2013 BIENNIAL REPORT ON THE CALIFORNIA MARINE INVASIVE SPECIES PROGRAM

PRODUCED FOR THE
CALIFORNIA STATE LEGISLATURE

By
C. Scianni, C. Brown, A. Newsom,
R. Nedelcheva, M. Falkner, and N. Dobroski

California State Lands Commission
Marine Facilities Division
February 2013

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 nonindigenous 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 vessels that are 300 gross registered tons and above. 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 biofouling management practices of the California commercial fleet; enforce laws and regulations to prevent introductions; and, facilitate outreach to promote information exchange among 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 2010 through June 2012.

Current Worldwide Efforts to Manage Vessels as Vectors of NIS Introduction

There is an extensive network of ballast water management requirements at various local, regional, state, federal, and international levels. Many of these requirements overlap, but vessels are subject to varying laws in different ports, states, and countries. Many jurisdictions are currently moving away from ballast water exchange as a management practice and towards discharge performance standards, as safety and better environmental protection are the ultimate goals.

The International Maritime Organization (IMO) has adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) in 2004, setting the stage for a set of international ballast water discharge performance standards. However, in the nearly nine years that have followed, the BWM Convention has not yet been ratified. Until the BWM Convention enters into force, the IMO-established performance standards will not be implemented and will not be enforceable.

At the United States (U.S.) federal level, both the United States Coast Guard (USCG) and the Environmental Protection Agency (EPA) regulate ballast water discharges. Both agencies currently require ballast water exchange for the majority of vessels operating in U.S. waters. However, the USCG issued a final rule in 2012 establishing performance standards for ballast water discharges that will be implemented during the remainder of this decade. These performance standards are currently aligned with the IMO standards contained within the BWM Convention. The EPA regulates ballast water under the Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (VGP), through authority contained within the Clean Water Act. The five-year general permit issued in December 2008 requires ballast water exchange. However, the EPA has issued a draft of the 2013 VGP that, as proposed, contains ballast water discharge performance standards that are aligned with the USCG standards. The final 2013 permit will be released by the EPA in March 2013 and will become effective in December 2013.

At the U.S. state level, several states have used their authority under the Clean Water Act to add additional requirements into the VGP when vessels operate in their state waters, while other states (e.g. California) have been granted the authority by their state legislatures to regulate ballast water independent of the Clean Water Act.

The regulation of vessel biofouling has lagged behind ballast water, but there has been much regional and international activity over the past two years. The IMO has adopted a set of Guidelines for the Control and Management of Ships' Biofouling during the summer of 2011, encouraging preventative management of all submerged or wetted vessel surfaces. Australia and New Zealand have been pursuing federal biofouling management requirements, and each anticipates completion in 2013. In the U.S., the Pacific states have been working cooperatively to address biofouling concerns over the past two years. The Commission is currently developing biofouling management regulations in consultation with stakeholders and expects to complete the rulemaking process in 2013. Commission staff has also been active participants in the task forces and working groups of regional states as biofouling management strategies are being discussed and drafted.

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 2010 through June 2012, 97% of forms were submitted as required, and 88% were submitted on time.

Arrival statistics from July 2010 through June 2012 appear to reflect the slow recovery from global economic downturn that has depressed international trade over recent years. The overall number of arrivals to California began decreasing in late-2006 and continued through the first half of 2010. The number of arrivals to California began to slowly increase during the first six months (July-December 2010) of the current two-year reporting period, and has remained constantly above the levels experienced during the twelve months preceding this reporting period. Arrivals to California continued to be dominated by container (48% of all arrivals) and tank (21%) vessels between July 2010 and June 2012. Ninety-nine percent of all container vessels arrived to the Ports of LA-LB and Oakland, while tank vessels mainly arrived to the Ports of LA-LB (42%), Richmond (22%), and Carquinez (20%). The primary vessel-reported practice for ballast water management continues to be retention on board, as the percentage of vessels reporting discharging activities in California has not exceeded 17% during any six-month period since 2004.

Compliance with ballast water management requirements in California remains extremely high. Of the more than 122 million metric tons (MMT) of vessel-reported ballast water carried into State waters between July 2010 and June 2012, 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 22.8 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 88%) had been exchanged prior to discharge, but in a location not acceptable under California law.

Discharges from unmanned barges are a unique situation and present a potentially high risk of species introductions into California waters. Due to safety concerns associated with transferring personnel to an unmanned barge to conduct ballast water exchange, unmanned barges often claim a legal safety exemption in California. While it is legal to discharge unexchanged ballast water when a safety exemption is claimed, the practice does result in the discharge of high-risk water to the State. As a result, unmanned barges are responsible for the third largest volume of high-risk ballast water (i.e. unexchanged or not exchanged at legal distances from shore) discharged in California, accounting for 11% of such discharges between July 2010 and June 2012. The use of shore-based or shipboard ballast water treatment technologies are management strategies that should allow unmanned barges to reduce the risk of NIS introduction while minimizing risk for vessel and crew safety.

Commission Marine Safety personnel verify vessel-reported ballast water management practices through onboard inspections of vessel logbooks and by sampling ballast water intended for discharge. Between July 2010 and June 2012, nearly 21% of the more than 19,000 arrivals were inspected by Commission staff and approximately 1.1% of arrivals were found to be in violation with operational aspects of the law, which includes improper ballast water management. The inspection of 21% of arrivals falls below the legislatively-mandated threshold of 25%, primarily due to staffing level reductions during the past several years.

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

Commission staff has also been moving forward with data collection and the development of management practices to prevent introductions via vessel biofouling. Beginning in 2008, vessels operating in California waters were 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 biofouling that accumulates on the wetted surfaces of vessels, influencing the risk for NIS introduction. Data from the HHRF forms have been used in concert with targeted biological research supported by the Commission to better understand how husbandry practices and voyage characteristics affect the quantity and quality of biofouling organisms arriving in California on commercial ships. These two data streams, in addition to consultation with a multi-disciplinary technical advisory group, have been critical in the ongoing process of developing biofouling management practices for vessels operating in California.

The rate of HHRF submission has improved dramatically, from 74.4% during 2008 (the first year the form was required), to over 90% each of the past three years, and the data collected indicates that most vessels are taking various steps to minimize biofouling growth. Data from 2011 annual submission of the HHRF shows that 81% of all vessels operating in California have been out of the water (either newly built or dry docked) and painted with fresh antifouling coatings within the past three years (98% within the past five years), a pattern that has consistently been recorded during the four years of HHRF collection. Because biofouling occurs not only on the smooth exposed surfaces of vessel hulls but also in niche areas (such as sea chests and internal piping networks), one-half to two-thirds of the vessels operating in California (50.1 – 65.7%, on average between 2008 and 2011) have installed marine growth prevention systems (MGPSs) to prevent biofouling from accumulating in these areas. However, more investigation will be needed to determine the location of MGPS installation and how often installed MGPSs are actually utilized.

HHRF data have highlighted a dramatic increase in the frequency and duration of extended vessel residency periods (i.e. stationary periods, short-term or long-term layup) between reports submitted in 2008 and 2011, and this appears to be a consequence of the global economic recession of recent years. These extended residency periods increase the likelihood of elevated biofouling accumulation and are considered an important biofouling risk factor. On a per-vessel basis, there was a 37% increase, between submissions in 2008 and 2011, in the total number of reported residency periods of ten days or greater since a vessels most recent dry docking or delivery. This pattern was particularly evident in auto carriers (414% increase between 2008 and 2011 submissions), unmanned barges (330%), and container vessels (137%). Large increases in the duration of extended residency periods was also observed between 2008 and 2011 submissions, including a 308% increase for residency periods of 70-99 days and a 390% increase for periods of 100-149 days.

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. Commission staff completed an update on the efficacy of ballast water treatment systems for use in California waters in September 2011, and is currently working towards finalizing a legislatively mandated report on the topic, in advance of the upcoming implementation date of January 1, 2014, for existing vessels with a ballast water capacity of 1500-5000 MT. Staff also adopted two new reporting forms in October 2010 to collect information on the installation and use of shipboard ballast water treatment systems. Staff is currently developing protocols for assessing compliance with California's ballast water discharge performance standards, to make inspection procedures completely transparent to the regulated community. These protocols are being developed in consultation with stakeholders and technical experts, and are currently being vetted through an independent panel of scientists. Finally, staff is working with stakeholders to request proposals for a study evaluating the feasibility of shore-based ballast water treatment facilities in California. This study will be an important tool for regulators, port authorities, and other components of the shipping industry as performance standards continue to be implemented in California and throughout the world.

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, regional, 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 are members of numerous working groups, including (but not limited to): the California Agencies Aquatic Invasive Species Team, the Pacific Ballast Water Group, the state of Washington's Ballast Water Working Group, the state of Oregon's Shipping Transport of Aquatic Invasive Species Task Force, the state of Hawaii's Alien Aquatic Organism Taskforce, and the Coastal Committee of the Western Regional Panel on Aquatic Invasive Species. Staff have also received invitations to speak or participate on committees/panels, including (but not limited to): the Great Lakes Ballast Water Collaborative, the North America Marine Environment Protection Association (NAMEPA), ETV Advisory and Stakeholder Panels, the California Invasive Species Advisory Council, and the Bay Planning Coalition (San Francisco, CA). Commission staff have 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 International Congress on Marine Corrosion and Fouling, the California and the World Oceans Conference, the Bay-Delta Science Conference (formerly the CalFED Science Conference), and the California State Lands Commission's Prevention First Symposium.

Marine Invasive Species Control Fund Status

All aspects of the Marine Invasive Species Program are funded through per-voyage fees assessed on vessels and deposited into the state's Marine Invasive Species Control Fund. The amount of the fee is adjustable, through regulatory changes, to account for inflation and changes in vessel arrival statistics. The amount of the fee has been raised and reduced several times since implementation, each time in consultation with a stakeholder advisory group. The current fee amount of $850 for the first California arrival of a vessel voyage has been in place since it was adjusted in November 2009. Commission staff will continue to monitor the status of the fund and vessel arrival statistics to ensure that the fund remains stable and is sufficient to fund all components of the MISP.

Looking Forward

In the coming years, Commission staff intends to: 1) work with stakeholders to evaluate plans to implement California's ballast water discharge performance standards as the upcoming implementation dates arrive; 2) continue to develop transparent protocols for assessing compliance with ballast water discharge performance standards, in consultation with stakeholders and utilizing an independent scientific review panel; 3) continue to support ballast water research, particularly methods to assess organism viability and tools to enable inspectors to safely and responsibly sample large volumes of ballast water onboard a vessel; 4) work with shipping industry representatives, port authorities, and other stakeholders to support a study assessing the feasibility of shore-based ballast water treatment facilities in California; 5) improve compliance with current ballast water management regulations by targeting outreach and enforcement for vessels types with comparatively lower compliance rates over the past two years; 6) continue to compile, analyze, and share vessel hull husbandry data, to inform developing management policies around the world; 7) continue to develop regulations governing the management of biofouling for vessels operating in California, in consultation with stakeholders and other regulators; 8) continue to support and conduct biofouling research to inform the development and revision of management policies in California and around the world; and 9) develop Memoranda of Understanding with regional and international agencies working in parallel with the Commission in developing vessel vector management strategies. 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 nonindigenous species introductions to California waters.

TABLE OF CONTENTS

EXECUTIVE SUMMARY……………………………………………………………………...... i

ABBREVIATIONS AND ACRONYMS………………………………………………………… xi

I. PURPOSE……………………………………………………………………………..……. 1

II. INTRODUCTION………………………………………………………………………..……. 2

Nonindigenous Species and Vehicles of Introduction – “Shipping Vectors”…………. 2

NIS Impacts……………………………………………………………………………… 3

Prevention Through Vector Management……………………………………………….. 6

III. REGULATORY OVERVIEW: BALLAST WATER……………………………….……... 11

International Maritime Organization…………………………………………………… 11

National Regulations Outside of the United States……………………………………... 13

United States Federal Legislation and Programs..…...………………………………… 17

U.S. State Programs……………………………………………………………………….. 24

IV. REGULATORY OVERVIEW: VESSEL BIOFOULING……………………………... 28

The International Maritime Organization………………………………………………… 28

National and Regional Programs Outside of the United States………..…………….. 30

United States Federal Biofouling-Related Provisions of the Vessel General Permit.. 33

U.S. State Hull Cleaning Certifications Under the Vessel General Permit.………….. 34

V. CALIFORNIA’S MARINE INVASIVE SPECIES PROGRAM………………………... 35

Programmatic Origins and Overview…………………………………………………….. 35

Performance Standards for Ballast Water Discharge………………………………….. 37

Vessel Biofouling………………………………………………………………………… 41

Structure and Function of the Commission’s Marine Invasive Species Program…… 42

VI. DATA ANALYSIS………………………………………………………………………… 50

Trends in Statewide Vessel Traffic……………………………………………………….. 50

Ballast Water Discharge, Management and Compliance……………………………… 59

Compliance Through Field Inspections………………………………………………….. 82

Trends in Vessel Biofouling-Related Practices and Patterns………………………….. 85

Fee Submission……………………………………………………………………………….. 93

VII. RESEARCH………………………………………………………………………………. 95

Collaborative and Funded Research…………………………………………………….. 95

Review of Current Vessel Vector Research…………………………………………….. 105

VIII. CONCLUSIONS AND LOOKING FORWARD……………………………………... 116

IX. REFERENCES…………………………………………………………………………. 125

ABBREVIATIONS AND ACRONYMS

AB	Assembly Bill
ABRPI	Aquatic Bioinvasions Research and Policy Institute
Act	Marine Invasive Species Act (Chapter 491, Statutes of 2003)
AFS Convention	International Convention on the control of Harmful Antifouling Systems on Ships
AMS	Alternative Management System
ANS	Aquatic Nuisance Species
ANZECC	Australian and New Zealand Environment and Conservation Council
APL	American President Lines
Biofouling Guidelines	Guidelines for the Control and Management of Ships' Biofouling
BOE	Board of Equalization
BWE	Ballast Water Exchange
BWM Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments
CANOD	California Aquatic Non-Native Organisms Database
CDFG	California Department of Fish and Game
CFR	Code of Federal Regulation
cfu	Colony-Forming Unit
Commission	California State Lands Commission
CWA	Clean Water Act
DAFF	Department of Agriculture, Fisheries and Forestry (Australia)
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
ER	Empty-refill
ETV	Environmental Technology Verification
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FT	Flow-through
GRT	Gross registered tons
HHRF	Hull Husbandry Reporting Form
IMO	International Maritime Organization

LA-LB	Los Angeles-Long Beach port complex
LoF	Level of Fouling
m	Meter
MARAD	U.S. Maritime Administration
ml	Milliliter
MDEQ	Michigan Department of Environmental Quality
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
MOU	Memorandum of Understanding
MPCA	Minnesota Pollution Control Agency
NAMEPA	North America Marine Environment Protection Association
NIS	Nonindigenous Species
NISA	National Invasive Species Act
nm	Nautical Miles
NOBOB	No Ballast on Board
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
ODEQ	Oregon Department of Environmental Quality
PCR	Pacific Coast Region
ppt	Parts Per Thousand
PRC	Public Resources Code
PSU	Portland State University
QV	Qualifying Voyage
RIS	Regulatory Impact Statement
ROV	Remotely Operated Vehicle
SAB	Science Advisory Board
SB	Senate Bill
SD	Standard Deviation

SERC	Smithsonian Environmental Research Center
STEP	Shipboard Technology Evaluation Program
TAG	Technology Advisory Group
TAPS	Trans-Alaska Pipeline System
TBT	Tributyltin
µm	Micrometer
U.S.	United States
USCG	United States Coast Guard
VGP	Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels
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 biofouling 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, five biennial reports have been completed (see Falkner 2003, Falkner et al. 2005, 2007, 2009, Takata et al. 2011). This document constitutes the sixth MISP biennial report reviewing program activities, administration, research, and data analyses from July 2010 through June 2012.

II. INTRODUCTION

Nonindigenous Species and Vehicles of Introduction – "Shipping Vectors"

Nonindigenous species, also known as "introduced," "invasive," "exotic," "alien," or "aquatic nuisance species," are transported to new marine, estuarine and freshwater regions through numerous human activities. Aquaculture, live bait release, intentional sportfishing introductions, release of aquarium pet and live seafood specimens, transfer via recreational watercraft, association with marine debris, and accidental release from research institutions are just a few of the mechanisms, or "vectors," by which organisms are introduced into United States (U.S.) waters (Weigel et al. 2005, Minchin et al. 2009). In coastal environments, commercial shipping is the most important vector for invasions, accounting for or contributing to 79.5% of introductions to North America (Fofonoff et al. 2003) and 74.1% across the globe (Hewitt and Campbell 2010). Commercial ships transport organisms through two primary mechanisms - ballast water and vessel biofouling.

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 ballast water when cargo is loaded in another port. 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 has the potential to release over 21.2 million individual free-floating animals (Minton et al. 2005).

Biofouling organisms are aquatic species attached to or associated with submerged or wetted hard surfaces. These include organisms such as barnacles, algae, and mussels that physically attach to any vessel wetted surfaces, and mobile organisms such as worms, crabs, and amphipods (small shrimp-like animals) that associate with the attached biofouling community. When vessels move from port to port, biofouling communities are transported along with their “host” structure. Biofouling organisms are introduced to new environments when they spawn (reproduce) or drop off their transport vector (i.e. vessels). Thus vessel biofouling has been identified as one of the most important mechanism for marine NIS introductions in several regions, including Australia, North America, Hawaii, the North Sea, and California (Ruiz et al. 2000a, 2011, Eldredge and Carlton 2002, Gollasch 2002).

NIS Impacts

The rate of species introductions, and thus the risk of invasion by species with detrimental impacts, has increased significantly during recent decades. In North America, and particularly in California and the rest of the west coast, the rate of reported introductions in marine and estuarine waters has increased exponentially over the last 200 years (Ruiz et al. 2000a, 2011). Prior to the implementation of ballast water management regulations in California, a new species was believed to become established every 14 weeks on average 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 led to significantly more ballast water, fouled hulls, and associated organisms moving around the world. The increased speed of vessels involved in global trade has allowed many more potentially invasive organisms entrained in ballast tanks to survive under shorter transit times (Ruiz and Carlton 2003) and arrive in recipient ports in better condition. 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 via commercial ships. 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 one billion dollars per 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 propagate 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). Zebra mussels have now invaded the San Justo Reservoir in San Benito County (CDFG 2012), and the closely related quagga mussels (*Dreissena bugensis*) have invaded multiple locations in southern California (USGS 2011). Should quagga mussels spread to the Lake Tahoe region, they could create costs of up to $22 million per year (U.S. Army Corps of Engineers 2009). Over $14 million has already been spent to control zebra and quagga mussels in California since the species were first found in 2007 (Norton, D., pers. comm. 2012). These costs represent only a fraction of the cumulative expenses related to NIS control over time, because control is an unending process.

These economic impacts are even more alarming when considering that California had the second largest ocean-based gross state product in the U.S. in 2009, and ranked number one for employment and second in wages (NOEP 2012a). California's natural resources contribute significantly to the coastal economy. For example, in 2010 total landings of fish were almost 438 million pounds, valued at more than $176 million (NOEP 2012b). Millions of people visit California's coasts and estuaries each year, spending money on recreational activities that are directly related to the health of the ecosystem. Annually, over 150 million visits are made to California's beaches: approximately 20 million for recreational fishing, over 65 million for wildlife viewing, and over 5 million for snorkeling or scuba diving (Pendleton 2009). Direct expenditures for recreational beach activities alone likely exceed $3 billion each year (Kildow and Pendleton 2006). In total, the tourism and recreation industries accounted for almost $15 billion of California's gross state product in 2009 (NOEP 2012a). NIS pose a threat to these and other components of California's ocean economy including fish hatcheries and aquaculture, recreational boating, and marine transportation.

NIS can also present environmental impacts that are difficult to quantify economically. In San Francisco Bay, the overbite clam (*Corbula amurensis*) spread throughout the region's waterways within two years of being detected in 1986. The clam can account 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 planktonic food base of the ecosystem (Feyrer et al. 2003, Sommer et al. 2007, Mac Nally et al. 2010). Worldwide, forty-two percent of the species listed as threatened or endangered in 2005 were listed in part because of negative interactions with NIS (e.g. competition) (Pimentel et al. 2005).

In addition to impacting the coastal economy, ecosystems and native species, NIS may 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 (Ruiz et al. 2000b, Takahashi et al. 2008), including the transport of the toxigenic *Vibrio cholerae* serotype O1 from Latin America to Mobile Bay, Alabama in 1991. This introduction led to the closure of nearly all Mobile oyster beds during the summer and fall of 1991, resulting in losses and damages estimated at $700,000 (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 (*Escherichia coli* and intestinal enterococci) (Reid et al. 2007).

As a local example of human health impacts, the Japanese sea slug *Haminoea japonica* was introduced, likely via ballast water, to San Francisco Bay in 1999. This slug is a host for parasites that cause cercarial dermatitis, or "swimmer's itch," in humans. Since 2005, cases of swimmer's itch at Robert Crown Memorial Beach in Alameda have occurred on an annual basis and are associated with high densities of *Haminoea japonica* (Brant et al. 2010).

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). This effort represents one of the few known successful eradication attempts, likely because of early detection and a well-funded rapid response plan. Control is likewise extremely expensive and labor-intensive. By the end of 2010, over $12 million was 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 and cost-effective way to address the NIS issue.

Ballast Water Management

The vast majority of commercial vessels currently use ballast exchange as the primary method of ballast water management prior to discharge. Ballast water exchange (BWE) 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. Open ocean organisms are likewise not expected to survive in coastal waters (Cohen 1998).

BWE is an interim ballast water management tool, however, because of its operational limitations and variable efficiency. Scientific research indicates that BWE typically eliminates between 70% and 99% of the organisms originally taken into a tank while the vessel is in or near port (Cohen 1998, Parsons 1998, Zhang and Dickman 1999, USCG 2001, Wonham et al. 2001, MacIsaac et al. 2002), and 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 vessel safety due to adverse sea conditions or antiquated vessel design. Furthermore, some vessels are regularly routed on short voyages, or voyages that remain within 50 nautical miles (nm) of shore, and 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 looked toward the development of effective ballast water treatment technologies as a promising management option. Ballast water treatment can reduce or eliminate NIS in vessel discharges, even 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. The use of effective ballast water treatment technologies will also 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.

Many barriers have hindered the development of ballast water treatment technologies, including equipment design limitations, the cost of technology development, regulatory inconsistencies, and the lack of guidelines for testing and evaluating performance. Many 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, they claimed, 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 systems 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. The California legislature adopted performance standards in 2006 and directed the Commission to implement the performance standards via regulations; this was completed in October of 2007. Commission staff is working with stakeholders to develop plans to implement these standards according to the schedule in Table III.2, including the development of procedures to assess vessel compliance with those standards (See Section V for more details).

Vessel Biofouling Management

Mariners have long been aware of biofouling (the attachment or association of aquatic organisms to the wetted surfaces of vessels) as a nuisance to vessel operations as it relates to vessel performance and fuel efficiency. Biofouling on the hull can create drag, increasing fuel consumption, and can cause engine strain. In pipes, biofouling can block inflowing seawater meant to cool machinery. To prevent such problems, common industry biofouling management strategies include cleaning of underwater vessel surfaces and the use of antifouling coatings and other antifouling 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 slowly releasing toxic compounds such as copper, zinc, and until recently tributyltin (TBT). 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 currently available non-TBT coatings utilize copper compounds as biocides, though they are generally less effective and their longevity is shorter than TBT (Lewis 2002). Copper-based antifouling coatings are also not immune to environmental concerns. Copper accumulation in the water column and sediments within marinas, and its impact on non-target organisms, has been extensively evaluated, particularly in San Diego, California (Schiff et al 2004, 2007, Neira et al 2011, Biggs and D'Anna 2012). Because of these concerns, bans and restrictions on copper-based paints are being considered and adopted in a number of places.

Biocide-free foul-release coatings are available, but are more costly to apply and most are currently only practically effective for active, swift vessels (those that cruise over 15 knots) (Lewis 2002, International Marine Coatings 2006), although there are claims that several recently introduced foul-release coatings are effective on slower moving vessels. These foul-release coatings produce a smooth 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 biofouling 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 biofouling 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 biofouling organisms and apply a fresh coat of antifouling paint. Because fouling continues to accumulate between required dry dockings and may reduce a vessel's fuel efficiency, vessel owners may also conduct interim in-water cleanings of the vessel hull. Out-of-water cleanings during dry dock allow for the containment of materials, including biofouling 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 California's Clean Water Act (CWA) Section 401 Water Quality Certification of the 2008 U.S. EPA Vessel General Permit (VGP), the California State Water Resources Control Board (Water Board) has prohibited in-water cleaning of copper-containing coatings in California water bodies that have been included in the CWA Section 303(d) list as "impaired" for copper. These include most of California's major shipping ports.

Despite the efforts of the maritime industry to minimize vessel biofouling by employing hull cleaning and antifouling coatings, recent studies indicate that biofouling is still an important mechanism by which NIS can be transported to new regions (Coutts and Dodgshun 2007, Davidson et al. 2009a, Hopkins and Forrest 2010, Hewitt and Campbell 2010, Sylvester et al. 2011). 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 biofouling accumulation. These "niche" areas, including dry docking support strips, thrusters, propellers, rudders, sea chests, and worn or unpainted areas, have the potential to harbor diverse assemblages of NIS (Coutts et al. 2003, Minchin and Gollasch 2003, Coutts and Taylor 2004, Davidson et al. 2009b). Although the vessel biofouling 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

California, other U.S. states, the federal government, and the international community are making great strides towards the development of a standardized approach for the management of discharged ballast water. However, existing legislation, standards and guidelines still vary by jurisdiction. The following is a summary of current ballast water management laws, regulations and permits by jurisdiction (excluding California, which is described in Section V), and a review of current and proposed processes for compliance assessment.

Nearly all international, U.S. federal, and state ballast water management laws allow ballast water exchange as a means to reduce the number of organisms entrained in ballast water discharges. Most of these laws provide exemptions for exchange requirements to protect the safety of vessels and vessel crews, and many also accept approved shipboard ballast water treatment systems or discharge to shore-based ballast water reception facilities in anticipation of the development and implementation of ballast water performance standards. Ballast water management laws and regulations require the onboard maintenance of ballast water logs and management plans, and many require the submission of forms detailing ballast management and discharge practices.

International Maritime Organization

In February 2004, after several years of development and negotiation, IMO Member States adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (BWM Convention) (see IMO 2005). The BWM Convention requires vessels to conduct exchange at least 50 nm from shore in waters at least 200 meters (m) deep, although exchange beyond 200 nm offshore is preferred (IMO 2005) until performance standards for ballast water discharges enter into force. Among its provisions, the BWM Convention establishes performance standards for the discharge of ballast water (Regulation D-2) with an associated implementation schedule based on vessel ballast water capacity and date of construction (Tables III.1 and III.2).

Exchange requirements will be removed once the implementation of performance standards begins.

Table III.1. Ballast Water Treatment Performance Standards

Organism Size Class	IMO D-2[a]/U.S. Federal[b]	California[a,c]
Organisms greater than 50 μm[d] 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[e]	< 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[f]/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

[a] See Table III.2 below for dates by which vessels must meet California and IMO Ballast Water Performance Standards.
[b] See Table III.4 for dates by which vessels must meet U.S. Coast Guard Ballast Water Performance Standards.
[c] Final discharge standard for California, beginning January 1, 2020, is zero detectable living organisms for all organism size classes.
[d] Micrometer = one-millionth of a meter.
[e] Milliliter = one-thousandth of a liter.
[f] Colony-forming unit (cfu) is a standard measure of cultural heterotrophic bacterial numbers.

Table III.2. Implementation Schedule for IMO and California Performance Standards[a]

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

[a] See Table III.4 for implementation schedule for USCG performance standards
[b] In California, the standards apply 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 no 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).
[c] Once the BWM Convention is ratified, all vessels flagged by a signatory to the BWM Convention and all vessels operating within the waters of a signatory country, and are constructed on or after January 1, 2009 must comply with the BWM Convention provision within 12 months.

The BWM Convention will enter into force 12 months after ratification by 30 countries representing 35% of the world's commercial shipping tonnage (IMO 2005). As of November 2012, 36 countries representing 29.07% of the world's shipping tonnage have signed the BWM Convention (IMO 2012). The U.S. has not yet signed the BWM Convention. Although the BWM Convention has not yet been ratified, several of the implementation dates have already passed. Once the BWM Convention is ratified, all vessels constructed on or after January 1, 2009 must comply with the BWM Convention provisions within 12 months if they are flagged by signatories to the BWM Convention or operate in waters of signatory countries. Existing vessels must comply according to the schedule set forth in Regulation B-3 of the BWM Convention (see Table III.2).

To enable globally uniform application of the BWM Convention, the IMO Marine Environment Protection Committee (MEPC) has adopted 14 implementation guidelines specifically called for in the BWM Convention, and several others released as BWM Circulars (Everett, R., pers. comm. 2012). These guidelines work together to establish a program to evaluate the performance and potential toxicity (for systems using chemicals) of shipboard ballast water treatment systems and provide a mechanism for flag state administrations to approve systems for use under the BWM Convention.

National Regulations Outside of the United States

Over a dozen countries other than the U.S. have ballast water management requirements. Nearly all include ballast water exchange at varying distances from shore as a primary management tool, although some also allow approved ballast water management systems 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. 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 other than the U.S. Some countries have ballast water treatment requirements for human health purposes (e.g. addition of chemicals to prevent cholera outbreaks), and these are included in Table III.3 because they function to reduce NIS release as well.

Table III.3. National Ballast Water Management Requirements for Countries Other than 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.	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.	BWT allowed if IMO D-2 Standards are met.		
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 Countries Other than the U.S.

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.	Reporting	Lloyd's Register, 2009
			Ships bound for Mediterranean ports must exchange in Atlantic Ocean.		
New Zealand		BWE at least 200 nm from shore and in waters over 200 m deep.	Permission must be granted for any discharge.	Log	Biosecurity New Zealand, 2005
		Discharge of fresh ballast water may be allowed.	Except in emergency, no discharge granted for "high risk" ballast water from Tasmania or Port Phillip Bay, Australia.	Reporting	
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 Countries Other than the U.S.

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. Liquefied 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

United States Federal Legislation and Programs

Ballast water discharges in the U.S. are under the jurisdiction of both the United States Coast Guard (USCG) and the United States Environmental Protection Agency (EPA). Prior to February 6, 2009, ballast water was regulated solely by the USCG through rules developed under the authority of the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, which was revised and reauthorized as the National Invasive Species Act (NISA) of 1996. The EPA began regulating ballast water discharges in 2009 after a court decision required ballast water and other discharges incidental to the normal operation of vessels to be regulated under the Clean Water Act (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). The USCG and EPA regulations and permits do not relieve vessel owners and operators of the responsibility of complying with applicable state laws and regulations. Vessels thus face a challenging environment for the management of ballast water discharges marked by the need to navigate regulation by two federal agencies as well as the states.

United States Coast Guard

The USCG currently regulates ballast water under regulations found in Title 33 of the Code of Federal Regulation (CFR) Part 151. The regulations include requirements for vessels arriving from outside of the U.S. Exclusive Economic Zone (EEZ) to conduct ballast water exchange prior to entering U.S. waters and discharging ballast. The EEZ is the oceanic zone that a nation has jurisdiction over for the use of marine resources, stretching generally out to 200 nm from its coast. Vessels that experience undue delay, however, are exempted from existing USCG ballast water management requirements.

Recognizing that ballast water exchange is only an interim management solution, the USCG published regulations on March 23, 2012 in the Federal Register that establish federal performance standards for living organisms in ships' ballast water discharged in U.S. waters. This rule became effective on June 21, 2012. The USCG standards are numerically identical to those established by the IMO BWM Convention (see Tables III.1 III.4) and will be implemented upon delivery for new build vessels constructed on or after December 1, 2013. Existing vessels (i.e. vessels constructed before December 1, 2013) must meet the standards as of the first scheduled dry docking after January 1, 2014, or 2016, depending on the vessel's ballast water capacity.

Table III.4. Implementation schedule for USCG ballast water performance standards.

U.S. Coast Guard Implementation Schedule for Approved Ballast Water Management Methods			
Vessel ballast water capacity (m^3)[a]		**Vessel construction date**	**Vessel compliance deadline**
New vessels	All	On or after Dec. 1, 2013	On Delivery
Existing vessels	Less than 1,500	Before Dec. 1, 2013	First scheduled dry docking after Jan. 1, 2016
	1,500 - 5,000	Before Dec. 1, 2013	First scheduled dry docking after Jan. 1, 2014
	Greater than 5,000	Before Dec. 1, 2013	First scheduled dry docking after Jan. 1, 2016

[a] Cubic meter = 1,000 liters

Vessel owners and operators have several options available to them to comply with the USCG standards. Vessels may retain all ballast water onboard (the most protective management strategy available), discharge ballast to an approved USCG shore-based treatment facility (although currently no such facilities exist), utilize potable water from the U.S. or Canada, or treat all ballast using a USCG approved shipboard treatment system. The USCG rule provides exemptions for vessels that operate exclusively within the Great Lakes, exclusively within one Captain of the Port Zone (USCG designated geographic regions that partition U.S. waters, defined in CFR 33 Part 3), vessels less than 1600 gross registered tons (GRT) in size that operate solely within the U.S. EEZ (many barges fit this definition), and Trans-Alaska Pipeline System (TAPS) trade tankers. Furthermore, vessel owners may request an extension of the implementation date if, despite all best efforts, the vessel will not be able to comply with the standards.

The USCG rule establishes procedures for the USCG to approve ballast water treatment systems for use in U.S. waters. The USCG Type Approval process includes requirements for land-based and shipboard evaluation of ballast water treatment system performance. Land-based testing must be conducted in accordance with the EPA's Environmental Technology Verification (ETV) protocols (see below for more information on the ETV protocols) utilizing a USCG approved Independent Laboratory. The USCG rule also requires vessels to install ballast water sampling ports to facilitate compliance verification testing, although no specific compliance assessment procedures are established by the rule.

Because the USCG anticipates that it may take several years to approve treatment systems, the final rule includes an Alternative Management System (AMS) provision. AMS approval is not U.S. Type Approval, but rather a "bridging strategy" that temporarily accepts the use of foreign Type Approved ballast water management systems in U.S. waters. AMS approval issued to a ballast water treatment system manufacturer will allow vessels to use that system for up to 5 years after the applicable implementation date while the USCG reviews the system for U.S. Type Approval.

The USCG continues to operate the Shipboard Technology Evaluation Program (STEP), which began in 2004. STEP is intended to facilitate the development of ballast water treatment technologies. Vessel owners and operators accepted into STEP may install and operate specific experimental ballast water treatment systems on their vessels for use in U.S. waters. In order to be accepted, treatment technology developers must assess the efficacy of systems for removing biological organisms, residual concentrations of treatment chemicals, and water quality parameters of the discharged ballast water (USCG 2004). Vessels accepted into the program are authorized to operate the system to comply with existing USCG ballast water management requirements and are grandfathered for operation under the USCG ballast water performance standards for the life of the vessel or the treatment system, whichever is shorter.

As of October 2012, five vessels are active in STEP (USCG 2012). The lengthy STEP review process and recent uncertainties regarding requirements for biological testing on

STEP vessels have delayed significant testing of treatment systems within STEP. The USCG has, however, made efforts to streamline the review process for future applicants. The USCG plans to continue STEP even after the implementation of performance standards, as STEP will serve to facilitate system shipboard testing for USCG approval, and will continue to promote vessel access for the research and development of promising experimental technologies (Everett, R., pers. comm. 2012).

United States Environmental Protection Agency

In December 2008 the EPA issued a National Pollutant Discharge Elimination System (NPDES) "Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels" (Vessel General Permit, or VGP). The VGP regulates 26 discharges, including ballast water. In large part, the 2008 VGP maintains the regulation of ballast water discharges by the USCG under 33 CFR Part 151 and does not include performance standards for the discharge of ballast water. Rather, the 2008 VGP specifies requirements for ballast water exchange that are in-line with the USCG rules and includes provisions for ballast water management of vessels transiting between Captain of the Port Zones along the Pacific Coast of the U.S. These vessels are required to conduct ballast water exchange at least 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. The 2008 VGP is a five-year general NPDES permit and will expire on December 18, 2013.

On November 30, 2011, the EPA released the draft 2013 Vessel General Permit. The draft 2013 VGP would require vessels to meet ballast water discharge performance standards equivalent to those established by the USCG final rule. Vessels may comply with the performance standards set forth in the draft 2013 VGP using the same options available for compliance with the USCG rule - through the retention of all ballast on board, use of potable water from the U.S. and Canada, discharge to onshore treatment facilities, or the use of shipboard ballast water treatment technologies. The implementation schedule is similar to that established by the USCG final rule. Vessels constructed on or after January 1, 2012, must meet the standards upon delivery of the vessel (and implementation of the permit – which takes place on December 19, 2013). Existing vessels constructed before January 1, 2012, must meet the standards as of the first scheduled dry docking after January 1, 2014, or 2016, depending on the vessel's ballast water capacity (see Table III.4). Similar to the USCG rule, the draft 2013 VGP exempts from performance standards requirements all vessels operating exclusively on the Great Lakes, unmanned and unpowered barges, and vessels operating within one USCG Captain of the Port Zone. Unlike ballast water management requirements under NISA, the CWA does not exclude TAPS trade tankers.

The draft 2013 VGP proposes to require vessels to conduct biological monitoring of select bacteria taxa (*Escherichia coli*, intestinal enterococci, and heterotrophic bacteria), yearly monitoring of sensors and control equipment, and frequent monitoring for residual biocides. These results must be reported to the EPA in yearly monitoring reports.

State agencies have the opportunity to add state-specific provisions to the VGP under the authority of Section 401 of the CWA. As of October 2012, five states have added ballast water provisions above and beyond those proposed by EPA to the draft 2013 VGP through their Section 401 certification of the permit. The EPA was scheduled to release the final permit in late-2012 to provide the regulated community with time to comply by the permit implementation date of December 19, 2013. The publication date has been delayed until March 15, 2013, but the implementation date remains unchanged.

EPA/USCG Collaborative Activities

The EPA and USCG have been working collaboratively on the development of the EPA VGP and USCG performance standards and on programs to evaluate ballast water treatment system performance. For example, the EPA ETV program is an effort to accelerate the development and marketing of environmental technologies. In 2001, the USCG and the EPA established a formal agreement to implement an ETV program focused on ballast water management. In September 2010, the EPA released the "Generic Protocol for the Verification of Ballast Water Treatment Technology" (see EPA 2010). The protocol established specific methods and procedures for verifying shipboard ballast water treatment system performance at land-based testing facilities. In 2012, USCG incorporated the ETV protocol into its final rule as part of the testing process to approve ballast water treatment technologies. EPA and USCG are currently pursuing the development of an ETV shipboard protocol to verify treatment system performance. Commission staff has participated on the advisory team for the development of both the land-based and shipboard protocols.

In 2010, EPA and USCG also worked together to commission two scientific studies to better inform understanding of ballast water performance standards and treatment technologies. The goals of the studies were to evaluate: 1) the risk of species introduction given certain living organism concentrations in ballast water discharges, and 2) the efficacy and availability of ballast water treatment technologies. The National Academy of Sciences' National Research Council (NRC) was charged with evaluating the organism concentration question, and the EPA Office of Water requested the Science Advisory Board's (SAB) Ecological Processes and Effects Committee, augmented with experts in ballast water issues, to address the efficacy and availability question. These two studies were published in 2011 (see NRC 2011 and SAB 2011).

Impacts of Federal Actions in California

The EPA VGP and the USCG regulations do not relieve vessel owners and operators (permittees) of the responsibility of complying with applicable state laws and regulations. Several states with authority to implement the CWA have added additional conditionsfor vessel discharges in state waters to the EPA's general permit through the CWA Section 401 certification process. Commission staff does not expect to see any impact from the implementation of the NPDES permit on individual states' ability to implement performance standards for the discharge of ballast water in state waters, including California. Vessels will have to comply with both state and federal regulations for ballast water management under the VGP and the USCG regulations. Until such time that ballast water treatment systems are type approved by the USCG or the 2013 VGP goes into effect, this may result in vessels having to exchange ballast water to comply with federal management requirements and also treat ballast water to comply with state regulations. Several legislative efforts are underway at the federal level to standardize ballast water regulations nationwide and preempt the conditions within the Clean Water Act that provide States with the authority to enact stricter standards based on individual State needs. Commission staff is closely monitoring proposed bills..

An additional effort is underway by Commission staff to prepare a report for the California Legislature comparing the new federal programs with California's MISP. California Public Resources Code Section 71271 requires such a comparison in order to determine "the federal program's relative effectiveness in preventing the introduction of marine invasive species from vessels visiting California." Upon completion of the analysis, the Commission shall recommend repeal of the MISP if the federal program "is equally or more effective at implementing and funding effective controls on the release of aquatic invasive species into the waters of the state." This report will be submitted to the Legislature in late-2013.

U.S. State Programs

States have taken two approaches to the implementation of ballast water management requirements, including performance standards for the discharge of ballast water. Some states have authority granted by state statute to establish ballast water management requirements, including performance standards, through regulation or by permit. Other states exercise authority to establish standards under Section 401 of the federal Clean Water Act, through the state certification of the VGP. The following is a selected summary of ballast water performance standards by state and how each has approached implementation.

Clean Water Act Section 401 Certifications Under the Vessel General Permit

Section 401 of the CWA allows states to certify federal permits and to add conditions above and beyond those present in the federal permit. As the draft 2013 VGP is not yet finalized, the following discussion only includes state provisions added as part of the certification of the 2008 VGP.

A number of states added conditions to ballast water management requirements in 2008 through the section 401 certification process. States that specifically included the establishment of performance standards in their 401 certification include: Illinois, Indiana, New York, Ohio, and Pennsylvania. The states of Illinois, Indiana and Ohio require vessels to comply with the IMO D-2 standard (see Table III.1) by 2012 for newly built vessels or 2016 for existing vessels. Pennsylvania originally established a two-phase discharge standard, but deleted those conditions from their 401 certification in December 2010. The New York 401 Certification of the 2008 VGP requires all vessels to install treatment systems that meet a standard roughly equivalent to 100 times more protective than the IMO D-2 standard by 2012. Due to a shortage in the supply of available technologies to meet the New York 401 conditions, the New York Department of Environmental Conservation issued a letter on February 16, 2012, extending the date by which vessels must comply with the standards until December 19, 2013, the end of the current VGP term.

Non-VGP State Ballast Water Programs

<u>Hawaii</u>

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) ballast water exchange for any ballast sourced from outside state waters.

<u>Oregon</u>

Oregon began requiring ballast water management in 2002. Vessels arriving from outside the U.S. 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. Based on 2010 Task Force recommendations, the 2011 Oregon Legislature passed SB 81 which established a $70 per arrival vessel fee to provide partial support for ballast program activities.

Washington

The Washington Department of Fish and Wildlife (WDFW) was directed by the Washington State legislature to develop and implement a ballast water management program in 2000. Current laws are found under Chapter 77.120 Revised Code of Washington and rules are found under Chapter 220-150 Washington Administrative Code. Washington State requires vessels to file a Ballast Water Reporting Form at least 24 hours prior to entering state waters, conduct an open-sea exchange (in waters at least 200 nm from shore and 2000 m deep) for voyages originating from outside the U.S. EEZ, and an open-sea exchange (in waters at least 50 nm from shore and 200 m deep) for vessels on coastal voyages that do not travel outside the U.S. EEZ.

Great Lakes Region

In response to the discovery of the invasive Ruffe fish (*Gymnocephalus cernuus*) in Lake Superior, Canada established guidelines in 1989 requesting all vessels entering the freshwaters of the St Lawrence River and the Great Lakes to exchange their ballast (Canadian Coast Guard 1989). The USCG established similar regulations in 1993. In January 2006, the Great Lakes Ballast Water Working Group (BWWG) was formed with the goal of harmonizing ballast water management efforts between the USCG, Transport Canada-Marine Safety, St. Lawrence Seaway Development Corporation and the St. Lawrence Seaway Management Corporation. In 2008, regulations were established by U.S. and Canadian St. Lawrence Seaway agencies. These regulations require 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 that may still pose a risk for species introductions.

Michigan

Michigan passed legislation in June 2005 (Act 33, Public Acts of 2005) requiring a permit for oceangoing vessels engaging in port operations in Michigan, beginning January 2007. Through the general permit (Permit No. MIG140000) developed by the Michigan Department of Environmental Quality (MDEQ), 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, or a vessel must certify no discharge of ballast water. In state waters, vessels must use treatment technologies in compliance with applicable requirements and conditions of use as specified by MDEQ. 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,” (MDEQ 2006).

Minnesota

Effective July 1, 2008, Minnesota state statute (Minn. Stat. 115.1703) requires vessels operating in state waters to have both a ballast water record book and a ballast water management plan onboard that has been approved by the Minnesota Pollution Control Agency (MPCA) (MPCA 2008). Additionally, based on the authority in Minnesota Statute 115.07, Minnesota Rule 7001.0020, subpart D, and Minnesota Rule 7001.0210, and to implement the recently enacted legislation, the MPCA approved a State Disposal System general permit for ballast water discharges into Lake Superior and associated waterways in September 2008 (MPCA 2008). Under the permit, all vessels transiting Minnesota waters must comply with approved best management practices. No later than January 1, 2012, new vessels will be required to comply with the IMO D-2 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). The State Disposal System permit expires in September 2013 and the MPCA is currently reviewing the discharge limitations and implementation schedule.

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. The permit was modified April 1, 2011. Among its provisions, the modified permit sets ballast water performance standards equivalent to the IMO D-2 standard. Vessels constructed on or after January 1, 2012 must meet the standard set forth in the permit. Existing vessels have until January 1, 2014 to comply.

IV. REGULATORY OVERVIEW: VESSEL BIOFOULING

While ballast water management has progressed substantially over the past thirteen years, until recently, comparatively little attention has been directed towards managing NIS introductions via vessel biofouling. Over the past few years, several countries and international organizations have developed voluntary commercial vessel biofouling management guidelines to address NIS introductions, while working towards developing mandatory requirements. However, currently there is no mandatory set of broad biofouling management requirements for commercial vessels anywhere in the world. Some regions have implemented restrictions on the use and cleaning of certain antifouling coatings applied to submerged portions of vessels, because many antifouling coatings discourage organism attachment by slowly releasing biocides or other toxic substances. Though such regulations were established to address water quality concerns, they also affect NIS associated with biofouling. The following is a summary of current and proposed vessel biofouling guidelines, laws, regulations, and permits by jurisdiction (excluding California, which is described in Section V).

The International Maritime Organization

International Convention on the Control of Harmful Antifouling Systems on Ships

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 shipping 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 biofouling, 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-based 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, indicating that the antifouling system currently used complies with the AFS Convention (IMO 2001).

On October 15, 2010, the U.S. Coast Guard Authorization Act of 2010 was signed into law, directing the Secretary of Homeland Security to administer and enforce the AFS Convention in the U.S., with this authority delegated to the Commandant of the USCG. On December 9, 2011, the USCG adopted a Final Rule amending 46 CFR 8.320(b) by adding the International Anti-fouling System Certificate to the current list of international convention certificates.

Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species

Recognizing the risk of NIS associated with vessel biofouling, the IMO MEPC developed and adopted the Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species (Biofouling Guidelines) in July 2011 (IMO 2011). The Biofouling Guidelines are intended to provide practical guidance and useful recommendations on general measures to minimize the risks associated with biofouling for all vessel types. The central components of the Biofouling Guidelines are a ship-specific Biofouling Management Plan and Biofouling Record Book, both of which are to be kept onboard the vessel. The Biofouling Management Plan is intended to outline the biofouling management measures to be undertaken on a ship, while the Biofouling Record Book is intended to house records of biofouling management practices.

The Biofouling Guidelines also include practical guidance on measures to reduce the risk of transferring NIS as a result of vessel biofouling. The most important piece of guidance provides suggestions for the proper selection, installation, and maintenance of antifouling systems (including coatings), with particular attention to niche areas that tend to accumulate biofouling more readily than the exposed hull. The selection of antifouling systems that are appropriate for the specific physical and operational characteristics of a ship is vital to effective biofouling management. The Biofouling Guidelines also include guidance on effective and appropriate in-water inspection, cleaning, and maintenance practices, as well as design and construction considerations to minimize biofouling accumulation, particularly by reducing the size and number of niche areas.

The Biofouling Guidelines are voluntary, and thus their ability to reduce the risk of NIS introduction into California and other coastal regions worldwide is entirely dependent on their voluntary adoption and implementation by shipping fleets across the globe. Time will tell whether voluntary adoption of these guidelines is occurring, and whether the risk of biofouling-mediated NIS introductions is reduced as a result.

National and Regional 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 biofouling. The Australian guidelines encourage vessels to utilize antifouling coatings in accordance with the AFS Convention, and to ensure they are utilized in niche areas where biofouling tends to accumulate more rapidly than on the 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, although the level of frequency is not specified. The installation and regular operation of marine growth prevention 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).

On December 1, 2011, Australia's Department of Agriculture, Fisheries, and Forestry (DAFF) released a consultation Regulatory Impact Statement (RIS) to accept public comments on Proposed Australian Biofouling Management Requirements. The RIS explored the costs and benefits of two options for managing the risk of NIS associated with biofouling becoming established in the Australian marine environment: 1) Introduction of regulations that would impose restrictions on vessels; or 2) Implementation of an education program to encourage voluntary biofouling management. The public comment period officially closed on February 29, 2012, and DAFF is currently considering the data and comments received and will use them to develop and analyse the final biofouling management policy, which they expect to consider for final adoption in early 2013.

State of Western Australia

The Australian state of Western Australia has several current legislative and regulatory restrictions and requirements to address vessel biofouling. Owners and Masters of vessels arriving to Western Australian ports from international waters, another state or territory within Australia, or from another area from within the state of Western Australia are required to ensure marine pests and diseases are not being carried in their vessels' ballast water or on their hulls. It is an offense under the Fish Resources Management Act of 1994 (FRMA) and the Fish Resources Management Regulations of 1995 to transport species that are not native to Western Australia. The FRMA provides state authority to manage marine pests and to minimize the risk of their introduction and spread in Western Australia waters. The powers also enable Western Australia to make directions to, and recover costs from, persons considered responsible for the biological threat.

Western Australia is also working towards the development of new strategies to reduce the risk of NIS introductions from vessel biofouling. These new strategies will likely include increased requirements for per-vessel risk assessments and inspections for a wide range of vessels visiting or operating in Western Australia waters. These strategies are still in development, and Commission staff will continue to closely monitor Western Australia's progress.

New Zealand

Biosecurity New Zealand is developing measures to reduce the risk of biological invasions via vessel biofouling. Background and consultation documents were distributed in mid-2010, describing recent research on the invasion risk posed by vessel biofouling 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. Biosecurity New Zealand 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). Public input was collected until June 10, 2010, and the division is currently reviewing and analyzing the submitted comments and expects to make a policy decision in early 2013.

Australian and New Zealand Environment and Conservation Council

In 1997, the Australian and New Zealand Environment and Conservation Council (ANZECC) published a Code of Practice for Antifouling and In-water Hull Cleaning and Maintenance (ANZECC 1997). This Code of Practice was developed in response to dual concerns over the toxic effects of antifouling biocides (particularly TBT and copper-based compounds) on the marine environment and the potential of in-water hull cleaning practices to facilitate the establishment of NIS. The Code provides guidance to ship owners and operators, other members of the shipping industry, and government on the application, maintenance, removal, and disposal of antifouling coatings, as well as guidance on in-water hull cleaning and maintenance.

Since the release of the ANZECC Code of Practice in 1997, a number of significant changes have occurred within the maritime industry, including ratification of the IMO AFS Convention and adoption of the IMO Biofouling Guidelines, as well as changes to antifouling coating technologies and vessel biofouling management practices. In light of these changes, the governments of New Zealand and Australia decided to review and revise the 15-year old Code of Practice to reflect the current state of knowledge about the costs and benefits of in-water cleaning operations. In October 2011, Australia and New Zealand simultaneously released the draft Anti-fouling and In-water Cleaning Guidelines (DAFF 2011a, 2011b, MAF 2011) for consultation and public comment. The public comment period for both of these agencies closed in late November 2011..

United States Federal Biofouling-Related Provisions of the Vessel General Permit

In addition to the regulation of ballast water, the EPA's 2008 Vessel General Permit also limits discharges originating from antifouling hull coatings, underwater ship husbandry, and seawater piping biofouling prevention. Antifouling hull coatings and chemicals used for seawater piping biofouling protection must be either registered according to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) 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 2008 VGP, and, as in the AFS Convention, vessels must remove such coatings or paint over them to prevent leaching of TBT. Under the 2008 VGP, underwater ship husbandry must be conducted in a manner that minimizes the discharge of biofouling organisms and antifouling hull coatings, and the cleaning of copper-based antifouling coatings must not produce a visible plume of paint.

The draft 2013 VGP (see Section III for description of ballast water requirements) would also regulate discharges associated with antifouling coating leachate, seawater piping biofouling prevention, and underwater ship husbandry discharges. These proposed 2013 VGP requirements are nearly identical to the corresponding requirements found in the 2008 VGP. The only significant addition to the draft requirements is text encouraging, "when feasible, attempts…to minimize the release of fouling organisms and antifouling systems (including copper-based coatings) into surrounding waters" during underwater ship husbandry operations.

U.S. State Hull Cleaning Certifications Under the Vessel General Permit

Three states included requirements related to hull cleaning and maintenance as part of their CWA Section 401 certifications of the 2008 VGP (EPA 2009). Massachusetts and Maine both prohibit in-water cleaning and biofouling removal. However, the rationale for implementing these restrictions differed between the two states. Maine prohibits in-water cleaning for water quality reasons, whereas Massachusetts did so to prevent NIS spread. With the exception of propeller polishing, the Water Board (California) has placed restrictions on in-water cleaning, but these restrictions vary depending on the type of coating applied to the vessel and the California water body where the cleaning will take place. Vessels coated with biocide-free antifouling coatings can be cleaned in all State waters, as the Water Board has deemed these coatings to be a "best available technology." However, vessels with biocidal coatings cannot be cleaned in certain waters that are listed in the EPA CWA Section 303(d) list as impaired for copper and (generic) metals, including the Ports of Los Angeles, Long Beach, and Oakland Inner Harbor (SWRCB 2009).

Because the draft 2013 VGP and the state-specific Section 401 certifications will not be final until the EPA publishes the final VGP in early 2013, there is the possibility that states will include additional requirements in their 2013 certifications beyond those included in 2008. Commission staff will review the final VGP when it is released and will continue to track the state-specific biofouling management requirements that are included.

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 threat at a time when national regulations were not mandatory. This legislation, 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). The MISP is funded through fees assessed on vessels arriving to California ports. The fees collected were deposited into the Exotic Species Control Fund, later renamed the Marine Invasive Species Control Fund, to fund all aspects of the program. The fee amount is set in regulation, and therefore is adjustable to account for inflation and changes to vessel arrival statistics. The amount of the fee has been raised and reduced several times since implementation, each time in consultation with a stakeholder advisory group. The current fee amount of $850 for the first California arrival of a voyage has remained steady since it was adjusted in November 2009 and is currently sufficient to cover all aspects of the MISP.

AB 703 required that vessels entering California from outside the U.S. EEZ manage ballast water before discharging into state waters. Vessels were required to exchange ballast water 200 nm offshore, retain all ballast water on board, discharge to an approved reception facility, or use an approved alternative management method. 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 at a time when federal action was expected, included a sunset date of January 1, 2004 in AB 703.

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 applies to all U.S. and foreign vessels 300 gross registered tons and above that arrive to 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 (CCR) 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 ports after operating within the PCR to conduct BWE at least 50 nm from shore in waters at least 200 m deep prior to discharging into California waters.

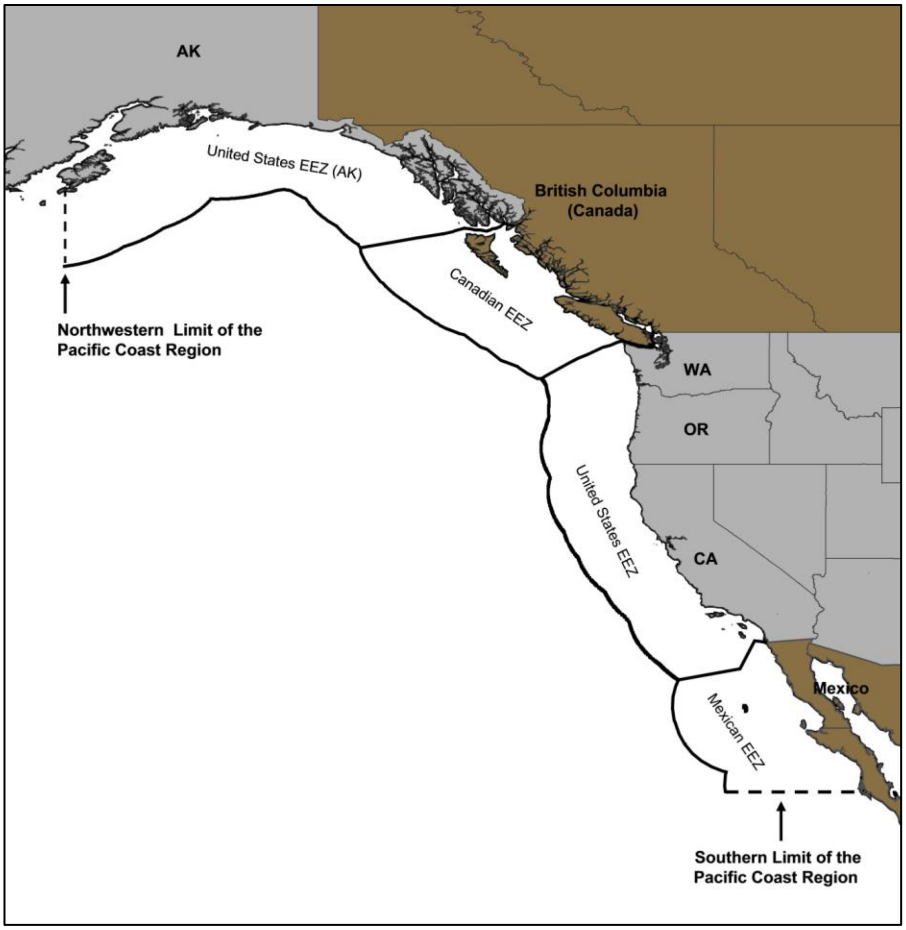


Figure V.1. Exclusive Economic Zones of Pacific North America (200 nm), and the Pacific Coast Region (PCR). The PCR extends from approximately Cooks Inlet, AK (154° west longitude) to ¾ down the Baja Peninsula (25° north latitude) and 200 nm offshore.

Performance Standards for Ballast Water Discharge

The 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 standards recommended by the majority of the panel 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 CCR § 2291 *et seq*. (see Tables III.1 and III.2).

The Coastal Ecosystems Protection Act also directed the Commission to review the efficacy, availability and environmental impacts of currently available ballast water treatment systems by January 1, 2008. This initial ballast water treatment technology assessment report was approved by the Commission in December 2007 (see Dobroski et al. 2007). In response to the recommendations in the 2007 report, the California Legislature passed Senate Bill (SB) 1781 (Chapter 696, Statutes of 2008) which, among its provisions amended PRC Section 71205.3 and delayed the initial implementation of California's performance standards for newly built vessels with a ballast water capacity of less than or equal to 5000 metric tons (MT) from January 1, 2009 to January 1, 2010 (see Table III.2 for implementation schedule). Additionally, SB 1781 required an update of the treatment technology assessment report by January 1, 2009. The 2009 report (see Dobroski et al. 2009) recommended that the Commission proceed with the initial implementation of California's performance standards beginning January 1, 2010 for newly built vessels with a ballast water capacity of less than or equal to 5000 MT.

Additional reviews must be completed 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). 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.

In August 2010, the Commission presented its third treatment technology assessment report (California State Lands Commission 2010) to the Legislature evaluating the availability of ballast water treatment systems for newly built vessels (i.e. construction began on or after January 1, 2012) with a ballast water capacity of greater than 5000 MT. Vessels within this category were required to meet the standards beginning January 1, 2012. The August 2010 report concluded that the lead time available for further technology development and refinement was sufficient to indicate that technologies were developing on schedule and would be available by the time these vessels must meet California's discharge standards.

As of January 1, 2012, all newly built vessels that discharge ballast in California waters must comply with California's performance standards. This includes vessels with a ballast water capacity at or below 5000 MT built on or after January 1, 2010, and vessels with capacity above 5000 MT built on or after January 1, 2012. Vessel construction often takes a year or more, and the first vessels that must meet the performance standards began arriving in California during late-2011 and 2012. As of July 2012, however, none of the vessels subject to these requirements had discharged ballast in California.

The next treatment technology assessment report will be presented to the Commission in 2013 and addresses the availability of ballast water treatment systems for existing vessels built before January 1, 2010, with a ballast water capacity between 1500 and 5000 MT. These vessels must comply with California's performance standards beginning January 1, 2014.

Implementing California's Performance Standards

Commission staff continue to work with stakeholders to evaluate plans to implement California's performance standards for the discharge of ballast water. 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 is focusing on dockside inspection of vessels for assessment 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 prior two years. If vessels opt to use shipboard ballast water treatment systems to comply with California's performance standards, information on the installation and use of shipboard systems will be needed to monitor compliance with the performance standards. Based on recommendations in Dobroski et al. (2009), AB 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." These forms were adopted through the California rulemaking process in October 2010 (see 2 CCR § 2297.1).

During an inspection, once Commission staff has reviewed applicable vessel paperwork and interviewed the crew, 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 currently 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 intending to discharge in California waters 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 and the EPA's Environmental Technology Verification protocols with additional input provided by the USCG (MEPC 2008, EPA 2010). 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 intending to discharge in California waters by the same year that they must comply with California's performance standards.

Commission staff is also in the process of developing ballast water sampling and compliance assessment protocols that would be utilized if a paperwork review and initial rapid assessment tests indicated potential noncompliance. The current draft of these ballast water sampling protocols was developed using the EPA's ETV protocols as a template and has been vetted by scientific and marine engineering experts on the MISP ballast water technical advisory group (TAG). As directed by the Commission, these protocols have also been independently reviewed by another group of scientific experts. Commission staff expects to continue work on this rulemaking in 2013.

Vessel Biofouling

Among its provisions, the 2003 Marine Invasive Species Act directed the Commission to analyze and evaluate the risk of NIS release from commercial vessel vectors other than ballast water (essentially vessel biofouling) in a report to the Legislature, developed in consultation with a TAG. The ensuing 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 biofouling.

In October 2007, the Governor signed AB 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 biofouling organisms from vessel hulls, piping, propellers, sea chests and other wetted portions of vessels on a regular basis. The Commission was also given authority to collect hull husbandry (e.g. dry-docking, in-water cleaning) and other biofouling-related information from vessels operating in California to fill key information gaps. This data was identified in the 2006 report to the Legislature as a critical need to help inform the development of any future management actions. In consultation with a biofouling-specific TAG, the Commission developed and adopted the Hull Husbandry Reporting Form (HHRF) in 2007, and has been collecting this detailed information annually from the California fleet since January 2008 (see Section VI for a summary of HHRF data).

The information provided in the HHRFs is used in conjunction with results from MISP-funded biological research on the occurrence and ecology of biofouling organisms on ships (see Section VII), other emerging research on commercial vessel biofouling to develop regulations governing the management of biofouling, as directed by AB 740.

In collaboration with regional partners and a TAG of industry representatives, regulators, IMO delegates from Canada and New Zealand, and scientists, Commission staff set out to develop the mandated biofouling management regulations in 2010. Technical advisory group meetings were held in August and October 2010, and February and April 2011. TAG meetings centered on the current state of the science surrounding vessel biofouling, approaches being undertaken by the IMO and other countries, and discussions of initial drafts of the regulation. The overall focus of the draft biofouling regulations has been to address niche areas and ships with extended residency periods while maintaining international consistency with the IMO.

Public comments and industry concerns have been incorporated into a total of seven different drafts to date (including all TAG drafts and public drafts), making accommodations to the proposed regulation while maintaining the Commission's mandate to reduce the risk of NIS introductions through the vessel biofouling vector. The most recent comment period closed in July 2012, and as of September 2012 the one-year deadline to finalize a rulemaking action under California's Administrative Procedures Act had expired. As a result, Commission staff will reintroduce a revised draft of the proposed regulations in 2013.

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 presentations at industry and scientific events.

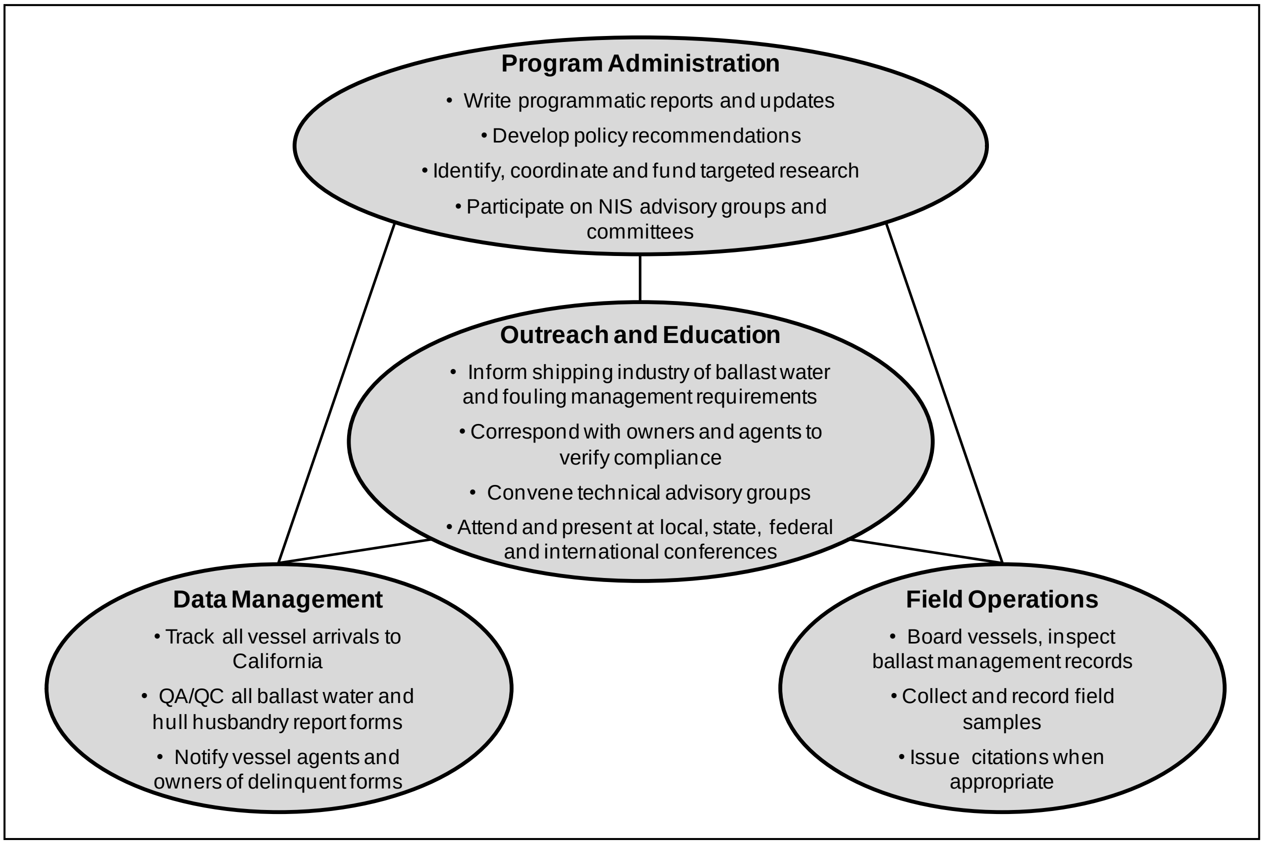


Figure V.2. Marine Invasive Species Program Components and Associated Functions

Marine Invasive Species Program Data Management

MISP data management staff tracks ballast water management, compliance and enforcement of more than 800 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 vessels that neglect to submit forms. Between July 2010 and June 2012, over 18,600 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 has continual contact with ship officers and agents, relaying information about MISP requirements. Staff coordinates information requests with field operations staff, so Marine Safety Inspectors can ensure that necessary information is delivered to or gathered from a vessel's crew when boarding.

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.

Marine Invasive Species Program 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 program requirements. Though the central role of inspectors/inspections is to enforce laws that vessels must obey in order to reduce the release of NIS 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 the agencies to which paperwork must be submitted. Education and outreach is considered one of the key drivers for the high compliance rates observed within California (see Section VI).

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 2003 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 legally 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 parts per thousand (ppt). Commission staff has recently proposed regulations to establish protocols that will be used by Marine Safety personnel and Commission scientists to assess vessel compliance with the ballast water discharge standards.

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 assessing compliance with the management requirements of the MISP, 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 Environmental Research Center (SERC), San Francisco State University, Moss Landing Marine Laboratories (MLML), and Portland State University (PSU).

Marine Invasive Species Program Administration and Policy Development

MISP administrative staff works closely with the data management and field staff teams in order to assess vessel compliance, 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, federal, and international 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 biofouling vectors.

In addition to the regulatory directives, the Act includes mandates to address management gaps to improve the Commission's ability to prevent NIS introductions from commercial vessel vectors. MISP administrative staff frequently assembles 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 and concerns of affected stakeholders, while fulfilling legislative mandates. The TAG 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 TAGs to discuss regulations for ballast water management within the PCR, the setting of performance standards for ballast water discharge, regulations for ballast water discharge compliance assessment, biofouling management regulation development, changes to the MISP fee, the development of forms to collect vessel biofouling and ballast water treatment technology data, and for assessments of ballast water treatment technologies.

Administrative staff also represents the MISP at 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. Commission staff are members of numerous working groups, including (but not limited to) the California Agencies Aquatic Invasive Species Team, the Pacific Ballast Water Group, the state of Washington's Ballast Water Working Group, the state of Oregon's Shipping Transport of Aquatic Invasive Species Task Force, the state of Hawaii's Alien Aquatic Organism Taskforce, and the Coastal Committee of the Western Regional Panel on Aquatic Invasive Species. Staff have also received invitations to speak or participate on committees/panels, including (but not limited to), the Great Lakes Ballast Water Collaborative, the North America Marine Environment Protection Association (NAMEPA), ETV Advisory and Stakeholder Panels, the California Invasive Species Advisory Council, and the Bay Planning Coalition (San Francisco, CA). 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 International Congress on Marine Corrosion and Fouling, the California and the World Oceans Conference, the Bay-Delta Science Conference (formerly the CalFED Science 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.

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 biofouling, 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.

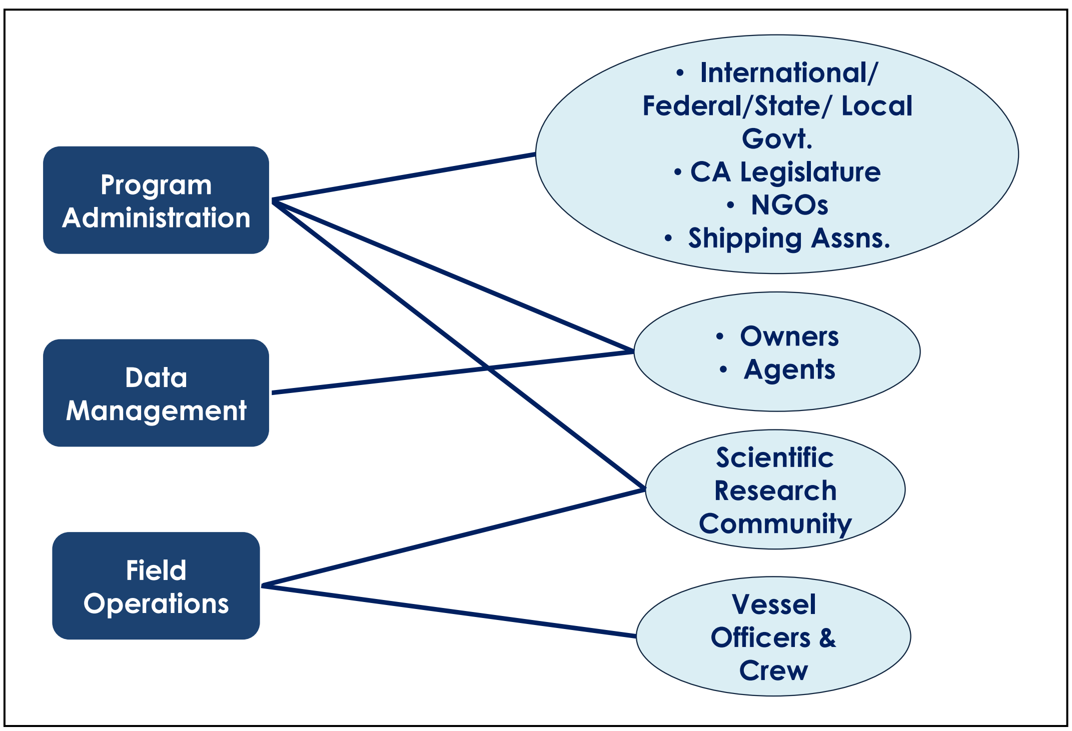


Figure V.3. Marine Invasive Species Program Information Exchange with Stakeholders

VI. DATA ANALYSIS

Trends in Statewide Vessel Traffic

Ballast Water Reporting Requirements

Under the Act (Chapter 491, Statutes of 2003), the master, owner, operator, agent, or person in charge of a vessel is required to submit the “Ballast Water Reporting Form” (see Appendix A for copy) 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 arriving to a California port or place. Commission staff 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, 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 reported 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) compliance 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, see Figure V.1) and foreign (arriving from outside of the PCR) vessel traffic to California ports. 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 2010 through June 2012. For purposes of data analysis and reporting, the six-month period from January through June of each year will be indicated as “a” and the period from July through December will be indicated as “b.” Between 2010b-2012a, 97% of QVs to California ports or places were compliant with reporting requirements, and 88% of QVs were both compliant and submitted forms on time (Figure VI.2).

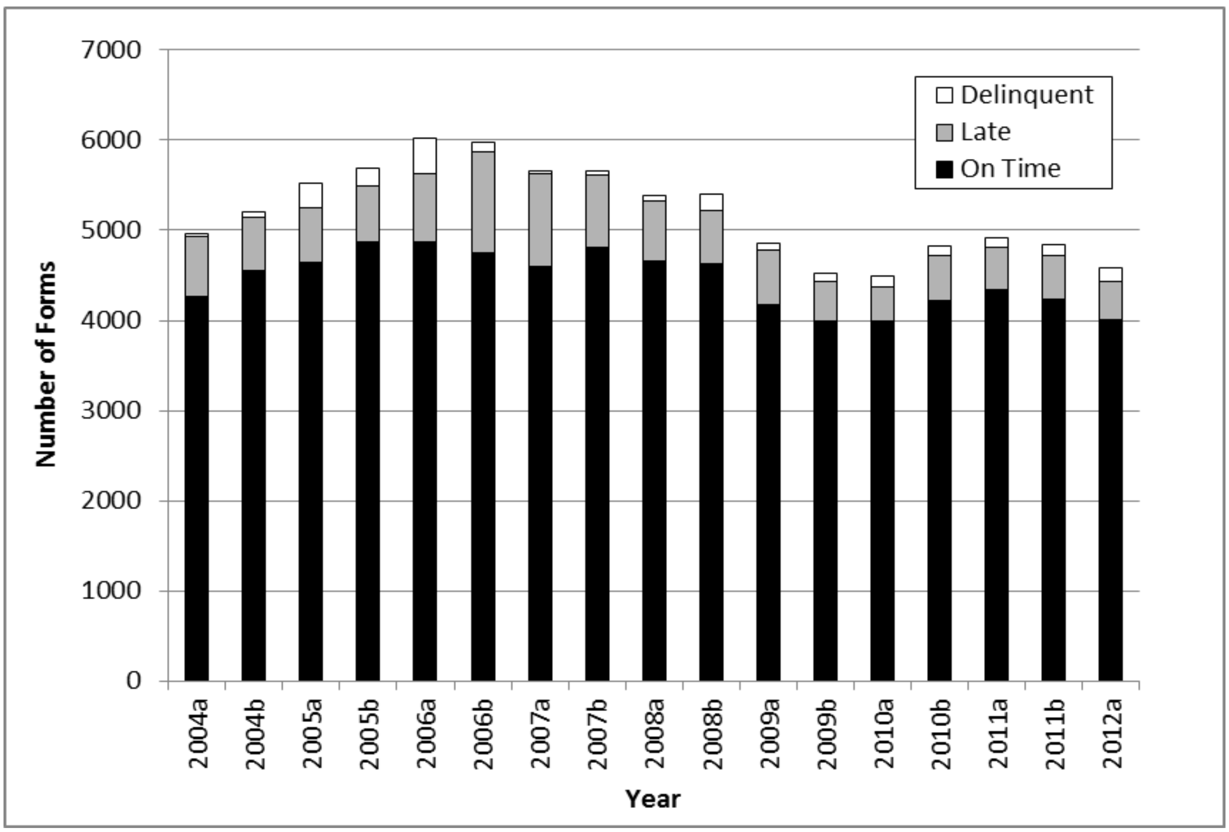


Figure VI.2. Compliance with Requirement to Submit the Ballast Water Reporting Form (a = January to June, b = July to December)

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. After a fairly steady decrease in vessel traffic from 2006a through 2010a (Figure VI.3), QV arrivals gradually increased during the first two six-month periods of this report (2010b-2011a), before slightly decreasing during the last two six-month periods (2011b-2012a). The recent slight upswing in the economy has likely contributed to the modest increase in vessel arrivals since late 2010 as more foreign consumer goods are imported from overseas ports.

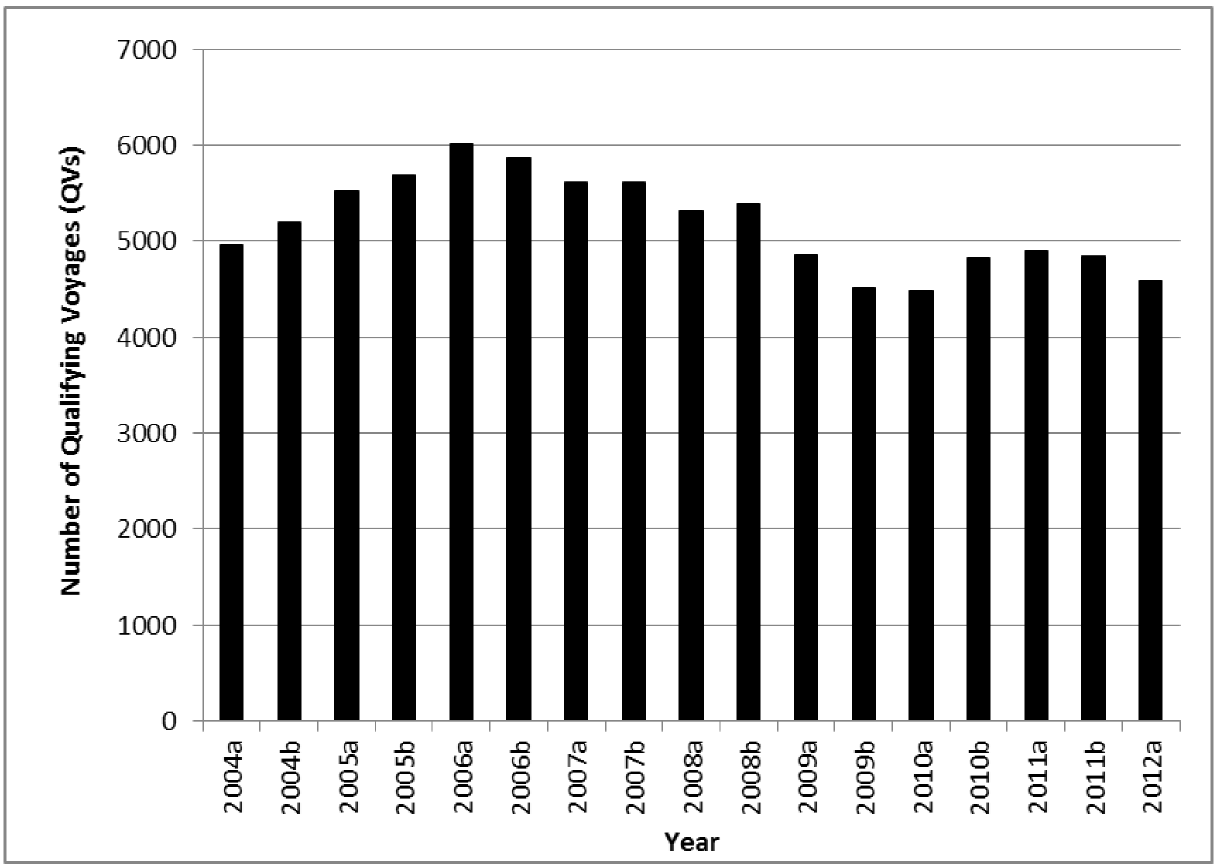
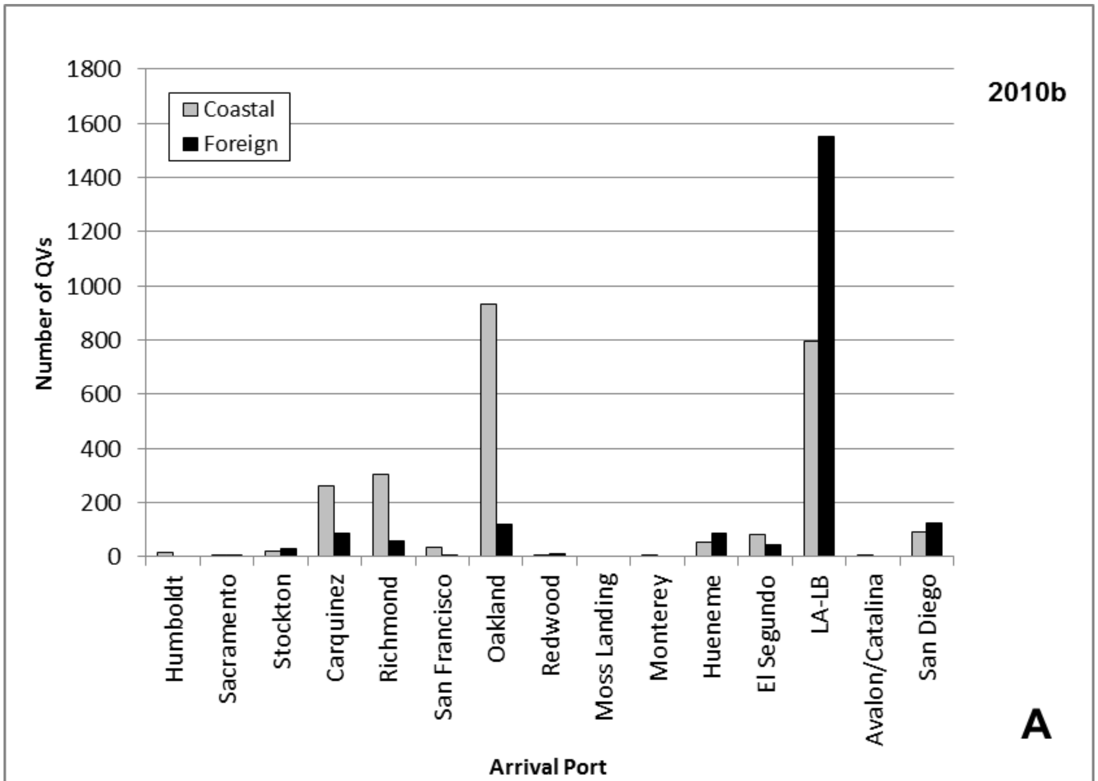


Figure VI.3. Number of Qualifying Voyage (QV) Arrivals to California Ports (a = January to June, b = July to December)



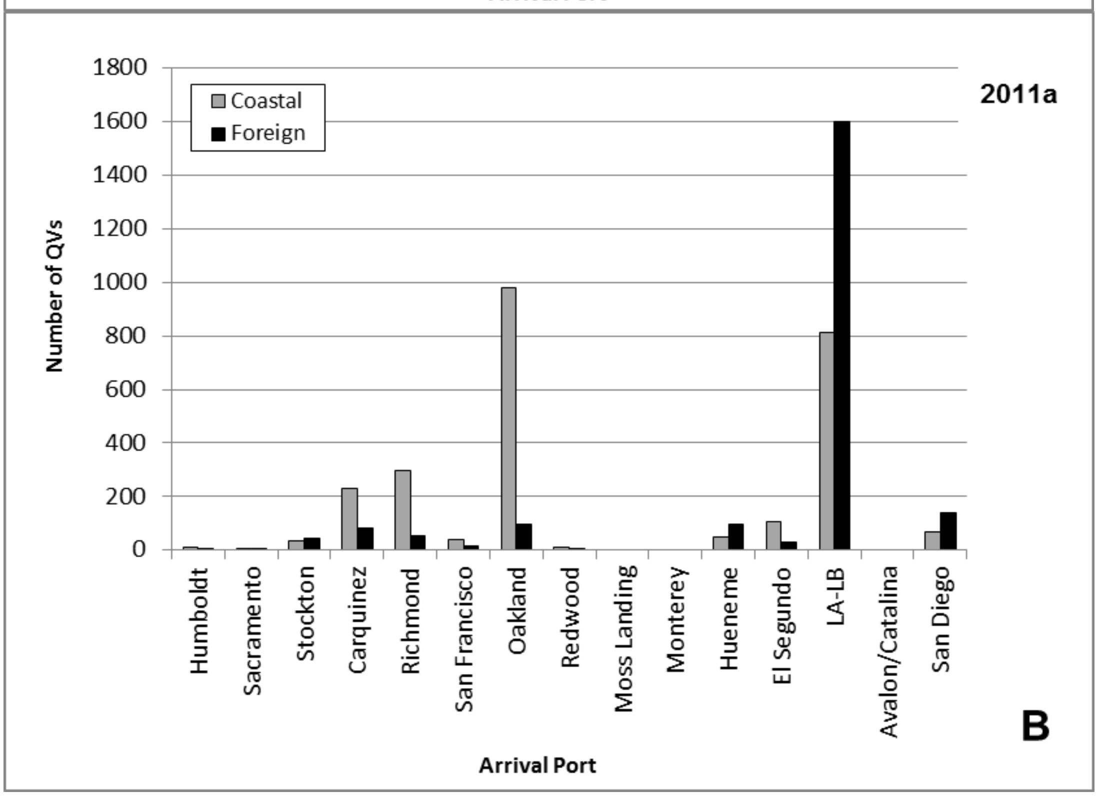
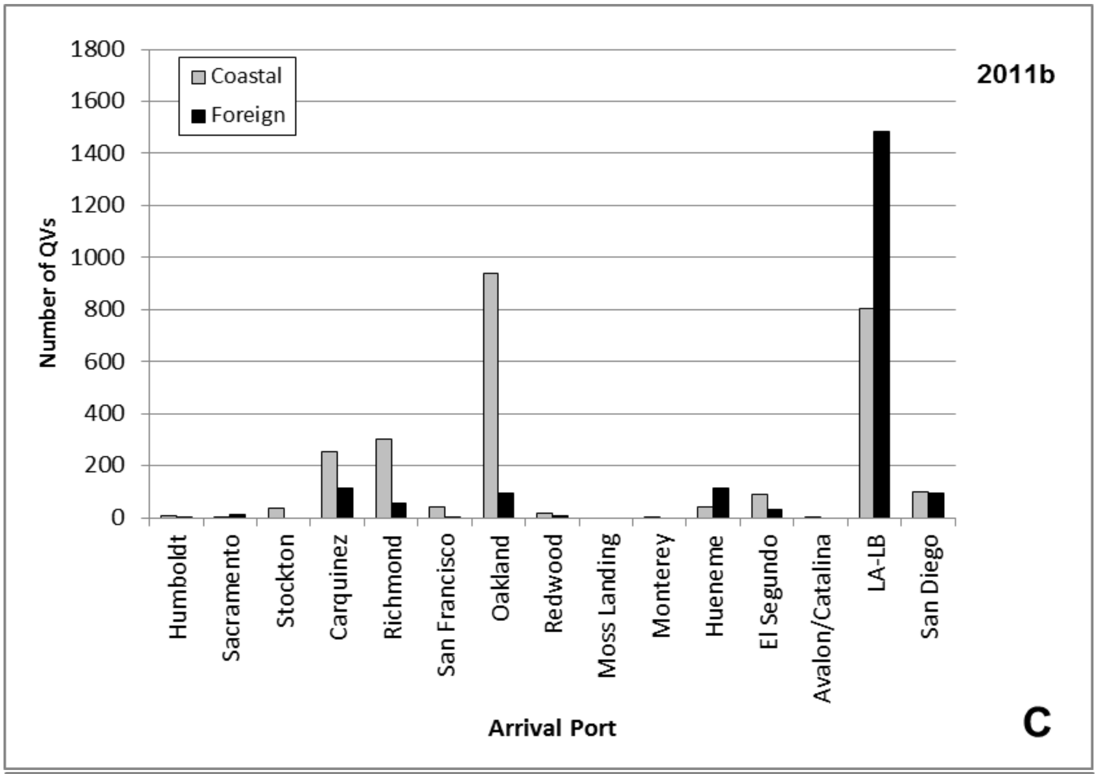


Figure VI.4. Distribution of Qualifying Voyage (QV) Arrivals by Port. Coastal voyages originate from Pacific Coast Region (PCR) ports, foreign voyages originate from non-PCR ports (see Figure V.1 for map of PCR).



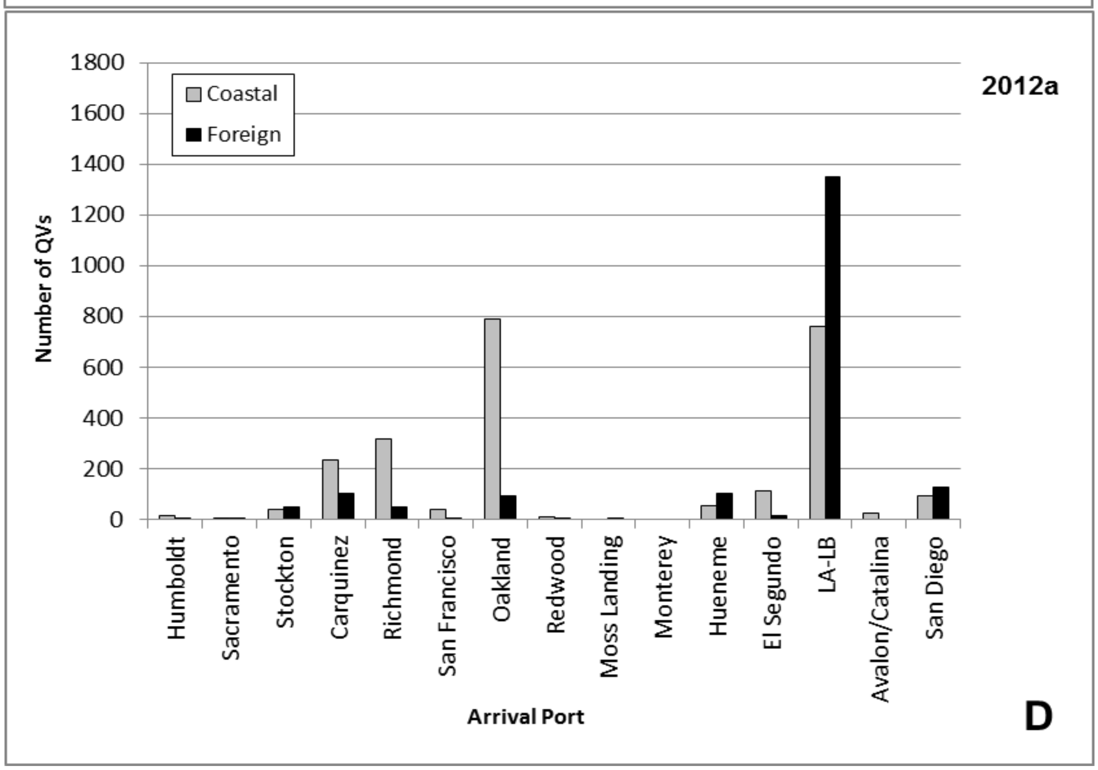


Figure VI.4 (continued). Distribution of Qualifying Voyage (QV) Arrivals by Port. Coastal voyages originate from Pacific Coast Region (PCR) ports, foreign voyages originate from non-PCR ports (see Figure V.I for map of PCR).

While the total number of QV arrivals is still down from the height of early-2006, the distribution of QV arrivals by port has remained consistent with previous reports (Figure VI.4 A-D, Falkner et al. 2007, 2009, Takata et al. 2011). As in previous years, the LA-LB Port Complex leads the state in arrivals, receiving 49% of all QVs to California ports between 2010b and 2012a. During this time, LA-LB received more foreign arrivals than any other port in California (a total of 5986 foreign QVs), and was a close second (3191) behind the Port of Oakland (3641) for the total number of coastal arrivals. Foreign arrivals accounted for two-thirds (65%) of total vessel traffic to LA-LB (Figure VI.4 A-D). While Oakland received comparable numbers of coastal arrivals as LA-LB, Oakland received less than a tenth of LA-LB's total number of foreign arrivals (Oakland = 409 total) (Figure VI.4 A-D). The percentage of foreign arrivals to Oakland (10%) remained consistent with the previous reporting period (2008b-2010a, see Takata et al. 2011), but still represents an overall decline from the high of 15% between 2006b and 2008a (Falkner et al. 2009).

In contrast to the drop in the proportion of foreign vessel arrivals reported between 2008b-2010a (Takata et al. 2011), Ports Hueneme and San Diego experienced minor increases during 2010b-2012a (2% and 1%, respectively; Figure VI.4). These modest gains likely reflect the current economic climate, which has been slowly gaining momentum.

The type of vessels calling on each of California's ports varies as a result of differences in local industry, demand, and port infrastructure (e.g. the presence of container cranes) (Figure VI.5). Container and tank vessels are by far the most common vessel types to call on California, representing more than two-thirds of all arrivals to the state between 2010b and 2012a (Container 48%, Tank 21%, Figure VI.5). The Ports of LA-LB and Oakland combined received 99% of all container vessel traffic to California ports. Forty-two percent of all tank vessels arrive to LA-LB with the remainder largely divided between the Ports of Richmond (22%), Carquinez (20%), and El Segundo (12%) (Figure VI.6 B). The Ports of LA-LB received the majority of bulk (54%) and passenger (60%) vessel arrivals to California (Figure VI.6 A). The majority of the remaining passenger vessels calling on California arrive to the Port of San Diego (23%) and the Port of San Francisco (13%). Auto carriers primarily arrive to LA-LB (32%), San Diego (28%), Hueneme (22%), and Carquinez (9%). Unmanned barges predominately arrive to LA-LB (34%), Carquinez (29%), and Richmond (28%).

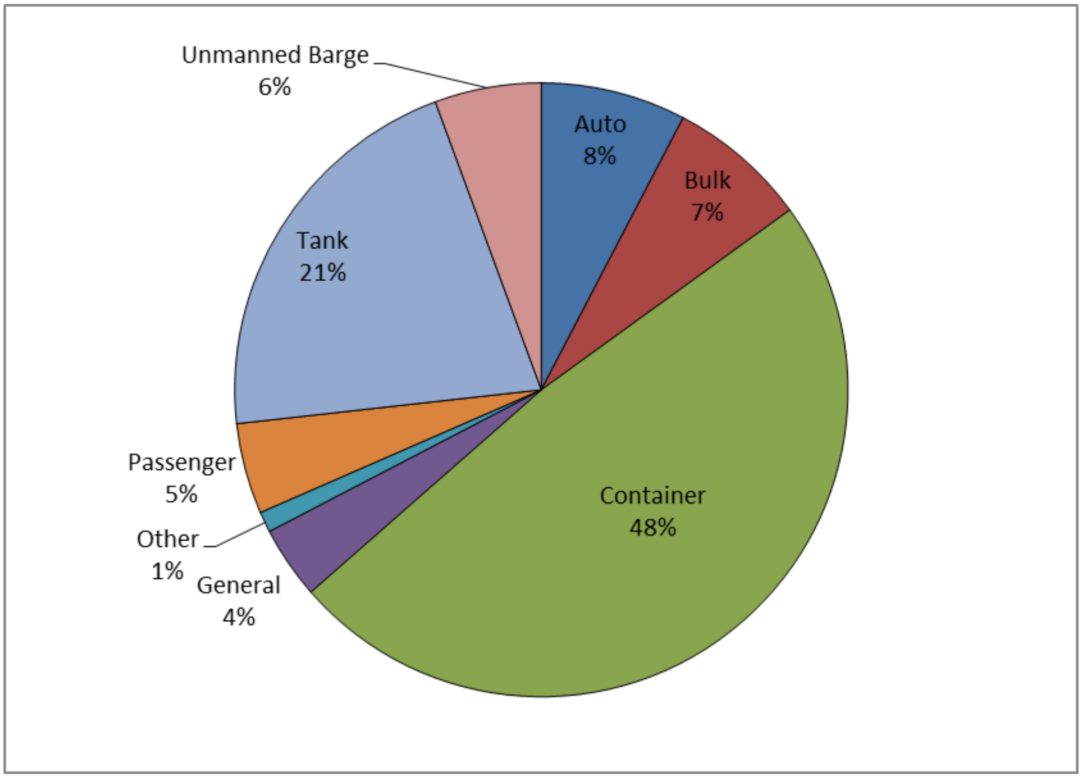


Figure VI.5. Percent of QV Arrivals to California by Vessel Type (2010b-2012a)

Since July 2010, nearly 56% of all arrivals to California originated from within the PCR (Figure VI.7, see Figure V.1 for map of PCR), representing a 6% increase over the previous reporting period (July 2008 through June 2010). Forty percent of QV arrivals to California ports came from other California ports (up 4% from previous report), 6% originated in Washington State, 3% 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") accounting for 24% of all QVs), followed by approximately 7% from foreign (non-PCR) Mexican ports, and 6% from Central America (Figure VI.7).

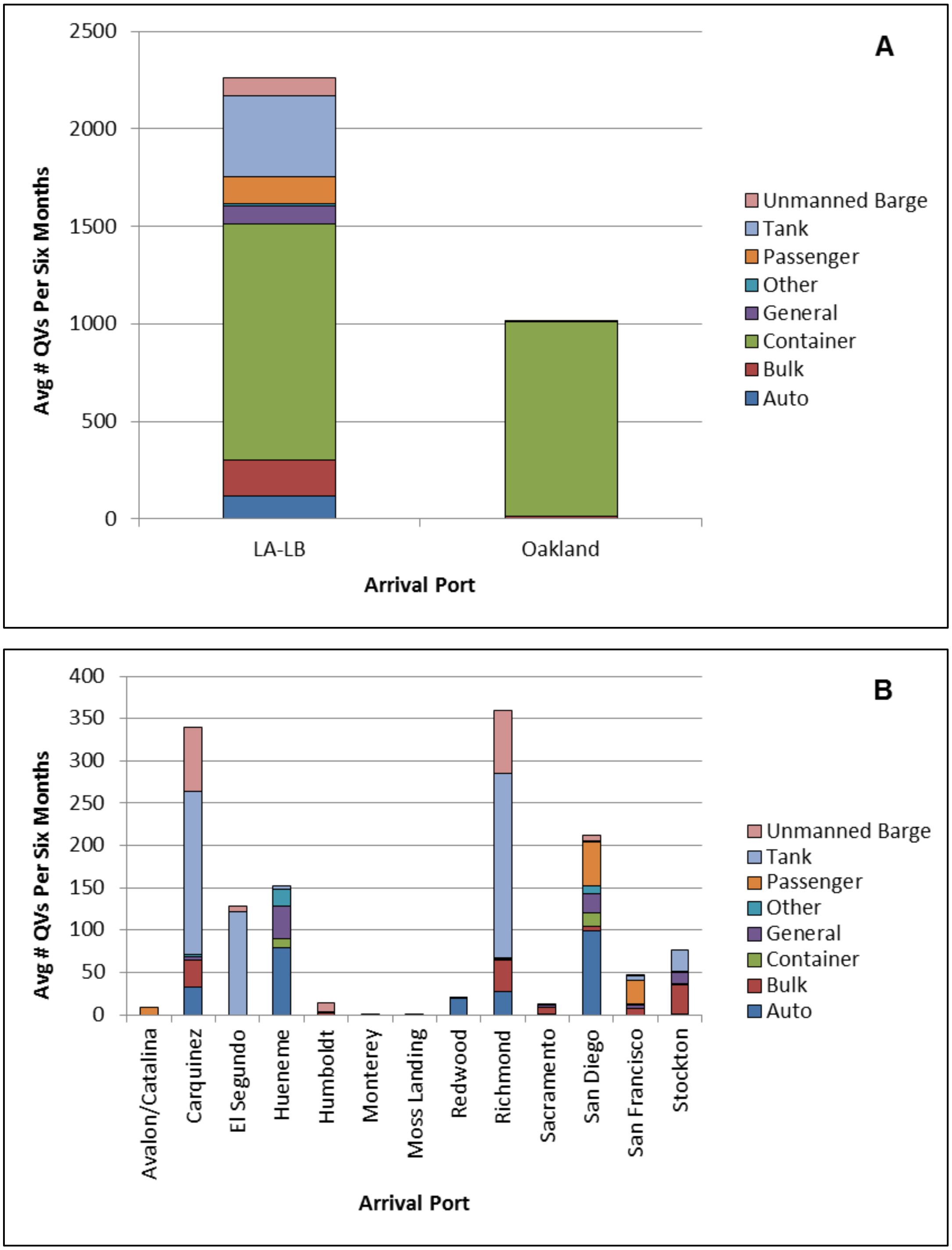


Figure VI.6. Average Number of Arrivals per Six-Month Period by Vessel Type and Port (2008b –2010a) for Oakland and LA-LB (A) and the Remaining California Ports (B). Note that the scales are not the same across panels.

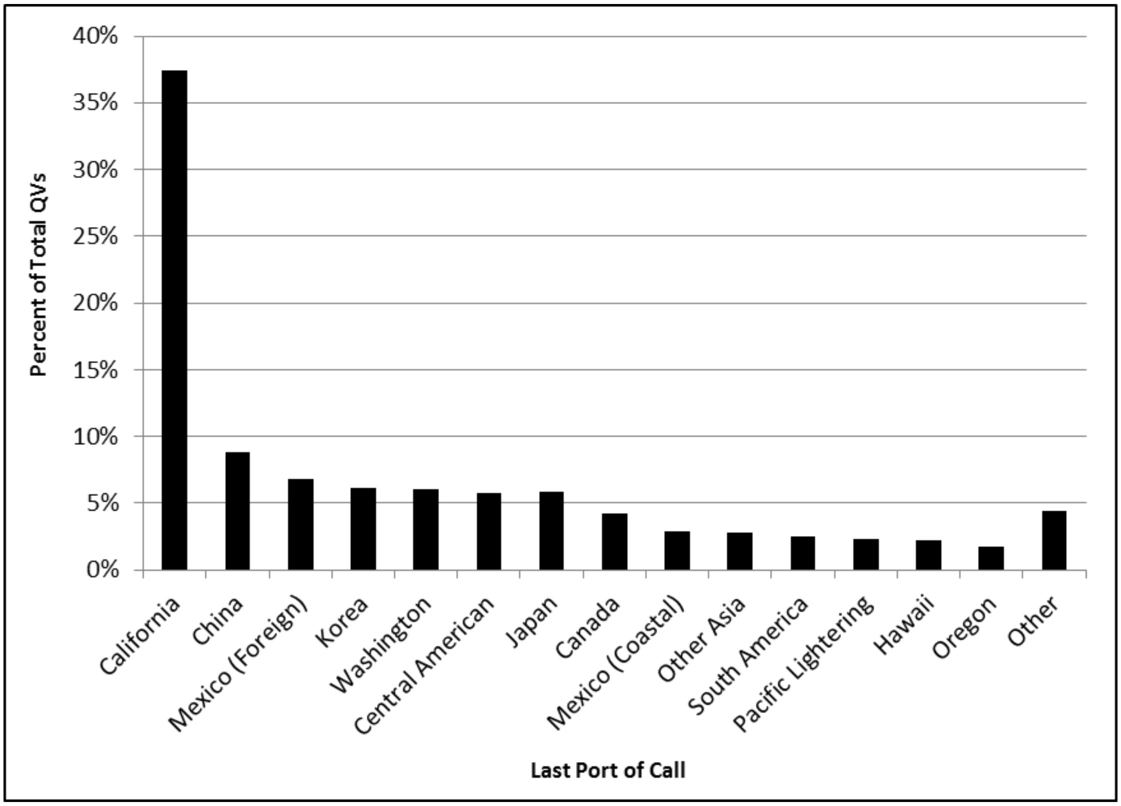


Figure VI.7. Last Port of Call for Qualifying Voyages (QVs) to California Ports (2010b-2012a)

Ballast Water Discharge, Management, and Compliance

Ballast Water Discharge Patterns

The risk of NIS introductions through ballast water discharge is founded on numerous 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, as reported by vessels on Ballast Water Reporting Forms, provides valuable background that may be used to frame relative trends and risk of species introductions into and throughout the State.

Not every vessel that enters California discharges ballast water. Factors such as vessel type, loading and unloading of cargo, and a vessel's particular route all determine ballasting needs. Vessels that do not discharge any ballast water within state waters pose zero risk of NIS introductions through the ballast water vector (see Section II for discussion of NIS introduction risks due to vessel biofouling); therefore, retention is currently the most protective management strategy available. Since 2004, the proportion of QVs reporting retention of all ballast water on board while in state waters (i.e. not discharging) has steadily remained between 83% and 86%. (Figure VI.8).

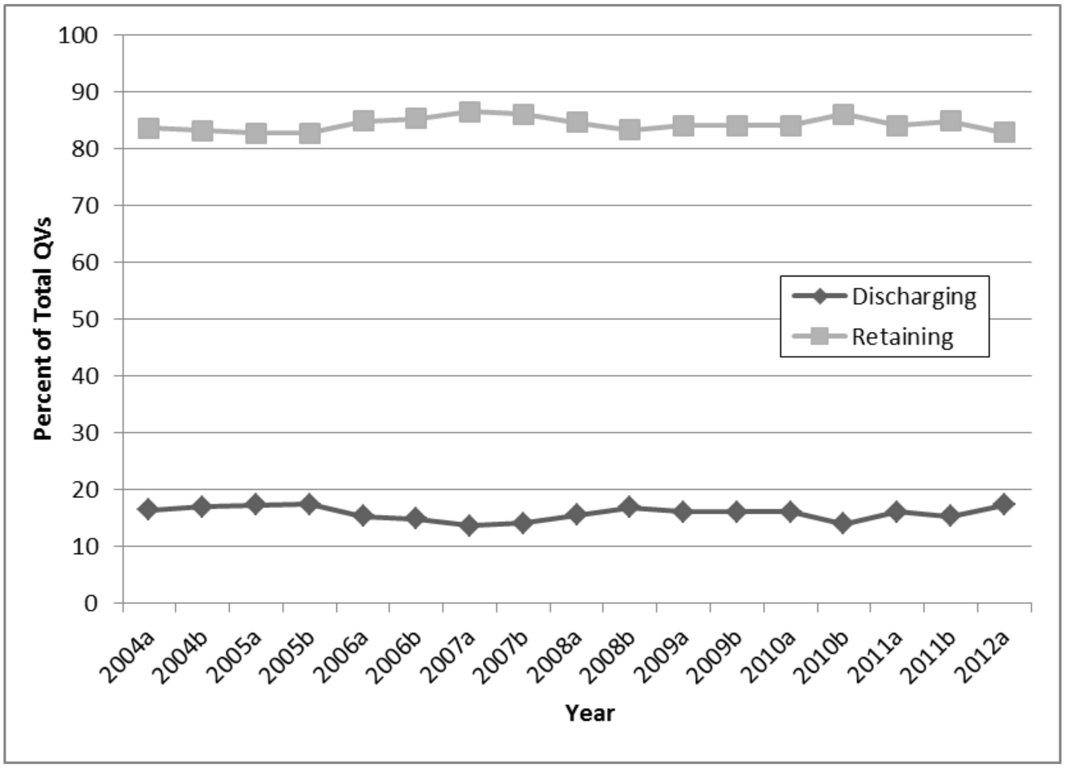


Figure VI.8. Reported Ballast Water Management (a = January to June, b = July to December)

As a result, the percent of QVs reporting discharging ballast in California waters has also remained relatively constant since 2004 at an average of 16% per six-month period (Figure VI.8). Despite this tendency, the total volume of ballast water discharged by all discharging QVs, and the average volume of ballast water discharged per discharging QV, has dramatically increased since 2004 (Figures VI.9 and VI.10, respectively). In 2012a, the State received the highest volume of reported discharged ballast water than in any six-month time period since the inception of the Marine Invasive Species Program (6.77 million metric tons, MMT, Figure VI.9). In fact, each of the last three reporting periods (2011a, 2011b, 2012a) have consecutively been the highest reported ballast water discharge amounts reported in California. Although the current ballast water management practice of mid-ocean exchange has gone a long way to reduce the introduction risk associated with discharges, coastal organisms may still be present in exchanged ballast (Ruiz and Reid 2007, Leichsenring and Lawrence 2011). As a result, any increase in the volume of ballast water discharged into California's ports has an associated increase in the potential risk of NIS introduction. In addition, the average volume of ballast water reported discharged per discharging QV dramatically increased from 2011a – 2012b, from approximately 7,500 MT per discharge to almost 9,000 MT per discharge (Figure VI.10). Despite the overall decrease in the number of ships reporting discharging ballast water, the potential risk of NIS introduction per discharging ship is higher today than at any time since reporting began.

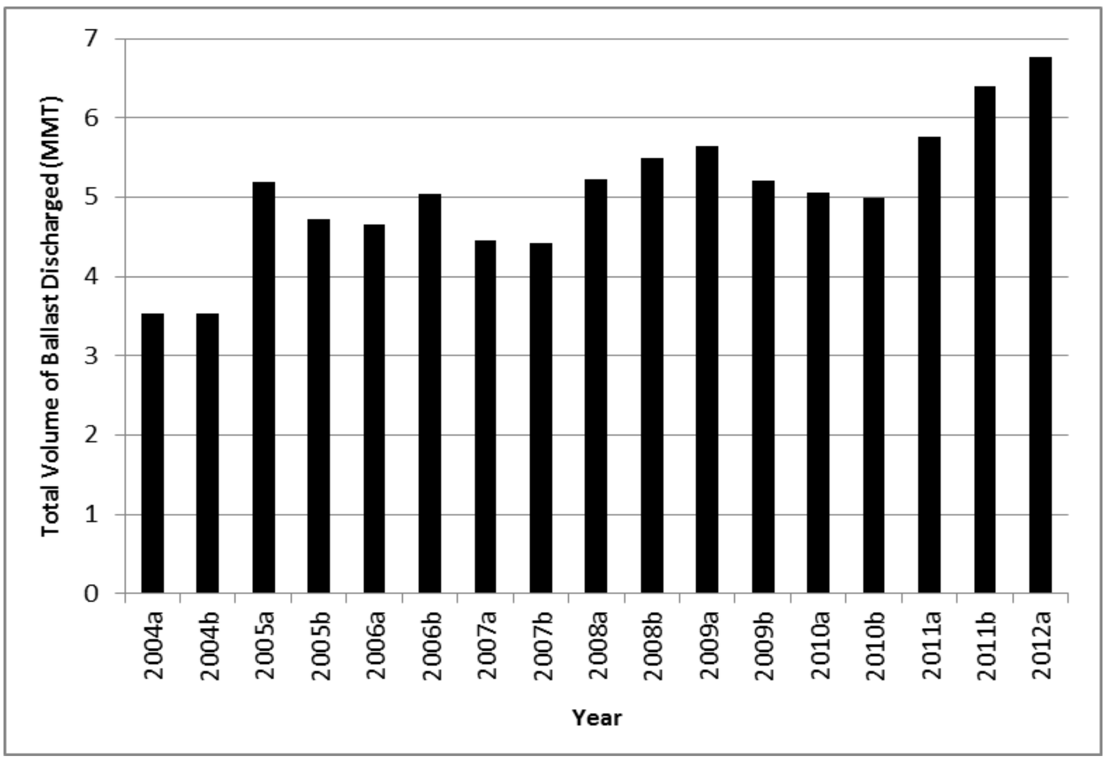


Figure VI.9. Total Reported Volume of Ballast Water Discharged (million metric tons; MMT) (a = January to June, b = July to December)

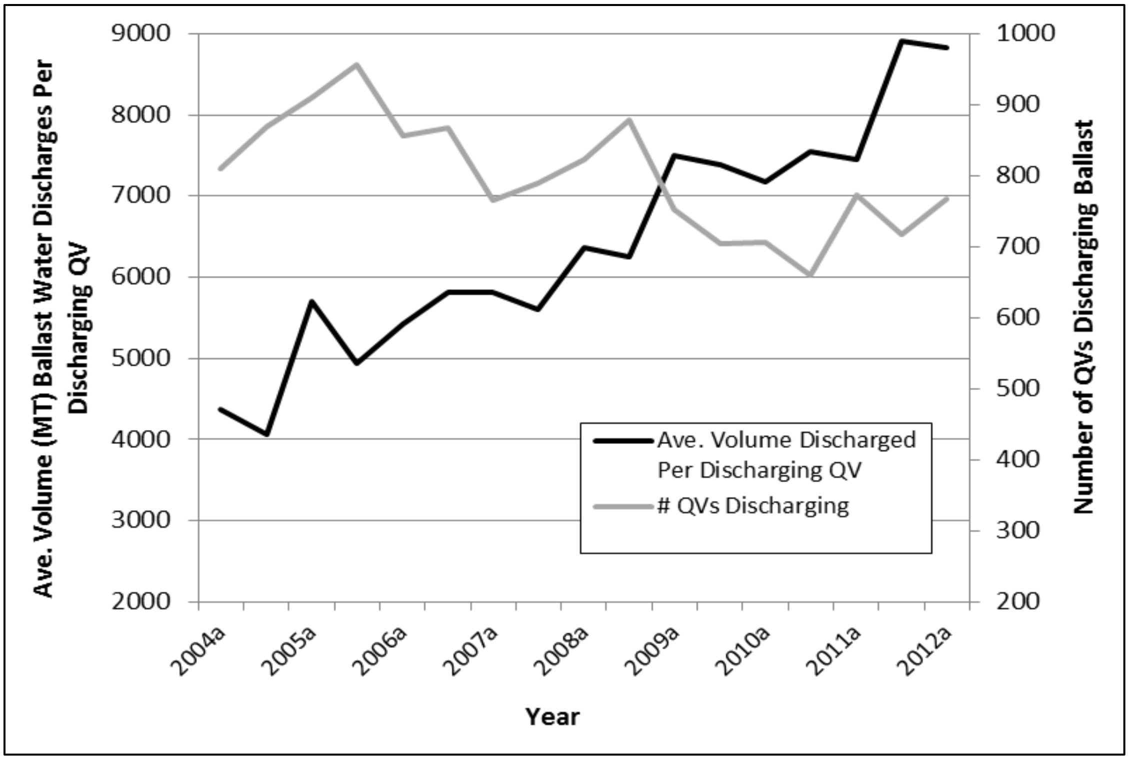


Figure VI.10. Average Volume (MT) of Reported Ballast Water Discharged per Qualifying Voyage (QV). Average calculated using the number of vessels reporting discharging not the total number of QVs. (a = January to June, b = July to December)

The increase in the reported total volume of ballast water discharged is driven, in large part, by bulk and tank vessels - the only vessel types showing an increase in the number of vessels discharging since 2004 (Table VI.1). 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 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.

More important than the total volume of ballast water a ship is capable of carrying, is the per vessel amount discharged in California. The reported average amount of ballast water discharged per discharging bulk vessel has risen 70%, from 9,889 MT in 2004a to 14,135 MT in 2012a. Due to the nature of their cargo operations, bulk and tank vessels often cannot retain ballast water on board. When these vessel types load cargo they

Table VI.1. Average Reported Volume of Ballast Water (metric tons; MT) Discharged per Year as a Function of Vessel Type.

(a = January to June, b = July to December)

Year	Auto		Bulk		Container		General	
	# discharging	avg. volume (MT)	# discharging	avg. volume (MT)	# discharging	avg. volume (MT)	# discharging	avg. volume (MT)
2004	17	739.55	258	9888.63	723	2261.57	84	3014.17
2005	19	1424.62	327	10412.75	654	2566.41	99	2568.52
2006	38	1190.97	318	11001.83	504	2750.3	91	3108.23
2007	33	713.45	271	10542.68	451	2495.29	96	3674.18
2008	21	703.91	303	11291.31	410	2631.31	95	4210.59
2009	7	872.91	321	11801.71	306	3025.07	65	5860.61
2010	16	531.71	304	12459.11	318	3204.61	65	4691.57
2011	3	126.36	373	13338.22	262	3686.41	67	5322.46
2012a	6	308.05	191	14135.03	99	3056.54	25	5976.47

Year	Other		Passenger		Tanker		Barge	
	# discharging	avg. volume (MT)	# discharging	avg. volume (MT)	# discharging	avg. volume (MT)	# discharging	avg. volume (MT)
2004	18	7406.5	16	624.31	279	7573.8	200	2736.07
2005	26	3860.03	9	808.03	430	12903.38	204	1933.06
2006	23	4802.97	25	639.88	486	11596.95	232	2576.55
2007	21	5755.03	75	656.7	419	8691.41	207	3427.43
2008	18	6409.42	144	602.84	543	8919.43	180	4423.87
2009	21	3943.04	96	562.25	483	9788.02	153	5718.8
2010	9	4944.01	52	462.98	441	9477.8	162	4633.65
2011	13	5976.22	42	694.38	516	9589.54	143	4553.8
2012a	8	747.06	79	836.33	284	9398.55	72	5658.31

frequently need to discharge the entire capacity of their ballast tanks. Thus, an average of 50% of arriving bulk vessels discharge in California waters, and 25% of arriving tankers discharge while in California (Table VI.2). Container vessels, on the other hand, are better able to adjust cargo operations so they can reduce discharge volumes or even eliminate the need to discharge completely. On average, only 6% of the containerships that arrived to California between 2010b and 2012a discharged ballast.

Table VI.2. Average Distribution of QVs and Reported Discharge Patterns by Vessel Type (2010b-2012a).

Vessel Type	Avg # of QVs Per 6 Month Period	Avg # Discharging Per 6 Month Period	% Discharging
Auto	358	5	1.4%
Bulk	345	174	50.4%
Container	2269	136	6.0%
General	179	31	17.3%
Other	51	6	11.8%
Passenger	224	35	15.6%
Tank	989	248	25.1%
Unmanned Barge	263	75	28.5%

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.3). As might be expected based on the numbers of QV arrivals (see Figure VI.4), the greatest number of reported ballast water discharges occur in the ports of LA-LB, Carquinez, Richmond, and Oakland. The Ports of LA-LB 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.3. Number of Qualifying Voyages that Reported Discharging Ballast by Port, Six-Month Period, and Origin of Voyage (2010b-2012a; 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	2010b		2011a		2011b		2012a	
	Coastal	Foreign	Coastal	Foreign	Coastal	Foreign	Coastal	Foreign
Humboldt	0	0	1	2	1	3	1	1
Sacramento	0	6	5	6	0	9	4	7
Stockton	2	11	11	22	16	0	14	24
Carquinez	99	23	88	22	86	34	100	27
Richmond	81	11	99	13	94	17	110	15
San Francisco	3	3	3	2	4	0	3	1
Oakland	43	5	49	10	33	8	38	11
Redwood	0	12	2	5	3	7	1	4
Hueneme	0	3	1	8	0	6	0	10
El Segundo	21	3	31	6	36	4	33	2
LA-LB	106	182	112	185	131	198	158	176
Avalon/Catalina	0	0	0	0	0	0	0	0
San Diego	19	11	7	15	7	3	11	15
TOTAL	**374**	**270**	**409**	**296**	**411**	**289**	**473**	**293**

The number of QVs reported discharging at each port (Table VI.3) is one indicator of potential risk of introduction, however the reported volume of ballast water released at these ports is perhaps a better gauge of invasion pressure (Table VI.4). 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 five times more ballast water than Oakland per six-month period (Table VI.4). The average volume of ballast water reported as 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. Despite more tank arrivals to LA-LB, the vessels appear to discharge more frequently in Carquinez, explaining the differences in volumes between the two ports (Table VI.4).

Overall, 59% of the reported volume of ballast water discharged in California between 2010b and 2012a came from vessels whose last port of call was within the PCR (Table VI.4), up 5% from the previous reporting period. Thus coastal ballast water plays an equal, if not more important, role in the transport of nonindigenous species into and throughout California as does foreign ballast water. Given the quantity of arriving coastal vessels and the large volumes of ballast water discharged by such transits (Tables VI.3 and VI.4), these data demonstrate the high potential for intraregional transport of introduced species across several recipient ports. Recent studies have demonstrated that there is a strong pattern of intraregional spread along the North American Pacific coast (Ruiz et al., 2011), which illustrates the added risk of NIS from the increase in coastal source discharges in California.

The type of ballast water management employed by a vessel can also affect the risk associated with ballast water discharges. Vessels primarily conduct two types of ballast water exchange: flow-through (FT) and empty-refill (ER). In FT exchange, ocean water is pumped continuously through a ballast tank to flush out coastal water from the ballast source port. Empty-refill exchange is conducted by draining a ballast tank of coastal source water as much as possible, and refilling it with open-ocean water. Regulations currently require vessels to perform a three-times FT exchange (i.e. 300% of tank volume) or a single ER. During the current reporting period, 56% of managed and discharged ballast water, by volume, was exchanged using ER compared to 44% using FT (Figure VI.11). While ballast water exchange, when properly practiced, can remove 95%-100% of the original source water (Hay and Tanis, 1998) and reduce the number of coastal species in ballast tanks, differences in the effectiveness of the two management options (FT and ER) exist. Flow-through exchange has been shown to be significantly less effective than ER in reducing the amount of coastal species in exchanged ballast tanks (Cordell et al., 2009). This is important for California, given that 44% of ballast discharges have been managed using FT (Figure VI.11).

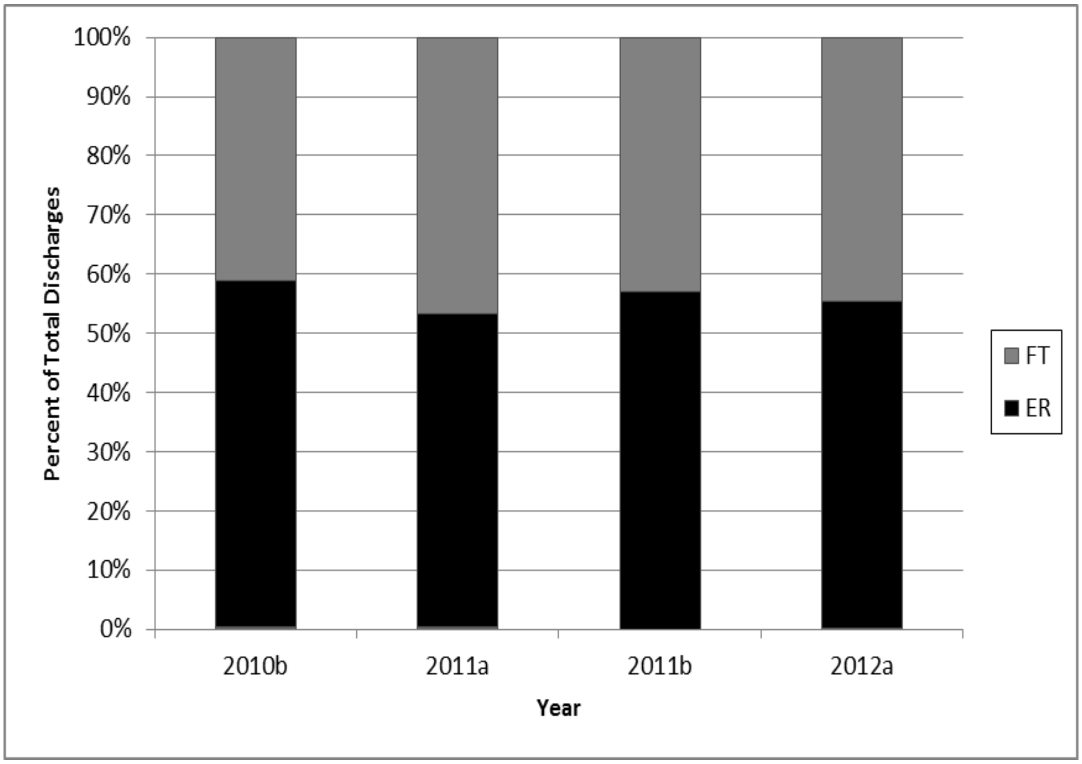


Figure VI.11. Percent of Total Managed Ballast Discharges (FT = flow through, ER = empty refill) for Vessels Reporting Discharging Ballast in California per Six-Month Period (2010b-2012a; a = January to June, b = July to December).

It is important to note that several factors influence invasion risk in addition to the volume of ballast water released and the type of exchange. 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 (Title 2 CCR, §2280 *et seq.*) require vessels to manage their ballast water when moving between ports in the PCR, before arrival to CA. The regulations have proved to be an important tool to help reduce the risk of new species introductions into California's ports, but as the discharge volume and related risk increases, so does the need for more protective management, such as California's discharge performance standards (see Section V), to help reduce the potential introduction of new NIS.

Table VI.4. Source of Ballast Water and Total Discharge Volume (metric tons = MT) by Port, Six-Month Period as Reported by QVs. (2010b-2012a; a = January to June, b = July to December)

Discharge port	2010b			2011a			2011b			2012a		
	% coastal discharges	% foreign discharges	total volume discharged (MT)	% coastal discharges	% foreign discharges	total volume discharged (MT)	% coastal discharges	% foreign discharges	total volume discharged (MT)	% coastal discharges	% foreign discharges	total volume discharged (MT)
Humboldt	0%	0%	0	33%	66%	20,952	25%	75%	43,034	50%	50%	17,388
Sacramento	0%	100%	35,873	45%	55%	106,451	0%	100%	81,408	36%	64%	82,767
Stockton	15%	85%	117,454	33%	66%	418,209	100%	0%	485,650	37%	63%	587,760
Carquinez	81%	19%	1,272,551	80%	20%	1,197,113	72%	28%	1,397,434	79%	21%	1,468,294
Richmond	88%	12%	805,038	88%	11%	983,687	85%	15%	960,611	88%	11%	1,100,030
San Francisco	50%	50%	12,034	60%	40%	24,155	100%	0%	41,328	75%	25%	81,322
Oakland	90%	10%	239,365	83%	17%	334,305	80%	20%	349,514	78%	22%	345,211
Redwood	0%	100%	141,718	29%	71%	90,198	30%	70%	99,198	20%	80%	48,293
Hueneme	0%	100%	2199	11%	88%	5,298	0%	100%	1,990	0%	100%	4,922
El Segundo	88%	12%	218,800	84%	16%	285,731	90%	10%	367,711	94%	6%	251,848
LA-LB	37%	63%	2,128,068	38%	62%	2,253,802	40%	60%	2,425,583	47%	53%	2,250,263
San Diego	63%	37%	13,055	32%	68%	21,253	70%	30%	8,989	42%	58%	34,041
TOTAL	**58%**	**42%**	**4,986,155**	**58%**	**42%**	**5,741,154**	**59%**	**41%**	**6,262,450**	**62%**	**38%**	**6,272,139**

Ballast Water Management Compliance

California's performance standards for ballast water discharge are currently in effect for vessels built on or after the first day of the year in 2010 or 2012, depending on ballast water capacity (see Table III.2 for implementation schedule). As of the writing of this report, none of these new build vessels have reported discharging ballast water in California, therefore, all of the discharges into California waters during the two-year period covered by this report (July 2010 through June 2012) were subject to California's ballast water exchange requirements. These exchange requirements for vessels discharging ballast water in California depend on where a vessel arrives from and the origin of ballast water intended for discharge.

California regulations (2 CCR Section 2280 *et seq.*) requires that the master, operator, or person in charge of a vessel arriving to a California port or place from another port or place within the Pacific Coast Region (see map in Figure V.1) with ballast water sourced from within the PCR, manage ballast water in at least one of the following ways:

- Exchange the vessel's PCR-sourced ballast water in near-coastal waters (more than 50 nm from land and at least 200 m deep) before entering the waters of the State.
- 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 outside of the Pacific Coast Region, or with ballast water sourced 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 (including islands) 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).

Of the more than 122 MMT of vessel-reported ballast water carried into State waters between July 2010 and June 2012, over 97.9%, or 120 MMT, was managed in compliance with California law. The majority of vessels arriving to a California port or place achieve compliance with California's requirements by retaining their ballast water on board. Between July 1, 2010 and June 30, 2012, approximately 84% of the QVs arriving to the State, an average of 4025 arrivals during each six-month period, did not report discharging ballast water (Figure VI.8) and were therefore compliant with California law.

Of the more than 22.8 MMT of vessel-reported ballast water discharged into California from July 2010 through June 2012, 87.5% was legally managed through ballast water exchange (Figure 12). Although the total volume of ballast water discharged into California has been increasing since the last half of 2006, the volume of noncompliant ballast water has exhibited a slight decreasing trend (Figure VI.12). Noncompliant ballast water has accounted for a smaller proportion of all ballast water discharges through the years, with slight variation, from 23.8% in the latter half of 2006 to 9.5% in the first half of 2012.

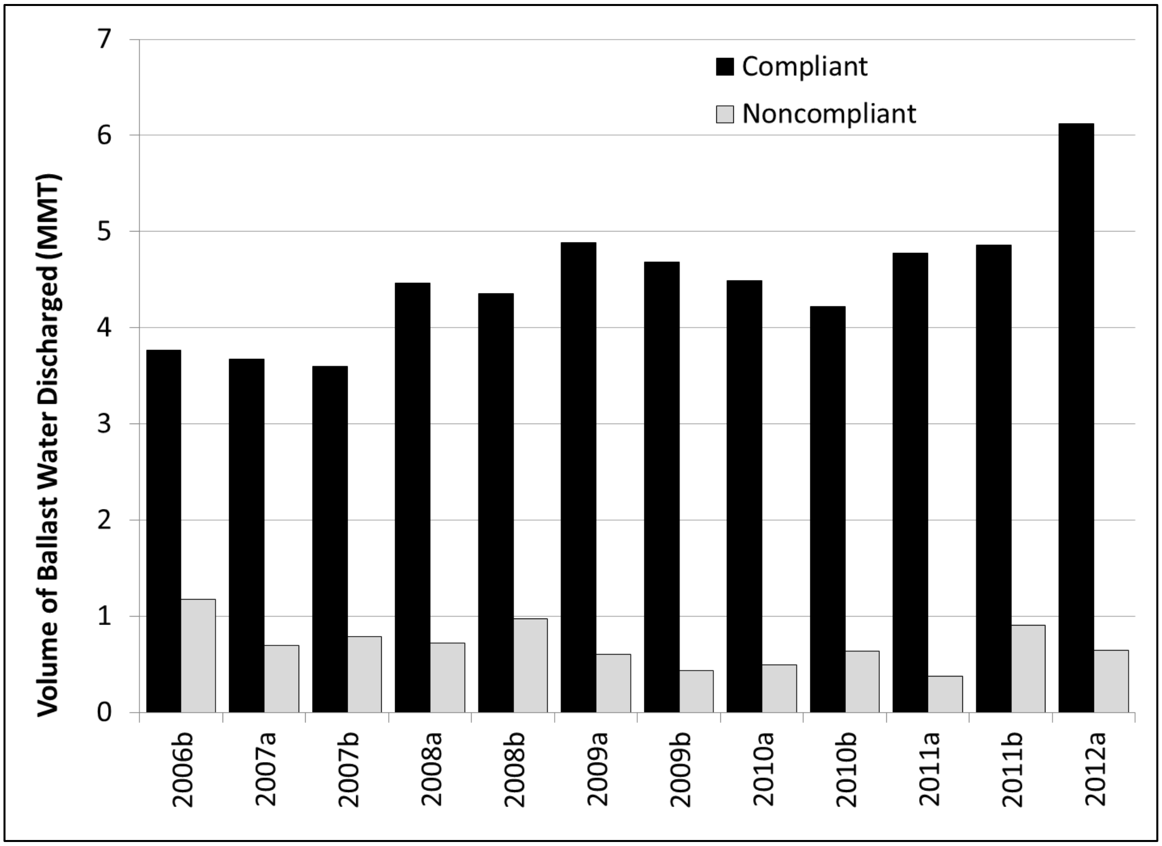


Figure VI.12. Volume (million metric tons, MMT) of Compliant and Noncompliant Ballast Water (BW) Reported as Discharged by Six-Month Period Since July 2006. Includes only compliance of discharging vessels and does not include data for vessels that comply by retaining ballast water (a = January to June,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

Approximately 2.5 MMT of reported noncompliant ballast water was discharged in California waters between July 2010 and June 2012. 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*.;
- Ballast water was not exchanged; or
- 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 two years, and accounted for 91.3% of noncompliant ballast water by volume in 2010b (79 qualifying voyages), 89.7% in 2011a (81 QVs), 88.6% in 2011b (68 QVs) and 90.0% in 2012a (84 QVs) (Figure VI.13).

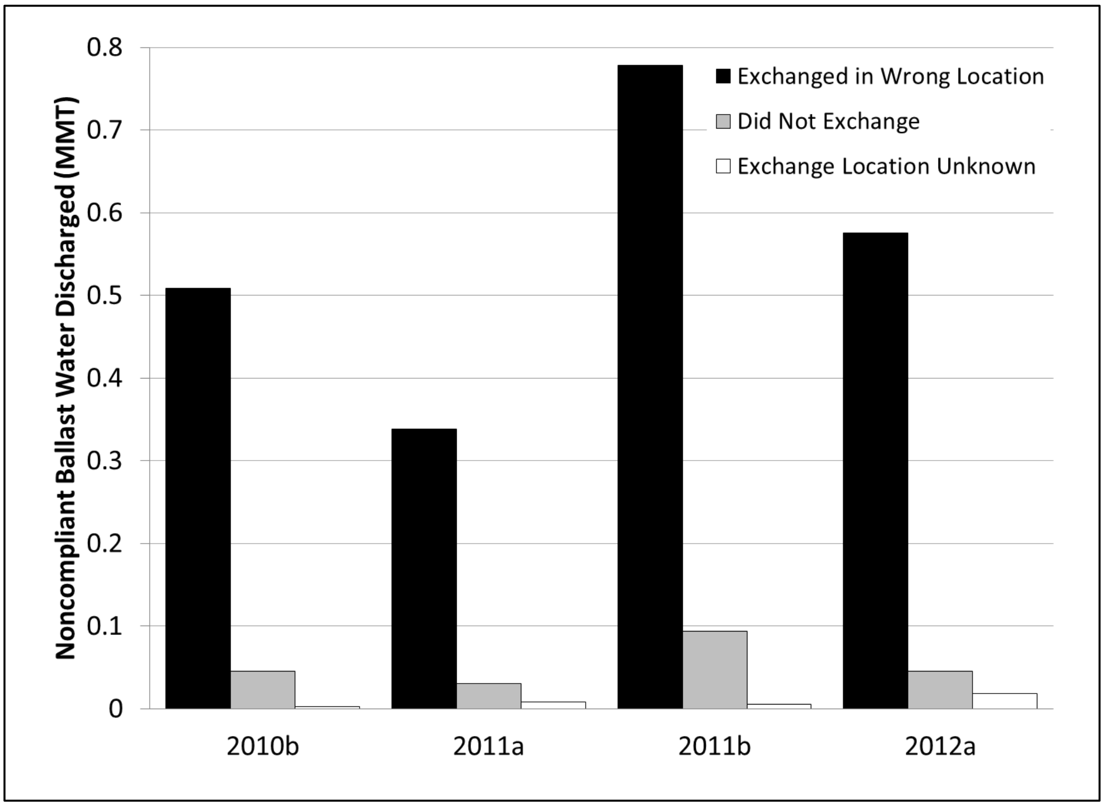


Figure VI.13. Volume (million metric tons; MMT) of Reported Noncompliant Ballast Water (BW) Discharged by Violation Type (a = January to June, b = July to December).

Of the vessel-reported noncompliant ballast water exchanged in the wrong location between 2010b and 2012a, 9.1% (0.215 MMT from 61 QVs) was exchanged within five percent of the required offshore distance (i.e. 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 (see Figure VI.14). These vessels that are attempting to conduct legal exchange but fail due to either exchanging within 5% of the legal boundary or by failing to take islands (e.g. Farallon Islands, Channel Islands) into account are prime candidates for targeted outreach by Commission Marine Safety personnel.

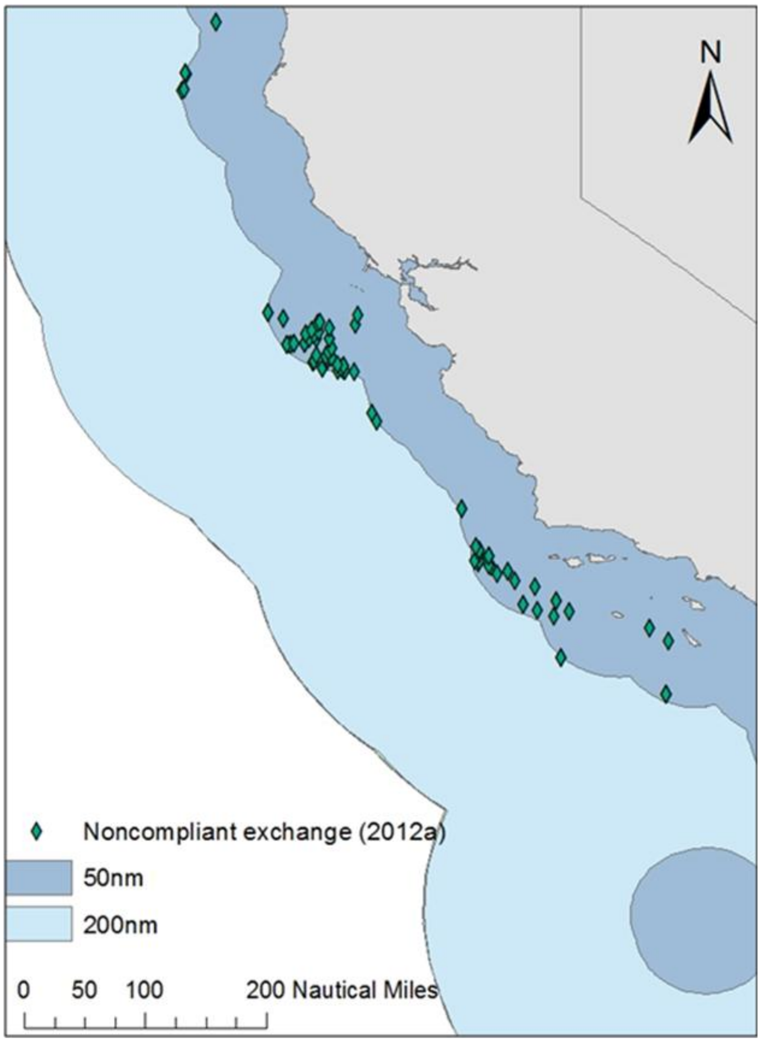


Figure VI.14. Examples of Noncompliant Ballast Tanks (green diamonds) Associated With an Attempt at Legal Exchange. Several tanks were exchanged near, but not beyond, required distance from shore. Others were exchanged greater than 50 nm from California mainland, but not 50 nm from any land, including islands.

Although ballast water that is not exchanged composes a much smaller proportion (8.8% from 2010b through 2012a) of noncompliant discharges in comparison to ballast water that was exchanged at inadequate distances from shore, these unexchanged discharges may represent a higher risk overall for NIS introduction to the State because there has been no ballast water management conducted. Although these occurrences are rare, vessels that do not conduct exchange are targeted for inspection and outreach when they commit the initial violation and are flagged for a follow-up inspection when they return to the State.

Across the two-year time period examined, the largest proportion of reported 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 2010 through June 2012, accounting for approximately 86.6% of the total volume. The relative contribution of both bulk and tank vessels were fairly consistent over this time span. Tankers accounted for between 44%-59% of noncompliant discharges. Bulkers accounted for between 25%-37% of noncompliant discharges. (Figure VI.15).

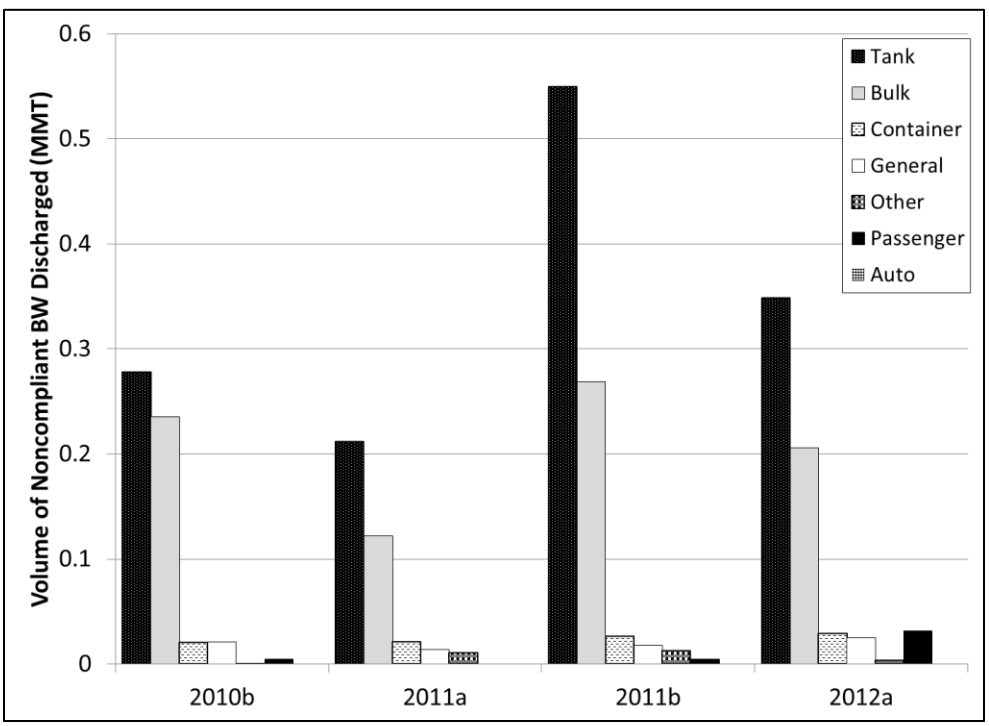


Figure VI.15. Volumes of Reported Noncompliant Ballast Water (BW) by Vessel Type (a = January to June, b = July to December)

Over the past eight and a half years, container vessels have continually accounted for the greatest proportion of QVs to California, 45.3% of all arrivals from January 2004 through June 30, 2012. However, the total volume and proportion of noncompliant ballast water reported as discharged from container vessels has been decreasing over the same time period - from 31.7% of all noncompliant ballast water discharges in 2004a (Falkner et al. 2007) to 4.5% in 2012a. During the entire two-year focus of this report, containerships were responsible for only 3.9% (by volume) of all noncompliant ballast water.

Discharges from unmanned barges are a unique situation and present a potentially high risk of species introductions into California waters. Due to safety concerns associated with transferring personnel to an unmanned barge to conduct ballast water exchange, unmanned barges often claim a safety exemption in California, which is allowed under PRC section 71203 if the safety of any vessel or its crew is compromised. In such cases, vessels are not required to exchange ballast water intended for discharge. While it is legal to discharge unexchanged ballast water when a safety exemption is claimed, the practice does result in the discharge of high-risk water to the State. As a result, unmanned barges are responsible for the third largest volume of high-risk ballast water (i.e. unexchanged or not exchanged at legal distances from shore) discharged in California (Figure VI.16). Between July of 2010 and June of 2012, unmanned barges accounted for 11% of all high-risk discharges by volume to the state.

These high-risk discharges account for nearly one-fifth of all unmanned barge discharges during this two-year period. The remaining 81% of discharged ballast water is compliant with current requirements even without a safety exemption, primarily because of uptake and discharge at ports legally considered the same port or place (i.e. ports within the San Francisco Bay or within the LA- LB Port Complex). Of the high-risk ballast water discharged from unmanned barges, 88% (0.22 MMT) was exchanged but at distances from land that would not be considered legal, and the remaining 12% (0.03MMT) was not exchanged at all (Figure VI.17). The use of either shore-based or shipboard ballast water treatment technologies may be tools to assist unmanned barges in reducing the risk of NIS introductions while minimizing risk for the vessel and crew safety.

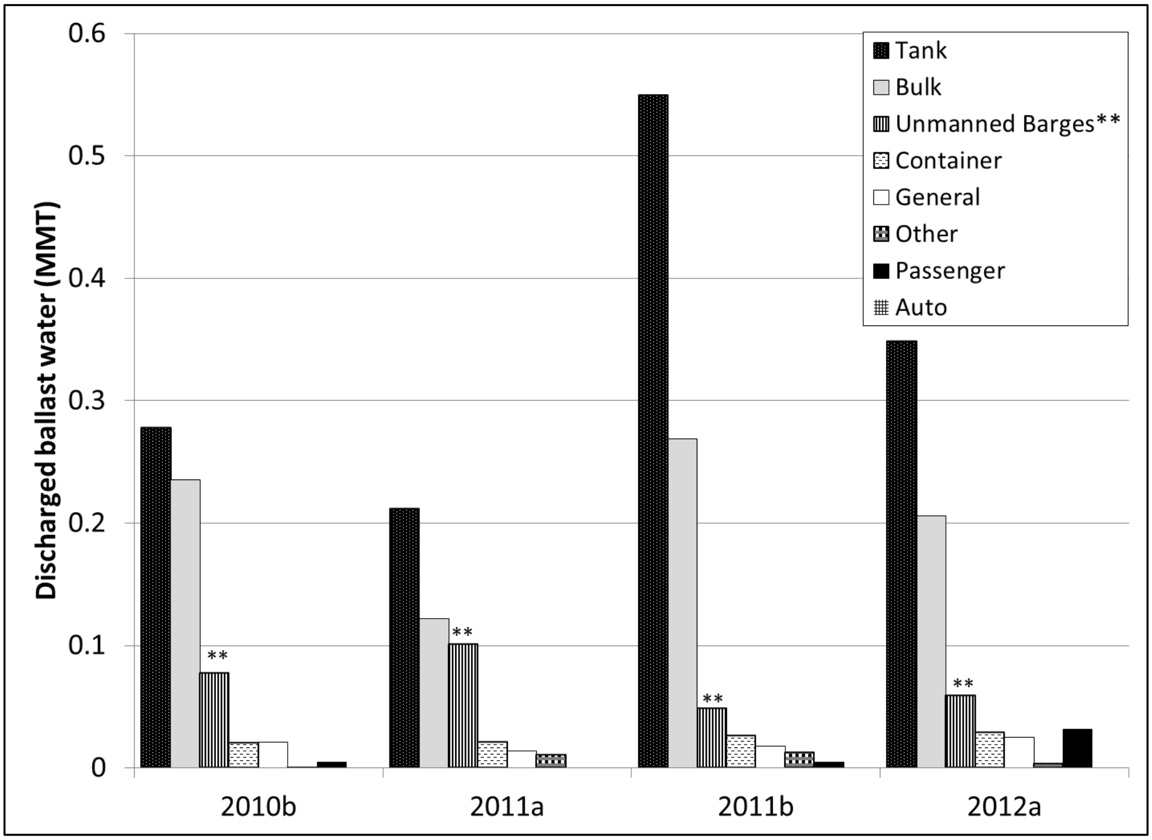


Figure VI.16. Volumes of High-Risk Ballast Water by Vessel Type, Inclusive of Unmanned Barges. This water is designated as high-risk because it was either exchanged at a location that was not at the legally required distance from shore or was not exchanged due to a legal safety exemption. (a = January to June, b = July to December)

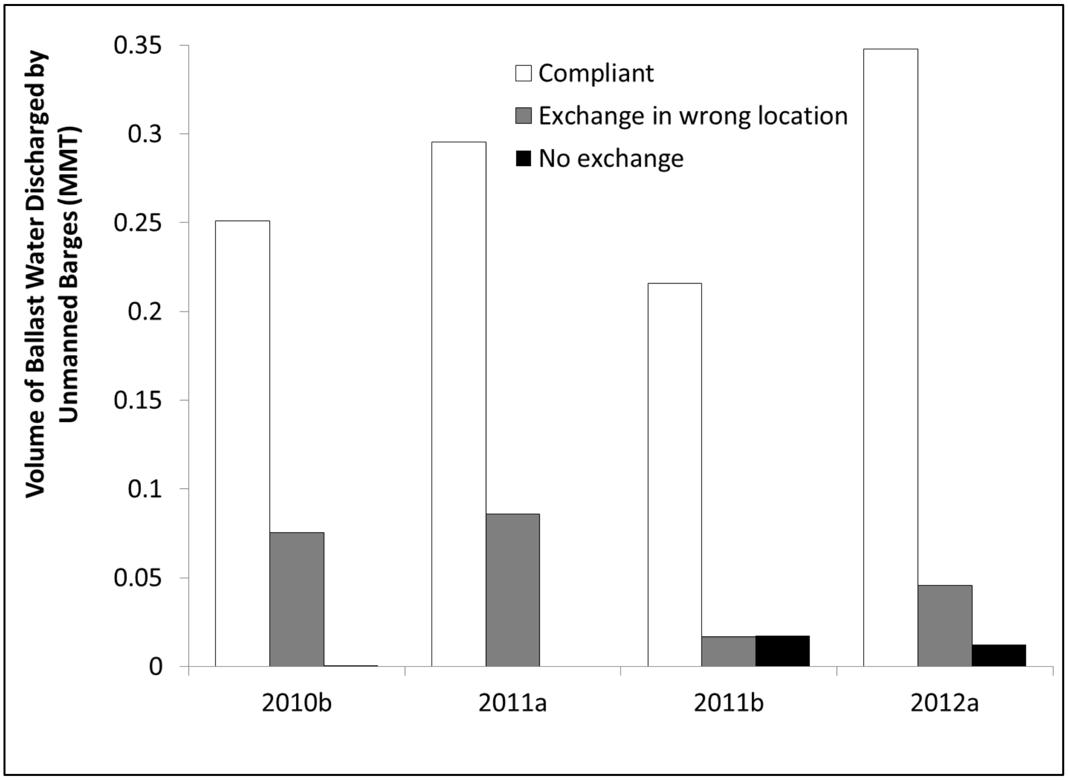


Figure VI.17. Volumes (million metric tons, MMT) of Ballast Water Reported as Discharged by Unmanned Barges (a = January to June, b = July to December). Black and grey bars denote ballast water that would be considered non-compliant, if the safety exemption was not utilized.

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 because risk may be related to chemical, physical, and biological similarities between source and receiving waters. The majority (an average of 71.1% per six-month period) of noncompliant ballast water reported as discharged in California from July 2010 through June 2012 originated from within the United States West Coast EEZ (200 nm or closer to the coasts of California, Oregon or Washington) and the Mexican EEZ. However, the proportion of water discharges from these two sources was not consistent through all four of the six-month intervals during this time period. Mexico was clearly the largest source of noncompliant discharged ballast water in 2010b (38.8% vs. 26.2% from the U.S. West Coast), while the U.S. west coast was clearly the dominant source during 2011a (41.0% vs. 25.3% from Mexico; Figures VI.18 - VI.21). Asia was another major source of noncompliant ballast water, fluctuating between 6.1% (2011b) and 23.7% (2010b), with no obvious increasing or decreasing trend during the examination period.

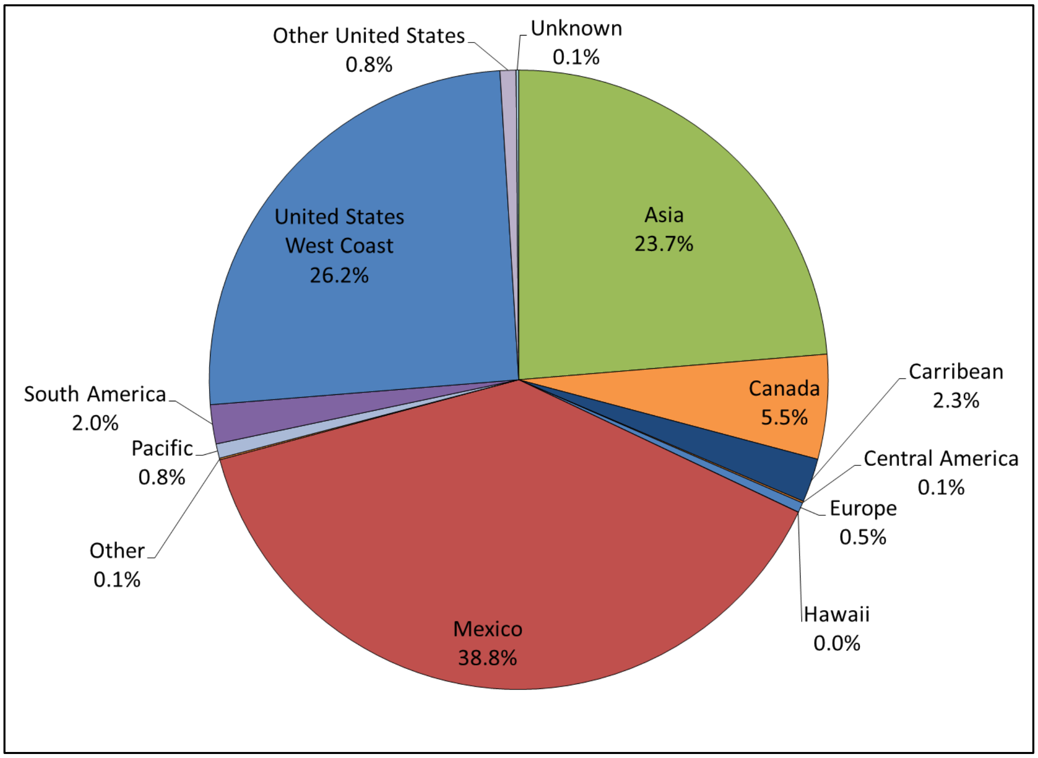


Figure VI.18. Source of Noncompliant Ballast Water (2010b; July-December 2010).

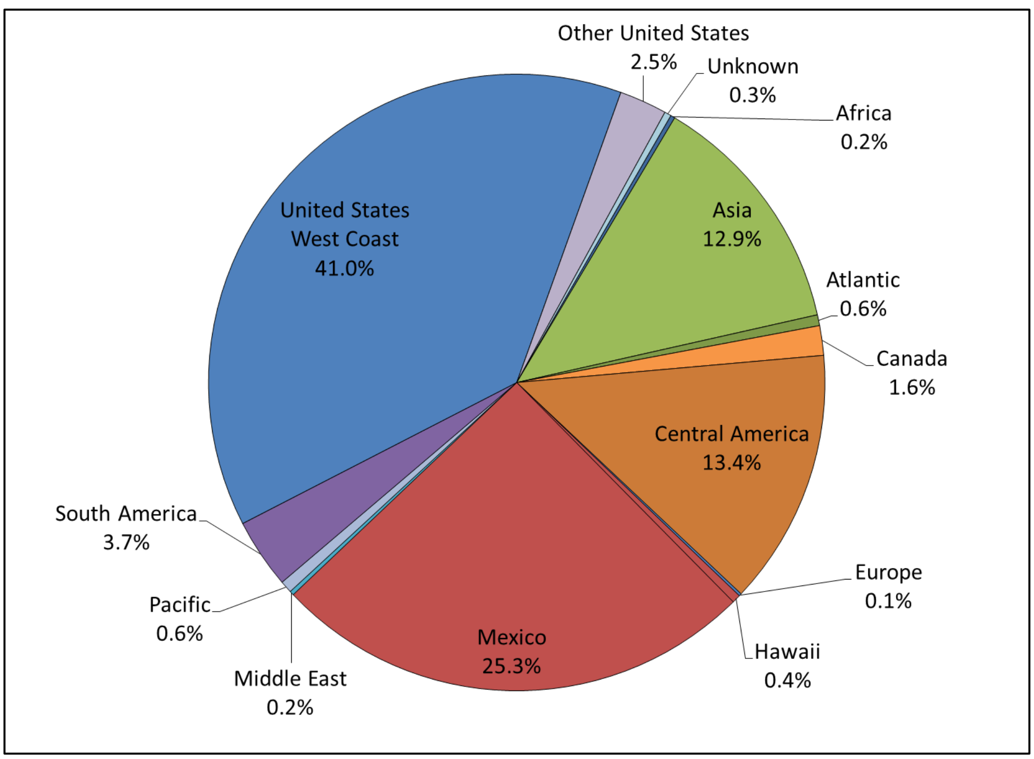


Figure VI.19. Source of Noncompliant Ballast Water (2011a; January-June 2011).

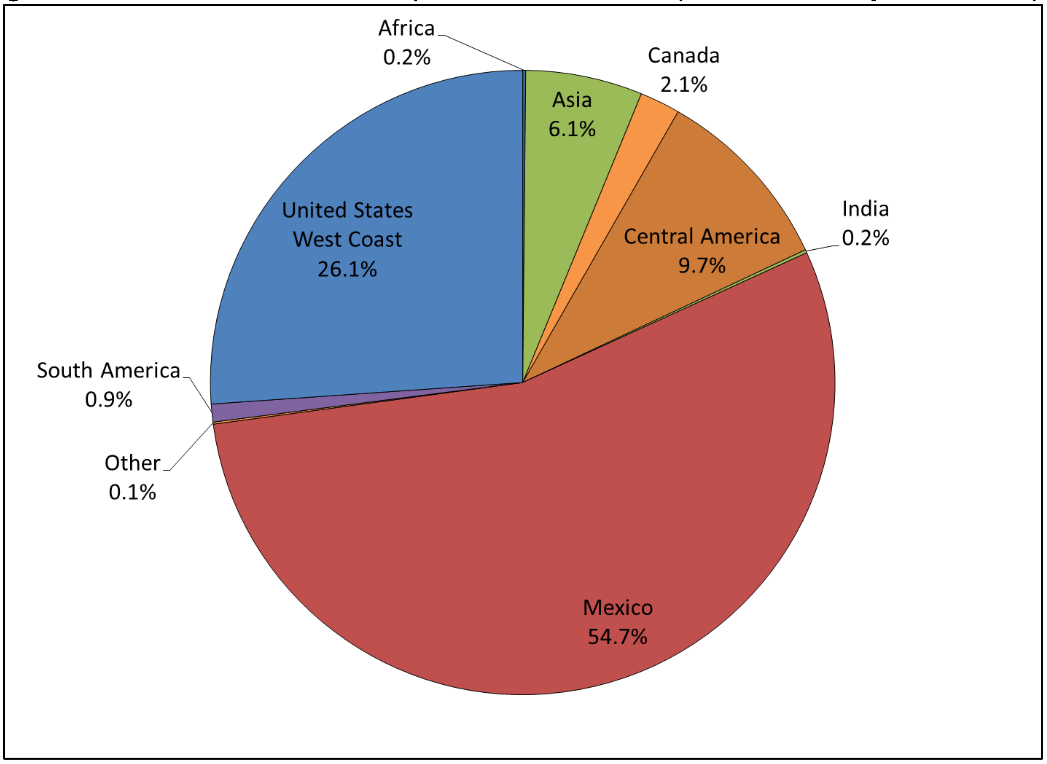


Figure VI.20. Source of Noncompliant Ballast Water (2011b; July-December 2011).

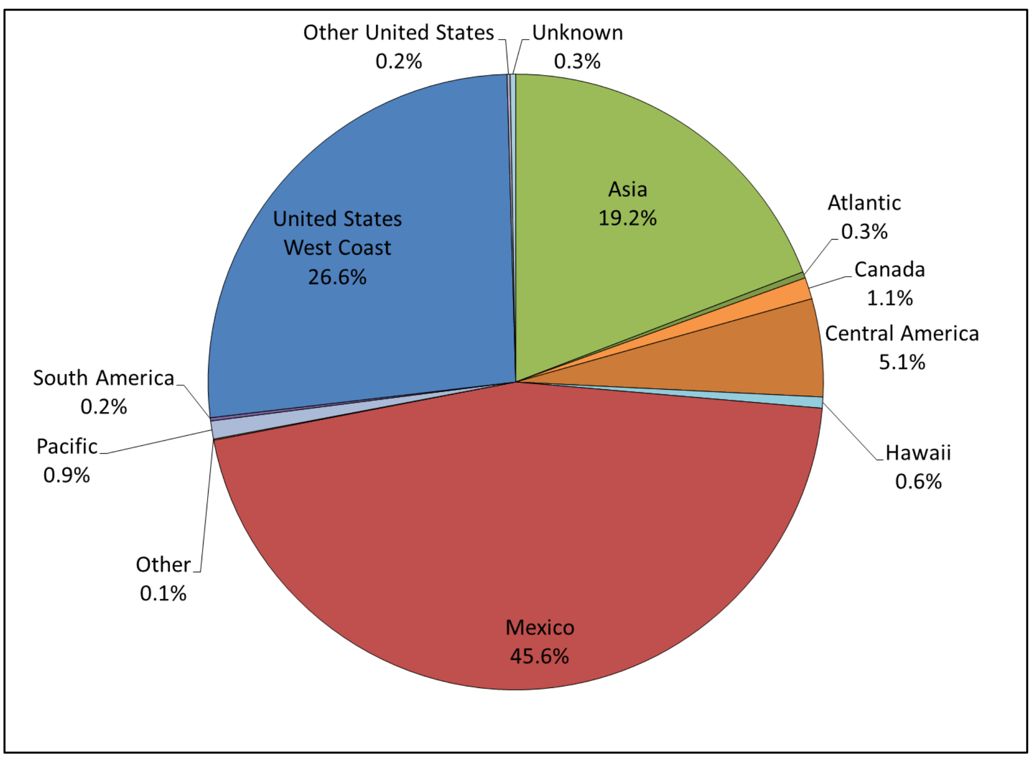


Figure VI.21. Source of Noncompliant Ballast Water (2012a; January-June 2012).

Noncompliant discharges reported as originating from Central American sources were much more variable during the two-year focus of this report (Figures VI.18 - VI.21) than in previous years (see Takata et al. 2011). Noncompliant discharges from Central American sources were nearly nonexistent in 2010b (1 QV discharging 0.1% of the total volume of noncompliant discharges), but peaked during 2011a (8 QVs discharging 13.4% of the total volume) and 2011b (8 QVs discharging 9.7% of the total volume). Much of this variability is the result of noncompliant tank vessel discharges, which were not present in 2010b, but accounted for a large percentage of noncompliant discharges sourced from Central American in 2011a (3 QVs discharging 43.2% of the total noncompliant discharge originating from Central America), 2011b (5 QVs discharging 79.3% of the total), and 2012a (2 QVs discharging 51.2% of the total). A large portion of the noncompliant ballast water reported as originating in Central America was discharged into the San Francisco Bay terminals within the Carquinez strait (i.e. Carquinez port, see Figure VI.1). Carquinez received 41.7% of the total volume of noncompliant ballast water originating in Central America during 2011a, 64.1% in 2011b, and 47% in 2012a. The fact that a large portion of the noncompliant ballast water reported as originating from Central America is associated with tank vessels and is primarily discharged into Carquinez suggests that this type of vessel (i.e. tank vessel arriving to Carquinez carrying ballast water sourced from Central America) could be a candidate for targeted outreach, in an attempt to achieve better compliance in the future. Targeted outreach would likely resonate in this particular scenario, as over 95% of the noncompliant ballast water from Central America discharged into California over the previous two years had been exchanged, but not at the legal distances from shore required by California law.

As indicated earlier in this subsection, unexchanged ballast water comprises a much smaller proportion of noncompliant discharges when compared to ballast water that was exchanged at inadequate distances from shore, but unexchanged ballast may also represent a greater risk of NIS introduction to California. This smaller subset of noncompliant ballast water exhibits slightly different source and vessel type patterns. The U.S. west coast accounted for nearly three-quarters of unexchanged ballast water discharged in California (Figure VI.22) between 2010b – 2012a, much larger than the portion of all noncompliant discharges sourced from the U.S. west coast during the same time period (average of 30%, see Figures VI.18 - VI.21). Because such a large proportion of unexchanged ballast water originates from other U.S. west coast areas, it indicates that there may be notable potential for NIS spread into and throughout California from other ports along the U.S. west coast. In addition, similar to the overall trend of noncompliant discharges over the previous two years, the vessel types primarily responsible for unexchanged discharges from all sources during these two years were bulkers (58.7%) and tankers (19.3%).

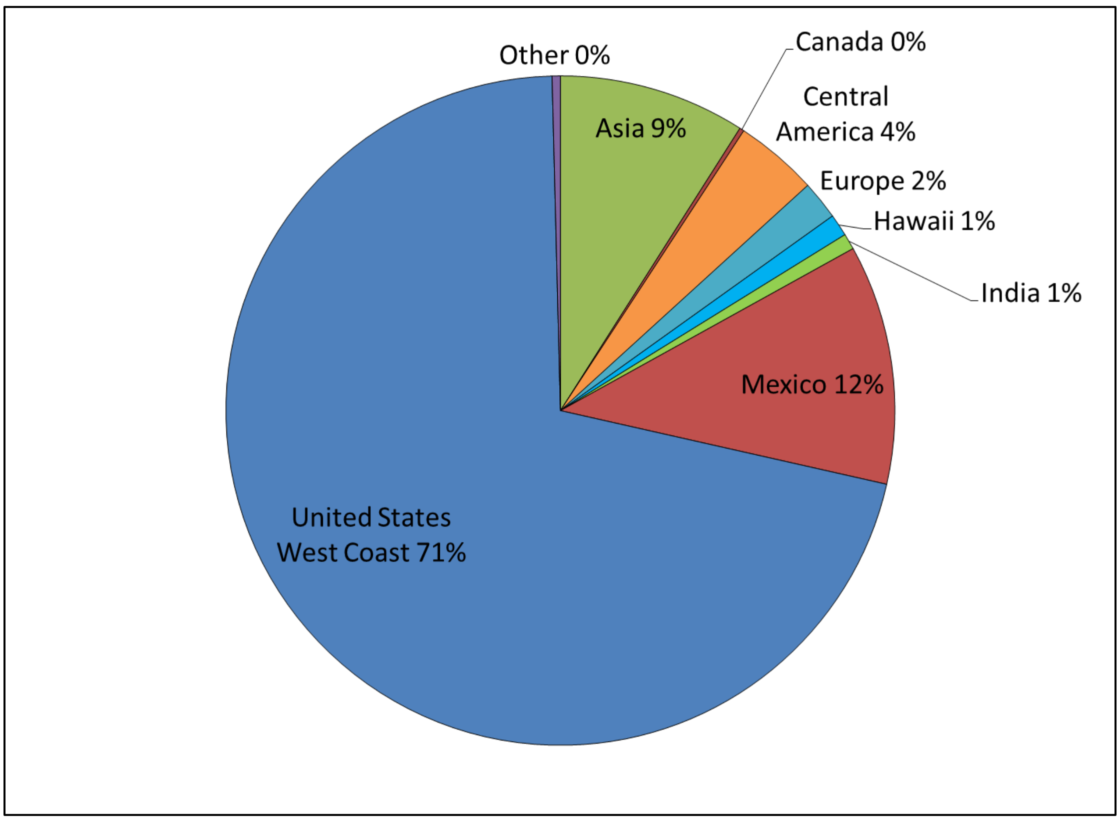


Figure VI.22. Sources of Noncompliant, Unexchanged Ballast Water (BW) Reported as Discharged in California from July 1, 2010 through June 30, 2012.

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 reported as discharged into California waters is relatively small and has been decreasing through time. Although variable, noncompliant ballast water discharges have recently decreased 52% from 1,009,232 MT (2006b) to 641,823 MT (2012a), even though overall discharges have exhibited a fluctuating, but generally increasing trend. During the two-year focus of this report, only 2.1% of the more than 122 MMT of vessel-reported ballast water carried into California waters 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.

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 20.9% (4002) of qualifying voyages between July 1, 2010 and June 30, 2012 (Table VI.5), slightly below the requirement to inspect at least 25% of arriving voyages. Fluctuating staffing levels resulting from state budgetary issues have influenced this inspection rate, as inspector positions have been reduced during recent years.

During the inspection process, inspectors interview crew and review paperwork, including but not limited to, Ballast Water Reporting Forms, ballast water management plans, ballast water and engine logbooks, and Hull Husbandry Reporting Forms. If these items are not in order as required, the vessel is cited for an administrative violation. Because most vessels operating in California are still subject to ballast water exchange requirements, salinity samples are taken as an indicator of ballast water exchange. These salinity samples are collected from the top, middle and bottom of a subset of tanks intended for discharge in California. Exchanged ballast water is expected to have salinity readings reflective of oceanic conditions, at or above 30 ppt. Any tank with a salinity reading below 29 ppt suggests an incomplete or lack of ballast water exchange, and serves as a flag for a potential violation. In these occurrences, the

Inspector more closely scrutinizes paperwork and re-interviews vessel officer(s) to ascertain possible reasons for the low reading.

Table VI.5. Vessel Inspections and Violations

	2006b	2007a	2007b	2008a	2008b	2009a	2009b	2010a	2010b	2011a	2011b	2012a
# Qualifying Voyages	5645	5463	5541	5382	5253	4857	4579	4606	4903	4940	4905	4610
# Inspections	818	897	969	1108	1053	1225	1061	1001	840	940	1005	1217
% of QVs Inspected	14.5	16.4	17.5	20.6	20.0	25.2	23.2	21.7	17.1	19.0	20.5	26.4
Total # Violations	148	114	82	66	59	50	20	22	23	15	25	30
# Administrative	123	86	59	53	41	34	13	16	12	10	18	21
# Operational	25	28	23	13	18	16	7	6	9	5	7	9

The majority of vessels inspected are found to comply with the Act. Seventy-four percent of the 654 violations assessed since 2006b (Table VI.5) are associated with administrative components of the law (e.g. incomplete ballast water management plan, inaccurate ballast report forms, incomplete ballast tank logs). Operational violations (e.g. exchanging in the wrong location, discharging unmanaged ballast) occur less frequently. 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.

California's vessel inspection program consistently yields positive results in minimizing repeat violations. From 2006b through 2012a, a total of 564 unique vessels have been assessed violations (both operational and administrative) in California. Of those 564 vessels, 407 (72.1%) returned to a California port at least once after receiving a violation. Only 48 (11.8%) of those returning vessels were assessed a repeat violation. Seventeen of the 48 repeat violators received the same violation a second time, with the majority of repeat violations assessed for a different infraction. The low numbers of repeat violators illustrates the effectiveness of the outreach built in to the inspection process. Inspectors spend time with vessel crew and agents explaining current law and helping make sure that repeat violations are minimized. Although outreach to the vessel crew has proven effective at minimizing repeat violations, the Commission has the authority to pursue civil and criminal penalties against violators if the situation warrants.

Bulkers account for the majority of repeat violators, followed by tankers and container vessels (Figure VI.23). Bulkers made up only 7% of QV arrivals during the last 2 years (Figure VI.5) and therefore account for a disproportionate number of repeat violations. Increased outreach should be aimed specifically at bulkers in order to limit this trend.

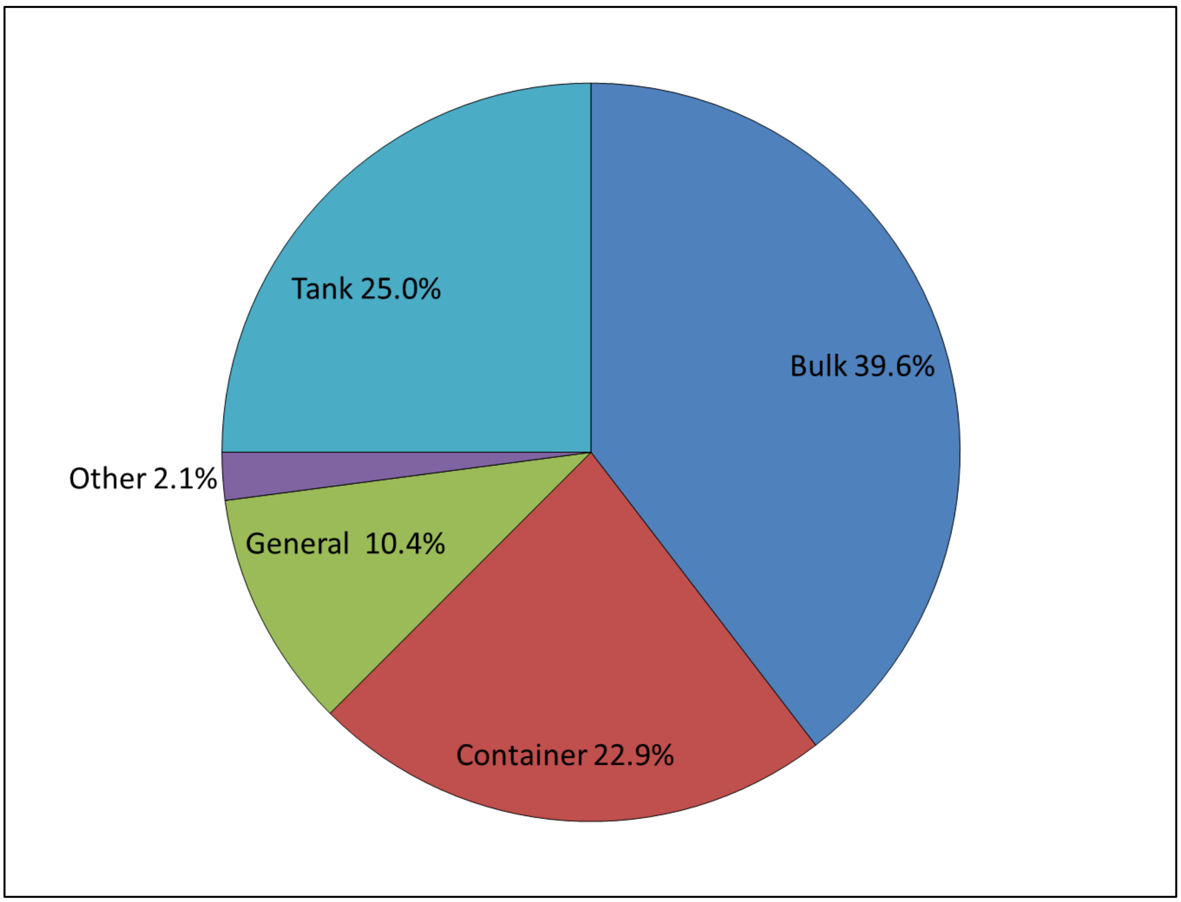


Figure VI.23. Percentage of Repeat Violations by Vessel Type Between 2006b and 2012a (sample size = 48 vessels).

Trends in Vessel Biofouling-Related Practices and Patterns

As illustrated in Figure VI.8, about 84% of the qualifying voyages into California manage their ballast water by retaining all ballast on board, and therefore pose ‘zero’ risk of introducing NIS through the ballast water vector. However, through vessel biofouling, every vessel represents a certain level of risk. This is because all vessels have submerged or wetted surfaces that are susceptible to accumulating biofouling, and unlike organisms within an enclosed ballast tank, these biofouling organisms cannot be completely contained or retained while a vessel is in port.

Title 2, Section 2298 of the California Code of Regulations (2 CCR § 2298) requires annual submission of the HHRF (see Appendix B for copy) from every vessel carrying, or capable of carrying, ballast water into the coastal waters of the state. The HHRF is an eleven question survey that is divided into two sections: one addressing hull husbandry practices relating to submerged vessel surfaces (e.g. dry docking and antifouling coating information), and the other relates to voyage characteristics that influence biofouling accumulation and complexity (e.g. traveling speed and extended stationary periods). During 2008, the first year of this reporting requirement, only 72.8% of the vessels that operated in California submitted the form as required, with only five of the eight vessel types recording over 70% compliance (Takata et al. 2011). Beginning in 2009, Commission staff utilized the monthly notification system already in place for delinquent Ballast Water Reporting Forms and has been able to increase the overall HHRF submission compliance rate to over 90% each of the past three years (2009-2011), including compliance rates of 94.6% in 2010 and 90.4% in 2011 (Figure VI.24). While submission compliance has increased substantially since 2008, each vessel type experienced a lower compliance rate in 2011 when compared to 2010, a trend that can be improved upon through more administrative outreach to vessel agents and operational outreach to vessel crews during inspections.

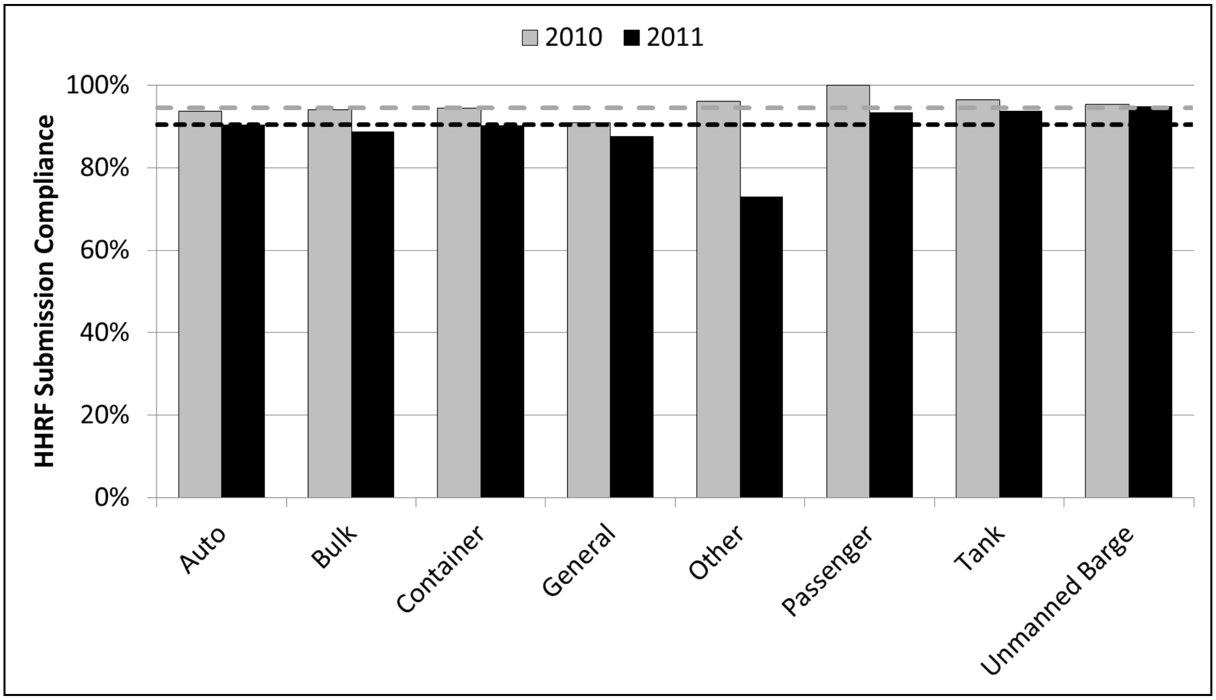


Figure VI.24. Percent Compliance for Hull Husbandry Reporting Form (HHRF) Submission by Vessel Type During 2010 and 2011. Dashed lines represent overall percent compliance for California fleet for given year.

Because vessels are only required to submit the HHRF once each year they operate in California waters, the data collected between 2008 and 2011 represent four snapshots of vessel practices and voyage characteristics for the California fleet, and provide insight into the consistency of these practices. This four-year dataset represents an important accumulation of a vast amount of information that will be presented in part in this report, but Commission staff intends to prepare a much more detailed report on the hull husbandry practices of the California fleet (including five years of data from 2008 through 2012) in the near future.

Husbandry Practices of the Commercial Fleet in California

One of the most common ways of reducing the amount of biofouling 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, as required at least every 5 - 7.5 years by most ship classification societies, which are organizations that establish and maintain technical standards for the construction and safety of ships. California law (PRC

71204(f)) also requires vessels to have biofouling organisms removed from their submerged surfaces on a regular basis, with regular basis defined as essentially no longer than 60 months since the vessel completed its last out-of-water dry docking. As such, more than 98% of the vessels operating in California each year from 2008 through 2011 have reported either being dry docked (and cleaned and treated with an antifouling coating) or delivered as new within the five years prior to reporting form submission (Figure VI.25), with most (at least 80% each year from 2008 through 2011) dry docked or delivered even more recently within the previous three years.

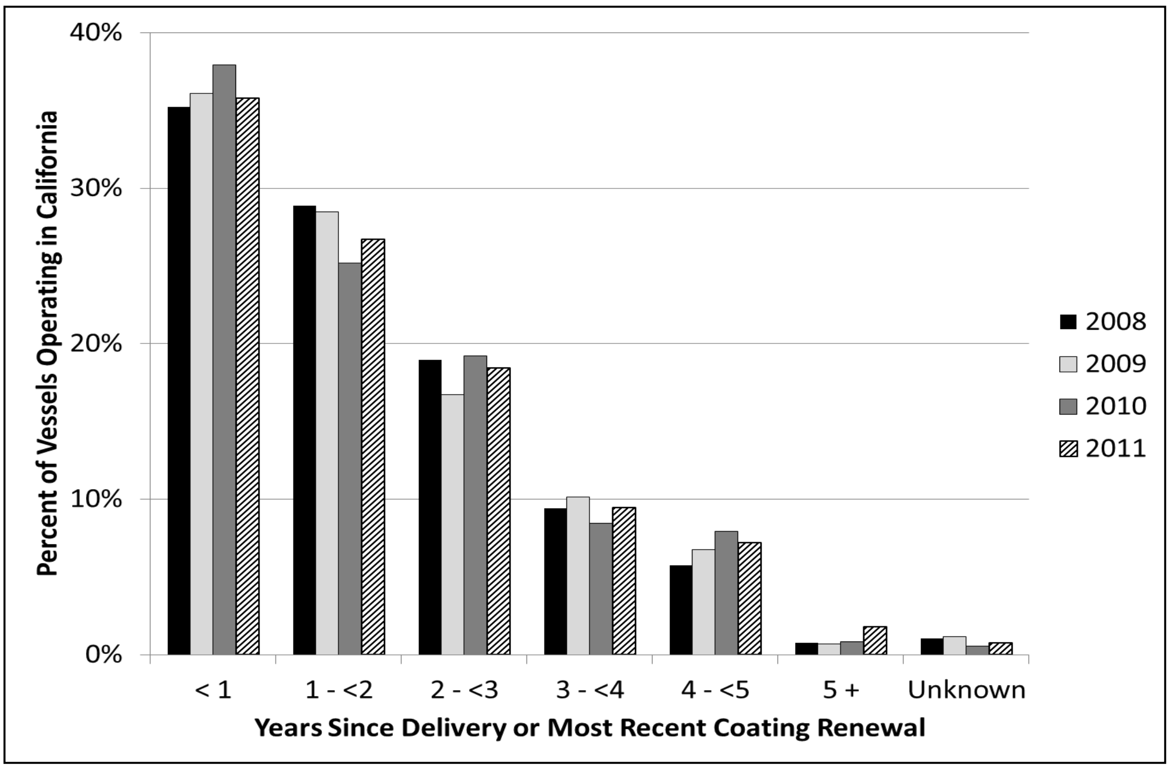


Figure VI.25. Percent of Vessels Reported Annually from 2008-2011 Delivered as New or Cleaned and Coated During Dry Dock Within Each of the Previous Five Years.

Aside from physical removal of biofouling organisms from vessels, vessel owners and operators utilize preventative measures to keep levels of biofouling to a minimum between required dry dockings. One of these preventative measures is the use of antifouling systems, with antifouling coatings being 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 average

age of the antifouling coatings on vessels operating in California, as reported on the HHRF, roughly mirrors the average amount of time since delivery or dry docking. The average coating age also provides insight into the potential effectiveness of antifouling coatings, because these coatings are generally considered to be most effective when freshly applied and many are expected to lose effectiveness with age.

Overall, the average age of antifouling coatings on vessels operating in California has been relatively consistent, ranging from 1.72 years in 2008 to 1.78 years in 2011. When evaluating by vessel type during the most recent two years (2010-2011), all but two vessel types (container and other) had average coating ages of less than two years in 2010, and all but three (container, other, and unmanned barges) fit this category in 2011 (Figure VI.26). Thus most coatings applied to vessels operating in California appear to be relatively young and likely still within the coating manufacturer's designated effective age, which is typically three to five years for most antifouling coatings.

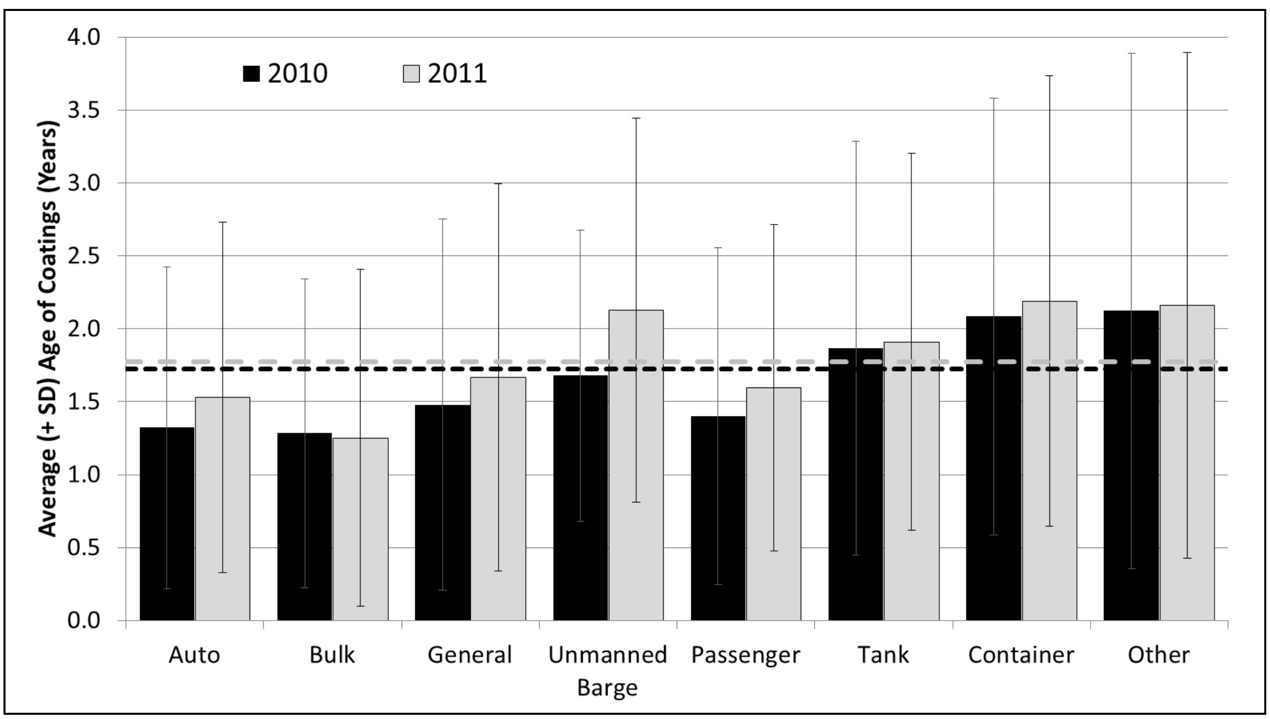


Figure VI.26. Average (+/- Standard Deviation, SD) Age of Antifouling Coatings (years), by Vessel Type, as Reported in 2010 and 2011. Dotted line represents overall average.

Another type of antifouling system in use on the majority of vessels operating in California is a marine growth prevention system (MGPS), which is typically placed within a vessel's sea chest to prevent biofouling organisms from accumulating within the sea chests and the downstream internal pipe network. MGPSs typically operate by dispensing small doses of copper ions or hypochlorite into the sea chest, which inhibits the growth of biofouling organisms. From an operational point of view, the vessel requires large volumes of water to flow through the sea chests and piping network for normal operations, thus keeping them free of biofouling is a priority. Sea chests have been recognized as a very important transport mechanism (Coutts and Dodgshun 2007) and potential source for new invasions, even when the exposed hull of a vessel may be relatively free of organisms. On average between 2008 and 2011, MGPSs were installed on 50.1 – 69.8% of the vessels operating in California (Figure VI.27). The large range is due to the occurrence of vague answers received on some HHRFs for this question (e.g. listing the manufacturer without the model), which limited the ability of Commission staff to verify the use of these systems for the portion of the fleet indicated as 'Likely MGPS' (gray portion of the bars) in Figure VI.27. When considering only those vessels that reported verified MGPSs, only the auto carriers, container vessels, and tank vessels had this type of system installed in at least 50% of their fleet (Figure VI.27).

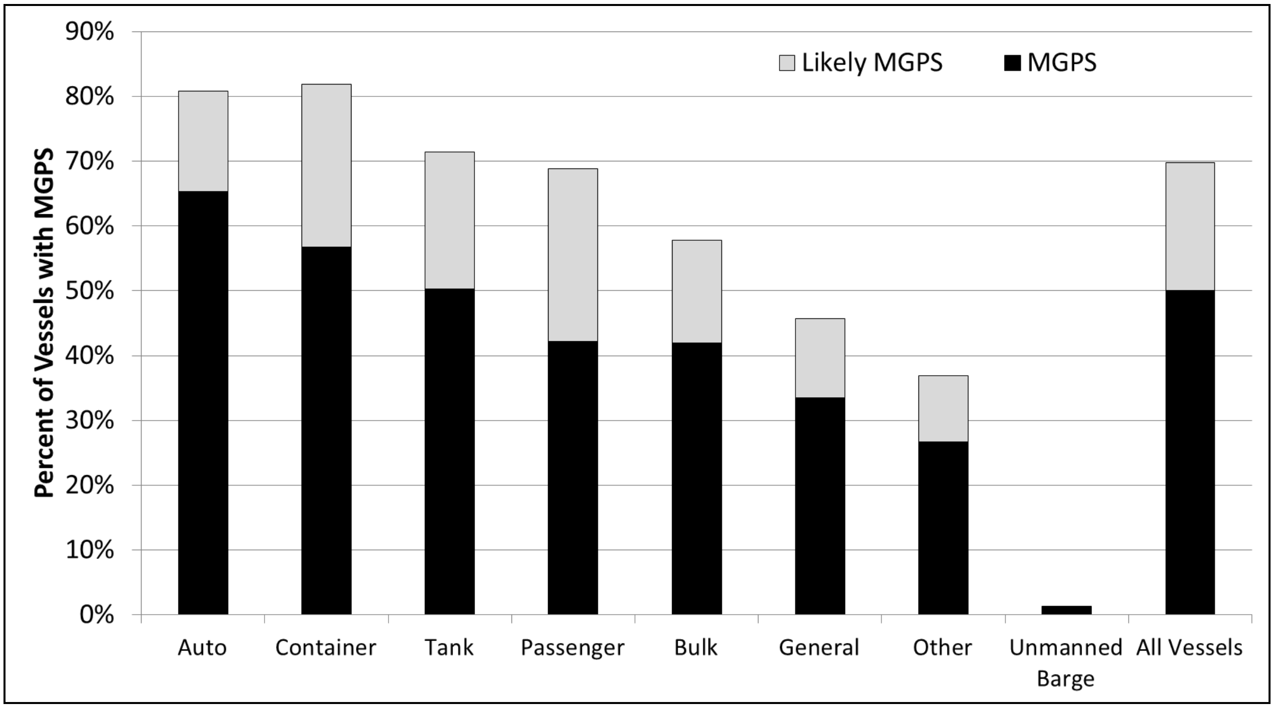


Figure VI.27. Percent of Vessels With a Marine Growth Prevention System (MGPS) Installed, on Average Between 2008 and 2011. "Likely MGPS" represents vessels reporting the installation of a MGPS but did not provide enough information on the manufacturer and model for verification.

Extended Idle Periods for Vessels Operating in California

In addition to hull husbandry practices, certain voyage characteristics influence the extent and diversity of vessel biofouling. One of these characteristics is the amount of time that a vessel remains stationary in a single geographic location, because longer and more frequent idle periods represent a greater potential for biofouling organisms to colonize submerged vessel surfaces. These extended idle periods have become more commonplace over the past several years as the recent 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, where they remain idle for periods of months to years while waiting to return to service (Pacific Maritime Magazine 2009).

The recent economic downturn has impacted the fleet of vessels that operate in California, as evidenced by the dramatic increase in the number of extended idle periods of ten days or greater that were reported on forms submitted in 2011 when compared to 2008. During the 2008 reporting year, 34.7% of the vessels operating in California 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 43.8% of the fleet during the 2011 reporting year. Many individual ships have also reported more than one extended layup during this time, therefore the total number of extended layups experienced by the vessels operating in California increased dramatically as well, up 37.3% on a per capita basis (i.e. number of layups normalized to number of vessels reporting). Four vessel types were disproportionately affected by extended layups: auto carriers (414% increase in layups reported on a per capita basis), unmanned barges (330% increase), container vessels (137% increase), and general cargo vessels (50.5% increase; Figure VI.28). The remaining four vessel types either remained unchanged or had minimal increases or declines in the number of layups reported. This trend is most likely the result of the fact that auto carriers, unmanned barges, container vessels, and general cargo ships all transport expendable commodities and goods, including fuel and building materials, that were not in high demand during the recession of the past several years.

Not only did the total number of extended layups increase during 2011 reporting, but the duration of the layups increased as well. The occurrence of layups spanning months to over a year increased dramatically. The largest increases from 2008 - 2011, on a per capita basis, were observed for layups spanning 100-149 days (390% increase), 70-99 days (308% increase), and 200 days or greater (227% increase; Figure VI.29).

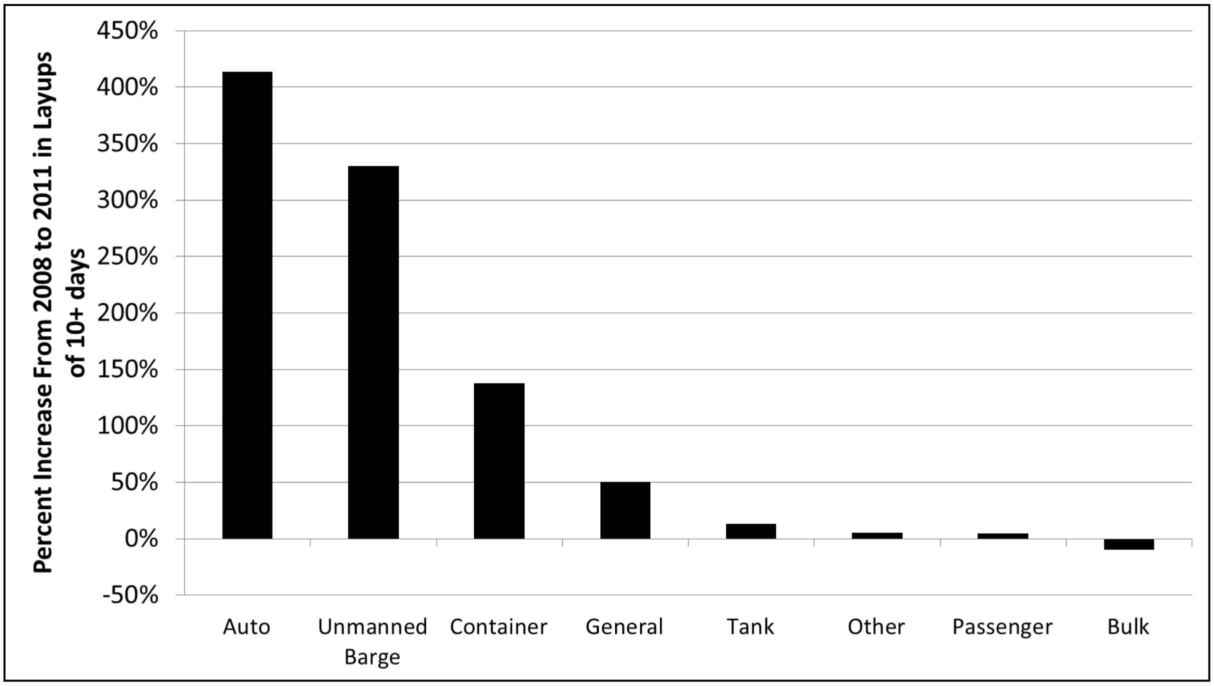


Figure VI.28. Percent Increase From 2008 to 2011 in Number of Reported Extended Layups of 10 or More Days by Vessel Type (normalized to number of submitted forms). Layups may have occurred any time since the vessels most recent dry docking or delivery if newly built.

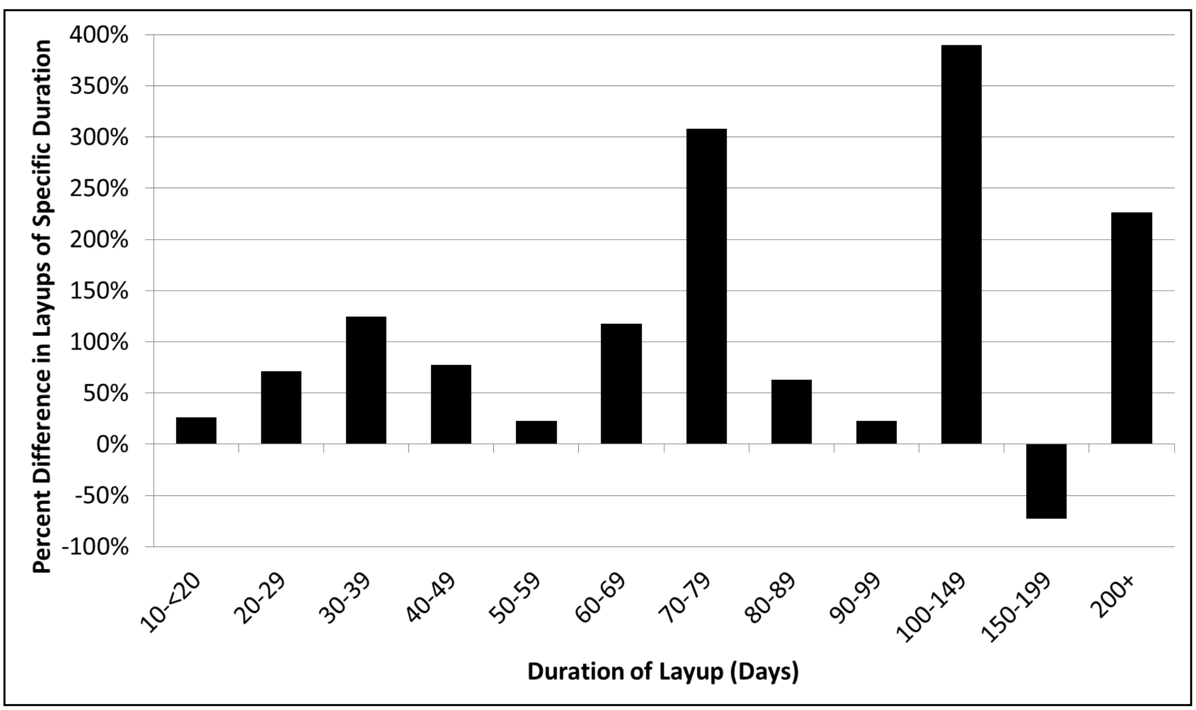


Figure VI.29. Percent Difference in Number of Reported Extended Layups of Specific Durations Reported from 2008 to 2011 (normalized by number of submitted forms). Layups may have occurred any time since the vessel's most recent dry docking or delivery if newly built.

The information collected via the HHRF since 2008, and presented in part within this report, has provided the Commission with valuable insight into the biofouling-related practices of the vessels operating within California waters. These husbandry practices and voyage characteristics all influence, to some degree, the level of risk associated with individual vessels, or even vessels of a given type. The data presented here have been and will continue to be used in conjunction with biological data collected through biofouling-related research currently funded through the MISP (see Section VII) to build a complete picture of 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 continue to guide and inform the ongoing development of regulations to manage biofouling for vessels operating in California (see Section V).

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 4,503 ballast accounts registered with the BOE, an increase of nearly 8% since July 2011. On average, 500 vessel billings are mailed per month. Fee payments received typically amount to just over 98% of the assessed amount (Table VI.6).

Table VI.6. Summary of Marine Invasive Species Fee Program.

Year	Voyages Billed	Voyages Reported[1]	Total Voyages	Fees Billed	Fees Reported[a]	Total Fees	Payments Recd. for Period[b]
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
2010	5,067	899	5,966	4,306,950	764,150	5,017,100	5,009,473
2011	5,174	930	6,104	4,397,900	790,500	5,188,400	5,143,239
Through June 2012[c]	2,843	428	3,271	2,416,550	364,650	2,781,200	2,607,616
TOTAL	**68,348**	**11,340**	**79688**	**34,909,409**	**5,749,325**	**40,658,734**	**40,197,396**

[a]Returns are due at the end of the month following the period of activity. [b]Actual cash received may exceed amount billed due to penalty and interest charges. [c]Amounts may be understated until return processing is complete. Voyages billed means individual billings for each arrival is sent by BOE to the operator or agent. Voyages reported are vessel operators/owners that self-report to BOE once a month.

VII. RESEARCH

Collaborative and Funded 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 biofouling. 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 Biofouling Research

The Commission has been actively evaluating the risk of NIS introductions into California through both the ballast water and vessel biofouling vectors over the past two years. As part of the evaluation of vessel biofouling, the MISP has funded research aimed at evaluating and understanding this vector more completely. This research is being conducted collaboratively by the Aquatic Bioinvasions Research and Policy Institute (ABRPI), a joint collaboration between the Smithsonian Environmental SERC and PSU, and Commission staff. 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.

<u>Richness, extent, condition, reproductive status, and parasitism of fouling communities on commercial vessels (Davidson et al. 2012a)</u>

Published, peer-reviewed journal articles on the vessel biofouling vector are dominated by studies measuring the identity and quantity of organisms associated with the submerged surfaces of ships. However, studies on the condition and reproductive status of biofouling organisms have been largely absent, even though these factors are an important indicator for the chances of a successful invasion. Many biofouling species are attached physically to vessel surfaces, and are generally unable to detach at will. The ability of biofouling organisms to release eggs or young in a recipient port is therefore an important way for them to be introduced to new locations.

This study evaluated the distribution, extent, richness (i.e. number of species), composition, condition (i.e. live or dead), reproductive status and degree of parasitism of biofouling communities of 23 vessels that operate on the U.S. West Coast. The goal was to collect further data on the typical metrics for evaluating biofouling (extent, richness) and conduct initial efforts to evaluate atypical measures (parasitism, condition) of organisms recorded on ship hulls and niche areas that contribute to measures of an organism's ability to disperse and its related introduction risk. The study found that 95% of the organisms collected from ships were alive, with high proportions of individuals from sampled target species in a reproductive state. Parasites were found within specific host organisms (e.g. mussels and barnacles) from several of the sampled ships. These results proved to be insightful and interesting, and illustrated the need for further studies to be developed to improve risk assessments related to introductions from vessel biofouling.

Additionally, this study concluded that the emergence of biofouling management strategies at international and regional levels will result in a strong focus on ship biofouling research for the foreseeable future. This study provided a basis of support for management efforts and guidance documents that will initially tackle niche area biofouling in particular. If species transfers and the role of contemporary shipping in NIS introductions are to be reduced, effective maintenance and prudent new strategies for retaining low levels of biofouling in niche areas will be a necessary step.

<u>Evaluating ship biofouling and emerging regulatory policies for reducing biofouling-mediated species incursions (Aquatic Bioinvasion Research and Policy Institute)</u>
Biofouling on the wetted surfaces of commercial vessels has been shown to be one of the most important mechanisms for transporting nonindigenous species into California and other coastal locations around the world. Previously funded research has characterized the extent and condition of biofouling on vessels operating in California and has guided the Commission during the development of draft regulations governing the management of biofouling on vessels operating in California, which are currently being refined through the public consultation process. The work being conducted here will build upon previously funded work and will fill information gaps related to the implementation and efficacy of the Commission's proposed biofouling regulations.

Four specific objectives are included in the proposed research. The first objective is to sample 8-15 vessels for biofouling abundance, diversity, composition, and condition, and to combine these data with an existing dataset to test the effects of vessel history (e.g. extended idle periods and voyage routes) and how it relates to the growth of biofouling organisms on ship hulls and niche areas. The second objective is to evaluate ship hulls and niche areas for percentage cover of organisms, in-line with the Commission's proposed biofouling management regulations. Third, a Level of Fouling (LoF) ranking system that has been used for risk assessments in other parts of the world and to evaluate biofouling extent will be tested on various underwater surfaces and will be compared to quantitative estimates of biofouling extent, to determine the utility of this metric for regulatory enforcement purposes in the future. The fourth objective includes an assessment of the utility of topside-estimated waterline LoF rankings and percentage cover estimates to indicate possible elevated biofouling accumulation on other underwater surfaces and for potential use for indicating violations of future biofouling regulations. Together, these four objectives will provide valuable insight on the application and efficacy of several provisions included in the Commission's proposed biofouling management regulations and will inform future revisions to those regulations over time.

Sampling efficacy comparison of divers vs. ROV for assessment of vessel biofouling (Smithsonian Environmental Research Center)

Commission scientists are collaborating with SERC and PSU scientists to conduct a formal comparison of in-water diver surveys versus remotely operated vehicle (ROV) surveys on the same vessels, upon arrival to U.S. Ports. Importantly, SERC will quantitatively evaluate paired results (of both methods) for in-service vessels, operating under routine conditions, and imposing real-world constraints on our methods.

While previous research has been conducted to evaluate biofouling on vessels using in-water diver surveys and also ROVs, very few of these past efforts have actually provided a head-to-head comparison of these two methods to assess potential tradeoffs in 1) quality of data (including estimates of percent cover and species identifications), 2) quantity of data, 3) effort in time, and 4) repeatability.

There is an explicit need to characterize and quantify (i.e. percentage cover) biofouling on ship hulls and niche areas, and to define standard methods for this purpose. In addition to evaluating the relative strength of different methods, this initial project is meant to help inform decisions about specific inspection and compliance assessment methodologies.

Ballast Water Research

American President Lines (APL)

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 N.E.I. 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 complete at the end of June 2011. As with other vessels participating in STEP, biological performance testing of the N.E.I. system on the *APL England* has been delayed by the USCG. APL's Technical Service Department and personnel from N.E.I., in consultation with USCG, are working with the Smithsonian Environmental Research Center to conduct the required biological testing, which is expected to begin in May 2013. While the biological testing has been delayed, performance optimization tests on the system began in November 2011. As a result, several engineering modifications are scheduled over the next 18 months to improve the future operations of the system.

Moss Landing Marine Laboratories - Bulk Plankton Viability Assay

In 2010, the Commission approved funding to support research by Dr. Nicholas Welschmeyer, from the Moss Landing Marine Laboratories, for the development of a rapid, bulk test for plankton viability. Ballast water treatment technologies are developing rapidly, but methods of assessing treatment performance have not kept pace. The goal of this research is to develop a simple, rapid and reliable method to assess ballast water treatment performance on board a ship. The method uses a fluorescent marker for living cell activity, with more concentrated marker (i.e. greater fluorescence) indicating more living cells in a sample. The method is expected to be able to detect gross exceedance of California's standards, but it will not provide specific organism concentrations.

Initial work on the validation of the test was performed in the summer of 2010 on discharge from a ballast water treatment system being evaluated at the Golden Bear Facility (California's ballast water treatment technology assessment facility based out of the California Maritime Academy in Vallejo, CA). The test was then packaged into kits and distributed to experts in the field of ballast water treatment technology assessment for scientific peer-review during the summer of 2011. Based on the input received from the peer-review process, the test kits were further optimized during 2012, with hopes to make the technique/test kit available for use by the Commission's Marine Safety personnel in the near future.

<u>The Glosten Associates – Ballast water sampling tool</u>

The Commission entered into an agreement with The Glosten Associates in 2011 to develop a ballast water sampling tool. The basis of the project is the development of a tool for compliance monitoring that gives real-time feedback to the vessel operator on the performance of their shipboard ballast water treatment system. It is hoped that this sampling tool, used in conjunction with Staff's proposed ballast water assessment protocols (see Section V; Performance Standards for Ballast Water Discharge), will provide Commission staff (or other regulatory authority) with a comprehensive ability to determine vessel discharge compliance with relevant performance standards.

The initial phase of the project included a feasibility study to select a promising approach and design to monitor compliance. After the initial study was completed in early 2012, Glosten presented Commission staff with a concept design for a prototype. Further work was then conducted to analyze the computational fluid dynamics of installing a sampling device into a vessel's ballast water discharge line (i.e. piping). As of October 2012, Glosten is preparing to develop a detail-level design and build the prototype sampling tool. Glosten will then engage in component testing prior to evaluation of the entire sampling tool at the Golden Bear Facility (Vallejo, CA) in 2013.

California Department of Fish and Game MISP Biological Monitoring

Pursuant to the Marine Invasive Species Act of 2003 and the Coastal Ecosystems Protection Act of 2006, the California Department of Fish and Game's Marine Invasive Species Program (CDFG-MISP) monitors the location and geographic ranges of native and nonindigenous 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 purpose of subsequent ongoing monitoring is to detect new introductions and assess the effectiveness of ballast water controls implemented under current laws and regulations.

Two large-scale surveys were completed on behalf of the CDFG-MISP during this reporting period. The longstanding contractor, Moss Landing Marine Laboratories, re-surveyed San Francisco Bay in 2010 and other Bays and Harbors sites in 2011. Due to an increase in the operating costs charged by MLML, budgetary constraints necessitated omission of some sites visited in the past. Written reports prepared by CDFG-MISP staff are forthcoming. Upon completion, these reports, as well as that of the 2005 San Francisco Bay Survey, will be posted on CDFG-MISP's website (under the Reports tab), http://www.dfg.ca.gov/ospr/Science/invasive_species.aspx#.

San Francisco Bay Survey

A total of 50 stations were sampled in the spring through summer of 2010. Taxonomic analyses and data entry were completed in June 2011. The number of introduced species and unresolved taxa (e.g. undescribed organisms, juvenile stages, damaged specimens) detected in 2010 were greater than in 2005, whereas the number of detected native and cryptogenic species (unknown whether native or introduced) has decreased over the same time period. Taxa counts for each status group were based on the current version of the California Aquatic Non-native Organism Database

(CANOD) and these numbers may differ slightly from those stated in earlier reports (CDFG 2008, 2011).

Table VII.1. Numbers of taxa, per status group, found during San Francisco Bay surveys completed to date

Status	2005	2010
Introduced	93	107
Cryptogenic	95	91
Unresolved	303	387
Unresolved Complex	3	2
Native	324	309
Total Taxa	818	896

These differences exist because the classification of some taxa may have undergone changes, based upon new information about taxonomy or native ranges. Introduced taxa comprised 11.4% of total taxa in 2005, and 11.9% in 2010. Notable occurrences from the 2010 survey included *Membranipora chesapeakensis*, a bryozoan from the east coast of North America that was recorded for the first time on the Pacific coast. New distribution records within California included three species that were new to San Francisco Bay: *Nicolea* sp. (a polychaete worm); *Caprella simia* (a skeleton shrimp); and *Grateloupia lanceolata* (a red alga). The results of this survey are summarized in greater detail in the CDFG-MISP Triennial Report to the Legislature (CDFG 2011).

<u>Bays and Harbors Survey</u>

The third Bays and Harbors survey took place in the commercial ports of Humboldt Bay, Port Hueneme, Los Angeles/Long Beach, and San Diego Bay, and 14 minor harbors and bays. A total of 52 sites were visited in spring and summer 2011. Except for the slight drop in unresolved taxa in 2006, numbers of each species status group increased over time (TableVII.2). Introduced taxa comprised 6.4% of total taxa in 2000-2002, 7% of total taxa in 2006, and 6.4% in 2011. Taxa new to California included *Dynoides saldanai* (northern range extension for this isopod) and *Molgula citrina* (a tunicate native to the North Atlantic).

Table VII.2. Numbers of taxa, per status group, found during Bays and Harbors surveys completed to date. Fishes were included only in the 2000-2001 survey.

Status	2000-2001	2006	2011
Introduced	67	82	105
Cryptogenic	125	132	189
Unresolved	400	390	600
Unresolved Complex	4	7	7
Native	455	561	739
Total Taxa	1,051	1,172	1,640

Overall

An interesting trend from the continued monitoring at all sites is that the number of unresolved taxa has grown more than any other group. For San Francisco Bay, known unresolved taxa increased by 28% between 2005 and 2010. An even greater increase (>50%) was observed since the previous survey of Bays and Harbors (Tables VII.1 and VII.2).

Accurate identifications and differentiation between native and introduced organisms are hampered by lingering uncertainties about systematics, biogeography, and baseline ecological community history. Moreover, species diversity, distribution, and abundance among marine organisms may fluctuate widely by season and over years, thus monitoring must be conducted at appropriate temporal and spatial scales so that invasion patterns, such as introduction rate and spread, may be gauged accurately. In addition, a sufficient level of replicate sampling is required to assure a high probability of detection, especially for rare species

A New Approach for NIS Detection

A third project funded by CDFG-MISP pursued a more streamlined monitoring approach that integrates DNA molecular techniques with a statistically-robust sampling strategy. The Smithsonian Environmental Research Center and the Molecular Ecology Laboratory at MLML collaborated in this three-year pilot study, which concluded in June

2012. Sampling was conducted at four index sites in San Francisco Bay and focused on the hard-substrate biofouling community. Methods were described in Section 3.1 and Appendix A of the 2011 MISP Triennial Report (CDFG 2011).

The pilot study showed that molecular techniques provided more accurate and consistent identifications than traditional morphological characters. Morphologically-based identifications were subject to errors because key traits in specimens could be missing, damaged, or otherwise invisible. A final report about this pilot study is currently in preparation. Upon completion, it will be posted on the CDFG-MISP website.

Future Direction

Protocols developed and refined during the San Francisco Bay pilot study will be implemented in a forthcoming survey of 10 major California estuaries over the next four years, commencing July 1, 2012. Sites include freshwater reaches of the San Francisco estuary and one outer coast site outside of the San Francisco Estuary. In addition, monitoring will continue at three of the San Francisco Bay pilot study index sites. CDFG-MISP-funded contracts have been executed with SERC and MLML for the first half of this project.

Reports and Publications

The Coastal Ecosystems Protection Act of 2006 established a triennial cycle for submission of the CDFG-MISP reports to the Legislature. Biological monitoring activities of the CDFG-MISP for the period July 1, 2008, through June 2011 were documented in the second triennial report, submitted in December 2011 (CDFG 2011).

A paper entitled “Marine invasion history and vector analysis of California: a hotspot for western North America,” co-authored by SERC and CDFG-MISP staff, was published in the journal *Diversity and Distributions* in late 2011 (Ruiz et al. 2011), see section below on *Review of Current Vessel Vector Research*.

Review of Current Vessel Vector Research

PRC Section 71212(e) requires each MISP biennial report to include a summary of ongoing research on the release of nonindigenous species by vessels. This section summarizes peer-reviewed journal articles published between July 2010 and June 2012 that examine the release of NIS via vessel biofouling and ballast water.

Vessel Vector Research

California plays a major role not only in regional and international vessel vector management, but also in regional invasion dynamics, as demonstrated by Ruiz et al. (2011). The authors, including staff of CDFG-MISP, examined California's role in the history of biological invasions in western North America and found that California's marine and estuarine waters serve as the entry point for the majority of the region's currently established NIS. Seventy-nine percent of the established NIS from California through Alaska were first detected in California waters, suggesting introduction in California followed by northward spread through coastal shipping and other mechanisms. This study also included an evaluation of the relative contribution of different transfer mechanisms to invasions into California over time, and found that vessels (ballast water or biofouling) were responsible for up to 81% of the NIS currently established in California. The authors emphasized the fact that California, especially San Francisco Bay, plays a pivotal role in marine invasion dynamics for western North America, and that any effective strategies to minimize new invasions throughout the region must focus attention on California.

Understanding the relative contributions of ballast water and biofouling to the introduction and establishment of NIS is important when trying to develop policies to reduce future introductions, but assessing the current risk of introducing species based on existing management strategies is also a key component in that process. Lo et al. (2012) published what they believe to be the first Canadian national-scale analysis of a proxy for invasion risk termed potential propagule pressure from ballast water and biofouling. The authors attempted to quantify the potential propagule pressure to the Canadian west, east, and Great Lakes coasts by assessing the relative contributions from ballast water and biofouling. One interesting result from this analysis was that the empty-refill method of ballast exchange was the dominant method of choice for vessels arriving to Great Lakes ports, while the (generally) less-effective method of flow-through ballast exchange was primarily used by vessels arriving to Canadian east and west coast ports. The authors believe that evaluating vessel patterns and practices, and estimating potential propagule pressure can be a relatively simple and inexpensive way to determine potentially high-risk ports and regions that could be targeted for specific management requirements.

Ballast Water-Related Research

With the publication of the seminal paper on the biology of ballast water in 1985, Carlton (1985) presented a foundation for contemporary views of the importance of oceangoing vessels as vectors of NIS, and initiated the worldwide push for policies and strategies to manage the vessel vectors of ballast water and biofouling to prevent the dispersal of coastal organisms across the globe. Davidson and Simkanin (2011) have highlighted the 25^{th} anniversary of the publication of this important work by identifying the effect that it has had on the science of marine vector ecology and the influence it has had on global and regional policy development. The authors describe how this foundational paper on the biology of ballast water helped launch a sub-discipline of bioinvasion science that spans academia, policy, and the maritime industry.

<u>Ballast Water Treatment</u>

With the impending ratification and implementation of the IMO BWM Convention, an understanding of the market availability of ballast water treatment systems is necessary for ship owners and regulators. King et al. (2012) present a preview of the global ballast water treatment system market, in advance of ratification of the BWM Convention. The authors have sorted the worldwide commercial fleet by flag country, vessel type and deadweight tonnage to evaluate the effort required to comply with the BWM Convention when it comes into force. The information presented includes current equipment and installation costs, designed to gauge the market size, which appears larger than earlier published estimates. The estimates published in this article suggest more than 68,000 vessels will be subject to the IMO BWM Convention by 2016, with the possibility that over 70,000 treatment system units will need to be built and sold to accommodate all vessels (including those larger merchant ships that may need to install more than one system).

During the approval process and once installed onboard vessels, treatment systems will need to be evaluated for their efficacy of organism removal or to assess compliance with performance standards. First et al. (2012) describe a prototype shipboard filter skid that was designed specifically for this purpose - to facilitate the collection and concentration of organisms 50 microns in size and greater. Their results indicate that the prototype filter skid performed better than traditional plankton nets at capturing and retaining organisms 50 microns in size and greater, with a capture efficiency ratio of 108% (i.e. the filter skid captured 8% more than what was captured in the plankton net). The results suggest that this, or similarly validated filter skids, would be appropriate for in-line sampling of plankton from relatively large volumes of water.

An important consideration when evaluating ballast water treatment systems for their ability to kill aquatic organisms is the residual effects of those treatments on human health. Banjeri et al. (2012) evaluated the existing human health risk assessment process for ballast water treatment systems, as required by BWM Convention type-approval procedures. The authors evaluated the available application dossiers for IMO type-approval and found that the majority of the active substances that are being used are oxidative in nature and therefore generate disinfection byproducts that may be released to the receiving waters. Because only a few of these byproducts are currently analyzed for risk assessment purposes, the authors have proposed a more comprehensive approach based on the type of ballast water treatment system, the quality of the water treated, and the toxicity of compounds discharged into the environment.

Localized Ballast Water Risk

As more local governments and jurisdictions begin to appreciate the risk associated with ballast water as a mechanism for NIS transport, more localized studies of the possible effects on receiving waters are becoming a priority for policy makers in these regions. Boltovskoy et al. (2011) evaluated the risk from ballast water discharge in Argentinian ports by surveying 194 commercial vessels for compliance with existing ballast water management regulations. This was accomplished through inspection of ballast water reporting forms and collection of physical and biological samples from ballast tanks. Three-quarters of the surveyed vessels had a reporting form onboard, but the information on these forms was often unclear, incomplete, and in some cases appeared to be fictitious. Despite the observation of poor ballast water management, there are relatively few NIS recorded in Argentinian waters, as certain factors such as voyage histories and the environmental setting of Argentinian ports appear to buffer the coastline from successful NIS introductions. The authors indicate that Argentina and other developing countries must significantly increase their efforts to enforce existing ballast water management regulations in order to maintain their waters relatively free of NIS.

While some port environments may be buffered to some degree from the effects of ballast-mediated NIS introductions, others appear to be highly susceptible. DiBacco et al. (2012) evaluated the risk of introducing nonindigenous zooplankton into Canadian ports by vessels with transoceanic voyages (where mid-ocean exchange is required) or coastwise voyages (where ballast exchange is only required for coastal voyages from distant ports, whereas nearby coastal voyages are exempt from exchange requirements). Canada's west coast ports received greater per-ship zooplankton densities and greater numbers of potential individuals released region-wide than east coast ports. Within west coast ports, nonindigenous zooplankton density and the number of released individuals were greatest for vessels with coastal voyages from nearby ports, where no exchange requirements exist. The authors suggest that these results indicate that coastally transiting vessels with unexchanged ballast water represent the greatest invasion risk to Canadian waters, as these vessels are likely to facilitate the transfer of raw water directly from previously invaded locations.

Coastal voyages also present a risk of introducing harmful algae into Canadian ports, as demonstrated by Roy et al. (2012) who sampled nonindigenous plant plankton (specifically dinoflagellates) and other species of potentially toxic harmful algae in the ballast tanks of 63 ships visiting eastern Canadian ports. Coastal tankers with unexchanged ballast carried the greatest densities of harmful algae, and the authors detected nonindigenous dinoflagellates in more than half of the sampled ships, with significantly more found in ships that underwent ballast exchange. The authors found that ballast exchange was not efficient in controlling the introduction of harmful algae, and in fact appeared to promote their transport, possibly because of their wide distribution along the North American east coast. These results suggest that coastal ship traffic is a significant pathway into Canadian ports for harmful algae even when ballast exchange is conducted.

Ballast water-mediated introduction of harmful algae was also the focus of Butron et al. (2011), who assessed the risk of harmful algae transport into and out of Bilbao Harbour, Spain. Between 1997 and 2006, the volume of ballast water loaded in Bilbao was more than three times greater than the volume that was discharged into the port, indicating that Bilbao Harbour was a net exporter of ballast and likely to be a source of NIS for other regions, mainly other European ports. The authors identified seven species of harmful algae that were considered to be a high risk for exporting from Bilbao to other European ports. The authors were also able to demonstrate that harmful algae strains from foreign waters were able to successfully grow in Bilbao Harbour water, suggesting that the risk of introducing harmful algae into Bilbao still exists even though the port is considered a net exporter of ballast water.

Biofouling-Related Research

Recent years have seen an increase in the number of studies evaluating the risk associated with biofouling communities found on the submerged or wetted surfaces of vessels arriving to certain geographic locations. Most of these studies have attempted to assess risk by describing the extent and composition of vessel biofouling communities and relate those patterns to a vessel's recent voyage and hull husbandry history. Sylvester et al. (2011) have added to this ever-increasing worldwide sample size of vessels, but have also attempted to determine the susceptibility of a major Canadian west coast port (Vancouver) and Canadian east coast port (Halifax) to biofouling-induced biological invasions. The authors conducted sampling of 40 ships in total, 20 in Vancouver and 20 in Halifax, and coupled those results with biological surveys of both harbors. Both the number of biofouling organisms and the species diversity on the sampled vessels were high, particularly on the Canadian west coast. The authors also found that biofouling extent increased with the cumulative amount of time that vessels spent in ports and also with the amount of time since application of antifouling coatings (i.e. coating age), highlighting the fact that certain variables related to a vessel's voyage and husbandry history may be used to predict and manage biofouling intensity. Of note for California, the authors also found that the biological communities on vessels and in the harbors were not similar, suggesting high invasion risk, and this was particularly so for the Canadian west coast port of Vancouver, British Columbia.

In addition to the impacts to local environments associated with vessel biofouling, there are also significant economic impacts to the shipping industry as a result of fouling-induced drag and elevated fuel consumption; this is especially important to the industry in the current economic climate. Schultz et al. (2011) evaluated this and other economic impacts of biofouling on a class of mid-sized naval surface ships (Arleigh Burke-class destroyer DDG-51). This was accomplished specifically by reviewing a range of biofouling-associated costs, including costs associated with fuel, the application and removal of antifouling coatings, and in-water cleaning. The authors found that the primary cost associated with biofouling was due to increased fuel consumption as a result of biofouling-induced frictional drag; while the costs associated with coating application and cleaning were much lower. It was also noted that reducing the level of fouling from a heavy slime (i.e. no macrofouling organisms, but a heavy layer of single-celled algae and a bacterial matrix) to a light slime would result in a savings of about $340,000 per vessel per year. This study highlights the strong financial incentive for vessel owners and operators to be proactive about biofouling management and to maintain consistently clean hulls.

Influence of Vessel Characteristics on Biofouling Accumulation

Certain vessel operational characteristics (e.g. cumulative time spent in port) can influence the accumulation and survival of biofouling organisms found on a ship's underwater surfaces. One of these characteristics is the speed at which a vessel travels, with the idea that slower vessels will allow organisms to maintain a foothold on the moving vessel. Coutts et al. (2010a) attempted to quantify the effect of vessel speed on the survivorship of biofouling assemblages, and this was accomplished through the use of a MAGPLATE system that included settling plates with established biofouling communities attached to the vessel hull through the use of a magnetic plate. The authors quantified the survivorship of these biofouling communities after subjecting them to short voyages at three different speeds: slow (4-6.5 knots), medium (8-9 knots), and fast (14-21.5 knots). Their results indicated that biofouling percentage cover and species richness were markedly reduced on faster vessels, likely resulting in reduced risk for vessels that travel at faster speeds versus those that travel at slower or more moderate speeds.

One of the reasons that vessel speed can influence the extent and composition of vessel biofouling communities is because certain species may be better adapted than others at remaining attached to a ship while in transit. Clarke-Murray et al. (2012) looked closely at this by characterizing the attachment strength and drag coefficient of common biofouling species in order to estimate the velocity required to dislodge them from boat and ship hulls, with the idea that known successful invaders may possess biomechanical properties that enable them to remain attached to hulls more successfully than similar species native to British Columbia (BC), where this study took place. The well-known invasive sea squirt *Styela clava* had both high attachment strength and low drag coefficient, and its dislodgement velocity was well above that of fast moving vessels (>50 knots), while the closely-related BC native *Styela gibbsii* had low attachment strength and higher drag coefficient. The authors also found that well-known invasive species that are colonial rather than solitary employed a different hitchhiking strategy. Two species of colonial sea squirts had low attachment strengths but also low drag coefficients, allowing them to be transported on slower moving vessels (e.g. barges). This study revealed that some characteristics of certain biofouling species allow them to be successful invaders and enables them to be easily transported on moving vessels.

An example of a slow moving vessel acting as a vector for transporting biofouling organisms into a new environment was described by Farrapeira et al. (2010), who documented the intraregional transport of a biofouling community on a tugboat from one northeastern Brazil port (Recife) to another (Natal). The authors documented 16 NIS associated with the tug, including seven that were not yet established in the area and three that have been classified elsewhere as invasive.

Hopkins and Forrest (2010) also evaluated risk associated with commercial slow moving vessels by repeatedly sampling the biofouling assemblages of five barges and two tugs in New Zealand over a one-year period. Of the 29 distinct taxa detected on these vessels, five were not native to New Zealand and 17 were not able to be classified due to insufficient taxonomic resolution. Similar to many of the biofouling studies that have been conducted all over the world in recent years, Hopkins and Forrest (2010) found that biofouling percentage cover was lowest on the main exposed surfaces of the hull and highest within dry docking support strips and other niche areas that are more protected and that typically have antifouling coatings that are in poor condition. These findings highlight the emerging understanding that much of the risk associated with vessel biofouling is concentrated in a vessel's niche areas.

While vessel speed has been evaluated as a characteristic that limits the ability of biofouling organisms to remain attached to a ship and to successfully arrive to a recipient port, other vessel characteristics may influence the initial step in the invasion process - an organism's ability to settle and colonize on a vessel in the first place. Wilkens et al. (2012) investigated the possibility that underwater sounds coming from large steel-hulled vessels may inadvertently act as a settlement cue for biofouling species, using the mussel *Perna canaliculus* as a model. The authors found that larval settlement time was significantly faster when exposed to the noise produced by a 125 meter steel-hulled ferry. The median settlement time was 22% faster when compared to controls with no sound present, and the settlement of all experimental larvae in a treatment was 40% faster when exposed to the underwater sounds. The authors also indicated that the reduced settling times were correlated with sound intensity, suggesting that underwater sounds emanating from vessels may be an important factor in facilitating attachment by mussels.

Biofouling Management

Preventative biofouling management (e.g. use of appropriate antifouling technologies) is an effective strategy and presents reduced risk when compared to reactive biofouling management (e.g. in-water cleaning). Nonetheless, the removal of biofouling organisms from the submerged or wetted surfaces of ships is still a necessary component of an effective biofouling management plan. Understanding the risks associated with removal activities is an equally important component of an overall management strategy. Coutts et al. (2010) examined the risk associated with removing a vessel from the water during routine dry docking events by using pre-fouled settling plates to simulate a vessel's removal from the water and quantifying the loss of mobile organisms to the surrounding waters while the fouled plate was removed from the water. The authors were able to demonstrate that a range of mobile organisms were lost to the environment during this process, and also found that the degree of biofouling accumulation (i.e. ascending in order of community complexity from low, moderate, and advanced levels of biofouling) influenced the abundance and composition of mobile organisms that were lost to the surrounding waters. Treatments with moderate biofouling lost the greatest percentage of total animals (19.8%) to the surrounding waters during removal from water when compared to losses associated with low biofouling (3.2%) and advanced biofouling (8.2%). The percentage of total animals lost from the more advanced biofouling communities was less than half of the loss from the moderate treatments, but the authors suggested that this unexpected result was likely due to the increased structural refuges and protection associated with more advanced biofouling assemblages. These results suggest that although removing ships from the water into dry dock is the most effective way to completely clean and treat underwater surfaces, the practice is not without risk and may not be as protective as is currently thought.

Biofouling can also be removed from a vessel through in-water cleaning, but most cleaning systems allow the removed organisms and other organic debris to be released to the seafloor. Hopkins et al. (2010) evaluated two separate in-water cleaning systems with suction and collection capabilities to determine their efficacy of biofouling removal and retention. Both of these systems were diver-operated and utilized a single rotating brush. Both systems demonstrated the ability to remove more than 80% of low to moderate biofouling assemblages, but performed less effectively when removing more advanced biofouling. For example, high proportions (up to 50%) of mature calcareous organisms remained attached after treatment. Of the organisms that were removed, more than 95% were collected and retained by both systems and the vast majority of the remaining 5% of debris was found to be crushed by the brushes and was not viable. However, there still were organisms that were removed from the vessel and lost to the surrounding environment, highlighting the fact that there is still risk associated with cleaning activities even when retention capabilities are present. The authors also indicated that unintentional removal associated with diver swim fins or the umbilical cord of the brush system is another mechanism for organism introduction into receiving waters indirectly associated with the cleaning process. One important issue not quantified by this study is the potential removal of copper and other biocides associated with water quality concerns as a result of in-water cleaning operations.

The fate of the removed biofouling organisms that are not collected by in-water cleaning systems is also important in assessing the likelihood of species introductions. Hopkins et al. (2011) conducted a series of laboratory and field experiments to evaluate various factors that influence survival and re-establishment success of biofouling organisms that were removed from ships and other artificial structures. While some species were found to be unsuccessful at reattaching, others were found to be quite successful, with greater reattachment success associated with larger organism or larger colony fragments. The authors also found that sedimentation and turbidity levels, as well as the presence of predators, in the receiving waters are likely to have a strong negative influence on survivorship. These results demonstrated that even fragments of organisms or colonies, can recover and re-establish after being removed from a vessel during in-water cleaning events.

VIII. CONCLUSIONS AND LOOKING FORWARD

Over the past several decades, NIS introduction mechanisms (or vectors) have received an increasing level of attention locally, regionally, nationally, and internationally. During this time, it has become apparent that shipping vectors (i.e. ballast water and vessel biofouling) are the primary means by which NIS are spread into and throughout coastal regions worldwide. As a result, a common theme among regulatory regimes across the globe is the management of ships as vectors. California led the way in 1999, by creating the Marine Invasive Species Program at a time when there was no mandatory federal ballast water management program in place. California then adopted ballast water performance standards in 2006, to improve upon the less-effective, interim practice of ballast water exchange. California is currently a leader in the development of both compliance assessment protocols for ballast water performance standards as well as biofouling management regulations, to ensure that California's coastal economy and coastal ecosystem continue to be protected.

Over the past two years, the Commission has continued to improve California's Marine Invasive Species Program through a variety of forward-looking and innovative strategies. Commission staff completed an update on the efficacy of ballast water treatment systems for use in California waters in September of 2011 (see Dobroski et al. 2011), and is currently producing a full legislative report on the same topic. During the past two years, the Commission has adopted two reporting forms through the state regulatory process to collect information on the use of shipboard ballast water treatment systems, and staff is currently working on two additional regulatory amendments, as described below. 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 in the prevention of NIS release via vessels also highlights 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:

Working with Stakeholders to Evaluate Plans to Implement California's Performance Standards for Ballast Water Discharge

According to the current implementation schedule, as directed by the state Legislature and adopted by the Commission through regulations, existing vessels with a ballast water capacity between 1500-5000 MT will be subject to California's ballast water discharge performance standards as of January 1, 2014. The Commission is currently preparing a legislative report, in cooperation with stakeholders, describing the efficacy of ballast water treatment systems in advance of the impending January 1, 2014 implementation date. Commission staff will continue to consult with all stakeholders to ensure that California's ballast water discharge performance standards are implemented fairly and responsibly.

Protocols to Assess Compliance with California's Ballast Water Performance Standards

Because Commission staff does not have the capacity to type approve ballast water treatment systems for use in State waters, the ability to assess compliance when a vessel arrives and intends to discharge is essential. Therefore, Commission staff has been developing sample collection protocols and evaluation methods that would allow staff to assess compliance with California's ballast water discharge performance standards. These protocols are being developed in consultation with a technical advisory group of ballast water scientists, state and federal ballast water regulators, and representatives from the shipping industry and non-governmental environmental groups. The intent is to produce a set of transparent procedures that will not only allow Commission staff to evaluate discharged ballast water for compliance purposes, but will also allow the shipping industry and ballast water treatment system vendors to use the exact same methods to conduct their own tests. At the direction of the Commission, staff has distributed the draft protocols to a panel of scientists for independent scientific peer review. Staff intends to pursue adoption of the protocols through the rulemaking process in 2013.

Continue to Support Ballast Water Research

Evaluating a vessel's compliance with ballast water discharge performance standards requires sensitive methods for assessing organism viability. These methods are continuing to improve, and Commission staff supports the development and refinement of these techniques. With Commission funding, researchers are developing rapid assessment techniques that can easily be conducted by scientists, inspectors, or vessel crews to gauge the likelihood of compliance. Commission support is also leading to the development of novel sampling techniques and skids that would enable Commission staff to process large volumes of ballast water in a safe, and quantifiable manner.

Assessment of Shore-Based Ballast Water Reception and Treatment Facilities

California's performance standards for ballast water discharge do not require ships to install shipboard treatment systems. Vessels have several options for compliance, including retention of all ballast water onboard and discharge to a shore-based reception facility. There are currently no shore-based ballast water reception facilities in California, but these facilities are a viable option to ensure vessels meet California's performance standards. In order to provide valuable information to the shipping industry, port authorities and other regulators, the Commission will be requesting proposals to conduct an in-depth assessment and feasibility study of shore-based treatment of ballast water in California. It is anticipated that the resulting report will add detailed insight into the economic, logistical, engineering, legal and physical issues surrounding developing California's ports as shore-based ballast reception facilities.

Improving Compliance with Ballast Water Management Regulations

Even though the total volume of vessel-reported ballast water discharged into California has been increasing over the past several years, the volume of noncompliant ballast water has decreased. Over 97.9% 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 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 9.5% in the second half of 2012. 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 0.9% of all discharges by volume between July 2010 and June 2012, this ballast water may represent a potentially higher risk for introduction to the State because there has been no ballast water management. Because such a large proportion of this ballast water originates from other U.S West Coast areas (71% of all unexchanged discharge, by volume), there may be notable potential for NIS spread into and throughout California from other ports in other West Coast states. This trend is alarming when considering the results of recent research evaluating North American west coast invasion dynamics (see Ruiz et al. 2011, described in Section VII), which suggests considerable intra-coastal spread throughout California and other west coast states. Commission staff plan on expanding and refocusing education, outreach, and inspection efforts to better target vessels in violation of ballast water management. The data presented in Section VI of this report highlight several areas where targeted outreach may be beneficial, including: 1) vessels that exchange ballast water near but not beyond the required distance from shore (i.e. within 5% of the required distance) and 2) vessels that do not take islands (e.g. Channel Islands, Farallon Islands) into account when determining legal distances from shore. An additional group of vessels that should be targeted as a high priority for outreach include tank vessels intending to discharge ballast water sourced from Central America, as this group accounted for a larger portion of noncompliant ballast water discharged into California waters between July 2010 and June 2012 than it has in the past.

A critical component of improving compliance is the staffing level for Marine Safety personnel, who board vessels to conduct compliance assessment inspections and to provide outreach to the vessel crews. The Commission is legislatively mandated to inspect at least 25% of arriving vessels for compliance with California's ballast water and biofouling management requirements. Between July 2010 and June 2012, Commission staff inspected 20.7% of arriving vessels (see Table VI.5 for a breakdown by six-month period), falling below the legislative threshold. This shortfall is primarily due to a reduction in staffing levels over the previous several years, as State budget concerns resulted in the reduction of inspector personnel despite the fact that funding for the MISP is separate from the state's general fund. In order to bring the inspection percentage back up to the mandated threshold, additional inspector staffing may be required.

Compile and Analyze Data Related to Vessel Hull Husbandry

Unlike the ballast water vector, all vessels pose some level of risk through vessel biofouling. However, because biofouling organisms are external, they are exposed to many more varying environmental conditions than sheltered ballast water organisms. These environmental conditions and voyage patterns influence the amount, complexity, and viability of biofouling on the submerged or wetted surfaces of vessels. Beginning in 2008, Commission staff began collecting annual data, using a Hull Husbandry Reporting Form, on the biofouling-related husbandry practices of the vessels operating in California. Staff has analyzed the first four years of these data (see Section VI) and has used them to inform policy decisions in California. Staff has also presented these data as participants in advisory panels and working groups. Staff will continue to analyze the incoming data that will soon represent a robust five-year dataset, and that will represent the most complete dataset of its kind in the world. Over the next several years, Commission staff intends to produce an informational report highlighting the results of these data analyses, as well as several peer-reviewed publications, in order to share this information with the shipping industry, policy makers, and scientists.

Continue to Support and Conduct Biofouling Research

The Commission has been supporting and collaborating on biofouling research that has influenced the development of proposed biofouling management policies. These studies have added to the worldwide knowledge of biofouling patterns associated with vessel operational patterns, and have introduced novel assessments of organism condition (e.g. reproductive capability and presence of parasites) and effects of salinity and other physical conditions on vessel biofouling organisms. The biofouling management regulations currently being developed by Commission staff have benefitted greatly from these studies, and future research will continue to influence the development and revision of management strategies. Commission staff is currently collaborating on projects assessing the feasibility of potential thresholds of allowable biofouling extent and a comparison of remotely operated vehicles and scuba divers for inspection and research purposes.

Commission staff intends to pursue research in the next several years utilizing a remotely operated vehicle to conduct video sampling transects of vessel hulls across a variety of vessel types, as well as to conduct video surveys of certain high-risk vessel niche areas. This information will inform future revisions of biofouling management regulations in California and staff hopes to share these data with regional and international partners, as well as the scientific community, through publication in peer-reviewed scientific journals.

Commission staff will also continue to work with partners at the Water Board (California) and the U.S. Maritime Administration (MARAD) to evaluate the efficacy of in-water hull cleaning operations that retain all removed biological material and heavy metal contaminants from the cleaning effluent. In-water cleaning has become a contentious issue over the past decade, as many jurisdictions have banned the practice due to concerns about potentially viable biological debris as well as chemical (e.g. heavy metal) contamination of the local environment. MARAD has invited Commission staff to participate in discussions of a pilot project to test the efficacy of an in-water cleaning system with the ability to retain all removed biological debris as well as dissolved chemicals. Commission staff will continue to collaborate and participate in these developments as the State and regional Water Boards work towards developing best management practices and eventually permits for in-water cleaning utilizing these types of technologies.

Continue to Develop Regulations Governing the Management of Biofouling for Vessels Operating in California

As specified in PRC § 71204.6, the Commission is required to develop and adopt regulations governing the management of biofouling on vessels arriving to a California port or place. Commission staff, as stated above, has been collecting and analyzing data detailing biofouling-related vessel practices and have been supporting targeted research in an effort to provide insight and guide development of these regulations. Using previously collected data, in addition to ongoing research on vessel biofouling and input from the technical advisory group, Commission staff will continue the rulemaking process to address the risk of vessel biofouling by reissuing a revised draft of proposed regulations in early 2013. Commission staff intends to ensure that these regulations are regionally and internationally consistent when possible, and will focus on management of high-risk vessel characteristics (e.g. remaining stationary for prolonged periods) and management of susceptible niche areas (e.g. recesses such as sea chests and thrusters).

Develop Memoranda of Understanding (MOU) with Regional and International Agencies Working in Parallel with the Commission in Developing Vessel Vector Management Strategies

Over the previous decade, Commission staff has worked cooperatively with regional (e.g. states of Oregon, Washington, Alaska, Hawaii) and international (e.g. Canada, Australia, New Zealand) partners to share data on ballast water and biofouling science and develop consistent management strategies. California has one of the most complete datasets of vessel ballast water and biofouling-related practices in the world, and therefore Commission staff regularly collaborates with these regional and international partners to share data and learn from each other. As an example, Commission staff has shared Hull Husbandry Reporting Form data with agencies in Oregon, Hawaii, Alaska, as well as with Australia's Department of Agriculture, Fisheries, and Forestry. Staff has also received biofouling data from New Zealand's Ministry for Primary Industries. While Commission staff has engaged in data sharing with these entities for years, staff believes formalizing relationships through MOUs will allow for better partnerships and collaboration on regulatory and scientific endeavors to solve NIS problems that are global in nature.

Follow Economic Climate and Assess Fund Status to Ensure Proper Functioning of Program Components

California's Marine Invasive Species Program is funded through a fee assessed on vessels arriving to a California port or place. Therefore, the status of the Marine Invasive Species Control Fund is dependent on the number of qualifying voyages arriving to the state in a given time period. Commission staff convenes a technical advisory group to discuss the status of the vessel fee and the Marine Invasive Species Control Fund to increase or decrease the per-voyage fee when warranted.

As the state, and global, economy recovers from the downturn of recent years, Commission staff will continue to monitor the status of the fund to ensure that the various components of the program are adequately covered.

IX. REFERENCES

Aguirre-Macedo M.L., V.M. Vidal-Martinez, J.A. Herrera-Silveira, D.S. Valdes-Lozano, M. Herrera-Rodriguez, and M.A. Olvera-Novoa. 2008. Ballast water as a vector of coral pathogens in the Gulf of Mexico: The case of the Cayo Arcas coral reef. Marine Pollution Bulletin 56: 1570-1577.

ANZECC. 1997. Code of practice for antifouling and in-water hull cleaning and maintenance. 12 pp.

Arms, M. Personal Communication, November 6, 2012.

Australian Quarantine and Inspection Service. 2008. Australian Ballast Water Management Requirements. March 31, 2008.14 pp.

Banjeri, S., B. Werschkun, and T. Hofer. 2012. Assessing the risk of ballast water treatment to human health. Regulatory Toxicology and Pharmacology 62: 513-522.

Biggs, T. and H. D'Anna. 2012. Rapid increase in copper concentrations in a new marina, San Diego Bay. Marine Pollution Bulletin 64(3): 627-635.

Biosecurity New Zealand. 2005. Import health standard for ships' ballast water from all countries. June 13, 2005. 4 pp.

Biosecurity New Zealand. 2010. Managing and controlling the risk posed to the marine environment from biofouling on arriving vessels. MAF Biosecurity New Zealand consultation paper 10/04. 15 pp.

Boltovskoy, D., P. Almada, and N. Correa. 2011. Biological invasions: assessment of threat from ballast-water discharge in Patagonian (Argentina) ports. Environmental Science & Policy 14: 578-583.

Brant, S.V., A.N. Cohen, D. James, L. Hui, A. Hom, and E.S. Loker. 2010. Cercarial dermatitis transmitted by exotic marine snail. Emerging Infectious Diseases 16:1357-1365.

Brazil Maritime Authority. 2005. Maritime Authority Regulation for Ships' Ballast Water Management. NORMAM 2O/DPC.

Butrón, A., E. Orive, and I. Madariaga. 2011. Potential risk of harmful algae transport by ballast waters: The case of Bilbao Harbour. Marine Pollution Bulletin 62: 747-757.

California State Lands Commission. 2010. Assessment of the Efficacy, Availability and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters. Produced for the California State Legislature. 141 pp.

Canadian Minister of Justice. 2006. Ballast Water Control and Management Regulations. SOR/2006-129. June 8, 2006.

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

Carlton, J.T. 1996. Pattern, process, and prediction in marine invasion ecology. Biological Conservation 78(1-2): 97-106.

Carlton, J.T. 1999. The scale and ecological consequences of biological invasions in the world's oceans. Pp 195-212 *In* Invasive Species and Biodiversity Management. O. Sandulund, P. Schei and A. Viken, eds. Kulwer Academic Publishers. Dordrecht, Netherlands.

Carlton, J.T. 2001. Introduced Species in U.S. coastal waters: Environmental impacts and Management Priorities. Pew Oceans Commission. Arlington, VA. 28 pp.

CDFG (California Department of Fish and Game). 2008. Report to the Legislature: Introduced Aquatic Species in the Marine and Estuarine Waters of California. California Department of Fish and Game, Office of Spill Prevention and Response. Sacramento, CA. December 2008. 66 pp.

CDFG (California Department of Fish and Game). 2011. Report to the Legislature: Introduced Aquatic Species in the Marine and Estuarine Waters of California. California Department of Fish and Game, Office of Spill Prevention and Response. Sacramento, CA. December 2011. 55 pp.

CDFG (California Department of Fish and Game). 2012. Quagga and Zebra Mussels. Website: http://www.dfg.ca.gov/invasives/quaggamussel/ Accessed: December 5, 2012.

Choi, K.H., W. Kimmerer, G. Smith, G.M. Ruiz, and K. Lion. 2005. Post-exchange zooplankton in ballast water of ships entering the San Francisco Estuary. Journal of Plankton Research 27: 707-714.

Clarke-Murray, C., T.W. Therriault, and P.T. Martone. 2012. Adapted for invasion? Comparing attachment, drag and dislodgment of native and nonindigenous hull fouling species. Biological Invasions 14: 1651-1663.

Cohen, A.N. 1998. Ships' Ballast Water and the Introduction of Exotic Organisms into the San Francisco Estuary. Current status of the problem and options for management. San Francisco Estuary Institute, Richmond, CA. 81 pp.

Cohen, A.N. and J.T. Carlton. 1995. Biological study. Non-indigenous Aquatic Species in a United States estuary: A case study of the biological invasions of the San Francisco Bay and Delta. U.S. Fish and Wildlife Service, Washington DC, and National Sea Grant College Program, Connecticut Sea Grant. NTIS No. PB96-166525.

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

Cohen, A.N. and A. Weinstein. 1998. The potential distribution and abundance of zebra mussels in California. A report for CALFED and the California Urban Water Agencies. San Francisco Estuary Institute.

Commonwealth of Australia. 2009a. National biofouling management guidelines for commercial vessels. 16 pp.

Commonwealth of Australia. 2009b. National biofouling management guidance for non-trading vessels. 60 pp.

Cordell, J.R., D.J. Lawrence, N.C. Ferm, L.M. Tear, S.S. Smith, and R.P. Herwig. 2009. Factors influencing densities of non-indigenous species in the ballast water of ships arriving at port in Puget Sound, Washington, United States. Aquatic Conservation: Marine and Freshwater Ecosystems 19: 322-343.

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

Coutts, A.D.M., K.M. Moore, and C. Hewitt. 2003. Ships' sea-chests: An overlooked transfer mechanism for non-indigenous marine species? Marine Pollution Bulletin. 46: 1504-1515.

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

Coutts, A.D.M. and T.J. Dodgshun. 2007. The nature and extent of organisms in vessel sea-chests: A protected mechanism for marine bioinvasions. Marine Pollution Bulletin 54: 875-886.

Coutts, A.D.M., R.F. Piola, M.D. Taylor, C.L. Hewitt, and J.P.A. Gardner. 2010a. The effect of vessel speed on the survivorship of biofouling organisms at different hull locations. Biofouling 26(5): 539-553.

Coutts, A.D.M., J.P. Valentine, G.J. Edgar, A. Davey, and B. Burgess-Wilson. 2010b. Removing vessels from the water for biofouling treatment has the potential to introduce mobile non-indigenous marine species. Marine Pollution Bulletin 60: 1533-1540.

DAFF (Department of Agriculture, Fisheries and Forestry, Australia). 2011a. Draft antifouling and in-water cleaning guidelines. 37 pp.

DAFF (Department of Agriculture, Fisheries and Forestry, Australia). 2011b. Draft antifouling and in-water cleaning guidelines consultation paper. 11 pp.

Davidson, I.C., C.W. Brown, M.D. Sytsma, and G.M. Ruiz. 2009a. The role of containerships as transfer mechanisms of marine biofouling species. Biofouling 25:645-655.

Davidson, I., G. Ashton, and G. Ruiz. 2009b. Biofouling as a vector of marine organisms on the US West Coast: a preliminary evaluation of barges and cruise ships. Aquatic Bioinvasion Research & Policy Institute. Final report for California State Lands Commission. 20 pp.

Davidson, I., G. Ashton, G. Ruiz, C. Scianni, and C. Brown. 2012a. Richness, extent, condition, reproductive status, and parasitism of fouling communities on commercial vessels. Aquatic Bioinvasion Research & Policy Institute**.** Draft final report to the California State Lands Commission. 54 pp.

Davidson, I.C. and C. Simkanin. 2012. The biology of ballast water 25 years later. Biological Invasions 14:9–13.

DiBacco, C., D. Humphrey, L. Nasmith, and C. Levings. 2011. Ballast water transport of non-indigenous zooplankton to Canadian ports. ICES Journal of Marine Science 69(3): 483–491.

Dobroski, N., L. Takata, C. Scianni, and M. Falkner. 2007. Assessment of the Efficacy, Availability and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters. Produced for the California State Legislature. 107 pp.

Dobroski, N., C. Scianni, D. Gehringer, and M. Falkner. 2009. Assessment of the Efficacy, Availability and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters. Produced for the California State Legislature. 173 pp.

Eldredge, L.G. and J.T. Carlton. 2002. Hawaii marine bioinvasions: A preliminary assessment. Pacific Science 56: 211-212.

EPA (U.S. Environmental Protection Agency). 2009. Vessel general permit for discharges incidental to the normal operation of vessels (VGP). Version 2/5/2009. 158 pp.

EPA (U.S. Environmental Protection Agency). 2010. Generic protocol for the verification of ballast water treatment technology. Produced by NSF International, Ann Arbor MI. 63 pp.

Everett, R. Personal Communication, March 11, 2010.

Everett, R. Personal Communication, June1, 2012.

Falkner, M.B. 2003. Report on the California Ballast Water Management Program. California State Lands Commission, Marine Facilities Division. 82 pp.

Falkner, M., L. Takata, and S. Gilmore. 2005. Report on the California Marine Invasive Species Program. Produced for the California State Legislature. 44 pp.

Falkner, M., L. Takata, and S. Gilmore. 2006. California State Lands Commission Report on Performance Standards for Ballast Water Discharges in California. Produced for the California State Legislature. 47 pp.

Falkner, M., L. Takata, S. Gilmore and N. Dobroski. 2007. Biennial Report on the California Marine Invasive Species Program. Produced for the California State Legislature. 79 pp.

Falkner, M., N. Dobroski, C. Scianni, D. Gehringer, and L. Takata. 2009. Biennial Report on the California Marine Invasive Species Program. Produced for the California State Legislature. 100 pp.

Farrapeira, C.M.R., G.F.A. Ferreira, and D.O. Tenorio. 2010. Intra-regional transportation of a tugboat fouling community between the ports of Recife and Natal, northeast Brazil. Brazilian Journal of Oceanography 58:1–14.

Feyrer, F., H.B. Matern, and P.B. Moyle. 2003. Dietary shifts in a stressed fish assemblage: Consequences of a bivalve invasion in the San Francisco estuary. Environmental Biology of Fishes 67: 277-288.

First, M., E. Lemieux, W. Hyland, J. Grant, C. Moser, S. Riley, S. Robbins-Wamsley, M. Steinberg, T. Wier, and L. Drake. 2012. Validation of a closed-housing filter skid for in-line sampling of aquatic organisms. Journal of Plankton Research 34(4): 321-331.

Fofonoff, P.W., G.M. Ruiz, B. Steves, and J.T. Carlton. 2003. In ships or on ships? Mechanisms of transfer and invasion for nonnative species to the coasts of North America. Pp. 152-181. *In* Invasive species, vectors and management strategies. G.M. Ruiz and J.T. Carlton eds. Island Press, Washington D.C.

Globallast. 2010. Ballast Water Management Country Profile Database. Website: http://globallast.imo.org/index.asp?page=country_profiles/intro.asp. Accessed: December 5, 2012.

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

Hallegraeff, G.M. 1998. Transport of toxic dinoflagellates via ships' ballast water: bioeconomic risk assessment and efficacy of possible ballast water management strategies. Marine Ecology Progress Series 168: 297-309.

Hay C. and D. Tanis. (1998) Mid ocean ballast water exchange: procedures, effectiveness and verification. A report prepared for the New Zealand Ministry of Fisheries. Cawthron Report No. 468. Cawthron Institute, Nelson.

Hewitt, C. and M. Campbell. 2010. The relative contribution of vectors to the introduction and translocation of invasive marine species. Final Report prepared for the Australian Department of Agriculture, Fisheries and Forestry. 56 pgs.

Hooff, R. 2010. Oregon Task Force report on the shipping transport of aquatic invasive species. June 2010. 81 pp.

Hopkins, G.A. and B.M. Forrest. 2010. A preliminary assessment of biofouling and non-indigenous marine species associated with commercial slow-moving vessels arriving in New Zealand. Biofouling 26(5): 613-621.

Hopkins, G.A., B.M. Forrest, and A.D.M. Coutts. 2010. The effectiveness of rotating brush devices for management of vessel hull fouling. Biofouling 26(5): 555-566.

Hopkins, G.A., B.M. Forrest, R.F. Piola, and J.P.A. Gardner. 2011. Factors affecting survivorship of defouled communities and the effect of fragmentation on establishment success. Journal of Experimental Marine Biology and Ecology 396: 233-243.

IMO (International Maritime Organization). 2001. International Convention on the Control of Harmful Antifouling Systems on Ships, 2001. Adopted on 18 October 2001. AFS/CONF/26.

IMO (International Maritime Organization). 2005. International Convention for the Control and Management of Ships' Ballast Water and Sediments. International Maritime Organization, London, 138 pp.

IMO (International Maritime Organization). 2007. Resolution A.1005(25). Application of the International Convention for the Control and Management of Ships' Ballast Water and Sediments, 2004. Adopted on 29 November 2007. A 25/Res.1005. 4 December 2007.

IMO (International Maritime Organization). 2011. International Maritime Organization Sub-Committee on Bulk Liquids and Gases BLG 15/WP.4: Annex 1. Draft Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species. 25 pgs.

IMO (International Maritime Organization). 2012. Summary of Status of Conventions as of November 31, 2012. Website: http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx. Accessed: December 5, 2012.

International Marine Coatings. 2006. TBT free antifoulings and foul release systems. Accessed October 15, 2005. http://www.international-marine.com/newbuilding/brochures/AF_Range_Brochure.pdf.

Kildow, J. and L. Pendleton. 2006. The non-market value of beach recreation in California. Shore and Beach 74: 34-37.

King, D., P. Hagan, M. Riggio, and D. Wright. 2012. Preview of global ballast water treatment markets. Journal of Marine Engineering and Technology 11(1): 3-15.

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

Leichsenring, J. and J. Lawrence. 2011. Effect of mid-oceanic ballast water exchange on virus-like particle abundance during two trans-Pacific voyages. Marine Pollution Bulletin 62(5): 1103-1108.

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

Lloyd’s Register. 2009. National Ballast Water Management Requirements. May 2009. 23 pp.

Lo, V., C. Levings, and K. Chan. 2012. Quantifying potential propagule pressure of aquatic invasive species from the commercial shipping industry in Canada. Marine Pollution Bulletin 64: 295-302.

Lovell, S.J. and L.A. Drake. 2009. Tiny stowaways: Analyzing the economic benefits of a U.S. Environmental Protection Agency permit regulating ballast water discharges. Environmenal Management 43: 546-555.

Mac Nally, R., J.R. Thompson, W.J. Kimmerer, F. Feyrer, K.B. Newman, A. Sih, W.A. Bennett, L. Brown, E. Flushman, S.D. Culberson, and G. Castillo. 2010. An analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR). Ecological Applications 20: 167-180.

MacIsaac, H.J., T.C. Robbins, and M.A. Lewis. 2002. Modeling ships' ballast water as invasion threats to the Great Lakes. Canadian Journal of Fisheries and Aquatic Science 59: 1245-1256.

MAF (Ministry of Agriculture and Forestry, New Zealand). 2011. Draft anti-fouling and in-water cleaning guidelines. MAF Discussion Paper No: 2011/13. 38 pp.

Martel, A.L., D.A. Pathy, J.B. Madill, C.B. Renaud, S.L. Dean, and S.J. Kerr. 2001. Decline and regional extirpation of freshwater mussels (Unionidae) in a small river system invaded by *Dreissena polymorpha:* The Rideau River, 1993-2000. Canadian Journal of Zoology 79: 2181-2191.

MDEQ (Michigan Department of Environmental Quality). 2006. Ballast water control general permit. Port operations and ballast water discharge. Permit No. MIG140000. Issued 11 October 2006.

MEPC (Marine Environment Protection Committee). 2003. Comments on draft Regulation E-2. Concentrations of organisms delivered in ships' ballast water in the absence of any treatment: Establishing a baseline for consideration of treatment efficacy. Submitted by the International Council for the Exploration of the Sea (ICES). MEPC 49/2/21. 23 May 2003.

MEPC (Marine Environment Protection Committee). 2008. Guidelines for ballast water sampling (G2). MEPC 58/23. Annex 3. Resolution MEPC.173(58). Adopted on 10 October 2008.

MEPC (Marine Environment Protection Committee). 2009. Second Regional Steering Committee Meeting on Ballast Water Management – Identification of ballast water exchange area outside the ROPME Sea Area. Submitted by ROMPE/MEMAC (Marine Emergency Mutual Aid Center). MEPC 59/INF.3. February 2, 2009.

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

Minchin, D., S. Gollasch, A.N. Cohen, C.L. Hewitt, and S. Olenin. 2009. Characterizing vectors of marine invasions. Pp. 109-116. *In* Biological invasions in marine ecosystems: Ecological, management, and geographic perspectives. G. Rilov and J.A. Crooks eds. Springer. Verlag, Berlin, Heidelberg.

Minton, M.S., E. Verling, A.W. Miller, and G. M. Ruiz. 2005. Reducing propagule supply and coastal invasions via ships: effects of emerging strategies. Frontiers in Ecology and the Environment 3(6): 304- 308.

MPCA (Minnesota Pollution Control Agency). 2008. Ballast water discharge general permit: FAQs for Vessel Owners and Operators. Water quality/Surface Water #8.03. October 2008.

National Research Council. 1996. Stemming the Tide: Controlling Introductions of Nonindigenous species by ship's ballast water. National Academy Press, Washington D.C. 141 pp.

Nehring, S. 2001. After the TBT era: alternative anti-fouling paints and their ecological risks. Senckenbergiana Maritime 31: 341-351.

Neira, C., G. Mendoza, L. Levin, A. Zirino, F. Delgadillo-Hinojosa, M. Porrachia, and D. Deheyn. 2011. Macrobenthic community response to copper in Shelter Island Yacht Basin, San Diego Bay, California Marine Pollution Bulletin 62(4): 701-717.

Nichols, F.H., J.K. Thompson, and L.E. Schemel. 1990. Remarkable invasion of San Francisco Bay (California, USA) by the Asian clam *Potamocorbula amurensis.* II. Displacement of a former community. Marine Ecology Progress Series 66: 95-101.

NOEP (National Ocean Economics Program). 2012a. Market – Ocean Economy search. Website: http://www.oceaneconomics.org/Market/ocean/oceanEcon.asp. Accessed: December 5, 2012.

NOEP (National Ocean Economics Program). 2012b. Natural Resources – Commercial Landings Data search. Website: http://www.oceaneconomics.org/LMR/fishSearch.asp. Accessed: December 5, 2012.

Northwest Environmental Advocates v. United States EPA, No. C 03-05760 SI, 2006 U.S. Dist. LEXIS 69476 (N.D. Cal. Sept. 18, 2006).

Norton, D. Personal Communication, March 15, 2012.

NRC (National Research Council). 2011. Assessing the relationship between propagule pressure and invasion risk. The National Academies Press, Washington D.C.

Pacific Maritime Magazine. 2009. More warnings for box sector. Pacific Maritime Magazine. Published July 2009. Page 8.

Panama Canal Authority. 2010. OP Notice to Shipping No. N-1-2010, Vessel Requirements. January 1, 2010. 61 pp.

Parsons, M.G. 1998. Flow-through ballast water exchange. Society of Naval Architects and Marine Engineers, Transactions 106: 485-493.

Pendleton, L. 2009. The economic value of coastal and estuary recreation. *In* The Economic and Market Value of Coasts and Estuaries: What's at Stake? pp. 140-175.

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

Prefectura Naval Argentina. 1998. Regulation on Environmental Protection. Prevention of Pollution by Aquatic Organisms in the Ballast Water of Ships Destined to Argentine Ports in the River Plate Basin. November 1998.

Reid, D.F., T.H. Johengen, H. MacIssac, F. Dobbs, M. Doblin, L. Drake, G. Ruiz, and P. Jenkins. 2007. Identifying, verifying and establishing options for best management practices for NOBOB vessels. Prepared for: The Great Lakes Protection Fund, the U.S. Coast Guard, and the National Oceanic and Atmospheric Administration. 173 pp.

Roy, S., M. Parenteau, O. Casas-Monroy, and A. Rochon. 2011. Coastal ship traffic: a significant introduction vector for potentially harmful dinoflagellates in eastern Canada. Canadian Journal of Fisheries and Aquatic Sciences 69: 627–644.

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

Ruiz, G.M., T.K. Rawlings, F.C. Dobbs, L.A. Drake, T. Mullady, S. Schoenfeld, A. Hug, and R.R. Colwell. 2000b. Global spread of microorganisms by ships. Nature 408: 49-50.

Ruiz, G.M. and J.T. Carlton. 2003. Invasion vectors: A conceptual framework for management. Pp. 459-498. *In* Invasive species, vectors and management strategies. G.M. Ruiz and J.T. Carlton eds. Island Press, Washington D.C.

Ruiz, G.M. and D.F. Reid. 2007. Current State of Understanding about the Effectiveness of Ballast Water Exchange (BWE) in Reducing Aquatic Nonindigenous Species (ANS) Introductions to the Great Lakes Basin and Chesapeake Bay, USA: Synthesis and Analysis of Existing Information. NOAA Technical Memorandum GLERL-142.

Ruiz, G.M., P.W. Fofonoff, B. Steves, S.F. Foss, and S.N. Shiba. 2011. Marine invasion history and vector analysis of California: a hotspot for western North America. Diversity and Distributions 17: 362-373.

SAB (Science Advisory Board, U.S. Environmental Protection Agency). 2011. Efficacy of ballast water treatment systems: a report by the EPA Science Advisory Board.

Schiff, K., D. Diehl and A. Valkirs. 2004. Copper emissions from antifouling paint on recreational vessels. Marine Pollution Bulletin 48:371-377.

Schiff, K., J. Brown, D. Diehl, and D. Greenstein. 2007. Extent and magnitude of copper contamination in marinas of the San Diego region, California, USA. Marine Pollution Bulletin 54: 322-328.

Schultz, M., J. Bendick, E. Holm, and W. Hertel. 2011. Economic impact of biofouling on a naval surface ship. Biofouling 27(1): 87-98.

Sommer, T., C. Armor, R. Baxter, R. Breuer, L. Brown, M. Chotkowski, S. Culberson, F. Feyrer, M. Gingras, B. Herbold, W. Kimmerer, A. Mueller-Solger, M. Nobriga, and K. Souza. 2007. The collapse of pelagic fishes in the upper San Francisco estuary. Fisheries 32: 270-277.

Spellman, M. Personal communication, October 13, 2010.

SWRCB (State Water Resources Control Board). 2009. Frequently asked questions document. Website: http://www.swrcb.ca.gov/water_issues/programs/beaches/cbi_projects/docs/vessel_faq.pdf. Accessed: December 5, 2012.

Sylvester, F., O. Kalaci, B. Leung, A. Lacoursiere-Roussel, C. Clarke-Murray, F.M. Choi, M.A. Bravo, T.W. Therriault, and H.J. MacIsaac. Hull fouling as an invasion vector: can simple models explain a complex problem? Journal of Applied Ecology 48: 415-423.

Takahashi, C.K., N.G.G.S. Lourenco, T.F. Lopes, V.L.M. Rall, and C.A.M. Lopes. 2008. Ballast water: A review of the impact on the world public health. Journal of Venomous Animals and Toxins Including Tropical Diseases 14: 393-408.

Takata, L., M. Falkner, and S. Gilmore. 2006. California State Lands Commission Report on commercial vessel fouling in California: Analysis, evaluation, and recommendations to reduce nonindigenous species release from the non-ballast water vector. 76 pp.

Takata, L., N. Dobroski, C. Scianni, and M. Falkner. 2011. Biennial Report on the California Marine Invasive Species Program. Produced for the California State Legislature. 125 pp.

U.S. Army Corps of Engineers. 2009. Lake Tahoe Region Aquatic Invasive Species Management Plan, California – Nevada. 84 pp.

USCG (United States Coast Guard). 2001. Report to Congress on the voluntary national guidelines for ballast water management. Appendix B: Status and trends of ballast water management in the United States. Biennial Report for the National Ballast Information Clearinghouse. 45 pp.

USCG (United States Coast Guard). 2004. Navigation and Inspection Circular No. 01-04. Shipboard Technology Evaluation Program (STEP): Experimental Ballast Water Treatment Systems. January 2004.

USCG (United States Coast Guard). 2012. Shipboard Technology Evaluation Program. Accessed: 16 July 2012. Website: http://www.uscg.mil/hq/cg5/cg522/cg5224/step.asp. Accessed: December 5, 2012.

USGS (U.S. Geological Survey). 2012. Zebra mussel and quagga mussel information resource page. Website: http://nas.er.usgs.gov/taxgroup/mollusks/zebramussel/ Accessed: December 5, 2012.

Weigle, S.M., L.D. Smith, J.T. Carlton, and J. Pederson. 2005. Assessing the risk of introducing exotic species via the live marine species trade. Conservation Biology 19: 213-223.

Wilkens, S.L., J.A. Stanley, and A.G. Jeffs. 2012. Induction of settlement in mussel (*Perna canaliculus*) larvae by vessel noise. Biofouling 28(1): 65-72.

Wonham, M.J., W.C. Walton, G.M. Ruiz, A.M. Frese, and B.S. Galil. 2001. Going to the source: role of the invasion pathway in determining potential invaders. Marine Ecology Progress Series 215: 1-12.

Woodfield, R. 2006. Invasive seaweed threatens California's coastline – an update. Ballast Exchange: Newsletter of the West Coast Ballast Outreach Project 6: 10-11.

Zhang, F. and M. Dickman. 1999. Mid-Ocean exchange of container vessel ballast water. 1: Seasonal factors affecting the transport of harmful diatoms and dinoflagellates. Marine Ecology Progress Series 176: 243-251.

APPENDIX A: BALLAST WATER REPORTING FORM

Release Date 12-Sept-2006

OMB Control Number 1625-0069
Expirationdate: 30-Sept-2006

BALLAST WATER REPORTING FORM

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

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

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

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

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

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

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

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

5. BALLAST WATER HISTORY: Record all tanks to be deballasted in port state of arrival *(enter additional tanks on page 2)*. IF NONE, GO TO #6

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

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

6. RESPONSIBLE OFFICER'S NAME AND TITLE: ____________

Dept Homeland Security USCG, CG-5662 (06-04)

2006ReportingForm-1.7.0.docPrevious edition may be used

APPENDIX B: HULL HUSBANDRY REPORTING FORM

California State Lands Commission
Marine Invasive Species Program
Hull Husbandry Reporting Form
Public Resources Code – 71205(e) and 71205(f)
June 6, 2008
Part I: Reporting Form

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

Hull Husbandry Information

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

   a. If Yes, enter the date and location of the most recent out-of-water maintenance:

Last date out of water (**Day/Month/Year**):	
Port or Position:	Country:

   b. If No, enter the delivery date and location where the vessel was built:

Delivery date (**Day/Month/Year**):	
Port or Position:	Country:

2. Were the submerged portions of the vessel coated with an anti-fouling treatment or coating during the **out-of-water** maintenance or shipbuilding process listed above?

Yes, full coat applied ☐
Yes, partial coat ☐ Date last full coat applied (**Day/Month/Year**)
No coat applied ☐ Date last full coat applied (**Day/Month/Year**)

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

Manufacturer/Company:
Product Name:

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

Manufacturer/Company:
Product Name:

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

APPENDIX B: HULL HUSBANDRY REPORTING FORM

Official / IMO Number: _____

Manufacturer/Company:
Product Name:

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

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

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

5. Are Marine Growth Protection Systems (MGPS) installed in the sea chests?

Yes☐ Manufacturer:	Model:
No ☐	

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

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

Date (**Day/Month/Year**):	
Port or Position:	Country:
Vendor providing cleaning service:	

Section(s) cleaned (**Check all that apply**):
Hull Sides ☐ Hull Bottom ☐ Propeller☐ Sea Chest Grating☐
Sea Chest☐ Bilge Keels ☐ Rudder☐ Docking Blocks☐
Thrusters ☐ Unknown ☐

Cleaning method: Divers ☐ Robotic ☐ Both ☐

7. Has the propeller been polished since the last **out-of-water** maintenance (including shipbuilding process) or **in-water** cleaning?

Yes ☐ Date of propeller polishing (**Day/Month/Year**):
No ☐

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

Voyage Information

9. List the following information for this vessel averaged over the last four months:

APPENDIX B: HULL HUSBANDRY REPORTING FORM

a. **Average** Voyage Speed (knots):			
b. **Average** Port Residency Time (hours or days):	**Hours**	or	**Days**

Official / IMO Number: _____

10. Since the hull was last cleaned (**out-of-water** or **in-water**), has the vessel visited:

a. Fresh water ports (Specific gravity of less than 1.005)?

Yes ☐	How many times?
No ☐	

b. Tropical ports (between 23.5° S and 23.5° N latitude)?

Yes ☐	How many times?
No ☐	

c. Panama Canal?

Yes ☐	How many times?
No ☐	

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

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

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

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

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

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

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

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

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

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

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

APPENDIX B: HULL HUSBANDRY REPORTING FORM

Official / IMO Number: _____

11. Since the **most recent** hull cleaning (out-of-water or in-water) or delivery, has the vessel spent 10 or more consecutive days in any single location (Do not include time out-of-water or during in-water cleaning).

No ☐ List the longest amount of time spent in a single location since the last hull cleaning:

Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:

Yes ☐ List all of the occurrences where the vessel spent 10 or more consecutive days in any single location since the last hull cleaning.

Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:
Number of Days:	Date of Arrival (Day/Month/Year):
Port or Position:	Country:

APPENDIX B: HULL HUSBANDRY REPORTING FORM

California State Lands Commission
Marine Invasive Species Program
Hull Husbandry Reporting Form
Public Resources Code – 71205(e) and 71205(f)
June 6, 2008
Part II: Supplementary Instructions for Completing Reporting Form

---

HULL HUSBANDRY REPORTING FORM TO BE SUBMITTED ANNUALLY WITHIN 60 DAYS OF RECEIVING A WRITTEN OR ELECTRONIC REQUEST FROM THE COMMISSION

SUBMIT THE COMPLETED FORM TO:

California State Lands Commission
Marine Facilities Division
200 Oceangate, Suite 900
Long Beach, CA 90802
FAX: 562-499-6444
Email: bwform@slc.ca.gov

Hull Husbandry Information

Question 1: Check the appropriate box to indicate whether, since delivery, the vessel has ever been removed from the water for maintenance.

- If Yes was selected, enter the date (Day/Month/Year) and location for the most recent **out-of-water** maintenance period (for example, if vessel was out of water for dry-dock from January 1-10, list January 10 as the last date out of water).
- If No was selected, enter the vessel's delivery date (Day/Month/Year) and the location where the vessel was built.

Question 2: Check the appropriate box to indicate whether the vessel's hull was coated with an anti-fouling treatment/coating during the out-of-water maintenance period or shipbuilding process described in Question 1.

- If "Yes, full coat applied" was selected, move on to Question 3.
- If "Yes, partial coat" was selected, list completion date (Day/Month/Year) of most recent full coat application of an anti-fouling treatment/coating.
- If "No coat applied" was selected, list completion date (Day/Month/Year) of most recent full coat application of an anti-fouling treatment/coating.

Question 3: For the most recent full coat application of anti-fouling treatment/coating, list the manufacturer(s)/company(ies) and product names of the treatment(s)/coating(s) and check the box next to the specific section(s) of the submerged portions of the vessel where each treatment was applied (check all sections that apply). List information for each anti-fouling treatment/coating if more than one was applied. Attach additional pages if necessary.

APPENDIX B: HULL HUSBANDRY REPORTING FORM

Question 4: Check the appropriate box to indicate whether the sea chest(s) were inspected and/or cleaned during the most recent out-of-water maintenance period described in Question 1. If no out-of-water maintenance since delivery, check Not Applicable.

Question 5: Marine Growth Protection Systems (MGPS) are systems installed in the sea chests to prevent the accumulation of fouling organisms within the sea chests and associated seawater circulation networks. Check the appropriate box to indicate if a Marine Growth Protection System is installed in the sea chest(s).

- If Yes was selected, list the Manufacturer and Model.

Question 6: Check the appropriate box to indicate if the vessel has undergone **in-water** cleaning on the submerged portions of the vessel since the last out-of-water maintenance period. **In-water** cleaning does not include cleaning carried out during out-of-water maintenance but does include cleaning carried out during the Underwater Inspection in Lieu of Dry-Docking (UWILD). For this question, out-of-water maintenance includes the shipbuilding process.

- If Yes was selected, answer Question 6a.
- If No was selected, move on to Question 7.

Question 6a: List date (Day/Month/Year) and location of most recent in-water cleaning (do not include cleaning performed during out-of-water maintenance period) as well as the vendor that conducted the in-water cleaning. Check the box next to the appropriate sections to indicate those sections of the vessel that were cleaned during the in-water cleaning described in Question 6. Indicate whether in-water cleaning was conducted by divers, a robotic system, or both.

Question 7: Check the appropriate box to indicate whether the propeller has been polished since the most recent out-of-water maintenance or in-water cleaning. For this question, **out-of-water** maintenance includes the shipbuilding process.

- If Yes was selected, list the date of the most recent propeller polishing.

Question 8: Check the appropriate box to indicate whether the anchor and anchor chains are rinsed during retrieval.

Voyage Information

Question 9a: Over the past four months, list the average speed (knots) at which this vessel has traveled.

Question 9b: Over the past four months, list the average length of time (either hours or days) that this vessel has spent in any given port.

Question 10a: Check the appropriate box to indicate whether this vessel has visited any freshwater ports (specific gravity of less than 1.005) since the hull was last cleaned (either in-water or out-of-water) or since delivery if the hull has never been cleaned.

- If Yes is selected, list the number of times that this vessel visited freshwater ports since the hull was last cleaned or since delivery if the hull has never been cleaned.

APPENDIX B: HULL HUSBANDRY REPORTING FORM

Question 10b: Check the appropriate box to indicate whether this vessel has visited any tropical ports between latitudes 23.5^o S and 23.5^o N since the hull was last cleaned (either in-water or out-of-water) or since delivery if the hull has never been cleaned.

- If Yes is selected, list the number of times that this vessel visited tropical ports since the hull was last cleaned or since delivery if the hull has never been cleaned.

Question 10c: Check the appropriate box to indicate whether this vessel has traversed the Panama Canal since the hull was last cleaned (either in-water or out-of-water) or since delivery if the hull has never been cleaned.

- If Yes is selected, list the number of times that this vessel has traversed the Panama Canal since the hull was last cleaned or since delivery if the hull has never been cleaned.

Question 10d: Starting with the most recent port, list the last 10 ports visited by this vessel. Provide information on the port or place, country, and the dates of arrival and departure.

If this vessel follows a regular route, visiting the same ports routinely, place a check in the box provided and list the information for the most recently completed route. You do not have to use all ten spaces if the regular route involves less than 10 ports. Add more lines if the regular route involves more than ten ports.

List all dates as Day/Month/Year.

Question 11: Check the appropriate box to indicate whether this vessel has spent 10 or more consecutive days in any single location since the last time the hull was cleaned (either in-water or out of water) or since delivery if the hull has never been cleaned. Do not include time spent out-of-water or time spent during in-water cleaning.

- If No is selected, enter the information for the single longest amount of time this vessel has spent in a single location since the last hull cleaning or since delivery if the hull has never been cleaned.
- If Yes is selected, list all of the occurrences where the vessel spent 10 or more consecutive days in any single location since the last hull cleaning or since delivery if the hull has never been cleaned.

AUTHORITY: Sections 71201.7, 71204.6 and 71205(e), Public Resources Code.

REFERENCE: Sections 71204.6, 71205(e) and 71205(f), Public Resources Code.