netherland Institute for Sea Research. As of November 2010, USCG has still not approved plans for shipboard testing according to STEP. Ecochlor initiated shipboard biological efficacy testing for

IMO Type Approval purposes in the summer of 2010, but it is not known if these tests will be acceptable for STEP purposes. Early results from the shipboard testing have been promising.

<u>American President Lines (APL)</u>

The Commission has also allocated funds for a ballast water treatment technology installation and evaluation onboard the American Presidential Lines (APL) *England*. This technology, developed by NEI Treatment Systems, treats ballast water through de-oxygenation using a low-sulfur inert gas to displace the oxygen, thereby creating a hypoxic (low oxygen concentration) environment that significantly decreases the survival of NIS. This system also claims an added benefit of reducing corrosion within ballast water tanks under certain operating conditions (Tamburri et al. 2005). The project was initially approved for funding from the Commission in 2006, however, the project was delayed while additional funds and agreements were obtained from the Ports of Los Angeles and Long Beach. All funding was in place by 2008, and Commission staff and APL finalized the contract in October of that year. Work on the installation of the system began in the fall of 2008, and the vessel was accepted into the USCG STEP in May of 2010. Installation was nearly complete at the end of June 2010, and biological testing is expected to begin in early-mid 2011.

<u>Glosten – T/S *Golden Bear*</u>

In 2008, the Commission approved funding to support the development of a ballast water treatment technology testing and evaluation facility onboard the California Maritime Academy's Training Ship *Golden Bear.* The Commission funding augments federal funds from the National Oceanic and Atmospheric Administration (NOAA) Sea Grant Ballast Water Management Demonstration Program and the Maritime Administration (MARAD). The project establishes the first ballast water treatment technology testing and evaluation facility on the West Coast, and the only facility in the world capable of conducting both dock-side (land-based) and shipboard testing. The Commission-funded modifications to the vessel were completed in May 2010.

The Golden Bear Facility was used for shipboard testing of the Alfa Laval Ballast Water Treatment System during the summer of 2010, and dockside testing of the Alfa Laval system will continue through the fall of 2010. The Golden Bear Facility has recently entered into a contract with the U.S. Environmental Protection Agency's Environmental Technology Verification program to field test protocols for the verification of ballast water treatment technologies. This work will take place between late-2010 and mid-2011.

Commission staff continues to collaborate with the staff from the Golden Bear Facility. The close proximity between Commission offices and the facility, located in the San Francisco Bay Area, will provide Commission staff with important vessel access necessary to beta test methods of verifying vessel compliance with California's performance standards for the discharge of ballast water. This facility provides valuable real-time information about shipboard operation of ballast water treatment systems, critical for the continued development of effective technologies to reduce NIS introductions through ballast water discharge.

<u>Moss Landing Marine Laboratories - Bulk Plankton Viability Assay</u>

In 2010, the Commission approved funding to support research by Dr. Nicholas Welschmeyer, from the Moss Landing Marine Laboratories (MLML), for the development of a rapid, bulk assay for plankton viability. Ballast water treatment technologies are developing rapidly, but methods of verifying treatment performance have not kept pace. The goal of Dr. Welschmeyer's research is to develop a simple, rapid and reliable method to assess ballast water treatment performance on board a ship. Dr. Welschmeyer intends to optimize a fluorescence-based test for evaluating organism viability. He will then package the test into kits and distribute for peer-review, with the ultimate goal of making the technique/test kit available for use by the Commission's Marine Safety personnel to verify vessel compliance with California's performance standards for the discharge of ballast water. Dr. Welschmeyer initiated the research in the summer of 2010, and intends to have a final report available to the Commission by late-2012.

California Department of Fish and Game MISP Biological Monitoring

Pursuant to the Marine Invasive Species Act of 2003, the California Department of Fish and Game (CDFG) monitors the location and geographic ranges of introduced species populations in the State's coastal and estuarine waters. A baseline inventory development began under mandate by the Ballast Water Management for Control of Nonindigenous Species Act of 1999. The subsequent ongoing monitoring is intended as a means of detecting new introductions. The 2003 Marine Invasive Species Act expanded the ongoing monitoring program to include intertidal and nearshore subtidal habitats along the open coast.

The CDFG's Marine Invasive Species Program (MISP) submitted the report, "Introduced Aquatic Species in the Marine and Estuarine Waters of California," to the Legislature in December 2008, detailing the results of five years of coastal non-native species monitoring and assessing the effectiveness of the MISP in controlling introductions from vessel vectors. The next report will be submitted in December 2011. The overall program is intended to assess the effectiveness of ballast water controls implemented under current laws and regulations.

Beginning in 2009, the CDFG-MISP, in partnership with the Smithsonian Environmental Research Center (SERC) and the Genomics Lab at Moss Landing Marine Laboratories (MLML), initiated a pilot non-native species detection program in San Francisco Bay. The two-year program uses a "next-generation" DNA sequencing process, known as massively parallel pyrosequencing (MPPS), to analyze the DNA extracted *en masse* from unsorted samples, containing many different organisms and species, collected from settling plates, field surveys of hard substrate, and plankton tows. Moss Landing Marine Laboratories will conduct molecular "probing," whereby the identities of the organisms present in samples are determined by comparing the DNA found from MPPS against a voucher-based reference set. If effective, this approach would be a rapid and cost-effective approach for widespread and frequent monitoring. Thus far, SERC has completed a full year of sampling and taxonomic identifications and MLML has extracted and sequenced the DNA from voucher specimens received. Whole-community samples collected to date are being readied for the first of two MPPS analyses scheduled for the fall of 2010 and 2011.

In 2010, the CDFG-MISP resumed a four-year cycle of large-scale field surveys of NIS in California bays and harbors (including San Francisco Bay) and the open coast. Multiple habitats will be sampled in 9 major ports; 21 harbors, marinas, and bays; and 22 sites along the open coast from Oregon to the Mexican border. San Francisco Bay sampling was completed in the summer of 2010 and is currently undergoing taxonomic analysis.

The CDFG-MISP staff collaborated with Smithsonian Environmental Research Center (SERC) staff on a journal article entitled “Marine invasion history and vector analysis of California: a hotspot for western North America.” Results indicate that California, especially San Francisco Bay, plays a pivotal role in marine invasions for western North America, providing an entry point from which many NIS spread. Of the 290 nonindigenous marine species (excluding fish and vascular plants) with established populations in western North America, 81% were first recorded in California. Many (31-70%) nonindigenous species in adjacent states and provinces were first reported in California, suggesting northward spread. Of 257 nonindigenous species established in California, 61% were first recorded in San Francisco Bay and 57% are known from multiple estuaries, also suggesting secondary spread. The manuscript has been submitted to the journal *Diversity and Distributions* and is currently in review. Future analysis will examine the issue of secondary spread on a finer scale.

CDFG is also involved with research projects aimed towards supplementing survey work with improved identification protocols for some species that are very difficult to identify. An MISP-funded genetic study of “Breadcrumb” sponges (genus Halichondria) was completed by Dr. Jon Geller at Moss Landing Marine Laboratories. This group of sponges is among the most difficult to recognize, even by leading taxonomic experts, but was suspected to be composed of at least two invasive species in California.

Results revealed a new undescribed native species and two introduced species of Atlantic origin. The analysis found that none of the genetically identified species correspond to the names previously used to describe these species and that species identification can be made only by genetic analysis.

Review of Current Vessel Vector Research

PRC Section 71212(e) directs that the MISP biennial report include a summary of ongoing research on the release of nonindigenous species by vessels. This section summarizes peer reviewed journal articles published between July 2008 and June 2010 that examine the release of NIS via vessel fouling and ballast water.

Organism Transfer in Ballast Water and the Efficacy of Ballast Water Exchange

A fundamental understanding of how organisms are transported via ballast water is critical for evaluating the effectiveness of ballast water management through exchange, and for developing improved management tools. Several studies examined sub-components to this topic, including the quantity, condition, and community composition of organisms transported in ballast water.

Cordell et al. (2009) sampled 380 ballast tanks on ships arriving to the Puget Sound area of Washington to examine the quantity and composition of zooplankton (tiny free floating/swimming animals including crustaceans and fish larvae). The empty-refill technique of ballast water exchange was more effective than the flow-through method for reducing the number of higher-risk zooplankton originating from nearshore (coastal) areas. However, large quantities of coastal zooplankton remained in tanks, whether or not the vessel reported conducting exchange at legally required distances. Higher densities were found on shorter voyages that originated from nearby Canadian, Alaskan or U.S. West Coast ports. Similarly, McCollin et al. (2008) found that while zooplankton decreased with ballast water exchange on short voyages between the United Kingdom, Germany, Spain, France and the Netherlands, many zooplankton from source areas remained. Authors of both papers suggest that the efficacy ballast water exchange may be inadequate for reducing NIS risk particularly on short, regional voyages, and Cordell et al. suggest that this may necessitate the implementation of ballast water treatment technologies to reduce the discharge of risky organisms.

As aquatic organisms grow and mature, many enter protective stages of development that increase survival during unfavorable environmental conditions. Diapausing (dormant) zooplankton eggs and the statoblasts (spores) of bryozoans (a type of aquatic/marine invertebrate) are two of these types of protective stages. Laboratory studies suggest that diapausing zooplankton eggs often found in the sediments of ballast tanks, can be resistant to saltwater exposure. Gray and MacIsaac (2009) placed containers with diapausing freshwater zooplankton eggs in ballast tanks transiting from the Great Lakes to Europe, and found that there was no difference in viability between eggs exposed to mid-ocean exchange and those that were not. Kipp et al. (2010) found the statoblasts of 11 species of freshwater bryozoans in the sediments of ballast tanks arriving to the Great Lakes from overseas, including 2 species not yet established in the region. Both authors indicate that the requirement for vessels that declare no ballast on board to flush tanks in open-ocean before entry to the St. Lawrence Seaway may reduce introductions of such organisms by purging sediments and organisms at sea and/or by exposing them to the shock of high salinity water.

Several papers examined the transport of bacteria and viruses in ballast tanks, including those that cause disease. Sun et al. (2010) examined bacterial quantities on ships arriving to Vancouver, Canada. Bacterial abundances were lower on ships that exchanged greater than 200 nm from shore in comparison to those that did not exchange. There were also fewer bacteria per liter in ballast tanks in comparison to quantities found in recipient port waters. Seiden et al. (2010) examined bacterial population trends throughout a voyage from Japan to the west coast of Canada. Initially, bacterial abundance increased and then began to decrease after 10 days. In contrast to findings of Sun et al. (2010), Seiden et al. (2010) found that bacterial abundance was not significantly reduced in exchanged tanks. Authors from both papers acknowledge that changes in bacterial community structure should be examined to determine if exchange is effective for reducing the movement of bacteria from one coastal environment to another. Tomaru et al. (2009) evaluated changes in abundance as well as bacterial community structure on a coal carrier in transit from Japan to Austraila. Genetic analyses indicated that coastal bacterial communities in-tank did indeed change with mid-ocean exchange. Bacterial communities from exchanged ballast tanks exhibited a genetic signature similar to the open sea where exchange was conducted, and less similar to the genetic signature of the Japanese source water. Findings indicate that coastal bacteria were replaced with an open ocean community, reducing the risk for port-to-port transfer of microbes that can survive in coastal habitats.

Disease-causing microbes are also known to be transported via ballast water. Aguirrer-Macedo et al. (2008) found high concentrations of bacteria pathogenic to both humans and corals in tanker vessels discharging at a terminal near Cayo Arcas coral reef (Gulf of Mexico). Bacteria included fecal coliform, *Enterococcus* spp., *Vibrio cholerae 01*, *Serratia marcescense* and *Sphingomoma spp.*

Diatoms are algae with cell walls composed of silica, ranging in size from microscopic (2 µm) to 200 µm, and include some species toxic to humans. Klein et al (2009) found 64 species of diatoms in ballast tanks on ships arriving to Vancouver, Canada, eleven of which had not yet been recorded in Canadian waters. As with other organism types, ballast water exchange appeared to decrease diatom densities, however, high numbers of live cells were still present upon arrival in Vancouver. Some of the species found are known to be toxigenic to humans (*Pseudo-nitzchia, Skeletonema)*.

Importance of Intra-Coastal Voyages: Evaluation of Potential Risk of NIS Introduction Via Ballast Water Using Ship Movement and Ballast Water Discharge Data

Several analyses of regional shipping traffic patterns and ballast water discharge highlight the potential importance of intra-coastal or local vessel traffic for the regional spread of introduced species. Simkanin et al. (2009) utilized such data for the U.S. West Coast port systems of San Francisco Bay, LA-Long Beach (LA-LB), Lower Columbia River (OR) and Puget Sound (WA) to evaluate the potential for future invasion. Findings indicate that approximately 33.3% of vessel traffic is intra-coastal (from one of the 4 port systems examined), discharging 27% of all ballast water discharged during the study period. LA-LB may be an important “stepping-stone” for invasion due to its connectedness to Asian ports, large number of arrivals, and due to the large volume of ballast water that is moved from LA-LB to the other West Coast port systems. In the Great Lakes, approximately 68 million MT of ballast water is moved by “Laker” vessels, operating wholly within the Great Lakes system. Fifty eight ports showed overlap of discharge from overseas vessels and uptake by Lakers. Lakers moved 20 times more ballast water than other vessels, highlighting the potential for secondary spread of NIS throughout the system (Rup et al. 2010). Lawrence and Cordell (2010) extrapolated composition and abundance data for zooplankton found in ballast tank samples to all arrivals to Puget Sound, WA to determine the relative NIS risk. Vessels arriving from the eastern Pacific that conducted ballast water exchange contained fewer coastal organisms than vessels arriving from other U.S. West Coast areas, regardless if exchange was conducted. In this estimate, domestically travelling articulated tug-barges/integrated tug-barges and tankers carrying unexchanged ballast delivered the vast majority of higher-risk coastal organisms (70%), though they discharged only 18% of ballast water by volume.

Dose-Response: Inoculation Pressure and its Relationship to the Chances for a Successful Invasion

A central information gap for the selection of numeric performance standards that minimize the risk for NIS establishment is the lack of understanding for the chances of a successful invasion given specific numbers of organisms introduced or “inoculated” into a new location via ballast water or vessel fouling (the “dose-response” relationship). Bailey et al. (2009) developed a conservative (risk minimizing) model for six Cladocera (water flea) species to evaluate the efficacy of proposed IMO BWM Convention performance standards (10 per m^3) for ballast water discharge. Their results indicate that implementation of the proposed standards could reduce invasion probabilities for some of the examined species threefold, however, for some species ballast water exchange is estimated to be equally as effective. To explore the dose-response relationship for fouling communities, Clark and Johnston (2009) investigated applied varying “doses” of larvae (the young, free-swimming stage of some marine organisms) of a successful marine fouling invader to existing fouling communities that had had various amounts of organisms removed. This experiment was conducted to investigate how various concentrations of larvae (doses) and how various levels of disturbance (organism removal) affected the successful establishment and persistence of a fouling NIS. For successful establishment, fouling communities had to experience some disturbance as well as high dosages (45 larvae per liter; L) for the establishment and persistence of the invader for 3 months or more. Though some settlement of larvae was observed at low (15 per L) and moderate (30 per L) doses initially, longer term survival did not occur.

Vessel Fouling: Vessel Behavior and the Potential for NIS Transfer

Certain vessel behaviors and maintenance practices are known to influence the quantity and condition of fouling organisms that accumulate on submerged wetted surfaces. Coutts et al. (2010) experimentally tested how various vessel speeds affect the survival of fouling organisms common to Northern Tasmania. Lower speeds (5 and 10 knots) had little impact on the number of species present, but high speeds of 18 knots reduced the number of species by 50%. Percent cover decreased with increasing speeds, but was most pronounced at the highest tested speeds of 10 and 18 knots, resulting in a 24-85% reduction in cover. Organisms with low-profile encrusting, hard, or flexible characteristics tended to survive better than soft bodied and protruding species. Such information can be used to help evaluate the risk of moving organisms from place to place in the fouling community of ships.

Vessel layup duration is also known to influence fouling accumulation, with longer layups resulting in more extensive fouling communities. Floerl and Coutts (2009) note that the recent contraction of the global economy that began in 2008 has led to the inactivity of a large portion of the merchant fleet. For example, statistics indicate that 10-35% of container ships have been laying at anchor in South East Asia, some for more than 3 months. When the economy recovers and such vessels are placed back in operation, the authors warn they will have the potential to move extensive fouling communities if preventative maintenance is not conducted first.

Efficacy of In-Water Cleaning to Control Fouling on Obsolete Vessels

Vessels in the Maritime Administration's (MARAD) three reserve fleets exhibit extreme characteristics conducive for heavy fouling accumulation. They have been stationary for extremely long periods (years to decades), have had little or no hull cleaning or hull maintenance, had have not had antifouling paints refreshed or reapplied in years. Movement of these ships for congressionally mandated decommissioning and deconstruction represents a high risk for NIS transfer and release. Davidson et al. (2008) examined the utility of in-water scrubbing to reduce the fouling load on a MARAD vessel that had been stationary for 13 years in the James River (Virginia) fleet. Scrubbing significantly reduced overall organism extent and abundance, but only reduced organism diversity from 37 species to 30 species. It may be possible that scrubbing along with additional measures may improve invasion prevention, but further assessments are needed to determine which additional measures might be effective.

Quantity and Diversity of Fouling Organisms on Vessels

Several studies surveyed the extent and composition of fouling communities on various types of vessels, operating in various geographic locations to characterize the risk that may be present under differing circumstances. With short port durations and swift travelling speeds, 22 container vessels visiting the Port of Oakland generally had little fouling across the extent of submerged surfaces (<1%). However, niche areas sheltered from strong shear water forces (e.g. inake pipes, behind bow thrusters, etc.) harbored a high diversity of species types, with one vessel having over 20 species (Davidson et al. 2009b). At the opposite end of the spectrum, a slow-moving semisubmersible oil platform that had layup periods ranging from 2 months to 9 years in locations including the South China Sea and California, was surveyed in drydock for decapods (e.g. prawns, crabs, lobsters) after 12 years in service. One-hundred percent of the submerged surface area was covered with fouling, including 25 species of decapods some of which bore eggs. Thirteen species were NIS to Singapore where the platform was transported for drydocking, and 2 were known to be invasive in other parts of the world (Yeo 2010). The authors warn that other slow-moving or frequently stationary vessels such as barges or drydocks, are potential sources for similarly large assemblages of NIS.

Though introductions via ballast water have been the center of concern for the Great Lakes, the risk of fouling introductions to the region has received little study. Sylvester and MacIssac (2010) characterized the NIS on 20 vessels arriving to the Great Lakes during 2007 and 2008. Though 109 taxa were observed, 72% were already present in the Great Lakes, and 31% were not expected to be able to establish or survive in freshwater. Only one individual of a freshwater NIS not yet reported in the Great Lakes was found, but its very poor condition indicated it would not persist. Authors conclude that vessel fouling poses a low risk for invasion to the region.

VIII. CONCLUSIONS AND LOOKING FORWARD

Through a variety of forward-looking and innovative strategies, the Commission has continued to improve California's Marine Invasive Species Program over the past two years. Commission legislative reports and activities completed since 2008 (Dobroski et al. 2009, Falkner et al. 2009, California State Lands Commission 2010) have been instrumental in the development of regulations to stem the transport of NIS in California. During the last two years, activities have lead to the development of regulations that: 1) implement California's performance standards for ballast water discharges; 2) reset the Fee amount that supports various MISP components, in light of the recent economic downturn; and 3) adopt forms to collect information on the use of ballast water treatment technologies onboard vessels. Furthermore, MISP continues to play a role in collaboration with other agencies and organizations to better address ship-born NIS issues.

MISP reports and collaborations with state, national and international agencies involved with the prevention of NIS release via vessels also highlighted challenges that the program will need to address over the next two years in order to fulfill legislative directives and to continue to "move the state expeditiously toward the elimination of the discharge of nonindigenous species into the waters of the State". To address these challenges, Commission staff is currently engaged in the following activities.

Improving compliance with ballast water management regulations

Even though the total volume of ballast water discharged into California has been increasing over the past several years, the volume of noncompliant ballast water has decreased. Over 98% of vessel-reported ballast water carried into the state was managed in compliance with California law. The majority of these vessels achieve compliance with California's requirements by retaining their ballast water onboard, representing zero risk for NIS introduction from this sub-vector. Furthermore, noncompliant ballast water has accounted for a smaller and smaller proportion of all ballast water discharges through the years, from 31.7% of all noncompliant ballast water discharges in 2004a (Falkner et al. 2007), to 9.8% in the second half of 2010. Importantly, the vast majority of these noncompliant ballast water discharges underwent some type of exchange, reducing the risk of NIS introductions.

Though unexchanged ballast water represents only 2.7% of all discharges by volume, this ballast water may represent a potentially higher risk for introduction to the State because there has be no attempt at ballast water management. Because such a large proportion of this ballast water originates from other U.S West Coast areas, there may be notable potential for NIS spread to California from other ports in other West Coast states. In addition, several recent research papers have indicated that ballast water discharges from vessels engaged on short, intra-coastal voyages may pose an elevated risk for transferring more coastal organisms than other voyage types (Section VII). Commission staff plan on expanding and refocusing education, outreach, and inspection efforts to better target vessels in violation of ballast water management. This may involve developing specific outreach materials for problematic vessel types (e.g. tank vessels and bulk carriers) and distributing them to appropriate agents and owners and increasing inspections on vessel with problematic or higher-risk profiles (e.g. tankers and bulkers transiting from other West Coast ports).

The noteworthy amount of noncompliant ballast water that was not exchanged attests to the pressing need for moving forward with the implementation of performance standards, where ballast water would undergo treatment before discharge. Because many ballast water treatment systems treat on uptake and/or discharge when a vessel is likely to be in the sheltered waters of a port, the use of technologies should allow vessels to reduce the risk of NIS introduction with significantly less concern for vessel and/or crew safety. Treatment technologies will be particularly effective for reducing invasion risk on vessels types for which exchange poses an elevated safety risk, such as on unmanned barges.

Ballast Water Treatment and Performance Standards

As discussed in Section V (California's Marine Invasive Species Program), Commission staff is actively involved in assessing ballast water treatment technologies to determine if systems will be available to meet California's performance standards for the discharge of ballast water. Commission staff work collaboratively with representatives from international, federal, regional and state governments and organizations as well as with the shipping industry and ballast water treatment sector to gather all available information about treatment system performance and to advise and guide the development of performance standards around the country. Thus far, based on the Commission's reports and reviews of available treatment technologies, staff has moved forward with the implementation of California's standards. However, very recent internal and external discussions (see Section V) have made it clear that the path forward may not be as clear as once thought. While several treatment systems have demonstrated the potential to comply with California's performance standards (see California State Lands Commission 2010), at this time no system meets California's standards 100% of the time. It will be necessary to balance the management and protection of California's resources from the introduction of nonindigenous species with the reality that systems do not yet clearly demonstrate the ability to meet California standards, particularly in time for the next implementation date on January 1, 2012. Therefore, Commission staff believes that the effective implementation of California's performance standards will require a change from the current course of action, which may include legislative or regulatory amendments.

Commission staff intends to convene a group of scientific experts, including scientists involved with the original development of California's performance standards (see Falkner et al. 2006) to discuss the recent Great Lakes Collaborative and EPA meetings and to determine if changes are necessary to existing legislation or regulations so that the standards may be implemented both fairly and effectively. Possible avenues of discussion may include revisiting the standards themselves, the use of a best available technologies strategy until the existing standards may be met, or a novel approach to compliance assessment that could take into the account the fact that the precision of current evaluation methods is not sufficient to verify compliance with California's standards. Any of these changes would require action either by the Legislature or through regulatory adoption or amendment.

In addition, based on the aforementioned EPA discussions, Commission staff wishes to revisit California's final discharge standard of no detectable living organisms in any organism size classes by 2020. Scientific experts believe this standard will remain impossible to achieve, even though 10 years remain before the date of implementation. Commission staff will discuss possible options for the final discharge standard with a scientific advisory panel, and will make recommendations to the Legislature based on the outcome of these meetings.

Finally, Commission staff continues to recognize that the assessment of available treatment technologies requires involvement and investment by the shipping industry to install and test experimental treatment systems. Experimental installation of systems are essential to gather new data about system performance and to identify real-time, real-world challenges associated with using these systems on working vessels. In addition, given the current recognition that treatment systems still do not clearly demonstrate the ability to meet California's performance standards consistently, continued investment in experimental systems is critical to foster the development of improved technologies, and to facilitate system evaluation. As mentioned in Section VII (Research), the USCG uses the Shipboard Technology Evaluation Program (STEP) to advance the development of treatment systems in the U.S. The Commission is currently providing partial funding for the installation of treatment systems on two STEP vessels. These vessels receive benefits for engaging in experimental work by receiving an equivalency to future USCG performance standards. In California, installations of experimental treatment technologies, approved by the Commission prior to January 1, 2008, are deemed to be compliant with California's performance standards for a period not to exceed five years from the date of implementation of the standards. The restrictive nature of the January 1, 2008 approval deadline has hampered the ability of staff to allow vessels enrolled in STEP to continue to operate in California waters.

Currently only 5 vessels operate in California under STEP. Staff believes that allowing additional STEP vessels, enrolled after January 1, 2008, to operate under the "grandfathering" clause will enhance the ability of both California and the federal government to better evaluate the performance of treatment technologies and closely monitor the installation, maintenance and use of these systems on operational vessels. Staff recommends that the PRC Section 71204.7 be amended to permit future STEP vessels to operate in California even if California's performance standards are not met. The knowledge gained from permitting the grandfathering of a small number of additional vessels under this important federal program greatly outweighs any risks involved with allowing them to discharge ballast potentially noncompliant with the standards.

Compile and analyze data related to vessel hull husbandry

Unlike the ballast water vector, all vessels pose some level of risk through the fouling vector. However, because fouling organisms are external, they are exposed to many more varying environmental conditions than sheltered ballast water organisms. These environmental conditions and voyage patterns are likely to influence the amount, complexity, and viability of fouling biota on the submerged surfaces of the commercial fleet. In January 2008, Commission staff began collecting data, using a Hull Husbandry Reporting Form (HHRF), on the fouling-related husbandry practices of the commercial vessel fleet visiting California waters. The data collected via the HHRF over the past two and a half years and into the next few years will provide the Commission with valuable insight into the fouling-related practices of the fleet as a whole. These data will be used in conjunction with the information learned through fouling-related research currently funded through the Commission to get a better idea of how husbandry practices and voyage characteristics affect the quantity and quality of fouling biota associating with vessels operating in California. Both sets of information will guide and inform the development of regulations on the management of fouling for vessels operating in California which the Commission is mandated to adopt by January 1, 2012.

Develop regulations governing the management of fouling for vessels operating in California

As specified in PRC § 71204.6, the Commission is required, by January 1, 2012, to develop and adopt regulations governing the management of hull fouling on vessels arriving to a California port or place. Commission staff has been collecting and analyzing data detailing fouling-related vessel practices and have been funding targeted research, all in an effort to provide insight and guide development of these regulations. Two areas of concern have emerged from these data gathering efforts: high-risk stochastic vessels and protected niche areas.

High-risk, irregularly occurring vessels fall into two categories; 1) those vessels that are involved in irregular trade and have unusual and unpredictable voyage characteristics (e.g. crane barges, dredge barges, and oil platforms) and 2) regularly trading vessels that are poorly maintained (small minority of the normally operated fleet) or that have undergone lengthy layups. These high-risk vessels share characteristics associated with elevated levels of fouling accumulation, particularly long stationary periods in coastal environments and slow traveling speeds.

Niche areas are protected nooks and crannies on a vessel, or areas not protected by antifouling paint, that facilitate the settlement and survival of fouling organisms. Because these areas do not experience the same harsh environmental conditions as the exposed hull, organisms may accumulate into very dense and diverse communities. Commission staff believes these two areas of concern are not adequately addressed by current requirements and therefore should be the focus of efforts to develop new regulations. To discuss and develop these regulations, Commission staff has convened a technical advisory group for two meetings during 2010 to begin discussions around the development of these regulations. Commission staff will continue consulting with this technical advisory group into early 2011 and will have a management strategy in place, including proposed regulations, by the statutory deadline of January 1, 2012.

Develop Memoranda of Agreement (MOAs) with international agencies working in parallel with the Commission in developing fouling management strategies

Over the past several years, the scientific and regulatory communities have become more aware of the important role of vessel fouling in NIS introductions. Recognizing this relatively unaddressed risk, the California State Legislature has tasked the Commission with developing regulations governing the management of vessel fouling for ships operating in California. At the same time, many other countries, international agencies, and international organizations have been on a parallel path to protect their waters from NIS incursions via vessel fouling. Commission staff has been consulting with a number of these international agencies in an attempt to teach and learn from each other and to maintain international consistency, where possible, in the development of management strategies. Part of this process involves the sharing of data with these international agencies. The hull husbandry data the Commission has been compiling since January 2008 represents the largest, most complete dataset of its kind in the world, and staff has received data sharing requests by a number of agencies from other states and countries. Countries such as Australia and New Zealand have developed prototype tools for evaluating fouling risk vessels arriving to their waters. Commission staff believes formalizing MOAs would enable better communication, cooperation, and information sharing with these international agencies.

Support research promoting in-water cleaning technology development

Vessel owners and operators strive to maintain clean hulls in order to minimize fuel costs, maximize vessel speed, meet classification society requirements, and to help ensure the structural integrity of their vessels. While complete cleaning and re-coating of vessel hulls with antifouling paint may provide better long-term antifouling protection than in-water cleaning, the dry dock facilities necessary to apply those paints are limited and expensive. Most owners and operators therefore conduct in-water cleaning between required dry dockings. In-water cleaning is one of several ways through which fouling NIS can be transferred from a vessel to a recipient port, because the activity can knock physically attached organisms off a vessel that may not otherwise be able to detach. However, there is still much uncertainty surrounding the comparative invasion risk associated with in-water cleaning vs. not allowing in-water cleaning. There are risks associated with both of these options, and both need to be taken into account when determining whether to allow either of them in State waters.

One strategy for high-risk vessels under discussion at the international level is the practice of ‘clean as you go.’ Stochastic vessels would be expected to have fouling organisms removed after spending a lengthy amount of time in one area and before transiting to a new area. Commission staff is considering advancing this practice for work vessels operating in California. In order to pursue this as a potential management strategy, California must permit some in-water cleaning in state waters. A technology that can collect and contain (or otherwise prevent the release of) in-water cleaning debris and paint material would be a desirable tool to prevent NIS release during in-water cleaning, while also providing commercial operators an avenue to clean hulls without placing a vessel in dry dock. Such a technology could also serve to alleviate water quality concerns related to in-water cleaning of vessels with biocidal antifouling coatings. The Commission should support the development of new technologies to address this issue.

Support research addressing the efficacy of technologies to prevent marine fouling organisms from accumulating within protective ‘niche’ areas

The fouling literature, including research funded by the Commission, includes numerous examples of certain ‘niche’ areas on ships (nooks and crannies or areas without antifouling coatings that are protected from the harsher conditions of the exposed hull) that are heavily fouled, even when main portions of the exposed hull appear to be free of fouling organisms. Certain technologies have been developed to address fouling accumulation within some of these niche areas, but third party evaluations of the efficacy of these technologies have been limited. The Commission should support the development of new technologies to address and prevent fouling within vessel sea chests and other niche areas, as well as independent assessments of these technologies to determine their usefulness as a tool to manage fouling on vessels operating within California.

Continue to work with the Water Board to address the growing jurisdictional overlap related to NIS prevention and vessel discharges

As described in Section III (United States Federal Regulations), federal authority to regulate ballast water discharges and certain hull-related discharges in the United States recently shifted to include the U.S. Environmental Protection Agency (EPA) through the Clean Water Act (CWA). Under the CWA section 401 certification process, this authority extends to the state level, allowing state water quality authorities to impose additional restrictions to such discharges in state waters. Discharge restrictions implemented for water quality purposes and those implemented for the purposes of reducing NIS introduction frequently overlap. For example, as part of the 401 certification process for the 2009 Vessel General Permit, some water quality agencies in other states imposed their own performance standards for ballast water discharge, as well as restrictions on in-water cleaning activities for underwater vessel surfaces.

In 2013, the EPA will revise and reissue the Vessel General Permit, and state water quality agencies will have the opportunity to again implement state restriction on vessel discharges, including ballast water and hull fouling. Because the overlapping goals of water quality protection and NIS prevention can often complement each other, but also have the potential to conflict, it will be important for Commission staff to remain abreast and involved with CWA-related developments within the California State Water Resources Control Board. Commission staff will strive to maintain invitations for open communication with the Water Board, and continue to encourage their participation during the Commission's development of ship-borne NIS regulations.

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