2023 BIENNIAL REPORT

ON THE

CALIFORNIA MARINE INVASIVE SPECIES PROGRAM

PRODUCED FOR THE
CALIFORNIA STATE LEGISLATURE

by the

CALIFORNIA STATE LANDS COMMISSION

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EXECUTIVE SUMMARY

The California State Lands Commission (Commission) prepared this report for the California Legislature pursuant to Public Resources Code sections 71210 and 71212. This is the eleventh biennial report to the California Legislature, and it summarizes California Marine Invasive Species Program (MISP) activities from January 1, 2020, through December 31, 2021. This report includes:

- A summary and analysis of vessel arrival patterns at California ports
- A summary of the information provided by vessels in the Ballast Water Management Report and Annual Vessel Reporting Form
- An analysis of the ballast water and biofouling management practices used by vessels in California
- An update on the implementation of ballast water discharge performance standards
- A summary of recent research related to nonindigenous species (NIS) and their pathways of spread
- An evaluation of the MISP accomplishments, actions Commission staff can take to improve the program, and recommendations to the California Legislature

What is the Marine Invasive Species Program?

The MISP was established in 1999 in response to threats to human health, the economy, and the environment posed by vessel-mediated aquatic NIS introductions. The MISP is a statewide, multiagency program that monitors new aquatic NIS introductions and prevents NIS introductions from vessels that are 300 gross registered tons and above, capable of carrying ballast water, and arriving at California ports.

The four MISP agencies are:

- California State Lands Commission: Administers the MISP and develops and implements vessel vector management regulations.
- California Department of Fish and Wildlife: Monitors and gathers data on NIS in California's coastal waters.
- State Water Resources Control Board: Consults with MISP partner agencies on topics related to water quality and toxicity.
- California Department of Tax and Fee Administration: Collects a fee (currently $1,000) from the owner or operator of each vessel that arrives at a California port from a port outside of California. (Pub. Resources Code, § 71215.) The collected fees are used to fund MISP activities.

Marine Invasive Species Program Update for 2020 and 2021

Vessel Arrival Patterns during 2020 and 2021.

- California ports received 9,765 arrivals in 2020 and 10,276 arrivals in 2021.
- Vessel arrivals decreased 13% from 2019 to 2020, which coincides with the COVID-19 pandemic's impact on vessel traffic.
- Southern California ports received 55% of all California arrivals from 2020 through 2021, while northern California ports received 45%.
- 60% of the arrivals at southern California ports came from outside the Pacific Coast Region (PCR) (see Figure 4.6 for a graphic of the PCR), while 19% of arrivals at northern California ports came from outside the PCR.
- Between January 1, 2020 and December 31, 2021, an average of 431 vessel arrivals were billed per month by the California Department of Tax and Fee Administration, with a collection rate of 99%.

Vessel Reporting Compliance in 2020 and 2021

- 89% of vessel arrivals submitted a Ballast Water Management Report (BWMR), compared to 83% from 2018 and 2019.
- 94% of vessels complied with the Annual Vessel Reporting Form reporting requirements, up from 88% in 2018 and 2019.

Vessel Inspections

The Marine Invasive Species Act (MISA) mandates that at least 25 percent of the vessels arriving at California ports be inspected to assess compliance with the MISA and associated ballast water and biofouling regulations.

Commission staff inspected 23 percent of all vessel arrivals at California ports in 2020 and 2021. However, 2,900 vessel arrivals were impractical for inspection because the Commission's Marine Environmental Protection Division field operations staff do not have access to a boat or other means to inspect vessel arrivals at Catalina Island and San Francisco Bay anchorages. Commission staff inspected 27 percent of arrivals that were practical for inspection (i.e., vessel was accessible for boarding). Additionally, Commission staff inspected 73 percent of vessel arrivals that were practical for inspection and designated as a high priority for inspection.

Improving the Vessel Inspection Prioritization Process

To improve the vessel inspections prioritization process and ensure the most efficient use of resources, Commission staff developed and tested a combined risk assessment model (CRAM) that combines inputs from ballast water and biofouling vectors. The CRAM results provide information to Commission staff to target inspection resources at vessels with the highest calculated likelihood of introducing NIS. Commission staff will continue refining the CRAM by evaluating other ballast water and biofouling operational factors and will seek peer review for the process prior to implementation.

Ballast Water Discharge

During 2020 and 2021, 88 percent of vessel arrivals that reported to the Commission were not discharging ballast water, presenting zero risk of ballast water-mediated species introductions. Overall, vessels that reported to the Commission discharged 19.03 million metric tons of ballast water into California waters.

The primary ballast water management method for discharging vessels is transitioning from ballast water exchange to ballast water treatment. This transition is highlighted as the total volume of treated ballast water has increased by over 600 percent from 2017 to 2021. Vessels are transitioning to using ballast water treatment systems to comply with ballast water discharge standards that are being phased in by the U.S. Coast Guard and the International Maritime Organization. Additionally, the Commission began implementing ballast water discharge performance standards on January 1, 2022. The Commission's performance standards and implementation schedule are the same as those implemented by the U.S. Coast Guard (Sections 151.2030(a) and 151.2035(b) of Title 33 of the Code of Federal Regulations).

Biofouling Maintenance and Vessel Operational Practices

During the reporting period, 260 million square meters of cumulative total wetted surface area arrived at California ports. Total wetted surface area (TWSA) is the area of the vessel susceptible to organism accumulation (i.e., biofouling) because it is permanently or temporarily submerged in water. TWSA can be used to estimate the likelihood of biofouling leading to a species introduction.

Antifouling coatings are applied to prevent biofouling from developing on the wetted surfaces of a vessel. These coatings are typically effective for three to five years. Overall, the average age of antifouling coatings on vessels that arrived at California ports during 2020 and 2021 was less than 2 years.

Extended idle periods, when vessels sit in one port or place for 10 days or longer, increase the risk of biofouling-mediated introductions because biofouling accumulates on wetted surfaces when vessels are not in motion. During 2020 and 2021, 79 percent of vessels reported having extended idle periods between 10 and 19.9 days and 12 percent of the reported idle periods were longer than 45 days.

Compliance with Ballast Water and Biofouling Requirements Remains High

During 2020 and 2021, 99.7 percent of the reported ballast water discharged in California waters was compliant with ballast water management requirements.

In addition to onboard inspections for ballast water management compliance, Commission staff can review BWMRs prior to a vessel's arrival. This review allows Commission staff to identify vessels that could potentially discharge noncompliant ballast water. During 2020 and 2021, Commission staff notified 23 vessels that their BWMR indicated they were planning to discharge potentially noncompliant ballast water. Of these 23 vessel arrivals, 17 changed their operations, preventing 141,563 metric tons of potentially noncompliant ballast water from being discharged into California, a volume nearly three times greater than the total volume of noncompliant ballast water that was discharged during the reporting period. This prevention of noncompliant ballast water discharge shows that the pre-arrival assessment and potential violation notifications significantly reduce the risk of NIS introductions and improves compliance rates.

For biofouling compliance assessment, thirty one percent (502 vessels) of vessels that were inspected to assess compliance with the California biofouling management and record keeping regulations were determined to be noncompliant. Vessels that are non-compliant with the biofouling regulations receive a 60-day grace period to address deficiencies. During the reporting period, Commission staff reinspected 330 vessels that arrived after the completion of a 60-day grace period and only 11 vessels (3.3 percent) were found to still be noncompliant.

California Department of Fish and Wildlife (CDFW) Survey Results

Since 2000, CDFW staff has managed aquatic NIS distribution surveys of California's estuaries and marine waters.

Between 2016 and 2021, there were four observations of new aquatic NIS in areas of California that were surveyed (see table 7-2). While there have been relatively few new species observations, six species initially observed in one part of California have now been observed in other parts. These range expansions may have been present earlier than when they were detected and could have eluded detection.

Improving the Implementation of California's Ballast Water Discharge Performance Standards Regulations

In 2020, California's ballast water regulations were amended to include ballast water discharge performance standards and related record keeping provisions. Commission staff began implementing the new regulations on January 1, 2022 and is refining the compliance assessment process. Additionally, Commission staff is improving outreach materials to help the regulated industry understand the new requirements.

Improving the Commission's Marine Invasive Species Act Enforcement Process

Commission staff plans to amend the Commission's enforcement regulations to incorporate a process for enforcing violations of the biofouling regulations and the recently implemented ballast water discharge performance standards regulations. Additionally, Commission staff is working to automate more of the tracking and enforcing of MISA reporting violations.

Improving Data Sharing

In October 2022, Commission staff launched a public facing data repository that can be viewed and downloaded from the MISP pages on the Commission's website (www.slc.ca.gov/misp). The repository includes historical data on vessel arrivals and ballast water discharge volumes. Both datasets are organized by quarter, vessel type, and location.

Peer-Reviewed Scientific Journal Publications

Staff co-authored nine peer-reviewed journal articles during 2020 and 2021 See section 9.1 for a list of publications.

Recommendations

The Commission makes the following recommendations to the Legislature and California state agencies and departments based on data presented in this report:

1. Support Commission efforts to secure ongoing funding for the Marine Invasive Species Control Fund (MISCF). The Commission's ability to collect fees will be limited by the federal (U.S. Environmental Protection Agency and the U.S. Coast Guard) implementation of the Vessel Incidental Discharge Act (VIDA). Once in effect, these restrictions are projected to cause the MISCF to lose between $300,000 and $500,000 annually. This loss of revenue will move the MISCF towards insolvency (see section 8.1.2).

2. Support an amendment of the Marine Invasive Species Act to require the report to the California Legislature mandated by Public Resources Code section 71212 (i.e., this report) to be updated triennially instead of biennially. Expanding responsibilities (see section 3.3.), impending revenue losses (see recommendation 1 and section 8.1.2), and future restrictions on raising the amount of the vessel arrival fee that supports the program will require adjustments to workloads and priorities. The production of this Legislative report is labor-intensive and time consuming, limiting staff's ability to maintain a high level of performance with an increasing workload. To ensure no lapse in vessel data availability with the recommended change, Commission staff has initiated quarterly vessel

data updates posted on the Commission's website to provide some of the types of data presented in this report for continued access for interested users (see section 9.1)

ABBREVIATIONS AND ACRONYMS

Abbreviation/Acronym	Description
µm	micrometers
AB	Assembly Bill
AMS	Alternate Management System
AVRF	Marine Invasive Species Program Annual Vessel Reporting Form
BWMR	Ballast Water Management Report
BWTS	Ballast Water Treatment System
CDTFA	California Department of Tax and Fee Administration
CFR	Code of Federal Regulations
CFU	colony-forming unit
Commission	California State Lands Commission
COVID-19	2019 corona virus disease
eDNA	environmental DNA
GIS	Geographic Information Systems
IMO	International Maritime Organization
ISO	International Organization for Standardization
IWC	In water cleaning
IWCC	In water cleaning and capture
ISS	Internal seawater system
LPOC	Last Port of Call
m	meter
MEPD	Commission's Marine Environmental Protection Division
MISA	Marine Invasive Species Act
MISCF	Marine Invasive Species Control Fund
MISP	Marine Invasive Species Program
MT	metric tons
MMT	million metric tons

MPA	Marine Protected Areas
MPI	Ministry for Primary Industries
NM	nautical miles
PCR	Pacific Coast Region
SERC	Smithsonian Environmental Research Center
U.S.	United States
USCG	United States Coast Guard
U.S. EPA	United States Environmental Protection Agency
UV	Ultraviolet Irradiation
VIDA	Vessel Incidental Discharge Act
TWSA	Total wetted surface area

DEFINITIONS AND VOCABULARY

Agent
A vessel's agent acts on behalf of the ship owner and provides information to the vessel crew about local requirements at each port

Antifouling coating
Specialized paint used to prevent biofouling growth on the vessel

Anchorage
Areas suitable for vessels to anchor away from shore while they wait for authorization to berth

Ballast water
Water used by vessels to improve and maintain stability, balance, and trim during cargo operations

Ballast water discharge performance standards
The legal restrictions setting the maximum allowable concentration of living organisms of various types and sizes (i.e., classes) in discharged ballast water

Ballast water exchange
Replacing the water in a ballast water tank with new water

Biocides
Toxic substances that have the potential to kill organisms

Biocidal coating
Antifouling coating containing biocides to prevent the attachment and accumulation of biofouling organisms

Biofouling
Attachment or association of an organism or group of organisms (community) to wetted surfaces (e.g., vessels and docks)

Dry dock
Removal of a vessel from the water for maintenance

Effective lifespan of the antifouling coating
Length of time that an antifouling coating is expected to be effective based on the specific application thickness and design of the coating

Idle period
Period of time where a vessel remains in one place and is not actively moving (also referred to as an "extended residency period")

In-water cleaning
Processes used to remove biofouling from the vessel's wetted surfaces while the vessel is in water (versus out-of-water or "dry dock")

Mid-ocean waters
Ocean water at least 200 nautical miles from any land and having a depth of least 2,000 meters

Nonindigenous species
Any species (or biological material capable of reproducing) that has been transferred from its location of origin or historical range into a new location

Out-of-water support strips
Areas on the vessel's hull where the support blocks are placed during dry dock (i.e., out-of-water maintenance) and remain unpainted and unprotected

Phytoplankton
Marine and freshwater microscopic photosynthetic (contain chlorophyll and require sunlight to live) organisms that drift in the water. Also known as microalgae.

Vector
Specific mechanisms that facilitate the movement of nonindigenous species

Wetted Surface Area
Measurement of all vessel surface area that is temporarily or continuously submerged in water and is susceptible to biofouling accumulation

Zooplankton
Marine or freshwater animals (including immature stages of some animals), often microscopic, that drift with the water current

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1 PURPOSE

The California State Lands Commission (Commission) prepared this report for the California Legislature pursuant to Public Resources Code sections 71210 and 71212. This is the 11th biennial report to the California Legislature; it summarizes California Marine Invasive Species Program (MISP) activities from January 1, 2020, through December 31, 2021.

Per statutory requirements, this report includes:

- A summary and analysis of vessel arrival patterns at California ports, including a summary of compliance rates categorized by geographic area and vessel type
- A summary of the information provided in the Ballast Water Management Reports submitted by vessels to the Commission, including the volumes and method(s) of ballast water management, volumes discharged into State waters, types of ballast water treatment, and locations at which ballast water was loaded and discharged
- An analysis of ballast water management practices and an update on the implementation of ballast water discharge performance standards
- A summary of Commission-sponsored research and programs to evaluate alternatives for treating or otherwise managing ballast water
- A summary and analysis of biofouling management practices reported by vessels arriving at California ports
- A summary of recent research addressing the release of nonindigenous species (NIS) by vessels and other relevant research relating to vessels and NIS
- An evaluation of the effectiveness of the MISP and measures taken to reduce or eliminate the discharge of NIS from vessels, including recommendations for actions that should be taken to improve the effectiveness of the MIS.

2 INTRODUCTION TO INVASIVE SPECIES

2.1 What are Nonindigenous Species?

Nonindigenous species (NIS) are organisms that are intentionally or unintentionally transported through human activities to new habitats, such as California's marine, estuarine, and freshwater environments. NIS can pose significant risks to human health, the economy, and the environment. Once a NIS is established in a new geographic location and causes impacts, it is considered an invasive species.

Because attempts to eradicate invasive species are costly and often unsuccessful, the most effective way to address NIS is to prevent species introductions by managing the ways they are moved.

2.2 What are Aquatic Nonindigenous Species and How are they Moved?

Nonindigenous species that are introduced into aquatic habitats (e.g., ocean, estuaries, rivers) are called aquatic NIS. Aquatic NIS are moved around the globe through many pathways, including:

- Aquaculture (Grosholz et al. 2012)
- Aquarium trade (Williams et al. 2012)
- Commercial shipping (Fofonoff et al. 2003)
- Live bait trade (Fowler et al. 2015)
- Live seafood trade (Chapman et al. 2003)
- Marine debris (Barnes 2002)
- Recreational watercraft (Ashton et al. 2012)

Each of these pathways contributes to aquatic NIS movement. However, commercial shipping has been recognized as a major contributor to the transport of these organisms worldwide (Ruiz et al. 1997; Hewitt and Campbell 2010).

Ballast water and vessel biofouling are vectors, or specific mechanisms, within the shipping pathway that transport aquatic NIS. Ballast water and vessel biofouling have contributed to a large percentage of the established coastal marine aquatic NIS introductions in California (Ruiz et al. 2011) and in North America (Ruiz et al. 2015).

2.2.1 Ballast Water as a Vector

Vessels use ballast water to improve and maintain stability, balance, and trim. Vessels take on, discharge, or redistribute ballast water during cargo loading and unloading, as they encounter rough seas, or as they transit through shallow coastal waterways. When vessels load ballast water, they take on any organisms that are drawn in with the water. As vessels move around the world, they pick up species in the water from one port and discharge them in different ports. This transfer of ballast water results in the worldwide movement of organisms (Figure 2-1).

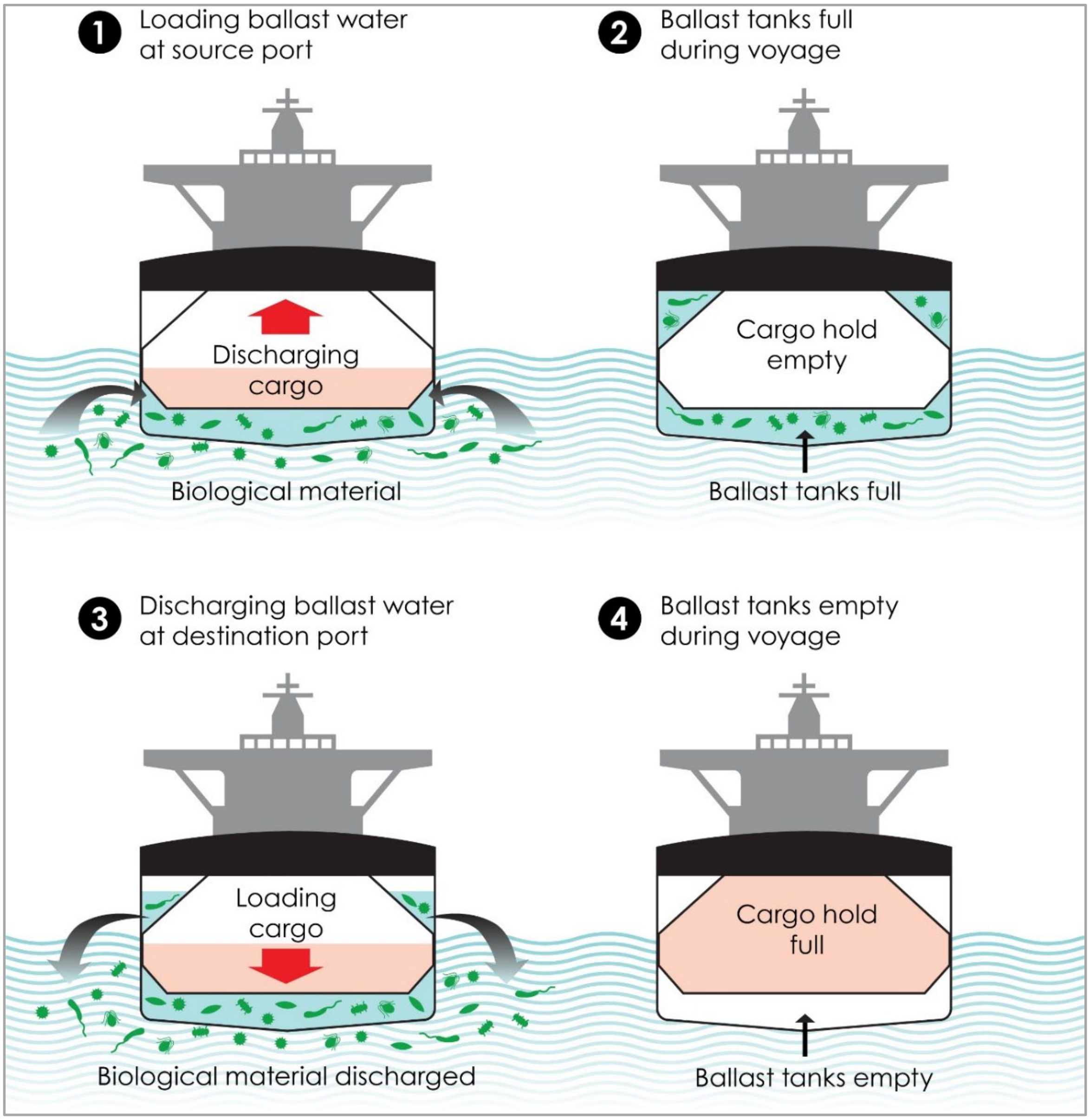


Figure 2-1. Ballast water loading and discharge in relation to vessel cargo operations.

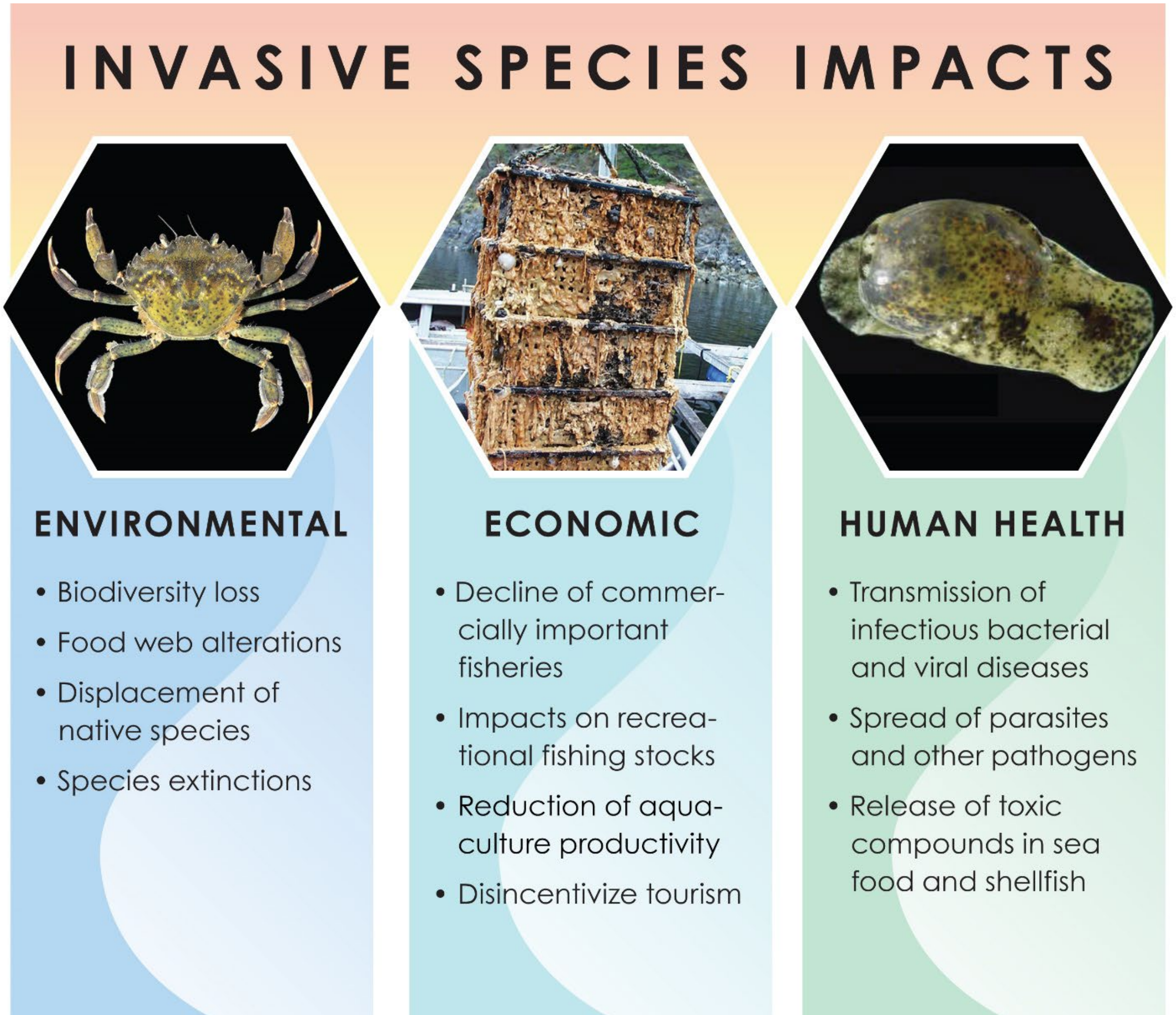
Prior to implementing ballast water management practices in the early 2000s, it was estimated that more than 7,000 aquatic species were moved around the world daily in ballast water (Carlton 1999). The discharge of unmanaged ballast water from a single vessel has the potential to release over 8.9 billion individual zooplankton (microscopic animals that drift or free float in water) (Minton et al. 2005).

2.2.2 Vessel Biofouling as a Vector

Vessel biofouling refers to the attachment or association of an organism or group of organisms (community) to a vessel's wetted surfaces (i.e., the areas of the vessel that are permanently or temporarily in contact with ambient water). Vessel biofouling communities consist of both sessile (directly attached to the vessel, e.g., barnacles) and mobile organisms that can survive long voyages and a wide range of environmental conditions. Biofouling communities can include fishes, barnacles, algae, mussels, worms, crabs, and other invertebrates.

As vessels transit from port to port, biofouling organisms can drop off or spawn (i.e., reproduce), resulting in aquatic NIS introductions. Vessel biofouling is considered a significant vector for aquatic NIS introductions in many regions, including Australia, the North Sea, Hawaii, and California (Ruiz et al. 2000, 2011; Eldredge and Carlton 2002; Gollasch 2002).

2.3 Invasive Species Impacts



Environmental Impacts

NIS significantly impact the ecology of invaded habitats by affecting community structure, food web interactions, resources availability, and biodiversity (Carlton 2001; Grosholz 2012). Worldwide, 42 percent of threatened or endangered species are listed because of impacts from NIS (Pimentel et al. 2005). Aquatic NIS are commonly found in bays and estuaries (Ruiz et al. 2000b; Ruiz et al. 2009) due to the influence of human-mediated pathways (e.g., shipping and recreational boating) in these areas (Miller et al. 2011).

The green crab (*Carcinus maenas*) is an invasive species that was first detected in San Francisco Bay in 1989 (Cohen and Carlton 1995). Green crabs negatively impact populations of native California shore crabs (Grosholz et al. 2000) and are also responsible for the loss of eelgrass beds, which are a critical habitat for young fish (Matheson et al. 2016). Since the early 2000s, scientists have been monitoring local populations of the green crab in California and even attempted an unsuccessful localized eradication (Grosholz et al. 2021).

Another example of an aquatic NIS that causes environmental impacts is the overbite clam (*Potamocorbula amurensis*). Native to estuarine habitats from eastern Russia to southern China, it was first detected in San Francisco Bay in 1986. The clam consumes 80 to 90 percent of the zooplankton from the water column in the shallow portions of the San Francisco Bay (Greene et al. 2011). *P. amurensis* has been associated with the decline of the native delta smelt and other pelagic fishes in the Sacramento-San Joaquin River Delta (Feyrer et al. 2003, Sommer et al. 2007, Mac Nally et al. 2010).

Quagga (*Dreissena bugensis*) and zebra mussels (*Dreissena polymorpha*) are believed to have been introduced via ballast water to the Great Lakes in the mid-1980s (Carlton 1993). Following their initial introductions into North America, the mussels are believed to have been moved to California through water deliveries and overland movement of recreational watercraft and equipment. The zebra mussel was first discovered in San Justo Reservoir (San Benito County, California) in 2008 (USGS 2020). Invasive bivalves (e.g., mussels and clams) filter vast amounts of water, dramatically reducing phytoplankton (marine and freshwater microscopic photosynthetic organisms that drift in the water) and zooplankton concentrations (Higgins and Vander Zanden 2010, Vanderploeg et al. 2010), which has been associated with the decline of recreationally valuable fishes (Cohen and Weinstein 1998).

Economic Impacts

In aquatic environments, invasive species threaten aquaculture operations, recreational boating, agriculture, water conveyance, commercial and recreational fishing, marine transportation, and tourism, among other industries - all of which are essential to California's economy. In 2019, California's ocean-based economy employed an estimated 598,327 people and accounted for almost $52 billion of California's total gross domestic product (NOEP 2022a).

The green crab is threatening California's fishing economy by competing for resources with the commercially important Dungeness crab *(Metacarcinus magister*) and other native species. Dungeness crab is one of the most important commercial fisheries in California, accounting for approximately $47 million in revenue in 2017 (NOEP 2022b).

The California Department of Fish and Wildlife (CDFW) is working to control the spread of quagga and zebra mussels in California because these mussels threaten water delivery systems (e.g., the California aqueduct) and hydroelectric facilities. Over $35.6 million has been spent by CDFW since 2008 to control the mussels, and this cost will continue as eradication is not possible (Volkoff, M., CDFW, *pers. comm*. 2022).

Tens of millions of dollars have been spent on managing and reducing the impact of other aquatic NIS introductions in California, including the following examples:

- Between 2000 and 2006, more than $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, approximately $34 million has been spent to manage the Atlantic cordgrass (*Spartina alterniflora*) in the San Francisco Bay-Delta (Olofson, P., Invasive Spartina Project, *pers. comm*. 2018).

These costs represent only a fraction of the cumulative expenses related to NIS management because eradication is rarely successful, and control is an unending process. The environmental damages and losses associated with NIS (aquatic and terrestrial) impacts in the United States have been estimated between $120 to $137 billion per year (Pimentel et al. 2005, Neill 2011).

Human Health Impacts

In addition to economic and ecological impacts, invasive species impact human health by acting as a vector for many human pathogens or by being the pathogens themselves. Some of the best studied epidemics can be traced to biological invasions, including the bubonic plague, which was caused by a bacterium in a flea that infested an invasive rat. Also, a cholera outbreak in South America during the 1990s was likely introduced into port areas through ballast water discharge (Ruiz et al. 2000b, Takahashi et al. 2008, Neill 2011).

Other examples of organisms that are harmful to humans and were introduced by vessel vectors include:

- Human intestinal parasites (e.g., *Giardia lamblia, Cryptosporidium parvum, Enterocytozoon bieneusi*) (Johengen et al. 2005, Reid et al. 2007)
- Microorganisms that cause paralytic shellfish poisoning (e.g., *Alexandrium fundyense*) (Hallegraeff 1998)
- Microbial indicators for fecal contamination (e.g., *Escherichia coli* and intestinal enterococci) (Reid et al. 2007)
- *Vibrio parahaemolyticus*, which infects shellfish and causes gastrointestinal illness in humans when ingested (Revilla-Castellanos et al. 2015)

The Japanese sea slug (*Haminoea japonica*), which serves as a host of the parasitic flatworm that causes cercarial dermatitis (i.e., swimmer's itch) (Brant et al. 2010).

3 CALIFORNIA’S MARINE INVASIVE SPECIES PROGRAM

California has responded aggressively to prevent vessel-mediated introductions of aquatic NIS. In 1999, the California Legislature established what later became known as the MISP. The MISP is a statewide, multiagency program designed to prevent the introduction of NIS from large vessels arriving at California ports. The mandate of the MISP is to:

> ***“Move the State expeditiously toward elimination of the discharge of nonindigenous species into the waters of the State or into waters that may impact the waters of the State, based on the best available technology economically achievable.”*** **(Pub. Resources Code, § 71201, subd. (d)(1).)**

3.1 MISP’s Statutory Authority

The Marine Invasive Species Act (MISA; Public Resources Code section 71200 et seq.) grants authority to four MISP agencies (California State Lands Commission, California Department of Fish and Wildlife, State Water Resources Control Board, and California Department of Tax and Fee Administration) to work collaboratively to address the risk of species introductions from vessel biofouling and ballast water discharge. Vessels subject to the MISA are 300 gross registered tons or more and carrying, or capable of carrying, ballast water.

The MISP consists of four agencies:

The California State Lands Commission (Commission)

Administers the MISP and is tasked with developing and implementing vessel vector management regulations and funding research.

The California Department of Fish and Wildlife's Office of Spill Prevention and Response (CDFW-OSPR)

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 to help to assess the effectiveness of the MISP.

MISP Agencies

The State Water Resources Control Board (Water Board)

Consults with MISP partner agencies on topics related to water quality and toxicity, including the in-water cleaning of vessels and use of ballast water treatment systems.

The California Department of Tax and Fee Administration (CDTFA)

Collects a fee from vessel owners and operators of qualifying voyages to California ports. Fees are deposited into the Marine Invasive Species Control Fund and support all MISP operations. The MISP does not receive any General Fund dollars.

For more details on MISP partner agency activities, see subsections 4.3.1 (Quantifying Arrivals and Fee Collection) and 7.3 (Marine Invasive Species Program: Species Monitoring Update).

The Commission administers the MISP, including policy development, data administration, field operations, and outreach. The Commission is also the fund administrator for the Marine Invasive Species Control Fund.

The Functions of the Commission's MISP are:

Program Management and Science-based Policy Development

- Recommend policy proposals to the Legislature
- Develop and implement regulations
- Review best available science to inform policy decisions
- Manage research contracts
- Analyze data to assess vessel compliance
- Prepare reports for the Legislature
- Pursue enforcement actions for violations of the Marine Invasive Species Act (MISA)

Data Administration

- Input data from ballast water and biofouling reporting forms
- Track form submission and compliance
- Assess quality and accuracy of data entry
- Maintain contact with stakeholders to relay information about MISP requirements

Field Operations

- Vessel inspections
- Disseminate, clarify, and answer questions about MISA requirements during inspections
- Compliance assessment of report submission, recordkeeping, and management requirements. Violations are written on-site when vessels are found noncompliant.

THE SHARED ROLE OF OUTREACH

One of the key components of the success of the MISP is the close communication, coordination, and outreach amongst Commission staff, the maritime industry, and other state, federal, and international agencies. By establishing and maintaining relationships with these diverse groups, MISP staff works towards:

- Improved compliance within the regulated community
- Development of well-informed policy decisions
- Use of management tools and strategies based on the best available science

The MISP management and scientific staff work closely with state, federal, and foreign regulatory agencies/authorities, technical advisory groups, non-governmental organizations, researchers, and the shipping industry. By consulting with other regulatory jurisdictions, the MISP effectively develops policies that are consistent regionally and internationally. MISP staff participates on numerous working groups, advisory panels, and committees including (but not limited to):

- California Agencies Aquatic Invasive Species Team
- California Marinas Interagency Coordinating Committee
- Delta Interagency Invasive Species Coordination 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 Nuisance Species (part of the federal Aquatic Nuisance Species Task Force)
- United States Coast Guard (USCG) Vessel Incidental Discharge Act Ballast Water Reporting and Enforcement Data Work Group
- International Maritime Organization: GloFouling Partnership workgroup collaborations

3.2 Legislative Evolution of the MISP

In 1999, the initial authorizing legislation for the MISP (Assembly Bill (AB) 703, Chapter 849, Statutes of 1999) required vessels arriving from foreign ports to manage ballast water. Since this initial authorizing legislation, the MISP has been reauthorized and expanded to improve protection of California waters from NIS introduced through the vessel-mediated vectors of ballast water and biofouling. Additionally, the Commission has adopted and amended regulations to implement the MISA (Public Resources Code section 71201.7).

The following is a list of notable amendments to the MISA and adopted regulations:

- In 2003 the Marine Invasive Species Act (MISA; AB 433, Chapter 491, Statutes of 2003) reauthorized and expanded the MISP and directed the Commission to adopt ballast water management regulations for vessels moving coastally between ports on the west coast of the United States (U.S.)
- In 2006, the MISA was amended (Senate Bill 497, Chapter 292, Statutes of 2006) and established California's interim and final ballast water discharge performance standards.

- In 2007, the MISA was amended (AB 740, Chapter 370, Statutes of 2007), directing the Commission to adopt biofouling management regulations.
- In 2017, the Commission adopted biofouling management regulations (California Code of Regulations, title 2, section 2298.1 et seq.).
- In 2017, the Commission adopted enforcement regulations (California Code of Regulations, title 2, section 2299.01 et seq.), giving the Commission a process to enforce violations of the MISA and its associated regulations.
- In 2019, the MISA was amended (AB 912, Chapter 433, Statutes of 2019) authorizing the Commission to:
  - Adopt and enforce the federal ballast water discharge performance standards (Section 151.2030(a) of Title 33 of the Code of Federal Regulations).
  - Delay implementation of the interim and final California ballast water discharge performance standards (Senate Bill 497, Chapter 292, Statutes of 2006) to 2030 and 2040, respectively.
  - Sample ballast water and biofouling for research purposes. Prior to AB 912, the Commission could sample only for compliance assessment.
  - Change the definition of the Pacific Coast Region (PCR) (see Figure 4-6 for revised PCR map).
- In 2020, the Commission amended regulations to implement AB 912.

The new mandates (e.g., biofouling management regulations, enforcement regulations, ballast water discharge performance standards regulations) better protect California waters from vessel-mediated NIS introductions but have increased Commission staff's responsibilities. Commission staff is implementing the new mandates and searching for new efficiencies to maintain a high level of performance with an increasing workload.

4 VESSEL ARRIVALS IN CALIFORNIA

4.1 Reporting Requirements and Arrival Tracking

MISP staff uses various resources to monitor vessel arrivals at California's ports (Figure 4-1) and to analyze ballast water management and discharge activity and biofouling management strategies. Staff obtains daily arrival information from the Marine Exchanges of Southern California and the San Francisco Bay Region. Ballast water and biofouling management information is obtained from required vessel-submitted reporting forms. The reporting forms are:

- ***Ballast Water Management Report (BWMR):*** The BWMR is a USCG form that must be submitted to the Commission by all vessels at least 24 hours prior to an arrival at a California port. The BWMR includes the vessel's voyage information and ballast water management and discharge activities and can be submitted either as a PDF via email or entered directly into the Commission's web-based reporting portal at https://MISP.io (hereafter referred to MISP.io).
- ***Marine Invasive Species Program Annual Vessel Reporting Form (AVRF):*** The AVRF is a Commission-adopted form that must be submitted at least 24 hours prior to a vessel's first arrival at a California port each calendar year. The AVRF includes details of the vessel's operational practices; biofouling maintenance practices; and the installation, use, and maintenance of the onboard ballast water treatment systems. During 2020, AVRFs could be submitted either as a PDF via email or entered directly onto MISP.io. Beginning on January 1, 2021, the Commission required online submission of the AVRF via MISP.io.

Receiving the information on reporting forms prior to an arrival is crucial for prioritizing vessels for inspection and identifying potentially noncompliant vessels before they arrive.

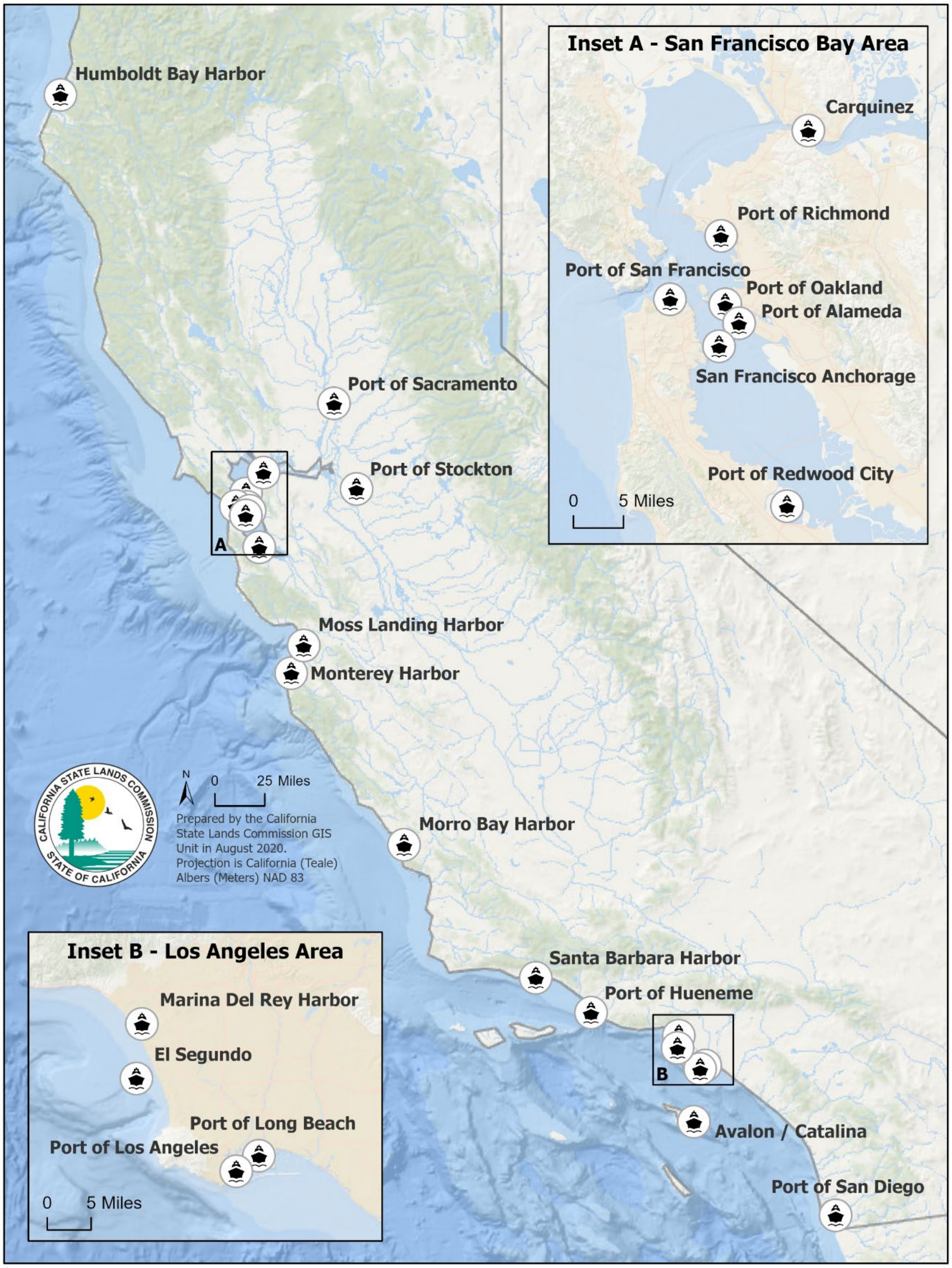


Figure 4-1. Map of California ports recognized by the Marine Invasive Species Program. Insert A: San Francisco Bay Area, Insert B: Los Angeles Area.

4.2 Reporting compliance

2020 and 2021 Reporting Highlights:

- **Ballast Water Management Report:** 89% of vessels complied with the ballast water reporting requirements, up from 83% in 2018 through 2019.
- **Annual Vessel Reporting Form**: 94% of vessels complied with the AVRF reporting requirements, up from 88% in 2018 through 2019.

Ballast Water Management Report:

MISP staff assesses reporting compliance by tracking vessel arrivals and determining if a BWMR was submitted for each arrival. MISP staff notifies vessel owners, operators, and agents via email if a BWMR is not received. During 2020 and 2021, 485 reports (2.7% of the BWMRs submitted) were received after staff sent this notification, increasing the overall submission rate and strengthening the Commission’s data.

Overall, 89 percent of vessel arrivals in 2020 and 2021 submitted a BWMR, compared to 83 percent from 2018 and 2019.

Annual Vessel Reporting Form:

MISP staff assesses AVRF reporting compliance by determining if an AVRF was submitted for each vessel that makes at least one arrival during each calendar year. The compliance submission rate in 2020 and 2021 was 94 percent, compared to 88 percent in 2018 and 2019.

Although AVRFs were required to be submitted via MISP.io in 2021, some vessels were unable to use the online platform because of internet limitations while sailing. In 2021, the Commission granted 99 vessels (4.7% of total AVRFs) an alternative submission method to comply with the reporting requirements, allowing these vessels to submit a PDF via email.

4.3 Vessel Arrivals

2020 and 2021 Vessel Arrival Highlights:

- Vessel arrivals decreased 13% from 2019 (11,199 arrivals) to 2020 (9,765 arrivals), which coincides with the COVID-19 pandemic impact on vessel traffic.
- 55% of all arrivals during 2020 and 2021 occurred in southern California, while 45% of all arrivals occurred in northern California.

The California Marine Invasive Species Program agencies (see Section 3) track vessel arrivals to collect fees, understand arrival patterns, and assess compliance through on-board inspections.

4.3.1 Qualifying Arrivals and Fee Collection

The Commission contracts with the California Department of Tax and Fee Administration (CDTFA) to collect a $1,000 fee from the owner or operator of a vessel for each qualifying arrival. A qualifying arrival is a vessel arriving at a California port from a port outside of California (Table 4-1; Pub. Resources Code, § 71215). Once a vessel leaves California waters, it will be assessed the fee upon the next arrival at a California port. Vessels moving from one port in California to another are not assessed a fee for subsequent arrivals within California.

The CDTFA, like the Commission, receives daily reports from California's regional marine exchanges to generate a list of all arrivals at California ports. These reports are reviewed by CDFTA to identify qualifying arrivals; vessel accounts are billed based on this arrival information. Between January 1, 2020, and December 31, 2021, an average of 431 vessel arrivals were billed per month. The collection rate for 2020 and 2021 was 99 percent (Table 4-1).

All received fees are deposited into the Marine Invasive Species Control Fund (MISCF). The MISCF supports all MISP operations and personnel, including the Commission's contract with CDTFA for collecting fees. The MISP receives no funding from the California General Fund.

Table 4-1. Annual Summary of Collected Marine Invasive Species Program Fees

Year	Total Voyages	Total Fees Billed ($)	Payments Recd. for Period* ($)
2010	5,966	5,017,100	5,009,473
2011	6,104	5,188,400	5,143,239
2012	5,246	4,459,100	4,356,722
2013	5,572	4,766,200	4,662,171
2014	5,632	4,787,200	4,697,234
2015	5,517	4,682,650	4,517,499
2016	5,676	4,816,100	4,706,981
2017	5,860	5,647,150	5,516,217
2018	5,688	5,688,000	5,567,095
2019	5,715	5,715,000	5,617,923
2020	5,098	4,728,423	4,643,965
2021	5,250	5,250,000	5,260,421
TOTAL	**121,323**	**78,384,934**	**77,227,174**

*Actual amounts received may exceed amount billed because of penalties and interest charges.

4.3.2 Vessel arrival patterns

Unlike the CDTFA that tracks only qualifying arrivals, the Commission tracks all vessel arrivals. California ports received 9,765 arrivals in 2020 and 10,276 arrivals in 2021. Vessel arrivals decreased 13 percent from 2019 (11,199 arrivals) to 2020, which coincides with the 2019 corona virus disease (COVID-19) pandemic's impact on vessel traffic (Figure 4-2).

Vessel arrivals began declining in early 2020 and continued declining through the middle of 2021 (Figure 4-4), as shipping companies adjusted cargo operations in response to the COVID-19 pandemic-related port disruptions, health guidelines, and personnel shortages.

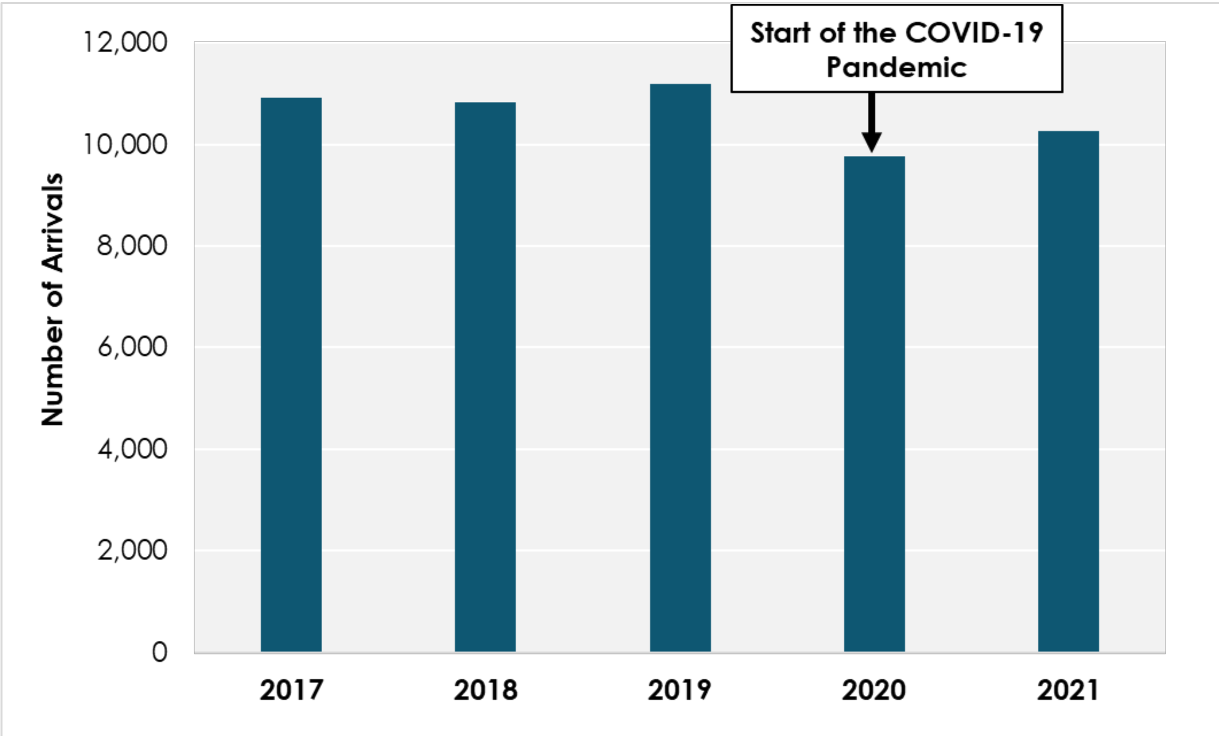


Figure 4-2. Number of vessel arrivals at California ports since 2017.

The impacts of the COVID-19 pandemic are prominent when reviewing monthly arrivals data. In April 2020, during the early stages of the pandemic, vessel arrivals in both northern and southern California steeply decreased (Figure 4-3). By the middle of 2021, vessel arrivals slowly rebounded to pre-pandemic levels for southern California but remained depressed for northern California throughout 2021.

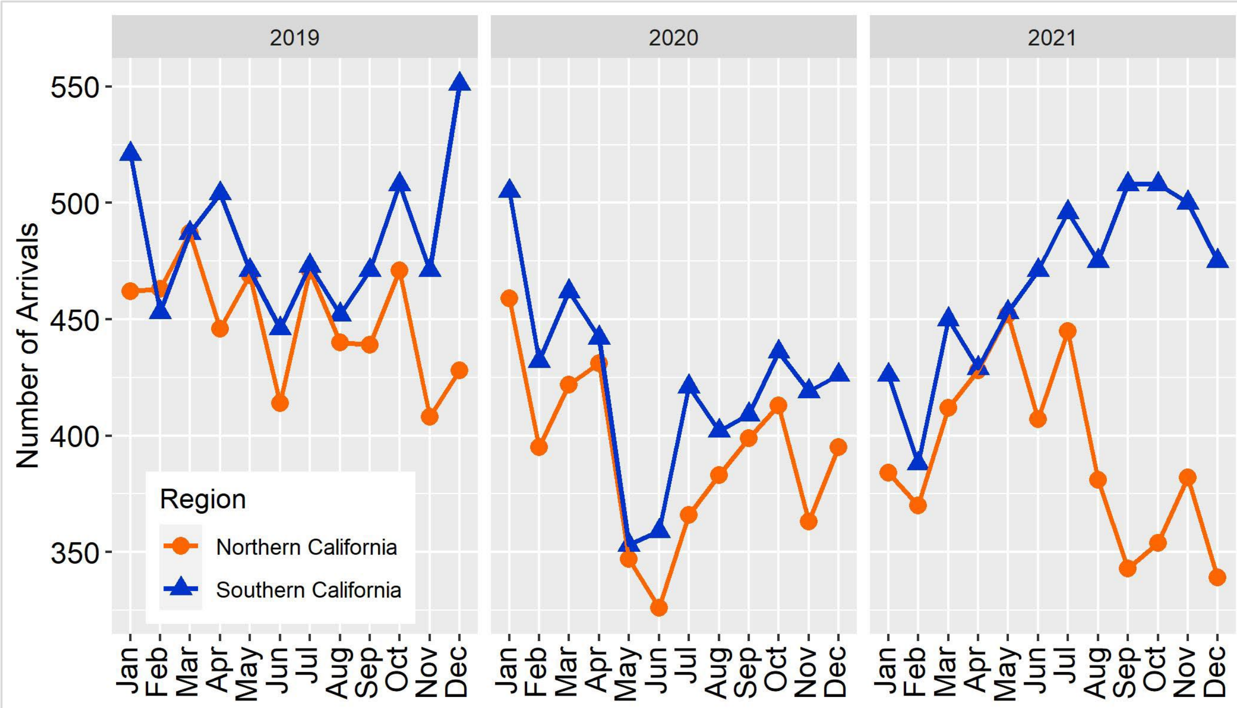


Figure 4-3. Number of vessel arrivals at northern and southern California ports from 2019 through 2021.

Regardless of COVID-19 pandemic-related impacts, southern California ports received 55 percent of all California arrivals during 2020 and 2021, while northern California ports received 45 percent. The Los Angeles/Long Beach port complex received an average of 4,316 (standard deviation ± 250) arrivals for each year of the reporting period, which was more than 45 percent of the total California arrivals and 81 percent of southern California arrivals (Figure 4-4). The Port of Oakland received an average of 1,123 (standard deviation ± 262) arrivals during 2020 and 2021, which was 12 percent of the total California arrivals and 26 percent of northern California arrivals.

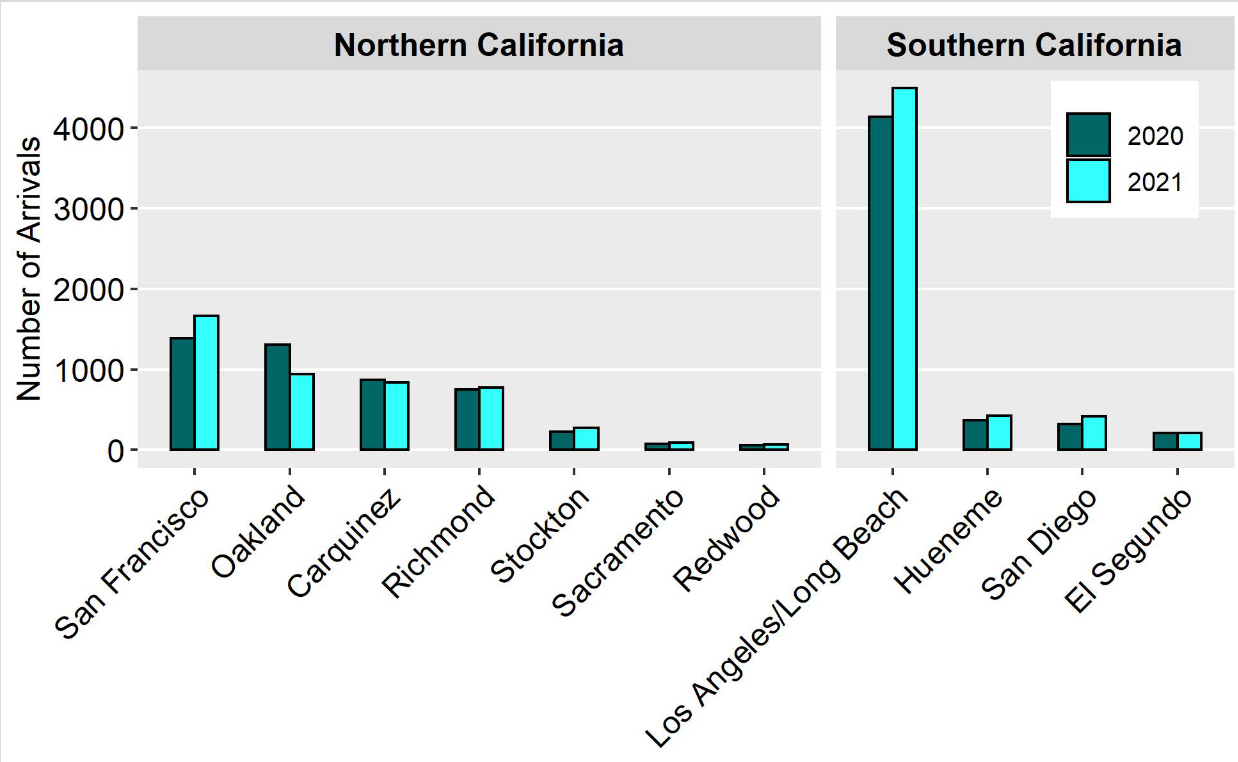


Figure 4-4. Total number of arrivals per port during 2020 and 2021. San Francisco includes anchorage arrivals.

4.3.3 Vessel Arrival Patterns by Vessel Type

Local industries, product demand, port infrastructure, and the economy contribute to the type of vessels arriving at California ports (see Table 4-2 for vessel type descriptions). During 2020 and 2021, container and tank vessels accounted for 61 percent of all vessel arrivals at California ports (Figure 4-5). Over the last 10 years, these two vessel types have consistently contributed to more than half of the total arrivals at California ports (Ceballos Osuna et al. 2021).

The COVID-19 pandemic caused passenger vessels to suspend operations during parts of 2020 and 2021. As a result, there were only 577 passenger vessel arrivals during 2020 and 2021 (Figure 4-5), a decrease of 58 percent from 2018 through 2019.

There were 2,882 bulk vessel arrivals in California during 2020 and 2021 (Figure 4-5), with 1,773 arrivals at northern California ports and 1,109 arrivals at southern California ports. The bulk terminals located in northern California received more vessel arrivals because of the variety of bulk products (e.g., rice, lumber, and sugar) that are imported and exported in the region.

Table 4-2. Description of the vessel type categories used in this report.

VESSEL TYPE	Description
Auto	Vessels designed to carry wheeled cargo such as cars, trucks, semi-trailer trucks, trailers, and railroad cars, that are driven on and off the ship on their own wheels or using a platform vehicle.
Bulk	Vessels designed to carry large quantities of dry cargo such as grain, coal, and ore.
Container	Cargo vessels that carry all their load in truck-size intermodal containers in a technique called "containerization."
General	Vessels designed to carry a wide variety of cargo. Cranes and other heavy equipment needed to move, load, and unload cargo are usually on board.
Offshore Supply Ships	Offshore Supply Ships are a vessel category specially designed to supply offshore oil and gas platforms.
Other	Broad group including fishing, research, and cable laying vessels.
Passenger	A vessel whose primary function is to carry passengers on the sea; includes cruise vessels and large yachts.
Tank	Vessels designed to transport or store liquids or gases in bulk. Major types of tankships include oil tankers, chemical tankers, and gas carriers.
Articulated tug and barge	An articulated tug and barge combination is a vessel that consists of a barge and a large powerful tug that is positioned in a notch in the stern (rear) of the barge which enables the tug to propel and maneuver the barge.
Barge+Tug	Unmanned flat bottom vessel (barge) that must be tugged or towed by another vessel (tug). In this report, a Barge+Tug is counted as a single unit.

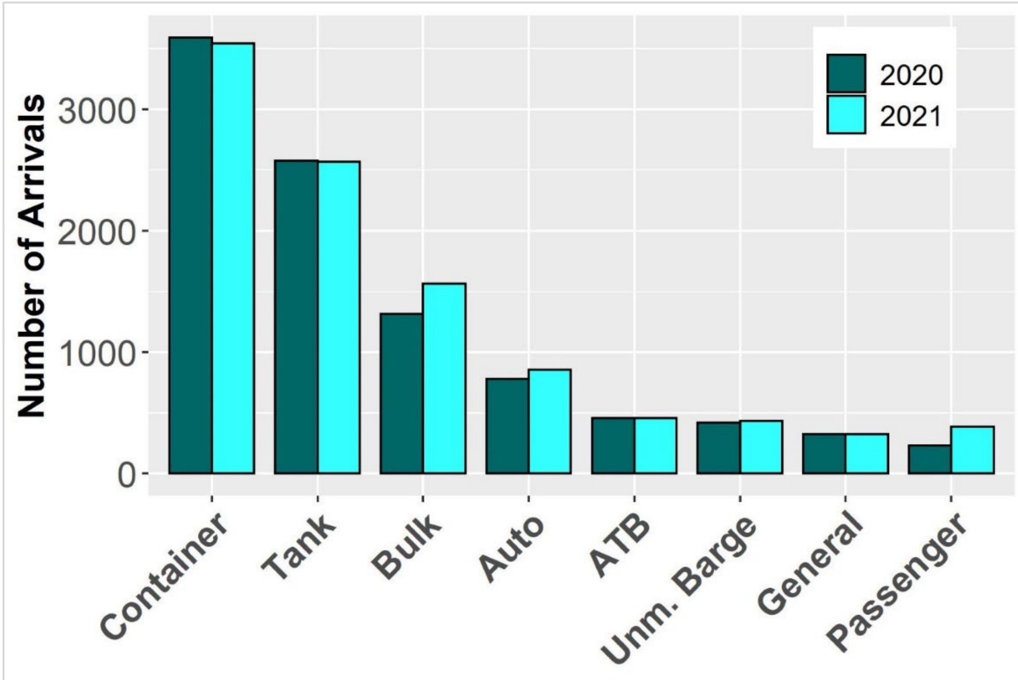


Figure 4-5. Number of vessel arrivals per year by vessel type at California ports during 2020 and 2021.

Where are the vessels coming from?

MISP staff tracks the last port of call (LPOC) for each vessel arrival to understand the potential source of vessel-mediated NIS and because it is used to assess compliance for vessels that use exchange as their ballast water management method. The exchange requirements depend on whether the vessel is coming from a port within or outside of the PCR, and whether the ballast water is sourced within or outside the PCR (Figure 4-6). The definition of the PCR was changed on January 1, 2020, to extend further south and include the Gulf of California. The PCR is now defined as "all coastal waters on the Pacific Coast of North America east of 154 degrees W longitude and north of 20 degrees N latitude, inclusive of the Gulf of California" (Public Resources Code section 71200, subdivision (l)).

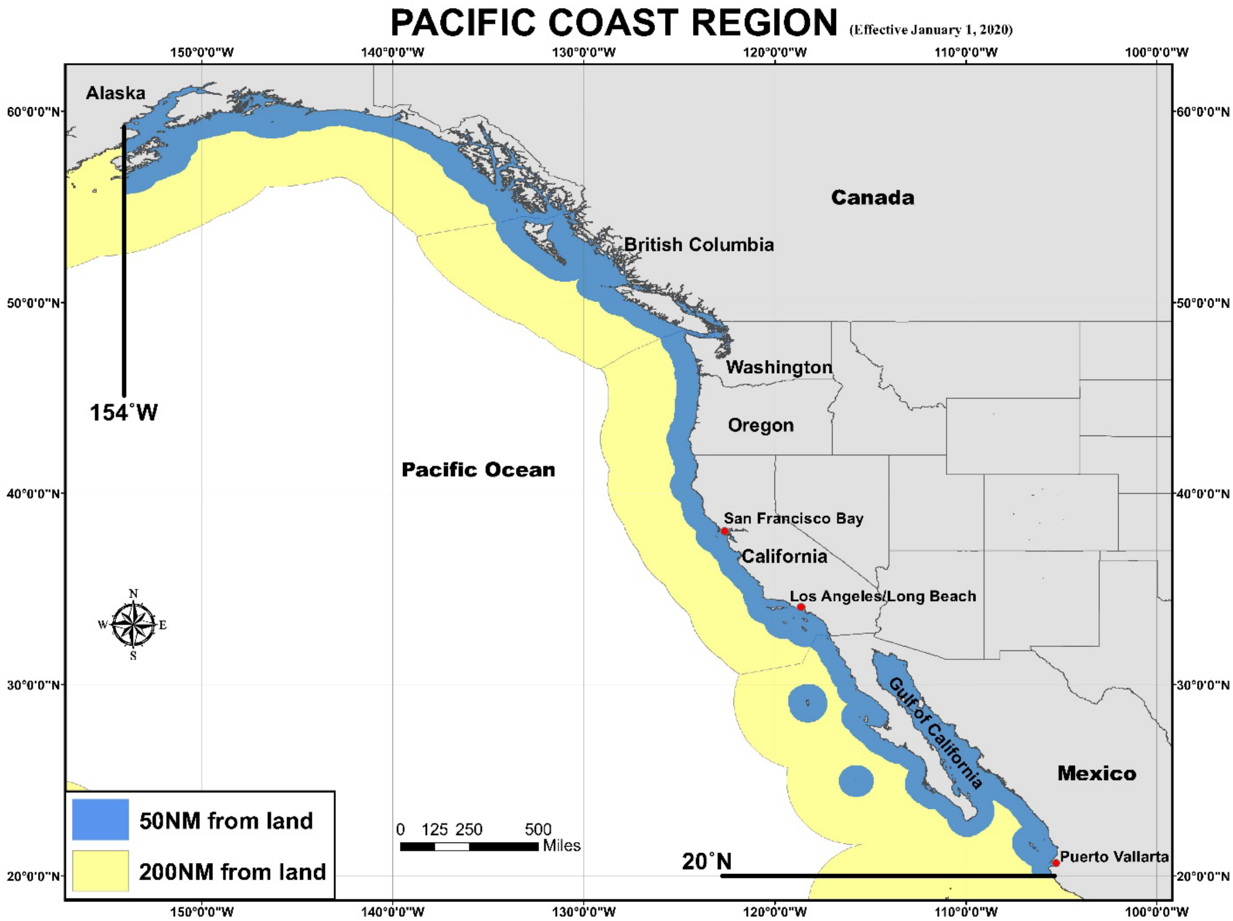


Figure 4-6. Map of the Pacific Coast Region (PCR) recognized by the Marine Invasive Species Program.

Consistent with patterns observed in the two previous MISP biennial reports (Scianni et al. 2019, Ceballos Osuna et al. 2021), 60 percent of southern California arrivals reported a LPOC outside the PCR. This pattern is driven primarily by arrivals at the Los Angeles/Long Beach port complex, which is often the first arrival port for many oceangoing vessels arriving from Asia to ports on the west coast of North America. For northern California ports, only 19 percent of arrivals were from outside the PCR (Figure 4-7), reflecting an influx of vessel arrivals from southern California ports and frequent voyages between ports within San Francisco Bay.

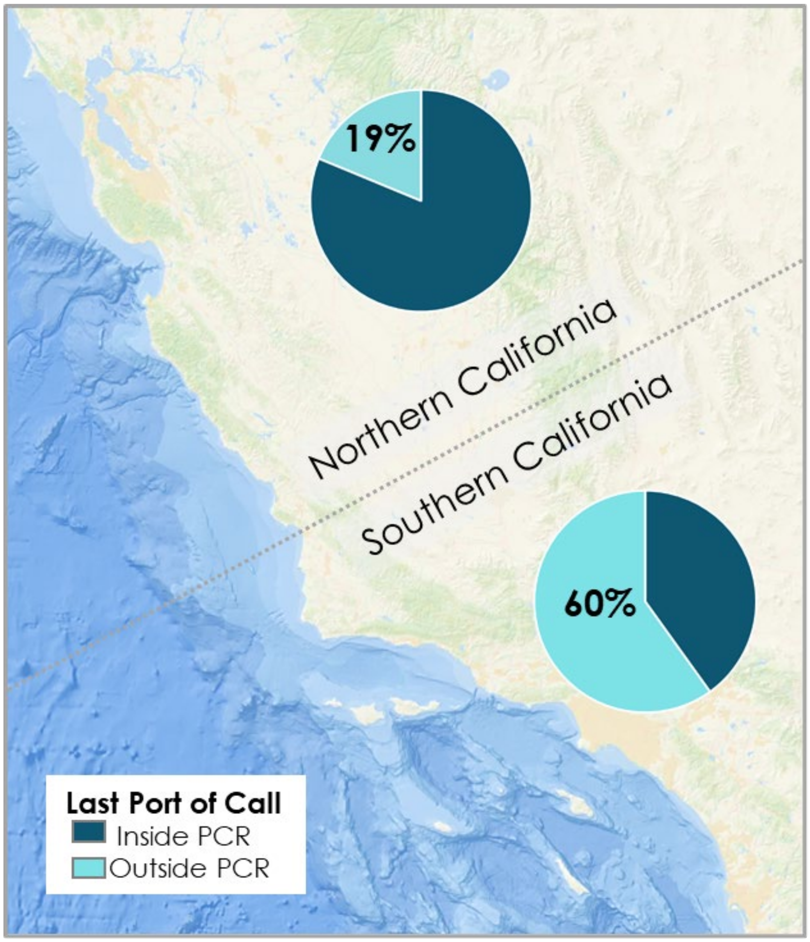


Figure 4-7. Percentage of vessel arrivals at California ports during 2020 and 2021 where the last port of call is inside or outside the Pacific Coast Region (PCR).

4.4 Vessel Inspections

2020 and 2021 Ballast Water Compliance and Enforcement Highlights

Commission Field Staff inspected:

- 23% of the 20,041 vessel arrivals at California ports
- 27% of arrivals that were practical for inspection were inspected. 2,900 arrivals were impractical for inspection because field operations staff do not have access to a boat or other means to inspect vessel arrivals at Avalon (Catalina Island) and San Francisco Bay anchorages
- 73% of high priority arrivals that were practical for inspection.

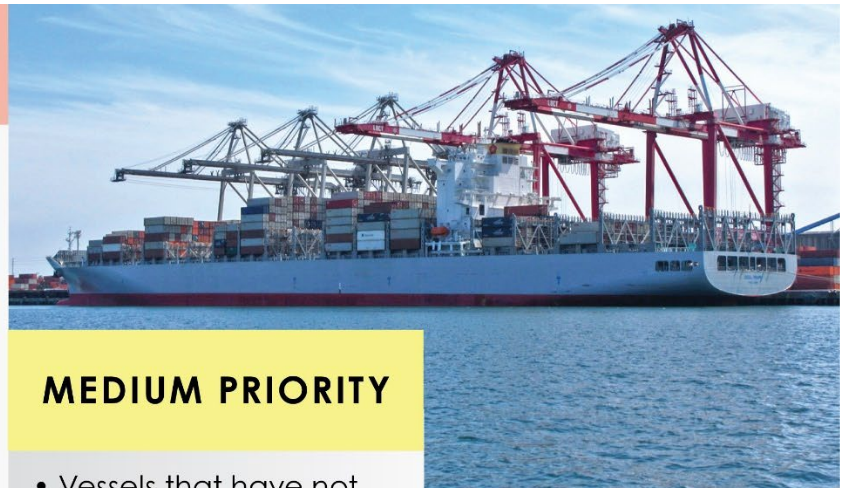
The Commission's Marine Environmental Protection Division (MEPD) field operations staff monitors and inspects vessel arrivals at California ports to assess compliance with the MISA and associated ballast water and biofouling regulations. The MEPD has two field offices, the Northern California Field Office in Hercules, and the Southern California Field Office in Long Beach. All vessels that are subject to the MISA are required to allow Commission staff on board access for inspections. The Commission is mandated to inspect at least 25 percent of all vessel arrivals. Vessel inspections can include:

- Examining ballast water and biofouling management documents and reporting forms
- Assessing the compliance of ballast water and biofouling management activities
- Collecting ballast water samples, if necessary
- Examining vessel hulls at the waterline for signs of biofouling
- Providing outreach on MISP requirements and invasive species (https://www.slc.ca.gov/marine-invasive-species-program/information-for-vessels-arriving-at-california-ports/)
- Answering vessel crews' questions about California's biofouling and ballast water requirements

Vessels that are determined to be noncompliant with management, recordkeeping, or reporting requirements receive a written violation, a letter of noncompliance, or notice of violation. Violations may result in an enforcement action (See table of Violation Classes and Penalties in Appendix C).

4.4.1 Prioritizing Arrivals for Inspection

As previously mentioned, MISP staff uses advanced arrival notifications from the regional marine exchanges to enter each arrival into the MISP database's vessel schedule. Once an arrival is entered into the vessel schedule, it is assigned an inspection priority level (High, Medium, Low, or not a priority for inspection) using the following criteria:



HIGH PRIORITY

- Vessels that have not been inspected in the past five years or vessels new to California
- Vessels discharging ballast water
- First arrival after becoming subject to the biofouling regulations
- Vessels with an unresolved previous violation
- Vessels that have changed their name
- Vessels with errors in their submitted ballast water and biofouling reporting forms
- Suspicion of improper ballast water or biofouling management

MEDIUM PRIORITY

- Vessels that have not been inspected in the past 12 months
- Vessels with resolved previous violations

LOW PRIORITY

- Vessels that have not been inspected in the past three months
- Vessels with an installed ballast water treatment system that are not discharging ballast water

These prioritization criteria are designed to reduce the risk of vessel-mediated species introductions by targeting vessels based on their interactions with the natural environment (e.g., vessels discharging ballast water). Additionally, to increase their awareness of California's ballast water and biofouling requirements, vessel arrivals are a high priority for inspection if a vessel is likely to have new vessel crews

4.4.2 Inspection Data

During 2020 and 2021, California received 20,041 vessel arrivals, corresponding to approximately 27 arrivals at California ports per day.

During this two-year period, Commission staff inspected 23 percent of all vessel arrivals at California ports (Table 5-3). However, 2,900 of the arrivals could not practicably be inspected because field operations staff do not have access to a boat or other means to inspect vessel arrivals at Avalon (Catalina Island) and San Francisco Bay anchorages. When removing vessel arrivals that are not practicable to inspect, Commission staff inspected 27 percent of arrivals.

Table 4-3. Vessel inspections during 2020 and 2021 at California ports.

YEAR	Region	Total Arrivals	Inspectable Arrivals*	Inspected Arrivals	Percent Inspected (from total arrivals)	Percent Inspected (from inspectable arrivals*)
2020	**Northern California**	4,699	3,390	682	15%	20%
2020	**Southern California**	5,066	5,048	1,521	30%	30%
2021	**Northern California**	4,697	3,148	773	16%	25%
2021	**Southern California**	5,579	5,554	1,669	30%	30%
2020-2021	**Entire State**	**20,041**	**17,140**	**4,645**	**23%**	**27%**

*Inspectable arrivals are those that can be accessed by the Commission field operations staff (excludes all arrivals at Avalon (Catalina Island) and all anchorage arrivals in San Francisco Bay).

The MISP's goal is to inspect 100 percent of inspectable high priority arrivals. During the years analyzed for this report, 4,621 arrivals (23% of all California port arrivals) were categorized as high priority for inspection, but 375 of these arrivals were impractical for inspection. During 2020 and 2021, staff inspected 73 percent of high priority vessel arrivals that were practical for inspection, and the remaining high priority arrivals that were practical for inspection were not inspected due to personnel shortages.

In March of 2020, Commission staff responded to the COVID-19 pandemic by temporarily implementing a practice to not enter the inside of vessels during inspections to limit person-to-person contact. This practice remained in effect throughout the rest of 2020 and all of 2021. This temporary practice resulted in dockside inspections and inspections on the vessel's deck.

4.4.3 Inspections: Looking Forward

To address personnel shortages, the Commission is committed to continue building on the changes to the hiring process mentioned in the 2021 MISP biennial report to the California Legislature (Ceballos Osuna et al. 2021). These changes were intended to improve the recruitment process to identify a larger and more diverse candidate pool. Resulting from this effort, the Commission has hired eight MEPD Marine Safety Inspectors/Specialists since 2020. However, at the time of this report, the Commission has five vacant MEPD Marine Safety Inspector/Specialist positions because of retirements and resignations. The Commission is planning to fill the vacancies in 2023.

Commission staff members are continuously working to improve inspection processes to improve compliance, meet policy goals, and meet inspection mandates.

5 BALLAST WATER VECTOR ANALYSIS

This section highlights the MISP's statutory and regulatory tools for reducing the risk of NIS introductions via ballast water discharge from vessels arriving at California ports.

5.1 Ballast Water Management Requirements

Vessels that discharge ballast water in California must follow best management practices to reduce the likelihood of introducing NIS into California waters.

Ballast Water Best Management Practices

- Discharge only the minimum amount of ballast water essential for operations
- Clean ballast tanks in accordance with applicable laws
- Minimize the discharge of ballast water in:
    - Marine sanctuaries
    - Marine preserves
    - Marine parks
    - Coral reefs
- Minimize the 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 NIS 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
    - Turbid waters or areas where tidal flushing is known to be poor
    - In darkness when bottom-dwelling organisms may rise in the water column
    - Areas where sediments have been disturbed (e.g., near dredging operations or where propellers may have recently stirred up sediment)

In addition to aforementioned best management practices, vessels arriving at California ports during 2020 and 2021were required to manage ballast water using one of following management methods before discharging ballast water in California waters (Public Resources Code section 71204.3 and California Code of Regulations, title 2, section 2284):

- Exchange ballast water at a minimum specified distance from land prior to discharge (see section 5.1.1)
- Use a Commission-approved alternative management method such as a ballast water treatment system (BWTS, see section 5.1.2) or freshwater from a Public Water System
- Take on and discharge ballast water at the same location (within one nautical mile (NM) of each other)
- Discharge to a Commission-approved shore-based reception facility (none currently exist in California; for more information on a Commission-funded study of the feasibility of shore-based treatment in California, see Commission 2018)
- Under extraordinary circumstances, exchange ballast water within an area agreed to in advance by the Commission in consultation with the USCG

Additionally, if a vessel's ballast water management threatens the safety of the vessel, its crew, or its passengers, then the vessel master, operator or person in charge can decide if managing ballast water is unsafe. If this determination is made, then the vessel master, operator or person in charge must do the following:

- Take all feasible measures, based on the best available technologies economically achievable, that do not compromise the safety of the vessel to minimize the discharge of ballast water containing nonindigenous species into the waters of the state, or waters that may impact waters of the state.
- Record a description of how ballast water management practice was unsafe in the ballast water log,
- Notify the commission of the determination at the earliest practicable time.

During the reporting period, vessels that discharged ballast water in California mainly managed ballast water using exchange, a ballast water treatment system, or a ballast water treatment system in combination with exchange.

5.1.1 Ballast Water Exchange

The intent of ballast water exchange is to replace the typically biologically rich water that is loaded into a vessel's ballast tanks in a port, or near the coast, with open ocean water (typically biologically poor). Coastal organisms that are found in bays, estuaries, and shallow coasts are not expected to survive or reproduce in the open ocean due to chemical, physical, and biological differences between the habitat types. Open ocean organisms are likewise not expected to survive in coastal waters (Cohen 1998).

Although ballast water exchange is intended to reduce the risk of introducing aquatic NIS into California waters, its effectiveness is variable. Some studies have shown that ballast water exchange eliminates between 70-99 percent of the organisms taken into a ballast tank (Parsons 1998, Zhang and Dickman 1999, USCG 2001, Wonham et al. 2001, MacIsaac et al. 2002). As a result, even after exchange, some coastal aquatic organisms can remain in the ballast water to potentially be released when a vessel discharges.

Most vessels can exchange ballast water, and this management practice typically does not require any special structural modification. However, exchange may pose a risk to vessel stability and safety depending on vessel design, weather conditions, and human factors. A proper exchange can take many hours to complete due to ballast pumping and piping capacities.

Methods of Ballast Water Exchange

Ballast water exchange is defined as replacing the water in a ballast tank using either of the following methods:

- **Flow-through exchange** – Flushing ballast water by continuously displacing water from the tank with mid-ocean water until at least 300% of the tank volume has been exchanged. (Pub. Resources Code, § 71200, subd. (h)(1).)
- **Empty-Refill exchange** – Pumping out each tank's ballast water taken on in ports, or estuarine or territorial waters, until it is empty or as close to 100% empty as is safe, then refilling the tank with mid-ocean waters. (Pub. Resources Code, § 71200, subd. (h)(2).)

The location where ballast water is required to be exchanged depends on a vessel's LPOC and the ballast water source based on the following:

- Vessels arriving from outside of the PCR (Figure 4-6), or carrying ballast water sourced from outside the PCR, are required to complete a mid-ocean ballast water exchange at least 200 NM from any land, including islands, in water at least 2,000 meters (m) deep (Public Resources Code sections 71200, subdivision (i), and 71204.3, subdivision (c))
- Vessels arriving from within the PCR, and with ballast water sourced within the PCR, are required to complete a near-coastal ballast water exchange in waters at least 50 NM from any land, including islands, in water more than 200 m deep (California Code of Regulations, title 2, section 2284)

5.1.2 Alternative Ballast Water Management Methods

The Commission has the authority to approve ballast water management methods that are alternatives to ballast water exchange. Occasionally, vessels request to use freshwater from a Public Water System as ballast, which is approved on a case-by-case basis. The most frequently requested and approved alternative during the reporting period was the use of BWTS. The Commission granted approval for the use of BWTSs that meet at least one of the following requirements:

- Type approved by the USCG
- Accepted by the USCG as an Alternate Management System (AMS). AMSs are BWTSs that:
    1. Are type approved by another country according to International Maritime Organization (IMO) guidelines
    2. Are not type approved by the USCG
- Installed on a vessel as part of a testing and approval process through the USCG Shipboard Technology Evaluation Program

Ballast Water Treatment Systems vs. Ballast Water Management Systems

Ballast Water Treatment Systems (BWTS) and Ballast Water Management Systems are water treatment technologies designed to decrease the number of organisms in ballast water. The terms are used interchangeably and may be seen on the Ballast Water Management Report, in California ballast water management requirements, and other MISP documents.

5.1.3 Ballast Water Recordkeeping and Reporting Requirements

In addition to managing all discharged ballast water, vessels that arrive at a California port must also comply with the MISA's reporting and recordkeeping requirements, including the following:

- Maintain a vessel-specific ballast water management plan that describes the ballast water management strategy employed by the vessel
- Train crew on the application of the management plan and keep proof of that training on board
- Maintain a separate ballast water log that outlines the ballast water management activities for each ballast water tank on board the vessel
- Report their ballast water management practices to the Commission via a USCG form (Ballast Water Management Report) (Appendix A and Section 4.1 of this report)

5.2 Ballast Water Discharge Patterns

2020 and 2021 Ballast Water Discharge Pattern Highlights:

- 12% of vessels reported discharging ballast water in California waters during the reporting period.
- Between 2012 and 2021, the lowest reported annual volume discharged was in 2020, when a total of 9.6 million metric tons (MMT) were discharged. This volume is16% below the annual average from 2012 to 2021. This reflects the impact of COVID-19 Pandemic on vessel activities.
- In 2020, 36% (396 arrivals) of discharging vessel arrivals used a ballast water treatment system, increasing to 50% in 2021.
- The volume of discharged ballast water that was managed using only a ballast water treatment system increased 586% from 2017 (0.7 MMT) to 2021 (4.8 MMT).

The risk of ballast water-mediated species introductions depends on several factors:

- The volume of ballast water discharge
- The frequency of ballast water discharge
- The number of organisms in the ballast water discharge
- Whether the organisms in the discharged ballast water will survive and reproduce in the location where they are introduced
- The management of ballast water

The highest risk vessels are those that do not manage ballast water that was sourced within 50 NM of land prior to discharging.

Commission staff analyzes ballast water discharge patterns to increase knowledge and understanding of vessel discharge trends and ballast water management strategies. Commission staff use these results to better protect California waters from invasive species by developing compliance assessment policies and recommending changes to the ballast water management requirements.

During 2020 and 2021, 88 percent of arriving vessels that reported to the Commission did not discharge any ballast water in California waters. Some arriving vessels do not have ballast water on board and others retain their ballast water, depending on cargo operations (Figure 2-1, Ballast water operations). Vessels that retain all ballast water on board present no risk for ballast-mediated NIS introductions because if no ballast water is discharged, no organisms within the ballast water are released into the environment.

The remaining 12 percent of arrivals that reported to the Commission discharged ballast water in California (Figure 5-1). No vessels reported discharging unmanaged ballast water that was sourced within 50 nautical from land during the reporting period.

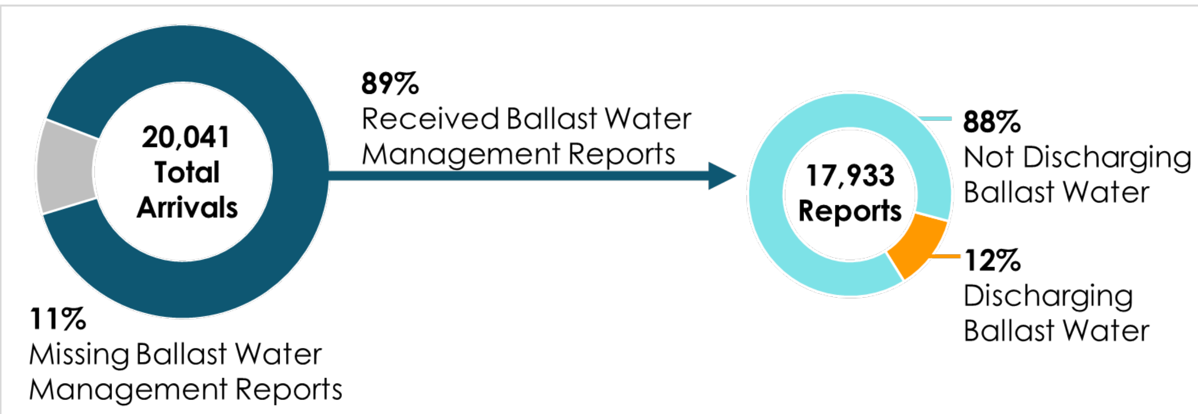


Figure 5-1. Percentage of ballast water management reports submitted and percentage of arrivals reporting ballast water discharges in California during 2020 and 2021.

During 2020 and 2021, vessels reported discharging 19.03 million metric tons (MMT) of ballast water into California waters (an average of 9.5 [standard deviation ± 0.5] MMT per year), which declined 17 percent from the previous reporting period (2018-2019), and 16 percent from the 10-year average. The reported volume of ballast water discharged into California waters varied between 2012 and 2021 from 9.6 to 12.6 MMT. The lowest reported volume from 2012 through 2021 was in 2020, which coincides with the decrease in vessel arrivals caused by the COVID-19 pandemic (Figure 5-2).

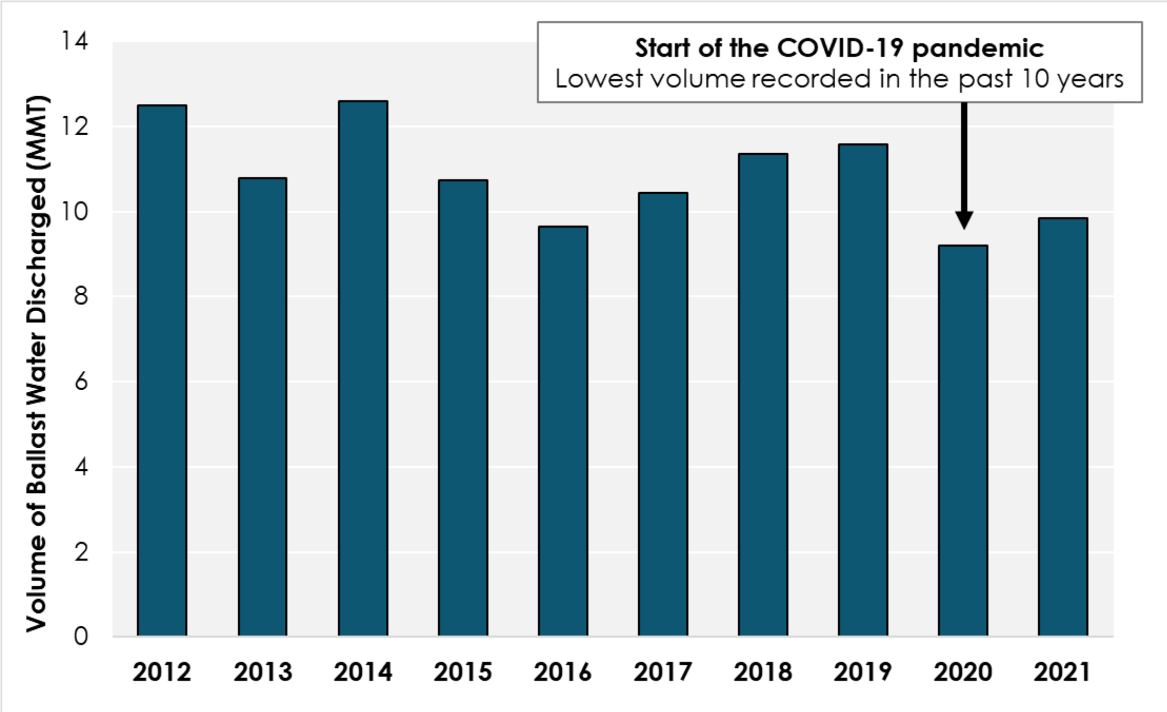


Figure 5-2. Total volume of reported ballast water discharge in California waters annually from 2012 through 2021. MMT: Million metric tons.

5.2.1 Ballast Water Discharge Patterns by Location

Vessels discharged 11.6 MMT into northern California ports (61% of the total volume discharged into California) and 7.4 MMT into southern California ports (39% of the volume discharged into California) during 2020 and 2021 (Figure 5-3A). The Los Angeles/Long Beach port complex received 37 percent of all the ballast water discharged during those two years, followed by Richmond (21%) and Carquinez (16%) (Figure 5-3B).

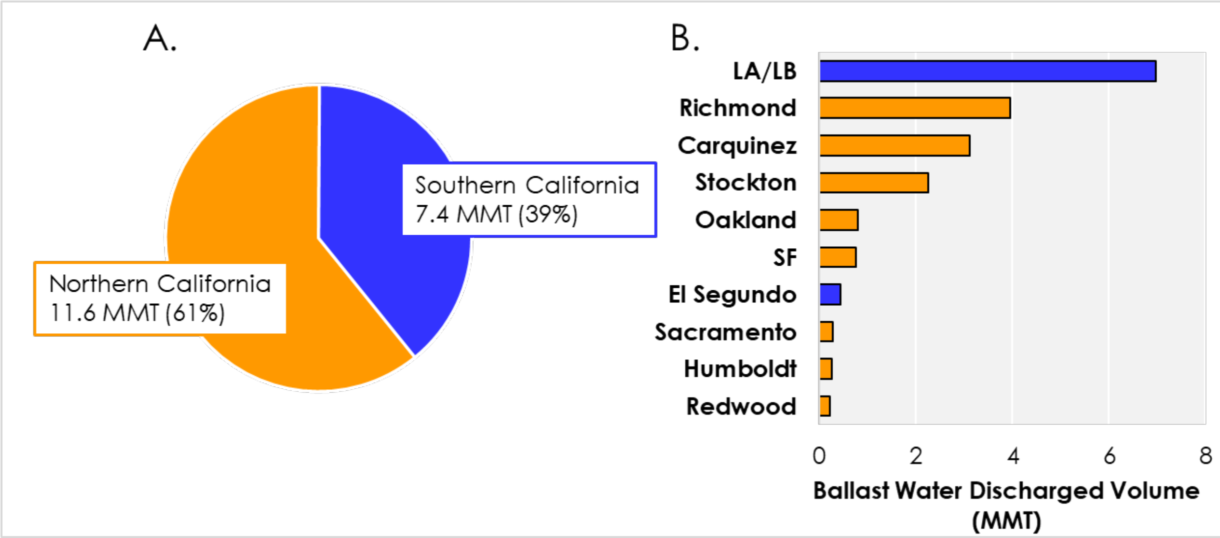


Figure 5-3. **A.** Volume and percentage of ballast water discharged in northern and southern California during 2020 and 2021. **B.** Volume of ballast water discharged at each port. Ports with less than 0.1 MMT discharged were removed from the graph. LA/LB: Los Angeles/Long Beach; SF: San Francisco.

5.2.2 Ballast Water Discharge Patterns by Vessel Type

Bulk (9.8 MMT) and tank (9.6 MMT) vessels discharged more ballast water than all other types of vessels combined during 2020 and 2021 (Figure 5-4). The pattern observed in these two vessel types is consistent with previous years because their cargo operations often require all-or-nothing ballast water discharges (i.e., partial discharges are rare). In contrast, auto carriers discharge ballast water infrequently and in small volumes (Figure 5-4).

Passenger vessels frequently discharged a relatively small volume of ballast water, however, that pattern changed during 2020 and 2021 because there was less passenger vessel activity resulting from the COVID-19 pandemic.

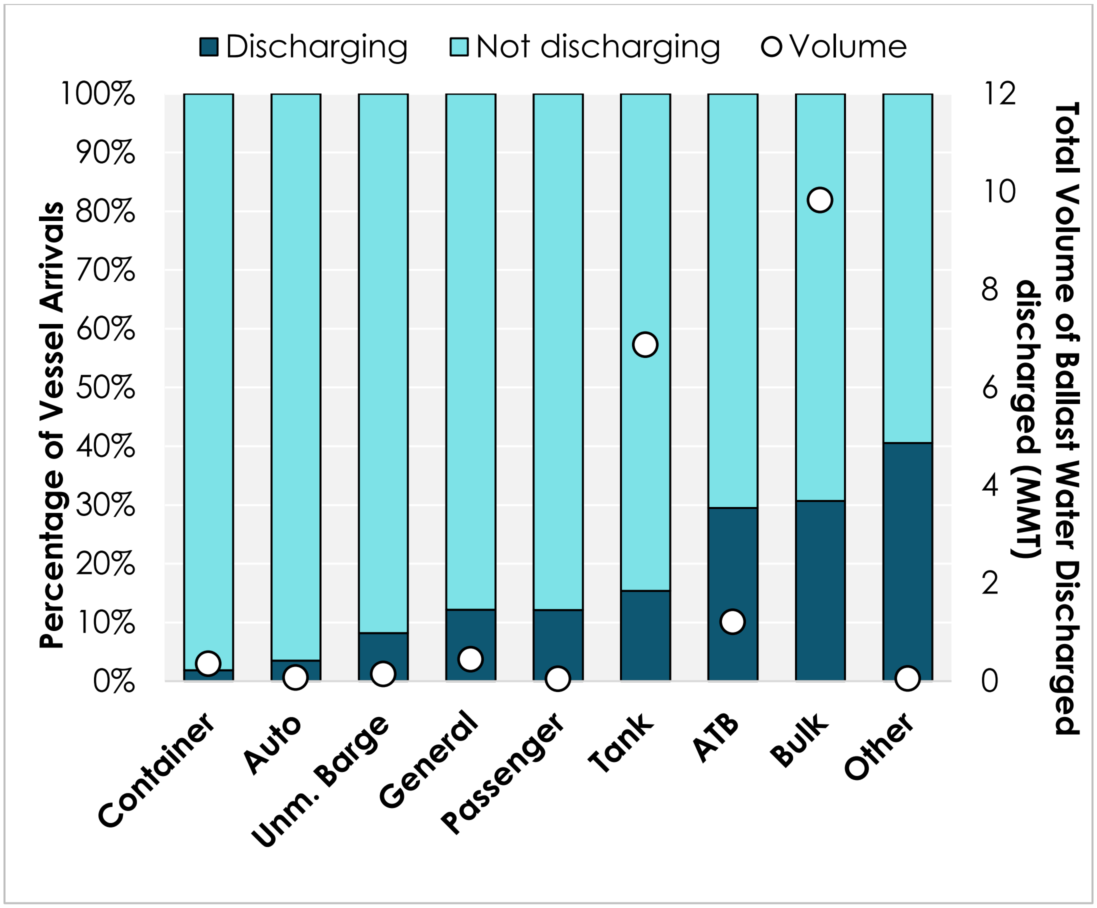


Figure 5-4. Ballast water discharge patterns by vessel type (percentage of arrivals and total volume of ballast water discharged) as reported during 2020 and 2021 (MMT: million metric tons). See Table 4-2 for a description of vessel types.

The operational patterns of tank vessel operations were initially impacted by the COVID-19 pandemic but recovered in 2021 (Figure 5-5A and Figure 5-5B). Bulk vessel arrivals were steady throughout the COVID-19 pandemic, however the volume of ballast water discharged by bulk vessels increased during 2021.

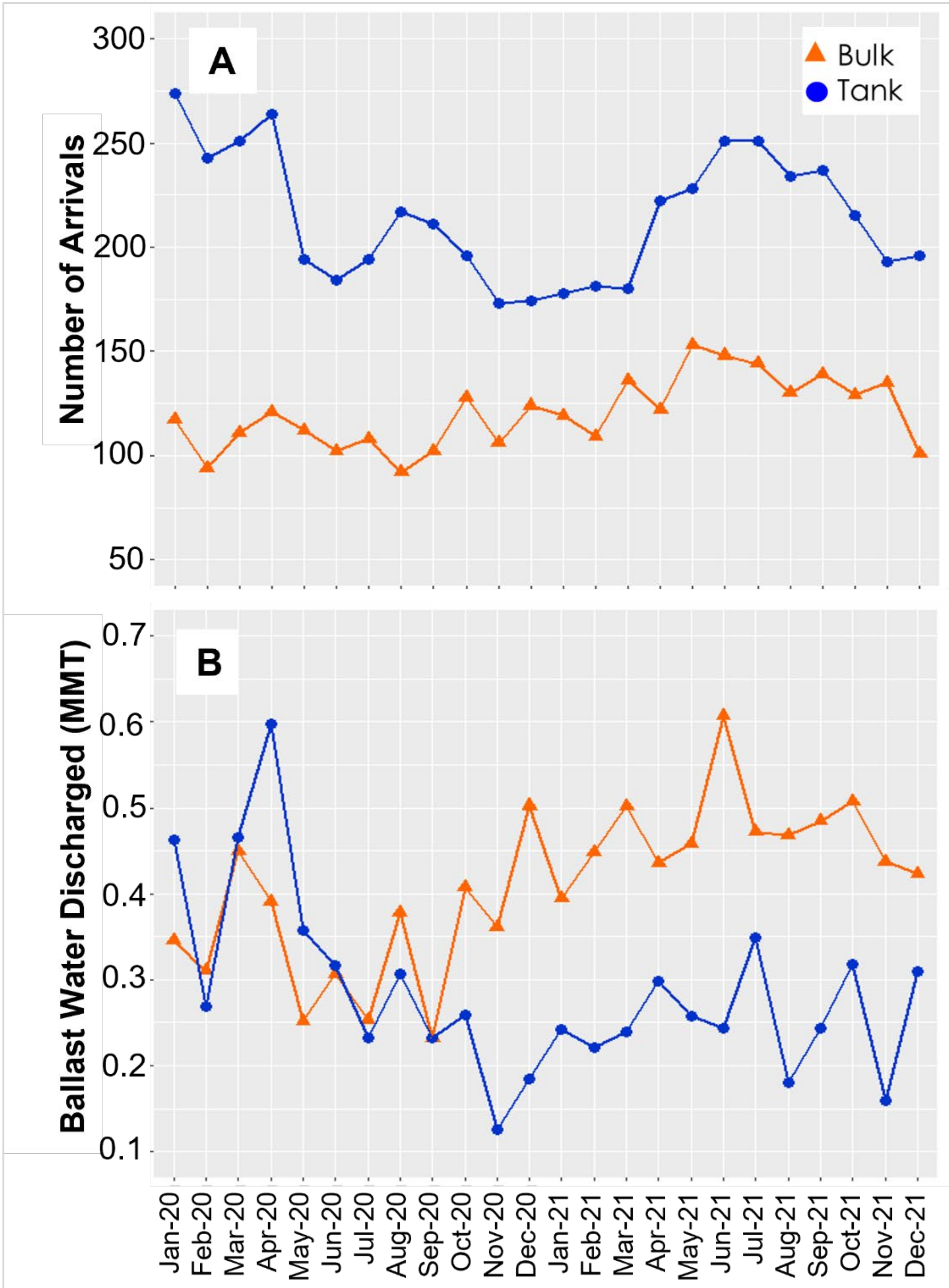


Figure 5-5 A. Total ballast water discharged by tank and bulk vessels in all California ports during 2020 and 2021. **B.** Number of bulk and tank vessel arrivals to California ports during 2020 and 2021.

5.2.3 Ballast Water Discharge Patterns by Management Type

Historically, vessels that discharged in California waters primarily managed their ballast water using only ballast water exchange. For example, during 2018 and 2019 (see Ceballos et al. 2021), 69 percent (2283 arrivals) of discharging arrivals reported using only ballast water exchange. During the current reporting period, the percentage of discharging vessels using only ballast water exchange decreased to 29 percent (319 arrivals) in 2020 and 24 percent (267 arrivals) in 2021 (Figure 5-6). As ballast water exchange has decreased, ballast water treatment system use (without other methods in combination) has increased. From 2018 through 2019, 24 percent of discharging arrivals used a BWTS, increasing to 36 percent (396 arrivals) in 2020 and 50 percent (549 arrivals) in 2021 (Figure 5-6).

In 2017, as the number of vessels using a treatment system sharply increased, Commission staff began evaluating the frequency of vessels using more than one ballast water management strategy (i.e., combinations of ballast water management strategies) (Figure 5-6). Some arriving vessels reported using ballast water treatment plus ballast water exchange. Vessels using treatment plus exchange increased from 7 percent (76 arrivals) in 2020 to 11 percent (116 arrivals) in 2021 (Figure 5-6). Other vessels used additional mixed strategies, with some combination of treatment, exchange, other alternatives (e.g., public water source), or no management (e.g., same source and discharge location, mid-ocean source).

Overall, 47 percent (515 arrivals) of discharging vessels used ballast water treatment in some form (either treatment only, treatment plus exchange, or mixed strategies with treatment) during 2020. In 2021, 66 percent (727 arrivals) of discharging vessels used ballast water treatment in some form (Figure 5-6).

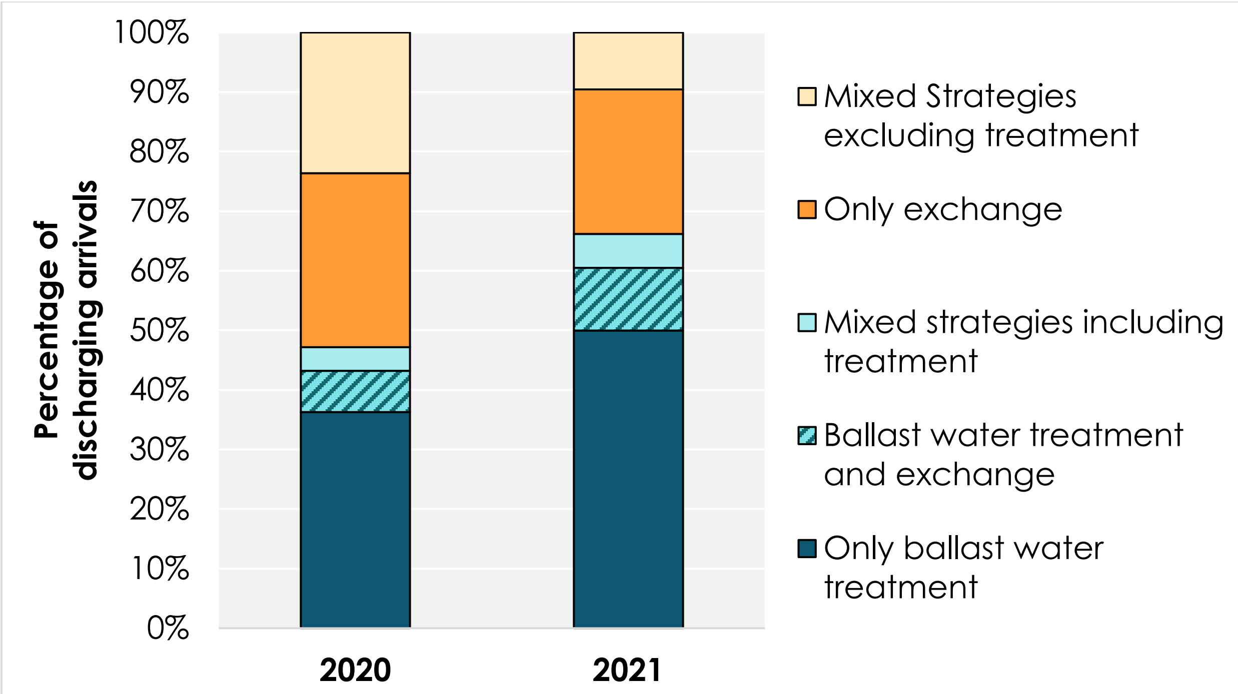


Figure 5-6. The percentage of discharging arrivals using each ballast water management strategy. Mixed strategies refer to arrivals where not all the tanks were managed using the same strategy (e.g., mid-ocean source and ballast water exchange).

Like the increase of vessels using BWTSs to manage ballast water, the overall volume of treated ballast water that is discharged has also increased. Discharged ballast water that was only treated (i.e., not in combination with exchange or any other method) increased 586 percent, from 2017 (0.7 MMT) to 2021 (4.8 MMT) (Figure 5-7). During the same period, the volume of discharged ballast water that was only exchanged decreased 64 percent, from 7.5 MMT in 2017 to 2.7 MMT in 2021 (Figure 5-7).

Vessels are transitioning from ballast water exchange to ballast water treatment. The total volume of treated ballast water increased by over 600 percent from 2017 (0.9 MMT) to 2021 (6.4 MMT). Furthermore, the 6.4 MMT of treated ballast water discharged in California in 2021 represents 66 percent of all ballast water discharged in California that year (Figure 5-7).

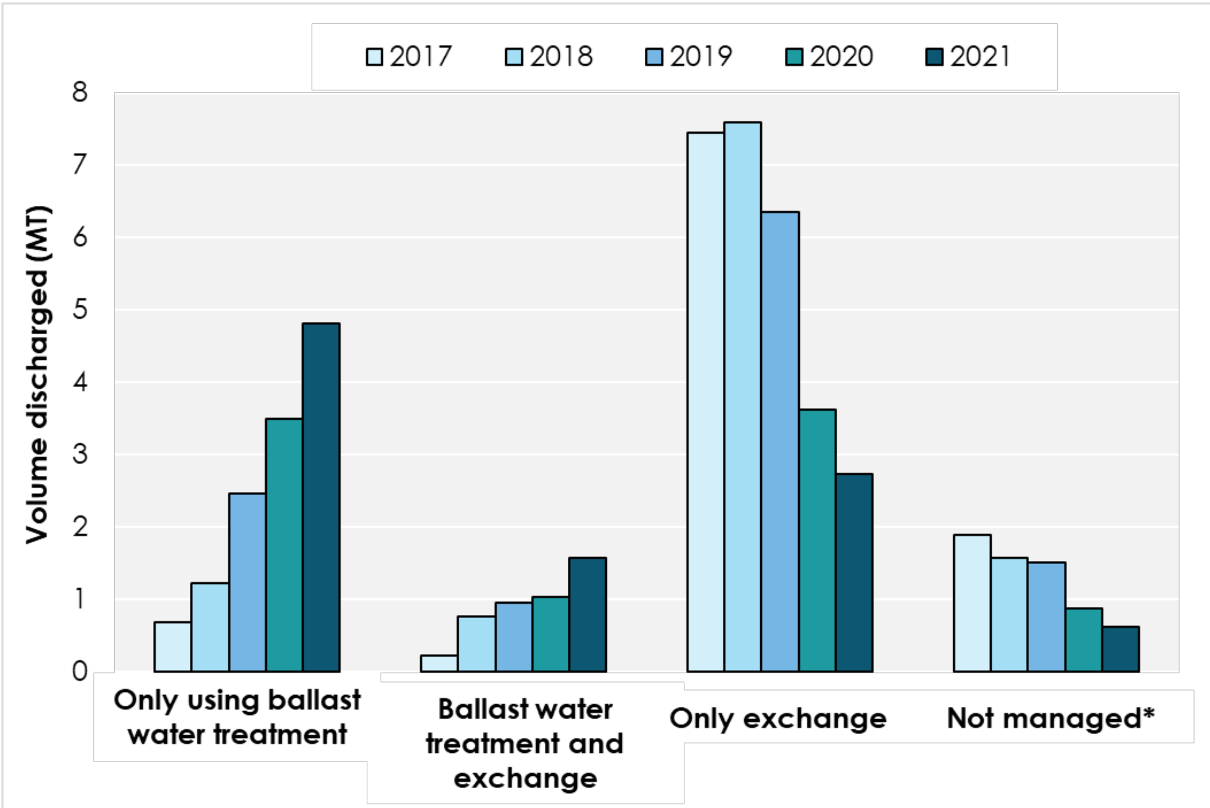


Figure 5-7. Volume of ballast water discharged in California from 2017 to 2021 separated by the management strategy used. *Not managed water includes mostly water that was sourced in the open ocean; however, a small proportion of this volume comes from discharges that failed to comply with the management requirements (see section 5.3 Ballast Water Compliance Assessment and Enforcement)

5.3 Ballast Water Compliance Assessment and Enforcement

Ballast Water Compliance and Enforcement Highlights

- 99.7% (19 million metric tons) of the reported ballast water discharged in California waters during 2020 and 2021 was compliant with ballast water management requirements.
- Bulk and tank vessels discharged 81% (40,841 MT) of the noncompliant ballast water that was discharged during 2020 and 2021(0.03% of all ballast water discharged).
- Commission staff's actions helped to prevent 17 vessels from discharging potentially noncompliant ballast water.

Commission staff assesses compliance with the MISA and associated regulations by analyzing the ballast water management and discharge information reported on the BWMR. The analysis has 3 phases:

1) **Pre-arrival assessment:** Review the BWMR discharge information in advance of vessel arrival to determine the type of management used and identify potential noncompliant discharges
2) **Onboard inspections:** Validate the submitted information upon arrival and assess recordkeeping requirements
3) **Post-arrival assessment:** Analyze ballast water management and discharge data for all arrivals within a given period (e.g., monthly, quarterly)

Pre-arrival Assessment:

The requirement to submit a BWMR at least 24 hours in advance of arrival provides Commission staff with opportunities to review BWMRs and identify vessels that intend to discharge. When possible, staff reviews the reported ballast water management information and maps the ballast water exchange locations (latitude and longitude) using Google Earth Pro to identify potential noncompliant discharges. When staff identifies a vessel that is planning to discharge ballast water in California that was not managed properly (e.g., the vessel did not exchange ballast water at an appropriate distance from land), staff immediately notifies the vessel and vessel's agent about the potential violation.

This pre-arrival assessment and notification process provides the vessel master with an opportunity to either properly manage ballast water prior to discharge or, if possible, change operations so the ballast water can be retained onboard upon arrival in California. This process allows staff to prevent potential new species introductions from ballast water discharges.

Onboard Inspection

Onboard vessel inspections by field operations staff (see section 4.4) are a critical part of the compliance assessment process. During an inspection, staff:

- Reviews all required documentation kept on board the vessel (e.g., ballast water management plan and log books)
- Determines if ballast water management followed the requirements (e.g., correct exchange location depending on the origin of the voyage and source of the ballast water, see PCR map Figure 4-6)
- Verifies that management activities are recorded in the ballast water log book
- Documents violations if needed (documented violations are later analyzed by administrative staff to determine enforcement options)
- Provides outreach to the vessel's crew to increase awareness and understanding of the ballast water requirements

Post-arrival Assessment: Detailed Analysis of Ballast Water Management Data

Staff assesses ballast water management compliance with the MISA and associated regulations for all discharging vessels using the Geographic Information Systems (GIS) software ArcMap. The GIS analysis accurately maps reported ballast water source and management locations (latitude and longitude), which helps staff identify noncompliant activities. ArcMap is capable of handling very large datasets, allowing staff to evaluate the ballast water management practices of all vessel arrivals statewide on a quarterly basis.

5.3.1 Ballast Water Discharge Compliance

During 2020 and 2021, 99.7 percent of reported ballast water discharged in California was compliant with the MISA and associated regulations. The noncompliant discharged ballast water (50,187 metric tons (MT); 0.3 percent of all reported ballast water discharged) was either exchanged in the wrong location or was not managed at all (Figure 5-8).

Ballast water source is an important consideration when assessing the risk of noncompliant water discharged in California. Fifty-nine percent of the noncompliant ballast water discharged (29,403 MT) during the reporting period was sourced from North American ports (mostly from U.S. Pacific Coast and Canada Pacific Coast) (Figure 5-8).

Some of the noncompliant ballast water that was discharged after exchange in the wrong location, is likely due to confusion about the definition of “land” when determining the required ballast water exchange distance from land. Vessel crews may not realize that islands (PCR map; Figure 4-6) are included in the definition of land and conduct exchanges that are not at the required distances.

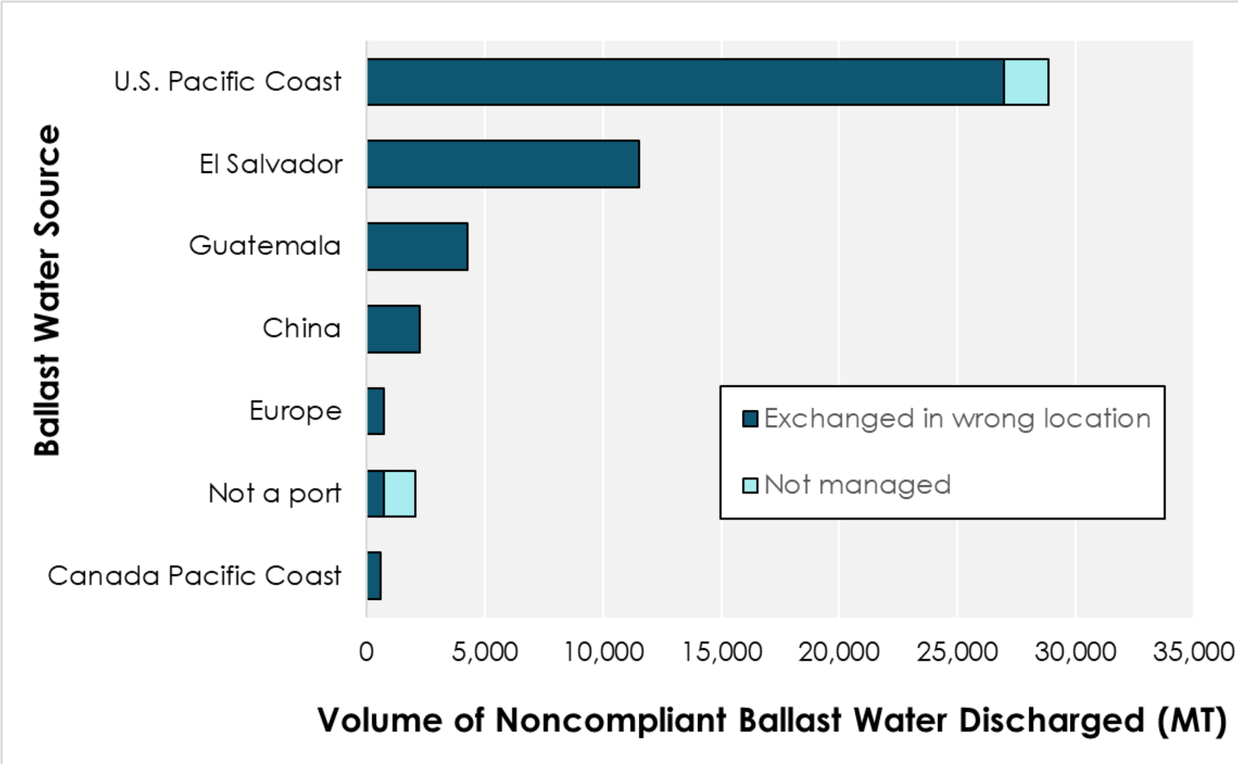


Figure 5-8. Reported source of noncompliant ballast water discharged in California waters during 2020 and 2021. "Not a port" represents discharges where the source was primarily from coastal waters, but not at a legally required distance from land. Twenty-two vessel arrivals represent all noncompliant ballast water discharged; half of which arrived from U.S. Pacific Coast ports. MT: metric tons.

During the reporting period, the unmanaged ballast water discharged in California was sourced primarily from coastal waters at a noncompliant distance from land (Figure 5-8, see requirements for ballast water management in section 5.1) and at U.S. Pacific Coast ports. The total unmanaged ballast water discharged was less than 0.1 percent (3,220 MT) of all reported ballast water discharged during 2020 and 2021.

5.3.2 Preventing Noncompliant Discharges

Commission staff review the reported ballast water management activities to assess potential noncompliant discharges (pre-arrival assessment). If a vessel reported that it is carrying ballast water that will be noncompliant if discharged at a California port, staff alerts the vessel and agent via email. This process gives vessel crews the opportunity to complete corrective actions before discharging noncompliant waters in California.

During 2020 and 2021, Commission staff sent 23 "potential violation" notifications to vessels and their agents. Commission staff works with the vessel crew and agent to ensure a minimal amount of noncompliant ballast water was discharged into California waters. Seventeen of the 23 alerted vessels decided to change their operations, avoiding the discharge of 141,563 MT of noncompliant ballast water in California (Figure 5-9). In these cases, vessels used a variety of methods to avoid discharging noncompliant ballast water (e.g., retaining the ballast water, exchanging at the appropriate distance, discharging outside of California's jurisdiction). Four vessels decided to discharge the noncompliant ballast water after the notification, and they were issued violations. Two vessels that were contacted about potential noncompliance had originally reported their management incorrectly and resubmitted their Ballast Water Management Reports to show that the ballast water was appropriately managed (Figure 5-9).

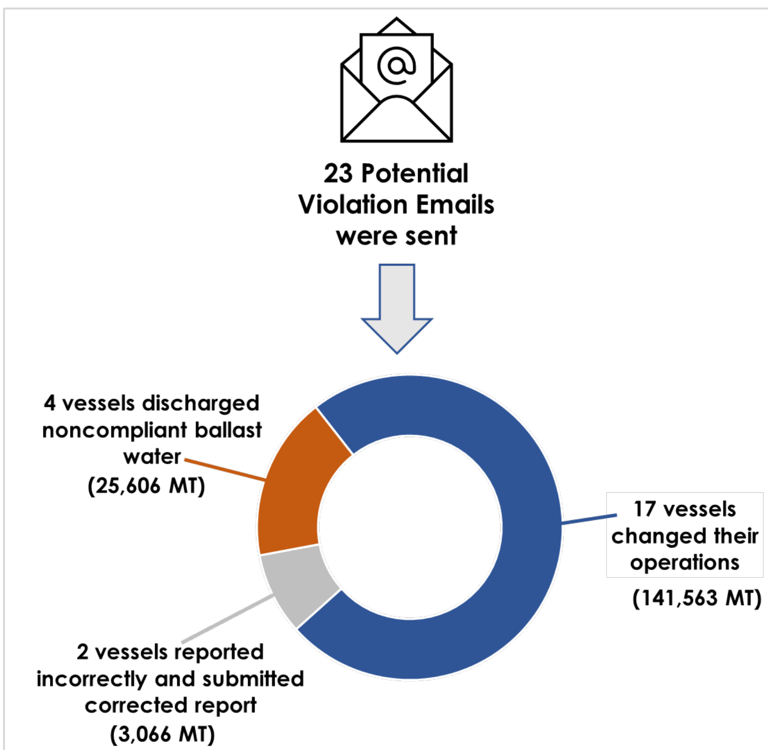


Figure 5-9. Number of potential violation emails sent to vessels intending to discharge potential noncompliant ballast water in California waters during 2020 and 2021. MT: metric tons.

The potentially noncompliant ballast water (141,563 MT) that was prevented from being discharged is almost three times larger than the total volume of noncompliant ballast water discharged (50,187 MT) during 2020 and 2021. This prevention of noncompliant ballast water discharge shows that the pre-arrival assessment and potential violation emails significantly reduce the risk of NIS introductions and improves compliance rates.

5.3.3 Ballast Water Violations and Enforcement

The Commission implements enforcement regulations (California Code of Regulations, title 2, section 2299.01 et seq.) that provide a clear and transparent process for enforcing MISA and regulatory violations. These enforcement procedures outline the violation classes and establish maximum penalties for these violation classes. (For more information on the MISA Enforcement Regulations including violation classification and penalty schedule, see Appendix C.)

There are two types of violations of the MISA:

- **Administrative violations**: These are violations of the reporting (document submission) requirements and the recordkeeping requirements (see section 5.1.3).
- **Operational violations**: These are violations for noncompliant ballast water management.

During 2020 and 2021, there were 374 administrative violations issued during inspections. Most vessels (between 90-94 percent depending on the type of violation) corrected the noncompliance after receiving the *Letter of Noncompliance*.

Vessels that are not compliant with ballast water management requirements under the MISA (i.e., operational violations) are issued a *Notice of Violation* and may be subject to enforcement action (see Appendix C). During 2020 and 2021, only 0.1 percent of vessel arrivals (22 total arrivals) violated the MISA ballast water management requirements and associated regulations. The Commission initiated seven enforcement actions in 2020 and 2021. All seven enforcement actions are settled totaling $141,840 in penalties. The penalties ranged from $5,000 to $105,000 and were based on the violation class (number of tank violations and the type of noncompliant ballast water management). Penalties from enforcement actions are deposited into the Marine Invasive Species Control Fund.

One of the factors considered during the enforcement process and penalty assessment is the environmental match of the noncompliant ballast water that is discharged. Environmental match refers to the similarity of environmental parameters (e.g., salinity and temperature; Spalding et al. 2007) between source and discharge locations and is a major driver for a successful NIS introduction and subsequent establishment (Ricciardi et al. 2013). Ballast water that is not managed prior to discharge represents the greatest NIS introduction risk because the organisms taken up at the source are directly discharged in the recipient port. However, this risk is even greater if the source and discharge ports have a strong environmental match. Thus, environmental match is one of the factors considered during the enforcement process and penalty assessment.

5.4 Ballast Water Research Review

As required by Public Resources Code 71212, subdivision (e), this biennial report includes summaries of recent research relating to vessel vectors and NIS introductions. This section summarizes selected peer-reviewed articles focused on ballast water that were published during 2020 and 2021.

Understanding the similarities or differences between ballast water source and discharge ports can be an important component for identifying and managing invasion risk. **Fernandes et al. (2021)** conducted a case study for Maranhão Harbor, Brazil, comparing samples from 357 global ports between 2010 and 2019 to measure "relative overall risk" from each region. Ten regions were found to have high NIS introduction risk, and ballast water sourced from these regions should warrant appropriate management. Similarities between source and discharge ports were also discussed by **Outinen et al. (2021),** who evaluated case studies to identify when exemptions to the requirements in the IMO Ballast Water Management Convention should be allowed. The authors found that exemptions should not be considered common alternatives to ballast water management.

Ballast water source and recipient regions were also the focus of **Bradie and Bailey (2020),** who created a science-based risk management tool specifically for resource managers who may not be scientists. The tool combines environmental matching between the origin and destination ports and introduction effort (e.g., the number and frequency of released organisms). Report data generated an estimated risk and ranking for more accessible decision making. The tool was tested to be effective in Canada and can be customized for specific needs in other regions of the world. This tool would be an aid to increase partnerships between scientists and managers that estimate invasion risk from incoming vessels.

Most ballast water research is focused on the introduction of invertebrates and algae; however marine pathogens are an overlooked and concerning. **Soleimani et al. (2021)** showed that aquatic organisms such as *Escherichia coli* (*E. coli*) and *Vibrio cholerae* can be spread through ballast water activities. Thirty-four samples were collected at the Bushehr port along the Persian Gulf. Several samples were positive for *E. coli*, highlighting the risk of these pathogens being spread via ballast water.

Modern BWTSs use physical and chemical methods to treat ballast water and reduce the likelihood of NIS introductions. **Lakshmi et al. (2021),** evaluated a variety of BWTS types and found that a combination of mechanical treatment (e.g., cavitation, ultrasound) and filtration was the most effective approach. **Casas-Monroy and Bailey (2021)** also evaluated the effectiveness of BWTSs when compared to ballast water exchange by counting the number and diversity of phytoplankton. Samples from vessels with BWTSs had significantly lower phytoplankton abundance, and slightly lower abundance of harmful NIS in comparison with ballast water exchange. Using both BWTSs and ballast water exchange, as suggested by **Bradie et al. (2021)** produced the best results for eliminating organisms in ballast water. Vessels using ballast water exchange and treatment were compared to vessels that used exchange only to evaluate the concentration of nonindigenous zooplankton in discharged ballast water at fresh water, brackish, and marine habitats in Canada. Vessels using exchange and treatment had fewer NIS when transiting from marine to freshwater ports. This combined approach can be practiced by all vessels to reduce NIS invasion risk when compared to only one of the methods, while each can serve as a backup plan for the other when either system fails. An alternative to ballast water treatment or exchange was described by **Jeba Kumar et al. (2020)**, using onshore wells or seabed gallery systems (i.e., subsurface wells or intakes that provide naturally filtered groundwater) to serve as a pretreatment to desalinate seawater and reduce seawater pollution for vessels that travel to freshwater ports. This method is affordable, environmentally safe, non-destructive, and can be applied world-wide.

Nevertheless, there are more treatment options than just vessel-based treatment. **Wang and Corbett (2021)** and **Wang et al. (2021)** compared conventional vessel-based BWTSs to alternative barge-based technologies to evaluate their relative cost-effectiveness at meeting existing global standards and a more stringent set of standards (i.e., California interim and final standards that have not been implemented). The authors found that vessel-based treatment systems were the most fitting for meeting the existing global standards, whereas barge-based treatment was the most fitting for meeting stricter standards.

Regardless of the management method used, ballast water discharges need to be assessed for compliance with discharge standards. **Casas-Monroy et al. (2020)** compared three ballast water sample collection techniques (in-line, in-tank, and Van Dorn bottle methods) on five voyages to determine the best sampling location and method to obtain accurate results during compliance sampling. The phytoplankton community showed a patchy pattern in all voyages, however statistical analysis identified in-line collection as the most reliable technique. Similarly, **Drake et al. (2021)** evaluated the size and placement of sample probes to assess compliance with International Organization for Standardization (ISO) standards. Through their survey, only 15 percent of the 72 sample ports fully aligned with the ISO standard. Ensuring that sample ports match the ISO standard should be prioritized in the future for accurate ballast water sampling to assess compliance with ballast water regulations.

Several studies evaluated the appropriateness of existing biotic and abiotic challenge conditions for ballast water type approval tests (i.e., standardized concentrations of organisms and sediments, or other abiotic substances, meant to provide a challenge to the BWTS under evaluation). **Soler-Figueroa et al. (2020)** examined the biotic side of the spectrum and questioned the IMO and USCG organism concentration-based challenge conditions. Thirty-one ports were sampled, none of the ports met the land-based challenge condition, and only 32 percent met the shipboard conditions. Additionally, 71 percent of the samples contained organisms that are unregulated under current standards and evaluation methods. Furthermore, **Rivas Zaballos et al. (2021)** pointed out the IMO Ballast Water Management Convention does not cover phytoplankton that are less than 10 µm. Three photosynthetic species, all smaller than 10 µm, were assessed and tested with ultraviolet (UV) light treatment. *Synechococcus* sp. have high UV resistance and high abundances globally and should be considered as standard test organisms for biological tests in ballast water samples. In contrast, **Gollasch and David (2021)** found issues surrounding the abiotic side of BWTS testing, by collecting 97 samples from ballast tanks over ten years. The authors found that total suspended solids and particulate organic carbon were found in much higher concentrations in the uptake samples than what was required as challenge conditions. The authors state that current challenge condition requirements do not reflect real world situations and do not appropriately challenge BWTSs.

In addition to issues with BWTS testing conditions, the actual performance of some of these systems in certain situations did not meet expectations. **Jang et al. (2020)** performed tests of three BWTSs treating highly turbid water (i.e., water with heavy sediment loads) from Shanghai, China. All three failed to properly operate due to clogging. The authors suggested bypassing filtration on ballast uptake and instead applying filtration during discharge. **SGS Global Marine Services (2020)** also presented data showing unreliable results for BWTSs during biological efficacy tests during on board commissioning evaluations after installation. Of the 95 BWTS sampled in nine countries, twenty-one percent failed to meet the IMO standards. Approximately 25 percent of the tests included both rapid indicative (i.e., proxy-based) and detailed complete (i.e., full sampling and counting of live organisms) analyses, and over half of the failures identified by rapid indicative analysis were refuted when detailed complete analyses were performed, suggesting that rapid indicative tests may be unreliable.

5.5 Ballast Water Looking Forward

In 2020, the COVID-19 pandemic caused many vessels to temporarily stop or change operations. Even with the COVID-19 pandemic-related operation challenges during 2020 and 2021, 99.9 percent of vessels complied with California's ballast water management requirements.

On January 1, 2022, as vessels were continuing to return to normal operations, the Commission began implementing ballast water discharge performance standards. Ballast water discharge performance standards are limits on the number of living organisms that may be discharged in ballast water. The performance standards implemented by the Commission are the same as the federal standards implemented by the USCG; found in 33 Code of Federal Regulations (CFR) 151.2030. The standards (see Table 5.1) require the master, owner, or operator of vessels that are subject to the performance standards, to comply with the following requirements:

- Any ballast water discharged must comply with the organism concentration limits of the performance standards
- Maintain and provide access to required documents
- Operate ballast water treatment systems within system manufacturer requirements

Table 5-1 Ballast Water Discharge Performance Standards

Organism Size Class	California/U.S. Federal
Organisms greater than 50µm [1] in minimum dimension	< 10 viable [2]/living [3]] organisms per cubic meter
Organisms 10-50µm in minimum dimension	< 10 viable [2] or living [3] organisms per ml [4]
Escherichia coli	< 250 cfu [5]/100 ml
Intestinal enterococci	< 100 cfu/100 ml
Toxicogenic *Vibrio cholerae* (O1 & O139)	< 1 cfu/100 ml or

[1] Micrometer = one-millionth of a meter
[2] IMO language describing the condition of the organisms
[3] USCG language describing the condition of the organisms
[4] Milliliter = one-thousandth of a liter
[5] Colony-forming unit (cfu) is a standard measure of cultural heterotrophic bacterial numbers

Not all vessels were immediately subject to the performance standards on January 1, 2022. The Commission's implementation schedule is the same as the U.S. federal implementation schedule (Table 5.2).

Table 5-2. USCG Implementation Schedule for Approved Ballast Water Management Methods (33 CFR § 151.2035) adopted by California

New or Existing Vessels	Vessel ballast water capacity (m^3)	Vessel construction date	Vessel compliance deadline
New vessels	All	On or after Dec. 1, 2013	On delivery
Existing vessels	Less than 1,500	Before Dec. 1, 2013	First scheduled dry docking after Jan. 1, 2016
Existing vessels	1,500 - 5,000	Before Dec. 1, 2013	First scheduled dry docking after Jan. 1, 2014
Existing vessels	Greater than 5,000	Before Dec. 1, 2013	First scheduled dry docking after Jan. 1, 2016

The implementation schedule is a phased-in approach based on a vessel's size and its last regularly scheduled out-of-water maintenance. The USCG may grant extensions to the implementation schedule to individual vessels (33 CFR 151.2036). The USCG approach to extending compliance dates is constantly evolving due to situations such as the COVID-19 pandemic. During the pandemic, the USCG issued guidance, through a Marine Safety Bulletin, allowing vessels to request a 12-month extension due to supply chain and workforce disruption (USCG 2021). Interested vessels should contact the USCG for more information on how to request an extension. Many vessels have been granted an extension by the USCG and now have an extended compliance date, which is typically 5 years after the original compliance date. Vessels with an extension must have a letter on board from the USCG approving the extension.

Additionally, vessels may use an AMS for 5 years after the end of their original or extended compliance date if the AMS was installed prior to the original or extended compliance date.

As an alternative to meeting the standards, vessels can use water from a public water system. The ballast tanks and supply lines need to be cleaned before using this alternative method if the ballast tanks have had water from a source other than a public water system. In addition, vessels using water from a public water system need to maintain a receipt, invoice, or other documentation recording which public water system was used.

On January 1, 2022, the Commission began inspecting vessels subject to the performance standards to assess compliance. The initial inspection process involves reviewing documents and data from BWTSs installed on board vessels. Commission staff continue to review and revise the compliance assessment process to identify potential improvements and ensure that State waters are protected from vessel-mediated NIS introductions.

California's previously adopted, but not yet implemented, Interim and Final Ballast Water Discharge Performance Standards (see Commission 2018 for more details) are scheduled to take effect in 2030 and 2040, respectively. These implementation dates were delayed because technology was not available to meet the standards.

6 BIOFOULING VECTOR ANALYSIS

6.1 Biofouling Management Requirements

The California biofouling management regulations (California Code of Regulations, title 2, section 2298 et seq.), implemented in 2017, were the first set of regulations worldwide to require vessels to have a biofouling management plan and biofouling record book. Collectively, these documents describe a vessel's biofouling management strategy and document that the strategy is being implemented. The strategy should include proactive measures (e.g., coatings, maintenance) to prevent biofouling accumulation and reactive measures (e.g., cleaning) to remove biofouling from vessel surfaces when necessary (Scianni and Georgiades 2019). These strategies should change from vessel to vessel based on the vessel's design and operational profile.

California's Biofouling Management Regulations Grace Periods

Because California's Biofouling Management Regulations were the first of their kind, the shipping industry was expected to initially struggle to understand and implement the new requirements. To assist the shipping industry with adjusting to new requirements, a vessel with a noncompliant or missing biofouling management plan or biofouling record book is given 60 days to correct any deficiencies. Following this 60-day grace period, the vessel would be a high priority for inspection to determine if the deficiency was corrected.

The California Biofouling Management Regulations apply to new vessels delivered into service on or after January 1, 2018, and existing vessels that complete a regularly scheduled out-of-water maintenance (i.e., dry docking) on or after January 1, 2018. The rest of this section applies to vessels that are subject to California's Biofouling Management Regulations.

The principal components of the California Biofouling Management Regulations include the following:

- Biofouling management plan

- Biofouling record book
- Strategies to manage biofouling on a vessel's wetted surfaces
- Managing biofouling after extended idle periods (an idle period is a period where a vessel remains in one place and is not actively moving, also referred to as an "extended residency period")
- Submitting the MISP Annual Vessel Reporting Form

6.2 Biofouling Recordkeeping

The Biofouling Management Plan Must:

- Describe the vessel's operational profile (e.g., typical speed, activity level)
- Describe the vessel's maintenance practices for preventing and removing biofouling organisms on a vessel's hull and niche areas (i.e., underwater recesses and appendages; see Figure 6-1)
- Indicate the effective lifespan of the vessel's antifouling coating (i.e., length of time the coating is expected to be effective, based on coating formulation and applied thickness). See section 6.2.2 for more information about antifouling coatings
- Be consistent with components of the biofouling management plan described in the IMO's voluntary "Guidelines for the Control and Management of Ships' Biofouling to Minimize the Transfer of Invasive Aquatic Species," hereafter referred to as "IMO Biofouling Guidelines" (IMO 2011)

The Biofouling Record Book Must:

- Be consistent with components of the biofouling record book described in the IMO Biofouling Guidelines
- Record all completed biofouling inspections and management practices

What are Niche Areas?

Niche areas include recesses, appendages, and other wetted vessel surfaces of the vessel that are more susceptible to biofouling due to structural complexity and inadequate protection by antifouling or foul-release coatings and other antifouling systems.

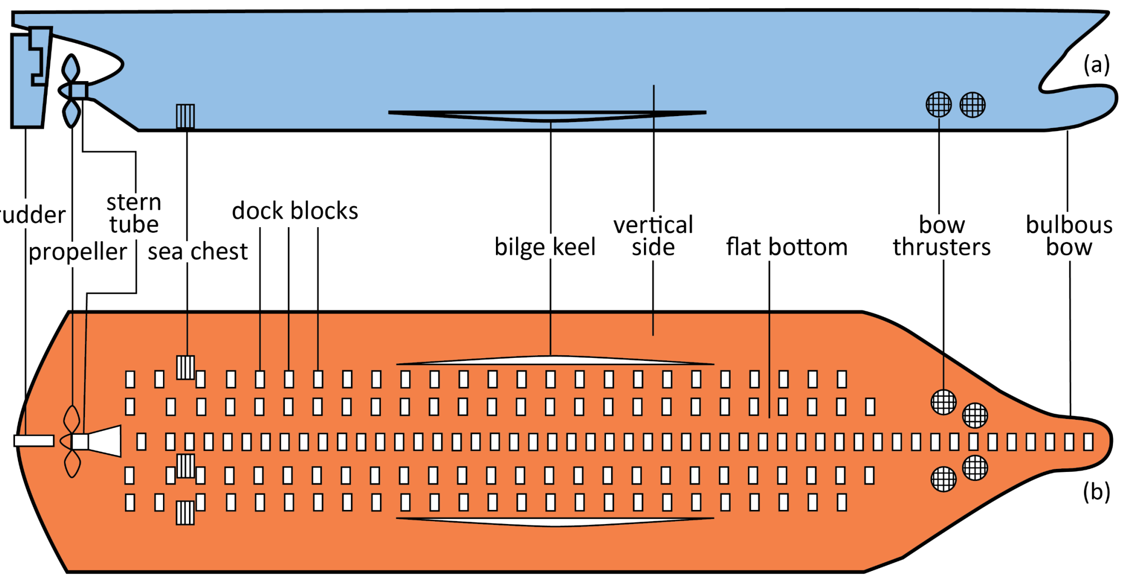


Figure 6-1. Niche areas susceptible to biofouling accumulation. a) Lateral view of a vessel. b) Bottom view of a vessel. Figure originally from Davidson et al. 2016.

6.2.1 Managing a Vessel's Hull

The biofouling management plan must describe the strategies used to manage biofouling on the vessel's hull. Vessels can use an antifouling or foul-release coating if the coating is not aged beyond its expected lifespan. The expected coating lifespan is the length of time that an antifouling coating is expected to be effective based on the specific application thickness and coating design. The biofouling management plan must include any action describing how biofouling on the hull will be managed after the expected lifespan of an antifouling or foul-release coating is exceeded or in the absence of either coating.

Antifouling coatings

An antifouling coating is a specialized paint that is applied to the wetted surfaces of a vessel (e.g., the hull) to prevent the accumulation of biofouling organisms. There are two main types of antifouling coatings:

- **Biocidal coatings:** rely on toxic substances (e.g., copper, zinc) to prevent organisms from attaching to, or growing on, the coated surface
- **Foul-release coatings:** rely on slippery surfaces, made from biocide-free materials like silicone, to prevent organisms from staying attached once the vessel starts to move

Vessel owners/operators determine the type of coating to be used based on the vessel's operational profile (e.g., how fast it moves, the locations through which it transits, the frequency and duration of its idle periods).

6.2.2 Managing Niche Areas

A vessel's biofouling management plan must include a plan for managing eight niche areas (e.g., use of antifouling coating, marine growth preventions system, regular cleaning) if they are present. These eight niche areas include:

- Sea chests
- Sea chest gratings
- Bow and stern thrusters
- Bow and stern thruster gratings
- Fin stabilizers and recesses
- Out-of-water support strips (also referred to as dock blocks)
- Propellers and propeller shafts (stern tube)
- Rudders

6.2.3 Managing Biofouling After Extended Idle Periods

Before arriving at a California port, any vessel that has experienced an extended idle period of 45 days or more must manage niche area biofouling consistent with the management actions described in its biofouling management plan. In most cases, biofouling that accumulates because of an extended idle period should be managed in the same location where the residency period occurred to prevent moving the biofouling organisms to new locations.

6.3 Vessel Practices that Influence Biofouling

2020 and 2021 Highlights of Vessel Practices that Influence Biofouling

- 260 million square meters of cumulative wetted surface area arrived at California ports during 2020 and 2021.
- 72% of all wetted surface area that arrived at California ports was from container and tank vessels.
- Overall, the average age of antifouling coatings on vessels that came to California during 2020 and 2021 was less than 2 years.
- 79% of the vessel reported idle periods of 10 days or longer were between 10 and 19.9 days, and 12% of them were longer than 45 days.

6.3.1 Total Wetted Surface Area

Total wetted surface area (TWSA) is an estimate of a vessel's total surface area, including niche areas, that are temporarily or continuously submerged in water.

TWSA is used to evaluate the potential for biofouling accumulation. TWSA varies by vessel type because of their different sizes and operational needs. Passenger vessels have the largest average TWSA, followed by containers, and tank vessels (Figure 6-2).

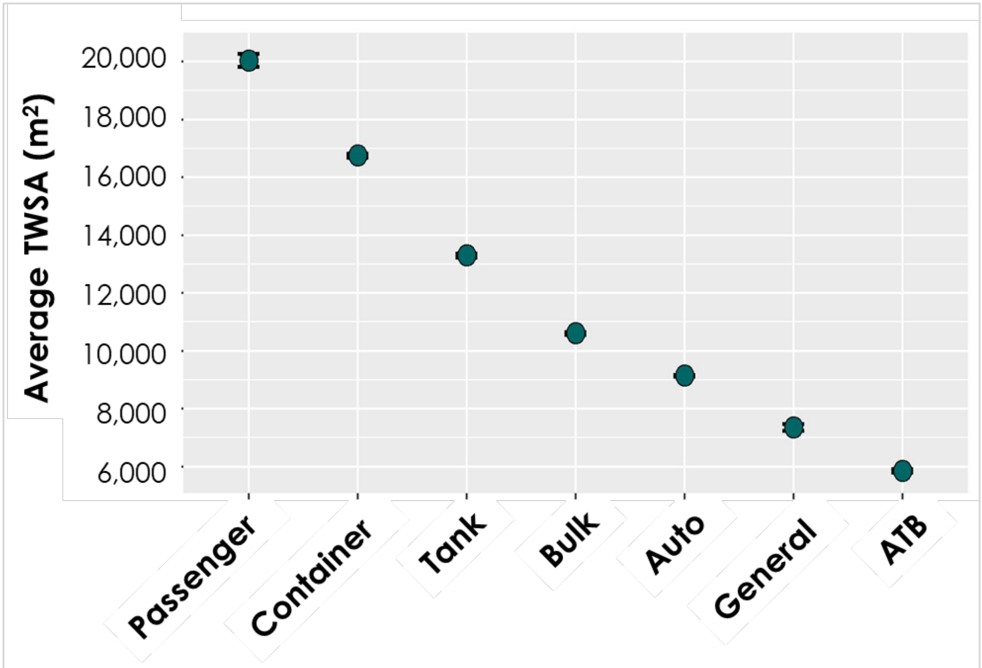


Figure 6-2. Average total wetted surface area (TWSA), of vessels arriving at California ports during 2020 and 2021.Vessel types are described in Table 4-2. Vessel arrivals from offshore supply ships, unmanned barges, and other categories were removed from this analysis because the TWSA could not be calculated due to the variability of each of these categories or the lack of specific details about the vessels. Error bars represent standard error (Values used to describe the variability of the observations from the average of a defined population).

6.3.2 Biofouling Maintenance and Vessel Operational Practices

Vessel maintenance and operational practices affect biofouling accumulation and survival of organisms during vessel voyages. Vessel biofouling is determined by:

- Type and age of antifouling coatings
- Frequency and duration of idle periods
- Vessel average speed
- Freshwater transits
- In-water cleaning events

Commission staff analyzes AVRF data to understand the potential level of biofouling on vessels arriving at California ports. This information can be used to improve inspection protocols, prioritize vessels for inspection, and inform the regulatory process.

Type and Age of Antifouling Coatings

There is a variety of antifouling coatings available to vessels to prevent biofouling accumulation.

During 2020 and 2021, 88 percent of the vessels that arrived at California ports relied solely on biocidal antifouling coatings (Figure 6-3). Of the biocidal coatings used, 97 percent were copper based. Only 0.9 percent of vessels relied solely on biocide-free foul-release coatings. An additional 1.2 percent of vessels used a biocide-containing coating on some surfaces (e.g., niche areas) and biocide-free foul-release coatings on other surfaces (e.g., hull).

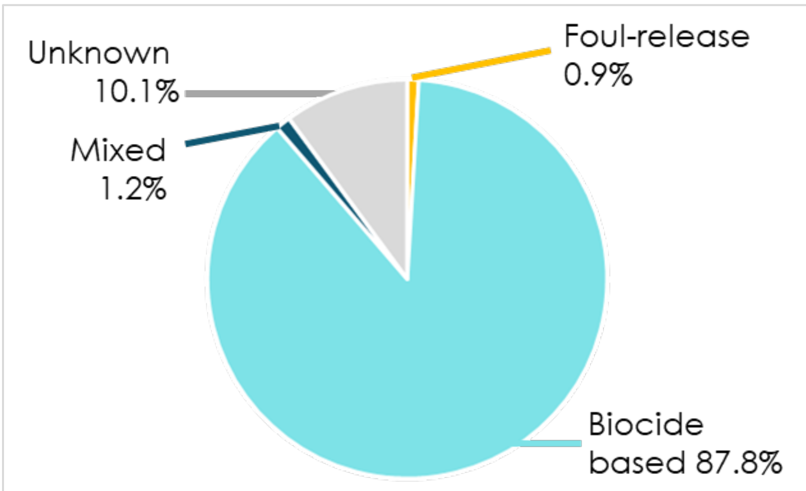


Figure 6-3. Antifouling coating types reported by vessels that arrived at California port during 2020 and 2021.

Most antifouling coatings are designed and applied to be effective for three to five years. During 2020 and 2021, 75 percent of vessels that reported to the Commission had coatings that were applied within the prior three years, which indicates that the coatings were still likely to be effective. Coatings aged beyond three years are in the latter stages of their service life and are likely to be less effective because of wear and damage. During 2020 and 2021, 25 percent of vessels that arrived at California ports had coatings that were between three and five years. Only 3.8 percent of the vessels reported coatings that were aged beyond five years. Overall, the average age of antifouling coatings on vessels that came to California during 2020 and 2021 was less than 2 years.

Frequency and Duration of Idle Periods

The frequency and duration of idle periods impact biofouling accumulation because most coatings require movement above a certain speed to be effective. The longer the idle period, the more likely the vessel is to accumulate biofouling and have many different species present (Davidson et al. 2020). As more biofouling accumulates, there is an increased likelihood of transporting and introducing those organisms as the vessel travels to new locations.

During 2020 and 2021, 1,820 vessels reported 6,056 idle periods of 10 days or longer since their hull was last cleaned. Most (79%) of these idle periods reported during these two years were between 10 and 19.9 days, and 12 percent of them were greater than 45 days.

The frequency of these idle periods that were 10 days or longer varied by vessel type. For example, container and auto carrier vessels averaged less than one of these idle periods per vessel, and unmanned barges averaged more than seven per vessel. The largest difference between 2020 and 2021 was observed in articulated tugs and barges, offshore supply ships, and passenger vessels, where the number of idle periods of 10 days or more since their hull was last cleaned doubled (Figure 6-4). These increases were likely due to impacts of the COVID-19 pandemic.

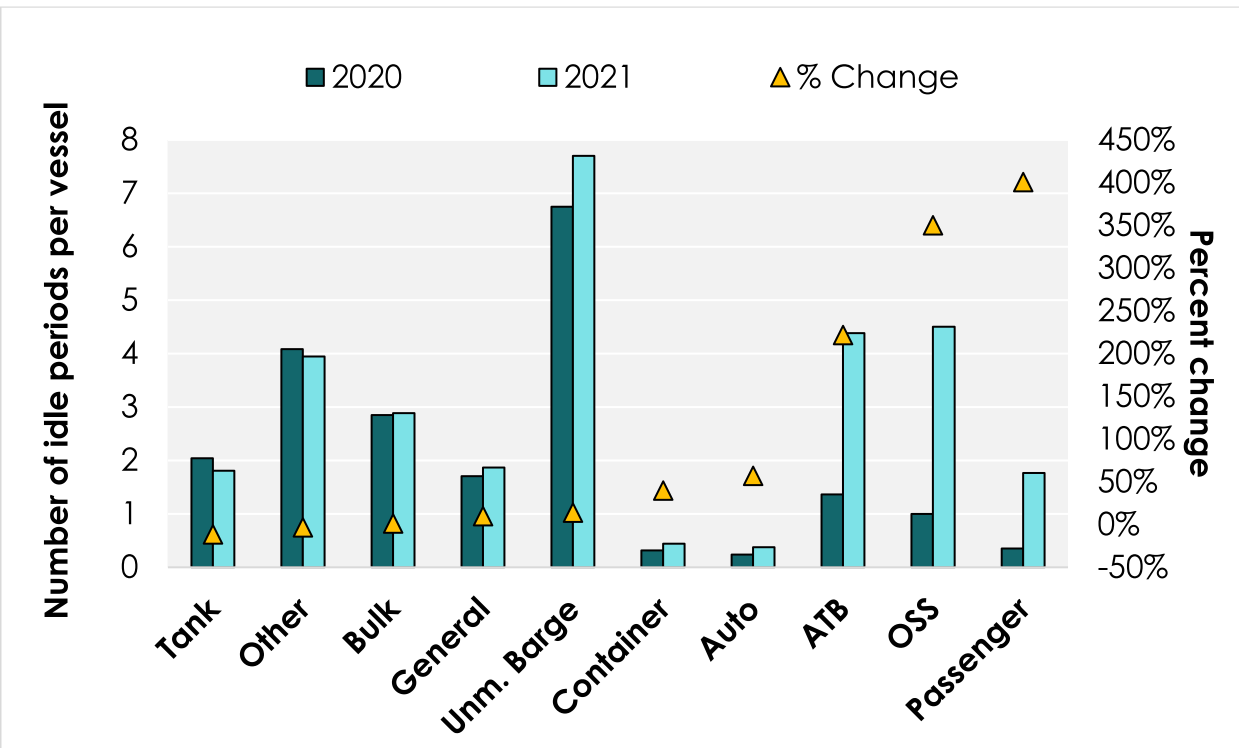


Figure 6-4. Number of idle periods per vessel reported during 2020 and 2021, and the percent change from 2020 to 2021 in each vessel type.

Vessel Average Speed

Vessel traveling speed influences biofouling because organisms are more likely to remain attached and survive at slower speeds. This in turn leads to an increase in the likelihood of NIS introductions (Coutts et al. 2010, Davidson et al. 2020). The average speed of the vessels operating in California has decreased 18 percent from 2008 (16.8 knots, Commission 2011) to 2021 (13.9 knots).

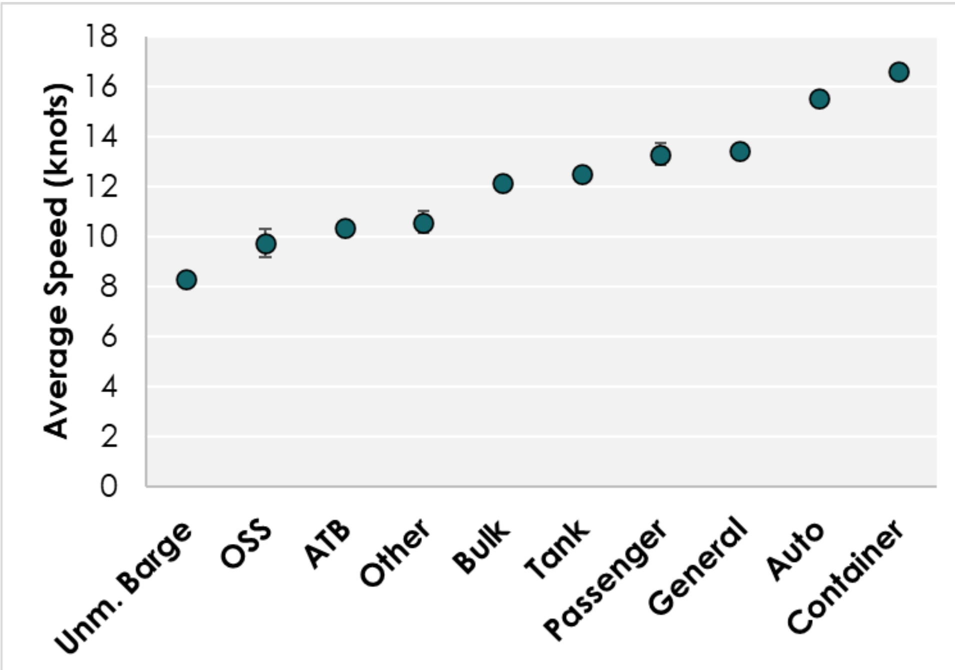


Figure 6-5. Average (± standard error) traveling speed reported by vessels that came to California between 2020 and 2021 by vessel type. See Table 4-2 for vessel type descriptions.

Freshwater Transits

Vessels that travel through freshwater are less likely to spread marine biofouling organisms because freshwater is a natural biocide for most marine organisms. During 2020 and 2021, 70 percent of vessels reported visiting a freshwater port or transiting the Panama Canal since the hull was last cleaned.

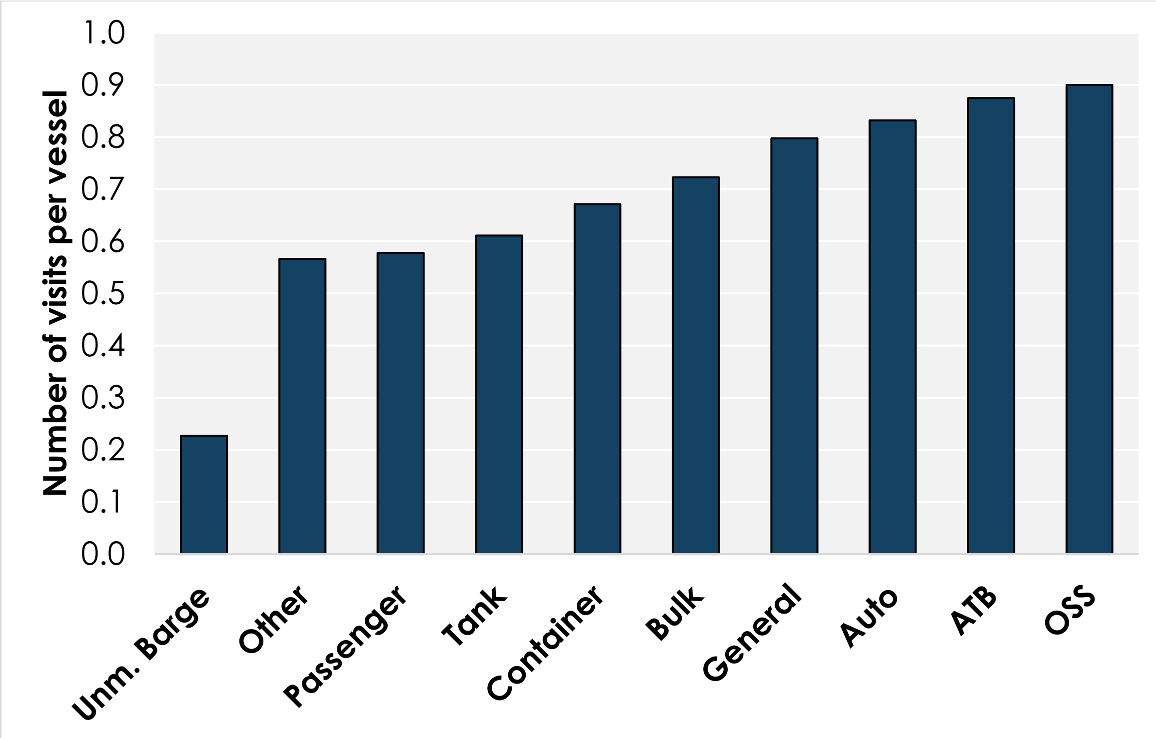


Figure 6-6. Number of freshwater ports visits or transits through the Panama Canal before arriving at a California port during 2020 and 2021 per vessel. See Table 4-2 for vessel type descriptions

In-Water Cleaning

In-water cleaning (IWC) of vessels can prevent or remove biofouling. As a result, vessels that reported at least one IWC event before coming to California are less likely to introduce species into California waters. The Commission collects IWC information on the AVRF to understand the maintenance practices of the vessels that visit California and the likelihood that the vessel has biofouling on its wetted surfaces.

During the reporting period, 38 percent of the vessels reported at least one IWC before arriving in California (Figure 6-7A and 6-7B). Of the IWCs that were reported:

- 56% were full cleanings
- 16% were partial cleanings (only some parts of the vessels)
- 25% were propeller cleanings only
- 4% were not specified as full or partial cleanings.

More than 70 percent of passenger vessels reported at least one IWC; no other vessel type had more than 50 percent of their vessels report an IWC (Figure 6-7 C).

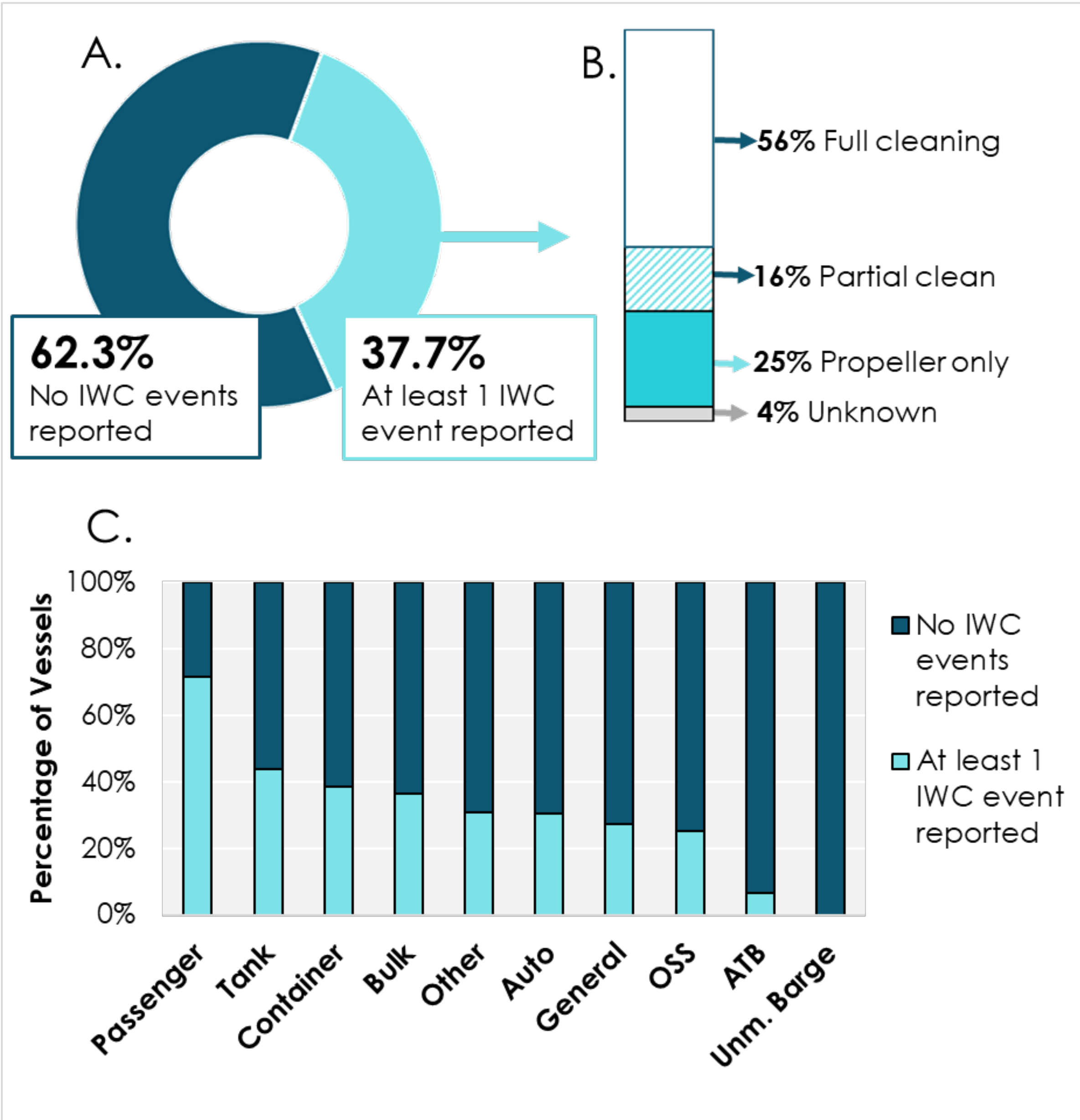


Figure 6-7. A. Percentage of vessels that reported in-water cleanings during 2020 and 2021. **B.** Percentage of reported cleanings that were hull and propeller or just propeller. **C**. Percentage of vessels within each vessel type that reported at least one in-water cleaning event before arriving to California. See Table 4-2 for vessel type descriptions.

6.4 Biofouling Compliance

2020 and 2021 Biofouling Compliance Highlights:

- Commission staff inspected 60% vessel arrivals (1622 vessel arrivals) that were newly required to comply with the California Biofouling Management Regulations
- 31% (502 vessels) of inspected vessels had at least one biofouling deficiency that resulted in the issuance of a 60-day grace period
- Only 11 of 330 vessels were found to be noncompliant during follow-up inspections after the expiration of a 60-day grace period

The Commission implements a biofouling compliance monitoring and enforcement program through vessel inspections and notifications. As mentioned in Section 5 (Vessel Arrivals in California), vessels are prioritized for inspection based on several factors. Vessels are assigned as a high priority for biofouling inspection if a vessel's arrival is its first arrival after being subject to the California's Biofouling Management Regulations (see Section 6.1) or for a vessel's first arrival after an expired 60-day grace period.

During 2020 and 2021, there were 2,725 vessel arrivals that were newly required to comply with the California Biofouling Management Regulations (Figure 6-9). Commission staff inspected 60 percent (1622) of those arrivals.

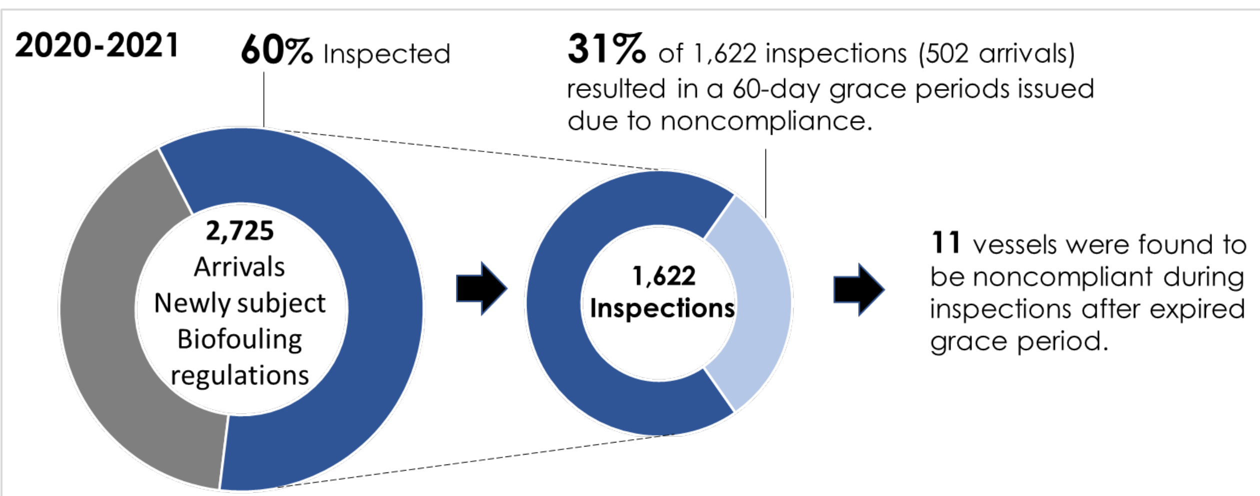


Figure 6-9 Inspection and compliance trends for vessels newly subject to the California Biofouling Management Regulations during 2020 and 2021.

During 2020 and 2021, 31 percent (502 vessels) of inspected vessels had at least one biofouling deficiency that resulted in the issuance of a 60-day grace period.

Of the vessels that were found to be noncompliant during their first biofouling inspection, 18.7 percent were noncompliant with both the biofouling management plan and biofouling record book requirements. The most common violations were due to:

- Not having documentation of the expected effective lifespan of antifouling coatings on board: 40.8%
- Lacking management descriptions for niche areas within the biofouling management plan: 33.6%
- Biofouling record book not specific to the vessel or not on board: 23.3%
- Biofouling management plan not specific to the vessel or not on board: 8.2%

During the reporting period, Commission staff inspected 330 (120 in 2020 and 210 in 2021) vessels with an expired 60-day grace period. Only 11 vessels (three in 2020 and eight in 2021) were found to be noncompliant during follow-up inspections after the expiration of the 60-day-grace period. These vessels were issued a violation letter.

Commission staff is preparing to amend the enforcement regulations (California Code of Regulations, title 2, section 2299.01 et seq. to create a more comprehensive enforcement process that includes a transparent biofouling management violation penalty structure.

6.5 Biofouling Research Review

As required by Public Resources Code 71212, subdivision (e), this Biennial Report includes summaries of recent research relating to vessel vectors and NIS introductions. This section summarizes selected peer-reviewed articles focused on biofouling that were published during 2020 and 2021.

Although vessel biofouling is a global issue, it can have considerable regional or local impacts. **Meloni et al. (2020)** investigated biofouling on vessels that served southwest Atlantic and Southern Ocean routes. The vessels were surveyed through both in-water sampling and dry dock (i.e., out of water maintenance) sampling in Mar del Plata, Argentina. Of the120 taxa (groups of organisms) found, ten species had not been previously reported for the port, and eight were completely new to the entire Argentinian coast. More samples and species were collected from dry dock surveys than in-water during the study. Therefore, the authors recommend sampling vessels during dry dock to better understand invasion risk. In another regional biofouling case study in Arzew, Algeria, **Kacimi et al. (2021)** evaluated vessel stay duration, port latitude, distance traveled, speed, and antifouling practices for 738 vessels. The evaluation was used to develop a model to predict the likelihood of successful species introduction. The authors found a high risk of introducing foreign species from six ecoregions across the globe and suggest specific management actions for high-risk vessels and ports.

Most of the concern with biofouling and NIS has been focused on invertebrates and algae while very little attention has been paid to marine pathogens, as observed by **Georgiades et al. (2021).** The authors found that marine pathogens heavily rely on biofouling to relocate to other regions of the globe where they can negatively affect the environment, economics, and social and cultural practices. An example of pathogens transferred through biofouling was presented by **Fuhrmann et al. (2021)**, who discussed *Ostreid herpesvirus*, a disease that has caused high mortality in Pacific oysters (*Crassostrea gigas*) in Europe, Australia, and New Zealand. Infected individuals could spread the virus via vessel traffic with potential impacts to a region's economy, aquaculture, and marine health.

The likelihood of transporting biofouling, including pathogens and marine diseases, can be influenced by a vessel's operational practices. **Davidson et al. (2020)** tested the effect of stationary periods of various lengths and high velocity water flow (approximately 14 knots to simulate vessel transit) on the accumulation and retention of biofouling on different antifouling coatings. The authors measured the rate of accumulation on the different coatings over a two-month period and found that most of the accumulated biofouling was removed during the simulated transits. **Edmiston et al. (2021)** tracked the microalgal community over time on the hull of an active vessel with an operational profile that included long residency periods. The authors found that the vessel's transit from the San Francisco Bay to the south Pacific temporarily decreased microalgal community abundance and biomass. Once the vessel returned to its home port in San Francisco Bay, the microalgal community abundance and biomass rebounded to values that were greater than at the beginning of the experiment.

Antifouling coatings can be a useful tool to minimize vessel biofouling accumulation, however those coatings, their biocides, and associated microplastics may have unintended environmental impacts. **Dibke et al. (2021)** developed a new procedure to detect plastic types in the ocean. The authors found that the types of plastic found near the shore and coastline were related to packaging waste, while the types of plastic found in open ocean and estuarine areas were from vessel antifouling coating materials and were likely trails of microplastic left by passing vessels. Similarly, **Muller-Karanassos et al. (2020)** discussed the risk of antifouling paint particles, and associated metals, which can enter the ocean as flakes from coatings on abandoned boats or from scrapes or damage of active vessels. The authors state stricter regulations are needed for the disposal of antifouling paints associated with boatyards and marinas. Likewise, **Soon et al. (2020)** analyzed effluents from dry dock hydroblasting (i.e., high intensity cleaning) and found that they included high concentrations of antifouling paint particles and heavy metal biocides, primarily copper and zinc. Although the risk of toxic chemicals released to the environment depends on the scale of cleaning operation and port environment, the effluent presents risk to the marine environment and needs to be regulated, collected, and treated to prevent toxic effects and harm to marine organisms.

External vessel biofouling can also be removed while the vessel is in water, and in many cases, the removed material is captured, filtered, and treated prior to discharge. **Tamburri et al. (2020)** evaluated an in-water cleaning and capture (IWCC) system on two vessels. The IWCC system reduced the presence of biofouling by 82 to 94 percent, however the concentrations of copper and zinc in the treated effluent was well above thresholds for discharge for one of the two cleaning events. **Soon et al. (2021)** also evaluated the contents of in-water cleaning effluent to identify the concentrations of copper, zinc, and other heavy metals, which were found to be elevated above local thresholds. The authors state that these cleaning practices pose clear risks to port environments unless the effluents are collected and managed properly. To avoid coating damage and excessive release of heavy metals during cleaning operations, **Oliveria and Granhag (2020)** recommended cleaning to be done at the early stages of the fouling process. Different cleaning frequencies were also listed for each type of antifouling coating. For biocidal-based coatings, the recommended frequency is bimonthly. For biocide-free foul release coatings, cleaning is recommended to be done less frequently. Finally, **Tamburri et al. (2021)** recommended technical considerations for regulators that permit in-water cleaning operations. The authors stressed the importance of quantitative and independently collected data. IWC technologies should always be operated by trained professionals under responsible management and consistent with biosecurity regulations.

Most existing research has focused on the biofouling that accumulates on external ship surfaces, but biofouling also occurs within the vessel. This overlooked category was discussed by **Davidson et al. (2021)**, who investigated vessels' internal seawater systems (ISS) and the ability of NIS to accumulate within it. ISSs are crucial to many operations within the ship, including engine cooling, condenser, air conditioning, and firefighting. However, the difficulty of accessing the ISS often prevents inspections and studies. Although antifouling coatings and marine growth prevention systems can be used, further research should focus on the role of biofouling and biofouling management on ISS efficiency.

To protect the marine environment and economic, social, and cultural values from harm, some jurisdictions have established biofouling policies and management requirements. **Georgiades et al. (2020)** discussed the history of biosecurity in New Zealand and marine policies developed by the Ministry for Primary Industries (MPI). Through MPI research and advice, an evidence-based decision was made to construct biofouling requirements in New Zealand on a voluntary basis starting in 2014, becoming mandatory in 2018. MPI's implementation plan also focused heavily on outreach and education and became an example for other jurisdictions to build their policies to best fit their needs. California also established new biofouling regulations that became effective in 2017, and **Scianni et al. (2021)** described the compliance trends and lessons learned from implementing these new regulations in California and New Zealand. Both sets of regulations were modeled after biofouling guidelines from the IMO to ensure consistency and encourage better compliance to reduce invasion risk. Although the learning curve was steep for the shipping industry, both sets of regulations included provisions to ease the transition and provide time and space for the industry to learn the new policies. These experiences can become a useful aid for others to develop similar biofouling policies. During the policy making process, **Luoma et al. (2021)** emphasize the importance of multi-perspective viewpoints, including environmental, economic, social, and cultural, when creating management policies. The authors used a conceptual influence diagram to identify the need for open and direct communication with stakeholders and other participants who would be affected by the changes.

With biofouling regulations in place or in development in different regions, shipowners and regulators need quick and inexpensive underwater assessments to accurately estimate, record, and analyze biofouling extent on vessel surfaces. **First et al. (2021)** used inexpensive cameras to capture images *in situ* for a machine learning system to estimate biofouling extent. The authors were able to train their system to successfully identify biofouling extent across seven types of biofouling. **Bloomfield et al. (2021)** had a similar approach, using a deep-learning automated system to assess in-water surveys and automatically identify and categorize the presence and severity of biofouling. The more than 10,000 images used in the study were a combination from several datasets, including a dataset provided by the Commission. After training the system, the automated assessment of 120 images showed an 89 percent agreement with assessments from three biofouling experts. With additional application of more precise instructions and training, this technology can be feasible and effective for biofouling assessments with reduced time, complication, and cost.

Shipowners can further increase efficiency and reduce costs by using effective yet inexpensive vessel parts for repairs. **Piola et al. (2021)** looked for a more stable yet effective material for antifouling purposes. The authors used 3-D printing technology with infused copper filaments to lower costs and save waiting time for delivery of vessel parts while maintaining effective antifouling properties. To test the effectiveness of the 3-D printed parts, three types of copper filament with various levels of copper content were used: 30 percent, 50 percent, and 80 percent. The filament with 80 percent copper content was found to be the most effective, remaining free of all fouling after 24 months.

6.6 Biofouling Looking Forward

In addition to implementing biofouling regulations and amending enforcement regulations to incorporate penalties for violations of the biofouling regulations, Commission staff continue to engage with collaborators and stakeholders. This collaboration aims to improve biofouling management for vessels operating in California and beyond.

The Commission has historically funded applied biofouling research to answer important questions for MISP policy development and implementation, but budgetary concerns have restricted this practice over recent years. Commission staff has filled this gap by seeking and joining externally funded, collaborative research that directly benefits policy development in California.

During 2020 and 2021, Commission staff participated in three in-water cleaning projects, all in collaboration with the University of Maryland, Alliance for Coastal Technologies, Maritime Environmental Resources Center, Smithsonian Environmental Research Center, and the Naval Research Laboratory.

One of these in-water cleaning projects evaluated the efficacy of repeated proactive in-water cleaning at preventing biofouling. This work was recently completed, and a technical report was published (see ACT/MERC 2022). A second project developed standardized protocols for testing the efficacy of in-water cleaning technologies to provide scientifically rigorous data for permitting agencies to consider when evaluating in-water cleaning permit applications. This work is ongoing and is expected to result in the publication of a technical report and an International Organization for Standardization standard. The final project evaluated the scope of microplastics released from anti-fouling coatings during in-water cleaning. This work is ongoing and is expected to result in a series of peer-reviewed publications.

The IMO is reviewing and revising the voluntary IMO Biofouling Guidelines (IMO 2011) to increase usability, effectiveness, and uptake. California's Biofouling Management Regulations are based on the IMO Biofouling Guidelines, and changes to the IMO Biofouling Guidelines will impact these regulations. Commission staff is part of the U.S. delegation to an IMO Correspondence Group created to recommend improvements to the IMO Biofouling Guidelines. The IMO Correspondence Group's review process is expected to continue into early 2023. Final recommendations will be presented to the IMO's Pollution Prevention and Response subcommittee during their April 2023 meeting.

As mentioned earlier in the report Commission staff is preparing to amend the enforcement regulations (California Code of Regulations, title 2, section 2299.01 et seq. to create a more comprehensive enforcement process that includes a transparent biofouling management violation penalty structure.

7 VESSEL VECTOR ANALYSIS: COMBINING BIOFOULING AND BALLAST WATER

Commission staff evaluates factors beyond the separate impacts of the biofouling and ballast water vectors and the implementation of their respective management requirements. This section is a summary of the following evaluations:

- Analysis of the combined contribution of the biofouling and ballast water vectors to NIS introduction risk
- Recent research relating to vessels as vectors of NIS introductions
- Marine Invasive Species Program: Species Monitoring Update

7.1 Analysis of the combined contribution of the biofouling and ballast water vectors to NIS introduction risk

A major component of NIS introduction risk analysis is counting or estimating the number of organisms released during an introduction event (Lockwood et al. 2009). Counting the number of organisms released during ballast water discharges would require time, personnel, and financial resources beyond those available to the Commission. Likewise, counting the number of biofouling organisms associated with a vessel is impractical for all vessels arriving at California ports.

Although counting organisms in ballast water discharges or biofouling related releases is impractical, Commission staff can analyze available information about the ballast water and biofouling vectors using proxies to understand NIS introduction risk. The available data on ballast water and biofouling are analyzed based on the following:

- ***Ballast water*** - analyzed using the volume and frequency of ballast water discharges

- ***Biofouling*** - analyzed using ship profile (TWSA) and operational factors (i.e., residency periods, traveling speed, coatings, in-water cleaning)

Commission staff is developing a combined risk assessment model (CRAM) to assess the likelihood of NIS introductions for each vessel arrival. Understanding how each vessel's vectors (ballast water and biofouling) contribute to the overall risk of introducing species is important for preventing new introductions.

The CRAM is a data-driven decision tool intended to prioritize the riskiest vessels for inspection. The CRAM incorporates ballast water and biofouling management or operational parameters (Table 7-1) that are used to calculate a "risk score" for each vessel arrival (see Appendix D for details about how the score is calculated). The combined vessel arrival risk score can then be used to assign a priority level (critical high, high, medium, or low) to each arrival (Figure 7-1). Inspection priority level thresholds can be adjusted based on data, resource availability, or targeted interests (e.g., specific locations, vessel type).

Table 7-1 Explanation of the ballast water and biofouling vectors' parameters used to develop a combined risk score as part of the combined risk assessment model

Vector	Parameters	Why included?
Ballast Water	Volume of ballast water discharged	Larger volumes likely to have more total organisms
Ballast Water	Management strategy used	Variable efficacy of different management strategies
Ballast Water	Saltwater discharge into freshwater port	Marine organisms are unlikely to survive after discharge into freshwater
Biofouling	Antifouling coating age	Effectiveness is reduced with increased coating age
Biofouling	Freshwater transits	Many marine biofouling organisms are unlikely to survive transit through freshwater ports/Panama Canal
Biofouling	In-water cleaning	In-water cleaning removes, or prevents accumulation of, biofouling
Biofouling	Vessel type (niche areas)	The amount of high-risk niche surface area varies by vessel type
Biofouling	Average speed	Slower speeds facilitate better biofouling survival
Biofouling	Long residency periods	Frequency and duration of idle periods facilitate the accumulation of biofouling

To evaluate the CRAM's results, Commission staff used the model to calculate risk scores for 2020 and 2021 arrivals. The CRAM evaluation resulted in 2.3 percent of arrivals categorized as "critical high" and 20 percent as "high." The critical high and high priorities are 22 percent of all arrivals, within the legislative mandate to inspect 25 percent of arrivals. If implemented, Commission staff could use the CRAM to prioritize the vessels with the greatest likelihood of NIS introduction for inspection.

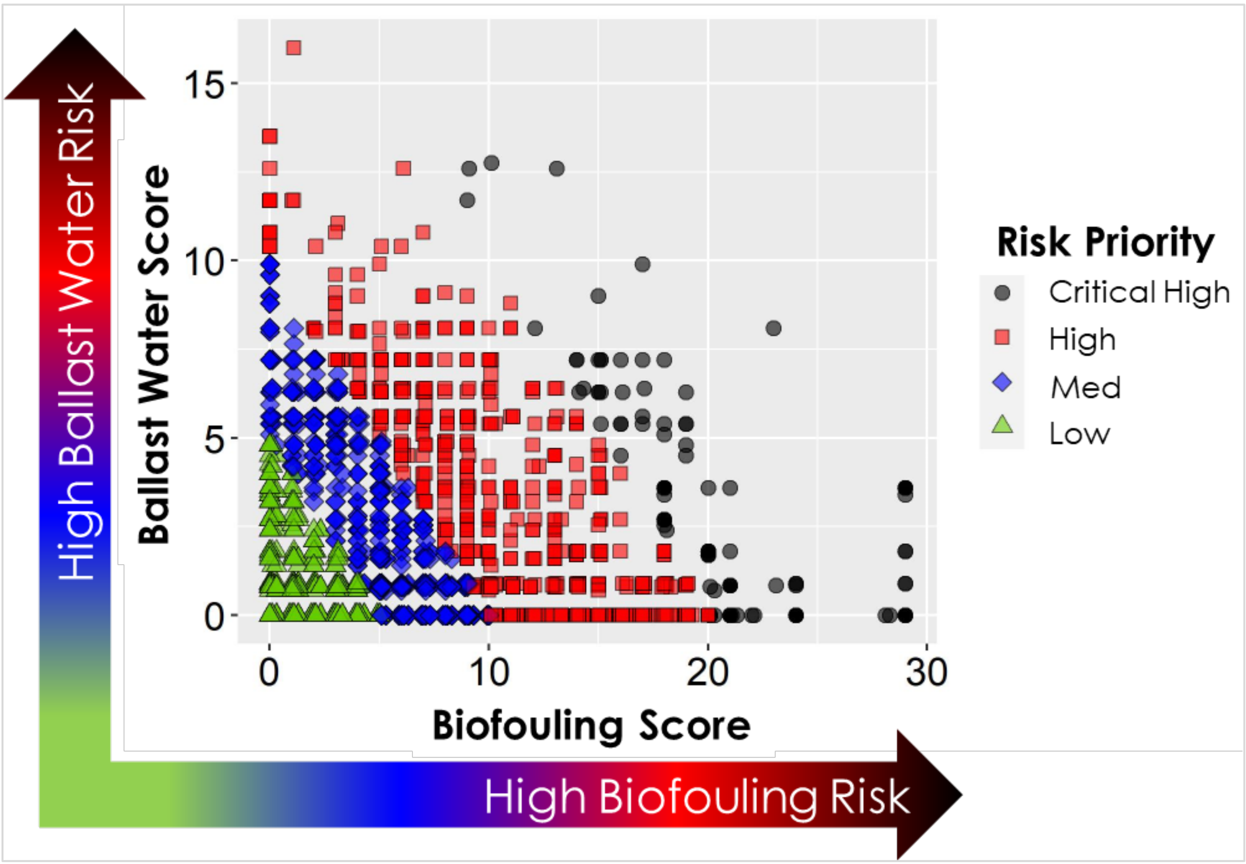


Figure 7-1. Combined vessel risk scores from all vessel arrivals during 2020 and 2021 using the MISP combined risk assessment model (CRAM) (see Appendix D for scoring process). Risk categories are based on the combined risk score: Total score >20 = Critical high; 10 to <20 = High; 5 to <10 = Medium; <5 = Low.

In addition to prioritizing arrivals using inputs from both vectors, the CRAM can be used to identify the likelihood of NIS introductions at a specific location or by vessel type. By combining the vessel arrival scores at each port or by vessel type, Commission staff can target locations and vessel types with the highest scores for inspection.

Commission staff is refining the CRAM to improve the vessel prioritization process. To accomplish this, staff will evaluate other ballast water and biofouling risk factors and will seek out peer review by international colleagues to improve the CRAM prior to using the model to prioritize arrivals for inspection.

7.2 Vessel Vector Research Review

As required by Public Resources Code section 71212, subdivision (e), this Biennial Report includes summaries of recent research relating to vessel vectors and NIS introductions. This section summarizes selected peer-reviewed articles focused generally on vessels and NIS that were published during 2020 and 2021.

While the impacts of international trade on species invasions have been well studied over recent decades, indirect effects are causing changes in environments and societies at import and export locations (e.g., new coastal infrastructure and trade routes). **Hulme et al. (2021)** emphasized a trend of higher demands for trade that may facilitate increased invasions. Due to the vessel traffic mediated NIS introductions and impacts on habitat, **O'Shaughnessy et al. (2020)** surveyed around port environments to compare the number and type of species in natural versus artificial habitats. The authors found that artificial habitats had greater variety of species, likely due to greater vessel traffic. A worldwide increase in vessel traffic may also increase NIS introductions to the Bering Sea in future years. **Droghini et al. (2020)** evaluated whether current temperatures and salinities in the Bering Sea were suitable for successful NIS introductions. The authors found that 80 percent of the NIS evaluated were suited to survive in the southern Bering Sea because of an expected northern expansion of suitable conditions (i.e., warmer water) by 2030-2039, but not the northern Bering Sea.

Identifying which vessels are most likely to introduce NIS is important for local NIS prevention managers. **Ceballos et al. (2021)** created a simple risk assessment model to prioritize vessels for inspection. The model inputs included representations from biofouling (wetted surface area) and ballast water (discharge volume). The authors (including Commission staff) validated the model using data from vessels arriving at California ports between 2015 and 2018. The model can be customized using different input based on the needs in different jurisdictions to produce per-vessel risk scores. **Tzeng et al. (2021)** created a similar scoring model that was based on vessel type. The model was evaluated and resulted in similar data to previous risk evaluation systems used in New Zealand ports. These risk assessment efforts are important because vessels can not only introduce invertebrates and algae, but also marine pathogens, as reported by **Rosenau et al. (2021)**. The authors examined ships and their potential to spread Stony Coral Tissue Loss Disease in Miami, Florida.

Several case studies were recently published to identify high risk species for specific geographic regions. **Tamburini et al. (2021)** presented the results of the first standardized species monitoring protocol for the Mediterranean Sea. The protocols, developed by SERC included surveys from five near-shore sites from 2018 to 2020. Eleven of the 79 species observed were NIS. **Miralles et al. (2021)** performed another case study at the port of Gijon in northern Spain using their newly developed NIS Invasion Threat Score to predict NIS invasion risk. This new scoring system was shown to detect recent introductions and provide accurate predictions to help support monitoring and policy development. **Iacarella et al. (2020a)** and **Iacarella et al. (2020b)** evaluated invasion risk within Marine Protected Areas (MPA) along the west coast of Canada under current and future climate conditions. The authors found that 29 percent of MPAs overlapped with areas that had established NIS and that 70 percent of the MPAs shared vessel traffic with invaded areas. The authors predict that as future climate conditions change, six NIS have a greater than 90 percent chance of occurring in over 70 percent of Canadian MPAs.

7.3 Marine Invasive Species Program: Species Monitoring Update

Since 2000, the California Department of Fish and Wildlife's component of the MISP has periodically surveyed California's estuaries and marine waters for aquatic NIS. Results of these surveys are used to understand aquatic NIS distribution in California waters and to evaluate the effectiveness of the ballast water and biofouling management requirements of the MISA and associated regulations at reducing the rate of aquatic NIS establishment over time.

From 2012 to 2020, the CDFW MISP staff has contracted with the Smithsonian Research Center (SERC) to complete 12 surveys across California. Between 2016 and 2021, there were four observations of new aquatic NIS in California waters (see table 7-2). While there have been relatively few observations of new species introductions into the State, many species have expanded their distribution (i.e., observed in one part of California and subsequently observed in other parts). These range expansions may have been present earlier than when they were detected and could have eluded detection for a long time.

Table 7-2 Observations of new species or species range expansion from 2016 through 2021. Port of LA/LB refer to the Ports of Los Angeles and Long Beach.

YEAR	Species	Status
2017	*Ampithoe valida* (amphipod)	Initial observation: Mission Bay (2000) Range expanded: Ports of LA/LB
2017	*Amathia citrina* (bryozoan)	New to California: Ports of LA/LB
2017	*Branchiomma* sp.	Initial observation: San Francisco Bay Range expanded: Ports of LA/LB and Newport Bay
2018	*Hydroides dianthus* (polychaete) pending identification	New to California: Ports of LA/LB
2018	*Caprella drepanochir* (amphipod)	Initial observation: Humboldt Bay (2001) Range expanded: Ports of LA/LB
2018	*Ianiropsis serricaudis* (isopod)	Initial observation: San Francisco Bay (1977) Range expanded: Ports of LA/LB
2018	*Leostyletus misakiensis* (gastropod)	Initial observation: San Francisco Bay (1962) Range expanded: Ports of LA/LB
2018	*Cratena pilata* (gastropod); pending identification	New to California: Ports of LA/LB
2019-2021	*Ascidiella aspersa* (tunicate)	Initial observation: Ports of LA/LB (2018) Range expanded: Ventura to San Diego
2021	*Caulerpa prolifera* (green alga)	New to California: Newport Bay

The CDFW contracted with SERC and the Moss Landing Marine Laboratories in 2020 for several ongoing projects. One project involves evaluating environmental deoxyribonucleic acid (eDNA) for detecting invertebrate species. If determined to be reliable and accurate, this method would reduce monitoring and identification costs for ongoing surveys.

Another project included surveys of the outer coast at seven rocky intertidal sites in Marin, Santa Cruz, and Monterey Counties and eight kelp forest sites in the Monterey area. Most survey sites were found to have relatively low NIS abundances or declines in populations of specific NIS that were used as indicators of population dynamics. In contrast to most sites, however, one site immediately outside of Monterey Bay is a hotspot for aquatic NIS, likely due to its proximity to the relatively heavily invaded Monterey harbor.

A third project included a redesign of the California Non-native Estuarine & Marine Organisms portal of the National Exotic Marine and Estuarine Species Information System database hosted by SERC.

In addition to the funded projects, the CDFW/MISP is gathering and analyzing additional data on aquatic NIS in California. One such effort is to partner with the California Department of Water Resources and the Interagency Ecological Program (https://iep.ca.gov/About). These groups have conducted long term surveys of the San Francisco Bay-Delta ecosystem that can be used to understand the distribution and abundance of established aquatic NIS.

8 FEDERAL VESSEL VECTOR MANAGEMENT UPDATES

8.1 Vessel Incidental Discharge Act

In late 2018, after months of negotiations, the U.S. Congress passed the Vessel Incidental Discharge Act (VIDA), included as Title IX within S.140, the Frank Lobiando Coast Guard Reauthorization Act of 2018. On December 4, 2018, the President signed VIDA into law. The law:

- Designates the U.S. Environmental Protection Agency (U.S. EPA) as the lead authority to establish national water quality standards for vessel discharges, including ballast water
- Designates the USCG as the lead authority to implement and enforce the national standards set by the U.S. EPA
- Will preempt state authority, once fully implemented, to adopt or implement state-specific management requirements or standards for vessel discharges, including ballast water, that are stricter than the federal standards

Certain provisions were included in VIDA that protect states from some of the impacts to their authority, including:

- Individual states retain authority to inspect vessels and enforce the federal ballast water management requirements
- Individual states retain authority to collect fees (with a cap) and Ballast Water Management Reports from vessels arriving at state ports
- Individual states may, through their Governors, petition the U.S. EPA for stricter discharge standards

State law is not preempted until the U.S. EPA and the USCG adopt regulations to establish discharge standards and implement enforcement procedures. The combined rulemaking process could take four years or more from the time VIDA was signed into law, as the U.S. EPA must first adopt regulations prior to USCG initiating its rulemaking process. During this time, states retain authority to continue implementing existing management programs.

8.1.1 Impacts Upon State Authority

Upon implementation of VIDA and state preemption, California will lose the authority to establish or implement any standards for discharges incidental to the normal operation of a vessel (including ballast water and hull husbandry discharges (e.g., some vessel in-water cleaning activities)) that are stricter than the federal standards. This means that unless changes are made to the federal law, California would be preempted from moving forward with the State's interim and final ballast discharge performance standards in 2030 and 2040, respectively. While the Governor can petition the U.S. EPA to set stricter standards, the process is complicated, and the types of data and information needed for a petition to be approved is unclear.

8.1.2 Fiscal Impacts

The implementation of VIDA will also initiate a cap on state fees that vessels must pay upon a qualifying voyage arrival at state ports to support ballast water management programs. The fee cap under VIDA is $1,000 per qualifying voyage. The California MISP fee is currently set at $1,000, so the Commission will be restricted from raising the fee even if fiscally necessary (although the cap may be adjusted for inflation once every five years). Additionally, VIDA sets a cap of $5,000 on the total amount of state fees that may be assessed per year on each U.S. flagged vessel. Due to this restriction, the MISCF is projected to lose between $300,000 and $500,000 in revenue each year. This loss of revenue will move the Marine Invasive Species Control Fund towards insolvency.

8.1.3 Implementation Status

In October 2020, U.S. EPA proposed regulations in the Federal Register to establish national standards of performance for discharges incidental to the normal operation of a vessel. The public comment period was open for 30 days. Commission staff submitted comments in response and worked closely with partner agencies in Pacific coast states to submit a regional response to the U.S. EPA. The Governor also submitted a Letter of Objection in accordance with the provisions of Clean Water Act section 312(p)(4)(A)(iii)(III).

In response to the state comment letters and Governors' objection letters, the U.S. EPA reengaged with the states in 2021. U.S. EPA held nine meetings with states between June and November 2021. Topics of discussion included ballast water best management practices, ballast water numeric discharge standards and best available technology determination, vessel biofouling, hull cleaning, exhaust gas cleaning systems, Great Lakes ballast water management requirements, and state petitions to U.S. EPA for more stringent standards. U.S. EPA staff members were active listeners during the state re-engagement meetings but did not participate in a dialogue with states and did not offer additional information that would help the states understand the U.S. EPA's plans for addressing state concerns with the proposed regulations.

At the close of the State re-engagement meetings, U.S. EPA staff indicated that States may submit additional comment letters if they had new information or comments to share that were not previously submitted to the U.S. EPA. Commission staff submitted a comment letter in January 2022 in response. As of October 2022, U.S. EPA staff has not issued any public statements as to their next steps.

8.2 Federal Comparison

Although federal VIDA regulations are still under development and will not be in force until the U.S. EPA and USCG each complete their regulation development process, both federal agencies have current regulatory programs in place to manage NIS introduction risk from vessels operating in U.S. waters. The Commission works cooperatively with both federal programs to fill management gaps and coordinate on inspections and enforcement actions. While Commission (2013) identified and discussed many of these complementary characteristics, several of the most prominent are highlighted in this section.

8.2.1 Differences in Reporting Requirements

Both the USCG and the Commission require submission of the same Ballast Water Management Report (see Section 5.1 Reporting Requirements). However, the required submission timing varies considerably between the two programs. The Commission requires submission of the BWMR at least 24 hours before arrival at a California port, whereas federal law requires submission no later than six hours after arrival (33 CFR part 151.2060(b)(3)). Receiving the BWMR prior to arrival allows the Commission to prioritize inspections for vessels that report intent to discharge ballast water, ensuring a more efficient use of a limited team of field operations staff. Pre-arrival submission also provides opportunities for Commission staff to assess compliance with ballast water exchange requirements and identify cases of potential noncompliance before the vessel arrives at a California port. As discussed in Section 6.3.3 (Preventing Noncompliant

Discharges), this identification and notification of potential noncompliance has resulted in the avoidance of 141,563 MT of noncompliant ballast water from being discharged in California waters during 2020 and 2021.

8.2.2 Differences in Biofouling Management Requirements

California's Biofouling Management Regulations provide a comprehensive framework for vessel-specific planning and proactive and reactive management to minimize the likelihood of NIS introductions (see Section 7.1 Biofouling Management Requirements for more details). These requirements were modeled after the IMO Biofouling Guidelines and were developed in coordination with similar regulations in New Zealand, all aimed at improving biofouling management for all vessel wetted surfaces, including niche areas. California's Biofouling Management Regulations fill important gaps in the federal regulation of biofouling management, providing context and specificity for what vessels are expected to do to minimize the likelihood of NIS introduction.

In contrast, the federal programs have narrow or vague biofouling management requirements. For example, the USCG has a requirement to "remove fouling organisms from the vessel's hull, piping, and tanks on a regular basis" (33 CFR part 151.2050), but the term "regular basis" is not defined and, therefore, is unenforceable. The USCG also requires vessels to include fouling maintenance procedures as part of their ballast water management plan (33 CFR part 151.2050) and allows for a biofouling management plan to serve this purpose.

Similarly, the U.S. EPA requires, through the 2013 Vessel General Permit for Discharges Incidental to the Normal Operation of Vessels (hereafter referred to as Vessel General Permit), removal of fouling organisms from seawater piping "on a regular basis," but this term is also undefined. The Vessel General Permit also includes a requirement to minimize the transport of attached living organisms when traveling into U.S. waters or between Captain of the Port Zones but does not describe how biofouling can or should be minimized.

8.2.3 Differences in Inspection Processes

California's MISP and the two federal programs (U.S. EPA and USCG) all include some level of vessel inspection to assess compliance with management requirements, but the reach and scope of the inspections differs considerably between programs. Commission inspections to assess compliance with the MISA are generally more thorough and targeted than ballast water inspections at the federal level (see Sections 6.3 Ballast Water Compliance Assessment and 7.3

Biofouling Compliance for more information about Commission inspections and enforcement).

The USCG inspects vessels during their domestic vessel surveys and Port State Control examinations for foreign vessels. Ballast water compliance assessment is one part of a large suite of examination components reviewed by USCG during an inspection. For example, Port State Control examinations include evaluation of all engineering systems, pollution prevention systems, marine facilities and structures, proper carriage of hazardous materials, checking licenses and certificates, and emergency drills, among others. Typically, USCG inspectors will spend 10-15 minutes of a multi-hour inspection on ballast water compliance assessment, given the large number of other duties required of them.

U.S. EPA inspects vessels for compliance with the Vessel General Permit through a combination of onsite inspections and offsite evaluations. U.S. EPA inspections focus on ballast water and all the other incidental discharges covered under the 2013 Vessel General Permit.

8.2.4 Intergovernmental Coordination

Coordination between the Commission and the federal programs is key to the success of all three programs. In many cases, a violation at the state level is likely to also result in a federal violation, and vice versa. Open communication between Commission staff and local USCG staff allows for rapid notification between programs of possible violations that might be of interest to the other party. In cases where the vessel is using a ballast water treatment system to comply with ballast water discharge performance standards and that system malfunctions prior to arrival and discharge at a California port, the vessel is required to notify both the USCG and Commission. Commission staff coordinate with the USCG to identify an appropriate alternative form of management, if warranted, and provide the same direction to the vessel. This open coordination ensures consistency and improves compliance

9 ACCOMPLISHMENTS, LOOKING FORWARD, AND RECOMMENDATIONS

9.1 Accomplishments

The Commission's Marine Invasive Species Program continues to be globally recognized as an active, cutting-edge program at the forefront of marine invasive species research and policy development. This section summarizes some of the major accomplishments achieved during 2020 and 2021.

Quarterly Posting of Vessel Data on MISP Website

The Commission launched a public facing data repository on the MISP portion of the Commission's website (https://www.slc.ca.gov/misp/) in October 2022 to present data updates for viewing and downloading by anyone visiting the Commission's website. The posted files include quarterly and historical data on vessel arrivals and ballast water discharge volumes; both datasets are available by quarter, vessel type, and location.

Compliance with Ballast Water and Biofouling Requirements Remains High

During 2020 and 2021, 99.7 percent of the reported ballast water discharged in California waters was compliant with ballast water management requirements.

Additionally, 31 percent (502 vessels) of vessels that were inspected to assess compliance with the California biofouling management regulations were originally noncompliant and were issued a 60-day grace period. Of the vessels inspected after the completion of the 60-day grace period, only 11 out of 330 (3.3%) were found to still be noncompliant.

Preventing Noncompliant Discharges

As highlighted in Section 5.3, Commission staff review pre-arrival submissions of BWMRs, when possible, to assess ballast water discharge compliance.

During 2020 and 2021, Commission staff notified 23 vessels that their BWMR indicated they were planning to discharge potentially noncompliant ballast water. Of these 23 vessel arrivals, 17 changed their operations, preventing

141,563 MT of potentially noncompliant ballast water from being discharged into California. This volume is almost three times larger than the total volume of noncompliant ballast water discharged (50,187 MT) during 2020 and 2021. Pre-arrival assessment and notification of potential violations significantly reduces the risk of NIS introductions and improves compliance rates.

COVID-19 Pandemic Impacts on the Marine Invasive Species Program

The COVID-19 pandemic impacted vessel operations in many ways. For example:

- Vessel arrivals at California ports decreased 13 percent from 2019 to 2020.
- The volume of ballast water discharged in 2020 was the lowest of any year from 2012 to 2021.

The COVID-19 pandemic impacted Commission staff as well. In response to the COVID-19 outbreak, the California Governor implemented a variety of stay-at-home orders for Californians during most of 2020 and 2021. The exception was personnel that conduct essential activities, and MISP vessel inspections were deemed essential activities. Commission field inspection staff were therefore deemed essential personnel.

Commission staff implemented a temporary practice to not enter the inside of vessels during inspections to limit person-to-person contact and protect essential Commission field inspection staff from COVID-19 infection. This practice began in March of 2020 and remained in effect throughout the remainder of 2020 and 2021. This temporary practice resulted in inspections on the outside deck of vessels or on the dock alongside the vessel.

Despite these challenges, and the lingering risk of COVID-19 infection, Commission field inspection staff were able to inspect 23 percent of the 20,041 vessel arrivals at California ports. Additionally, staff were able to inspect 73 percent of vessels arrivals that were practical for inspection and designated as a high priority for inspection.

Peer-Reviewed Scientific Journal Publications

Staff co-authored nine peer-reviewed journal articles during 2020 and 2021. Additionally, MISP-funded research contracts require contractors to submit a manuscript to a peer-reviewed journal as one of the deliverables. Staff was lead author or co-author on the following publications during 2020 and 2021:

- Artificial structure density predicts fouling community diversity on settlement panels (Susick et al. 2020)

- An experimental test of stationary lay-up periods and simulated transit on biofouling accumulation and transfer on ships (Davidson et al. 2020)
- In-water cleaning and capture to remove ship biofouling: an initial evaluation of efficacy and environmental safety (Tamburri et al. 2020)
- The role of vessel biofouling in the translocation of marine pathogens: management considerations and challenges (Georgiades et al. 2021)
- Proxy-based model to assess the relative contribution of ballast water and biofouling's potential propagule pressure and prioritize vessel inspections (Ceballos Osuna et al. 2021)
- Yes, we CANZ: Initial compliance and lessons learned from regulating vessel biofouling management in California and New Zealand (Scianni et al. 2021)
- Stage-specific overcompensation, the hydra effect, and the failure to eradicate an invasive predator (Grosholz et al. 2021)
- A review of biofouling of ships' internal seawater systems (Davidson et al. 2021)
- Technical considerations for development of policy and approvals for in-water cleaning of ship biofouling (Tamburri et al. 2021)

Staff is drafting new scientific manuscripts that are expected to be submitted in early 2023. These peer reviewed manuscripts advance the world's understanding of invasive species and the biofouling and ballast water vectors of species movements. This knowledge is used to develop policies in California and elsewhere to prevent new introductions through improved vector management, resulting in increased protection against the threats posed by invasive species.

9.2 Next Steps

Over the next two years, MISP staff will work on high priority actions to improve the protection of California waters from the introduction of nonindigenous species, including:

Update the Marine Invasive Species Act (MISA) Enforcement Process

Commission staff is working to amend the MISP enforcement regulations (*Marine Invasive Species Act Enforcement and Hearing Process,* California Code of Regulations, title 2, section 2299.01 et seq.) to incorporate an enforcement process for violations of the biofouling regulations described in section 6.1 and the ballast water discharge performance standards described in section 5.5.

Staff is also working to develop and implement a process to apply more automation to the tracking and enforcement of MISA reporting compliance violations (see section 4.2 and Class 3 violations in Appendix C).

Improve the Vessel Inspection Prioritization Process

Commission staff developed and is currently testing a combined risk assessment model (CRAM, see Section 7.1) using inputs from ballast water and biofouling vectors to improve the process for prioritizing vessels for inspection. The CRAM results provide information to Commission staff to target inspection resources toward vessels with the greatest calculated likelihood for introducing NIS. Commission staff will continue refining the CRAM by evaluating other ballast water and biofouling operational factors and will seek out peer review for the process prior to implementation.

Continue to improve the implementation of ballast water discharge performance standards and associated requirements

As discussed in section 5.5, the Commission began implementing ballast water discharge performance standards on January 1, 2022. Commission staff assesses compliance during inspections of vessels subject to the performance standards and continues to develop and refine the compliance assessment process. This effort includes incorporating changes to the existing inspection protocols to assess compliance more efficiently. Staff is also working to improve outreach materials to help the regulated industry understand the new requirements.

9.3 Recommendations

The Commission makes the following recommendations to the Legislature and California state agencies and departments based on data presented in this report:

1. Support Commission efforts to secure ongoing funding for the Marine Invasive Species Control Fund. The Commission’s ability to collect fees will be limited by the federal (U.S. Environmental Protection Agency and the U.S. Coast Guard) implementation of the Vessel Incidental Discharge Act (VIDA). Once in effect, these restrictions are projected to cause the Marine Invasive Species Control Fund (MISCF) to lose between $300,000 and $500,000 annually. This loss of revenue will move the MISCF towards insolvency (see section 8.1.2).

2. Support an amendment of the Marine Invasive Species Act to require the report to the California Legislature mandated by Public Resources Code section 71212 (i.e., this report) to be updated triennially instead of

biennially. Expanding responsibilities (see section 3.3.), impending revenue losses (see recommendation 1 and section 8.1.2), and future restrictions on raising the amount of the vessel arrival fee that supports the program will require adjustments to workloads and priorities. The production of this Legislative report is labor-intensive and time consuming, limiting staff's ability to maintain a high level of performance with an increasing workload. To ensure no lapse in vessel data availability with the recommended change, Commission staff has initiated quarterly vessel data updates posted on the Commission's website to provide some of the types of data presented in this report for continued access for interested users (see section 9.1).

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In memory of Blanca Garcia and Thomas Macey

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APPENDIX A

Ballast Water Management Report[1] (Page 1 of 2)

OMB number 1625-0069
Exp. date: 31-July-2023

Ballast Water Management Report

Vessel Information

Vessel name

ID number IMO number

Country of Registry Select country

Owner/operator

Type Select vessel type Gross Tonnage

Ballast water volume units Select units

Total ballast water capacity Number of tanks on ship

Onboard BW Management System

Last dry dock date

Voyage Information

Arrival port (port and state) Select state

Arrival date

Last port (port and country) Select country

Next port (port and country) Select country

Total ballast water on board Number of tanks in ballast

Number of tanks discharged

Certificate of accurate information

By checking this box, I attest to the accuracy of the information provided and that ballast water management activities were in accordance with the ballast water management plan required by CFR 151.2050(g). ☐

Responsible Officer's name and title

Report type Select report type

Submitted by Contact information

Ballast Water History

On the following page(s), provide the ballast water history for each tank discharged into the waters of the United States or to a reception facility, en route to or at the arrival port. Vessels entering the Great Lakes or Hudson River (north of George Washington Bridge) from beyond the US EEZ must also provide the history for empty tanks that underwent alternative management.

Submit report via e-mail Submit report on-line

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[1] This is a sample; a complete downloadable form can be found at https://www.slc.ca.gov/marine-invasive-species-program/information-for-vessels-arriving-at-california-ports/.

APPENDIX A

Ballast Water Management Report (Page 2 of 2)

Ballast Water History

Tank name/number | Tank capacity

Event	Date	Location(s) (for Management event include Start pt. / End pt.)	Volume
Discharge to US waters			
Select event			
Select event			
Select event			
Select event			

If BW management was *not* conducted for this tank, select one of the following reasons **Select reason**

Tank name/number | Tank capacity

Event	Date	Location(s) (for Management event include Start pt. / End pt.)	Volume
Discharge to US waters			
Select event			
Select event			
Select event			
Select event			

If BW management was *not* conducted for this tank, select one of the following reasons **Select reason**

Tank name/number | Tank capacity

Event	Date	Location(s) (for Management event include Start pt. / End pt.)	Volume
Discharge to US waters			
Select event			
Select event			
Select event			
Select event			

If BW management was *not* conducted for this tank, select one of the following reasons **Select reason**

Tank name/number | Tank capacity

Event	Date	Location(s) (for Management event include Start pt. / End pt.)	Volume
Discharge to US waters			
Select event			
Select event			
Select event			
Select event			

If BW management was *not* conducted for this tank, select one of the following reasons **Select reason**

APPENDIX B

Marine Invasive Species Program Annual Vessel Reporting Form[2] (Page 1 of 6)

STATE OF CALIFORNIA – STATE LANDS COMMISSION
MARINE INVASIVE SPECIES PROGRAM ANNUAL VESSEL REPORTING FORM
SLC 600.12 (Revised 08/17)
Public Resources Code Sections 71201.7, 71205

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

1. Does the vessel have a ballast water treatment system installed?

Yes ☐ IF "YES" Complete sections 1 and 2
No ☐ IF "NO" Complete section 1 only

Section 1: Hull Husbandry Maintenance and Operational Information

2. 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:

3. 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**)

Official / IMO Number_______________

[2] This is a sample; vessels are required to enter this information online at https://MISP.io.

APPENDIX B

Marine Invasive Species Program Annual Vessel Reporting Form (Page 2 of 6)

STATE OF CALIFORNIA – STATE LANDS COMMISSION
MARINE INVASIVE SPECIES PROGRAM ANNUAL VESSEL REPORTING FORM
SLC 600.12 (Revised 08/17)
Public Resources Code Sections 71201.7, 71205

4. 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 ☐

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 ☐

5. Were the sea chests inspected and/or cleaned during the out-of-water maintenance listed above? If no out-of-water maintenance was performed 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 ☐

6. Are Marine Growth Prevention Systems (MGPS) installed in the sea chest(s) or sea strainer(s)?

Yes ☐ Manufacturer:	Model:
If Yes, MGPS installed in (**check all that apply**): Sea Chest(s) ☐ Sea strainer(s) ☐	
No ☐	

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APPENDIX B

Marine Invasive Species Program Annual Vessel Reporting Form (Page 3 of 6)

STATE OF CALIFORNIA – STATE LANDS COMMISSION
MARINE INVASIVE SPECIES PROGRAM ANNUAL VESSEL REPORTING FORM
SLC 600.12 (Revised 08/17)
Public Resources Code Sections 71201.7, 71205

7. 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 ☐	

8. 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 ☐	

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

10. 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**

11. 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 ☐	

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APPENDIX B

Marine Invasive Species Program Annual Vessel Reporting Form (Page 4 of 6)

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12. List the previous 10 ports visited by this vessel in the order they were visited (start with most recent). You do not have to use all 10 spaces if the vessel has a regular route that involves less than 10 ports.

Check here ☐ if the vessel visits the same ports on a regular route.

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:

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APPENDIX B

Marine Invasive Species Program Annual Vessel Reporting Form (Page 5 of 6)

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13. 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 ☐ Indicate the longest amount of time spent in a single location since the last hull cleaning

Number of Days:	Date of Arrival:
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. List dates as (**Day/Month/Year**):

Number of Days:	Date of Arrival:
Port or Position:	Country:
Number of Days:	Date of Arrival:
Port or Position:	Country:
Number of Days:	Date of Arrival:
Port or Position:	Country:
Number of Days:	Date of Arrival:
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Marine Invasive Species Program Annual Vessel Reporting Form (Page 6 of 6)

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SLC 600.12 (Revised 08/17)
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Section 2: Ballast Water Treatment System Information

COMPLETE ONLY IF VESSEL HAS A BALLAST WATER TREATMENT SYSTEM INSTALLED

Note: Complete a separate Section 2 for each installed ballast water treatment system.

14. Provide the following information about the vessel's installed ballast water treatment system:

Manufacturer/Company:
Product Name:
Model Number:
Date System Commissioned (**Day/Month/Year**):

15. Has the installed ballast water treatment system been used to treat ballast water in the last 12 months?

Yes ☐
Number of times the system was used in the last 12 months:
No ☐

16. Has the installed ballast water treatment system malfunctioned in the last 12 months?

Yes ☐	Date of Most Recent Malfunction (**Day/Month/Year)**
Describe all malfunctions during the previous 12 months:	
Describe all repairs for all malfunctions during the previous 12 months :	
No ☐	

17. Has an onboard test for biological performance of the vessel's installed ballast water treatment system been completed since the system was commissioned?

Yes ☐ If "YES", List the dates of the tests (**Day/Month/Year):**
No ☐

Official / IMO Number________________

APPENDIX C

In August 2016, the Commission adopted regulations to codify the Marine Invasive Species Act Enforcement and Hearing Process (California Code of Regulations, title 2, section 2299.01 et seq.). The regulations established an administrative enforcement process for violations of the MISA and associated regulations. The violations and associated penalties are classified as follows:

Class 1: Noncompliant ballast water discharges classified based on the distance from land at which ballast water exchange was conducted (operational violation)
Note: Violations are assessed on per tank basis.

Violation Level	Type of Violation	Maximum Penalty
Minor	• <u>Arrival from outside of the Pacific Coast Region (PCR) and carrying ballast water from outside the PCR</u>: Ballast water exchanged less than 200 NM and equal to or greater than 180 NM from land • <u>Arrival from inside the PCR and carrying ballast water from inside the PCR:</u> Ballast water exchanged less than 50 NM and equal to or greater than 45 NM from land	$5,000
Moderate:	• <u>Arrival from outside of the PCR and carrying ballast water from outside the PCR:</u> Ballast water exchanged less than 180 NM and equal to or greater than 100 NM from land • <u>Arrival from inside the PCR and carrying ballast water from inside the PCR:</u> Ballast water exchanged less than 45 NM and equal to or greater than 25 NM from land	$10,000
Major I:	• <u>Arrival from outside of the PCR and carrying ballast water from outside the PCR:</u> Ballast water exchanged less than 100 NM from land • <u>Arrival from inside the PCR and carrying ballast water from inside the PCR:</u> Ballast water exchanged less than 25 NM from land	$20,000
Major II:	No ballast water exchange	$27,500

APPENDIX C

Class 2: Failure to properly maintain required documentation on board (administrative violation)

Occurrence	Penalty
First occurrence	A Letter of Noncompliance is issued with no monetary penalty
Second occurrence	Maximum penalty of $10,000 per violation

Class 3: Failure to submit required reporting information to the Commission (administrative violation)

Occurrence	Penalty
First occurrence	A Letter of Noncompliance is issued with no monetary penalty
Second occurrence	Maximum penalty of $1,000 per violation

APPENDIX D

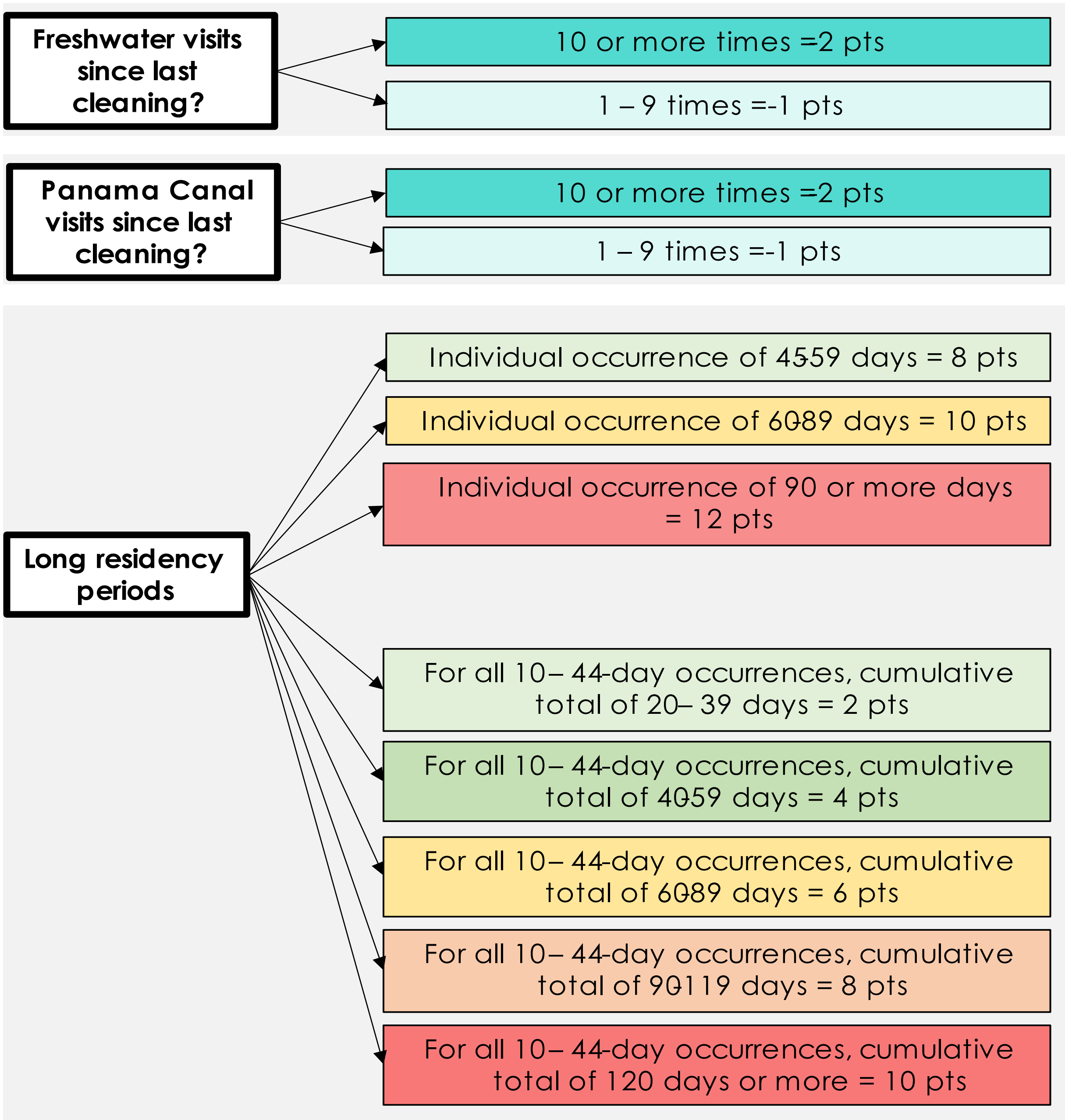
Combined Risk Assessment Model

BIOFOULING RISK SCORE

How old is the coating?	Less than 3 years = 0 pts
	3 through less than 4 years = 3 pts
	4 through less than 5 years = 6 pts
	5 or more years = 9 pts
Is a Marine Growth Prevention System used?	Yes = 0 pts
	No = 1 pts
Has the vessel been cleaned in-water?	Yes, within prior 6 months = 4 pts
	Yes, between 6- 12 months ago =-2 pts
	Yes, more than 12 months ago = 0 pts
	No = 0 pts
Vessel's average speed over previous 4 months	Greater than 13 knots = 0 pts
	Between 10 knots and 13 knots = 2 pts
	Less than 10 knots = 4 pts
Average port residency time?	Less than 6 days = 0 pts
	6 – 7.9 days = 1 pts
	8 – 9.9 days = 2 pts
	10 days or greater = 3 pts

APPENDIX D

Combined Risk Assessment Model



APPENDIX D

Combined Risk Assessment Model

Risk based on niche area contribution by vessel type

VESSEL TYPE	Points
Unmanned Barge	4 pts
Tug-Barge Combo (ATB)	4 pts
Passenger	3.9 pts
General	1.3 pts
Container	1.3 pts
Auto	1.1 pts
Tank	1.1 pts
Other	1.1 pts
Bulk	1 pts

Salinity Mismatch Correction Factor

- Arrival to a freshwater port = 0
- All other ports = 1

BF score = **Add all points for each question** + **Vessel type points (niche area)** X **Salinity Correction**

APPENDIX D

Combined Risk Assessment Model

BALLAST WATER RISK SCORE

Ballast Water Discharge Volume (BWD Vol)

Volume ranges in m³		Points	Percentile
>0	2821	1	5th
>2821	5638	2	10th
>5638	8452	3	15th
>8452	11279.5	4	20th
>11279.5	14095.4	5	25th
>14095.4	16930.8	6	30th
>16930.8	19750.3	7	35th
>19750.3	22562.2	8	40th
>22562.2	25137.1	9	45th
>25137.1	28134	10	50th
>28134	31028	11	55th
>31028	33457.1	12	60th
>33457.1	36406	13	65th
>36406	39019.1	14	70th
>39019.1	42002.2	15	75th
>42002.2	56448.9	20	80th-100th

Ballast Water Management Correction Factor (BWM Corr)

- BW Treatment + Exchange = 0.7
- BW Treatment = 0.8
- Mid-ocean source = 0.85
- BW Exchange = 0.9
- Mixed management = 0.9

Salinity Mismatch Correction Factor (Sal Corr)

- BWE or [BWE + BWT] and Freshwater port discharge = 0
- All other discharges = 1

BW score = (BWD vol) X (BWM Corr) X (Sal Corr)

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