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EXECUTIVE SUMMARY

The California Marine Invasive Species Program (MISP) is a multi-agency program designed to prevent the introduction of nonindigenous species into State waters from vessels 300 gross registered tons and above. The MISP was established by the Ballast Water Management for Control of Nonindigenous Species Act of 1999, and reauthorized and expanded by the Marine Invasive Species Act of 2003. The mandate of the MISP is to move the state expeditiously towards elimination of the discharge of nonindigenous species into California waters (Public Resources Code (PRC) section 71201(d)).

The California State Lands Commission (Commission) is charged with MISP oversight and administration. The Commission takes a multi-faceted approach to advancing program goals, including:

- Developing sound, science-based policies in consultation with technical experts and stakeholders;
- Tracking and analyzing ballast water and vessel biofouling management practices of the California commercial fleet;
- Enforcing laws and regulations to prevent introductions; and
- Facilitating outreach to promote information exchange among scientists, legislators, regulators, and other stakeholders.

This report is a programmatic update to the California Legislature on MISP activities from July 2012 through June 2014 and fulfills the reporting mandates set forth in PRC sections 71210 and 71212.

Nonindigenous Species and Vectors of Introduction

Nonindigenous species (NIS) are organisms that are transported to new environments through human activities, either intentionally or unintentionally. NIS pose significant threats to human health, the economy, and the environment. Attempts to eradicate species after they have become established are often unsuccessful and costly; therefore, prevention of species introductions through vector management is considered the most effective way to address NIS.

Shipping is the major mechanism (i.e. vector) by which aquatic NIS are transported around the globe. Shipping is responsible for or has contributed to 79.5% of established aquatic NIS introductions in North America (Fofonoff et al. 2003). Commercial ships transport organisms through ballast water and vessel biofouling. Ballast water is used by ships to maintain stability at sea. When ballast water is loaded in one port and discharged in another, the entrained organisms are introduced to new regions. Vessel biofouling consists of the organisms attached to or associated with submerged or wetted vessel surfaces. Biofouling organisms are introduced to a new environment when they fall off their “host” structure or release larvae in the water as they reproduce.

Vessel Arrival Statistics at California Ports

The Commission collects information from qualifying vessel (largely commercial ships) arrivals to California ports to track NIS management patterns and compliance with the law. All vessels are required to submit a Ballast Water Reporting Form (BWRF) upon departure from each port or place of call in California. These forms provide specific information about vessel ballast water capacity, voyage particulars, and the origin and management of ballast water that is discharged in the state. For the reporting period, 94% of BWRFs were submitted as required.

Between July 2012 and June 2014, 18,739 qualifying voyages (QVs) arrived to California ports. The distribution of arrivals by port remains consistent with previous years; 47% of QVs arrived to the Ports of Los Angeles and Long Beach, 20% to the Port of Oakland, 8% to the marine oil terminals in the Carquinez Strait, and 8% to the Port of Richmond. The majority of arrivals (57%) to California ports came from other California ports (e.g. from LA-LB to Oakland); 23% of QVs listed a last port of call in Asia (predominantly China, Korea, and Japan).

The types of vessels that arrived at California ports were also consistent with previous years; 45% of arrivals at California ports were containerships, and 22% were tank vessels. Almost all (98%) container vessel traffic arrived to LA-LB and the Port of Oakland. Tank vessels called at Los Angeles-Long Beach, Richmond, the marine oil terminals in the Carquinez Strait, and the El Segundo offshore oil terminal.

Ballast Water Management

Eighty-four percent of qualifying voyages to California ports reported retaining all ballast water on board while in California waters. Retention is the most protective ballast water management strategy available to prevent species introductions from the ballast water vector.

Not all vessels can retain ballast water due to operational needs or safety concerns. Sixteen percent of QVs discharged ballast water in California between July 2012 and June 2014. The total volume of ballast water discharged in the state continues to rise. More than 6.9 million metric tons of ballast water were discharged in California in the first half of 2014 – more than in any six-month time period over the last 10 years. Tank vessels and bulk cargo vessels accounted for 87% of the total discharge volume.

The greatest volume of ballast water discharged in the state between July 2012 and June 2014 was in Los Angeles-Long Beach, Carquinez, Richmond, and Oakland, respectively. On a regional scale, the ports and marine terminals in the San Francisco Bay-Delta (including San Francisco, Redwood City, Oakland, Richmond, Carquinez, Sacramento, and Stockton) received more discharged ballast water than the Los Angeles region (12.8 million metric tons vs. 9.5 million metric tons, respectively) over the current reporting period.

Ninety-eight percent of the ballast water carried to California was reported as managed in compliance with the law through retention of all ballast on board or legal management prior to discharge. The majority (79% by volume) of noncompliant ballast water discharged was managed, but in the wrong location (i.e. the ballast water was exchanged at 150 nautical miles (NM) from land instead of the required 200 NM). Water that undergoes some type of management, even if in the wrong location, reduces the risk of NIS introductions. Water that does not undergo any type of management represents the highest risk for NIS introductions from ballast water; 20.4% of noncompliant discharges by volume fall into this highest risk category.

Tankers and bulkers are responsible for the majority (93%) of noncompliant ballast water discharged in the state. Unmanned barges account for the third largest volume of unmanaged ballast water discharged into California. Some barges claim a safety exemption due to dangers associated with transferring personnel to a barge in order to conduct ballast water exchange. While it is legal to discharge unmanaged ballast water when a safety exemption is claimed, the practice does result in the discharge of high-risk water.

Ballast Water Treatment Systems and the Implementation of Ballast Water Discharge Standards

As California, the U.S. Federal government, and the International Maritime Organization (IMO) move towards the implementation of ballast water discharge performance standards, vessel owners are beginning to install ballast water treatment technologies onboard their ships. Since 2012, 58 vessels have arrived at California ports and reported having an installed ballast water treatment system. However, only 12 of those ships have reported managing their ballast water prior to discharge in California using their ballast water treatment system.

In 2014, the Commission assessed the availability of ballast water treatment technologies to meet the California ballast water discharge performance standards (see Commission 2014). The report reviewed shore-based and shipboard methods of treatment. No shore-based treatment facilities able to kill or remove organisms in ballast water currently exist in the United States. Shipboard ballast water treatment systems have not demonstrated the ability to meet the California performance standards. The lack of options available to the shipping industry with which to comply with California's performance standards at this time is an obstacle to implementation of the standards.

To augment existing information on shore-based ballast water treatment, the Commission is currently funding a study of the feasibility of shore-based ballast water treatment in California. The study is being managed by the Delta Stewardship Council (DSC). The DSC selected a contractor in August 2014, and the Commission approved the budget in December 2014. A final report should be available by late 2015.

Commission staff is also engaged in developing ballast water sampling tools and protocols. These protocols will be used to sample ballast water discharged from vessels that arrive at California ports. These samples will allow the Commission to assess shipboard ballast water treatment system performance.

The performance standards are currently scheduled for implementation on January 1, 2016. The implementation schedule, which is set in statute, must be changed to reflect the lack of available treatment technologies, enable collection of data on shipboard treatment system performance, and receive the results of the shore-based treatment feasibility study.

Hull Husbandry Practices Reported by the Shipping Industry

In 2007, the Commission was authorized to collect information on vessel hull husbandry practices in order to gather necessary data to inform the development of biofouling management regulations. The Commission adopted the Hull Husbandry Reporting Form (HHRF) through regulations in 2008. All vessels that arrive at California ports must submit the form once each year. The data present an annual snapshot of hull husbandry and operational practices of vessels that arrive at California ports. Between 2012 and 2013, 92% of vessels submitted the HHRF.

Between 2008 and 2013, at least 79% of vessels reported having antifouling coatings that were less than three years old. Coatings of this age are likely to be within the effective lifespan to prevent species accumulation. Between 83% and 88% of vessels used biocidal coatings to prevent species attachment; most of these coatings are copper-based.

When preventative management of biofouling fails (i.e. antifouling coatings are not effective), ships may use reactive measures, including in-water cleaning, to remove attached organisms. Data from the HHRF indicate that between 11 and 20 vessels per year are cleaned in-water in the LA-LB region; the majority of these cleanings are occur more than three nautical miles from land (i.e. outside of state waters) on vessels with copper-based antifouling coatings. The State Water Resources Control Board (Water Board) currently prohibits in-water cleaning of vessels with copper-based coatings in State waters that are impaired for copper. This prohibition presents challenges to the shipping industry when vessels need to manage their biofouling in California. Commission staff is working closely with the Water Board and impacted industries to discuss the possible use of newly developed in-water cleaning technologies that remove the organisms and copper prior to discharge.

The recent Great Recession has influenced vessel operational practices in a way that has likely increased the risk of NIS introduction. Vessels are sitting idle due to reduced trade and cargo transport and are reducing travel speeds (i.e. slow steaming) to increase fuel efficiency; both practices increase the risk of species attachment and survival during transit. The vessel practice of remaining stationary for ten days or greater has increased 75% from pre-recession (2008) to post-recession (2013). The median traveling speed of the vessels operating in California has decreased 13.8%, from 16.0 knots in 2008 to 13.8 knots in 2013. The adoption of proposed biofouling management regulations will establish requirements to minimize the transport of NIS via biofouling, and will provide the Commission with tools to address extended vessel residency periods and other high risk vessel operational practices.

Data from Cooperating Agencies

The MISP is supported by a vessel arrival fee. The Board of Equalization collects the fee and deposits it in the Marine Invasive Species Control Fund. The fund supports all MISP activities and personnel. The MISP receives no general fund dollars. The fee is set at $850 per qualifying arrival and may be adjusted through regulation (to a maximum of $1000) to account for inflation or changes in the number of vessels arriving to the State. The current fee amount has not changed since 2009. The average collection rate is 98%.

The California Department of Fish and Wildlife's Marine Invasive Species Program (CDFW-MISP) conducts species monitoring in California to assess the effectiveness of the vessel vector management requirements. In 2012 and 2013, CDFW-MISP sampled sites in San Francisco, San Diego, Bodega, Tomales, Morro, and Mission bays. Identification of species and preliminary data analysis are proceeding.

The CDFW-MISP maintains an online database of NIS in California. The California Non-Native Organism Database will soon be merged with a federal NIS database (National

Exotic Marine and Estuarine Species Information System) to enhance the information available to the public, and improve data vetting and technical support.

A summary of all CDFW-MISP biological monitoring activities for the period July 1, 2011, through June 2014 were documented in the third triennial report to the California Legislature, which was submitted in December 2014. The report is available on the CDFW-MISP website.

Challenges to California's Regulation of Vessel Vectors

California's regulation of ballast water and vessel biofouling is threatened by federal initiatives to preempt states' authority. Bills were introduced in 2014 that would place all authority of ballast water and hull husbandry discharges with the United States Coast Guard. The Commission voted to formally oppose such legislation on June 2, 2014. Although the 2014 U.S. Congress adjourned without passing legislation that would effectively dismantle the MISP, it is anticipated that similar legislation will be introduced in the near future. Commission staff will continue to follow the issue closely and will inform the Legislature of potential threats to California's authority to prevent species introductions in California waters.

Looking Forward

Looking forward the Commission will continue to work to improve compliance with ballast water and biofouling reporting and management requirements. Outreach will be focused on vessel types that exhibit frequent noncompliant behavior, including bulk vessels and tankers. Commission staff is developing enforcement regulations to outline penalties associated with noncompliance. The proposed enforcement regulations should provide Commission staff with the necessary tools to increase compliance if education and outreach efforts fail.

Commission staff will also work with unmanned barge operators to discuss avenues to discuss legal, but unmanaged, discharges of ballast water in California. These unmanaged discharges present a high risk for NIS introduction. Ballast water treatment technologies may be important tools to manage ballast water discharges from this vessel type.

Commission staff is actively engaged with shipping companies to board vessels and take ballast water samples to assess ballast water treatment system performance. The Commission awaits the results of the shore-based ballast water treatment feasibility study. Staff is working closely with the shipping industry, environmental organizations, and legislative staffers to identify options for the implementation of the ballast water performance standards given the lack of available treatment technologies.

The Commission is also developing biofouling management regulations and expects to begin the rulemaking process by mid-2015. Commission staff has worked cooperatively with members of the shipping industry, scientists, environmental organizations, antifouling coatings manufacturers, and regulatory agencies to ensure requirements are based on the best available technology, protect the waters of the state, and align, as much as possible with international guidelines established by the IMO.

As part of all of these efforts, the Commission will continue to use current resources to work proactively to reduce the risks of NIS introductions to California waters.

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ABBREVIATIONS AND ACRONYMS

ABRPI	Aquatic Bioinvasions Research and Policy Institute
AMS	Alternative Management System
ASTM	American Society for Testing and Materials
BOE	Board of Equalization
BWRF	Ballast Water Reporting Form
CANOD	California Aquatic Non-Native Organisms Database
CCR	California Code of Regulations
CDFW	California Department of Fish and Wildlife
CDFW-MISP	California Department of Fish and Wildlife's Marine Invasive Species Program
CFR	Code of Federal Regulation
cfu	colony-forming unit
CMA	California Maritime Academy
Commission	California State Lands Commission
CWA	Clean Water Act
DSC	Delta Stewardship Council
EEZ	Exclusive Economic Zone
EPA	Environmental Protection Agency
ER	empty-refill
FT	flow-through
GDP	gross domestic product
GRT	gross registered tons
GSP	gross state product
HACCP	Hazard Analysis and Critical Control Point
HHRF	Hull Husbandry Reporting Form
IMO	International Maritime Organization
LA-LB	Los Angeles-Long Beach port complex
m	meter
MARAD	U.S. Maritime Administration
ml	milliliter
MISA	Marine Invasive Species Act
MISCF	Marine Invasive Species Control Fund
MISP	Marine Invasive Species Program
MLML	Moss Landing Marine Laboratories
MMT	million metric tons
MT	metric tons
NAMEPA	North America Marine Environment Protection Association
NEMESIS	National Exotic Marine and Estuarine Species Information System
NIS	nonindigenous species

NISA	National Invasive Species Act
NM	nautical miles
NPDES	National Pollutant Discharge Elimination System
PCR	Pacific Coast Region
ppt	parts per thousand
PRC	Public Resources Code
PSU	Portland State University
QV	qualifying voyage
SB	Senate Bill
SERC	Smithsonian Environmental Research Center
STEP	Shipboard Technology Evaluation Program
TAG	technology advisory group
TAP	technology advisory panel
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)

I. PURPOSE

The California State Lands Commission (Commission) prepared this report for the California Legislature pursuant to Public Resources Code (PRC) sections 71210 and 71212. According to statute, the report must be updated biennially and, at a minimum, include:

- A summary and analysis of ballast water management practices reported by the industry;
- A summary and analysis of monitoring and inspection information, including compliance rates;
- A summary of recent research addressing the release of nonindigenous species (NIS) by vessels;
- A summary of Commission sponsored research and programs to evaluate alternatives for treating or otherwise managing ballast water;
- An evaluation of the effectiveness of the California Marine Invasive Species Program (MISP); and
- Recommendations to improve upon the effectiveness of the program.

Since the inception of the MISP in 2000, the California Legislature has expanded the purview of the program to include, among other responsibilities, ballast water discharge performance standards and the regulation of vessel biofouling. The Commission has expanded the report accordingly to include:

- An update on the implementation of the ballast water performance standards;
- A summary and analysis of biofouling management practices reported by the shipping industry; and
- A summary of Commission sponsored research to address biofouling science, management, and treatment.

This seventh biennial report to the California Legislature summarizes MISP activities from July 1, 2012 through June 30, 2014.

II. INTRODUCTION

Nonindigenous Species Impacts

Aquatic nonindigenous species (NIS) are non-native species that have been transported to new marine, estuarine, and freshwater environments through human activities. Once established, NIS can have severe economic, human health, and ecological impacts.

The zebra mussel (*Dreissena polymorpha*) is an example of a NIS that has caused significant impacts in a receiving environment. Zebra mussels were introduced to the Great Lakes from the Black Sea in the mid-1980s via ballast water discharge from commercial ships (Carlton 1993). The 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 estimated annual damage and control costs of one billion dollars (Pimentel et al. 2005).

Zebra mussels have altered ecological communities, causing localized extinction of native species (Martel et al. 2001) and declines in recreationally valuable fish species (Cohen and Weinstein 1998). They crowd out other species and filter vast amounts of water, dramatically reducing concentrations of plankton (tiny floating plants and animals) from the water. Plankton are the foundation of aquatic food webs, and disruptions to this base propagate throughout the ecosystem.

In California, zebra mussels are now established in San Justo Reservoir in San Benito County, and the closely related quagga mussel (*Dreissena bugensis*) is found in multiple locations in southern California, including the Colorado River Aqueduct System (USGS 2014).

Economic Impacts

NIS, including zebra and quagga mussels, pose a threat to California’s economy. In aquatic and marine environments, NIS threaten aquaculture operations, recreational boating, commercial and recreational fishing, marine transportation, and tourism, among other industries. In 2011 (the latest year for which data are available), California had the second largest ocean-based gross state product (GSP) in the U.S., ranked number one for ocean-based employment, and was second in wages (NOEP 2014a). The 2012 landing of commercial fish in California, totaling 353 million pounds, was valued at more than $231 million (NOEP 2014b). The coastal tourism and recreation industries accounted for almost $17 billion of California’s GSP in 2011 (NOEP 2014a).

In 2014, water hyacinth, a nonindigenous aquatic plant, caused significant negative impacts to the Port Stockton and several San Francisco Bay-Delta marinas. Shipping traffic to the Port of Stockton was restricted to daylight hours due to high densities of the plant in waterways. The Port spent $200,000 to mechanically remove the plant, and the shipping industry lost an estimated $300,000 due to delays in cargo operations (Wingfield, J. pers. comm. 2015). The City of Stockton cancelled its annual holiday boat parade resulting in an estimated loss of $40,000 - $50,000 in tourism trade (KCRA 2014). The dense plant populations have restricted opportunities for local citizens to boat on California's waterways, impacting recreation-based revenue generation.

To limit the impacts of NIS on California's valuable ocean- and coastal-based industries, millions of dollars have been spent on control and eradication of NIS. 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 Harbor) in southern California (Woodfield 2006). Since 2000, $27.5 million has been spent to manage the Atlantic cordgrass (Spartina alterniflora) in the San Francisco Bay-Delta (Latta, M., pers. comm. 2014). Over $21 million has been spent or budgeted by the California Department of Fish and Wildlife (CDFW) and California State Parks to control zebra and quagga mussels in California since the species were first detected in 2007 (Volkoff, M., pers. comm. 2014). These costs represent only a fraction of the cumulative expenses related to NIS control; eradication is rarely successful and control is an unending process.

Human Health Impacts

NIS pose a risk to human health in addition to impacting the coastal economy. Vessels and port areas have been connected to the spread of epidemic human cholera (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 Bay oyster beds during the summer and fall of 1991 due to health concerns.

In addition to cholera, microbes found in ships have included coral pathogens (Aguirre-Macedo et al. 2008), human intestinal parasites (*Giardia lamblia, Cryptosporidium parvum, Enterocytozoon bieneusi)* (Johengen et al. 2005), the microorganisms that cause paralytic shellfish poisoning (Hallegraeff 1998), and microbial indicators for fecal contamination (*Escherichia coli* and intestinal enterococci) (Reid et al. 2007).

The Japanese sea slug *Haminoea japonica* was first detected in San Francisco Bay in 1999. It is a host for parasites that cause cercarial dermatitis, or "swimmer's itch." Since 2005, cases of swimmer's itch at Robert Crown Memorial Beach in Alameda have occurred regularly and are associated with high densities of *H. japonica* (Brant et al.

2010). In 2013, the Alameda Department of Environmental Health issued a "Swimmer's Itch Advisory" to the public due to the high number of cases (ACEH 2014).

Environmental Impacts

NIS also cause significant environmental impacts. Worldwide, forty-two percent of threatened or endangered species are listed, in part, because of impacts from NIS (e.g. competition) (Pimentel et al. 2005). In San Francisco Bay, the overbite clam (*Potamocorbula amurensis*) spread throughout the region's waterways within two years of first detection in 1986. A recent study shows that the overbite clam is able to consume 80% to 90% of the microzooplankton (microscopic animals) from the water column in the shallow portions of the bay (Greene et al. 2011). By dramatically reducing microzooplankton concentrations in the water, the clam is believed to be contributing to the decline of several pelagic fish species in the Sacramento-San Joaquin River Delta, including the threatened delta smelt (Feyrer et al. 2003, Sommer et al. 2007, Mac Nally et al. 2010).

Mechanisms of Introduction – "Shipping Vectors"

NIS are introduced into U.S. waters through multiple mechanisms, or "vectors", including: the aquaculture industry, live bait release, intentional sportfishing introductions, release of aquarium pet and live seafood specimens, transfer via recreational watercraft, association with marine debris, and commercial shipping (Weigel et al. 2005, Minchin et al. 2009, Cohen 2012a, Cohen 2012b, Grosholz et al. 2012, Williams et al. 2012, Ashton et al. 2012).

In coastal environments, commercial shipping is the most significant vector for NIS introductions, accounting for or contributing to 79.5% of introductions to North America (Fofonoff et al. 2003) and 74.1% globally (Hewitt and Campbell 2010). Commercial ships transport organisms through two primary mechanisms - ballast water and vessel biofouling.

Ballast Water

Ballast water is necessary for many functions related to the trim, stability, maneuverability 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 that water when cargo is loaded in another port.

The 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 could be moved around the world in unmanaged ballast water on a daily basis (Carlton 1999). Moreover, each unmanaged ballast water discharge has the potential to release over 21.2 million individual planktonic animals (Minton et al. 2005).

Vessel Biofouling

Vessel biofouling consists of 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).

Vessel biofouling has been identified as one of the most important vectors 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). More specifically, biofouling is believed to be responsible for 42.6% of coastal NIS introductions globally (Hewitt and Campbell 2010) and up to 60% of coastal species introductions in California (Ruiz et al. 2011).

Vector Management for the Prevention of NIS Introductions

Prevention of species introductions through vector management is considered the most effective way to address NIS, because attempts to eradicate species after they have become established are often unsuccessful and costly (Carlton 2001).

Ballast Water Management

Retention of all ballast water on board a vessel is the most protective NIS management strategy available. No water is discharged; therefore, no organisms are released into the environment. For those vessels that must discharge ballast due to operational needs or safety concerns, ballast water exchange is currently the primary method of ballast water management. During exchange, the biologically rich water that is loaded while a vessel is in port, or near the coast, is exchanged with the comparatively biologically-poor waters of the open ocean. Coastal organisms adapted to the environmental 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). Most vessels are capable of conducting exchange, and this management practice does not require any special structural modification to most vessels in operation.

Ballast water exchange is generally considered an interim ballast water management tool due to its variable efficacy and operational limitations. Scientific research indicates that exchange typically eliminates between 70-99% of the organisms taken into a ballast tank (Cohen 1998, Parsons 1998, Zhang and Dickman 1999, USCG 2001, Wonham et al. 2001, MacIsaac et al. 2002). Therefore, even if a vessel reports exchanging 100% of its ballast water, there is a possibility that living source organisms will remain in the tank after exchange.

A proper exchange can take many hours to complete due to ballast pump and piping capacities. In some circumstances, exchange may not be possible without compromising vessel safety due to adverse sea conditions or vessel design. Some vessels may be routed on short voyages, or voyages that remain within 50 nautical miles (NM) of shore. In such cases, the exchange process may create a delay or require a vessel to deviate substantially from their route. This would cause additional fuel usage and increased air emissions.

Because of the aforementioned limitations on exchange, regulatory agencies and the commercial shipping industry look toward the widespread use of effective ballast water treatment technologies as the next promising management option. Ballast water treatment should be able to reduce or eliminate organisms in vessel discharges, even in situations where exchange may be unsafe or impossible. Technologies that eliminate organisms more effectively than exchange could provide a consistently higher level of protection to coastal ecosystems from NIS. The use of effective ballast water treatment technologies should also allow voyages to proceed along the shortest routes, in all operational scenarios, thereby saving time and money, and avoiding the safety/stability issues related to ballast water exchange (although treatment technologies may pose their own risks for safety).

Many barriers have hindered the development of ballast water treatment systems including: equipment design limitations, both on the part of the ballast water treatment system and the vessel; the cost of technology development associated with research and development and performance evaluation; regulatory inconsistencies; and the lack of guidelines for testing and evaluating treatment system performance.

Many shipping industry representatives, technology developers, and investors cited the absence of a specific set of ballast water performance standards as a primary deterrent to progress. In response, the International Maritime Organization (IMO), the United

States Coast Guard (USCG), the United States Environmental Protection Agency (U.S. EPA), and multiple U.S. states, including California, adopted ballast water discharge standards. These standards are in various stages of implementation. See Section III for more information about the California performance standards and implementation.

Vessel Biofouling Management

Vessel biofouling is an important historical and contemporary vector of species introductions (Carlton and Hodder 1995). Mariners are well aware of biofouling as a hindrance to vessel performance and fuel efficiency. Biofouling on the hull can create drag, increase fuel consumption, and can cause engines to work harder to push the vessel through the water. In pipes, biofouling can block inflowing seawater meant to cool machinery.

To prevent biofouling accumulation, common management strategies include the use of antifouling coatings and marine growth prevention systems and cleaning of underwater vessel surfaces. Antifouling coatings function to reduce the extent to which organisms can attach to submerged portions of vessels. Biocidal antifouling coatings are applied during out-of-water (dry dock) vessel maintenance, and deter the attachment of fouling organisms by slowly releasing toxic compounds containing copper, zinc, and, until recently, tin (e.g. 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.

Biocide-free foul-release coatings (e.g. silicone-based coatings) are also available, but are more costly to apply. Most are currently only effective for active, swift vessels (those that cruise over 15 nautical miles per hour (i.e. knots)) (Lewis 2002, International Paint 2014). Several coating manufacturers claim that recently introduced foul-release coatings are effective on slower moving vessels (Hempel 2014, International Paint 2014). These foul-release coatings produce a smooth surface making it difficult for fouling organisms to remain attached once the vessel is underway.

In addition to the use of antifouling coatings, vessels owners and operators also regularly clean underwater portions of their vessels to manage biofouling growth. The frequency with which most vessels are inspected or cleaned is based on the maintenance rules of their Classification Society (organization that establishes and applies technical standards for ship design, construction, and surveys). Vessel-specific maintenance programs include a cycle of annual in-water surveys and special dry dock surveys (generally every five years).

During dry docking vessel hulls are cleaned of biofouling organisms and a fresh coat of antifouling paint is applied. Because biofouling can continue 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's underwater surfaces. Hull cleaning during dry dock allows for the containment of biofouling organisms as well as paint remnants, which can include copper and other heavy metals. In-water cleaning, however, may allow organisms and paint debris to enter the water column; it has, therefore, increasingly come under scrutiny due to concerns about water quality and NIS introductions.

In spite of the efforts of the maritime industry to minimize vessel biofouling with the use of antifouling coatings and in-water cleaning, biofouling remains a significant vector by which NIS are transported to new regions (Coutts and Dodgshun 2007, Davidson et al. 2009a, Hopkins and Forrest 2010, Hewitt and Campbell 2010, Sylvester et al. 2011, Ruiz 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). Additionally, "niche" areas, including dry docking support strips, bow and stern thrusters, propellers, rudders, sea chests, and worn or unpainted areas, have been found to be more prone to biofouling accumulation due to insufficient management and poor water flow over these areas (Coutts et al. 2003, Minchin and Gollasch 2003, Coutts and Taylor 2004, Davidson et al. 2009b, Frey et al. 2014).

Commission staff is currently working on developing biofouling management regulations for vessels calling on California ports (see Section III).

III. CALIFORNIA’S MARINE INVASIVE SPECIES PROGRAM

Governing Legislation

Ballast Water Management for Control of Nonindigenous Species Act
Recognizing the risk of species introductions to California waters from vessel vectors, the California Legislature approved the Ballast Water Management for Control of Nonindigenous Species Act in 1999 (Management and Control Act; Assembly Bill 703, Chapter 849, Statutes of 1999). The Management and Control Act established the Marine Invasive Species Program (MISP), a statewide multi-agency program to prevent NIS introductions from commercial vessels. The Commission, the California Department of Fish and Wildlife (CDFW; formerly the California Department of Fish and Game), the State Water Resources Control Board (Water Board) and the Board of Equalization (BOE) were charged with:

- Directing research on vessel vectors of NIS;
- Developing policy and regulations;
- Monitoring vessel arrivals, management compliance, and species introductions in California waters; and
- Consulting with one another to address NIS management.

The MISP is funded through the collection of fees authorized by the Management and Control Act. The fee is assessed on a vessel’s arrival at a California port or place after operating outside the waters of the State. The fee is deposited into the Marine Invasive Species Control Fund (formerly the Exotic Species Control Fund) and supports all program staff, research, and management activities.

The maximum fee amount is set in statute, however it can be adjusted through regulation based on inflation or changes in the number of vessel arrivals to the State. Adjustments to the fees are made in consultation with a stakeholder advisory group. The current fee of $850 was adopted in November 2009 (see Title 2 California Code of Regulations (CCR) § 2270 et seq.).

The Management and Control Act required vessels arriving to California from outside the U.S. Exclusive Economic Zone (EEZ) to manage their ballast water before discharging into State waters. Additionally, each vessel that arrives at a California port or place must comply with reporting and inspection requirements.

Marine Invasive Species Act
In 2003, the Marine Invasive Species Act (MISA; Assembly Bill 433, Chapter 491, Statutes of 2003) revised and reauthorized the Management and Control Act, adopting

recommendations from the 2003 “Report on the California Ballast Water Management Program” (see Falkner 2003).

Qualifying vessels under the MISA include all vessels that arrive at a California port or place that are 300 gross registered tons (GRT) or above and carry, or are capable of carrying, ballast water.

The MISA does not apply to vessels of the U.S. Armed Forces (as defined in the Code of Federal Regulations (CFR) Title 33 section 1322) or vessels in innocent passage through California waters (PRC section 71202). Vessels are exempt from the requirement to conduct ballast water management if the process would threaten the safety of the vessel, its crew, or its passengers (PRC section 71203).

The MISA requires vessels to maintain a ballast water management plan and ballast water activity records and log. The MISA directed the Commission to adopt regulations for vessels arriving at California ports from within the Pacific Coast Region (PCR; see Figure III-1) and to address gaps in vessel vector management that do not involve ballast water, such as for vessel biofouling (see PRC section 71204.5 and 71210.5, respectively). Finally, the MISA directed the Commission to consult with the Water Board, the United States Coast Guard (USCG), and a technical advisory panel. Using the information gathered the Commission was to recommend performance standards for the discharge of ballast water to the Legislature (see PRC section 71204.9).

In response to MISA mandates, the Commission:

- Adopted regulations in 2005 for vessels arriving to California ports from within the PCR (see 2 CCR § 2280 et seq.);
- Evaluated vessel vectors other than ballast water (see Takata et al. 2006); and
- Recommended performance standards for the discharge of ballast water (see Falkner et al. 2006).

These activities have led to additional legislation, regulations, and projects within the MISP to reduce the risk of NIS introductions to California’s coastal and estuarine waters.

Ballast Water Management

The Commission implements a comprehensive ballast water management program designed to prevent NIS introductions.

Best Management Practices

All vessel owners, masters, operators, and persons in charge must follow best management practices to minimize the release of NIS into California waters (see PRC section 71204). Vessels should: discharge only the minimum amount of ballast water essential for operations; clean ballast tanks in accordance with applicable laws; and rinse anchors and anchor chains when they are retrieved. Vessels must also minimize the discharge of ballast water in marine sanctuaries, marine preserves, marine parks, or coral reefs, and minimize uptake of ballast water in areas that are high risk due to the presence of NIS, such as:

- Areas known to have infestations or populations of nonindigenous organisms and pathogens;
- Areas near a sewage outfall;
- Areas for which the master, owner, operator, or person in charge of a vessel has been informed of the presence of toxic algal blooms;
- Areas where tidal flushing is known to be poor or in turbid waters;
- In darkness when bottom-dwelling organisms may rise up in the water column; and
- Areas where sediments have been disturbed, such as near dredging operations or where propellers may have recently stirred up sediment.

Ballast Water Management Practices

Vessel owners and operators have several options available to them to manage ballast water and decrease the risk of introducing NIS into California waters (see PRC section 71204.3). Vessels can:

- Retain all ballast water onboard (the most protective management strategy available);
- Take on and discharge ballast water at the same location;
- Exchange ballast water at a minimum specified distance offshore;
- Discharge to an approved shore-based facility (currently none are available);
- Use an approved alternative management method; or
- Under extraordinary circumstances, exchange ballast water within an area agreed to in advance by the Commission in consultation with the USCG.

The “same location” provision applies within one NM of the berth or within the recognized breakwater of a California port or place at which the ballast water was loaded (PRC section 71204.3(c)(2)). All ports and marine oil terminals in the San Francisco Bay area east of the Golden Gate Bridge (including the Ports of Stockton and Sacramento) are considered the same “port or place,” as are the Ports of Los Angeles, Long Beach, and the El Segundo offshore marine terminal.

Ballast water exchange requirements vary depending on where a vessel arrives from and the source of the ballast water. Vessels arriving at California ports from a port or place outside of the Pacific Coast Region (PCR) are required complete a full ballast water exchange at least 200 NM from any land, including islands, in water at least 2,000 meters (m) deep before discharging ballast water (see PRC sections 71200(i) and 71204.3(a)).

In 2005, the Commission adopted regulations requiring vessels that operate within the PCR to manage their ballast water prior to discharge into California waters (CCR Title 2, Division 3, Chapter 1, Article 4.6; see Figure III-1). 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. Vessels arriving to California ports from a port or place within the Pacific Coast Region and carrying ballast water sourced within the Pacific Coast Region are required complete a full ballast water exchange at least 50 NM from any land, including islands, in water at least 200 m deep before discharging ballast water (2 CCR section 2284).

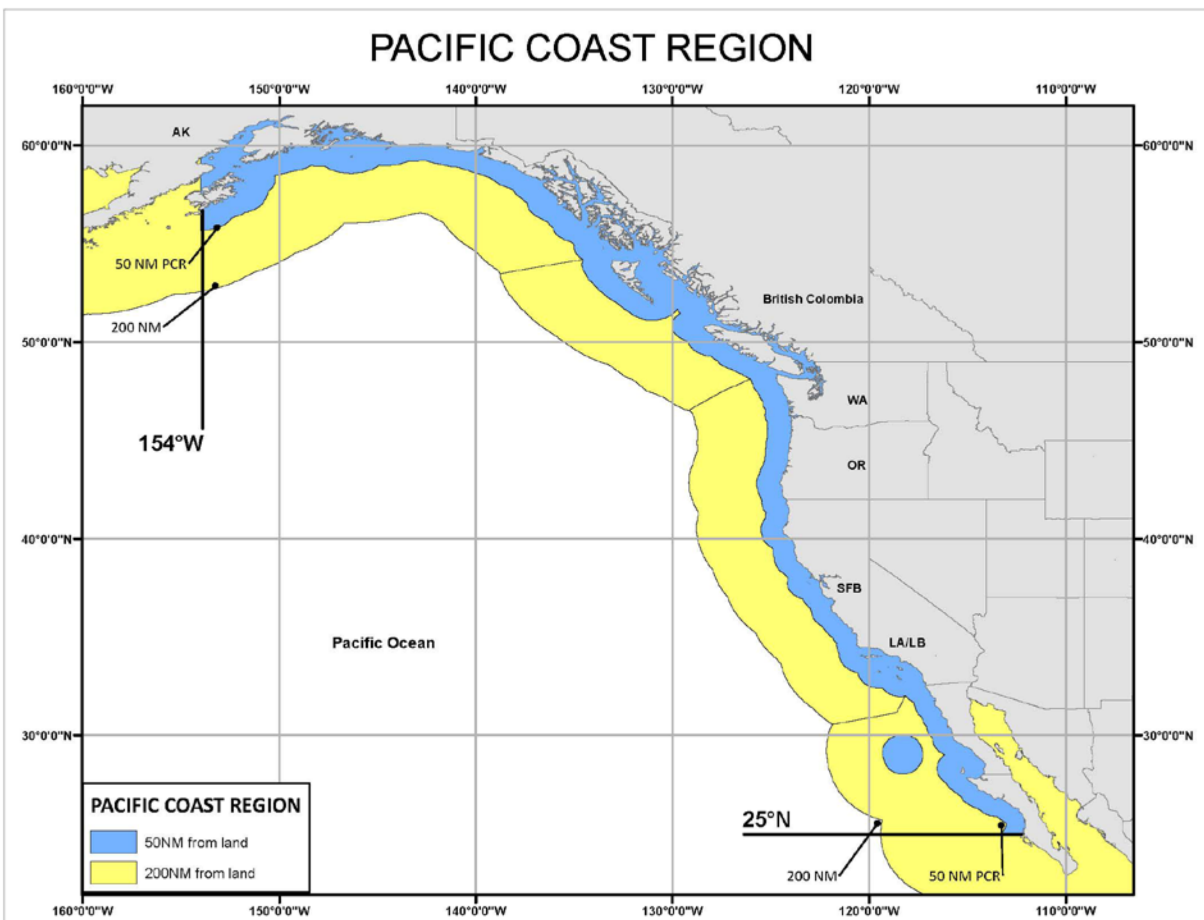

Figure III-1. Pacific Coast Region (PCR)

Approved alternative management methods include the use of ballast water treatment systems or other methods approved on a case-by-case basis (e.g. use of U.S. sourced potable water as ballast). Ballast water treatment systems must either be accepted by the USCG as an Alternative Management System (AMS) or involved in the U.S. Coast Guard Shipboard Technology Evaluation Program (STEP).

Alternative Management Systems are ballast water treatment systems that have been type-approved by other countries and accepted by the USCG as being at least as effective as ballast water exchange. The USCG maintains a regularly updated list of accepted AMS on a publicly available website (https://homeport.uscg.mil/mycg/portal/ep/home.do).

The USCG STEP facilitates the development of ballast water treatment technologies by providing: 1) vessels with incentives to install experimental ballast water treatment systems to comply with USCG ballast water management requirements; and 2) USCG with the ability to collect data on the performance of treatment technologies.

Ballast Water Management Plan, Recordkeeping, and Reporting
Ballast water management planning and recordkeeping are important components of the MISA. All vessels must maintain a vessel-specific ballast water management plan that describes the management strategy. A vessel's crew must be trained on the application of the management plan. Vessels must also maintain a separate ballast water log that outlines the ballast water management activities for each tank onboard the vessel and verifies that the vessel has followed their plan.

The MISA requires all vessels to submit the USCG Ballast Water Reporting Form (BWRF; OMB number 1625-0069; Appendix A) to the Commission upon departure from a California port or place. The form details ballast water management information for each voyage. The BWRF is analyzed by Commission staff to assess vessel compliance with ballast water management requirements and to gather data on vessel traffic arriving at California ports.

Vessels that use a ballast water treatment system and discharge treated ballast into California waters must also complete and submit two reporting forms (see Appendix A): 1) The "Ballast Water Treatment Technology Annual Reporting Form," to be submitted within 60 days of receiving a written or electronic request; and 2) the "Ballast Water Treatment Supplemental Reporting Form," to be submitted upon departure from a California port or place.

Compliance Assessment

The Commission is required to inspect at least 25% of vessels arriving at California ports to assess compliance with the MISA. Commission Field Operations staff boards vessels to review and inspect vessel paperwork, interview the crew, and collect ballast water samples (see Structure and Function of the MISP, later this section, for more details). Commission staff also reviews vessel-submitted reporting forms to map ballast water management locations and ensure each vessel adheres to NIS management requirements (see Section V for more details and data analysis). Enforcement may be administered through the imposition of administrative, civil, and/or criminal penalties.

Implementation of Ballast Water Performance Standards

The Coastal Ecosystems Protection Act (Senate Bill (SB) 497; Chapter 292, Statutes of 2006), adopted performance standards for the discharge of ballast water. The performance standards were based on recommendations from a majority of a technical advisory panel that was convened by the Commission. The Panel consisted of scientists, regulators, representatives from the shipping industry, and environmental organizations.

The Commission adopted the standards via regulation in 2007 (2 CCR § 2291 et seq. (see Table III-1)). The standards will be phased-in based on each vessel's year of construction and ballast water capacity (see Table III-2).

As part of implementing the ballast water performance standards, the Commission is required to report to the Legislature on the efficacy, availability, and environmental impacts of currently available ballast water treatment technologies. Reports are due 18 months prior to each performance standard implementation date.

The 2007 and 2013 reports found a lack of available treatment technologies to enable vessel compliance with the California performance standards. As a result, the implementation timeline was delayed in 2008 (SB 1781, Chapter 696, Statutes of 2008) and 2013 (SB 814, Chapter 472, Statues of 2013). Therefore to date, five reports have been prepared and submitted to the Legislature (see Dobroski et al. 2007, 2009; and Commission 2010, 2013, 2014).

Table III-1. Ballast Water Discharge Performance Standards

Organism Size Class	IMO BWM Convention Regulation D-2[1]/U.S. Federal (USCG, EPA)	California[1,2]
Organisms greater than 50 µm[3] in minimum dimension	< 10 viable organisms per cubic meter	No detectable living organisms
Organisms 10 – 50 µm in minimum dimension	< 10 viable organisms per ml[4]	< 0.01 living organisms per ml
Living organisms less than 10 µm in minimum dimension		< 10^3 bacteria/100 ml < 10^4 viruses/100 ml
Escherichia coli	< 250 cfu[5]/100 ml	< 126 cfu/100 ml
Intestinal enterococci	< 100 cfu/100 ml	< 33 cfu/100 ml
Toxicogenic Vibrio cholerae (O1 & O139)	< 1 cfu/100 ml or < 1 cfu/gram wet weight zooplankton samples	< 1 cfu/100 ml or < 1 cfu/gram wet weight zoological samples

[1] See Table III-2 below for implementation dates for U.S. Federal (United States Coast Guard (USCG), U.S. Environmental Protection Agency (EPA)) and IMO ballast water discharge standards. See Table III-3 for implementation dates for California performance standards.
[2] Final discharge standard for California, beginning January 1, 2020, is zero detectable living organisms for all organism size classes.
[3] Micrometer – one-millionth of a meter
[4] Milliliter – one-thousandth of a liter
[5] Colony-forming unit – a measure of viable bacterial numbers

Table III-2. Implementation Schedule for California's Performance Standards

Ballast water capacity of vessel	Standards apply to new vessels in this size class constructed on or after:	Standards apply to all other vessels in this size class beginning on:
<1500 metric tons	January 1, 2016	January 1, 2018
1500-5000 metric tons	January 1, 2016	January 1, 2016
>5000 metric tons	January 1, 2016	January 1, 2018

In the 2014 review of ballast water treatment systems (see Commission 2014), the Commission found that systems will not be available to enable implementation of the California performance standards on January 1, 2016 for new build vessels or existing vessels with a ballast water capacity of 1500-5000 metric ton (MT).

Shipboard ballast water treatment systems cannot be considered available to meet the California performance standards because:

1. No ballast water treatment system has demonstrated efficacy for all of the California performance standards based on the best available data;
2. There are no proven methods/technology to analyze ballast water samples to determine treatment system efficacy for some of the California performance standards; and
3. A lack of sampling/compliance protocols precludes the ability of the Commission to make a conclusive determination about the availability of shipboard ballast water treatment systems to meet the California performance standards.

Shore-based ballast water reception facilities designed to receive ballast water and remove or kill NIS are not currently available in California or the United States. However, California law does allow a vessel to discharge ballast water to a shore-based treatment facility in compliance with the discharge standards, if such facilities become available.

The Commission (2014) examined three related reasons why shore-based facilities are unavailable:

1. California, the U.S. Federal Government (USCG and EPA), and the IMO do not require vessels to discharge ballast water to shore-based facilities;
2. Collaborative efforts thus far among international, U.S. federal, and state (including California) regulators and the shipping industry to implement discharge standards have focused on the use of shipboard ballast water treatment systems; and
3. Lacking a regulatory mandate and economic demand to develop shore-based facilities, treatment technology manufacturers have allocated available resources and research to the development of shipboard treatment systems.

Next Steps in the Implementation of Ballast Water Performance Standards

Additional research and policy development will be necessary to enable implementation of California's ballast water performance standards. Evaluating the biological efficacy of shipboard ballast water treatment systems remains a challenge. In 2012, the USCG adopted protocols for treatment system evaluation (i.e. Type Approval). These protocols were forecast by many in the industry to spur a wave of treatment system testing and new technology development. Currently, little data is available from this testing process. More importantly, even if data from the USCG Type approval process were available, the USCG sampling protocols do not test to the California performance standards.

The development and adoption (via regulation) of California-specific ballast water discharge sampling protocols is essential to enable Commission staff to gather important data on the operational efficacy of shipboard ballast water treatment systems. This needs to be done under real world operating conditions. The data gathered would augment existing type approval data from the IMO testing process (for the international standards). Until these additional data become available, it will be difficult for Commission staff to accurately assess system efficacy and determine if shipboard ballast water treatment systems are available to meet the California performance standards.

The Commission also believes shore-based treatment should continue to be studied as an option to enable vessel compliance with the California performance standards. To that end, the Commission is currently funding a study to evaluate the feasibility of shore-based reception and treatment facilities in California. The final report is due in late 2015.

Due to the lack of available treatment systems and the need to conduct further research and analysis on shipboard and shore-based ballast water treatment, the existing implementation schedule for the performance standards will need to be addressed. Staff is working with the regulated industry, environmental organizations, and interested parties on a proposal for the 2015 legislative session.

Vessel Biofouling Management

In 1999, the Management and Control Act established a requirement for vessels arriving at California ports to remove biofouling from their hulls and other wetted surfaces on a regular basis. The term “regular basis” was undefined in statute until 2007 (see Chapter 370, Statutes of 2007). The amended language now requires “regular” biofouling removal at a periodicity no longer than the expiration of either: 1) the vessel’s Safety Construction Certificate, or 2) the USCG Certificate of Inspection; however, no longer than 60 months following the last drydocking (PRC section 71204(f)(2)).

Through the adoption of this amendment to the MISA, the Legislature recognized the need for California to address the risk of NIS introductions from vessel biofouling. They created a path to address a major gap in the vector management strategies employed by the MISP.

Reporting Requirements
To enhance this management requirement, the Legislature granted authority to the Commission in 2007 to collect information on hull husbandry practices and other shipping activities that influence biofouling accumulation and survival. Collection of these data is accomplished through mandatory annual submission of the Commission's Hull Husbandry Reporting Form (HHRF; see Appendix A) from every vessel arriving at a California port or place. The HHRF was developed and adopted via regulation in 2007 (see 2 CCR § 2298) after consultation with a biofouling-specific technical advisory group (TAG).

Hull Husbandry Reporting Forms have been collected from the vessels calling at California ports each year since 2008 (see Chapter IV for summary of HHRF data). These data now represent the most extensive and complete dataset of biofouling-influencing vessel practices in the world. These data enable Commission staff to identify gaps in industry-implemented management practices and the prevalence of vessel activities that are likely to result in increased risk of NIS introduction. These data are being used to support the development of comprehensive biofouling management regulations in California.

The data collected through the HHRF have proven to be important regionally as well as internationally. Commission staff has provided targeted subsets of these data to help other states and countries with development of biofouling management strategies. These include Oregon (see Paul 2011), Washington (see Davidson et al. 2014a), Alaska (see Cordell et al. 2009), and most recently Hawaii. California's HHRF data has also been used to help validate a NIS introduction risk assessment tool under development by the Australia Department of Agriculture.

Next Steps in Biofouling Management
The amendments to the MISA in 2007 placed a mandate on the Commission to develop and adopt regulations governing the management of biofouling on vessels calling at California ports. The Commission is required to consult with a biofouling-specific TAG, and to use the data collected via the HHRF to guide regulation development. Commission staff began the process by convening a TAG during the summer of 2010. The TAG reviewed the state of the science surrounding vessel biofouling and NIS, and discussed the biofouling management approaches being developed at the IMO and other international agencies and organizations. After four formal TAG meetings and several rounds of informal draft document reviews, the Commission began the official rulemaking process in September 2011 (see Notice Register 2011, Volume 37-Z). The proposed biofouling management regulations went through several public comment periods and subsequent revisions. However, the one-year Administrative Procedures

Act deadline to complete the rulemaking process was reached before a final satisfactory product could be produced.

During 2012 and early 2013, Commission staff consulted with individual stakeholders to better understand their comments and concerns. After these discussions, Commission staff reconvening the biofouling-specific TAG to discuss new information and revisions to the proposed regulations. After several rounds of draft document reviews, Commission staff is now preparing to initiate the official rulemaking process. Staff anticipates completion of the rulemaking in late 2015.

Structure and Function of the Marine Invasive Species Program

The California Marine Invasive Species Program is a collaborative effort among the Commission, the CDFW, the Water Board, and the BOE.

- The Commission is the administrator of the MISP and is tasked with developing and implementing vessel vector management policy (see below for a detailed description of the Commission MISP).

- The CDFW monitors and gathers data on species to maintain an inventory of NIS populations in the coastal and estuarine waters of the state. These data are used in conjunction with information on vessel arrivals and NIS management practices to assess the effectiveness of the MISP.

- The Water Board consults with MISP sister agencies on topics related to water quality and toxicity. More recently, the Commission has worked with the Water Board on the implementation of the U.S. Environmental Protection Agency's National Pollutant Discharge Elimination System (NPDES) Vessel General Permit (VGP) for Discharges Incidental to the Normal Operation of Vessels and on policies related to in-water cleaning of vessels in California.

- The Board of Equalization collects the fee from qualifying voyages (as defined for fee collection in PRC 71215(b)(2) and 71215(c)) and deposits these funds into the Marine Invasive Species Control Fund (MISCF). All program activities are supported by the MISCF.

The Commission's MISP

To effectively carry out the administrative and operational requirements of the MISA, the Commission's MISP is separated into three primary functional components: program administration and policy development, data management, and field operations.

Program Administration and Policy Development

To reduce the introduction and spread of NIS, the Commission, through the MISP program administration staff, develops NIS prevention strategies for vessel ballast water and biofouling vectors, and:

- Recommends policy proposals to the Legislature;
- Proposes and implements regulations;
- Coordinates and funds research; and
- Assesses vessel compliance.

The MISP administrative and policy development staff work closely with all MISP teams, regulatory agencies/authorities, technical advisory groups, non-governmental organizations, researchers, and the shipping industry. By consulting with other regulatory jurisdictions (states, federal, international) the MISP increases efficiency, consistency, and effectiveness by sharing successes and failures. MISP staff members participate on numerous working groups, advisory panels, and committees including (but not limited to):

- California Agencies Aquatic Invasive Species Team;
- Pacific Ballast Water Group;
- State of Washington's Ballast Water Working Group;
- State of Oregon's Shipping Transport of Aquatic Invasive Species Task Force;
- State of Hawaii's Alien Aquatic Organism Taskforce;
- Western Regional Panel on Aquatic Invasive Species; and
- Great Lakes Ballast Water Collaborative.

Administrative staff also present to committees and panels, including (but not limited to):

- American Bureau of Shipping;
- Los Angeles and San Francisco Harbor Safety Committees;
- Marinas and Antifouling Strategies Interagency Coordinating Committee;
- Institute of Marine Engineering, Science & Technology;
- North America Marine Environment Protection Association (NAMEPA); and
- California Invasive Species Advisory Council.

Administrative staff represents the MISP at conferences related to invasive species science and management. Such participation is particularly important given the global nature of shipping and the methods of transporting NIS. In many cases, MISP staff members are invited to participate due to their extensive knowledge and experience with vessel vector management. Presentations have been given at numerous local, state, national, and international conferences, including:

- International Conference on Marine Bioinvasions;
- International Conference on Aquatic Invasive Species;
- International Congress on Marine Corrosion and Fouling;

- California and the World Oceans Conference;
- Bay-Delta Science Conference;
- State of the Estuary;
- California State Lands Commission's Prevention First Symposium; and
- Coastal and Estuarine Research Federation.

The MISP administrative staff assembles Technical Advisory Groups/Panels (TAGs or TAPs) to exchange information and ideas for the implementation of legislative mandates. TAGs are an effective outreach tool to keep stakeholders abreast of Commission actions and activities. These groups review the best available science and the concerns of affected stakeholders in the development of rulemakings and policy recommendations. TAGs include representatives from the maritime industry, ports, state, federal, and international agencies, environmental organizations, and research institutions. The MISP administrative program has assembled TAGs for the development and review of:

- Regulations to establish ballast water management requirements within the PCR;
- Performance standards for ballast water discharge;
- Regulations for ballast water discharge compliance assessment;
- Regulations for biofouling management;
- Changes to the MISP fee;
- Forms to collect vessel biofouling and ballast water treatment technology data; and
- Reports assessing the ability of ballast water treatment systems to meet the California performance standards.

Data Management

The MISP data management staff inputs data from ballast water and biofouling management reporting forms. More than 800 forms are submitted every month. Data from Ballast Water Reporting Forms (BWRF) are matched with arrival data from the Marine Exchanges of the San Francisco Bay Region and Los Angeles/ Long Beach. Between July 2012 and June 2014, over 18,100 BWRFs were received, reviewed, entered into the program database, and reconciled with actual port arrival data. The staff also tracks ballast water treatment technology reporting forms and Hull Husbandry Reporting Form submission and compliance. Submitted forms are reviewed for inconsistencies and are then entered into the MISP database. Quality control procedures are followed to ensure accuracy of data entry.

MISP staff reconciles the data received against vessel arrival data to determine if reporting requirements have been met. Notices are sent to owners, operators and/or agents when vessels fail to submit required forms or submit inconsistent, incorrect, or questionable data. These vessels are also flagged for follow-up by Field Operations staff.

The data management staff also maintains contact with ship owners, officers, and agents to relay information about MISP requirements. They coordinate with the Commission's Field Operations personnel to request data from or distribute information to vessels.

Field Operations

Commission Field Operations staff are the primary means of assessing vessel compliance and distributing information to vessel personnel. They implement an extensive inspection program, including vessel boarding, monitoring, and outreach to enforce MISP laws and regulations. MISP Field Operations personnel are based out of offices located in both northern and southern California.

Education and outreach during vessel inspections is key to maintaining the high rate of compliance with California's management, reporting, and recordkeeping requirements (see Section V for compliance data). During inspections, staff examines the vessel's ballast water management plan, deck logbook, engine logbook, and required MISP reporting forms. Vessel reporting and recordkeeping errors are identified and crew are instructed in proper recordkeeping, as needed. Commission staff members are also available to respond to questions from vessel crew members.

Additionally, ballast water samples are collected from select ballast tanks intended for discharge. The samples are analyzed for salinity (a measure of the salt concentration in water) as an indicator for legal ballast water exchange.

Vessels that violate the reporting, recordkeeping, or management requirements are cited and targeted for re-inspection. Citations are given to the vessel crew and an enforcement letter is sent to the vessel owner.

In addition to assessing compliance with the requirements of the MISP, Field Operations staff plays a key role in MISP activities by facilitating access to vessels, with the cooperation of vessel operators, for researchers engaged in data collection for NIS research. This assistance is important due to heightened security levels at ports.

The Shared Role of Outreach

One of the key components for the success of the MISP is the close communication, coordination, and outreach between Commission staff, the maritime industry, and other state, federal, and international agencies. Outreach is a role shared by everyone in the

MISP (Figure III-2). By establishing and maintaining relationships with the diverse groups that play a role in preventing new introductions of NIS, MISP staff helps work towards improved compliance within the regulated community, development of well-informed policy decisions, and the utilization of management tools/strategies based on the best available science.

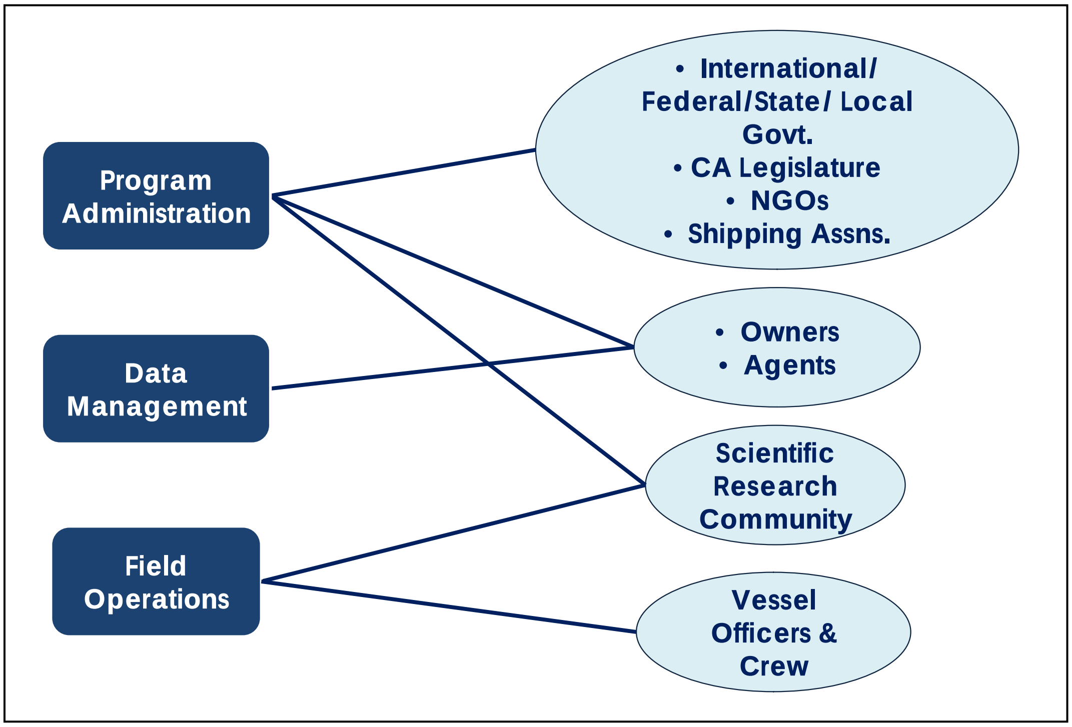

Figure III-2. Marine Invasive Species Program Information Exchange with Stakeholders

IV. EMERGING ISSUES

Ballast Water Management

Availability of Ballast Water Treatment Systems
Any vessel that operates in U.S. waters (including California waters) must comply with the requirement to use a USCG approved ballast water management system. The protocols for management system performance evaluation and approval were adopted by the USCG in 2012. Currently no system manufacturer has applied to the USCG for approval. The USCG is anticipating that the first approvals may be granted in late 2015.

The availability of USCG Type Approved ballast water management systems is important to the implementation of the California performance standards. The California performance standards do not require the use of USCG approved systems, but vessels operating in California must comply with USCG requirements. Until the USCG approves systems, many vessel owners are unwilling to install treatment technologies on their vessels. The installation of treatment technologies will be costly, and there is no guarantee that a system a ship owner may install will ultimately be approved for use in U.S. waters.

In its most recent report to the Legislature, the Commission concluded that ballast water treatment technologies are not currently available to meet the California performance standards (see Commission 2014). Commission (2014) also discusses the necessity of gathering data on the operation of ballast water treatment systems installed on vessels to determine if the systems are able to meet the California performance standards. If vessel owners are waiting for USCG approval of systems prior to purchasing and installing systems, then the Commission may face a lengthy delay before the data on treatment system performance can be collected.

Commission staff is currently working with the shipping industry, technology manufacturers, the USCG, and California legislative staffers to discuss avenues for amendments to existing statute or regulations that may address the issues of technology availability and implementation of the California performance standards. Nevertheless, a great deal of uncertainty remains about what technologies may ultimately be available for vessels to comply with either the California or U.S. federal ballast water discharge standards.

Biofouling Management

The Commission’s proposed biofouling management regulations encourage a comprehensive management approach, relying on the appropriate use of anti-fouling coatings to prevent biofouling accumulation (i.e. proactive measures) and responsible removal of biofouling already accumulated on a vessel (i.e. reactive measures). While better and more appropriate use of anti-fouling coatings will likely reduce the need for regular biofouling removal, reactive management will still be a necessary component of a comprehensive approach to biofouling management.

In-Water Cleaning

Biofouling removal typically takes place while a vessel is taken out of the water and into a drydock for maintenance and inspection, a process that generally occurs every five years. In the period between dry dockings, biofouling removal occurs through a process called in-water cleaning.

In-water cleaning typically involves a large diver-controlled scrubbing brush unit that moves along a vessel’s hull scrubbing off any accumulated biofouling. This practice has received scrutiny across the globe in recent years. The removed biological debris and the metallic biocides incidentally removed from the anti-fouling paint are not contained and are allowed to disperse freely throughout the water column and onto the seafloor, presenting a risk of NIS introduction (Hopkins and Forrest 2008, McClary et al. 2008, Hopkins et al. 2011) and chemical pollution to the surrounding water body.

In-water cleaning was allowed in California waters until the implementation of the U.S. Environmental Protection Agency (EPA) Vessel General Permit for Discharges Incidental to the Normal Operation of a Vessel (VGP) in 2008. The California-specific provisions in the VGP prohibit in-water hull cleaning except for vessels with biocide-free antifouling coatings. Vessels with biocidal antifouling coatings may clean in limited areas that are not impaired for metals; however, many ports within California are federally listed as copper-impaired (State Water Board 2010, Morrisey et al. 2013), and copper is the primary biocide used in most anti-fouling coatings.

In-water cleaning in California may be permitted in the future if conducted using the best available technology economically feasible. Commission staff has coordinated discussions with the State Water Board, Los Angeles Regional Water Quality Control Board, and the Ports of Los Angeles and Long Beach during the first half of 2014 to identify emerging technologies that contain and treat in-water cleaning effluent to remove biological debris and heavy metal contamination. The situation is complicated by the fact that in-water cleaning regulation falls under the authority of multiple agencies.

Commission staff continues to engage relevant agencies and stakeholders in discussions to identify a path towards allowing responsible in-water cleaning in California. The Los Angeles Regional Water Board is beginning to review data from potential in-water cleaning vendors as a precursor to developing permits for in-water cleaning in the Ports of Los Angeles and Long Beach. The San Francisco Bay Regional Water Quality Control Board has already taken the first steps in this process and has produced a Best Management Practices document identifying acceptable in-water cleaning practices within the San Francisco Bay. Commission staff continues to work with these regulatory partners providing information as requested.

Elevated NIS Introduction Risk Resulting from the Great Recession
The Great Recession in 2008 and 2009 had a profound effect on the global economy, with the combined gross domestic product (GDP) of advanced economies contracting at greater than 4% during the first two quarters of 2009 (IMF 2010). This reduction in global GDP resulted in a decrease in goods and cargo moving around the globe, severely impacting the maritime shipping industry, and forcing a large number of vessel owners and operators to take their vessels out of service and into long-term layup (Bradsher 2009). These layups (or prolonged residency periods) became so extensive during the peak of the Great Recession that 10.6% of the global containership fleet was sitting idle at anchor during April 2009 (Pacific Maritime 2009; see Section V for data on drop in vessel arrivals to California during this time).

Prolonged residency periods, typically three months or greater, negatively impact the performance of anti-fouling coatings, many of which require consistent water flow to release the contained biocide, increasing the likelihood of biofouling accumulation on a vessel's underwater surfaces (Floerl and Coutts 2009). Unless the biofouling on these vessels is removed or otherwise managed prior to the vessel reentering service and arriving to California, these vessels represent an elevated risk of NIS introduction (see Chapter V for summary of residency period data for vessels operating in California).

The financial losses of the Great Recession coupled with increasing fuel costs also led many ship owners and operators to operate their vessels at speeds much slower than normal in an effort to increase fuel efficiency, a practice referred to as "slow steaming" (Kontovas and Psaraftis 2012). Even in the current recovering economy, many ship owners continue to implement slow steaming across their fleets due to a desire to reduce fuel consumption and because of excess capacity in the global shipping fleet (Hollmann 2014). A byproduct of slow steaming is an increased risk of biofouling-mediated NIS introductions. Ships that travel at slow speeds have been associated with an increase in biofouling accumulation, survival, and species diversity (Davidson et al. 2008, Coutts et al. 2010, Hopkins and Forrest 2010) (see Chapter V for summary of speed data for vessels operating in California).

Commission staff will continue to monitor the prolonged residency periods and slow steaming of vessels arriving to California ports. Identifying risk factors like these is important for prioritizing resources as the Commission begins to implement future biofouling management regulations.

Vessel Vector Management

Federal/State Conflicts

At the federal level in the U.S., ballast water discharges are under the jurisdiction of both the USCG and the EPA. The dual federal agency regulation of ballast water under the National Invasive Species Act (NISA, as implemented by USCG) and the Clean Water Act (CWA, as implemented by the EPA) has resulted in conflicting vessel requirements for some NIS management activities. Several articles discussing the complicated federal ballast water management situation have recently been written in trade journals (see Waldron et al. 2014, K&L Gates 2014).

The U.S. House Committee on Transportation and Infrastructure, Subcommittee on Coast Guard and Maritime Transportation convened a hearing on March 4, 2014, to address conflicting EPA/USCG ballast water regulation, among other topics (http://transportation.house.gov/calendar/eventsingle.aspx?EventID=366221). During the hearing, EPA and USCG representatives reiterated that each agency approaches the regulation of ballast water through the authority of differing federal statutes (the CWA and the NISA, respectively), and while the agencies continue to work together to ease the situation for the regulated industry, the requirements of those governing statutes do place restrictions on the actions of each agency.

Soon after this hearing, Senators Mark Begich (Alaska) and Marco Rubio (Florida), joined by 20 co-sponsors, introduced S. 2094, the Vessel Incidental Discharge Act. This bill proposed to establish uniform national standards for the discharge of ballast water and other discharges incidental to the normal operation of a vessel. It proposed to remove ballast water and vessel incidental discharges from regulatory authority under the CWA and place them solely under the jurisdiction of the USCG. Additionally, the bill proposed to preempt state regulation of these discharges, including ballast water and discharges associated with in-water cleaning. States would only be permitted to enforce laws implementing state ballast water discharge standards more stringent than U.S. federal standards if the state law was in place at the time the federal bill is passed and if the Secretary of Homeland Security approved a state's petition to retain those more stringent standards.

S. 2094 was not passed before the 2013-14 U.S. Congressional Session ended in December 2014. It is anticipated that similar legislation will be proposed in the future. Commission staff will continue to follow this situation closely.

V. DATA ANALYSIS

The Commission is required to summarize NIS management patterns and vessel compliance with the requirements of the MISA (PRC section 71212). To conduct this analysis, Commission staff collects data from the following sources:

- Vessel-submitted forms: Ballast Water Reporting Form, Hull Husbandry Reporting Form, Ballast Water Treatment Technology Annual Reporting Form, and Ballast Water Treatment Supplemental Reporting Form;
- Inspections conducted by Commission Field Operations staff; and
- Transportation statistics received from the two California Marine Exchanges, individual ports, and shipping agents.

The data is entered into a state database that was created under the Management and Control Act and was modified pursuant to the MISA. The data are then analyzed to understand:

- Rates of compliance with mandatory reporting requirements (see *Reporting Compliance*);
- Qualifying voyage traffic patterns (see *Vessel Traffic Patterns*);
- Patterns of reported ballast water discharge and management according to vessel type and geographic area (see *Ballast Water Discharge Patterns*);
- Rates of compliance with ballast water management requirements (see *Ballast Water Management Compliance*); and
- Patterns of reported hull husbandry and vessel operational practices (see *Biofouling Management Practices and Patterns*).

Reporting Compliance

Data Synopsis

- Ballast Water Reporting Forms were submitted by 94% of Qualifying Voyages between 2012b-2014a.
- Less than 1% of vessels calling on California ports report using a ballast water treatment system.
- Hull Husbandry Reporting Form submission compliance was 91% in 2012 and 93% in 2013.

Ballast Water Reporting Form

The Ballast Water Reporting Form (BWRF; see Appendix A) summarizes all ballast water management activities for each vessel arrival. This information is used to identify patterns of vessel traffic at California ports and to prioritize resources to effectively implement and enforce the MISA. These vessel data are also useful for other regulatory agencies throughout California (e.g. Air Resources Board) that do not collect vessel arrival statistics themselves.

Under the MISA (Chapter 491, Statutes of 2003), the master, owner, operator, agent, or person in charge of a vessel is required to submit the BWRF upon departure from each port or place of call in California. A qualifying voyage (QV) for the purposes of reporting refers to all vessels greater than 300 gross registered tons carrying or capable of carrying ballast water that arrive at a California port or place. The Commission has identified 19 port regions in California (Figure V-1).

Prior to the passage of the MISA, only vessels arriving to California from outside of the U.S. Exclusive Economic Zone were required to submit BWRFs to the Commission. However, since the passage of the MISA in 2004, all vessels are required to submit the BWRF.

Due to this reporting requirement change in 2004, all time-series data from the BWRF are presented from January 2004 forward, with a specific focus on the two-year period from July 2012 through June 2014.

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.”

Figure V-1. Commission Identified California Port Regions.

Between 2012b-2014a, 94% of QVs to California ports submitted BWRFs to the Commission (Figure V-2). Eighty (80) percent of QVs submitted their reporting forms on-time, a drop of 8% since 2010b-2012a (see Scianni et al. 2013). Commission staff is considering approaches to increase the reporting compliance rate including education and outreach and stepped up enforcement of violators.

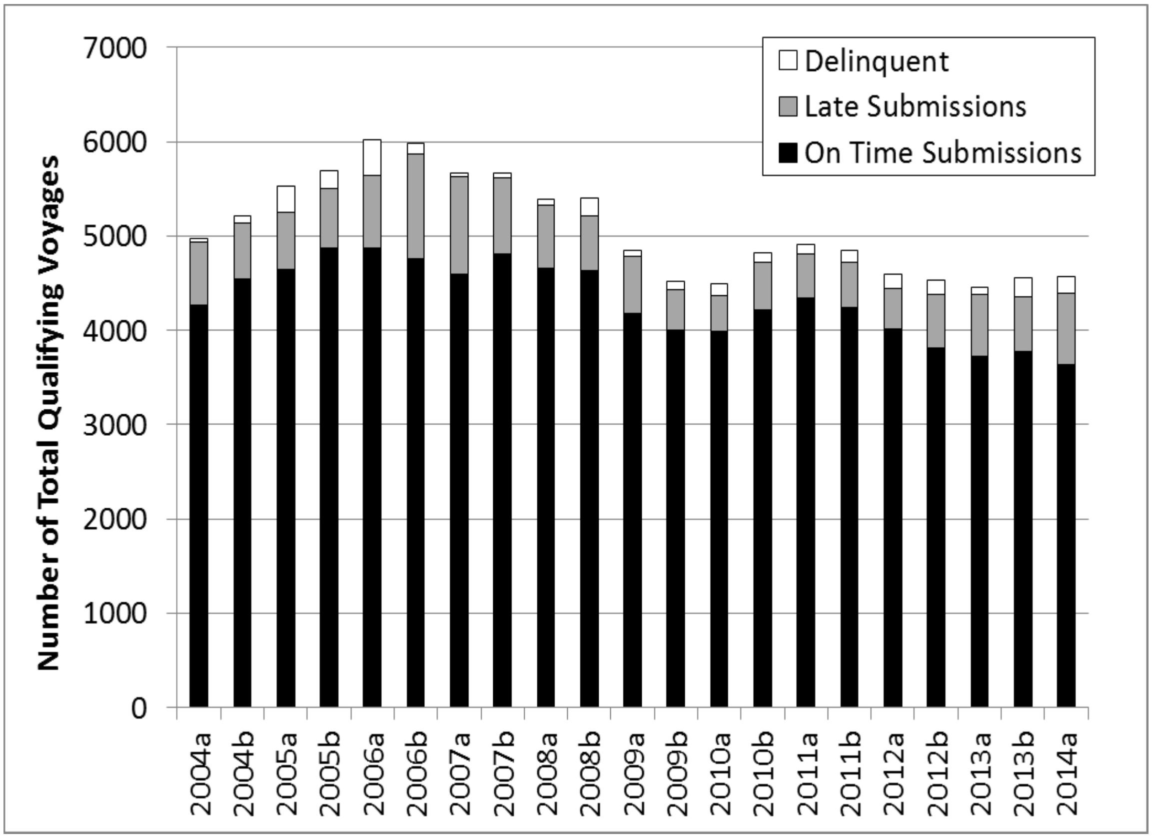

Figure V-2. Number of Total Qualifying Voyages (QVs) Submitting Ballast Water Reporting Forms (a = January to June, b = July to December).

Ballast Water Treatment Technology Reporting Forms

The Commission requires vessels that discharge ballast water treated by a ballast water treatment system to submit two reporting forms (see 2 CCR § 2297.1). The Ballast Water Treatment Technology Annual Reporting Form (Appendix A) is submitted once per year and provides information about the type of ballast water treatment technology used by the vessel. The Ballast Water Treatment Technology Supplemental Reporting Form (Appendix A) is submitted on a per voyage basis and details the volume of treated ballast water discharged by the vessel and any malfunctions of the treatment technology prior to the reported discharge event.

Since the adoption of the treatment technology forms in 2012, the number of vessels submitting the Ballast Water Treatment Technology Annual Reporting Form has increased from 3 in 2012b to 17 in 2014a. Less than one percent of qualifying vessels operating in California have reported using a ballast water treatment system to manage ballast water. It is expected that this number will increase substantially as ballast water discharge standards are implemented internationally and at the U.S. federal level over the next several years.

At this time, Commission staff is having difficulty tracking compliance with treatment technology form submission requirements. Vessels are only required to submit the forms when they discharge treated ballast in California. If the vessel does not indicate on their BWRF that they used a treatment system, and if the vessel was not inspected by Field Operations staff, Commission staff does not have the necessary information to follow-up and ensure that the treatment technology forms were submitted. Commission staff is considering alternative submission requirements to better track which vessels are required to submit the ballast water treatment technology forms.

Hull Husbandry Reporting Form

Every vessel carrying, or capable of carrying, ballast water into the waters of the State (see 2 CCR § 2298) is required to submit the HHRF annually (Appendix A). The HHRF is an eleven question survey that is divided into two sections: 1) vessel hull husbandry practices (e.g. dry docking and antifouling coating information), and 2) voyage and operational characteristics that influence biofouling accumulation and complexity (e.g. traveling speed and prolonged port residency periods).

During 2008, the first year of the HHRF reporting requirement, only 72.8% of the vessels that operated in California submitted the form as required (Takata et al. 2011). Beginning in 2009, Commission staff utilized the monthly notification system already in place for delinquent Ballast Water Reporting Forms to track and alert shipping agents and owners of HHRF deficiencies. This has led to an overall HHRF submission compliance near or above 90% each of the past five years (2009-2013), including compliance rates of 91% in 2012 and 93% in 2013 (Figure V-3). While submission compliance has increased substantially since 2008, including 100% compliance for unmanned barges in 2013, these overall compliance rates can still be improved upon through additional targeted outreach to vessel agents and vessel crews.

The data from 2008 through 2013 represents six annual snapshots of vessel husbandry practices and voyage characteristics (Note that 2014 data are not presented here because the 2014 reporting year was ongoing during the preparation of this report).

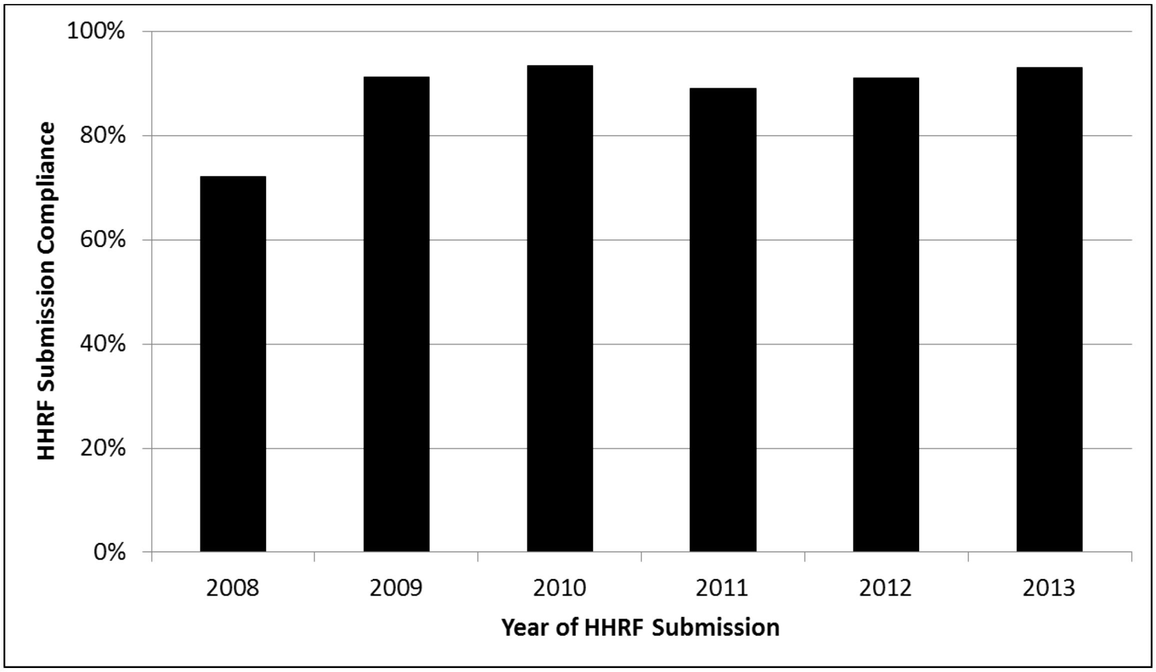

Figure V-3. Percent Compliance for Annual Hull Husbandry Reporting Form (HHRF) Submission from 2008 through 2013.

Vessel Traffic Patterns at California Ports

Data Synopsis

- On average, California receives 9,500 vessel arrivals per year.
- The Los Angeles-Long Beach (LA-LB) port complex receives the largest number of vessel arrivals in the state.
- 57% of arrivals to California ports come from other ports within the Pacific Coast Region (PCR).
- The Ports of Oakland and LA-LB receive similar numbers of arrivals from PCR ports, but LA-LB receives nearly 14 times as many arrivals from non-PCR ports.
- 45% of arrivals to California ports are containerships; 22% are tank vessels.
- 98% of all containership traffic arrives to the Ports of Oakland and LA-LB.

Ballast Water Reporting Form data combined with information on vessel arrivals from the State’s two Marine Exchanges enable Commission staff to track QV arrivals to California ports. For the two-year period between 2012b and 2014a, 18,739 QVs arrived to California ports After a steady decrease in arrivals from 2006b through 2010a, the number of QV arrivals to California ports since 2010b now averages 4,738 per six month period (or 9,500 per year) (see Figure V-2).

The distribution of QV arrivals by port remains consistent with previous years (Figure V-4; see Falkner et al. 2007, 2009, Takata et al. 2011, Scianni et al. 2013). The Ports of LA-LB received 47% (8,481) of all QVs to California ports between 2012b and 2014a.

The Port of Oakland had the second greatest number of arrivals in the State for that time period (3,598). The marine oil terminals located in the Carquinez Strait collectively account for the third greatest number of QV arrivals (1,522) to California, followed by the Port of Richmond (1,413).

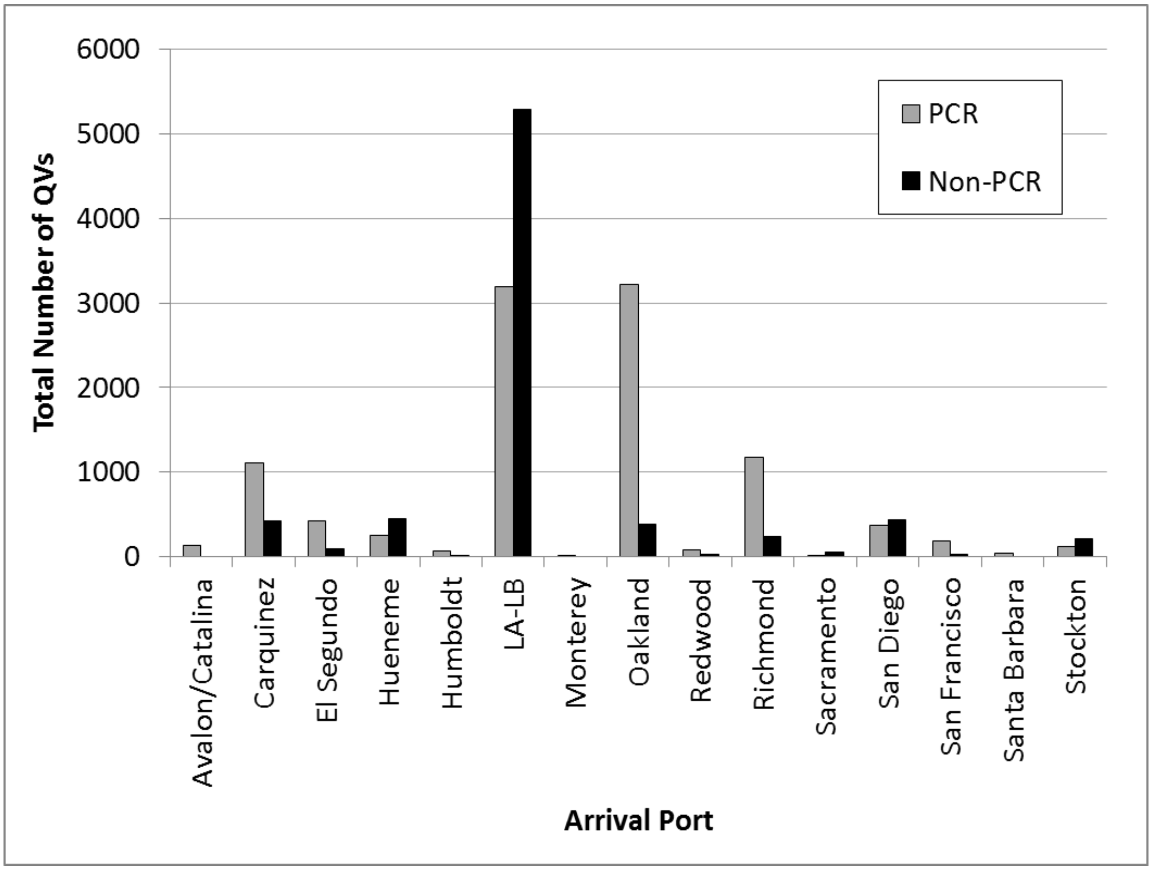

Figure V-4. Distribution of QV Arrivals by Port (2012b-2014a). PCR voyages originate from within the Pacific Coast Region (PCR). Non-PCR voyages originate from ports outside the PCR (see Figure III-1 for map of PCR).

Last Port of Call

Commission staff tracks the last port of call for each QV to identify required ballast water management practices. Vessels arriving from ports located within the Pacific Coast Region (see Figure III-1) are referred to as "PCR arrivals," and vessels arriving from ports located outside the Pacific Coast Region are referred to as "non-PCR arrivals" (Note: In previous reports, PCR arrivals were referred to as "coastal" and non-PCR arrivals were referred to as "foreign").

Similarly to the previous reporting period (Scianni et al. 2013), 57% of all QV arrivals to California for this reporting period originated within the PCR (Figure V-5; see Figure III-1 for map of PCR). Thirty-nine (39) percent of all QV arrivals to California ports came from other California ports, and 18% of all QVs originated from PCR ports outside of CA. The majority of non-PCR arrivals to California came from Asian ports, accounting for 23% of all QVs, followed by 7% from Central America, and 5% from Mexican ports located outside of the PCR (Figure V-5).

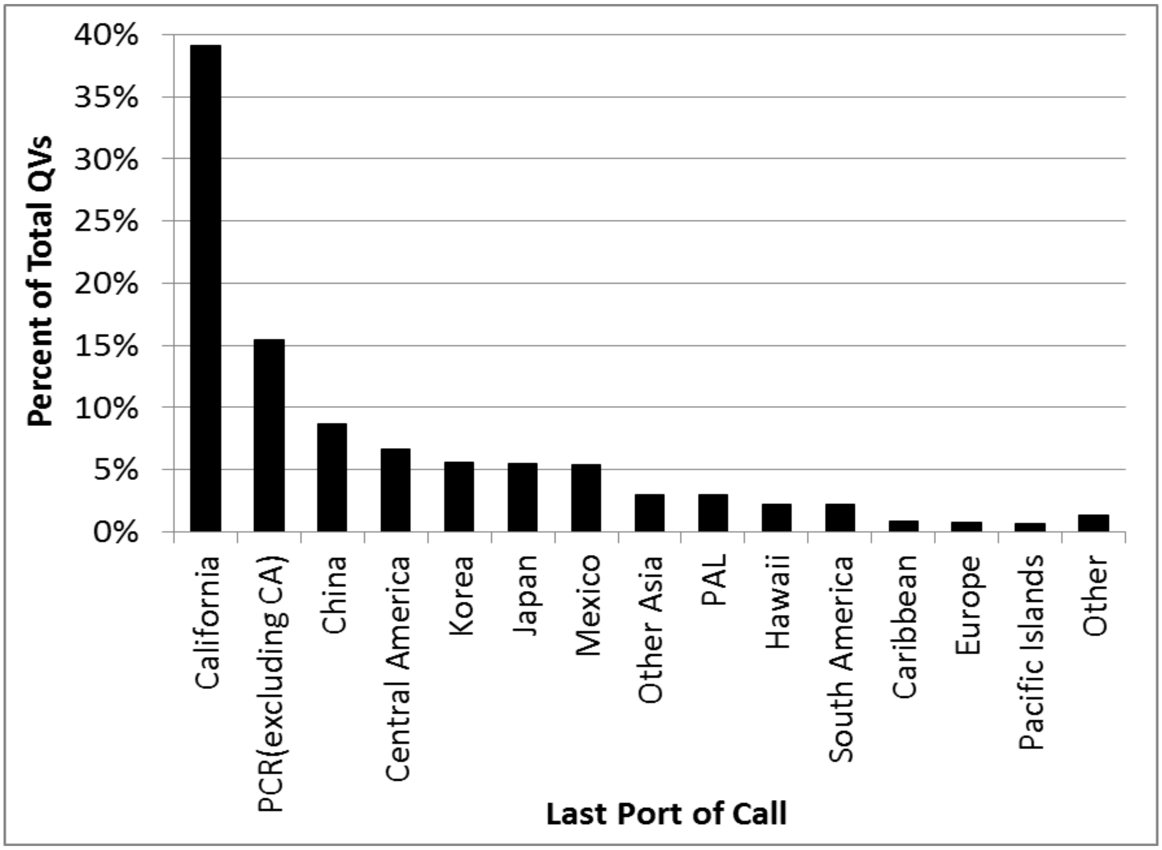

Figure V-5. Last Port of Call for QVs to California Ports (2012b-2014a). PAL refers to the Pacific Area Lightering.

Between 2012b and 2014a, the Ports of Oakland and LA-LB had similar numbers of PCR arrivals, 3,215 and 3,203 respectively (Figure V-4); the majority of PCR arrivals to Oakland listed LA-LB as the last port of call. LA-LB, however, had almost 14 times more non-PCR arrivals than Oakland (5,278 vs. 383).

Both Carquinez and Richmond receive primarily PCR arrivals (1,122 and 1,188, respectively). Carquinez, however, received almost double the number of non-PCR arrivals (400) as Richmond (225).

Arrivals by Vessel Type

The types of vessels calling at each of California's ports vary as a result of differences in local industry, demand, and port infrastructure (e.g. the presence of container cranes). Container and tank vessels are by far the most common vessel types to call in California, representing more than two-thirds (45% and 22%, respectively) of all arrivals to the state between 2012b and 2014a (Figure V-6).

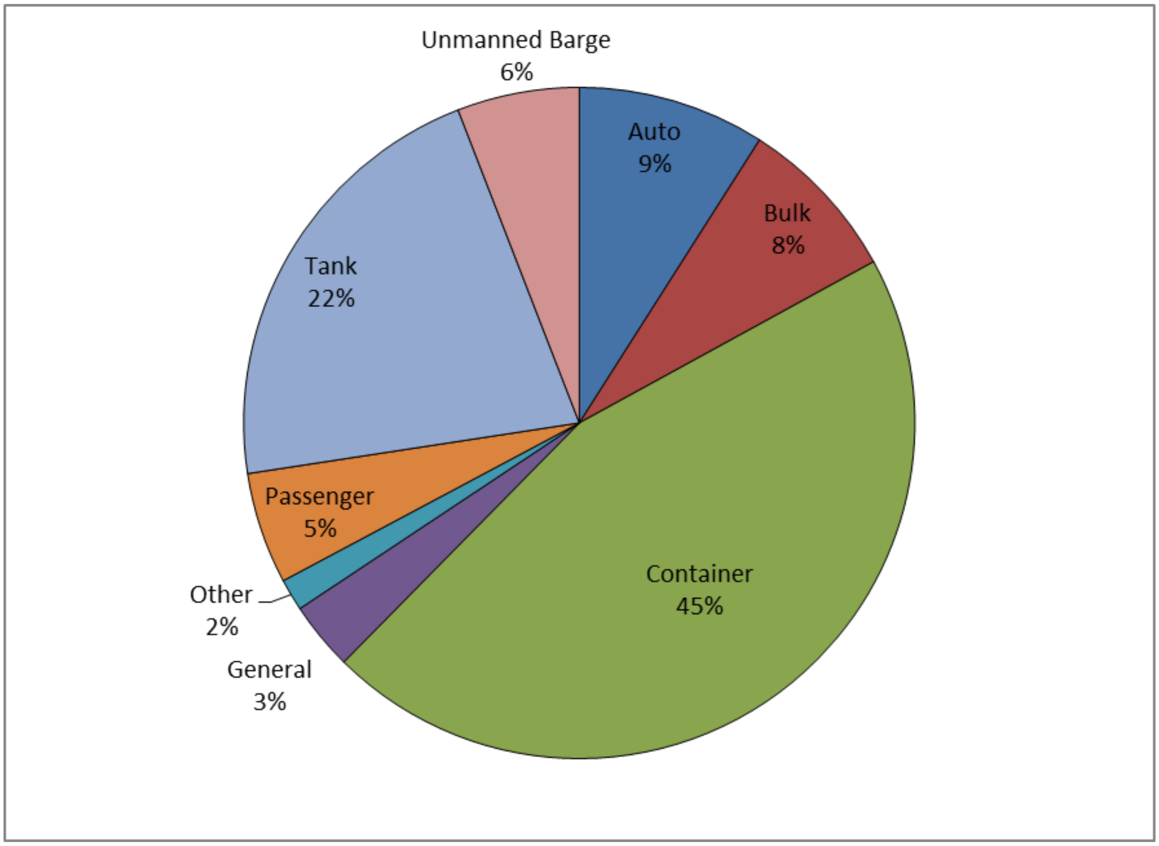

Figure V-6. Percent of QV Arrivals to California by Vessel Type (2012b-2014a).

The Ports of LA-LB and Oakland combined received 98% of all container vessel traffic to California (Figure V-7 A, B). Forty-one (41) percent of all tank vessels arrived to LA-LB, with the remainder largely divided between Richmond (21%), Carquinez (21%), and El Segundo (12%) (Figure V-7 A, B). The ports of LA-LB also received a preponderance of bulk (49%) and passenger (52%) QVs to California (Figure V-7 A). Passenger vessel voyages also arrived to San Diego (15%), San Francisco (14%) and Avalon\Catalina (14%). Auto carriers primarily arrived to LA-LB (30%), San Diego (26%), and Hueneme (22%). Unmanned barges predominately arrived to LA-LB (31%), Carquinez (29%), and Richmond (28%).

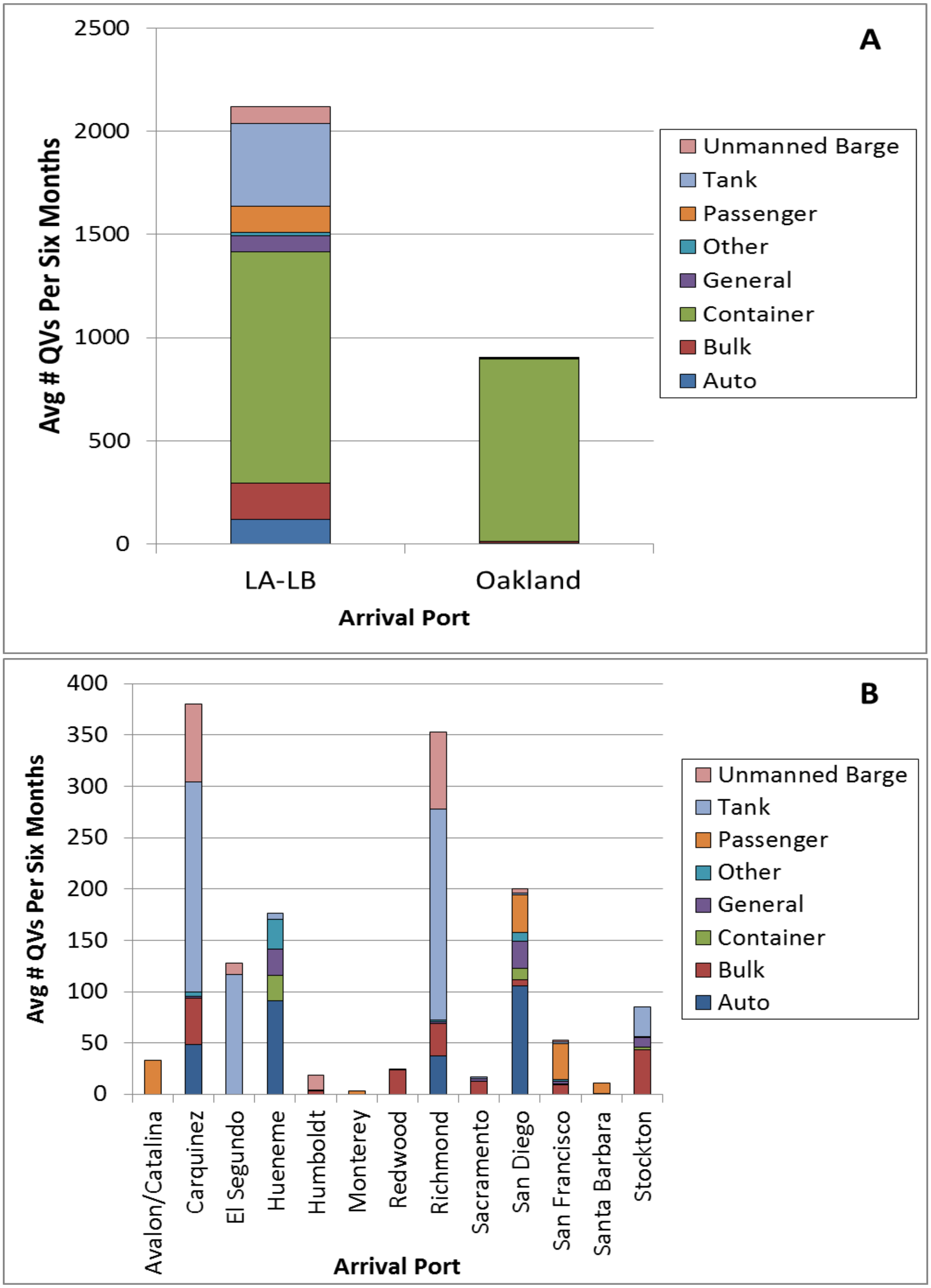

Figure V-7. Average Number of Arrivals per Six-Month Period, by Vessel Type and Port (2012b–2014a) for Oakland and LA-LB (A) and all other California Ports (B). Note that the y-axis scale is not the same across graphs.

Ballast Water Discharge Patterns

Data Synopsis

- Since 2004, 84% of voyages arriving to California retained all ballast water on board.
- The total volume of ballast water discharged to state waters continues to increase.
- Bulk and tank vessels discharge the largest volumes of ballast water, on average.

The risk of NIS introductions through ballast water discharge is influenced by several factors (Carlton 1996, Ruiz and Carlton 2003):

- Type of ballast water management;
- Volume of ballast water released;
- Age of the ballast water discharged (organisms often survive better when held for a short period of time);
- Degree of repeated inoculation (frequency with which ballast water is discharged in a given area); and
- Similarity between source and recipient regions (biological, chemical, and physical characteristics at each port).

An examination of geographic and volumetric patterns of ballast water discharge therefore provides valuable information that can be used to assess the risk of species movement and establishment throughout the State and help frame policy/management recommendations.

Not every vessel that enters California discharges ballast water. Factors such as vessel type, cargo operations, and localized environmental conditions (e.g. weather) all determine a vessel’s 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, ballast water retention is the most protective management strategy available.

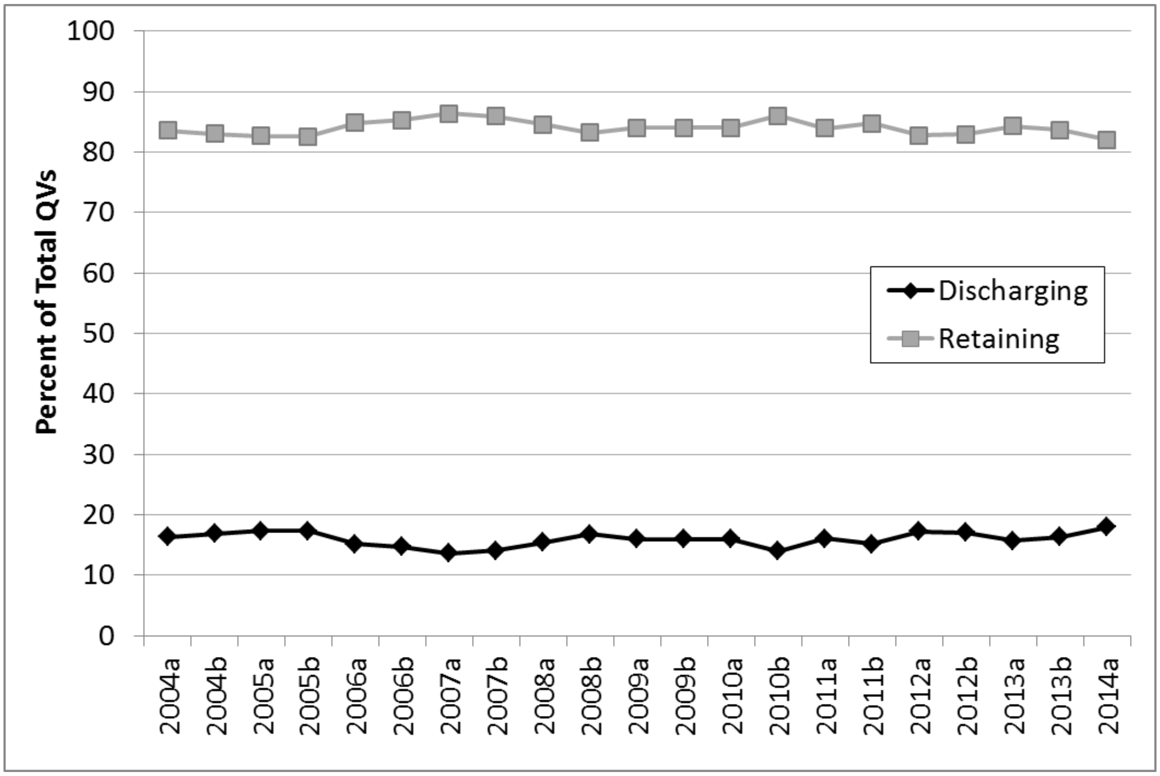

Figure V-8. Reported Ballast Water Discharge vs. Retention (a = January to June, b = July to December).

Since 2004, 84% of QVs have reported retention of all ballast water on board while in State waters (Figure V-8). However, the total volume of ballast water discharged in State waters has climbed steadily since 2004 (Figure V-9). In 2014a, the reported volume of discharged ballast water topped 6.9 million metric tons (MMT), more than in any six-month time period over the last 10 years.

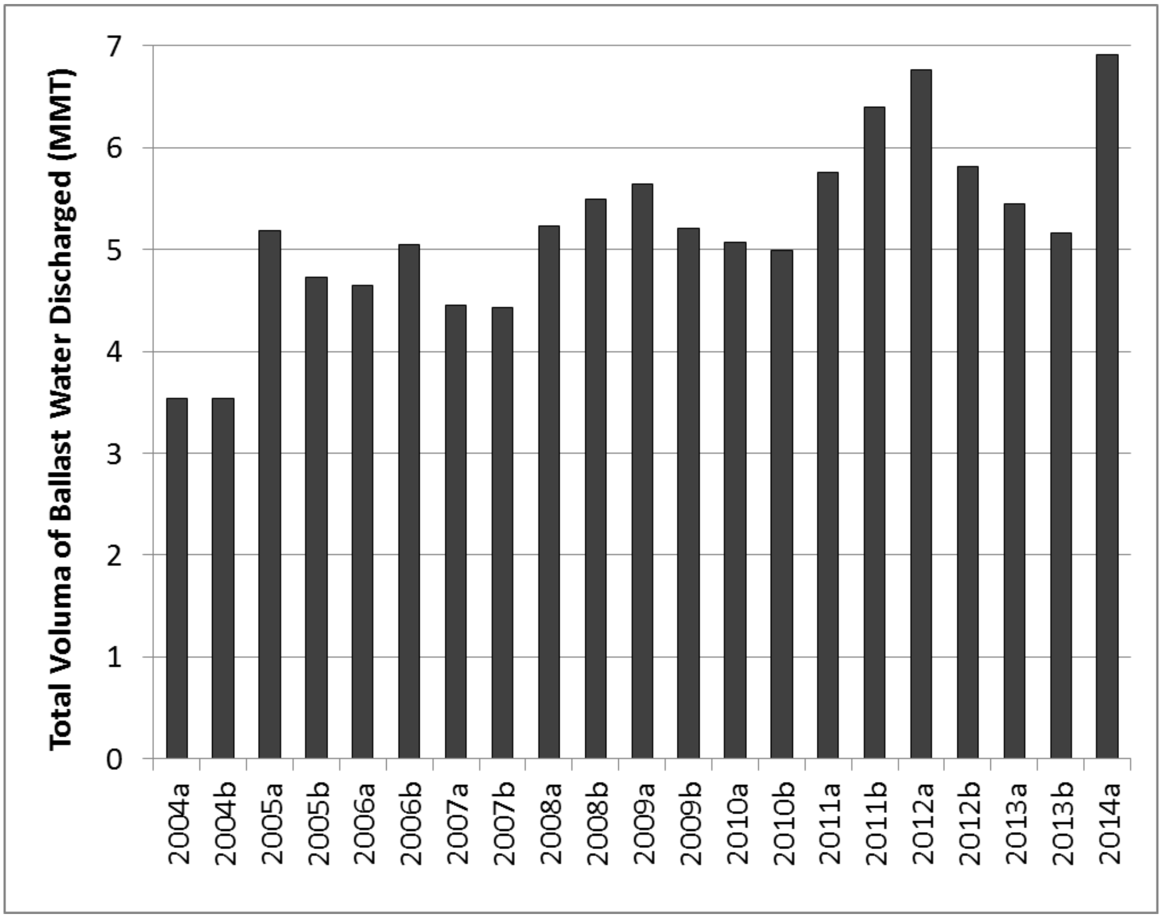

Figure V-9. Total Reported Volume of Ballast Water Discharged (million metric tons; MMT) (a = January to June, b = July to December).

Following a similar pattern, the average volume of ballast water discharged per discharging QV has also climbed steadily since 2004 (Figure V-10). These patterns are likely due to the current industry trend of building and operating vessels of larger size and greater ballast water capacity (Commission unpublished data).

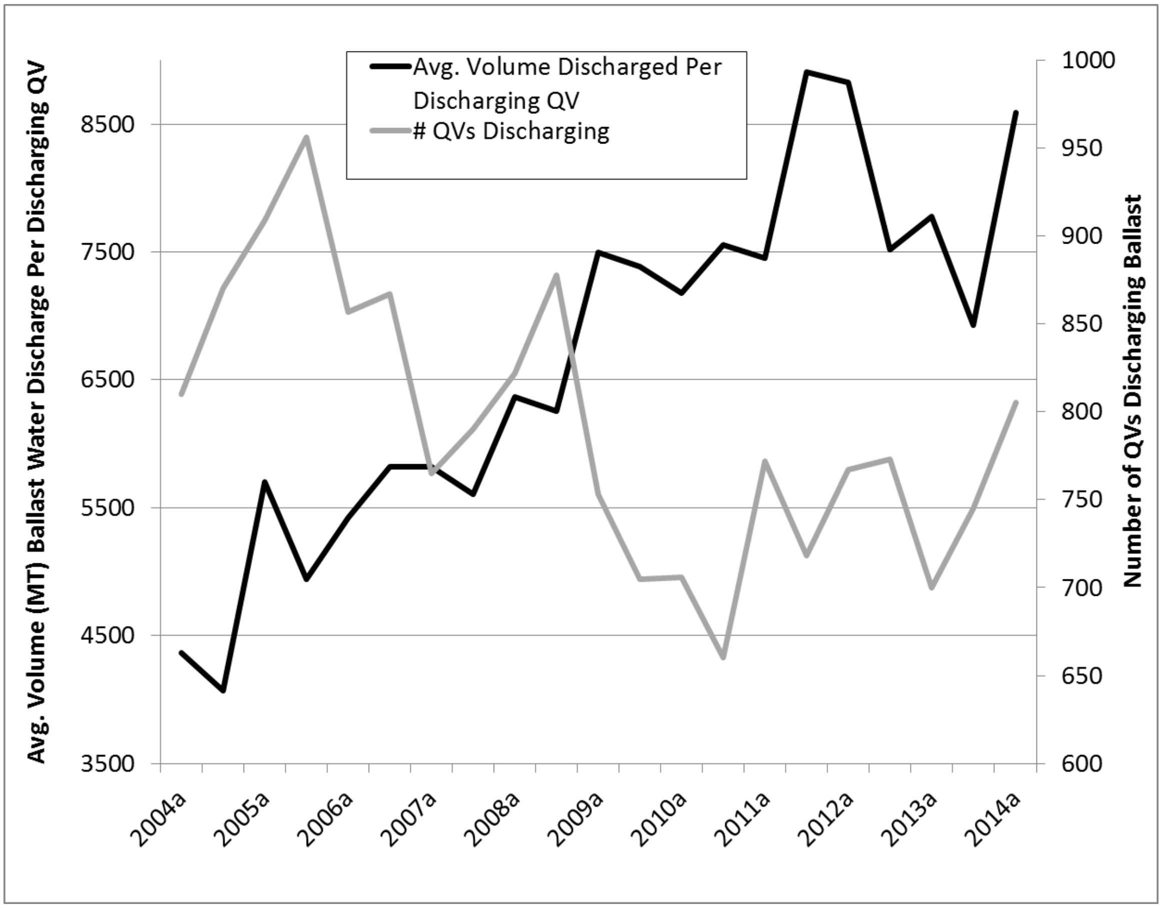

Figure V-10. Average (Avg) Volume (MT) of Reported Ballast Water Discharged per Qualifying Voyage (QV). Average calculated using the number of vessels reporting discharging not the total number of QVs. Note different scales of y-axes (a = January to June, b = July to December).

Ballast Water Discharge by Vessel Type

The increase in the total and average per QV reported volume of ballast water discharged is driven, in large part, by bulk vessels. Between 2012b-2014a, bulk vessels discharged a greater volume of ballast water into California waters than any other ship type (Figure V-11). Due to the nature of their cargo operations, bulk vessels often cannot retain ballast water on board. When bulk vessels load cargo, they frequently need to discharge the entire capacity of their ballast tanks. An average of 54% of arriving bulk vessel voyages discharged in California waters during the 2012b-2014a reporting period (Table V-1),

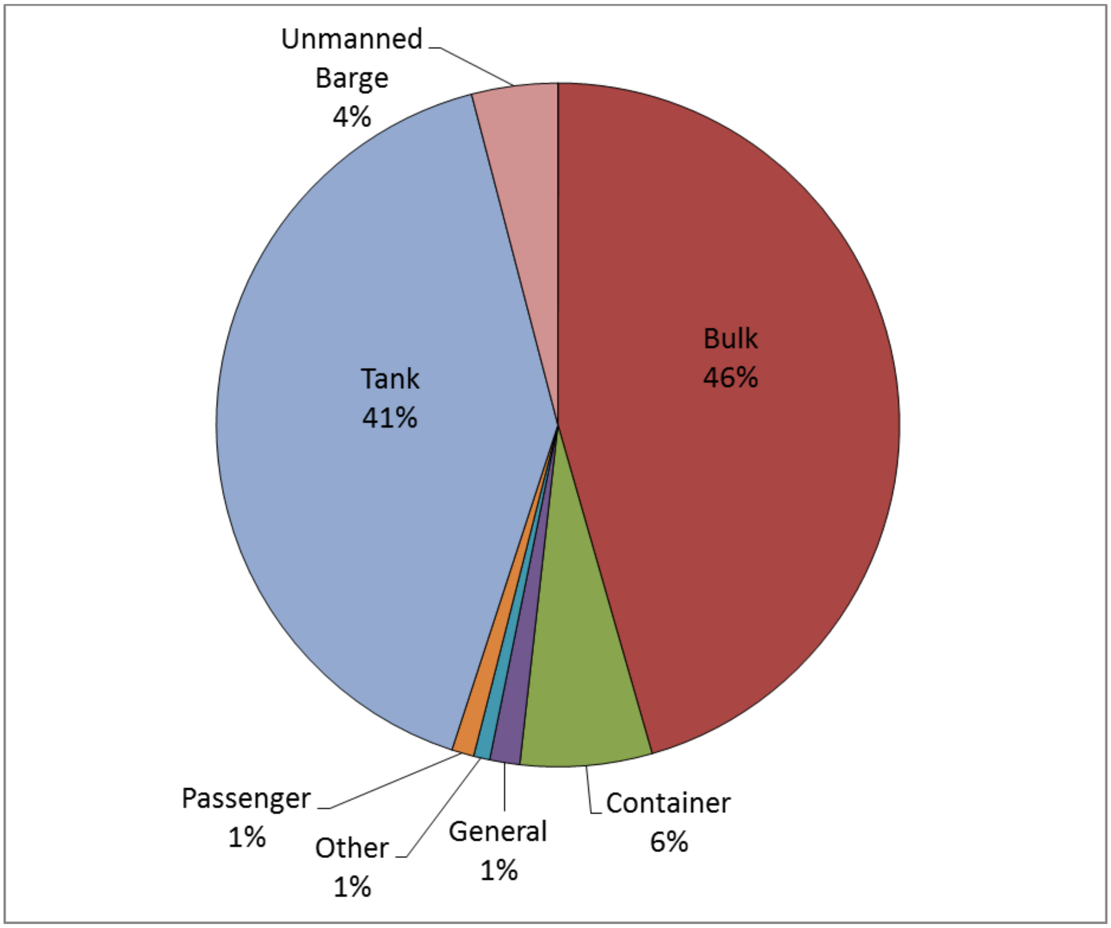

Figure V-11. Volume of Ballast Water Discharged by Vessel Type.

Table V-1. Average Number of QVs and Reported Discharge Patterns by Vessel Type (2012b-2014a).

Vessel Type	Avg. Number of Arrivals Per 6-Month Period	Avg. Number Discharging Per 6-Month Period	Percent Discharging
Auto	407	4	1.0%
Bulk	361	194	53.8%
Container	2043	108	5.3%
General	148	20	13.2%
Other	70	11	15.8%
Passenger	242	80	33.1%
Tank	973	279	28.7%
Unmanned Barge	265	60	22.7%

Individual bulk vessels discharged a larger average volume of ballast than any other vessel type (Table V-2). That average volume of ballast discharged has risen 49%, from 9,889 MT in 2004 to 14,724 MT in 2014a (Table V-2).

From 2012b though 2014a, 33% percent of passenger vessels reported discharging ballast water compared to 16% from 2010b through 2012a (Table V-1 and Table V-2 in Scianni et al. 2013). However the volume of ballast water discharged by passenger vessels remains low compared to the volume discharged by other vessel types (Table V-2).

Unmanned barges are another vessel type that has showed an increase in the volume of ballast water discharged over the last ten years. Although the number of unmanned barges that reported discharging ballast water has decreased from 2004 to 2014a, the average volume of ballast water discharged on a per barge basis has increased by 73% for the same period of time (Table V-2).

Table V-2. Average Reported Volume of Ballast Water Discharged Per Vessel by Vessel Type. (a = January to June, b = July to December).

Year	Auto		Bulk		Container		General	
	# Discharging Vessels	Avg. Volume per Vessel (MT)	# Discharging Vessels	Avg. Volume per Vessel (MT)	# Discharging Vessels	Avg. Volume per Vessel (MT)	# Discharging Vessels	Avg. Volume per Vessel (MT)
2004	17	739.6	258	9,888.6	723	2,261.6	84	3,014.2
2005	19	1,424.6	327	10,412.8	654	2,566.4	99	2,568.5
2006	38	1,191.0	318	11,001.8	504	2,750.3	91	3,108.2
2007	33	713.5	271	10,542.7	451	2,495.3	96	3,674.2
2008	21	703.9	303	11,291.3	410	2,631.3	95	4,210.6
2009	7	872.9	321	11,801.7	306	3,025.1	65	5,860.6
2010	16	531.7	304	12,459.1	318	3,204.6	65	4,691.6
2011	3	126.4	373	13,338.2	262	3,686.4	67	5,322.5
2012	12	303.0	382	13,702.4	233	3,021.9	46	5,321.7
2013	9	246.4	384	13,322.3	186	3,241.7	36	3,790.7
2014a	1	471.3	202	14,723.8	111	4,074.7	21	4,647.1

Year	Other		Passenger		Tank		Unmanned Barge	
	# Discharging Vessels	Avg. Volume per Vessel (MT)	# Discharging Vessels	Avg. Volume per Vessel (MT)	# Discharging Vessels	Avg. Volume per Vessel (MT)	# Discharging Vessels	Avg. Volume per Vessel (MT)
2004	18	7,406.5	16	624.3	279	7,573.8	200	2,736.1
2005	26	3,860.0	9	808.0	430	12,903.4	204	1,933.1
2006	23	4,803.0	25	639.9	486	11,597.0	232	2,576.6
2007	21	5,755.0	75	656.7	419	8,691.4	207	3,427.4
2008	18	6,409.4	144	602.8	543	8,919.4	180	4,423.9
2009	21	3,943.0	96	562.3	483	9,788.0	153	5,718.8
2010	9	4,944.0	52	463.0	441	9,477.8	162	4,633.7
2011	13	5,976.2	42	694.4	516	9,589.5	143	4,553.8
2012	19	1,171.6	162	826.5	558	9,164.8	125	5,237.9
2013	19	3,026.2	139	780.6	531	7,869.8	141	3,026.8
2014a	14	7,393.4	98	709.8	311	9,466.1	47	5,885.6

Ballast Water Discharge by Port

The data collected through the BWRFs also allow for analysis of discharge patterns by arrival port. As might be expected based on the numbers of QV arrivals (see Figure V-4), the greatest number of reported ballast water discharges occur in LA-LB, Carquinez, Richmond, and Oakland, respectively (Table V-3). LA-LB had large numbers of discharging vessels from both PCR and non-PCR origin, while the majority of voyages discharging in the San Francisco Bay ports/terminals of Oakland, Carquinez, and Richmond are of PCR origin.

Table V-3. Number of QVs Discharging Ballast Water in California ports (2012b-2014a; a = January to June, b = July to December).

Discharge Port	**2012b**		**2013a**		**2013b**		**2014a**	
	PCR	Non-PCR	PCR	Non-PCR	PCR	Non-PCR	PCR	Non-PCR
Carquinez	79	48	76	42	93	42	74	56
El Segundo	55	6	47	3	25	6	23	4
Hueneme	1	13	0	2	3	4	0	1
Humboldt	2	2	1	1	5	2	1	1
LA-LB	159	208	171	167	158	175	216	163
Oakland	47	8	29	9	28	9	45	12
Redwood	1	5	0	7	3	3	2	5
Richmond	78	12	73	12	82	26	85	41
Sacramento	3	9	2	9	3	10	2	10
San Diego	9	1	10	4	9	3	5	3
San Francisco	5	1	6	2	18	1	9	4
Stockton	5	16	4	23	10	25	8	34
TOTAL	**444**	**329**	**419**	**281**	**437**	**306**	**470**	**334**

While knowing the number of vessels discharging ballast in California provides valuable information, the volume of ballast water released at California ports (Table V-4) is perhaps a better gauge of invasion pressure. Over the past two years, more ballast water was discharged at LA-LB than any other port in California (Table V-4).

On a regional scale, the ports and marine terminals in the San Francisco Bay-Delta (including San Francisco, Redwood City, Oakland, Richmond, Carquinez, Sacramento, and Stockton) received more discharged ballast water than the Los Angeles region (LA-LB and the El Segundo marine terminal) (12.8 million MT vs. 9.5 million MT, respectively) (individual port volumes in Table V-4).

The San Francisco Bay-Delta numbers are largely driven by tank vessels discharging ballast water at Richmond and Carquinez, and bulk vessels discharging in Stockton and Carquinez. LA-LB and El Segundo also receive most of their ballast water discharged from both bulk and tank vessels.

Fifty-nine percent of the reported volume of ballast water discharged in California between 2012b and 2014a came from vessels whose last port of call was within the PCR (Table V-4). Given the number of arriving PCR vessels and the large volumes of ballast water discharged by such transits (Tables V-3 and V-4), these data demonstrate the risk of intraregional transport of NIS across several recipient ports. There is a strong pattern of intraregional NIS spread along the North American Pacific coast (Ruiz et al. 2011), a pattern that highlights the elevated risk of NIS introduction from PCR-sourced ballast water discharged in California. The high risk of intraregional NIS spread underscores the importance of the ballast water management regulations for the PCR that were implemented by the Commission in 2006.

Table V-4. Ballast Water Source Region and Total Discharge Volume (metric tons = MT) by Port . (2012b-2014a; a = January to June, b = July to December).

Discharge Port	2012b			2013a			2013b			2014a		
	%PCR	%Non-PCR	Total Volume Discharged (MT)	%PCR	%Non-PCR	Total Volume Discharged (MT)	%PCR	%Non-PCR	Total Volume Discharged (MT)	%PCR	%Non-PCR	Total Volume Discharged (MT)
Carquinez	62	38	1,590,225	64	36	1,485,042	69	31	1,180,810	57	43	1,592,901
El Segundo	90	10	585,507	94	6	506,205	81	19	134,882	85	15	320,948
Hueneme	7	93	9,476	0	100	2,868	43	57	5,490	0	100	747
Humboldt	50	50	30,374	50	50	11,843	71	29	32,550	50	50	25,436
LA-LB	43	57	2,185,470	51	49	2,062,768	47	53	1,182,721	57	43	2,554,870
Oakland	85	15	326,990	76	24	250,643	76	24	216,595	79	21	249,437
Redwood	17	83	87,561	0	100	74,771	50	50	47,068	29	71	99,393
Richmond	87	13	558,440	86	14	569,899	76	24	910,117	67	33	1,147,594
Sacramento	25	75	97,780	18	82	98,283	23	77	89,417	17	83	99,506
San Diego	90	10	5,522	71	29	38,512	75	25	6,121	63	38	40,746
San Francisco	83	17	29,220	75	25	4,211	95	5	37,074	69	31	47,306
Stockton	24	76	243,677	15	85	325,797	29	71	561,535	19	81	737,633
TOTAL	**57%**	**43%**	**5,814,161**	**60%**	**40%**	**5,443,537**	**59%**	**41%**	**5,159,170**	**58%**	**42%**	**6,916,516**

Ballast Water Management and Compliance

Data Synopsis

- Ballast water management requirements vary as a function of the vessel's last port of call and ballast water source.
- Vessels use two methods of ballast water exchange, empty-refill and flow-through.
- The majority (98%) of ballast water carried into California waters is managed in compliance with the law.
- Noncompliant ballast water discharges consist mainly of water that was managed in the wrong location and water that did not receive any type of management.
- Discharges of unmanaged water represent the highest risk of ballast water NIS introduction.
- Outreach efforts should be increased to address lingering noncompliance issues.

Ballast water retention is the most protective ballast water management strategy available. Until California's ballast water performance standards are implemented (see Table III-2 for current schedule), all ballast water that is discharged into California waters must be managed using either ballast water exchange or another approved alternative method. The requirements for ballast water exchange depend on the vessel's last port of call and the source of the ballast water to be discharged (See Section III, Ballast Water Management Practices, pg 11).

California regulations (2 CCR §2280 *et seq.*) require 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 Figure III-1 for map of PCR), 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 more than 50 NM from land and in water at least 200 m deep (near-coastal waters) 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 management;
- Discharge the ballast water to an approved reception facility (currently there are no such facilities in California); or
- Under extraordinary circumstances, perform a ballast water exchange in an area agreed to in advance by the Commission in consultation with the USCG.

Public Resources Code 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 following ways:

- Exchange ballast water in areas at least 200 NM from land and in waters at least 2,000 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 management (such as a USCG accepted AMS);
- Discharge the ballast water to an approved reception facility (currently there are no such facilities in California); or
- Under extraordinary circumstances, perform a ballast water exchange in an area agreed to in advance by the Commission in consultation with the USCG.

Method of Ballast Water Exchange

Vessels that use ballast water exchange to manage their ballast water prior to discharge generally use one of two methods of exchange: flow-through (FT) or empty-refill (ER). The method of exchange used by a vessel is based on ship and ballast tank engineering.

In FT exchange, ocean water is pumped continuously through a ballast tank to flush out water originating 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. Existing regulations require vessels to perform a three-times FT exchange (i.e. 300% of tank volume) or a single ER (i.e. 100% of tank volume).

During the current reporting period, 49% of discharged ballast water, by volume, was managed using ER, compared to 38% managed using FT (Figure V-12). Some vessels fail to report on their BWRF the type of management conducted, therefore these data are shown as “other” and account for 13% of the data reported (Figure V-12).

While properly exchanged ballast water can remove 95%-100% of the original source water (Hay and Tanis 1998) and reduce the number of coastal species in ballast tanks, FT 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).

Therefore vessels that conduct their ballast water exchange using the less effective FT method are increasing the likelihood of discharging coastal organisms into California ports; however, as previous noted, the method of exchange is generally a function of vessel design. While it is important to track the method of exchange for information purposes, it is not possible to have all vessels shift towards using ER to lower the risk of species introductions to California.

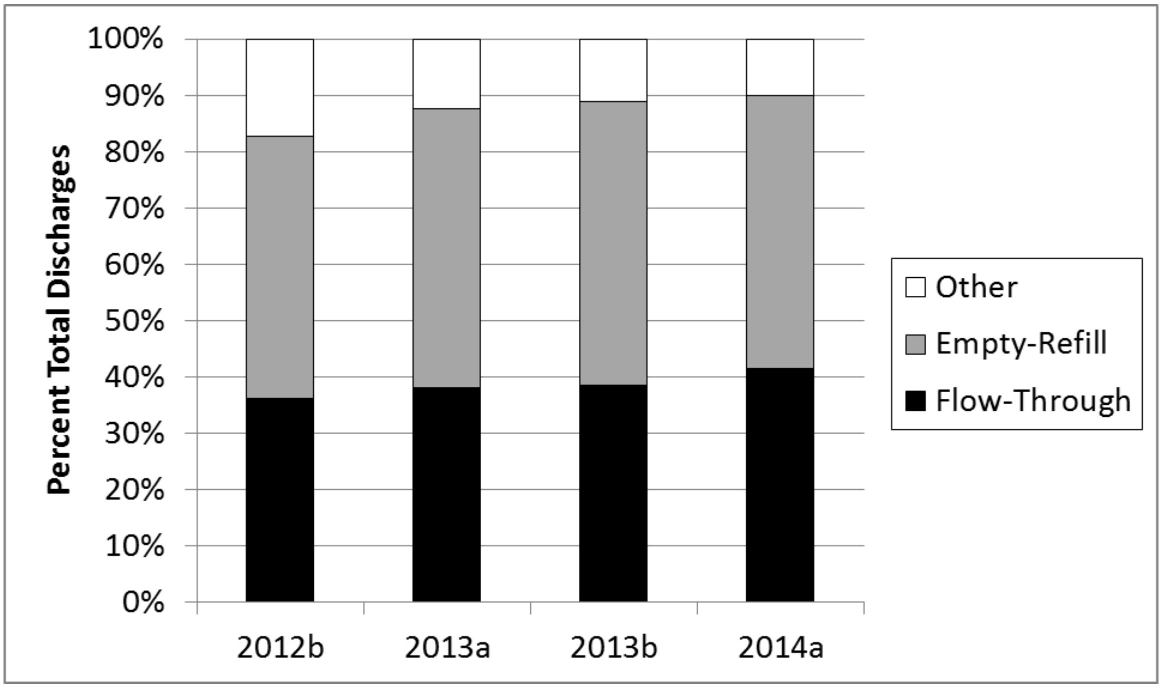

Figure V-12. Type of Ballast Water Exchange Reported by Vessels Discharging Ballast in California (2012b-2014a; a = January to June, b = July to December).

During the two-year focus of this report (2012b-2014a), 97.9% of the more than 122 MMT of vessel-reported ballast water carried into California was managed (including retention) in compliance with State law. Furthermore, the majority (79%) of the noncompliant ballast water discharged in State coastal waters underwent some type of management (but not to legal standards), likely reducing the risk of NIS introductions.

During the reporting period 23.4 MMT of ballast water was discharged into California waters and 92.0% (21.5 MMT) was in compliance with management requirements either through proper ballast water exchange or the use of an approved alternative management method (e.g. USCG accepted AMS) (Figure V-13). While the total volume of ballast water discharged into California has increased over the past 10 years (see Figure V-9), the proportion of noncompliant discharges has decreased. Noncompliant discharges represented 23.8% of the total volume of ballast water discharged in California in 2006b (when existing coastal management regulations began), but only 4.7% in 2014a.

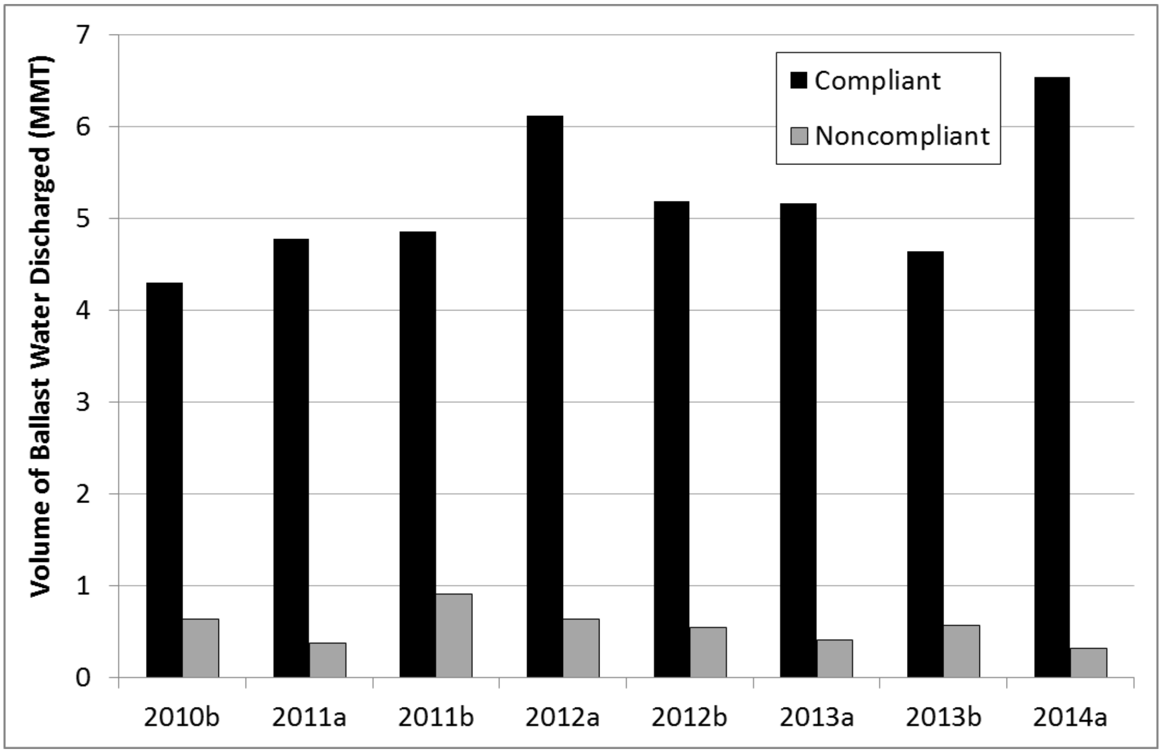

Figure V-13. Volume (million metric tons, MMT) of Compliant and Noncompliant Ballast Water Reported as Discharged by Six-Month Period Since July 2010. Includes only compliance of discharged ballast water and does not include data for vessels that comply by retaining ballast water (a = January to June, b = July to December).

Noncompliant Discharged Ballast Water

A total of 1.9 MMT of noncompliant ballast water was discharged in California waters between July 2012 and June 2014. Noncompliant ballast water commonly falls 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 2 CCR §2280(a)(1);
- Ballast water was not managed; or
- Vessel reported exchanging ballast water, but the location of exchange was unknown or unspecified.

<u>Ballast Water Exchange in the Wrong Location</u>

Commission staff determines the location of ballast water source and exchange locations using vessel-reported coordinates and the Geographic Information Systems (GIS) software ArcMAP (ESRI 2011). This analysis accurately determines reported ballast management locations (latitude and longitude) and also helps MISP staff determine patterns and trends of noncompliance.

Most vessels in violation of ballast water management requirements performed ballast water exchange before discharging in California, but did so in a location not acceptable by California law. While ballast water exchanged at the required distance from land is clearly more protective, an illegal ballast water exchange (i.e. an exchange conducted too close to land) can be, in some cases, better than no exchange at all due to the potential flushing of unwanted source organisms. The volume of ballast water exchanged in the wrong location prior to discharge accounted for 79% of noncompliant ballast water by volume during the current reporting period (Figure V-14).

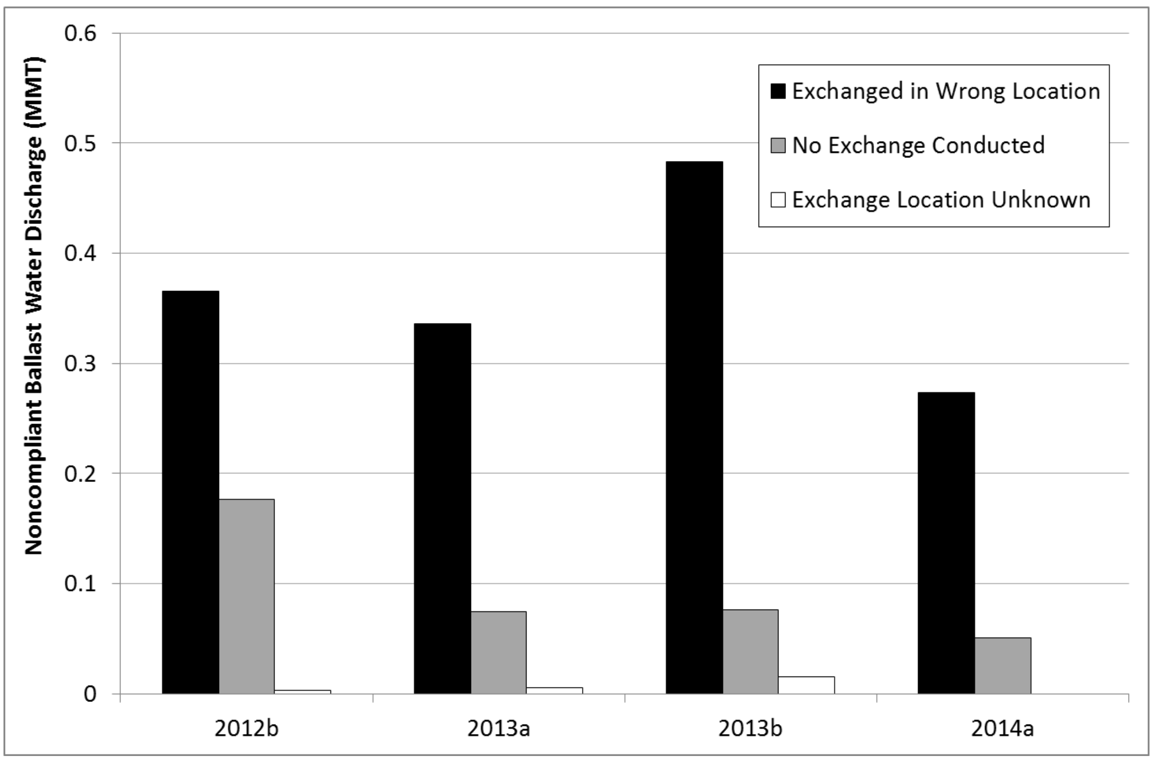

Figure V-14. Volume (million metric tons; MMT) of Reported Noncompliant Ballast Water (BW) Discharged by Violation Type (a = January to June, b = July to December).

The majority of noncompliant ballast water exchanges (82% by volume) in the wrong location occur along the North American west coast. Between 2012b-2014a, the "hotspots" of noncompliant ballast water exchange (by volume) occurred off of San Francisco Bay and in several locations along the Baja California coast (Figure V-15). Although the actual volumes of improperly exchanged water fluctuate over time, the "hotspots" illustrated in Figure V-15 are relatively constant.

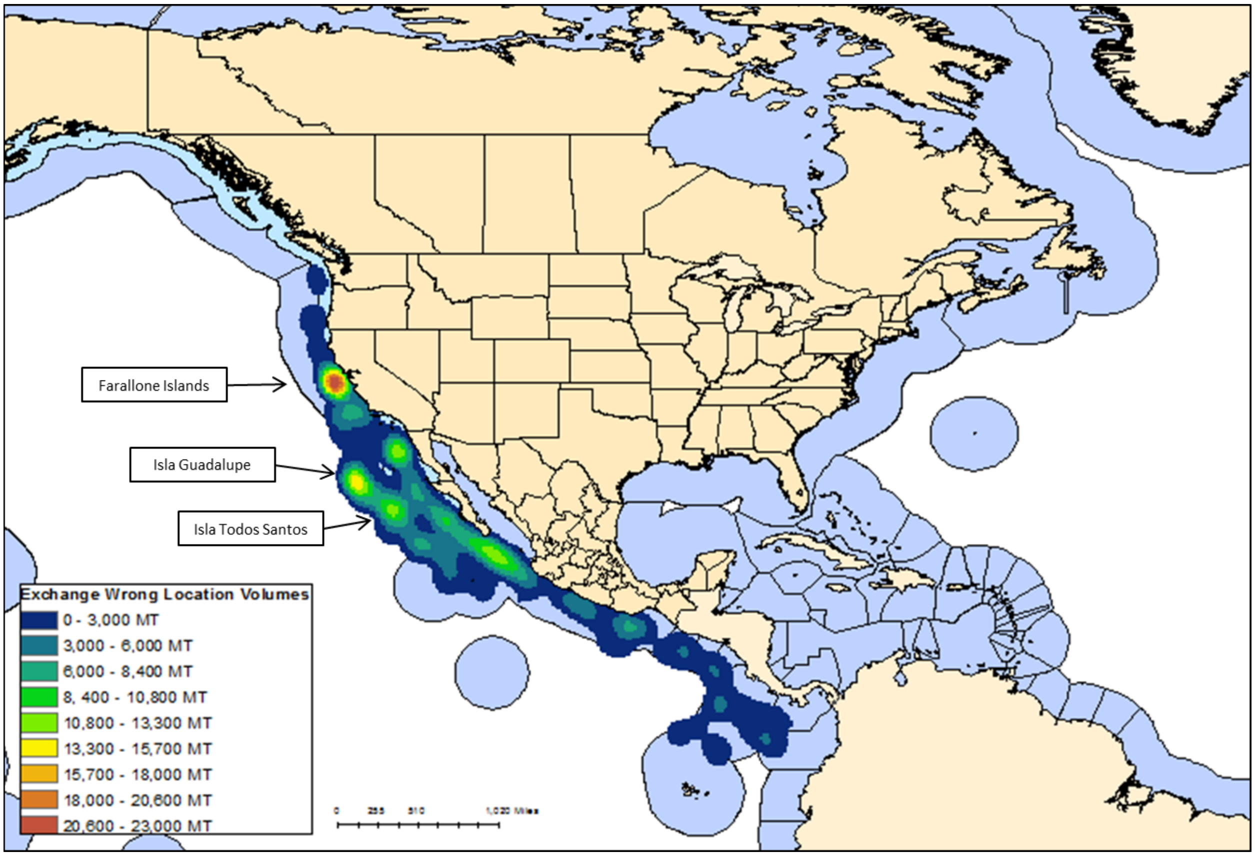

Figure V-15. Volumes and Locations of Illegally Exchanged Ballast Water. Locations based on vessel reported latitude and longitude and plotted using the GIS software ArcGIS.

Vessels conducting improper exchanges are most likely attempting to comply with California regulations, but may be misinterpreting the required exchange distances (i.e. assuming the required distance is from the mainland and not any land, including islands). There are a number of small islands situated off the coast of California and Baja California (e.g. the Farallones, Isla Guadalupe, and Isla Todos Santos). Vessels discharging ballast water originally sourced at ports in South/Central America and Mexico need to take these islands into account when calculating distance from land to conduct their exchanges. Commission staff is targeting these vessels for additional outreach to clarify management requirements.

<u>Unmanaged Discharges</u>

Ballast water that was not managed (i.e. not exchanged) made up 20.4% of noncompliant discharges by volume during this reporting period (Figure V-14). These discharges represent the highest overall risk of NIS introduction to the State because there has been no ballast water management conducted. Knowing the geographic source of unmanaged water is important information for assessing the risk of NIS introductions because risk may be influenced by chemical, physical, and biological similarities between source and receiving waters.

Of the unmanaged ballast water discharged into California waters, 81% originated from the west coast of North America. The west coast of North America can be divided into areas that share similar physical characteristics (e.g. temperature, salinity). As shown in Figure V-16 (geographic classifications based on Spalding et al. 2007) and mapped in Figure V-17. The following are percentages of unmanaged discharged ballast water by origin:

- 54% (205,959 MT) originated from the warm temperate eastern Pacific, an area that roughly expands from the tip of the Baja California peninsula north to Point Conception in California;
- 14% (54,060 MT) originated from the cold temperate eastern Pacific, an area characterized by cooler temperatures that expands from Alaska south to Point Conception; and
- 13% (49,357 MT) originated from the tropical eastern Pacific, an area from Central America north to the tip of Baja California.

These volumes are noteworthy, given that the coastal spread of NIS by shipping has been shown to be a major factor in the movement of species within and out of the State. California is the “entry point” for 79% of established NIS along the North American west coast (Ruiz et al. 2011). California’s two most active port regions, LA-LB and the San Francisco Bay-Delta, are located in the warm temperate eastern Pacific and cold temperate eastern Pacific zones, respectively.

The remaining proportion of unmanaged ballast water discharged in California waters (17%; 63,003 MT) originated from ports located in the cold temperate west Pacific, which roughly spans from the western Aleutian Islands south to China (Figure V-17). The west Pacific is known to be a major source of NIS that have successfully established in California (Ruiz et al. 2000a).

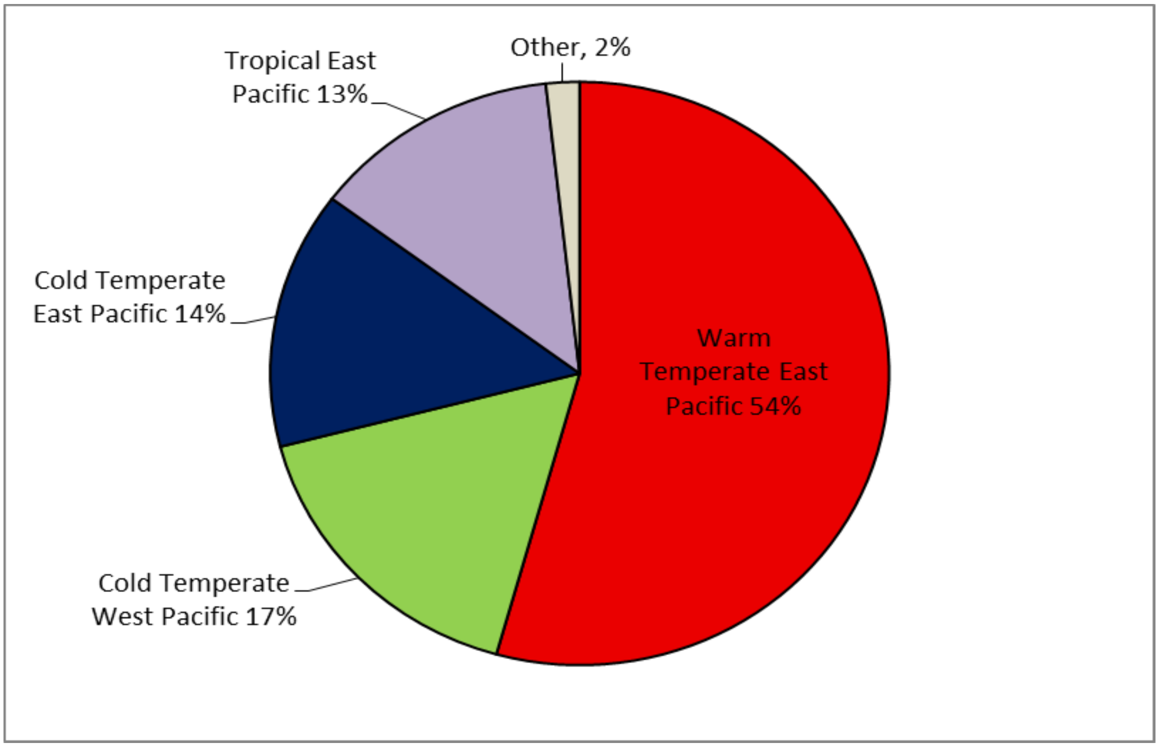

Figure V-16. Sources of Noncompliant, Unmanaged Ballast Water (BW) Reported as Discharged in California from 2012b through 2014a.

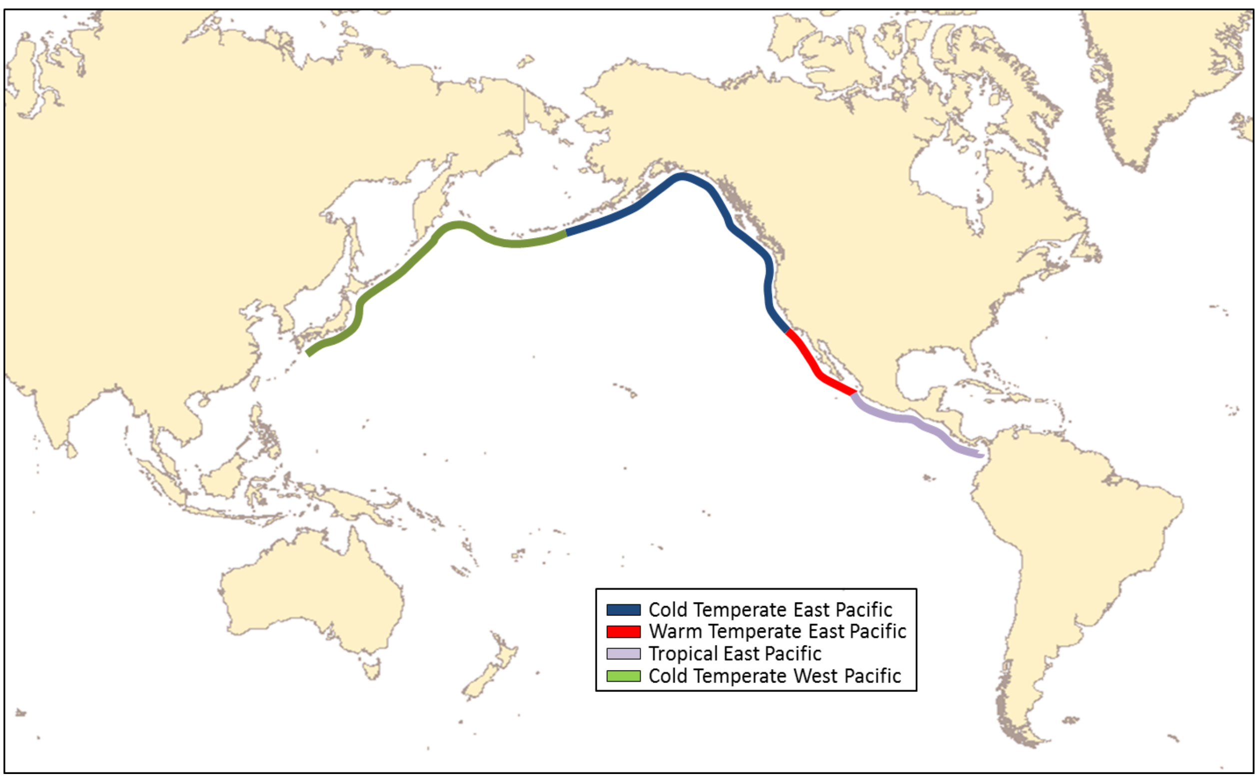

Figure V-17. Map of geographic source regions for unmanaged ballast water discharged in California.

Noncompliant Ballast Water Discharge by Vessel Type

Since 2006, the largest proportion of noncompliant ballast water reported discharged in California can be attributed to tank and bulk vessels (Figure V-18). From 2012b–2014a, these two vessel types accounted for 92.6% of the total volume of noncompliant ballast water discharged in the state. Tankers accounted for 43% and bulkers accounted for 49% of noncompliant discharges by volume (Figure V-17).

Container vessels have the greatest number of annual QVs to California, accounting for approximately 45% of all arrivals to California since 2000. However, the total reported proportional volume of noncompliant ballast water discharged from container vessels has decreased from 31.7% in 2004a (Falkner et al. 2007) to 1.8% 2014a.

During this reporting period, containerships were responsible for 2.5% (by volume) of all noncompliant ballast water discharged into the State.

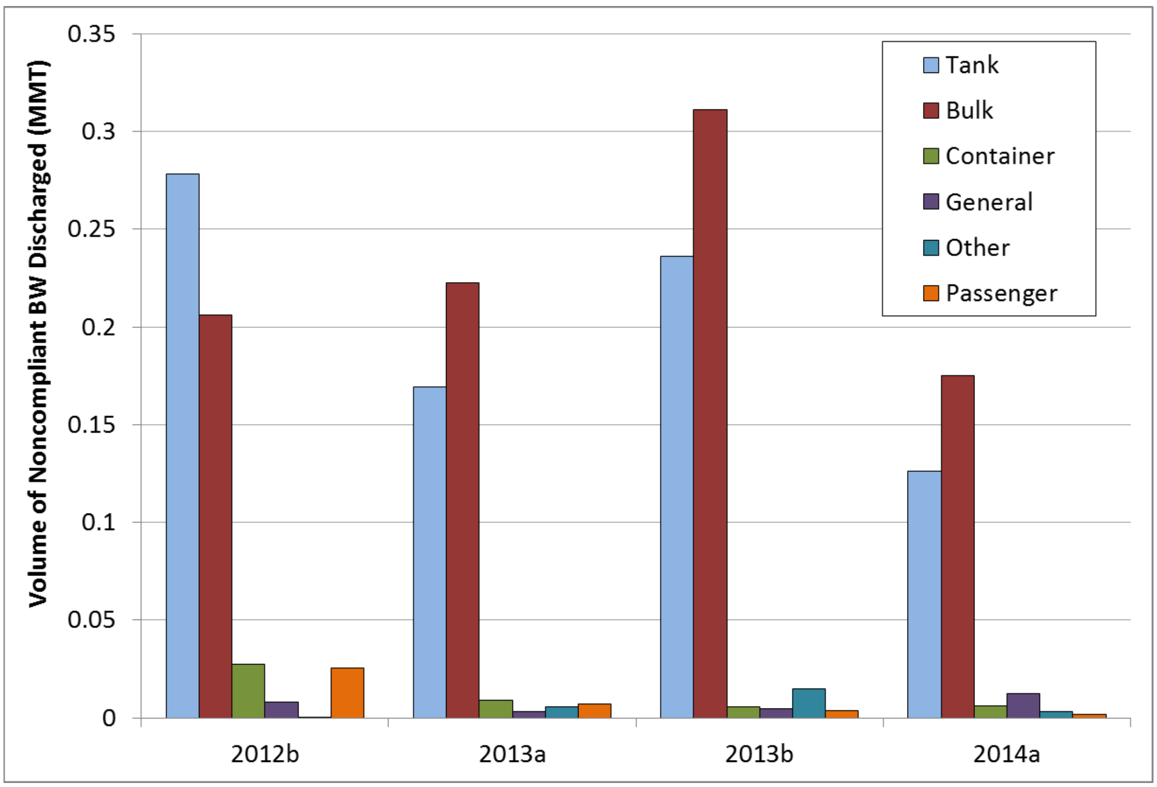

Figure V-18. Volumes of Reported Noncompliant Ballast Water (BW) by Vessel Type (a = January to June, b = July to December).

Unmanned Barges

Unmanned barges are responsible for the third largest volume (behind tank and bulk vessels) of high-risk ballast water (i.e. unmanaged or not exchanged at legal distances from shore) discharged in California (Figure V-19). These unmanaged discharges represent a high risk of species introductions into California waters and warrant additional attention

Barges regularly claim a safety exemption in California due to concerns associated with safely transferring personnel to an unmanned barge to conduct ballast water exchange. Safety exemptions are allowed under PRC § 71203 if the safety of any vessel or its crew could be compromised by a management action. In such cases, vessels are not required to manage ballast water prior to discharge. While it is legal to discharge unmanaged ballast water when a safety exemption is claimed, the practice does result in the discharge of high-risk water to the State.

Unmanned barges typically operate on regular routes along the U.S. west coast, thus presenting an opportunity for repeat inoculation and facilitation of coastal spread of NIS. It has been shown that California serves as a hub for species introduction along the West Coast of North America; 79% of marine and estuarine NIS established in western North America were first detected in California (Ruiz et al. 2013). The movement of unmanaged ballast water from port to port may be one of the vectors responsible for this movement of species.

While unmanned barges account for the third largest volume of unmanaged ballast discharges into California waters, there are many that do comply. From 2012b–2014b, 88% of discharges by volume (838,048 MT) were managed in compliance with California law. For those unmanned barges unable to safely perform ballast water exchange, the use of either shore-based or shipboard ballast water treatment technologies may be considered tools to reduce the risk of NIS introductions while minimizing threats to the safety of the vessel and its crew.

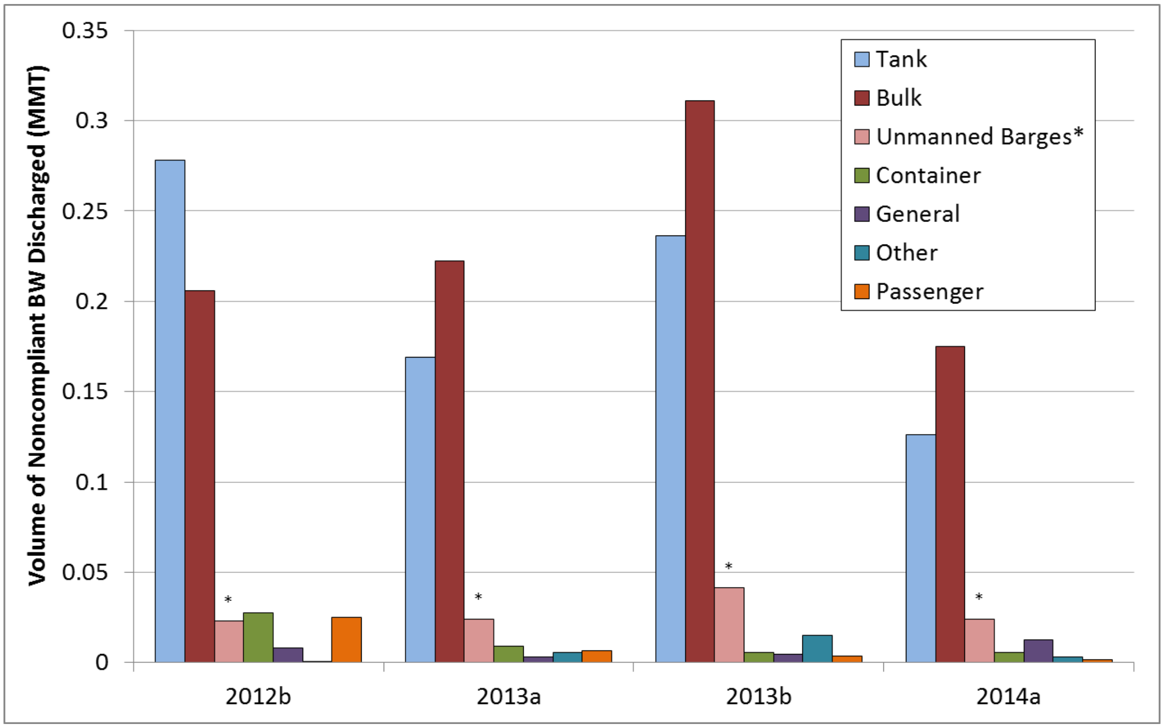

Figure V-19. Volumes of High-Risk Ballast Water by Vessel Type Inclusive of Unmanned Barges. This water is designated as high-risk because it was either exchanged at a location that was not at the legally required distance from shore or was unmanaged due to a legal safety exemption. (a = January to June, b = July to December).

Use of Ballast Water Treatment Technologies in California

Data Synopsis

- 58 vessels arriving to California report having an installed ballast water treatment system.
- 12 vessels have used a shipboard ballast water treatment system to manage ballast water prior to discharge in California waters.
- The volume of treated ballast water discharged in California in 2014a was six times the volume discharged in previous years.

As the IMO, U.S. Federal government, and states implement ballast water discharge standards, vessel owners and operators are installing shipboard ballast water treatment systems. Starting in 2012, the USCG began allowing vessels to install and use AMS to treat ballast water in lieu of ballast water exchange. In May 2013, the Commission approved the use of USCG-accepted AMS as an alternative ballast water management method (in lieu of exchange) under PRC § 71204.3(d).

The Commission is gathering information on the use of ballast water treatment systems in California through the Annual and Supplemental ballast water treatment technology forms.

A total of 58 vessels have arrived at California ports and reported an installed shipboard ballast water treatment system. Shipboard treatment systems in use in California are either USCG accepted Alternative Management Systems (AMS) or systems installed on vessels as part of the USCG Shipboard Technology Evaluation Program (STEP).

Vessels Using Treatment Systems

Of the 58 vessels reporting, 12 used their shipboard treatment system prior to discharging ballast water in California. These treatment systems use a variety of treatment methods to kill organisms in ballast water. All of these multi-step systems use mechanical filtration as a first step followed by ultraviolet radiation, electrochlorination, or biocide (Table V-5).

Table V-5. Total volume (MT) of treated ballast water discharged in California between 2012b and 2014a for the 12 vessels reporting the use of a ballast water treatment system. Treatment method and vessel type are also listed. All of the listed treatment system types listed use a filter in combination with the treatment method.

Vessel Type	Treatment Method	2012b	2013a	2013b	2014a
Container	electrochlorination				12,837
Bulk	ultraviolet radiation				6,119
Bulk	ultraviolet radiation				10,066
Passenger	ultraviolet radiation				392
Passenger	ultraviolet radiation			367	
Bulk	electrochlorination				33,296
Bulk	electrochlorination				23,603
Other	biocide	563		2,971	4,928
Passenger	ultraviolet radiation				2,322
Tank	electrochlorination				4,858
Bulk	ultraviolet radiation		6,147		
General	ultraviolet radiation				2,378
Total Volume Discharged (MT)		**563**	**6,147**	**3,338**	**100,799**

From 2012b through 2013b, three vessels reported using a ballast water treatment system to treat ballast water prior to discharge. In 2014a, that number increased to 10.

Additionally, the combined reported volume of treated ballast water discharged into California waters in 2014a is almost 6 times the combined volumes from 2012b through 2013b (Table V-5).

The ten vessels that reported using a shipboard ballast water treatment system in 2014a, discharged treated ballast at four California ports. Six vessels discharged the treated ballast water at LA-LB. The other vessels discharged treated ballast water at Carquinez, San Francisco, or Stockton.

Staff will continue tracking ballast water treatment system installation and use. The information from the treatment technology report forms will be paired with biological sampling of treated discharges to increase knowledge of treatment system performance (relative to the California performance standards) under real-world operating conditions.

Enforcement of MISA Requirements

Vessel Inspections

Under PRC § 71206, the Commission assesses compliance of any vessel subject to the MISA and associated regulations through a vessel inspection program operated out of the Commission's Southern California and Northern California field offices.

Statewide, Field Operation personnel inspected 24.3% (4,573) of QVs between 2012b and 2014a (Table V-6), marginally below the mandate to inspect a minimum of 25% of arriving voyages. Changes to the vessel boarding prioritization process in late 2013 increased the number of inspections, but a reduction in inspector staffing levels during the last budgetary slowdown continue to impact the overall vessel inspection rate.

During vessel inspections, Commission staff interview vessel crew and review paperwork, including but not limited to: Ballast Water Reporting Forms, ballast water management plans, ballast water and engine logbooks, Hull Husbandry Reporting Forms, and ballast water treatment technology reporting forms (as applicable). If these items are not in order as required, the vessel is cited for an administrative violation.

Inspectors also verify that discharged ballast water was properly managed prior to exchange. Staff collects a ballast water sample to quantify the salinity of the ballast water. Ballast water that has been exchanged is expected to have a salinity reading reflective of oceanic conditions at or above 30 parts salt per thousand parts water (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 situations, the Inspector more closely scrutinizes paperwork, reported ballast water exchange coordinates, and re-interviews vessel officer(s) to ascertain possible reasons for the discrepancy. Any violation of ballast water management requirements is considered an operational violation.

Between 2012b-2014a, 97.5% of inspected vessels were compliant with management requirements. Of the 114 violations assessed during this two-year period, 54% were administrative and 46% were operational (Table V-6). 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 to ensure the violation has been properly addressed.

Table V-6. Summary of Vessel Inspections and Violations (2012b-2014a).

	2012b	**2013a**	**2013b**	**2014a**
Number Qualifying Voyages	4762	4578	4751	4648
Number Inspections	1057	1023	1176	1317
Percent of QVs Inspected	22.2	22.3	24.8	28.3
Total Violations	36	23	19	36
Administrative	19	10	11	22
Operational	17	13	8	14

Enforcement through GIS Analysis of Vessel-Reported Data

Because it is logistically and physically infeasible for the Commission’s Marine Safety Personnel to inspect every QV arrival to a California port or place, MISP staff conducts routine GIS analyses of all vessel-submitted Ballast Water Reporting Forms for compliance assessment and enforcement of ballast water management requirements. Every quarter, data for approximately 2,000 discharged ballast water tanks are analyzed to determine: the ballast water sources, whether exchange was conducted, and the exchange location. MISP staff utilizes GIS to aid in this compliance analysis.

During the reporting period of June 2012 through July 2014, 378 ballast water management (operational) violations from 251 vessels were discovered using GIS analyses. Each vessel may have multiple ballast water tanks that can be managed independently; therefore any individual vessel could be responsible for multiple operational violations.

Beginning in early 2014, MISP staff implemented updated procedures for notifying vessel owners and shipping agents of these violations. Information gathered from these quarterly analyses has helped guide the creation of proposed enforcement regulations that will outline penalties associated with different categories of ballast water management noncompliance (e.g. exchange in the wrong location, no management).

It is expected that the rulemaking process for the proposed enforcement regulations will begin in early 2015.

Biofouling Management Practices and Patterns

Data Synopsis

- A majority of vessels (at least 79% each year between 2008 and 2013) have antifouling coatings that were less than three years old and are still likely to be effective.
- Between 11 and 20 vessels per year are being cleaned in-water within the Ports of LA and LB, and the majority of those vessels have copper-based antifouling coatings.
- The recent Great Recession has influenced vessel operational practices in a way that has likely increased the risk of NIS introduction:
    - The occurrence of the high-risk vessel practice of remaining stationary for ten days or greater increased 75% from pre-recession (2008) to post-recession (2013);
    - The median traveling speed of the vessels operating in California has decreased 13.8%, from 16.0 knots in 2008 to 13.8 knots in 2013.

Every vessel poses some level of biofouling-mediated species introduction risk, because all vessels have submerged or wetted surfaces that are susceptible to accumulating biofouling. Unlike organisms within an enclosed ballast tank, these biofouling organisms can never be completely contained or retained. However, biofouling organisms can be managed, and the biofouling management practices of the fleet of vessels operating in California waters is discussed in this section.

Hull Husbandry Practices of the Commercial Fleet in California

Antifouling Coatings

Vessel biofouling can be proactively managed in a variety of ways, most often through:

1. Antifouling coatings to prevent or deter biofouling attachment to vessel surfaces; or
2. Foul-release coatings to reduce biofouling adhesion strength so organisms detach through regular vessel movement.

Antifouling and foul-release coatings are applied approximately every five years during a vessel's routine dry docking. These coatings are expected to provide some protection from biofouling during the period between dry dockings.

Data on vessel coating age provides insight into effectiveness of biofouling management efforts and potential risks for species transport. Antifouling coatings are generally designed to be effective for five years, and most coatings lose effectiveness over time.

Data from annual HHRF submission between 2008 and 2013 (2014 data is not yet available) demonstrate that over 60% of the vessels operating in California had coatings that were less than two years old; and over 79% of vessels had coatings that were less than three years of age (Figure V-20).

Although it is encouraging to see most vessel's using coatings within their effective lifespan, approximately 2% of the vessels during 2011 – 2013 reported coatings that are extended beyond their effective lifespan (5 years) (Figure V-20). Two percent does not represent a large portion of the vessels operating in California, but it did represent 36 unique vessels in 2012 (accounting for 284 QVs) and 27 unique vessels in 2013 (accounting for 211 QVs) that likely had ineffective coatings, ineffective biofouling protection, and therefore, ineffective NIS protection.

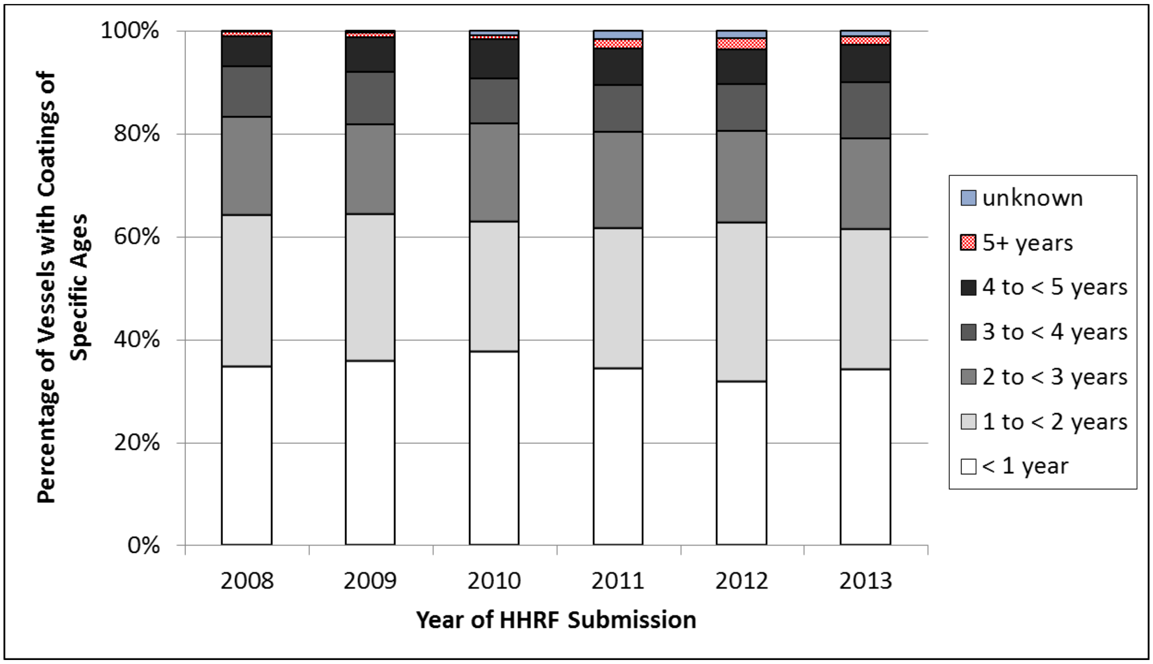

Figure V-20. Coating Ages for Vessels Operating in California Each Year from 2008 through 2013. Coatings aged five years or greater are generally outside of their effective lifespan.

The type(s) of antifouling or foul-release coating(s) applied to a vessel is an important component of an effective biofouling management strategy. There are many different types of coatings available on the market, most of which have been designed for specific vessel operational profile characteristics (e.g. speed, trading area). Understanding the prevalence of different coating types is useful for identifying the current biofouling management strategies of the vessels that operate in California.

Annually, from 2008 through 2013, between 83% and 88% of vessels operating in California used biocidal coatings only (Figure V-21), most being copper-based. The biocidal coating only' strategy is primarily being driven by container vessels, as they account for 25-33% of the unique vessels operating in California each year.

Small proportions of vessels used biocide-free foul-release coatings (2-5%) or a combination of foul-release coatings with targeted application of biocidal coatings in niche areas (3-4%; Figure V-21).

Although passenger vessels account for only a small portion of the overall fleet (2-3%), their combined use of foul-release coatings on the hull and biocidal coatings in niche areas has increased from 16% of the unique passenger vessels in 2008 to 38% in 2013. This 38% represents only 18 unique passenger vessels in 2013, but these vessels make numerous repeated visits to California throughout the year.

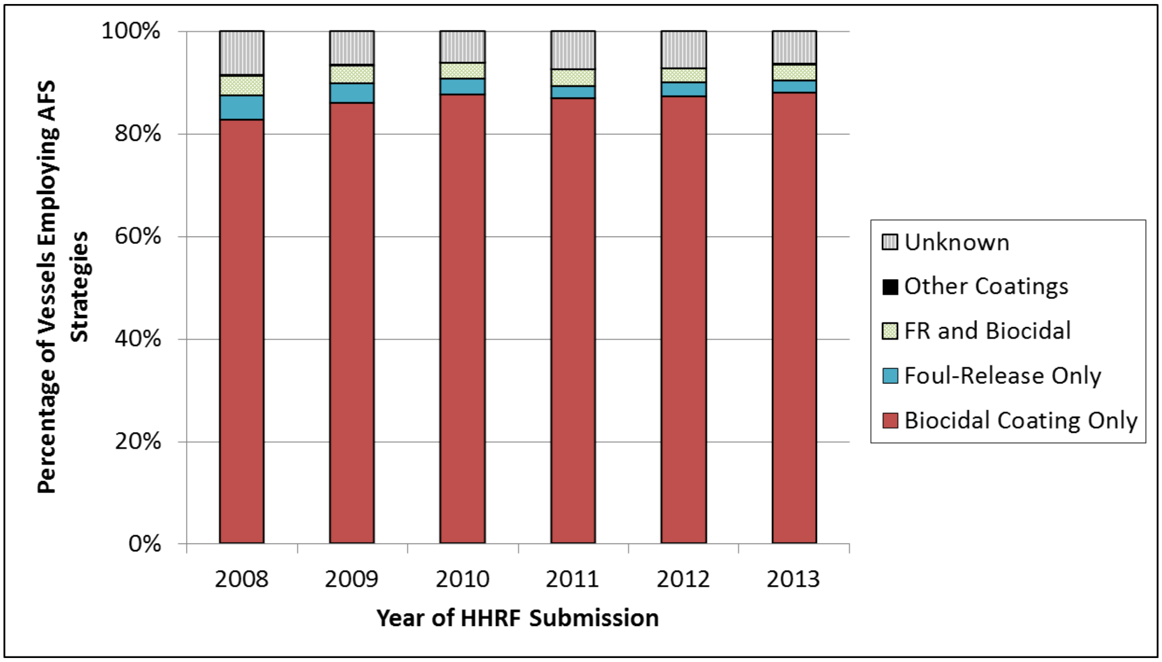

Figure V-21. Antifouling Coating Use for Vessels Operating in California During Each Year from 2008 through 2013. “FR” represents foul-release coatings. “Other coatings” includes the use of hard coatings or surface treated coatings that do not have preventative properties and therefore rely on a dedicated in-water cleaning regime.

<u>In-Water Cleaning</u>

Reactive biofouling management is the removal of biofouling already associated with a vessel, either during a vessel’s out-of-water dry docking or through in-water cleaning.

Reports of vessels undergoing in-water cleaning increased from 7.9% in 2008 to 14.2% in 2013. Bulk vessels, container vessels, and unmanned barges accounted for the majority of reported in-water cleanings (Figure V-22).

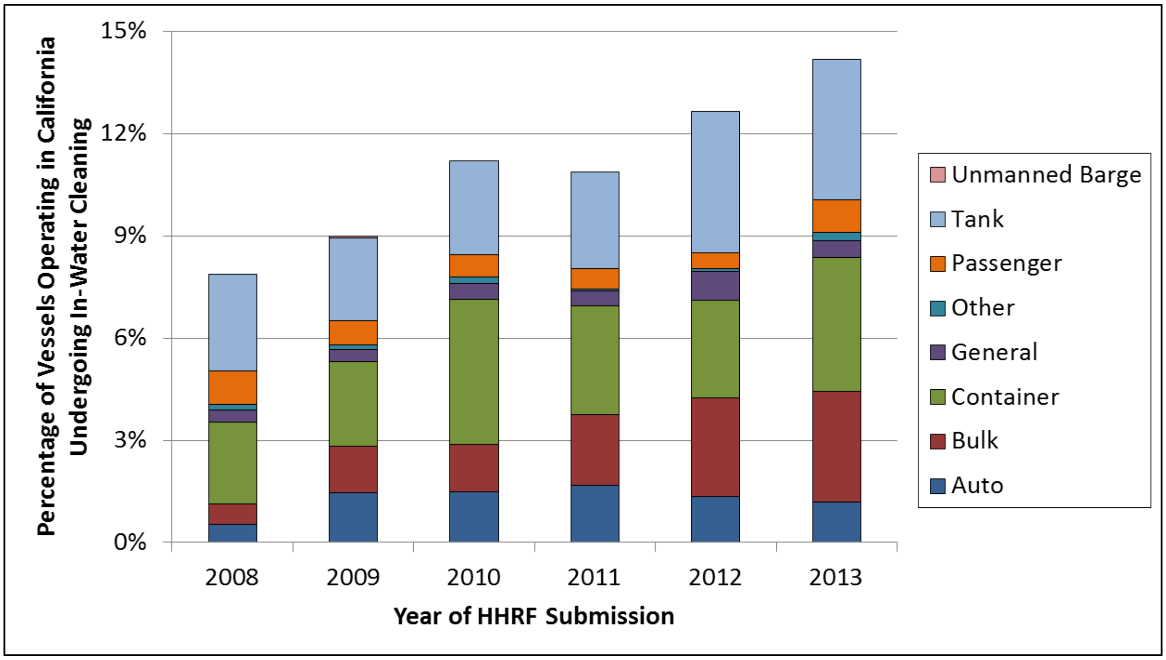

Figure V-22. Percentage of Vessels Undergoing In-Water Cleaning Since Most Recent Dry Docking. Note: This figure represents in-water cleaning that took place in any global port, not just in California.

These in-water cleanings occurred in ports within 40 different countries across the globe. In California, data indicate that between 11 and 20 in-water cleaning actions occur in LA-LB each year; the majority of these cleanings took place on vessels with copper-based or other biocidal coatings (Figure V-23).

It is impossible to determine with existing HHRF data where in the LA-LB region these in-water cleanings are taking place exactly. Anecdotal evidence suggests that in-water cleanings of vessels with biocidal coatings are taking place outside of the ports and outside of state waters to avoid violating existing State Water Board prohibitions on the practice (Barta, R., pers comm. 2014).

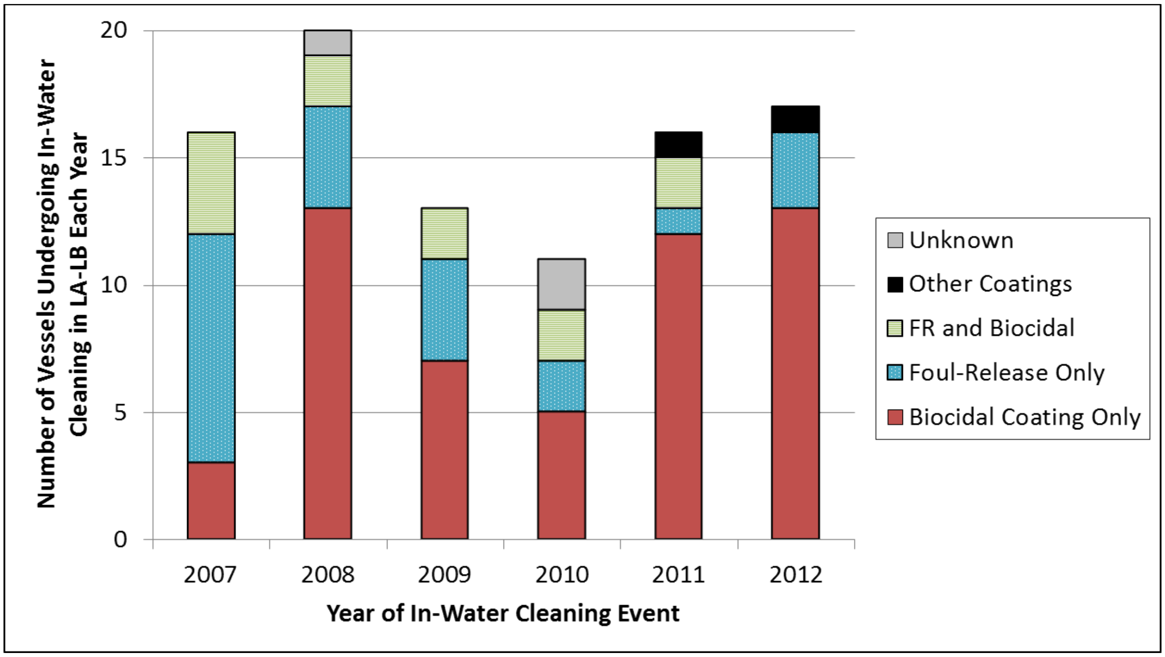

Figure V-23. The Number of Vessels Undergoing In-Water Cleaning In or Around the Ports of Los Angeles and Long Beach Each Year, and the Type of Antifouling Coatings Employed by Those Vessels. In-water cleaning actions occurred between 2007 and 2012, as reported on annual forms submitted between 2008 and 2013. “FR” represents foul-release coatings. “Other coatings” includes the use of hard coatings or surface treated coatings that do not have preventative properties and therefore rely on a dedicated in-water cleaning regime.

Operational Practices of the Commercial Fleet in California

The recent Great Recession (NBER 2010) has altered certain vessel operational practices, especially those that are subject to changes in market demand and the global economy (e.g. activity level and speed). Many of these operational characteristics also influence the extent, diversity, and survivorship of biofouling (Davidson et al. 2008, Floerl and Coutts 2009, Coutts et al. 2010, Hopkins and Forrest 2010).

One of these Great Recession-influenced operational practices is a vessel experiencing a long-term layup or remaining stationary for a prolonged amount of time (i.e. extended residency period). Extended residency periods increase the amount of time that a vessel’s surfaces can be colonized by biofouling organisms and reduce the effectiveness of coatings that are designed to function under a certain amount of water flow.

Newspaper and trade magazine articles have highlighted the increased frequency of long-term layups or extended residency periods. These increased layups and extended residency periods have resulted from drastic recession-induced reductions in consumer spending and the movement of goods through the maritime shipping sector (Bradsher 2009, Pacific Maritime 2009). HHRF data show a similar pattern for vessels operating in California.

There was a 75% increase in the number of residency periods of 10 days or greater between the 2008 (pre-recession period) and 2013 (post-recession period) reporting years (Figure V-24). When looking more closely at the specific durations of these residency periods, the largest increases from 2008 to 2013 were for residency periods:

- Greater than ten and less than 20 days - 70% increase;
- 20 to less than 30 days - 107% increase;
- 30 to less than 45 days - 214% increase; and
- 60 to less than 75 days - 213% increase (Figure V-24).

The increase in the number of extended residency periods, specifically for 20 days or more, may increase the likelihood that these vessels will accumulate extensive and diverse biofouling communities prior to arriving to a California port or place (Floerl and Coutts 2009).

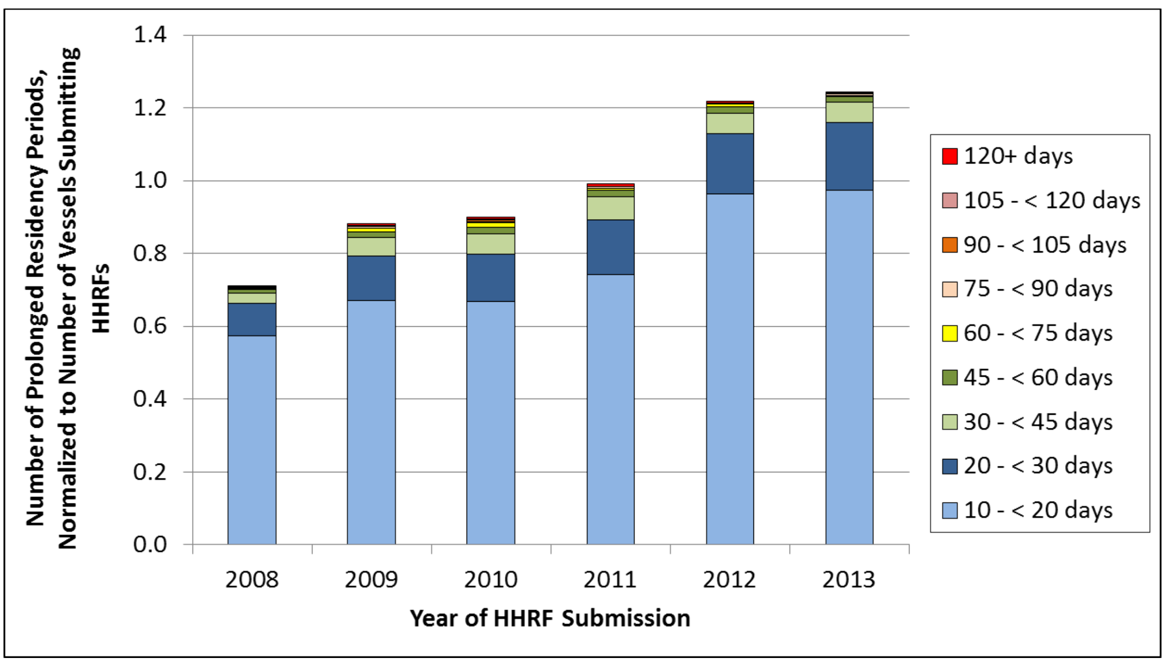

Figure V-24. Number and Duration of Prolonged Residency Periods During Each Reporting Year for Vessels Operating in California. Data are normalized by number of vessels submitting HHRFs each year, to allow for appropriate comparisons between years. Data represent stationary periods occurring since a vessels' most recent dry docking or in-water cleaning.

The increases in residency periods were not distributed evenly across the California fleet; only auto carriers (289% increase), container vessels (131% increase), and tank vessels (59% increase) had an increase of more than 50% from the 2008 – 2013 reporting years (Figure V-25). These three vessel types are driving the overall pattern observed in the entire fleet.

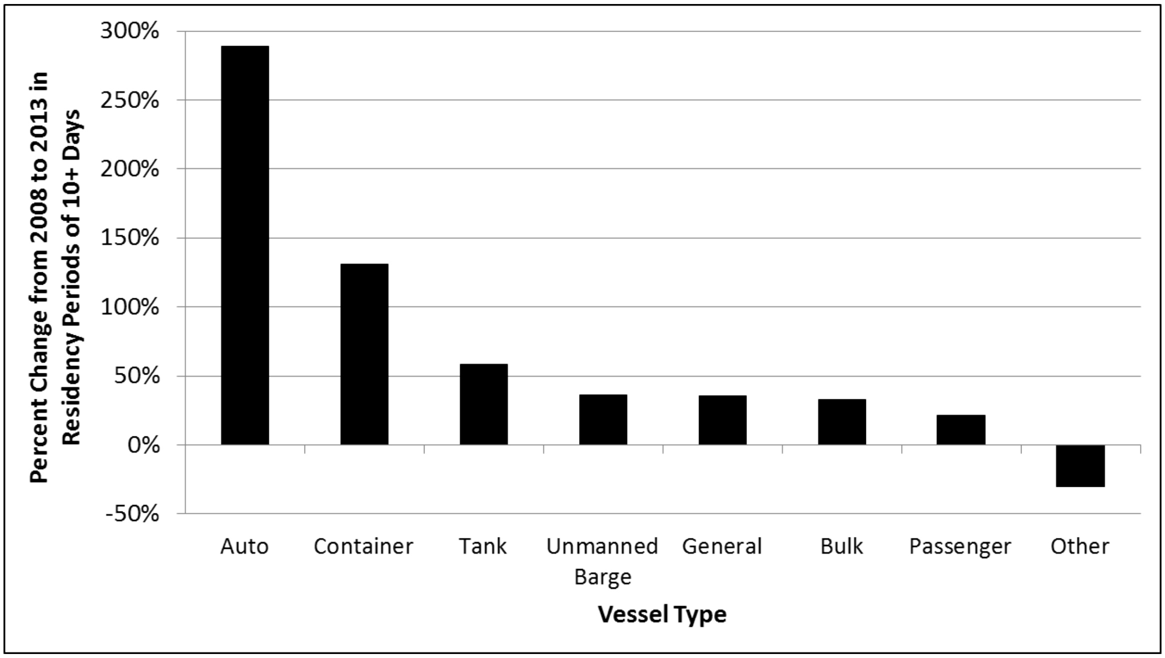

Figure V-25. Percent Change From 2008 to 2013 HHRF Reporting Years in the Number of Prolonged Residency Periods of 10 days or Greater for Each Vessel Type. Data are normalized by number of vessels submitting HHRFs each year to allow for comparisons between years. Data represent stationary periods occurring since a vessels' most recent dry docking or in-water cleaning.

Another consequence of the Great Recession has been a reduction in vessel traveling speeds resulting from vessels implementing "slow steaming" programs to improve fuel efficiency and to keep operating costs down (Kontovas and Psaraftis 2012). Slower vessel traveling speeds result in greater biofouling survivorship when compared to elevated speeds (Davidson et al. 2008, Coutts et al. 2010, Hopkins and Forrest 2010). This increases the risk of vessels arriving to a port with healthy, reproductively competent biofouling communities.

Data from the fleet of vessels operating in California display a pattern of reduced median traveling speeds from a pre-recession high of 16 knots in 2008 to a post-recession low of 13.8 knots in 2013 (Figure V-26).

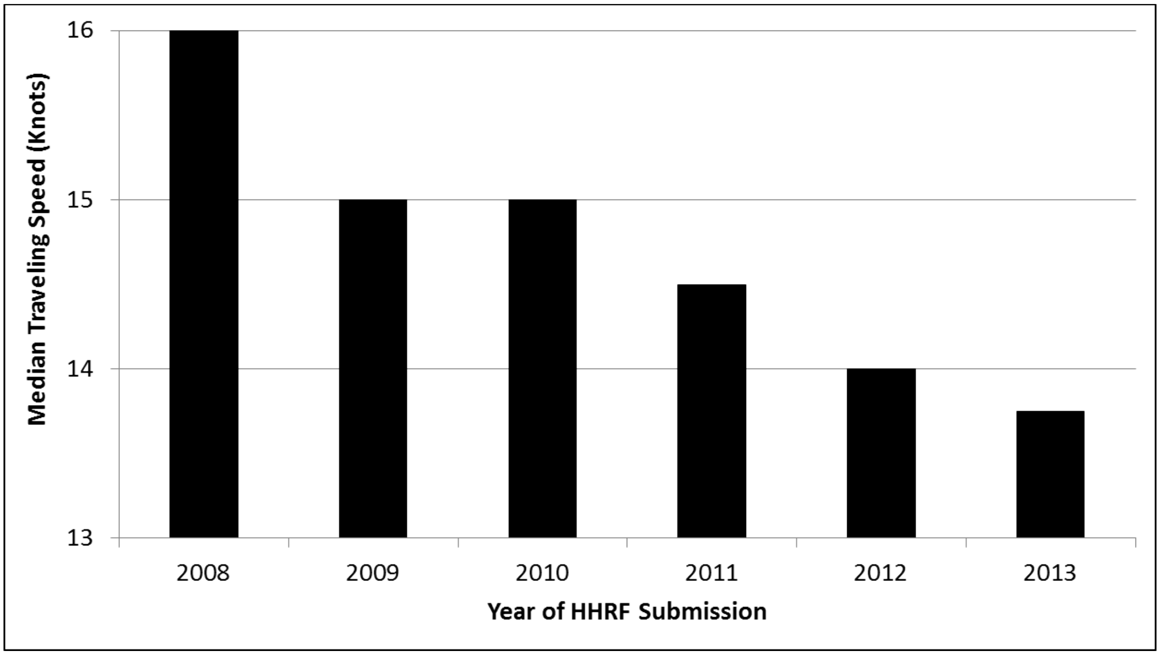

Figure V-26. Median Traveling Speed (knots) of the Vessels Operating in California Each Year from 2008 through 2013.

The HHRF data has shown that the Great Recession has resulted in changes in the operational practices of vessels that trade in California. An increase in the frequency and duration of prolonged stationary periods enhances the possibility that these vessels will accumulate extensive and diverse biofouling communities prior to arrival to California. The overall reduction in traveling speeds increases the likelihood that these biofouling communities will be able to survive the transit between ports and arrive in California in better condition, potentially increasing the risk of NIS establishment in State waters.

VI. COOPERATING AGENCIES: DATA ANALYSIS

Board of Equalization

As stated in Section III, 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 (PRC section 71215).

The BOE receives daily reports from the Marine Exchanges of Southern California and the San Francisco Bay Region listing all arrivals to California ports. Received reports are reviewed to identify qualifying voyages that are subject to the fee under the MISA. Vessel accounts are billed based on the arrival information.

There are currently 5,500 ballast accounts registered with the BOE. On average, 415 vessel billings are mailed per month. The average collection rate is 98% (Table VI-1).

Table VI-1. Summary of Marine Invasive Species Fee Program.

Year	Voyages Billed	Voyages Reported[a]	Total Voyages	Fees Billed	Fees Reported[b]	Total Fees	Payments Recd. for Period[c]
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
2012	4,479	767	5,246	3,807,150	651,950	4,459,100	4,356,722
2013	4,753	819	5,572	4,070,050	696,150	4,766,200	4,662,171
2014[d]	2,485	417	1,421	2,112,250	354,450	1,207,850	2,332,332
TOTAL	77,222	12,915	88,656	42,482,309	7,087,225	48,310,684	48,941,005

[a]Voyages reported are vessel operators/owners that self-report to BOE once a month.
[b]Returns are due at the end of the month following the period of activity.
[c]Actual cash received may exceed amount billed due to penalty and interest charges.
[d]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.

California Department of Fish and Wildlife Marine Invasive Species Program

The California Department of Fish and Wildlife's Marine Invasive Species Program (CDFW-MISP) began a baseline inventory of NIS populations in the State's coastal and estuarine waters under mandate by the Ballast Water Management for Control of Nonindigenous Species Act of 1999. The CDFW-MISP monitors the location and geographic ranges of NIS, to detect new introductions and assess the effectiveness of ballast water controls implemented under current laws and regulations. This monitoring is mandated by the MISA and the Coastal Ecosystems Protection Act.

Monitoring

The NIS monitoring program samples randomly (stratified) selected sites using advanced genetic tools. Monitoring focuses on ten major California estuaries, comparing NIS populations between five estuaries that support commercial shipping and five that do not (see Figure VI-1). Each estuary is sampled once over a seven year period with the exception of San Francisco Bay, which is sampled continuously.

Figure VI-1. Map of CDFW-OSPR NIS Monitoring Sites.

During 2012 and 2013, sites were sampled in San Francisco, San Diego, Bodega/Tomales, Morro, and Mission Bays. Multiple habitats and organism types were sampled: the hard-substrate (i.e. rocky) invertebrate community (epifauna), soft-sediment (i.e. sand, mud) invertebrate community (infaunal), and plankton in the water column. The epifauna was sampled using PVC settling plates set at ten sites per estuary over a three-month period.

Identification/verification of species and preliminary data analysis are proceeding. Surveys of LA-LB harbors, Humboldt Bay, Newport Bay, Port Hueneme, and Marina del Rey will take place between 2015 and 2017.

Previous MISP surveys of California's outer coast in 2004 and 2007 detected few NIS; however, some unpublished data suggest that estuary discharges may contribute propagules to adjacent outer coast sites. To test this hypothesis, the CDFW-MISP is planning a pilot study at one outer coast location adjacent to San Francisco Bay, with hopes for future monitoring across a broader scale of estuarine-influenced waters.

Relocation of the California Database

The CDFW-MISP must maintain an online inventory of NIS in California (PRC §71211). In response, the California Aquatic Non-native Organism Database (CANOD) was developed. In mid-2015, CANOD will be merged with the National Exotic Marine and Estuarine Species Information System (NEMESIS), a web-based database maintained by the Smithsonian Environmental Research Center (SERC). This merger will result in a larger, centralized database, with fully-vetted information and long-term technical support. All current data will be available to the public, but individual species profiles will be enhanced by photographs, invasion history (distribution and occurrences), ecology, impacts, and interactive maps. CANOD and NEMESIS data for California NIS will be synchronized after an extensive review by CDFW and SERC staff.

Settling Plate/Molecular Detection Pilot Study Results

Final reports on a two-year pilot study to compare methods of species identification were recently completed by SERC and the California State University System's Moss Landing Marine Laboratories (MLML). The reports discuss the development of an integrated genetic and morphology-based system of species identification for future monitoring projects.

Specimens collected during the study were used to compare two methods of species identification, one based on examination of physical attributes of the organism (morphology) and one based on genetics (i.e. DNA). Further evaluations were made using genetics to detect cryptic species (species not detected using traditional identification methods).

Survey data indicate that estimates of the numbers of different NIS can be obtained for fouling invertebrates by sampling with settling plates. Genetically-analyzed plankton samples also effectively detected many of the species found on settling plates, indicating that regular plankton sampling with genetic analysis could be part of a cost-effective strategy for detection of NIS with planktonic life cycles. DNA analysis also found many organisms that were previously suspected or determined to be cryptic species.

Overall, genetic analysis out-performed morphologically-sorted analysis for settling plates and plankton analysis. Going forward, an integrated genetic and morphology-based system of identification could be more rapid and accurate, and less costly, for continued monitoring.

A journal article based on the work done for the MISP Molecular Detection Pilot Study was published in 2013 (see Geller et al. 2013). The paper describes laboratory methods for the replication of DNA for a diverse assemblage of organisms contained in a single sample.

CDFW-MISP Triennial Report to the Legislature

Biological monitoring activities of the CDFW-MISP for the period July 1, 2011 through June 2014 were documented in the third triennial report to the California Legislature, which was submitted in December 2014. The report is available on the CDFW-MISP website.

VII. COLLABORATIVE AND FUNDED RESEARCH

The purpose of the MISP is, "to move the state expeditiously toward elimination of the discharge of nonindigenous species into the waters of the state" (PRC § 71201). The MISP advances this goal through a comprehensive multi-pronged approach to vessel vector management including funding and coordination of research that advances the development of strategies to prevent the introduction of NIS from ballast water and vessel biofouling. Specifically, PRC § 71213 requires 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 . . . ."*

To advance the goals of the MISP, the Commission has funded specific research addressing many of the NIS-related issues. This includes 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.

Ballast Water Research

As the implementation of the California ballast water performance standards draws near, the Commission has funded research investigating the development of compliance assessment technologies and potential contingencies to shipboard ballast water treatment systems. Recently funded research is/has been conducted or managed by: the Moss Landing Marine Laboratories (MLML), the Glosten Associates, the Delta Stewardship Council (DSC), and the California Maritime Academy (CMA). The research includes four separate projects: 1) development of a rapid compliance assessment method; 2) development of a full-scale ballast water discharge sampling tool; 3) a feasibility study of shore-based ballast water treatment; and 4) development of an emergency, portable ballast water treatment system. Commission staff are also comparing available indicative treatment methods for potential use by Commission Field Operations staff. A brief discussion of each of these studies is presented below.

Moss Landing Marine Laboratories (MLML) - Bulk Plankton Viability Assay
In 2010, the Commission approved funding to support research by Dr. Nicholas Welschmeyer from the MLML for the development of a rapid, bulk assay for plankton viability.

The goal of this research is to develop a simple, rapid, and reliable method to assess shipboard ballast water treatment system performance by detecting gross exceedance of the California performance standards. The method uses a fluorescent marker for living cell activity.

Initial validation tests were performed in the summer of 2010 on discharge from a ballast water treatment system being evaluated at the Golden Bear Facility (one of only four worldwide USCG-approved ballast water treatment system testing facilities, based out of the CMA in Vallejo, CA). The prototype 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.

While this test kit remains in the development phase, the Commission's Marine Invasive Species Program scientists tested a unit based on similar technology in the field during spring 2014 and presented their results at the annual Pacific Ballast Water Group meeting in Portland, OR. Further testing on vessels actively using ballast water treatment systems will be conducted by Commission staff in 2015.

The Glosten Associates – Ballast Water Sampling Tool
The Commission funded The Glosten Associates (Glosten) in 2011 to develop a ballast water sampling tool. This tool would be used for monitoring vessel discharge compliance with relevant performance standards and would provide real-time feedback on the performance of a shipboard ballast water treatment system.

The initial phase of the project included a feasibility study to select an approach and design to monitor compliance. In early 2012, as part of the project's second phase, Glosten presented Commission staff with a concept design, analysis of fluid dynamics, component specifications, and estimated construction costs for the prototype sampling tool.

The third and final phase of the project was completed in February 2014 and included full-scale component testing, biological testing, and a fabrication cost report. Samples collected using the Glosten prototype sampling tool were highly comparable with Golden Bear Facility sampling. Organism counts for both zooplankton and phytoplankton showed no significant difference in biological makeup between the two sample sets.

The final results show the Glosten system to be effective at providing representative samples of ballast water. The tool is currently geared toward evaluating vessel compliance to the IMO/U.S. Federal discharge standards, but with additional development may be a useful tool for California's ballast water performance standards compliance testing.

Despite these initial successes, issues remain to be addressed in future versions of the sampling tool. First, as currently designed, the sampling tool requires a four inch diameter sampling port to be present at some point along the ballast water discharge piping downstream of the ballast water treatment system. While most ballast water treatment system installations add a port to allow for ballast water sampling, there is no requirement that the port be four inches in diameter. Therefore, it is necessary to build some adaptability into the tool's ability to pull samples from different sized sample ports.

Second, as currently configured, the ballast water sampling tool consists of five separate pieces, each of which weighs between 50-100lbs. On most vessels, the ballast water piping is only accessed in the engine room, which is usually down several flights of narrow, often steep stairs. The accessible area around the ballast water piping on vessels is often very limited. These factors combined will require the final ballast water sampling tool be reduced as much as possible in both size and weight. Glosten is currently investigating ways to address both of these issues.

The Delta Stewardship Council – Shore-Based Ballast Water Treatment Feasibility Study

Per PRC section 71204.3, vessels may comply with California's pending ballast water performance standards by discharging ballast to a shore-based reception facility. However, there are no shore-based facilities in California or the United States that are designated to treat nonindigenous species in ballast water. Previous research on the feasibility of shore-based ballast water treatment has found encouraging potential for such facilities to manage ballast water. Unfortunately, these studies have been limited in scope, generally focusing on only one port or place or containing only a coarse level of analysis.

The Commission determined that the information gap regarding shore-based ballast water treatment in California must be addressed and in June 2013, approved funding for a feasibility study to investigate the use of shore-based treatment and reception facilities to enable vessels to comply with the California performance standards.

Given the scope of the issue and the importance of the findings to the regulated community and concerned stakeholders, it was recommended that the study be managed by an independent, third party. The Commission approved the DSC, a state agency with a strong focus on independent scientific review, to manage the study.

In 2014, the DSC released the Request for Proposals, and subsequently conducted interviews and evaluations of potential contractors. The winning contractor was announced in August 2014. The Commission approved the budget of the selected contractor on December 17, 2014. A final report is expected in late 2015.

California Maritime Academy – Ballast Responder

In 2014, the Commission provided funds to the California Maritime Academy to evaluate a portable ballast water treatment technology that could be used by a vessel to manage ballast water in emergency or contingency situations (e.g. equipment failure). The "Ballast Responder" was developed by the U.S. Geological Survey, the National Park Service, and the Glosten Associates. The device uses a three-step process to kill organisms in ballast tanks:

1. A mixing device is lowered into a ballast tank;
2. An active substance (e.g. sodium hypochlorite) is added to the ballast tank being mixed; and
3. A neutralizing agent is added to render the treated ballast water safe for discharge to local waters.

The study involves lab-scale biological testing to verify the required active substance dosage and full-scale biological testing to assess system efficacy relative to the IMO/U.S. Federal discharge standards. The study is due to be complete by July 2016.

Indicative Tests of Ballast Water Treatment System Performance

There is a need to develop and test compliance assessment tools that will measure compliance with ballast water discharge standards. Several companies have recently developed indicative testing tools geared towards measuring gross exceedance of the IMO/U.S. Federal discharge standard for the 10-50µm organism size class.

These indicative testing tools are hand-held, fast and simple to use, requiring minimal training of the potential end users. The tools provide a predictive "red light-green light" relative to a discharge standard (note: most of these tools are being developed for the U.S. federal or international standards, not the California standards). If a tested sample gets a "green light," the concentration of organisms in the vessel's ballast water is not grossly exceeding the discharge standard. If the sample gets a "red light," the discharge standard is likely exceeded and additional sampling would be needed to verify non-compliance and proceed with enforcement.

In early 2014, MISP staff were loaned indicative testing tools from three different manufacturers. MISP staff sampled the ballast tanks of eight vessels and ran parallel analyses of the water with the three indicative tools. In addition, staff performed cell counts using an epifluorescence microscope in order to compare the results of the indicative tools to the actual counts of phytoplankton (single-cell algae) in the samples.

While the overall results were encouraging, increased sensitivity for measuring cell counts in low concentrations is still needed to confidently determine if a ballast water discharge is within an allowable gross exceedance level of compliance. More testing is planned for 2015, with the goal of sampling vessels actively using ballast water treatment systems.

These results were presented at the 2014 Pacific Ballast Water Group meeting and also shared with the tool manufacturers.

Vessel Biofouling Research

During the past two years, the Commission has actively evaluated the risk of vessel biofouling-mediated NIS introductions into California through funding and collaborating on targeted research. This research has been a collaboration between the Aquatic Bioinvasions Research and Policy Institute (ABRPI), the Smithsonian Environmental Research Center (SERC), and Commission staff, and includes two related projects: 1) a Commission-funded study that has been completed; and 2) a U.S. Maritime Administration (MARAD)-funded study that is currently being investigated.

Evaluating Ship Biofouling and Emerging Regulatory Policies
This study (Davidson et al. 2014b) characterizes biofouling extent and viability on commercial vessels while also evaluating options for implementing the Commission's developing biofouling management regulations (see Section III).

The authors sampled nine vessels, and the data were added to a dataset of previously sampled vessels (total of 59 vessels) to evaluate the influence of vessel practices on biofouling accumulation. The study builds upon previous Commission-funded work by increasing the number of vessels sampled to better understand the influence of vessel maintenance and operational practices on biofouling extent and condition.

One-third of the identified species on these vessels were either NIS or cryptogenic (with uncertain origin) in California; several of these NIS are not yet established in California, presenting a clear cause for concern.

The authors found a correlation between freshwater port visits and a decrease in biofouling. This result suggests that the effect of freshwater on marine biofouling organisms may reduce the likelihood that a vessel arriving to a California port directly after transiting the Panama Canal or visiting ports within the Columbia River System will have a healthy, robust biofouling community associated with it.

This study also assessed the usefulness of emerging methods for evaluating biofouling extent, and the appropriateness of these methods for inspection and enforcement purposes. One of the methods employed during this study evaluated biofouling extent within "sub-niche" areas. For example, rather than sampling a vessel's bow thruster as one entire niche area, this approach would involve the sampling of the thruster grating, thruster edge, thruster tunnel, and thruster assembly separately. Biofouling is expected to accumulate differently within each of these sub-niches because they all have unique shapes and varying directional orientations. This novel approach allows for a better understanding of the variability within a given niche area and will allow for better targeted inspections in the future.

This study also included an evaluation of heavily fouled waterlines as an indicator of potential biofouling on other underwater vessel surfaces. This rapid assessment of the waterline, along with a detailed review of a vessel's required documents may be an effective indicator for a more thorough underwater inspection.

This study increases the knowledge of the factors influencing biofouling accumulation on vessels and provides a better understanding of the sources of variation in traditional evaluations of biofouling in niche areas. The study also provides useful insight into potential tools that may be used to implement biofouling regulatory policies in California and across the globe.

Evaluating Emerging Regulatory Policies for Reducing Biofouling-Mediated Incursions
This study tested novel methods and sampling designs to maximize the efficiency, accuracy, and precision of vessel biofouling measurements. This study, while funded by the U.S. Maritime Administration, is an extension and continuation of collaborative work conducted in California by SERC and Commission staff (see Davidson et al. 2014b).

The specific goals of this research are similar to the goals of Davidson et al. (2014b) and include: measuring percentage cover, composition, and diversity of biofouling on internationally traveling vessels; comparing these biofouling measurements to vessel operational histories; and evaluating new methods for measuring biofouling extent. This study will also include several new components, including an evaluation of biofilm (i.e. films of bacteria and single-celled algae) composition using molecular techniques, and the use of advanced camera equipment to create composite (stitched) whole niche area images to help advance methods of analysis. This study is expected to be completed in 2015.

VIII. REVIEW OF CURRENT VESSEL VECTOR RESEARCH

MISP biennial reports are required to include a summary of ongoing research on vessel vectors of NIS (PRC Section 71212(e)). This section summarizes selected peer-reviewed journal articles published between July 2012 and June 2014 that examine the release of NIS via ballast water and vessel biofouling.

Vessel Vector Research

Ruiz et al. (2013) examined the impact of commercial shipping on the geographic distribution of NIS in sixteen bays in the United States. The study explored the relationship between the number of NIS present in a bay with shipping activity over time (i.e. number of vessel arrivals and volume of ballast water discharge). The authors found that the number of NIS is significantly greater for Pacific Coast bays, including California's largest bays, than Atlantic and Gulf Coast bays. San Francisco Bay has over 200 documented NIS, more than twice the number of NIS found in any other bay in this study.

Overall, the authors were not able to show a clear relationship between the number of NIS in these 16 bays and shipping activity (using data from 2005-2007). Therefore, the authors concluded that vessel arrivals and ballast water discharge volume, by themselves, should not be used to estimate the number of NIS potentially being released to these bays. Additional research is necessary to directly measure supply of organisms from ships and to establish a relationship between the method of delivery (i.e. ballast water vs. biofouling) and the risk of species introduction and establishment.

Seebens et al. (2013) used a model to identify high-risk invasion routes, hot spots of bioinvasions, and major NIS source regions. Invasion risk was evaluated through the examination of global shipping routes, ballast water discharge, environmental matching of the source and destination port, reported invasion events, and biogeographic dissimilarities.

The authors determined that the northeast Pacific, including the coastal waters of California, is characterized by high invasion risk and receives species mainly from the northwest Pacific, which includes the coastal waters of countries in eastern Asia. Understanding invasion and vessel traffic patterns in conjunction with the use of effective multi-variable models can allow development of targeted, effective NIS management methods.

The risk of species introductions is expected to change as routes and operations of vessels change. For example, Miller and Ruiz (2014) found that the reduction of Arctic sea-ice coverage due to global climate change has led to a rapid increase in trans-Arctic shipping traffic through the northern sea route. According to the authors, there will be a shift in global shipping routes as more vessels choose to use the northern sea route. This shift may result in an alteration of current marine invasion dynamics.

Ballast Water Research

The Challenges of Collecting Ballast Water Samples

As the implementation of California's ballast water discharge standards approach, Commission staff is working on developing protocols to assess vessel compliance. However, developing protocols is challenging due to difficulties in obtaining samples that represent the contents of the ballast water tanks.

Carney et al. (2013) conducted a small-scale experiment to determine limiting factors in obtaining representative ballast water samples. The authors added a known cell density of a green algae species to storage tanks and measured the density at different times during the discharge event. The authors found that with decreasing sampling frequency, the accuracy of sampling results decreased due to heterogeneous distribution (i.e. clumping) of organisms in the ballast tanks.

Frazier et al. (2013) explored statistical issues associated with collecting representative ballast water tank samples and sampling at low organism concentrations. Biological organisms tend to aggregate, and this behavior could lead to a non-random distribution. Distribution of organisms in the ballast water tanks affects their distribution during discharge. Similar to Carney et al. (2013), Frazier et al. discuss the importance of sampling at different frequencies to obtain a representative sample. The study concluded that subsampling frequently during a ballast water discharge can provide a more representative sample than collecting larger, infrequent samples.

Organism distribution in ballast water tanks was also the focus of First et al. (2013). The authors found that organism distribution in ballast tanks can vary due to vertical migration of mobile organisms. First et al. collected ballast water samples over time and counted the organisms within each sample. The results indicated that fewer organisms were detected per sample in the beginning of the discharge, compared to the end of the discharge. The authors explained that these differences in concentration can be due to vertical migration of the organisms and to particle settlement in the water. They further clarified that as particles settle, the organisms that are attached to them will also settle, changing the overall distribution of organisms in the tanks. The authors also suggest that collection of subsamples evenly spaced over time during discharge may produce more representative samples of the concentration of organisms in a ballast water tank.

Emerging Issues Related to Ballast Water Treatment

<u>Comparing Treatment Methods</u>
Studies that evaluate the effects of different treatments on organisms carried in ballast water are necessary to develop effective ballast water treatment systems that can be used to protect marine environments from NIS introductions.

First and Drake (2014) examined the effects of ultraviolet (UV) light and chlorine dioxide on ambient microorganisms. They determined treatment method differentially affects organisms within organism size classes. They suggested that this topic needs to be studied in more detail to determine if one organism size class can be used as an indicator of treatment effects on others.

Zhang et al. (2014) compared the effectiveness of ultraviolet radiation (UV) plus titanium dioxide (TiO_2) treatment versus UV-only. They determined that the density of organisms after using UV/ TiO_2 treatment is significantly lower compared to UV treatment alone.

<u>Ballast Water Treatment in Freshwater</u>
There is a concern that existing treatment systems may not be able to operate reliably in fresh water (U.S. EPA 2010, NRC 2011). Ballast water exchange provides a high level of protection against NIS introductions from/to fresh water ports due to organism mortality resulting from salinity shock. Absent the salinity shock from exchange, any freshwater organisms that remain after ballast water treatment could directly invade freshwater habitats upon discharge. Potential ineffectiveness of ballast water treatment systems in fresh water could increase the risk of NIS introductions in California's freshwater ports of Stockton and Sacramento.

To increase the level of environmental protection for freshwater ports, Briski et al. (2013) examined the biological efficacy of ballast water treatment plus exchange. In addition to treating the organisms before release into the receiving environment, the organisms will also have to cope with the stress of salinity shock associated with ballast water exchange.

Their results show that ballast water treatment in combination with ballast water exchange reduced the abundance of select organism classes (i.e. organisms greater than 50 micrometer (µm), 10 to 50µm, and heterotrophic bacteria) significantly compared to ballast water treatment alone. The authors conclude that ballast water treatment in combination with ballast water exchange would reduce the risk of NIS introductions.

Biofouling Research

Studies published during the reporting period have evaluated the risk of introducing NIS through biofouling. These studies focus on the presence and composition of biofouling assemblages and the factors that influence biofouling accumulation and survival.

Chapman et al. (2013) studied the accumulation of two species of barnacles and one species of oyster on the research vessel *Oceanus*. Based on the observed size structure of the populations, the authors were able to estimate when the organisms had originally attached to the vessel (i.e. settlement). The authors were then able to take these settlement timing calculations and compare them with the working history of the vessel (since its last dry dock) to determine where settlement had occurred.

Their results indicate that settlement for one barnacle species (*Balanus trigonus*) had occurred in every tropical port visited by the vessel. In addition, this barnacle species demonstrated resilience, as some survived several winters in Woods Hole, MA. The same species was also able to tolerate passage through freshwater in the Panama Canal.

The findings of Chapman et al. (2013) indicate that every vessel port call poses a risk for biofouling species attachment to a vessel. These biofouling species may be able to survive in a variety of environmental conditions, thereby enabling their continuous global transport.

Factors that Influence Biofouling Accumulation

McDonald et al. (2014) examined if fishing vessel generator noise influences biofouling settlement. The authors found a relationship between the spatial patterns of biofouling and the intensity and frequency of the noise generated by fishing vessels. In the laboratory component of this study, the authors released larvae, exposed them to vessel generator noise, and observed their settlement, metamorphosis, and survival. They found that settlement and metamorphosis happen significantly faster when the larvae are exposed to generator noise, and overall survival also significantly increased in these treatments.

A study by Stanley et al. (2014) examined the effects of commercial vessel noise as a cue for biofouling settlement. Stanley et al. found that noise generated by car/passenger ferries influenced the settlement behavior of biofouling species. They recorded the noise from a ferry and exposed panels (with attached biofouling organisms) to that noise, while keeping control panels in a noise free environment.

There was a significantly higher number of biofouling species attached to panels exposed to the noise when compared to the control panels, which were not exposed to the vessel generated noise. The findings by both McDonald et al. (2014) and Stanley et al. (2014) indicate that noise could be a significant factor influencing biofouling accumulation. These results may indicate an added benefit (i.e. reduced biofouling settlement cues) of a recent shift at many ports around the globe to implement shore-side power in lieu of vessel engines while at berth.

Dobretsov et al. (2013) investigated the effect of substratum color on the formation of macrofouling (i.e. large visible organisms) and microfouling (e.g. microscopic bacteria and algae) communities. The authors painted acrylic tiles either black or white and all tiles were covered by a transparent surface to maintain a consistent attachment surface. Dobretsov et al. observed higher densities of both macro- and microfouling on the black tiles. The high density of macrofouling on black tiles persisted for up to 30 days, but the effect of the color diminished after that. As a result, the authors concluded that over long-term time periods, color should have no significant effect on biofouling communities.

Ralson and Swain (2014) examined the effect of previous biofouling communities affect the settlement of new biofouling organisms. Settlement panels were painted with a silicone coating and deployed in the water for four months at three sites in Florida. After an initial period, the panels were cleaned and redeployed at a different location. Ralson and Swain found that the original biofouling community did affect the colonization by new biofouling species. These effects were observed for up to 14 months after transplantation. The authors discussed that the original biofouling organisms may have left biochemical cues that facilitate new biofouling settlement. In addition, they discussed that the silicone may have been imbued with these cues. Future studies will focus on the development of anti-fouling technologies that use organism chemical signatures to deter biofouling settlement.

Biofouling Associated with Sea Chests

Frey et al. (2014) examined the types and abundance of biofouling organisms found in 82 sea chests sampled from 39 commercial vessels arriving to ports on Canada's east and west coasts. The authors also investigated the influence of voyage history and vessel characteristics on the biofouling community found in these sea chests. They found that 80% of the surveyed vessels showed evidence of sea chest biofouling, and 46% included at least one NIS. Frey et al. also found that factors such as time since last cleaning and previous port calls could influence the extent of biofouling in sea chests. Their research highlights the role of sea chests as biofouling hot spots on vessels, and the need to actively manage biofouling within these niche areas.

Piola and Hopkins (2012) examined the use of heated seawater to treat biofouling in sea chests. The authors performed laboratory trials and replica sea chest trials on a floating pontoon. The results from the laboratory trials show that 100% mortality was achieved for most taxa examined during all temperature/duration regimes. However, the authors were not able to achieve even heat distribution during the field trials, leading to non-uniform mortality. This study shows that heated seawater can be a successful treatment for biofouling, but more effective application methods need to be developed.

The Effect of Anti-Fouling Coatings on Biofouling Accumulation

Zargiel and Swain (2014) observed the effects of dynamic (i.e. with constant movement) versus static (i.e. stationary) immersion on the settlement of diatoms on different coatings. According to the authors, it is important to test dynamic settlement because it more accurately represents the conditions that biofouling communities encounter onboard vessels.

Zargiel and Swain used six different coatings for this experiment: one biocidal anti-fouling coating, four fouling-release coatings, and one standard surface (epoxy). The authors observed differences in community composition between the static and dynamic conditions and that diatom adhesion was significantly different among coatings. The standard surface epoxy had the highest adhesion values while the fouling-release coatings had the lowest adhesion values. These findings indicate that fouling-release coatings may be the most effective in deterring diatom settlement on ship hulls.

A study by Earley et al. (2014) looked at the leaching rates of copper from two recreational vessel anti-fouling coatings containing cuprous oxide as an active biocide. The authors discovered that for both coatings, the leaching rate peaked on the third day after deployment in the water.

The authors also simulated in-water cleaning techniques to examine copper release into the environment. They used two methods for recreational vessel cleaning - one representing the Best Management Practice and the other representing non- Best Management Practice. When panels were cleaned, the concentration of copper leaching into the environment increased and peaked approximately three days post cleaning. The use of Best Management Practices resulted in one-third less copper leached, on average. This study underlines the potential release of copper into the marine environment during in-water cleaning, and may influence the development of future in-water cleaning regulations.

Woods et al. (2012) evaluated the viability of removed biofouling organisms after in-water and out-of-water cleaning. Though the authors tested cleaning methods used by recreational vessel owners, the NIS introduction considerations are similar to commercial vessel cleaning operations. The authors reported survival rates and viability of soft-bodied organisms that was significantly greater for in-water cleaning than for out-of-water cleaning. The greater survivorship and viability associated with in-water cleaning underscores the necessity of collection and treatment of removed debris during in-water cleaning actions. These results also support Commission staff's collaborative efforts with other stakeholders to discuss in-water cleaning organism collection methods and technologies for use in California. (For more information on in-water cleaning, see Section IV. Emerging Issues).

Other Technical Reports (non-peer reviewed)
In many jurisdictions, in-water cleaning has been restricted or prohibited because of the potential release of chemical contaminants (i.e. biocides) from the vessel's anti-fouling coatings and the potential release of NIS if the removed organisms are not contained. There are clearly environmental risks and benefits resulting from the practice of in-water cleaning.

Morrisey et al. (2013) investigated the balance between these risks and benefits to identify situations where in-water cleaning should be allowed in New Zealand. The authors assessed water quality concerns by predicting copper concentrations released during in-water cleaning and comparing these with U.S., New Zealand, and Australian water quality guidelines. The biological risks were estimated using the judgment of subject matter experts informed by a review of relevant literature.

The authors found that the acceptability of in-water cleaning risks was dependent on factors such as vessel type, level and type of biofouling, location, and cleaning frequency. Decision-making tools were developed for various scenarios. One general finding was that the risk of NIS introduction was too great for vessels with biofouling extent greater than 15 percent cover; in-water cleaning was deemed unacceptable in these cases. The authors suggested several mitigation measures to employ when in-water cleaning posed an unacceptable risk. These measures include removing the vessel from the water to be cleaned, have the vessel's visit reduced to less than 48 hours, or refusal of entry altogether.

IX. NEXT STEPS IN VESSEL VECTOR MANAGEMENT

The data from vessel-submitted reporting forms, augmented by Commission-funded research, have strengthened the knowledge and ability of the Commission to prevent NIS introductions. The Commission has summarized this information in reports to the Legislature leading to new legislation and increased agency responsibilities.

The following section highlights challenges and information gaps that need to be addressed over the next two years in order for the Commission, together with MISP sister agencies, to fulfill new legislative directives and to continue to “move the state expeditiously toward elimination of the discharge of nonindigenous species into the waters of the state.”

Ballast Water Management

The California ballast water performance standards are discharge standards, therefore it is essential that staff collects ballast water samples upon discharge from ships to assess compliance with the California performance standards. Therefore, in 2012 Commission staff developed ballast water sample collection and evaluation protocols. These protocols were developed in consultation with a Technical Advisory Group of scientists specializing in ballast water issues, state and federal ballast water regulators, and representatives from the shipping industry and non-governmental environmental groups. In 2013, at the direction of the Commission, staff distributed the proposed collection protocols to an additional panel of scientists for independent scientific review. Feedback of the collection protocols was largely positive, and staff is currently reviewing and updating the protocols to incorporate the comments received.

Worldwide, there is little sampling being done to assess the performance of ballast water treatment systems installed and in use on vessels in “real world” operational situations. The bulk of current sampling and testing being conducted occurs either in land-based or ship-board facilities in highly controlled environments as part of the type-approval process. Although many ballast water treatment systems have been type approved for use under the International Maritime Organization’s Ballast Water Management Convention, the Convention is not yet ratified. Therefore, no countries have begun collecting compliance assessment data. As a result, there is currently little follow-up once a ballast water treatment system is type-approved to ensure that systems continue to operate as originally tested while under the highly varied conditions of normal vessel operations.

There is a need to collect samples from vessels actively using shipboard ballast water treatment systems in order to understand how these systems are performing under normal vessel operations. Commission staff will begin working with shipping companies in 2015 to: 1) collect data on the efficacy of shipboard ballast water treatment systems currently in use; and 2) assess the performance of Commission staff's draft sample collection and evaluation protocols.

Commission staff will reach out to vessel owners to participate in the research and work with analytical labs and university researchers to process the samples. This research should provide essential information regarding the effectiveness of the collection protocols and provide transparency to stakeholders and interested parties.

Biofouling Management

Identify factors to prioritize resources in assessing compliance with proposed biofouling management regulations
As the Commission moves towards adopting and implementing biofouling management regulations, staff will need to develop a weighted risk assessment matrix to categorize high priority vessels for inspection and outreach. This approach will enable staff to focus limited resources on the inspection of vessels that represent the greatest perceived risk of NIS introduction. A key step in creating this matrix is determining which vessel maintenance and operational practices to include for predicting a high risk/priority vessel. Commission staff continues to work with regulatory partners in New Zealand and Australia in the process of implementing new biofouling management policies to identify factors to include in these pre-arrival risk assessments.

Develop Biofouling Compliance Assessment Protocols
Commission staff will need to assess compliance with biofouling management regulations, and will need a transparent set of underwater protocols to carry out inspections if a shipboard document review and preliminary inspection indicate potential noncompliance. Developing a standardized approach for underwater inspection will enable better regulatory enforcement and will allow the regulated industry to utilize the same methods to determine their likelihood of compliance. Commission staff will consult with a biofouling Technical Advisory Group to develop these protocols, and will test them on vessels operating in California in order to determine their effectiveness. These protocols will be adopted through the California rulemaking process prior to implementation.

Determining the efficacy of biofouling management technologies
Commission staff will continue collaborating with regional and international partners to evaluate the efficacy of existing (e.g. Marine Growth Prevention Systems) and emerging biofouling management tools (e.g. in-water cleaning technologies with recapture/treatment ability). These management tools are likely to play a large role in a

vessel's comprehensive biofouling management strategy. Understating how well these tools perform on a variety of vessel types and for a variety of operational profiles will be critical to the Commission's efforts to implement policies to reduce the risk of biofouling-mediated introductions of NIS.

Comprehensive Vector Management

Ballast water and biofouling are two sub-vectors associated with commercial shipping. Commission staff is moving forward with specific actions (above) to manage risks associated with biofouling and ballast water, but it is also necessary to take a step back and ensure that vessel vector management is comprehensive to reduce species introductions to California waters.

One of the mechanisms that could be used to identify and correct NIS management gaps is Hazard Analysis and Critical Control Point (HACCP) planning. HACCP is a five-step process used to reduce the risk of unwanted hazards from occurring. The HACCP process examines activities to determine if a hazard may occur. For activities that require interaction with the natural environment, a potential hazard is the unintentional movement of organisms, which after becoming established, may impact the economy, the environment, or human health.

HACCP has been used around the world by the food industry for decades as a proactive method to ensure product purity. The National Sea Grant Program first adapted HACCP to reduce the risk of spreading NIS and help fish processors comply with federal seafood safety regulations. The use of HACCP to prevent the spread of NIS is an American Society for Testing and Materials (ASTM) International standard under the Standard Guide for Conducting Hazard Analysis-Critical Control Point Evaluations (ASTM E2590-09).

The application of the HACCP process has been identified as a potential solution to addressing voyage-based risk assessments (SAB 2011). To decrease the risk of vessels spreading NIS via the ballast water and biofouling vectors HACCP can:

- Determine specific points to apply management actions;
- Define and monitor details of vessel-specific management activities;
- Provide a back-up plan for instances when management activities are not operating as intended or cannot be used; and
- Manage the risk of individual vessels as vectors for spreading NIS.

Vessel owners and operators could use HACCP to develop and organize their NIS prevention plans (e.g. Ballast Water Management Plan). The HACCP planning process would be specific for each vessel, and would identify points during voyages to implement measures to reduce interactions with NIS. For instance, as vessels move from an origin to a destination, they could diagram their trip and identify places to conduct ballast water loading, in-water cleaning, and other actions that decrease the risk of moving NIS. The HACCP process is also a tool that vessel operators can use to train personnel in the vessel's biofouling and ballast water prevention and management activities.

The HACCP process is a novel approach for vessels to show that they manage their ballast water in compliance with MISP requirements. HACCP may provide an added benefit by organizing the details that are needed to verify vessel compliance. The specifics would vary based on the ballast water management action that was taken, but HACCP could be used for shipboard treatment, exchange, retention, or shore-based treatment.

Commission staff is in the information gathering phase about the utility of such an approach to help prevent species introductions, and are working with staff from the USFWS and the National Oceanic and Atmospheric Administration to discuss existing invasive species HACCP efforts.

X. DISCUSSION AND CONCLUSIONS

In 1999, the California Legislature took a proactive stance against species introductions from ballast water discharge with the passage of the Ballast Water Management for Control of Nonindigenous Species Act. In the 15 years since the inception of the Marine Invasive Species Program, the adoption of the Marine Invasive Species Act (2003), the Coastal Ecosystems Protect Act (2006), and multiple legislative amendments have expanded MISP authority and added new mandates to reduce the risk of species introductions to California waters from vessel vectors.

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 initiatives and strategies. The California MISP leads the way in developing strong and science-based management strategies to prevent the introduction of NIS into California waters from vessel vectors. The MISP continues to work cooperatively and collaboratively with the shipping industry, environmental organizations, researchers, regulatory partners, and other interested parties in California to craft innovative NIS management solutions and move the state expeditiously towards the elimination of the discharge of NIS into the waters of the state.

The following sections summarize key issues related to ballast water and vessel biofouling management and make recommendations on how to address management gaps and improve the MISP.

Ballast Water Management

Eighty-four percent (84%) of the 18,739 qualifying voyage arrivals to California ports between July 2012 and June 2014 retained all ballast water on board. These arrivals posed no risk for species introductions associated with ballast water discharges. Some vessels, however, must discharge ballast due to cargo operations, navigation, and/or safety concerns.

As ships increase in size, so does the capacity of their ballast water tanks and the volume of ballast water discharged. Since 2004, the total volume of ballast water discharged in California has increased 96% from 3.5 million metric tons (MMT) (2004a) to 6.9 MMT (2014a).

The increase in the volume of discharged ballast water in California is driven, in large part, by bulk vessels. Bulk vessels accounted for only 8% of vessel arrivals to California between July 2012 and June 2014, yet were responsible for 45% of total volume of ballast water discharged during that same time period. Moreover, the average reported volume of ballast water discharged per discharging bulk vessel has risen 49% from 9,889 MT in 2004 to 14,724 MT in 2014a.

Perhaps more importantly, bulkers are also responsible for the largest proportion (49% by volume) of noncompliant ballast water discharged in California waters between 2012b-2014a. Ballast water that is not managed in compliance with the law poses an increased risk of species introduction and associated impacts to California waters.

Education and outreach are important tools that can be used to increase compliance. However, many bulk vessels are engaged in irregular trade routes that bring them to California ports infrequently. In these cases, it will be important to pair education with a strong enforcement program to deter first time offenders. Commission staff will introduce proposed enforcement regulations in 2015 to improve existing compliance assessment efforts.

Management Gaps

Unmanned barges discharge the third largest volume of unmanaged ballast water into state waters, posing a significant risk for NIS introduction. Unmanned barges regularly claim a safety exemption (per PRC §71203) from management requirements due to the risk associated with transferring personnel from a tug to a barge while underway to conduct ballast exchange.

Unmanned barges often operate on regular routes along the U.S. west coast, thus presenting an opportunity for repeat introductions of NIS. According to Ruiz et al. (2011), California serves as a hub for species introduction along the West Coast of North America; 79% of marine and estuarine NIS established in western North America were first detected in California. The movement of unmanaged ballast water from one port to another may be one of the reasons for this movement of species.

Shore-based and/or shipboard ballast water treatment technologies should be considered tools to fill the existing management gap for unmanned barges and reduce the risk of NIS introductions while minimizing threats to the safety of the vessel and its crew. In the near future, Commission staff will work with unmanned barge owners and operators to clarify current management requirements, gain knowledge about unmanned barge voyage characteristics, and identify management options for this vessel type.

Next Steps

The next phase of ballast water management involves the implementation of ballast water discharge standards and the development and use of ballast water treatment systems. The Commission recently concluded that ballast water treatment systems are not currently available to meet the California performance standards (see Commission 2014).

The lack of available treatment systems is not restricted to California. No ballast water treatment systems have been approved by the USCG to meet the U.S. federal discharge standards. Due to the lack of approved treatment systems, the USCG is offering extensions for compliance with the federal standards. As all vessels that operate in California must comply with USCG requirements, the lack of federally approved ballast water treatment systems is hindering installation and opportunities for evaluating system performance on ships arriving to California ports.

Commission staff is working to develop ballast water sampling tools and protocols. These protocols will be used to sample treated ballast water discharge from vessels that arrive at California ports to expand the available data set on treatment system performance. These protocols will also be used to assess vessel discharge compliance once the performance standards are implemented.

There is a need for data on the use of ballast water treatment systems under real world conditions. Treatment systems have been tested at land-based facilities and in limited shipboard scenarios, but no data is available on extended “real world” use. Furthermore, no jurisdiction has released compliance assessment protocols to assess vessel discharge compliance with the full range of organism size class standards.

The Commission is also exploring the feasibility of shore-based ballast water treatment as an option for vessels to comply with the California discharge standards. Currently there are no shore-based facilities in the U.S. designed to treat nonindigenous species in ballast water. The Commission approved funding in 2013 for a feasibility study of shore-based ballast water treatment in California. The study is being managed by the Delta Stewardship Council. A final report should be available in late 2015.

Until California’s ballast water performance standards are implemented, Commission staff will continue to work to improve compliance with ballast water exchange requirements through increased and targeted education and enforcement action as necessary.

Biofouling Management

The 2003 Marine Invasive Species Act mandated that the Commission conduct a review of non-ballast vectors of shipping-mediated species introductions. Takata et al. (2006) concluded that biofouling is a significant vector of species introductions to California waters, a conclusion that has been supported by recent research (Ruiz et al. 2011). Takata et al. (2006) led to adoption of statutory requirements to clean underwater vessel surfaces on a prescribed basis and a mandate for the Commission to adopt biofouling management regulations.

To guide the development of the biofouling management regulations, the Commission adopted the Hull Husbandry Reporting Form in 2007 to collect biofouling management data from the fleet of vessels arriving to California ports. The Commission has the most detailed data set in the world on hull husbandry and operational practices that influence biofouling accumulation on commercial ships.

During each of the prior six years (2008 – 2013), at least 79% of the vessels operating in California had biocidal or biocide-free antifouling coatings that were less than three years of age, generally within the effective lifespan of these coatings. The use of biocidal coatings is the dominant biofouling management strategy (used by at least 83% of vessels operating in California) to deter organism attachment to vessel surfaces. However, due to water quality restrictions, vessels with biocidal coatings are unable to conduct in-water cleaning in most California ports (see *Management Gaps* discussion below).

HHRF data have demonstrated that the recent Great Recession has altered several vessel operational practices in a way that has likely increased the risk of NIS introductions to California. These data indicate a 75% increase in the number of residency periods of 10 days or greater between the 2008 (pre-recession period) and 2013 (post-recession period) reporting years. Long residency periods enhance the possibility that vessels will accumulate extensive and diverse biofouling communities prior to arrival to California.

Commission staff has also identified a steady reduction in traveling speeds (i.e. slow steaming) since the pre-recession period, a practice that is likely to increase survivorship of existing biofouling communities on ship underwater surfaces. The combined influence of increased extended residency periods and reduced speeds will likely increase the risk of ships arriving to California with extensive, healthy biofouling communities that are able to readily invade.

Management Gaps

In-water cleaning of ships with biocidal coatings is currently prohibited in California waters impaired for copper or other metals. However, in-water cleaning of a vessel's underwater surfaces can be a useful biofouling management tool to reduce the risk of NIS introductions.

New technologies that collect and remove biofouling debris and heavy metal biocides from antifouling coatings are being developed and used across the globe. The use of these technologies in California could help to reduce the overall risk of NIS introductions while severely reducing the release of chemical pollutants into California waters.

Commission staff is coordinating with the State Water Board and Regional Water Quality Control Boards to identify a path toward reviewing and approving the use of these technologies. However, until in-water cleaning of ships with biocidal coatings is regulated and permitted, California will continue to lack a valuable management tool to prevent the introduction of NIS into California waters.

Next Steps

In accordance with Public Resources Code section 71204.6, Commission staff is developing biofouling management regulations. The development of regulations as a driver for biofouling management is a relatively new endeavor, with only a few regulatory agencies across the globe leading the way. Commission staff has relied heavily on research, cooperation, and discussions with regional, U.S. federal, and international partners, and stakeholders from the shipping and coatings industries, environmental groups, and regulatory agencies. The regulation development process is necessary to ensure requirements are based on the best available technology, protect the waters of the state, and align, as much as possible, with international guidelines (i.e. IMO Biofouling Guidelines). Commission staff will be initiating the public rulemaking process in early 2015.

Threats to California's Ability to Protect State Waters from NIS Introductions

The ability of California to address vessel discharges and protect state waters from the introduction of NIS is being threatened by federal initiatives to preempt states' authority. Although the 2014 U.S. Congress adjourned without passing legislation that would preempt portions of the MISP, it is anticipated that legislation to this effect will be introduced in future congressional sessions.

The Commission will continue to work with state partners throughout the U.S. to voice concerns about legislation that eliminates states' ability to address NIS with state-specific solutions. The Commission believes that California must retain authority to protect its waters through the MISP's implementation of ballast water and biofouling management requirements, inspection of vessels, and enforcement of California law.

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APPENDIX A

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: ______________________________

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
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			m3	C			m3		ER				m3	sg
			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

California State Lands Commission
Marine Invasive Species Program
Ballast Water Treatment Technology Annual Reporting Form
Public Resources Code Section 71205(g)
January 20, 2010

Vessel Name:
Official / IMO Number:
Responsible Officer's Name and Title:
Date Submitted (DD/MM/YYYY):

Treatment System Information

1. List the treatment system installed on board the vessel:

   Manufacturer/Company: ______________________________

   Product Name: ______________________________

   Model Number: ______________________________

   1a. Mode(s) of Action (check all that apply):

Filtration ☐	Cavitation ☐	Hydrocyclone ☐	Deoxygenation ☐
Active Substance/Biocide ☐	Ultra Violet Irradiation ☐	Heat ☐	
Other ☐, please describe:			

   1b. List all substances (i.e. chemicals, biocides, flocculants, neutralization agents) created or used by the treatment system (if any), and indicate whether or not the Material Safety Data Sheet is kept on board for each substance.

Substance	MSDS on Board?
	Yes ☐ No ☐ N/A ☐
	Yes ☐ No ☐ N/A ☐
	Yes ☐ No ☐ N/A ☐
	Yes ☐ No ☐ N/A ☐
	Yes ☐ No ☐ N/A ☐
	Yes ☐ No ☐ N/A ☐
N/A ☐, No substances used by system.	

1c. Are manufacturer's technical guides, publications and/or manuals for the treatment system kept on board? Yes ☐ No ☐

2. When did the system receive classification society approval?

   Date (DD/MM/YYYY): ____

3. Did the system installation occur:

As part of a scheduled out of water dry docking?	Yes ☐ No ☐
During a special/non-routine out of water dry docking?	Yes ☐ No ☐
Without the need for out of water dry docking?	Yes ☐ No ☐

4. Has there been any significant upgrade/modification to the system since classification society approval? (Do not include repairs. See instructions for more information and definition of significant.)

Yes ☐	Date of Upgrade (DD/MM/YYYY):
Describe upgrade:	
No ☐	

5. Has any unscheduled or emergency maintenance been performed on the system since classification society approval (or since the previously submitted Ballast Water Treatment Technology Annual Reporting Form)?

Yes ☐	Date of Most Recent Event (DD/MM/YYYY):
Describe most recent maintenance event:	
No ☐	

6. Is the vessel in compliance with the requirement to maintain a ballast water treatment performance log on board? (This log may be incorporated into the existing ballast water management log. See form instructions for minimum requirements). Yes ☐ No ☐

7. Is system performance (i.e. biological efficacy) verified on a regular basis? Verification is not a requirement by the State of California, however, regular performance testing will allow the vessel to ensure the system is working properly.

Yes ☐				
How often:	Weekly ☐	Monthly ☐	Yearly ☐	Every 2 years ☐
	Other ☐, describe:			
No ☐				

January 20, 2010

California State Lands Commission
Ballast Water Treatment Supplemental Reporting Form
Public Resources Code Section 71205(g)
ALL VESSELS MUST ALSO SUBMIT BALLAST WATER REPORTING FORM

IS THIS AN AMENDED REPORTING FORM? Yes ☐ No ☐

Vessel Information	**Voyage Information**
Vessel Name:	Arrival Port:
Official/IMO Number:	Arrival Date (DD/MM/YYYY):

Ballast Water Treatment

1. Did the treatment system experience any malfunction that affected the treatment of ballast water to be discharged at this arrival port?

   Yes ☐ , please provide the following information:

   Date of malfunction (DD/MM/YYYY): ______________________________

   Explain the malfunction: ______________________________

   If applicable, how was the situation resolved? ______________________________

   No ☐

2. Ballast Water Treatment History. Provide information for all ballast tanks that will be discharged at arrival port. Enter additional tanks on page 2. One tank per line. If none, go to Question #3.

Tanks/ Holds	**BW Source**			**BW Discharge**			**BW Treatment**		
	Date (DD/MM/YY)	Port/Lat-Long	Volume (Units)	Date (DD/MM/YY)	Port/Lat-Long	Volume (Units)	Date of 1st treatment (DD/MM/YY)	Date 2nd treatment (if applicable) (DD/MM/YY)	Volume Ballast Treated (Units)
Ballast Water Tank Codes: Forepeak = FP, Aftpeak = AP, Double Bottom = DB, Wing = WT, Topside = TS, Cargo Hold = CH, Other = O									

3. Responsible Officer's Name and Title: ______________________________

Vessel IMO Number: ____________________________

Tanks/ Holds	BW Source			BW Discharge			BW Treatment		
	Date (DD/MM/YY)	Port/Lat-Long	Volume (Units)	Date (DD/MM/YY)	Port/Lat-Long	Volume (Units)	Date of 1st treatment (DD/MM/YY)	Date 2nd treatment (if applicable) (DD/MM/YY)	Volume Ballast Treated (Units)
Ballast Water Tank Codes: Forepeak = FP, Aftpeak = AP, Double Bottom = DB, Wing = WT, Topside = TS, Cargo Hold = CH, Other = O									

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☐

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:

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

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:

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:

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Port or Position: Country:

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