2013 Assessment of the Efficacy, Availability, and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters

PRODUCED FOR THE
CALIFORNIA STATE LEGISLATURE

California State Lands Commission

June 2013

EXECUTIVE SUMMARY

Nonindigenous species (NIS) pose significant risks to human health, the economy, and the environment. California's economy depends on marine resources. California had the second largest ocean-based Gross Domestic Product in the U.S. in 2009 (the latest year for which data are available), and ranked number one for marine-related employment and second in wages. NIS threaten these and other components of California's ocean economy, including fish hatcheries and aquaculture, tourism, recreational boating, and marine transportation. The number of introduced invertebrates and algae in California exceeds that of most marine regions of the world. Ballast water is a significant ship-based introduction vector and is one of the primary routes by which NIS enter the coastal waters of California. NIS control measures cost millions of taxpayer dollars every year in California, and are ongoing because NIS are often impossible to remove once established. For these reasons, California is in a unique biological and economic position in relation to the global threat from NIS.

To limit the introduction and spread of NIS in California, the Coastal Ecosystems Protection Act (Act) of 2006 (SB 497) established performance standards for the discharge of ballast water and charged the California State Lands Commission (Commission) to implement those standards via regulation. Per governing statute and regulations, vessels have four options to comply with California's performance standards, including: 1) retention of all ballast water on board; 2) use of potable water as an alternative ballast water management method; 3) discharge to a shore-based ballast water reception and treatment facility; and 4) treatment of all ballast prior to discharge by a shipboard ballast water treatment system. While a large proportion (over 80%) of voyages to California waters retain all ballast water on board, a vessel may still need to discharge ballast on 20% of its voyages for either operational or safety purposes, and thus will need a method of ensuring that any discharged ballast is in compliance with the standards. Potable water may not be

an option for many vessels due to cost and the volume of water needed for ballasting purposes. Thus shipboard or shore-based ballast water treatment will be necessary for the majority of vessels discharging ballast in California waters.

In order to determine if ballast water treatment technologies are available to meet California's performance standards, the Act requires the Commission to prepare a report assessing the efficacy, availability, and environmental impacts, including effects on water quality, of available treatment technologies. If technologies are not available to meet California's performance standards, the report must discuss why they are not available. The current report reviews the availability of treatment technologies prior to the implementation of California's performance standards for existing vessels with a ballast water capacity of 1500-5000 metric tons on January 1, 2014. However, the ballast water treatment efficacy findings stated here apply to all vessel sizes.

The report specifically examines two platforms for the treatment of ballast water—shore-based ballast water reception and treatment facilities and shipboard ballast water treatment systems. Shore-based reception and treatment facilities include barge- or land-based facilities that treat ballast water after it has been transferred from a vessel. Shore-based facilities offer multiple advantages including ease of regulation, enhanced safety, reliability, compliance monitoring, and operation by dedicated trained personnel. At this time, there are no shore-based ballast water reception and treatment facilities in California or elsewhere in the U.S., and thus this option is not currently available to the shipping industry to comply with California's performance standards. Commission staff is securing the services of a third party manager to develop a request for proposals to produce a report examining the feasibility of shore-based treatment in California.

Shipboard ballast water treatment systems are installed on board the vessel and integrated into the vessel's ballast water system. Shipboard systems accommodate flexibility of vessel operations including discharging while underway or in ports throughout the world that do not have reception facilities available. Commission staff reviewed 75 shipboard ballast water treatment systems for this analysis, however, significant limitations in the existing data hamper the ability of Commission staff to determine if shipboard ballast water treatment systems are available to meet California's performance standards. Existing data for the 10 – 50 micron organism size class are not yet sensitive enough to confirm if California's performance standards are being reached, however it is clear that many systems are failing to meet this standard. No data are available to determine if California's viral standards can be met. Data for the remaining organism size classes (organisms greater than 50 microns in size, human health indicator species, and total bacteria) range in reliability in demonstrating the ability, under limited testing scenarios, to meet California's standards. Therefore, the Commission concludes that no shipboard ballast water treatment systems are currently available to meet all of California's performance standards for the discharge of ballast water.

In light of the lack of currently available options for discharging vessels to comply with California's performance standards for the discharge of ballast water, the Commission recommends that the California Legislature amend Public Resources Code section 71205.3 to delay implementation of the standards until such time that technologies can be deemed available to meet the standards.

This delay is an adaptive approach to the implementation of California's performance standards which will provide time for data to be collected on shipboard treatment system installation and performance and for the shore-based feasibility study to be completed while continuing to move the state towards fulfilling the Marine Invasive Species Program legislative mandate to eliminate the discharge of nonindigenous species into the waters of the state.

The findings and conclusions in this report replace and supersede any inconsistent findings in prior reports.

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ABBREVIATIONS AND TERMS

Act	Coastal Ecosystems Protection Act
CCR	California Code of Regulations
CFR	Code of Federal Regulations
CFU	Colony-Forming Unit
CSLC/Commission	California State Lands Commission
Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments
CWA	Clean Water Act
EEZ	Exclusive Economic Zone
EPA	United States Environmental Protection Agency
ETV	Environmental Technology Verification Program
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GESAMP-BWWG	Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection – Ballast Water Working Group
IMO	International Maritime Organization
MEPC	Marine Environment Protection Committee
Michigan DEQ	Michigan Department of Environmental Quality
ml	Milliliter
MPCA	Minnesota Pollution Control Agency
MT	Metric Ton
NIS	Nonindigenous Species
nm	Nautical Mile
NPDES	National Pollutant Discharge Elimination System
NRL	Naval Research Laboratory
PRC	Public Resources Code
STEP	Shipboard Technology Evaluation Program
TRC	Total Residual Chlorine
µm	Micrometer or Micron (one millionth of a meter)
USCG	United States Coast Guard
UV	Ultraviolet Irradiation
VGP	Vessel General Permit for Discharges Incidental to the Normal Operation of Commercial Vessels and Large Recreational Vessels
Water Board	California State Water Resources Control Board
WDNR	Wisconsin Department of Natural Resources

DISCLAIMER

This report provides information regarding the availability of ballast water treatment systems to meet California's performance standards for the discharge of ballast water. This report does not constitute an endorsement or approval of any treatment system, system manufacturer or vendor by the California State Lands Commission (Commission) or its staff. Data are presented for informational purposes regarding systems currently available on the market, but the Commission strongly recommends that any party wishing to purchase a treatment system consult with system vendors directly regarding system operational capabilities and third-party testing data. Any ballast water discharged into California waters must comply with California's Marine Invasive Species Act (Public Resources Code section 71200 et seq.) and associated regulations (Title 2 California Code of Regulations section 2270 et seq.) for preventing species introductions, as well as all other applicable laws, regulations, and permits.

I. PURPOSE

This report was prepared for the California Legislature pursuant to Public Resources Code (PRC) section 71205.3. Among its provisions, PRC section 71205.3(b) requires the Commission to implement performance standards for the discharge of ballast water and to prepare and submit to the Legislature, "a review of the efficacy, availability, and environmental impacts, including the effect on water quality, of currently available technologies for ballast water treatment systems." If no systems exist that can meet California's performance standards, this report must contain an analysis of why systems are unavailable.

California's regulations implementing statutory performance standards for the discharge of ballast water were approved by the Commission in 2007 (see California Code of Regulations (CCR), title 2, division 3, chapter 1, article 4.7). The

Commission completed an initial ballast water treatment technology assessment report in 2007 (see Dobroski et al. 2007) and revised reports in 2009 (see Dobroski et al. 2009a) and 2010 (see California State Lands Commission 2010). Additional reports are due to the California Legislature 18 months prior to each of the implementation dates for California's performance standards (see Tables III-1 and III-2). This report is in response to the legislative mandate to assess the availability of ballast water treatment technologies prior to the January 1, 2014 implementation of California's performance standards for existing vessels (those built prior to January 1, 2010) with a ballast water capacity of 1500–5000 metric tons (MT). The report summarizes the Commission's conclusions on the advancement of ballast water treatment technology development, reviews industry efforts to retrofit existing vessels with ballast water treatment systems, and discusses progress by the Commission in implementing California's performance standards for the discharge of ballast water.

Because the central findings of this report are not affected by vessel size, the ballast water treatment efficacy information and conclusions stated here may be applied to all vessel sizes. As this report presents the latest information available, the findings found herein may be considered to replace and supersede any inconsistent findings in prior reports. For immediate consideration, this would include qualifying new build vessels with a ballast water capacity of less than or equal to 5000 metric tons that began construction on or after January 1, 2010, and new build vessels with a ballast water capacity of greater than 5000 metric tons that began construction on or after January 1, 2012. Those vessels have either already arrived or will begin arriving into California waters in 2013 and will be required to comply with California's performance standards for the discharge of ballast water.

II. INTRODUCTION

Nonindigenous species have negative economic, ecological, and public health impacts that are costly at the state, federal, and international levels

Nonindigenous species (also known as “introduced,” “invasive,” “non-native,” “exotic,” “alien,” or “aquatic nuisance species”) are organisms that have been transported by human activities to regions where they did not historically occur, and have established reproducing wild populations (Carlton 2001). Once established, nonindigenous species (NIS) can have serious human health, economic and environmental impacts in their new environment. Economic impacts from NIS may include property damages and declines in fishery yields and tourism. Costs also arise from efforts to control or eradicate NIS once they are established, and these efforts are often unsuccessful (Carlton 2001). Since 1956, for example, the U.S. and Canada have each spent more than $16 million every year on control of sea lampreys alone in efforts to protect Great Lakes fisheries (Lodge et al. 2006). For this reason, prevention of NIS introductions is considered more desirable than control. Cumulative costs in the United States related to NIS were estimated to cost taxpayers $120 billion in 2005 (Pimentel et al. 2005).

NIS also create environmental problems where they are introduced. The comb jelly *Mnemiopsis leidyi*, for example, was introduced from North America to the Black Sea, where it feeds on plankton and fish eggs (Purcell et al. 2001), and has contributed to declines in locally important fish species. Worldwide, 42 percent of the species listed as threatened or endangered in 2005 were listed, in part, because of negative interactions with NIS (e.g. competition) (Pimentel et al. 2005).

In addition, many human pathogens and contaminant indicator micro-organisms have been introduced to locations all over the world. These pathogens include human cholera (*Vibrio cholerae* O1 and O139) (Ruiz et al. 2000), toxic aquatic microbes that cause paralytic shellfish poisoning (Hallegraeff 1998), human intestinal parasites, and microbial indicators for fecal contamination (*Escherichia* *coli* and intestinal enterococci) (Reid et al. 2007). Larger NIS can also serve as intermediate hosts for human parasites (Brant et al. 2010).

Ballast water can transport nonindigenous species that are harmful to the economy, public health, and important native species in California

Commercial shipping is an important transport mechanism, or “vector,” for nonindigenous species in marine, estuarine and freshwater environments, contributing up to an estimated 80 percent of invertebrate and algae introductions to North America (Fofonoff et al. 2003, see also Cohen and Carlton 1995 for San Francisco Bay). Fofonoff et al. (2003) discuss that ballast water is a possible vector for 69 percent of shipping introductions of NIS, with the remaining introductions attributed solely to biofouling. Therefore, ballast water is a significant ship-based introduction vector, and is one of the primary routes, along with biofouling, by which nonindigenous species enter the coastal waters of California (Fofonoff et al. 2003, Ruiz et al. 2011). The number of introduced invertebrates and algae in California exceeds that of most marine regions of the world, with the exception of the Mediterranean and the Hawaiian Islands (Ruiz et al. 2011), and includes three NIS recently identified by the California Department of Fish and Wildlife (formerly the California Department of Fish and Game) that have not previously been observed in San Francisco Bay (CDFG 2011). Ballast water was cited as a possible mechanism for all three of these new introductions.

Ballast water is necessary for many functions relating to the trim, stability, maneuverability, stress management, and propulsion of large oceangoing vessels (National Research Council 1996). Vessels take on, discharge, and redistribute ballast water during cargo loading and unloading, during fuel loading and burning, in rough seas, or in transit into or through shallow coastal waterways. Typically, ships take on ballast water after cargo is unloaded in one port, and later discharge that water when cargo is loaded in another port. This transfer of ballast water from “source” to “destination” ports results in the movement of many organisms from one region to another. It is estimated that more than 7000 species are moved around the world every day in ballast water (Carlton 1999). In California, some of these ballast water-mediated introductions have had significant negative environmental and economic impacts.

One of the most infamous examples of a costly NIS in California, and the United States as a whole, is the zebra mussel (*Dreissena polymorpha*). This tiny mussel was introduced to the Great Lakes in the mid-1980s via ballast water from the Black Sea (Carlton 2008), and was later found in California in 2008 (CDFG 2008). Zebra mussels, and the closely related invasive quagga mussel (*Dreissena rostriformis bugensis*), attach to hard surfaces in dense aggregations that have clogged municipal water systems and electric generating plants, costing approximately $1 billion per year in damage and control for the Great Lakes (Pimentel et al. 2005). Zebra mussels have invaded San Justo Reservoir in San Benito County (California), and quagga mussels have invaded multiple locations in southern California (USGS 2012). Should quagga mussels spread to the Lake Tahoe region, they could create control costs of up to $22 million per year (US Army Corps of Engineers 2009). Over $14 million has already been spent to control zebra and quagga mussels in California (Norton, D., pers. comm. 2012). These costs represent only a fraction of the cumulative expenses related to NIS control over time, because such control is an unending process.

Ballast water introductions in California also present risks to public health. For example, the Japanese sea slug *Haminoea japonica* was introduced, likely via ballast water, to San Francisco Bay in 1999. This slug is a host for parasites that cause cercarial dermatitis, or “swimmer’s itch,” in humans. Since 2005, cases of swimmer’s itch at Robert Crown Memorial Beach in Alameda have occurred on an annual basis and are associated with high densities of *Haminoea japonica* (Brant et al. 2010). Ballast water has also been shown to transport viable human pathogens such as *Vibrio cholerae* (Ruiz et al. 2000), which remains a public health concern anywhere ballast water is discharged.

NIS also negatively impact native California species. The invasive overbite clam (*Corbula amurensis*) has been linked in multiple studies to the decline of endangered delta smelt in the Sacramento-San Joaquin River Delta. It is believed that these clams reduce the plankton food base in this ecosystem and limit food availability for these endangered native fish species (Feyrer et al. 2003, Sommer et al. 2007, MacNally et al. 2010).

Open ocean exchange does not adequately address ballast water introductions

Due to safety and efficacy limitations of ballast water exchange, regulatory agencies and the commercial shipping industry have looked toward the establishment of ballast water performance standards and the development of shore-based ballast water treatment facilities and shipboard ballast water treatment systems capable of meeting those standards. For regulators, such technologies would provide NIS prevention, even under adverse conditions that would preclude exchange, and could provide a higher level of protection from NIS in general. For the shipping industry, the use of effective ballast water treatment technologies might allow voyages to proceed along the shortest available routes, without having to conduct exchange. For many vessels, this could mean safer conditions for ships and crews, as well as savings in transit time and money.

For the vast majority of commercial vessels, ballast water exchange is currently the primary management technique to prevent or minimize the transfer of coastal, bay, and estuarine organisms. During exchange, the biologically rich water that was loaded when a vessel was in port or near the coast is exchanged with the comparatively species-poor waters of the mid-ocean (Zhang and Dickman 1999).

Organisms adapted to coastal environments that were taken up with ballast water in port are flushed into the open ocean environment where they are not expected to survive and reproduce due to differences in biological factors (competition, predation, food availability) and oceanographic factors (turbidity, temperature, salinity, nutrient levels) (Cohen 1998). Any organisms taken up from mid-ocean environments are similarly not expected to survive or reproduce in coastal waters (Cohen 1998).

Ballast water exchange is generally considered to be an interim tool because of its variable efficacy, and operational and safety limitations. Studies indicate that ballast water exchange eliminates between 50–99 percent of organisms in ballast tanks (Cohen 1998, Parsons 1998, Zhang and Dickman 1999, USCG 2001, Wonham et al. 2001, MacIssac et al. 2002), however exchanging more ballast water does not necessarily improve its biological efficacy. Additionally, vessels routed on short voyages or that remain within 50 nautical miles (nm) of shore may have to delay or divert from the most direct course available to perform a proper exchange. A delay or deviation in a ship's route can extend travel distance, increase costs for personnel time and fuel consumption, and lead to increased air emissions.

Occasionally, ballast water exchange cannot be performed because it would compromise crew or vessel safety. Vessels that encounter adverse weather or experience equipment failure may be unable to conduct exchange safely. Unmanned barges are incapable of conducting exchange without extensive engineering modifications, unless personnel are transferred onboard. Personnel transfer to a barge presents unacceptable safety risks if performed in the open ocean. State and federal ballast water regulations allow vessels to forego exchange should the master or other person in charge determine that it would place a vessel, its crew, or its passengers at risk. This provision is primarily invoked by unmanned barges, and the vessels that use it sometimes discharge unexchanged ballast into state waters, which elevates the risk of NIS introduction.

California adopts statutory performance standards to prevent the introduction of nonindigenous species through ballast water discharge

California's coastal waters have been the entry point for 79 percent of known invertebrate and algal invasions by nonindigenous species on the west coast of the United States (including Alaska) and Canada , due in part to the high frequency of marine commerce and large variety of habitats present in San Francisco Bay (Ruiz 2011). This fact places California in a unique position regarding NIS management and prevention. California took the U.S. lead in the prevention of marine NIS introductions in 1999 by being the first state to adopt mandatory ballast water management requirements (Ballast Water Management for Control of Nonindigenous Species Act, Chapter 849, Statutes of 1999). In 2006, California cemented its leadership role by adopting statutory performance standards for ballast water discharge (Coastal Ecosystems Protection Act, Stats. 2006, ch. 292, codified as Public Resources Code (PRC) section 71205.3), which are being implemented via regulations adopted in October 2007 (see California Code of Regulations (CCR), title 2, section 2291 et seq.). Other states and the federal government have since followed suit and have adopted or are in the process of developing performance standards for ballast water discharge (see Section III. Regulatory and Programmatic Overview, for more details).

California's legislatively-adopted performance standards set limits for the allowable concentration of living organisms discharged from vessels. The absence of such standards was once identified by shipping industry representatives, ballast water technology developers, and investors as a major impediment to the development of treatment technologies (MEPC 2003). Since that time, the adoption of a single discharge standard by the International Maritime Organization (IMO) and the

United States Coast Guard (USCG) has provided a universal benchmark for the rapid development of treatment systems. While developers of treatment systems are seeking the complete removal or killing of all species in ballast water, type approval testing to meet the IMO/USCG standard enables administrations and ship owners/operators to assess system performance against thresholds set in regulations. California's protective ballast water treatment standards were designed, in part, to encourage the development of innovative and effective ballast water treatment technologies, and new systems have emerged rapidly since 2006. New systems and new data on existing systems continue to emerge and are the focus of this technology assessment report.

III. REGULATORY AND PROGRAMMATIC OVERVIEW

The regulatory framework and context of performance standards development for ballast water discharges has influenced the advent of new ballast water treatment technologies. For this reason, a thorough review of the implementation of performance standards in California and the technologies available to treat ballast water must include an overview of regulatory activities at the state, national, and international levels. Currently, there are no formally adopted and implemented international, federal, or state programs that include all three of the following, (though all three are currently being developed at the International and Federal levels):

1) performance standards;
2) testing guidelines or protocols to verify the performance of treatment technologies (i.e. type approval); and
3) methods to sample and analyze discharged ballast water for compliance purposes.

California, other U.S. states, the federal government, and the international community continue to work towards the development of standardized approaches for the management of discharged ballast water, however, existing legislation, standards, and guidelines still vary by jurisdiction. The following is a summary of current performance standards-related laws, regulations, and permits by jurisdiction, and a review of current and proposed processes for treatment system evaluation and compliance assessment.

International Maritime Organization

In February 2005, after several years of development and negotiation, International Maritime Organization (IMO) Member States adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Convention) (see IMO 2005). Among its provisions, the Convention includes performance standards for the discharge of ballast water (Regulation D-2) with an associated implementation schedule based on vessel ballast water capacity and date of construction (Tables III-1 and III-2).

The Convention, as proposed, would enter into force 12 months after ratification by 30 countries representing 35 percent of the world's commercial shipping tonnage (IMO 2005). As of April 30, 2013, 36 countries representing 29 percent of the world's shipping tonnage have ratified the convention (IMO 2013). The Convention cannot be enforced upon any ship until it is ratified and enters into force (IMO 2007). Because the Convention did not enter into force before the first performance standards implementation date in 2009, the IMO General Assembly adopted Resolution A.1005(25) (IMO 2007). The resolution delays the date by which new vessels built in 2009 with a ballast water capacity of less than or equal to 5000 MT are proposed to comply with Regulation D-2 from 2009 until the vessel's second annual survey, but no later than December 31, 2011 (IMO 2007). In September 2009, another draft resolution was put forth to encourage the installation of ballast water treatment systems on new build ships based on the existing implementation dates, even though the Convention had not yet been ratified (MEPC 2009j). That resolution was adopted at the 60th meeting of the Marine Environment Protection Committee (MEPC) in March 2010. However, since the conditions of the resolution are not mandatory, the implementation dates for all other vessel size classes and construction dates remain the same as originally proposed (Table III-2).

Table III-1. Ballast Water Discharge Performance Standards

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

[1] See Table III-2 below for dates by which vessels must meet California and U.S. Federal (USCG/EPA) adopted standards and IMO proposed Ballast Water Performance Standards.
[2] Final discharge standard for California, beginning January 1, 2020, is zero detectable living organisms for all organism size classes.
[3] Micrometer = one-millionth of a meter
[4] Milliliter = one-thousandth of a liter
[5] Colony-forming unit (CFU) is a standard measure of viable bacterial numbers.

Table III-2. Implementation Schedule for Performance Standards

Ballast Water Capacity of Vessel	Standards apply to new vessels in this size class constructed on or after			Standards apply to all other vessels in this size class beginning in[1]
	IMO	CA	USCG/ EPA	
< 1500 metric tons	2009[2]	2010	Dec. 1, 2013[3]	2016
1500 – 5000 metric tons	2009[2]	2010	Dec. 1, 2013[3]	2014
> 5000 metric tons	2012	2012	Dec. 1, 2013[3]	2016

[1] In California, the standards apply to vessels in this size class as of January 1 of the year of compliance. The IMO Convention would apply to vessels in this size class no later than the first intermediate or renewal survey, whichever occurs first, after the anniversary date of delivery of the ship in the year of compliance (IMO 2005). According to USCG Final Rule and EPA 2013 Vessel General Permit, existing vessels must meet the standards as of the first scheduled dry docking after January 1, 2014 or 2016, depending on the vessel's ballast water capacity.

[2] IMO delayed the initial implementation of the performance standards for vessels constructed in 2009 in this size class until the vessel's second annual survey, but no later than December 31, 2011 (IMO 2007).

[3] USCG/EPA standards will be implemented upon delivery for new build vessels.

Once the Convention enters into force, it will apply to vessels flagged from parties to the Convention and vessels arriving to ports administered by parties to the Convention. In order to enable globally uniform application of the requirements of the Convention, the IMO MEPC has adopted 14 implementation guidelines (Everett, R., pers. comm. 2010). Most relevant to this report, Guideline G8, "Guidelines for Approval of Ballast Water Management Systems" (MEPC 2008f), and Guideline G9, "Procedure for Approval of Ballast Water Management Systems That Make Use of Active Substances" (MEPC 2008e), work together to create a framework for the evaluation of shipboard ballast water treatment systems by the MEPC and Flag State Administration (the country or flag under which a vessel operates) (Figure III-1). Flag States (not the IMO) are authorized under this Convention to grant approval (also known as "type approval") to shipboard treatment systems that have demonstrated the ability to comply with the

Convention’s Regulation D-2 performance standards based upon recommended procedures detailed in Guideline G8 for full-scale land-based and shipboard testing. A treatment system may not be used by a vessel for compliance with the Convention D-2 standards unless that system is type approved by a representative Flag State.

Before receiving type approval from the Flag State, shipboard ballast water treatment systems using “active substances” must first be approved by the IMO MEPC based upon Guideline G9 (IMO 2005). An active substance is defined by IMO as, “…a substance or organism, including a virus or a fungus, that has a general or specific action on or against Harmful Aquatic Organisms and Pathogens” (IMO 2005). For all intents and purposes, an active substance is a chemical or reagent (e.g. chlorine, ozone) that kills organisms in ballast water. The MEPC has decided that ultraviolet radiation (UV) does not classify as an active substance. The IMO approval pathway for treatment systems that use active substances is more complex than the evaluation process for technologies that do not. As required by Guideline G9, technologies utilizing active substances must go through a two-step “Basic” and “Final” approval process. Active substance systems that apply for Basic and Final Approval are reviewed for environmental, ship, and personnel safety by the IMO Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) – Ballast Water Working Group (BWWG) in accordance with the procedures detailed in Guideline G9. The MEPC may grant Basic or Final Approval based upon the recommendation of the GESAMP-BWWG.

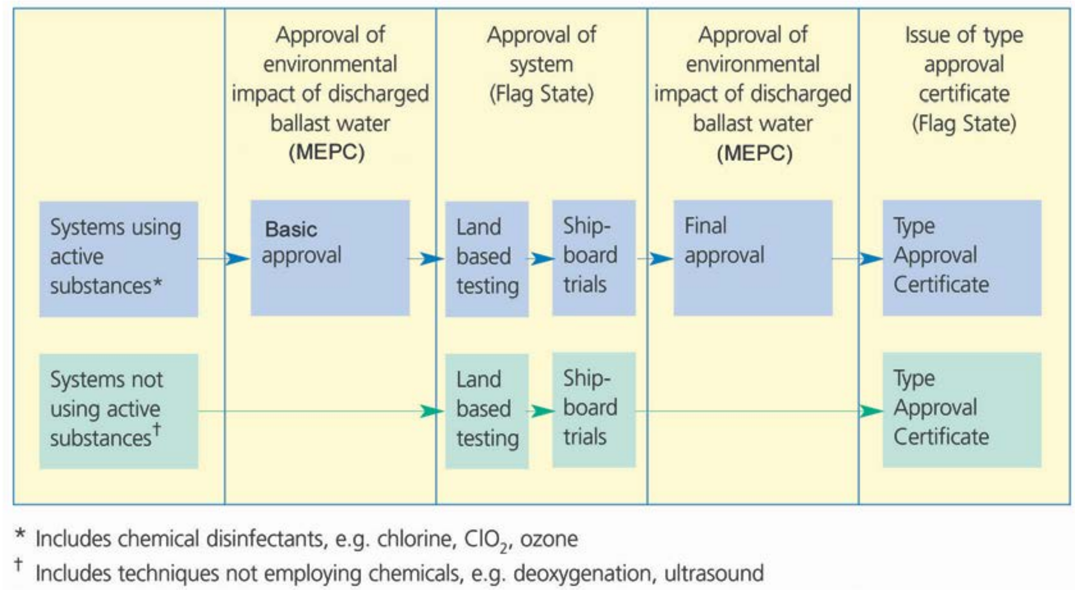

Figure III-1. Summary of IMO approval pathway for ballast water treatment systems. (Modified from Lloyd's Register (2007))

The entire IMO evaluation process, including approval for systems using active substances, may take two or more years to complete depending on the time lag for GESAMP-BWWG review and the number of systems attempting to gain Type Approval from any Flag State at one time. Once a ballast water treatment system has acquired Type Approval (and the Convention is ratified and in force), the system is deemed acceptable by parties to the Convention, under regulation D-3, for use in meeting the requirements of the Convention.

Since the U.S. has not signed on to the Convention, U.S. treatment vendors may seek IMO type approval for their treatment systems through association with other IMO Member States, and several have or are in the process of doing so. This IMO member state type approval will not, alone, be sufficient for operation in the U.S. under the USCG rule for living organisms discharged in ships' ballast water, but can be used to apply to the USCG for acceptance as an alternate management strategy (AMS) (discussed below). Unless the U.S. signs on to the Convention, and the Convention is ratified and enters into force, the U.S. is not party to IMO requirements. Hence, vessels calling on U.S. ports cannot rely on treatment systems approved solely through the IMO type approval process to meet U.S. ballast water management requirements. Vessels calling on U.S. ports must ensure that their systems meet and are approved under the USCG approval process or as an AMS (discussed below). It should be noted, that treatment systems installed by vessel owners/operators to comply with the IMO Convention may not subsequently be type approved by the USCG, even if they are accepted as an AMS. Should this occur, those vessels might be required to replace previously installed treatment systems with USCG approved systems, regardless of the status of the IMO Convention.

U.S. Federal Legislation and Programs

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

USCG

The USCG currently regulates ballast water under regulations found in title 33 of the Code of Federal Regulation (CFR) part 151. The regulations include requirements for vessels arriving from outside of the U.S. Exclusive Economic Zone (EEZ) to conduct ballast water exchange prior to discharge in U.S. waters. On March 23, 2012 the USCG published final regulations in the Federal Register that establish federal performance standards for living organisms in ships' ballast water discharged in US waters. This rule became effective on June 21, 2012. The USCG standards are the same as those established by the IMO Ballast Water Convention (see Table III-1), although the Federal regulations do allow for a review and possible strengthening of the standards as treatment technology improves. The USCG standards will be implemented upon delivery for new build vessels constructed on or after December 1, 2013. Existing vessels (i.e. vessels constructed before December 1, 2013) must meet the standards as of the first scheduled dry docking after January 1, 2014 or 2016, depending on the vessel's ballast water capacity. Vessel owners may request an extension of the implementation date if, despite all best efforts, the vessel will not be able to comply with the USCG standards. The USCG rule provides exemptions for vessels that operate exclusively within the Great Lakes, exclusively within one Captain of the Port Zone, and for those vessels less than 1600 gross registered tons in size that operate solely within the U.S. Exclusive Economic Zone.

Vessel owners and operators have several options available to them to comply with the USCG standards. Vessels may retain all ballast water onboard (the most protective management strategy available), discharge ballast to a USCG-approved shore-based treatment facility, utilize potable water from the U.S. or Canada, or treat all ballast using a USCG approved shipboard ballast water treatment system.

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

Because the USCG anticipates that it may take several years to approve treatment systems, the final rule includes an Alternative Management System (AMS) provision. AMS acceptance is not "USCG Type Approval", but rather a bridging strategy that temporarily accepts the use of previously-installed foreign type approved ballast water treatment systems in U.S. waters. USCG acceptance of an AMS will allow vessels to use that system for up to five years after the applicable implementation date while the USCG reviews the system for approval. The USCG published an initial list of accepted AMS on April 16, 2013. The list will be updated on the USCG website as additional AMS are reviewed and accepted.

Vessels that install treatment systems before the USCG type approval process is completed (such as to comply with IMO or state laws) will not have any assurance that the treatment system will later be approved by the USCG. This uncertainty, coupled with the high cost of procuring and installing treatment systems on board ships, is one reason why the shipping industry has been hesitant to begin installing treatment systems at this time—even in the face of the implementation of performance standards by California.

The USCG continues to operate the Shipboard Technology Evaluation Program (STEP) to facilitate the development of ballast water treatment technologies. Vessel owners and operators accepted into STEP may install and operate specific experimental ballast water treatment systems on their vessels for use in U.S. waters. In order to be accepted, treatment technology developers must assess the efficacy of systems for removing biological organisms, residual concentrations of treatment chemicals, and water quality parameters of the discharged ballast water (USCG 2004). Vessels accepted into the program are authorized to operate the system to comply with existing USCG ballast water management requirements and will be grandfathered for operation under future ballast water discharge standards for the life of the vessel or the treatment system, whichever is shorter. As of May 2013, five vessels are enrolled in STEP (USCG 2013). The lengthy STEP review process and recent uncertainties regarding requirements for biological testing on STEP vessels have delayed significant testing of treatment systems on STEP vessels. The USCG has, however, made efforts to streamline the review process for future applicants. USCG plans to continue STEP even after the implementation of performance standards, as the STEP will serve to facilitate system shipboard testing for USCG approval, and will continue to promote vessel access for the research and development of promising experimental technologies (Moore, B., pers. comm. 2010; Everett, R., pers. comm. 2010).

EPA

On February 6, 2009, the EPA joined USCG in the regulation of ballast water in U.S. waters. The EPA regulates ballast water, and other discharges incidental to normal vessel operations, through the Clean Water Act (CWA). This requirement stems from a 2003 lawsuit filed by Northwest Environmental Advocates against the EPA in U.S. District Court, Northern District of California, challenging a regulation originally promulgated under the CWA (*Nw. Envtl. Advocates v. U.S. EPA*, (N.D. Cal.

Sept. 18, 2006, No. C 03-05760 SI) 2006 U.S. Dist. LEXIS 69476). The regulation at issue, 40 Code of Federal Regulations section 122.3(a), exempted effluent discharges "incidental to the normal operations of a vessel," including ballast water, from regulation under the National Pollutant Discharge Elimination System (NPDES). The plaintiffs sought to have the regulation declared *ultra vires,* or beyond the authority of the EPA, under the CWA. On March 31, 2005, the District Court granted judgment in favor of plaintiffs and on September 18, 2006 the Court issued an order revoking the regulation (40 C.F.R. section 122.3(a)) as of September 30, 2008. The EPA filed an appeal with the Ninth Circuit U.S. Court of Appeals which was denied in July 2008 (*Nw. Envtl. Advocates v. U.S. EPA*, (9th Cir. July 23, 2008, No. 03-74795) 2008 U.S. App. LEXIS 15576).

In June 2008, the EPA released for public comment the draft NPDES "Vessel General Permit for Discharges Incidental to the Normal Operation of Commercial Vessels and Large Recreation Vessels" (VGP). In September 2008, the District Court granted a motion to delay the order vacating regulation section 122.3(a) from September 30 to December 19, 2008. The implementation of the permit was later delayed to February 6, 2009 to provide the regulated community with additional time to comply. The VGP regulates 26 discharges incidental to the normal operation of vessels, including ballast water and hull husbandry discharges. In large part, the VGP maintains the regulation of ballast water discharges by the USCG under 33 Code of Federal Regulation part 151 and does not include performance standards for the discharge of ballast water. The current version of the VGP expires on December 18, 2013.

In 2009, the State of Michigan and environmental groups filed suit against the EPA charging that the VGP violates the Clean Water Act because it does not adequately protect U.S. waters from invasive species and could lead to violation of water quality standards. In March 2011, plaintiffs and the EPA reached a settlement in the case. The settlement required the EPA to release a draft revised Vessel General Permit by November 30, 2011 that includes numeric effluent limits for the concentration of living organisms in discharged ballast water (i.e. performance standards). Additionally, the EPA agreed to provide additional time to states to review the draft permit and add state-specific provisions under the CWA section 401 certification process.

The EPA released the draft 2013 Vessel General Permit in the Federal Register on December 8, 2011. The draft 2013 VGP was open to public comment between December 8, 2011 and February 21, 2012, and the EPA hosted public meetings and information sessions during that time to answer questions about the proposed permit. The 2013 VGP was finalized and released on March 28, 2013, prior to publication in the Federal Register on April 12, 2013. The 2013 VGP, which takes effect on December 19, 2013, will require vessels to meet performance standards for the discharge of ballast water equivalent to the standards set forth by the IMO Ballast Water Convention and the USCG final rule on standards for living organisms discharged in ships' ballast water. Vessels may comply with the performance standards set forth in the permit through the use of shipboard ballast water treatment systems, potable water, onshore treatment facilities, or retention of all ballast on board. The implementation schedule is similar to that established by the USCG final rule. Vessels constructed after December 1, 2013 must meet the standards upon delivery of the vessel (and implementation of the permit—which takes place on December 19, 2013). Existing vessels constructed before December 1, 2013, must meet the standards as of the first scheduled dry dock after January 1, 2014 or 2016, depending on the vessel's ballast water capacity. The 2013 VGP exempts from performance standards requirements vessels operating exclusively on the Great Lakes, unmanned, unpowered barges, vessels operating within one USCG Captain of the Port Zone, and inland and seagoing vessels less than 1600 gross registered tons.

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

Twenty-five states added state-specific requirements to the 2013 VGP through the Clean Water Act section 401 certification process. The California State Water Resources Control Board (Water Board) submitted conditions for California, including requirements for compliance with all provisions of California's Marine Invasive Species Act. See "U.S. State Legislation and Programs," this section, for further discussion of selected states' 401 certification provisions.

EPA/USCG Collaborative Activities

The EPA and USCG have been working collaboratively to develop performance standards and programs to evaluate shipboard ballast water treatment system performance. One such program, the EPA Environmental Technology Verification (ETV) program, is an effort to verify the performance of and accelerate the entrance of new technologies that have the potential to improve protection of human health and the environment. In 2001, the USCG and the EPA established a formal agreement to implement an ETV program focused on ballast water management. Under this agreement, the ETV program developed a draft protocol in 2004 for verification of the performance of shipboard ballast water treatment technologies. Subsequently, the USCG established an agreement with the Naval Research Laboratory (NRL) to evaluate, refine, and validate this protocol and the test facility design required for its use. This validation project resulted in the construction of a model ETV Ballast Water Treatment System Test Facility at the NRL Corrosion Science and Engineering facility in Key West, Florida. The research conducted at the NRL facility has led to the development of technical procedures for testing shipboard ballast water treatment systems for the purpose of approval and certification. Based on the information collected during the evaluation of the 2004 draft protocol, ETV staff, in consultation with an advisory panel (of which Commission staff is a member), revised the protocol. In September 2010, the EPA released the “Generic Protocol for the Verification of Ballast Water Treatment Technology” (see EPA 2010). The protocol established specific methods and procedures for verifying shipboard ballast water treatment system performance against a range of standards at land-based testing facilities. In 2012, the USCG incorporated by reference the requirements of the ETV protocol into its final rule as part of the testing process to approve shipboard ballast water treatment systems. EPA and USCG are currently pursuing the development of an ETV shipboard testing protocol to verify treatment system performance at sea. Commission staff has been invited to participate in this process.

In 2010, the EPA and USCG also worked together to direct two scientific studies (commissioned by the EPA) to better inform understanding of ballast water performance standards and treatment technologies. The goals of the studies were to evaluate: 1) the risk of species introduction given certain living organism concentrations in ballast water discharges, and 2) the efficacy and availability of ballast water treatment technologies. The National Academy of Sciences’ National Research Council (NRC) was charged with evaluating the organism concentration question, and the EPA Office of Water requested the EPA Science Advisory Board’s (SAB) Ecological Processes and Effects Committee, augmented with experts in ballast water issues, to address the efficacy/availability question. The outcomes of these two studies were considered in the development of the USCG final rule on living organisms discharged in ships’ ballast water and the EPA 2013 Vessel General Permit.

On June 2, 2011, the NRC released the report "Assessing the Relationship Between Propagule Pressure and Invasion Risk in Ballast Water" (see NRC 2011). The goal of the report was to "inform the regulation of ballast water by helping EPA and the USCG better understand the relationship between the concentration of living organisms in ballast water discharges and the probability of nonindigenous organisms successfully establishing populations in U.S. waters." The report concluded that there is currently insufficient information to determine the probability of invasion associated with any particular discharge standard, but nonetheless recommended establishing a "benchmark" discharge standard, such as the IMO standards, stating that this would be "clearly a first step forward, serving to reduce propagule pressure and thus the scale (number and rate) of invasions." The report further recommended the selection of a risk-based model to guide the collection of experimental and field-based data for further analysis to inform the selection of science-based standards in the future.

The SAB report, "Efficacy of Ballast Water Treatment Systems: a Report by the EPA Science Advisory Board," was finalized in July 2011 (see SAB 2011). The panel examined 51 shipboard ballast water treatment technologies, of which only nine systems were deemed to have reliable data (defined by the SAB as including, at a minimum, methods and results from land-based or shipboard testing) that was publically available and allowed for scientifically credible assessment of performance. The SAB evaluated the ability of those nine systems, condensed into five operational types (e.g. filtration + electrochlorination), to meet various existing and proposed performance standards, ranging from the IMO D-2 standard to a standard 1,000 times more stringent than IMO for organisms greater than 50 microns in minimum dimension and organisms 10–50 microns in minimum dimension. The limit of 1000 time more stringent than the IMO standards for organisms 10-50 microns in minimum dimension is the same as the California standard for that organism size class, but California's standards for other organism size classes were not specifically included in the analysis.

The SAB report concluded that the nine systems could meet the IMO D-2 standard, but that "the detection limits for currently available test methods preclude a complete statistical assessment of whether [ballast water treatment systems] can meet standards more stringent than IMO D-2/[USCG standard]. However, based on the available testing data, it is clear that while five types of [ballast water treatment systems] are able to reach IMO D-2/[USCG standard], none of the systems evaluated by the panel performed at 100 times or 1000 times the [USCG] [IMO D-2] standard." Despite the challenges posed by currently available detection limits, the panel concluded that based on existing data no systems could currently meet standards 100 or 1,000 times more stringent than IMO D-2 and none would be able to do so in the foreseeable future. Furthermore, the panel believed that reaching standards 100–1,000 times more stringent than IMO D-2 would require wholly new treatment technologies. The panel considered the use of risk management systems approaches to reduce species introductions from vessels, including, for example, modifications to vessel operations and ship design, as well as options for shore-based ballast water reception and treatment facilities. The SAB report represents the most comprehensive federal effort to assess technologies available to manage ballast water now and in the near future.

Commission staff has reviewed the conclusions in the SAB report with some caution. The SAB report did not include some systems for which Commission staff was able to obtain third-party testing data, and the report does not address all seven of California's performance standards in the analysis of available systems. Both Commission Staff and the staff from the New York Department of Environmental Conservation submitted comments letters to the SAB raising concerns about the methods of analysis and ultimate conclusions of the report.

These letters are available for public review on the SAB Ballast Water Advisory panel's website.

Impacts of Federal Actions in California

The EPA VGP and the USCG regulations do not relieve vessel owners/operators (permittees) of the responsibility of complying with applicable state laws and/or regulations. Some states have added specific provisions, including performance standards for vessel discharges in state waters, to the EPA's general permit through the CWA section 401 certification process (see next section). Although there is not expected to be any impact from the implementation of the NPDES permit on individual states' ability to implement performance standards for the discharge of ballast water in state waters, including California, there will likely be practical effects because of the Coast Guard's regulations requiring all shipboard ballast water treatment systems to be USCG approved. Since vessels will have to comply with both state and federal regulations for ballast water management under the VGP and USCG regulations, until such time that ballast water treatment systems are approved by the USCG, and the USCG standards go into effect, this may result in vessels having to both exchange ballast water to comply with federal management requirements and also treat ballast water to comply with state regulations. Furthermore, it is possible that if a vessel installs a treatment system to meet state regulations, and that system does not receive USCG approval, that the vessel would then need to install a different system (at great cost) in order to meet federal requirements. The regulated industry considers this an untenable situation.

Because of the challenges associated with the implementation of conflicting vessel discharge regulations both at the federal level and on a state by state basis, several bills were recently introduced in the U.S. Congress that would change the way the EPA/USCG and states regulate ballast water. These bills contained language that would set the federal ballast water discharge standard to the USCG standard, and preempt any state from adopting more stringent ballast water discharge standards. None of these bills, to date, have passed both houses of Congress. As currently written, the National Invasive Species Act and the Clean Water Act allow states to implement more stringent standards than the federal government. Therefore, unless legislation is changed at the federal level, USCG and EPA actions do not directly prohibit Commission's efforts to implement California's performance standards. Staff will continue to follow any proposed federal legislation that could impact vessel discharge regulation in California.

U.S. State Legislation and Programs

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

CWA Section 401 Certifications under the Vessel General Permit

Section 401 of the Clean Water Act requires states to approve federal permits and allows states to add conditions, if necessary, above and beyond those present in the federal permit. A number of states established ballast water management programs and/or requirements in 2008 through the VGP. States that specifically included the establishment of performance standards in their 401 certification include: Illinois, Indiana, Ohio, and Pennsylvania. Illinois, Indiana, and Ohio require vessels to comply with the IMO D-2 standard (see Table III-1) by 2012 for newly built vessels or 2016 for existing vessels. Pennsylvania originally established a two-phase discharge standard, but deleted those conditions from their 401 certification in December 2010.

Originally, the New York 401 certification of the VGP required all vessels to install treatment systems that meet a standard roughly equivalent to 100 times the IMO D-2 standard by 2012. Vessels constructed on or after 2013 were required to install systems that meet California's performance standards. However, the New York Department of Environmental Conservation (DEC) issued a letter on February 16, 2012 indicating that due to the "unavailability of supply" of treatment systems to meet the New York section 401 conditions, the NY DEC is extending the date by which vessels must comply with the standards until December 19, 2013, the end of the current VGP term. For the 2013 VGP, New York, Michigan, Minnesota, Rhode Island, and Ohio submitted 401 conditions requiring vessels to comply with the IMO D-2 standard with an additional requirement for ocean-going vessels to conduct ballast water exchange. Maine and Indiana will require vessels with ballast water sourced from outside the U.S. EEZ to conduct open ocean exchange or saltwater flushing. Wisconsin included requirements for vessels originating beyond the EEZ to perform open ocean ballast water exchange or saltwater flushing, in addition to requirements established by Wisconsin permit (see below).

Non-VGP State Ballast Water Programs that Include Performance Standards

Michigan

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

Minnesota

Effective July 1, 2008, Minnesota state law (Minn. Stat. 115.1701 to 115.1707) requires vessels operating in state waters to have both a ballast water record book and a ballast water management plan onboard that has been approved by the Minnesota Pollution Control Agency (MPCA) (MPCA 2008). Additionally, based on the authority in Minn. Stat. 115.07, Minn. R. 7001.0020, subp. D, and Minn. R. 7001.0210, and to implement the recently enacted legislation, the MPCA approved a State Disposal System general permit for ballast water discharges into Lake Superior and associated waterways in September 2008 (MPCA 2008). Under the permit, all vessels (oceangoing and lakes-only) transiting Minnesota waters must comply with approved best management practices. No later than January 1, 2012, new vessels are required to comply with the IMO D-2 performance standards for the discharge of ballast water (see Table III-1), and existing vessels will be required to comply with those standards no later than January 1, 2016 (MPCA 2008).

Wisconsin

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

Discharge Elimination System. The permit was established by the Wisconsin Department of Natural Resources (WDNR) under authority provided by Chapter 283, Wisconsin Statutes. Among its provisions, the permit sets ballast water performance standards equivalent to the IMO D-2 standard. Wisconsin originally set a standard of 100 times more stringent than the IMO standard, but changed its standard in 2010 to the IMO D-2 standard when it determined that no systems were available, particularly for vessels operating in freshwater, to meet the higher standard. Vessels constructed on or after December 1, 2013 must meet the standard set forth in the permit. Existing vessels have until the first scheduled dry-docking after January 1, 2016 to comply.

California Legislation and the Implementation of Performance Standards

Review of Legislation

California's Marine Invasive Species Act of 2003 directed the Commission to recommend performance standards for the discharge of ballast water to the State Legislature in consultation with the State Water Resources Control Board (Water Board), the USCG and a technical advisory panel (see PRC Section 71204.9). The legislation directed that standards should be selected based on the best available technology economically achievable, and should be designed to protect the beneficial uses of the waters of the state.

In 2005, Commission staff convened a cross-interest, multi-disciplinary panel consisting of regulators, research scientists, industry representatives, and environmental organizations and facilitated discussions over the selection of performance standards. Many sources of information were used to guide the performance standards selection including: biological data on organism concentrations in exchanged and un-exchanged ballast water, theories on coastal invasion rates, standards considered or adopted by other regulatory bodies, and available information on the efficacy and costs of experimental treatment technologies. Though all sources and panel members provided some level of insight, none could provide solid guidance for the selection of a specific set of standards that would reduce or eliminate the introduction and establishment of NIS. At a minimum, it was determined that reductions achieved by the selected performance standards should improve upon the status quo and decrease the discharge of viable ballast organisms to a level below quantities observed following legal ballast water exchange. Additionally, the technologies used to achieve these standards should function without introducing chemical or physical constituents to the treated ballast water that may result in adverse impacts to receiving waters. Beyond these general criteria, however, there was no concrete support for the selection of a specific set of standards. This stems from the key knowledge gap that NIS invasion risk cannot be predicted for a particular quantity of organisms discharged in ballast water (MEPC 2003), with the exception that zero organism discharge equates to zero risk.

The Commission ultimately proposed interim performance standards recommended by the majority of the Panel because they encompassed several desirable characteristics: 1) A significant improvement upon ballast water exchange; 2) Representative of the best professional judgment of scientific experts that participated in the development of the IMO Convention; and 3) Approached a protective zero discharge of living organisms standard. The proposed interim standards were based on organism size classes (Table III-1). The standard of "no detectable living organisms" for the largest organism size class (greater than 50 microns in minimum dimension) has the potential to be either more or less protective than the IMO standard, depending on how it is implemented through compliance assessment regulations. The standard for the second largest size class of organisms (10 – 50 microns in minimum dimension) is significantly more stringent (1000 times) than those proposed by the IMO Convention. The majority of the Panel also recommended standards for selected organisms less than 10 µm in minimum dimension including human health indicator species and total counts of living bacteria and viruses. The recommended bacterial standards for human health indicator species, *Escherichia coli* and intestinal enterococci*,* are identical to those adopted by the EPA in 1986 for recreational use and human health safety (EPA 1986). The implementation schedule proposed for the interim standards is similar to the schedule contained in the IMO Convention at the time the standards were recommended (Table III-2). A final discharge standard of zero detectable organisms for all organism size classes was supported by the Panel and Commission staff (see Falkner et al. 2006). The Commission included an implementation deadline of 2020 for this final discharge standard. A minority report was submitted by shipping industry representatives of the Panel, and included in the report to the Legislature (see below) that recommended the Commission adopt the proposed IMO D-2 standard.

The Commission submitted the recommended standards and information on the rationale behind its selection in a report to the State Legislature in January of 2006 (see Falkner et al. 2006). By the fall of that same year, the Legislature passed the Coastal Ecosystems Protection Act (Stats. 2006, ch. 292) directing the Commission to adopt the recommended standards and implementation schedule through the California rulemaking process by January 1, 2008. The Commission completed that rulemaking in October, 2007 (see 2 CCR § 2291 et seq.).

In anticipation of the implementation of the interim performance standards, the Coastal Ecosystems Protection Act (Stats. 2006, ch. 292) also directed the Commission to review the efficacy, availability, and environmental impacts of currently available ballast water treatment systems by January 1, 2008. The review and resultant report was approved by the Commission in December, 2007 (see Dobroski et al. 2007). Additional reviews are due 18 months prior to the implementation dates for all other vessel classes and 18 months before the implementation of the final discharge standard on January 1, 2020 (see Table III-2 for full implementation schedule). During any of these reviews, if it is determined that existing technologies are unable to meet the discharge standards, the report is to describe why such technologies are unavailable.

Treatment Technology Assessment Reports

The first legislatively-mandated treatment technology assessment report (Dobroski et al. 2007) determined that technologies would not be available to meet California's discharge standards for new vessels with a ballast water capacity of less than or equal to 5000 MT by the original 2009 implementation date. In response, the Legislature passed Senate Bill 1781 in 2008 (Stats. 2008, ch. 696). Senate Bill 1781 amended Public Resources Code section 71205.3(a)(2) to delay the implementation of the interim performance standards for new vessels with a ballast water capacity of less than or equal to 5000 MT for one year, from January 1, 2009 to January 1, 2010. Senate Bill 1781 also required an additional assessment of available ballast water treatment technologies by January 1, 2009 (see Dobroski et al. 2009a) prior to the new 2010 implementation date. The Commission's assessment (Dobroski et al. 2009a) concluded that technologies that demonstrated the "potential" to meet California's performance standards were available. The report recommended that the Commission proceed with the initial implementation of the performance standards for newly built vessels with a ballast water capacity of less than or equal to 5000 MT for January 1, 2010.

In August 2010, the Commission completed another legislatively-mandated report examining the availability of ballast water treatment systems for newly built vessels (those constructed on or after January 1, 2012) with a ballast water capacity greater than 5000 MT (see California State Lands Commission 2010). That report concluded that eight systems demonstrated the "potential" to meet the California standards in at least one test of system performance, and thus the

Commission proceeded with implementation for this size class of vessels on January 1, 2012.

Due to rapid increases in the availability of new data on treatment system performance in recent years, Commission staff also conducted two interim assessments of available shipboard treatment technologies. The first interim update was completed in October 2009 (Dobroski et al. 2009b) and the second update was completed in September 2011 (Dobroski et al. 2011). These interim technology updates were not legislatively mandated and were not reviewed by the technical advisory panel nor approved by the Commission. Updates were intended as a resource for the Commission and stakeholders interested in ballast water treatment systems for use in California waters. Technology updates also provide Commission staff with an opportunity to begin identifying and focusing on issues of concern for the full, legislatively mandated technology assessment reports.

The current legislative report reviews the availability of ballast water treatment technologies for existing vessels, those constructed before January 1, 2010, with a ballast water capacity between 1500 and 5000 MT. The central findings of this report, however, are not affected by vessel size, and thus the ballast water treatment efficacy findings stated here apply to all vessel sizes. For immediate consideration, this would include qualifying newly built vessels with a ballast water capacity of less than or equal to 5000 metric tons that began construction on or after January 1, 2010, and newly built vessels with a ballast water capacity of greater than 5000 metric tons that began construction on or after January 1, 2012. Those vessels have either arrived, and reported not discharging into California waters, or will begin arriving in 2013 and must comply with the California performance standards.

Implementing California's Performance Standards

Pursuant to Public Resources Code section 71205.3, as of January 1, 2012, all newly built vessels (i.e. vessels constructed on or after January 1, 2010 with a ballast water capacity less than or equal to 5000 MT and vessels constructed on or after January 1, 2012 with a ballast water capacity greater than 5000 MT) that discharge ballast in California waters must comply with California's performance standards. Vessel construction often takes a year or more, and Commission staff has only recently seen newly built vessels arrive to California's waters that are subject to the performance standards. Thus far, no qualifying newly built vessel has reported discharging ballast in California, and thus these vessels are in compliance with the performance standards, however Staff expects to see newly built vessels arriving in California in the near future that will have the need to discharge ballast water for operational and/or safety purposes. Commission staff has consulted with vendors and manufacturers to determine if treatment systems have been or will be purchased for newly built vessels that will operate in California. Commission staff is aware of vessels that operate in California waters and have purchased shipboard treatment systems. Other vessels in the midst of construction are leaving dedicated space for a ballast water treatment system so it may be installed at the last possible moment to ensure that the system purchased is the most current available. Many vessel owners/operators have expressed hesitancy to install systems given continuing uncertainty regarding which shipboard treatment systems will receive approval from the USCG for operation in U.S. waters.

The Commission does not have the practical ability to test and approve ballast water treatment systems for use in California waters. Commission staff has encouraged the shipping industry to collaborate with treatment vendors and third party testing organizations to conduct performance verification testing and determine the best treatment solution for each vessel based on the vessel's configuration, regular routes, and availability of USCG/IMO type approved treatment technologies. Commission staff will focus on dockside inspection of vessels for assessment of compliance with the California discharge standards (in accordance with Public Resource Code section 71206). Vessel inspections will consist of both an administrative review of applicable ballast water management plans and reporting documents as well as the collection of ballast water samples for analysis and assessment of compliance with the standards.

California law requires vessels to keep an up-to-date ballast water management plan on board as well as copies of all ballast water reporting forms submitted to the Commission within the past two years. The Commission's Report to the Legislature in 2009 (Dobroski et al. 2009a) recommended that additional authority be granted to the Commission to allow for the collection of specific information about the installation, use, and maintenance of ballast water treatment systems on vessels operating in California waters. This information is necessary to monitor the effective implementation of California's performance standards. In response to the recommendation in Dobroski et al. (2009a), Assembly Bill 248 (Stats. 2009, ch. 317) was passed in the fall of 2009, which provides the Commission with the authority to request the aforementioned information on forms developed by the Commission. Those forms, the "Ballast Water Treatment Technology Annual Reporting Form" and the "Ballast Water Treatment Supplemental Reporting Form" were adopted via regulation in November 2010 (see 2 CCR § 2297.1).

Once Commission staff has reviewed applicable vessel paperwork, a ballast water sample will be drawn from vessels intending to discharge in California waters. California's performance standards are a discharge standard, and thus samples must be drawn from the vessel's ballast water discharge piping. Most existing vessels do not have the equipment (ports) to allow samples of ballast water to be taken from the discharge line. Therefore, the Commission developed regulations in the fall of 2009 that require vessels that discharge ballast in California waters to install sampling ports (i.e. sampling facilities) as near to the point of discharge as practicable (2 CCR § 2297). Vessels that plan to discharge are required to install the sampling ports by the same year that they must comply with California's performance standards.

Commission staff is developing regulations for the collection and analysis of ballast water samples in order to assess vessel discharge compliance with the performance standards regulations. The USCG is also developing ballast water discharge compliance assessment regulations, and the 2013 EPA VGP imposes monitoring requirements as well. Commission staff has worked with federal counterparts at the USCG and EPA, and a technical advisory panel of state, federal, and international experts in shipboard ballast water treatment systems, in developing these draft regulations to assess viable organism concentration for each of California's standards. The advisory panel met four times in 2011 – June, August, October and November. During the first three meetings, staff met solely with scientists and engineers involved in shipboard technology evaluation and sample analysis. During the last meeting in November 2011, staff convened the larger advisory panel which included industry representatives, environmental organizations, and state and federal regulators, in addition to the scientists and engineers. An initial draft of the compliance protocol regulations was discussed at the November 2011 panel meeting, and copies of the notes from all meetings are available from Commission staff. Based on the outcome of these meetings, Commission staff drafted a rulemaking package which was submitted to the California Office of Administrative Law for publication in the February 24, 2012 Notice Register to begin the public rulemaking process. The proposed rulemaking was open for public comment from February 24 through April 17, and a public hearing was held on April 17 to discuss the draft regulations. On January 25, 2013, a Notice of Decision Not to Proceed with the rulemaking was published in the California Regulatory Notice Register, as Commission staff was about to exceed the one year rulemaking limit set by the California Administrative Proceedures Act. A scientific peer review of the protocol methods was completed in January 2013, and Commission staff is reviewing the results of the scientific peer review with the intent to reintroduce the proposed regulations in the future.

IV. TREATMENT TECHNOLOGY ASSESSMENT PROCESS

Public Resources Code (PRC) section 71205.3(b) directs the Commission to prepare "a review of the efficacy, availability, and environmental impacts, including the effect on water quality, of currently available technologies for ballast water treatment systems. If technologies to meet the performance standards are determined in a review to be unavailable, the commission shall include in that review an assessment of why the technologies are unavailable." Reports are due to the Legislature 18 months prior to each of the implementation dates for the performance standards (see Table III-2 for implementation dates). In accordance with the Marine Invasive Species Act, the Commission has consulted with, "the State Water Resources Control Board, the United States Coast Guard, and the stakeholder advisory panel described in subdivision (b) of PRC section 71204.9." This stakeholder panel also provided guidance in the development of the 2006 performance standards report to the California Legislature (see Falkner et al. 2006).

In preparation of this report, Commission staff conducted an extensive search of literature on shore-based treatment facilities and shipboard ballast water treatment systems. Staff focused its review on recently available scientific articles, performance verification reports, and water quality impact analyses from independent testing organizations. Staff also contacted shipboard treatment technology vendors (no shore-based ballast water treatment facilities exist) in order to gather the most up-to-date information about system development, testing, and approvals.

This 2013 report is mandated to address the availability of ballast water treatment technologies for existing vessels (those built before January 1, 2010) with a ballast water capacity between 1500–5000 MT (= approximately 8% of vessels operating in California waters) . The central findings of this report are not affected by vessel size. The ballast water treatment efficacy findings stated here apply to all vessel sizes, and for immediate consideration, this would include qualifying newly built vessels with a ballast water capacity of less or equal to 5000 metric tons that began construction on or after January 1, 2010 and vessels with a ballast water capacity of greater than 5000 metric tons that began construction on or after January 1, 2012. These vessels either have arrived to California and not reported discharging ballast, or will begin arriving into California waters in 2013 and must comply with the California discharge standards.

As with previous reports (Dobroski et al. 2009a, California State Lands Commission 2010), data were summarized relative to the ballast water capacities and pump flow rates of the vessel fleet operating in California waters in order to determine if systems both meet California's performance standards and are available for the applicable size class of vessels. Commission staff also gathered the latest available data on environmental impacts, including effects on water quality, and the economics of treatment system installation and operation. Upon completion of the data analysis, Commission staff drafted a preliminary report for review by the Commission's stakeholder advisory panel (see Appendix A for list of panel members and meeting notes), the Water Board, and the USCG. Further drafts of the report were reviewed and modified in consultation with a subset of the advisory panel, including representatives from the Pacific Merchant Shipping Association, the Western States Petroleum Association, The Bay Institute, the California Association of Port Authorities, the San Francisco Estuary Partnership, the California State Water Resources Control Board, the Cruise Lines International

Association, Maersk, Inc., EnviroManagement, California State Controller's Office, and Dr. Andrew Cohen.

Commission staff assessed treatment system efficacy as whether or not discharges from treatment system performance tests would meet each of California's performance standards for the discharge of ballast water. Staff does not conduct any of the tests themselves, but instead compiles and summarizes data made available to them. Treatment system discharge performance was determined by reviewing the results of relevant third-party efficacy tests as provided by technology vendors, consultants, and research organizations. No test data are available on the performance of shore-based ballast water treatment facilities. It is possible to extrapolate shore-based performance to some degree through a review of the treatment capabilities of water treatment facilities. This issue is discussed in Section VI, Shore-based Ballast Water Reception and Treatment Facilities. All other analyses, as discussed below, were conducted on data from performance assessments of shipboard ballast water treatment systems.

In previous reports, for a shipboard system to be considered as having "demonstrated the ability to meet California's performance standards," a system needed to discharge treated ballast with organism concentrations consistent with California's standards for each organism size class in one land-based or shipboard test (averaged across replicates). While this criterion is lenient in determining the availability of ballast water treatment systems that can meet California standards, Commission staff paired this preliminary analysis with a more critical look at system consistency over multiple tests (see Table VI-3, California State Lands Commission 2010).

In this report, Commission staff more closely parsed out which standards could be analyzed for shipboard treatment system performance given the limitations of existing testing protocols and methods of sample analysis. As this report presents the latest information available, the findings replace and supersede any inconsistent findings in previous reports.

Available test data for analysis of system efficacy were, in large part, collected under the type approval test regimens established by the IMO G8 Guidelines (see MEPC 2008f) to determine the ability of shipboard treatment systems to meet the IMO D-2 standards. A smaller subset of the test data was collected according to the ETV protocols (see EPA 2010) for land-based assessment of treatment system performance. The ETV protocols have been incorporated into the USCG Type Approval process to assess the ability of systems to meet the USCG standards for living organisms in ships' discharge (which are numerically the same as the IMO standards). As the California standards differ from both the IMO and USCG standards, not all data collection procedures and methods of analysis are scaled appropriately for analysis with each of California's performance standards. A discussion of some of the challenges of data analysis for each organism size class in California's performance standards follows. This information is most relevant to the analysis of shipboard ballast water treatment system efficacy (see Section VII. Shipboard Ballast Water Treatment Systems).

Organisms Greater than 50 Microns in Minimum Dimension

The California standard for organisms greater than 50 microns in minimum dimension is "no detectable living organisms." Thus this standard will vary based on the limits of available detection techniques. To ensure equal analysis of discharges from all vessels, it will be essential for compliance assessment protocols to be codified in regulation so that specific methods of analysis (and therefore a specific limit of detection) is set for all discharging vessels. Existing methods of sample analysis, as detailed in the IMO G8 Guidelines (MEPC 2008f) and the ETV protocols (EPA 2010) are used to detect compliance with the IMO and USCG/EPA standards of 10 organisms per cubic meter of discharged ballast water. The data presented in Table VII-2 as indicating system compliance with the California standards is based on no-detectable living organisms being found in the greater than 50 micron size class in samples collected according to the testing protocols within the IMO G8 Guidelines and/or the ETV protocols.

Organisms 10 – 50 Microns in Minimum Dimension

The California standard for organisms 10-50 microns in minimum dimension is 0.01 living organisms per ml of discharged ballast (= 1 organism per 100 ml of discharged ballast). The available test data, collected according to the IMO G8 and/or ETV testing protocols, cannot be used to detect concentrations of organisms low enough to confirm that treated ballast water meets the California standard for organisms between 10 and 50 microns in minimum dimension. It is possible, however, to determine that a system cannot meet the standard in this size class, since any organisms detected in a one ml sample, using current methods of analysis, would be above the California standard of 0.01 organisms/ml.

As the data is summarized for the 10-50 micron size class in Table VII-2 (shown as the ratio of successful tests to total number of tests conducted), shipboard ballast water treatment systems for which results of system performance were all clearly above the California standard are indicated as having no (zero) tests in compliance with the standard. For systems that had some tests demonstrating zero or no-detectable organisms in the discharge, it was impossible to verify that the system met the California standard given the limits of currently available detection techniques. The results of these tests are indicated as “lim. det” with the specific number of tests for which that was the finding in parentheses. The use of “lim. det.” in Table VII-2 is meant to alert the reader to the uncertainty of whether or not California standards were met, and at the same time allow the reader to determine how many tests were clearly out of compliance with the California standard.

Human Health Indicator Species (*E. coli*, intestinal enterococci, and *Vibrio cholerae*)

The California standards for *E. coli*, intestinal enterococci, and *Vibrio cholerae* are 126 colony forming units (cfu) per 100 ml, 33 cfu per 100 ml, and 1 cfu per 100 ml (Toxicogenic *Vibrio cholerae* serotypes O1 and O139), respectively. Since these are human health indicator species and of concern to a variety of regulatory agencies, the available testing protocols and methods of analysis are well-established and sensitive enough to determine if discharges from treatment systems meet the concentrations of indicator organisms in California's standards. Thus Commission staff can analyze these data to determine if systems are available to meet the aforementioned performance standards.

One of the challenges associated with analysis of system performance for these organisms is that the natural population densities of *E. coli*, intestinal enterococci, and *Vibrio cholerae* (serotypes O1 and O139) are extremely low in many coastal and ocean waters. This is inherently a good thing, as these organisms can cause significant human illness. However, low natural population densities make it difficult to assess system performance at treating these organisms, as the influent concentration of these organisms (before treatment) is often the same as the effluent concentration (post treatment) – i.e. zero or non-detectable. The IMO G8 Guidelines and ETV protocols for assessing ballast water treatment system performance have *no minimum influent concentration requirements* to conduct system performance tests for these organisms. This means that if the natural population densities of these organisms are zero or non-detectable in the influent water, a valid test, for IMO or USCG Type Approval purposes, may still proceed. This stems from the fact that it would be extremely dangerous to "spike" the influent water with added concentration of these disease-causing bacteria. If the treatment system were unable to kill all of the organisms, these pathogens could infect humans in close proximity to testing facilities.

While a test with an influent concentration of zero or non-detectable levels of bacteria is perhaps not the best indicator of system performance, Commission staff has decided to present the land-based and shipboard test data as available to *remain consistent* with IMO and USCG testing procedures. Tests where the influent concentration of bacteria was zero or non-detectable are indicated as such in Table VII-2, see Section VII) in order to present all available information. Many of the treatment technology killing methods (i.e. chlorine, UV, ozone, see Section V) are well-documented to kill human health indicator species. Any potential customers of these treatment systems should work with the system vendor to ensure that each treatment approach clearly demonstrates its efficacy at killing these pathogens in small-scale, controlled laboratory experiments and/or by providing a comprehensive literature review of related work.

Living Organisms Less than 10 Microns in Minimum Dimension

Bacteria

The California bacteria standard is set as less than 1000 living bacteria per 100 ml. This standard is difficult to assess because there are no accepted methods to quantify total living bacteria in a ballast water sample. There are some relatively easy and inexpensive stains available that can be used to quickly enumerate bacteria in ballast water samples, however these methods are generally used to distinguish intact vs. disrupted (i.e. dead) cell walls, and have limited ability to distinguish between living cells and cells which are dead yet still intact. Because of this, the only currently available, reliable means of knowing that a bacterium is alive is to conduct grow-out (culture) experiments in the laboratory. Unfortunately, less than 10% of all bacteria species are capable of growing in the environmental conditions present in laboratories (i.e. the culturable heterotrophic bacteria) (Azam et al. 1983, Hobbie et al. 1977). As the California standard for bacteria is for living organisms, staff conducted the assessment of treatment system performance at meeting this standard using data from bacterial cultures of discharged ballast water, as cultures are the most reliable means to ensure that the bacterial population is living. Commission staff will continue to work with microbiologists and to follow the literature on methods of quantifying living bacteria with hopes that novel techniques in the future will quantify a greater proportion of the total living bacterial population in a ballast water sample.

Viruses

The California standards for the viral size class is less than 10,000 living viruses per 100 ml. No methods of sample analysis are currently available, at any scale, to assess total living virus concentrations in ballast water samples, and thus no data are available to assess system performance and discharge compliance for this organism class. Therefore the viral standard is not included in the data analysis portion of this report.

Reliability of Data

In the shipboard treatment system efficacy section of this report (see Section VII. Shipboard Ballast Water Treatment Systems, System Efficacy), Commission staff presents only “reliable” data from treatment system performance. The EPA SAB report (SAB 2011) notes that not all data can be considered “reliable,” and defines reliable data as consisting of both methods and results from land-based and shipboard tests. Commission staff agree with this definition, and thus for this report only consider systems that can provide methods and results of third-party tests gathered as part of the type approval process when evaluating system success rates. Tables that do include vendor-collected data are indicated as such.

Land-Based and Shipboard Tests of System Performance

Ballast water treatment systems are evaluated in both land-based and shipboard environments for type approval purposes. Land-based tests are the most rigorous available, but do not necessarily reflect the range of actual conditions experienced by a vessel. In other words, shipboard tests likely produce data that more accurately reflect conditions under which any compliance evaluation in California would take place than do land-based testing data.

For shipboard treatment systems, Commission staff also examined the ability of a system to be installed on an existing vessel (i.e. retrofit capability). Commission staff developed and distributed a retrofit questionnaire to shipboard treatment systems vendors and selected marine engineers that included questions regarding the space and power requirements of shipboard treatment systems, and whether the vendor had yet received or completed any retrofit orders. A copy of this questionnaire is provided in Appendix B, and the responses to these questions are summarized in Table VII-4.

Finally, shipboard treatment systems were also assessed regarding their environmental impacts. Commission staff assessed environmental impacts by reviewing whether a system utilizes active substances to kill or remove organisms, the type(s) of active substance(s) used, and whether the system has received relevant approvals for pollutant discharges from the IMO or other administrative or regulatory authorities. Staff also determined whether available shipboard treatment systems conformed to the standards for pollutant discharges set out by the U.S. EPA Vessel General Permit and conditions established by the California Clean Water Act section 401 certification of that permit.

V. BALLAST WATER TREATMENT TECHNOLOGIES

The California Coastal Ecosystems Protection Act established performance standards for the discharge of ballast water and required the adoption of regulations to implement those standards. The Act does not, however, prescribe how the standards are to be met. Vessel owners and operators understand the unique needs and capabilities of their ships, and can select from a variety of ballast water management strategies to ensure that all ballast water discharged in California waters is compliant with California's performance standards.

One option available for compliance with the performance standards, and the strategy most protective of California waters, is for vessels to retain all ballast onboard while in California waters. Over 80 percent of voyages to California ports report that they do not discharge ballast into California waters (Takata et al. 2011). It is important to note, however, that this percentage does not equate to 80 percent of all vessels. A vessel that calls on a regular schedule may not need to discharge ballast for the majority of its port calls (i.e. voyages) in California, but may require discharge for some port calls due to operational needs and/or safety concerns. Thus, vessels will not be able to rely solely on retention to comply with California's standards.

For vessels that will need to discharge ballast in California, an option available to meet California's performance standards is to use an alternative source of ballast water (such as potable water). Potable water is likely to meet the discharge standards without the need for ballast water treatment. The USCG and EPA permit the use of of ballast from a public water supply (i.e. potable water), if sourced from the U.S. or Canada, to meet the federal ballast water discharge standards. On a case-by-case basis Commission staff has approved the use of potable water as an alternative ballast water management method (per PRC section 71204.3(d)). However, potable water is expensive for vessels to purchase, and the ballast water volume requirements of many vessels will likely preclude the use of potable water for the majority of the fleet operating in California.

Alternatively, vessels may discharge ballast to shore-based reception and treatment facilities, where available. Shore-based treatment facilities include barge- or land-based facilities that treat NIS in ballast water after it has been transferred from a vessel. At this time, there are no shore-based facilities designed to remove organisms from ballast water available in the U.S. Finally, vessels may use shipboard ballast treatment prior to discharge. Shipboard treatment occurs on a vessel through the use of technologies integrated into the ballasting system.

Shore-based treatment and reception facilities and shipboard ballast water treatment systems must be capable of eradicating a wide variety of organisms in order to prevent species introductions. Organisms in unmanaged ballast water that must be removed or killed include viruses, bacteria, plankton (microscopic plants and animals), as well as larger species. The wide variety of vessel types, shipping routes, and port geographies further complicates the development of treatment technologies. Shipping routes and port geographies, for example, influence the water quality, salinity, sediment loads, and organisms that a ship might take up with ballast water and then need to treat on board or discharge to a reception facility.

Many of the technologies that could be used to treat ballast water are already in use to some degree by the water and wastewater treatment industries. A preliminary discussion of these treatment technologies follows and forms the basis of a more detailed analysis and discussion of treatment technologies (see Sections VI. Shore-Based Ballast Water Reception and Treatment Facilities and VII. Shipboard Ballast Water Treatment Systems). The diverse array of methods currently under development for use in the treatment of ballast water fall into four general categories: mechanical, chemical, physical, and biological treatments. These methods are typically combined in some manner to maximize treatment efficacy.

Mechanical Treatment

Mechanical treatments are those that trap and remove mid- to large-sized particles from ballast water. In shipboard systems, mechanical treatment typically takes place upon ballast water uptake in order to limit the organisms and sediment that enters ballast tanks and to discharge any backwash at the point of uptake. Filtration and hydrocyclonic separation are the two most common mechanical treatment methods.

Filtration captures organisms and particles as water passes through a porous screen, membrane, or filtration medium, such as sand or gravel. The size of organisms trapped by the filter depends on the mesh size (for screen or disk filters), or on the size of the interstitial space and depth and type of bed material for filtration media. Screen and disk filters are more commonly used in shipboard treatment systems than filtration media, though there has been some research on the use of crumb rubber as a filtration medium in recent studies (Tang et al. 2006, 2009). Typical mesh sizes for shipboard ballast water filters range from 25 to 100 micrometers (µm) (Parsons and Harkins 2002, Parsons 2003); most appear to be 40 or 50 µm. In contrast most water treatment facilities use deep bed media filtration. Another approach in use in some water treatment facilities that could be used in shore-based ballast water facilities is the use of membrane filters (including microfiltration, ultrafiltration, and reverse osmosis), which can remove extremely small particles and organisms, down to bacteria (typically 0.2 to 1.0 µm in size) and even viruses (typically 0.02 to 0.2 µm in size). These systems are considered impractical for shipboard ballast water treatment, because of space requirements. Most filtration-based technologies use a backwash process that removes organisms and sediments that can clog filters. Backwash systems can discharge particles and organisms at the port of origin before the vessel is underway. Filter efficiency is a function not only of initial mesh size, but also of water flow rate and backwashing frequency. Some shipboard technology developers utilize proprietary technology to clean filters without backwashing (American Bureau of Shipping, 2011). In either shipboard or shore-based treatment, some chemicals may be used to clump or coagulate organisms in order to assist with their mechanical removal.

Hydrocyclonic separation, also known as centrifugation, relies on density differences to separate organisms and sediment from ballast water. Hydrocyclones create a vortex that causes heavier particles to move toward the outer edges of the cyclonic flow where they are trapped in a weir-like device and can be discharged before entering the ballast tanks (Parsons and Harkins 2002). Hydrocyclones used in ballast water treatment generally trap particles in the 50 to 100 µm range (Parsons and Harkins 2002). One challenge associated with hydrocyclone use, however, is that many small aquatic organisms have a density similar to seawater and are thus difficult to separate.

Chemical Treatment

A variety of chemicals (i.e. active substances) are available to kill organisms in ballast water. Chemical treatment can take place during ballast uptake, vessel transit, or discharge. Chemicals can be stored in liquid or gas form, or they can be generated on demand through electrochemical processes.

Chemicals used in ballast water treatment are either oxidizing or non-oxidizing. Oxidizing agents (e.g. chlorine, chlorine dioxide, bromine, hydrogen peroxide, peroxyacetic acid, ozone) are commonly used in water or wastewater treatment and work by destroying cell membranes and other organic structures (National Research Council 1996, Faimali et al. 2006). Electrochemical oxidation combines electrical currents with naturally occurring reactants in seawater and/or air (e.g. salt, oxygen) to produce killing agents. For example, electrochemical oxidation can produce products such as hydroxyl radicals, ozone, or sodium hypochlorite that are capable of damaging cell membranes. Non-oxidizing biocides, including Acrolein ®, gluteraldehyde, and menadione (Vitamin K3), are reported to work like pesticides by interfering with an organism's neural, reproductive, or metabolic processes (National Research Council 1996, Faimali et al. 2006).

Ultimately, chemicals used in ballast water treatment should maximize organism mortality while minimizing environmental impact. Environmental concerns surrounding chemical use in ballast water focus on the impacts of residuals or byproducts in treated discharge on receiving waters. The effective use of chemicals in ballast water treatment requires a balance between the amount of time required to achieve an inactivation of organisms, with the time needed for those chemicals and residuals to degrade or be neutralized to environmentally acceptable levels. Both of these times vary as a function of ballast water temperature, salinity, organic content, and sediment load. As a result, certain chemicals might be more effective than others depending on ballast volume, voyage length, and water quality conditions. Additional concerns about chemical use specific to shipboard operation include corrosion of metals, personnel and ship safety, and vessel design limitations that impact the availability of space onboard for both chemical storage and equipment for dosing.

Physical Treatment

Physical treatment methods include a range of non-chemical means to kill organisms in ballast water. Like chemical treatment, physical treatment can occur on ballast uptake, during vessel transit, or during discharge. Heat, UV, ultrasound, cavitation, and deoxygenation are all physical treatment methods used by shipboard ballast water treatment systems and could be used in shore-based facilities as well.

Rigby et al. (1999, 2004) discuss the use of waste heat from the ship's main engine as a mechanism to heat ballast water and kill unwanted organisms during vessel transit. However, it would be difficult to heat ballast water to a sufficient temperature to kill all bacterial species due to lack of sufficient energy/heat available on a vessel (Rigby et al. 1999, 2004). An alternative involves the use of microwaves, though as of 2010 such a treatment would be prohibitively expensive (up to $2.55/m^3$). Additional research and development could reduce costs to acceptable levels (Balasubramadian et al. 2008, Boldor et al. 2008).

Ultraviolet (UV) irradiation is another physical method of sterilization that is commonly used in water treatment. UV damages genetic material and proteins, disrupting reproductive and physiological processes, and can be highly effective against pathogens (Wright et al. 2006). Both low-pressure and medium-pressure UV systems have been used to treat ballast water on vessels. The pairing of UV light and a catalyst (e.g. titanium dioxide) results in an advanced oxidative process that generates hydroxyl radicals.

Ultrasound (or ultrasonic treatment) kills through high frequency vibration that creates microscopic bubbles. These bubbles rupture cell membranes (Viitasalo et al. 2005). The efficacy of ultrasound varies based on the intensity of vibration and length of exposure. Cavitation is another physical treatment method that uses mechanical forces to generate and collapse microscopic bubbles that crush or implode organisms in ballast water. Deoxygenation involves the displacement or "stripping" of oxygen with another inert gas such as nitrogen or carbon dioxide. This process is primarily physical in nature, although the addition of carbon dioxide might trigger a chemical response that would reduce ballast water pH (Tamburri et al. 2006).

Biological Treatment

The least common method of ballast water treatment involves the use of organisms to directly kill or produce conditions that will kill NIS present in ballast water. These treatment organisms are considered an “active substance” according to the IMO definition (IMO 2005). One example of biological treatment is the use of yeast to produce low-oxygen (hypoxic) conditions in ballast tanks. Yeast cells extract the available oxygen in the ballast water tank during cell replication (Bilkovski, R. pers. comm. 2008). The resultant hypoxic environment is toxic to many of the remaining organisms in the ballast tank, though some organisms are resistant to hypoxic conditions. Vendors of biological treatment systems will need to address how systems will meet the performance standards as the organisms responsible for producing the desired killing effect on NIS could trigger non-compliance if detected at sufficient levels in the discharged ballast. This is because yeast cells used by such systems could themselves become invasive if released in ballast water discharges.

Combination of Treatment Methods

The vast majority of shipboard ballast water treatment systems kill organisms by combining mechanical, chemical, physical, and/or biological treatment methods. Any single treatment method might not be effective to treat ballast water, but in combination the methods produce significantly improved results. The most common combined treatment methods use mechanical removal of larger organisms and particles followed by a physical or chemical process to kill remaining organisms.

VI. SHORE-BASED BALLAST WATER RECEPTION AND TREATMENT FACILITIES

As previously mentioned, vessels may discharge ballast water to a shore-based treatment facility to comply with California's performance standards. Ballast water discharge to shore-based reception facilities is also permitted under the IMO Convention, USCG regulations, and the EPA Vessel General Permit. Shore-based ballast water treatment includes reception and treatment facilities physically located on the shore (or dock) that receive ballast water from vessels through ship-to-shore connections or from barges that may move ballast water from the vessel to a shore-based treatment plant.

Shore-based treatment of ballast water is an appealing option, particularly from a regulatory perspective (see SAB 2011 for additional discussion). Permitting, inspection and compliance monitoring of a fixed shore-based treatment facility is significantly easier than the regulation of discharges from mobile point sources such as vessels. Shore-based treatment also provides an option for treatment technologies and methods that are not feasible onboard vessels due to space and/or energy constraints, such as reverse osmosis. Instead of a ships' crew, who are not able to solely focus on the operation and maintenance of ballast water treatment facilities, shore-based facilities could be operated by specially trained water treatment and wastewater engineers. Operation of shore-based facilities by full-time water treatment staff should increase treatment reliability over that of shipboard ballast water treatment systems (SAB 2011). Furthermore, treatment of ballast water may be safer onshore as personnel will not be exposed to the tight working conditions and ship movements while at sea. Shore-based facilities may also be easier to upgrade. Brown and Caldwell (2008) state that shore-based facilities "provide treatment flexibility, allowing additional treatment processes to be added or modified as regulations and treatment targets change." Additional advantages of shore-based facilities include cost and treatment efficacy (discussed in more detail in the shore-based assessment section below).

Even if vessels do elect to install and operate shipboard ballast water treatment systems, shore-based facilities should remain an important component of Port contingency planning to prevent species introductions. If a shipboard treatment system fails, shore-based treatment facilities could provide an important back-up location where unmanaged ballast water could be held or treated so that a vessel does not violate applicable discharge standards. Shoreside treatment facilities could even be equipped to allow vessels to exchange untreated ballast water for treated, “clean” ballast water. This would require treatment facilities to be present at ports (Tsolaki and Diamadopoulos 2010).

The adoption of shore-based facilities is not without challenges. Vessels must have the appropriate piping and attachment mechanism to establish a ship-to-shore connection with a shore-based facility or reception barge. An international standard would be necessary to design these connections to ensure that ships could connect to shore-based facilities all over the world, and the cost of these retrofits could be significant (CAPA 2000, King and Hagan 2013). Additionally, vessels must be able to discharge ballast at a rate that prevents vessel delays. To pump ballast water ashore at rates required for changes in cargo loading or discharging, additional plumbing and changes in vessel pump configuration and size will likely be required. Ships may also need to discharge ballast before reaching berth if needed to reduce the draft of the vessel as it approaches shallows. These discharges may occur within harbor conditions when stability and stress limits are relaxed, but before the vessel arrives at berth.

If existing municipal facilities are to be used for the purposes of ballast water treatment, they will need to be modified. Municipal wastewater treatment plants are not designed to treat saline water (Water Board 2002, Moore, S. pers. comm. 2012). Furthermore, a new extensive network of piping and associated pumps would be required to distribute ballast water from vessels at berth to the treatment plants. The establishment of new piping and facilities dedicated to ballast water treatment, while technically feasible, would require the acquisition of land for facility construction. New land acquisition would be difficult and costly in California's densely populated coastal and port areas.

While reception facilities are allowed by international, U.S., and state regulatory programs, no shore-based treatment facilities designed to kill or remove organisms in ballast water currently exist in the U.S., and the timetable for the implementation of performance standards may be faster than ballast water treatment facilities can be constructed, permitted, and made operational. Thus vessel owners, needing to comply with the impending implementation of standards, are turning towards shipboard ballast treatment systems to ensure all discharges will comply with the law. In the event that the international community ratifies the IMO Convention and it enters into force, the vessels that are subject to the Convention will likely have to install shipboard treatment systems in order to be in compliance as they call in ports around the world, unless every port in every country party to the Convention installs shore-based facilities.

Prior to the completion of the 2010 ballast water treatment technology assessment report (see California State Lands Commission 2010), Commission staff was contacted by a company interested in developing a barge-based reception facility for use in California and along the west coast. This company was contacted again prior to the 2013 report, and has ceased development of this type of facility. Another company is currently investigating barge-based treatment cooperatives in California port areas.

In California, shore-based treatment facilities would have to be evaluated for their ability to comply with all applicable state laws regarding wastewater discharges, which include parameters for organism concentrations and pollutants. Treated ballast water discharged from shore-based treatment facilities would fall under the jurisdiction of the Water Board, and not the Commission, but uncertainty remains about a vessel's legal liability for any discharged ballast water once that water has been discharged to a shore-based treatment facility.

The EPA SAB report (2011) provides a preliminary review of shore-based facilities including a table of published manuscripts on shore-based treatement facilities that identifies 33 articles and reports from the peer-reviewed and grey literature. Of those 33, 18 anticipated that shore-based treatment would be feasible, at least in some circumstances, and form a portion of the global ballast water management schema (see Appendix B in SAB 2011). Nine reports concluded that shore-based facilities would be the best option for ballast water treatment based on economic and/or potential efficacy, and two stated the opinion, in brief, that shore-based facilities were inferior in some aspect to shipboard treatment of ballast water. The remaining manuscripts considered were not associated with a specific conclusion on the relative merits of shore-based treatment facilities versus shipboard treatment, but presented additional information on reception facilities. None of these reports were able to present comparative ballast water treatment efficacy data for shipboard versus shore-based treatment, but some have been able to provide conceptual designs and cost analyses for the construction of shore-based treatment facilities and retrofitting vessels to deballast to such facilities.

It is clear that more information about the feasibility of shore-based treatment is necessary. To date, limited studies have been conducted (see references in Falkner et al. 2006, U.S. EPA SAB 2011). In California, one study specific to cruise ships indicated that because cruise ships rarely deballast in California there is little demand for shore-based treatment except in emergencies (Bluewater Network 2006). A study by McMullin et al. (2008) assessed the potential for shore-based treatment at the Port of Milwaukee. The authors concluded that shore-based treatment is a feasible alternative to shipboard treatment, but only under certain conditions. In addition to a universal standard for retrofitted ballast water piping connections to shore-based pumps, procedures would need to be developed for each vessel to maintain its stability and ensure safe deballasting rates during cargo loading. The authors caution against extrapolation of the report's conclusions to port areas outside Milwaukee, however, as each region presents a unique set of challenges. A recent report from King and Hagan (2013) reviews the economic and logical feasibility of port-based ballast water treatment at the Port of Baltimore. The authors found that while technically feasibly, port-based ballast water treatment "may be logistically impractical from the ship owner's perspective" due the need for a large network of available port-based facilities worldwide. Furthermore, "since most ships will still need to install on-board [ballast water treatment systems] in order to maintain the option to deballast and take on cargo in ports that do not have port-based [ballast water treatment systems], the cost of port-based [ballast water treatment] will not significantly reduce fleet-wide costs associated with the purchase and installation of ship-board [ballast water treatment systems.]"

The EPA SAB report (2011) recommends that a comprehensive analysis be conducted "comparing biological effectiveness, cost, logistics, operations, and safety associated with both shipboard [ballast water treatment systems] and [shore-based] reception [and treatment] facilities." A California-specific report is also necessary to determine the feasibility of and demand for shore-based facilities for all commercial vessel types across California's port zones. This should include assessments by those involved in the water and wastewater treatment industries on whether existing shore-based technologies can meet California's performance standards.

Assessment of Shore-based Treatment Facilities

Public Resources Code section 71205.3 specifically mandates an assessment of "the efficacy, availability, and environmental impacts, including the effect on water quality, of currently available technologies for ballast water treatment systems. If technologies to meet the performance standards are determined in a review to be unavailable, the commission shall include in that review an assessment of why the technologies are unavailable." At this time, no shore-based treatment facilities are under development or currently exist in California or elsewhere in the U.S. that are specifically equipped to reduce organism concentrations in ballast water, therefore Commission staff cannot conduct a review of such facilities and this option cannot be considered available for industry use.

Commission staff can, however, provide preliminary information on potential technology performance based on information from drinking water and wastewater treatment facilities. Municipal water and wastewater treatment facilities already utilize many of the technologies being developed for use in shipboard treatment systems. Freshwater treatment technologies such as wastewater facilities can make use of larger and more sophisticated technologies and filtration steps than are feasible onboard a vessel. For drinking water, the combination of filtration and disinfection technologies can reach 4.7–4.9 log reductions in viruses, bacteria and organisms 10–50 microns in minimum dimension. California standard for organisms 10-50 microns (0.01 organisms/ml) would require an approximate 4.5 log reduction in these organisms' concentrations from unmanaged ballast. Thus shore-based efficacy should be within a range necessary to meet California's standard for organisms 10–50 microns in minimum dimension. It remains to be seen whether these technologies can reach similar reduction of organism concentrations in the estuarine and ocean waters typically taken up as ballast.

Fewer shore-based treatment facilities would be needed to manage California's ballast water than shipboard systems, since multiple ships could be served by a single facility (SAB 2011). Other benefits to shore-based ballast water treatment include the use of technologies such as reverse osmosis, which are highly effective at removing organisms from water while not requiring the addition of active substances. The Water Board would regulate any active substances released from a shore-based reception facility under the federal Clean Water Act and California's Porter-Cologne Water Quality Act. Economic feasibility studies have been conducted regarding shore-based treatment facilities, but are based on outdated information (SAB 2011).

To address the paucity of information on shore-based treatment facilities, and the promise such facilities represent in terms of ballast water management, Commission staff is securing the services of a third-party manager to develop a request for proposals to conduct a study on the feasibility of such facilities in California. This study will include, but not be limited to: a literature review, an up-to-date economic and feasibility analysis of the resources needed to build and operate such facilities, an assessment of vessel retrofit needs for ships that intend to use shore-based treatment facilities, a comparative assessment of environmental impacts and effectiveness, and an assessment of the need for barge-based reception facilities for vessels that must deballast to navigate through waterways before entering port. Information from this report may help direct implementation of California's performance standards and research examining treatment options.

VII. SHIPBOARD BALLAST WATER TREATMENT SYSTEMS

Shipboard ballast water treatment systems are installed on board the vessel and integrated into the vessel's ballast water system. Shipboard systems are considered broadly applicable because they allow flexibility to manage ballast water during normal operations. Shipboard systems allow vessels to discharge while underway as necessary to navigate shoals and bridges. Shipboard systems are also important for vessels that need to discharge in offshore lightering zones during the transfer of crude oil or other liquid cargo (SAB EPA 2011). One of the biggest arguments for the installation of shipboard treatment systems is that they allow vessels to treat ballast and conduct ballasting operations anywhere in the world, as it is unlikely that every port a vessel will visit will have a shore-based facility available.

The installation of shipboard ballast water treatment systems onboard vessels is not without significant challenges, however, including, "vibration, small and busy crews, limited space and weight allowances, limited power, potentially increased corrosion rates and sometimes short voyages," which would limit what treatment systems could be installed due to necessary chemical degradation and holding times (EPA SAB 2011). Existing vessels that must be retrofit for the installation of treatment systems face additional challenges due to the necessity to rework and relocate existing installations (plumbing, electric circuitry) and equipment. A shipboard ballast water treatment system must be effective under a wide range of environmental conditions, including variable temperature, salinity, nutrient concentrations, and suspended solids. It must also function under difficult operational constraints including high flow-rates of ballast water pumps, large water volumes, and variable retention times (time ballast water is held in a ballast tank).

In recent years the vast majority of time, money, and effort in the development of ballast water treatment technologies has been focused on shipboard treatment systems. In addition, portions of existing federal law, as well as the IMO Convention, are focused on shipboard treatment.

Assessment of Shipboard Ballast Water Treatment Systems

For this report, Commission staff compiled and reviewed information on 75 shipboard ballast water treatment systems (Table VII-1, Figure VII-1). In the six years since the first Commission ballast water treatment technology assessment report (see Dobroski et al. 2007), staff has seen an almost tripling of the number of shipboard treatment systems under development (from 28 in 2007 to 75 in 2013). Over the same time period, the number of these treatment systems that have received type approval according to the IMO G8 Guidelines has jumped from 1 in 2007 to 34 in 2013 (see Figure VII-1).

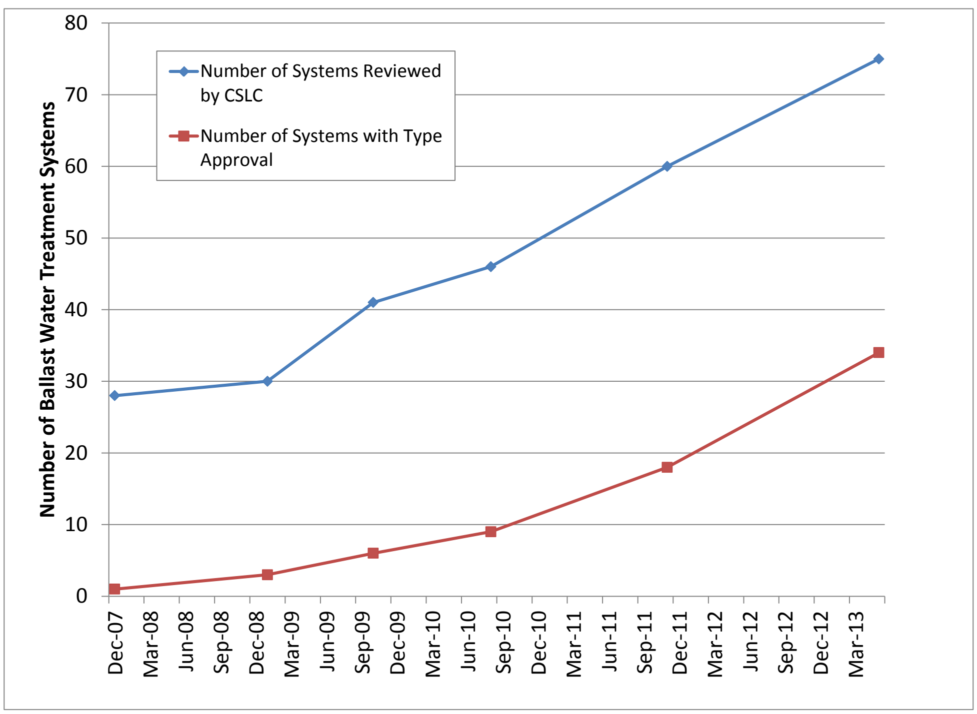

Figure VII-1. The number of shipboard treatment systems reviewed by Commission staff during each of the Commission's treatment technology assessment reports and updates. The number of systems with type approval (IMO) is also shown.

Seventy-six percent (= 57) of the shipboard treatment systems reviewed here utilize a combination of treatment methods, the majority of which combine mechanical treatment with another treatment method(s). Aside from mechanical separation, the most common method used in ballast water treatment systems is chemical. Of the 75 systems reviewed, 48 use an active substance in the treatment process (Table VII-1). Specifically:

- 18 systems use electrolysis which may generate an array of oxidants including bromine, chlorine, and/or hydroxyl radicals
- 8 systems use the electrochemical generation of sodium hypochlorite
- 9 systems use ozone
- 2 systems use Peraclean Ocean
- 5 systems use chlorine (not electrically generated)
- 1 system uses chlorine dioxide
- 1 system uses ferrate
- 7 systems use other chemicals or active substances including a coagulant or biocides not identified at this time

The next most commonly used method of ballast water treatment amongst the systems reviewed is UV irradiation. Twenty-three (23) treatment systems use UV as a means to kill or deactivate organisms found in ballast water. All of these systems combine UV treatment with filtration and/or hydrocyclonic mechanical separation methods. Seven of these systems have an additional treatment step involving another physical or chemical process.

Only six systems use deoxygenation as a treatment method. Other approaches to ballast water treatment include a heat treatment technology and one that uses electrical pulses to kill organisms (Table VII-1).

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Alfa Laval	Sweden	PureBallast 2.0/2.0 Ex	combination	filtration + advanced oxidation technology (UV + TiO_2)	IMO Basic and Final, Type Approval (Norway)
AQUA Eng. Co. Ltd.	Korea	AquaStar™ BWMS	combination	filtration + electrolysis + neutralization (sodium thiosulfate)	IMO Basic and Final, Type Approval (Korea)
Aquaworx ATC GmbH	Germany	AquaTriComb™	combination	filtration + ultrasound + UV	IMO Basic
ATLAS-DANMARK	Denmark	ABWS	combination	filtration + electrolysis (ANOLYTE + CATHOLYTE)	
Auramarine Ltd.	Finland	CrystalBallast®	combination	filtration + UV	Type Approval (Norway)
BIO-UV	France	BIO-SEA BWTS	combination	filtration + UV	Type Approval (France)
Brillyant Marine, LLC	USA	BrillyantSea™	physical	electric pulse	
Coldharbour Marine Ltd.	United Kingdom	Coldharbour BWTS	physical	deoxygenation	
China Ocean Shipping Company (COSCO)	China	Blue Ocean Shield	combination	hydrocyclone + filtration + UV	IMO Basic, Type Approval (China)

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Dalian Maritime University Environment Engineering Institute (DMU-EEI)	China	DMU ·OH BWMS	combination	filtration + active oxygen radicals and ions + neutralization (sodium thiosulfate)	IMO Basic
DESMI Ocean Guard A/S	Denmark	DESMI Ocean Guard OxyClean BWMS	combination	filtration + UV + ozone	IMO Basic and Final, Type Approval (Denmark)
Dow Chemical Pacific Pte Ltd.	Singapore	Dow-Pinnacle BWMS	combination	filtration + ozone + neutralization (sodium thiosulfate)	
Ecochlor	USA	Ecochlor® BWTS	combination	filtration + biocide (chlorine dioxide)	IMO Basic and Final, STEP[1], Type Approval (Germany)
EcologiQ	USA/Canada	BallaClean	biological	deoxygenation	
Electrichlor	USA	Model EL 1-3 B	chemical	electrolytic generation of sodium hypochlorite	
Environmental Technologies Inc.	USA	BWDTS	combination	ozone + sonic energy	

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Envirotech and Consultancy Pte. Ltd.	Singapore	BlueSeas BWMS	combination	filtration + electrolysis + neutralization (sodium thiosulfate)	IMO Basic
Envirotech and Consultancy Pte. Ltd.	Singapore	BlueWorld BWMS	combination	filtration + electrolysis + neutralization (sodium thiosulfate)	IMO Basic
Erma First ESK Engineering Solutions S.A.	Greece	ERMA FIRST BWTS	combination	filtration + hydrocyclone + electrolysis + neutralization (sodium bisulfite)	IMO Basic and Final, Type Approval (Greece)
Ferrate Treatment Technologies LLC	USA	Ferrator	chemical	biocide (ferrate)	
GEA Wesfalia Separator Group CmbH	Germany	BallastMaster ultraV	combination	filtration + UV	IMO Basic, Type Approval (Germany)
GEA Westfalia Separator Group GmbH	Germany	BallastMaster ecoP	combination	filtration + electrolysis + neutralization (sodium thiosulphate)	IMO Basic
Hanla IMS Co., Ltd.	Korea	EcoGuardian™	combination	filtration + electrochlorination + neutralization (sodium thiosulfate)	IMO Basic and Final

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Headway Technology Co. Ltd.	China	OceanGuard™ BWMS	combination	filtration + electrolysis + ultrasound	IMO Basic and Final, Type Approval (Norway)
Hi Tech Marine	Australia	SeaSafe-3	physical	heat treatment	New South Wales EPA
Hitachi Plant Technologies, Ltd.	Japan	ClearBallast	combination	filtration +flocculation	IMO Basic and Final, Type Approval (Japan)
Hwaseung R&A Co. Ltd.	Korea	HS-Ballast	chemical	electrolysis + neutralization (sodium thiosulfate)	IMO Basic
HyCa Technologies Pvt Ltd.	India	HyCator® BWT Reactor System	combination	filtration + electrochlorination + neutralization (sodium thiosulfate)	
Hyde Marine Inc.	USA	Hyde GUARDIAN	combination	filtration + UV	STEP[1], Type Approval (UK)
Hyundai Heavy industries Co. Ltd.	Korea	EcoBallast	combination	filtration + UV	IMO Basic and Final, Type Approval (Korea)

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Hyundai Heavy industries Co. Ltd.	Korea	HiBallast	combination	filtration + electrolysis + neutralization	IMO Basic and Final, Type Approval (Korea)
JFE Engineering Corp.	Japan	JFE BallastAce	combination	filtration + biocide (sodium hypochlorite) + cavitation + neutralizing agent (sodium sulfite)	IMO Basic and Final, Type Approval (Japan)
JFE Engineering Corp.	Japan	JFE Ballast Ace with NeoChlor Marine™	combination	filtration + biocide (sodium hypochlorite) + neutralization (sodium sulfite)	IMO Basic and Final
Jiujiang Precision Measuring Technology Research Institute	China	OceanDoctor BWMS	combination	filtration + UV + photo-catalytic reaction	IMO Basic and Final
Katayama Chemical Inc.	Japan	SKY-SYSTEM®	chemical	biocide (Peraclean® Ocean) + neutralization (sodium sulfite)	IMO Basic
Knutsen Ballastvann AS	Norway	KBAL BWMS	physical	pressure vacuum reactor + UV	Type Approval (Norway)
KT Marine Co., Ltd.	Korea	KTM-BWMS	combination	cavitation + electrolysis + neutralization (sodium thiosulfate)	IMO Basic

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Kuraray Co. Ltd.	Japan	MICROFADE™ BWMS (formerly Kuraray BWMS)	combination	filtration + biocide (calcium hypochlorite) +neutralizing agent (sodium sulfite)	IMO Basic and Final, Type Approval (Japan)
Kwang San Co. Ltd.	Korea	En-Ballast	combination	filtration + electrolysis + neutralizing agent (sodium thiosulfate)	IMO Basic
MAHLE Industrial Filtration	Germany	Ocean Protection System	combination	filtration + UV	IMO Basic and Final, Type Approval (Germany)
MARENCO Tech. Gr.	USA	MARENCO BWTS	combination	filtration + UV	
Maritime Solutions Inc.	USA	MSI BWTS	combination	filtration + UV	
Mexel Industries	France	Mexel®	chemical	non-oxidizing biocide	
MH Systems	USA	MH BWT System	combination	deoxygenation (inert gas + CO_2)	
Mitsui Engineering and Shipbuilding	Japan	SPO-SYSTEM	combination	filtration + mechanical treatment + biocide (Peraclean Ocean)	IMO Basic (from Peraclean MEPC 54)

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Mitsui Engineering and Shipbuilding	Japan	FineBallast MF	physical	pre-filtration + microfiltration (membrane)	
Mitsui Engineering and Shipbuilding	Japan	FineBallast® OZ (formerly SP-Hybrid BWMS Ozone)	combination	filtration + mechanical treatment + ozone + neutralization	IMO Basic and Final, Type Approval (Japan)
NEI	USA	Venturi Oxygen Stripping (VOS)	combination	deoxygenation + cavitation	Type Approval (Liberia, Malta, Marshall Islands, Panama), STEP[1]
NK CO., LTD	Korea	NK- 03 BlueBallast	chemical	ozone	IMO Basic and Final, Type Approval (Korea)
Ntorreiro	Spain	Ballastmar	combination	filtration + electrochlorination + neutralization (sodium metabisulphite)	
Nutech 03 Inc.	USA	SCX 2000, Mark III	chemical	ozone	
OceanSaver	Norway	OceanSaver BWMS	combination	filtration + electrolysis (optional nitrogen supersaturation)	IMO Basic and Final, Type Approval (Norway)

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
OptiMarin	Norway	OptiMarin Ballast System	combination	filtration + UV	Type Approval (Norway)
Panasia Co. Ltd	Korea	GloEn-Patrol™	combination	filtration + UV	IMO Basic and Final, Type Approval (Korea)
Panasia Co. Ltd.	Korea	GloEn-Saver™	combination	filtration + electrochlorination + neutralization (sodium thiosulfate)	IMO Basic
REDOX Maritime Technologies AS	Norway	REDOX AS BWMS	combination	filtration + ozone + UV	IMO Basic
Resource Ballast Technologies (Pty.) Ltd.	South Africa	Resource BWTS	combination	cavitation + ozone + sodium hypochlorite	IMO Basic and Final, Type Approval (South Africa)
RWO Marine Water Technology	Germany	CleanBallast	combination	filtration + electrolysis + neutralization (sodium thiosulfate)	IMO Basic and Final, Type Approval (Germany)
Samkun Century Co. Ltd.	Korea	ARA Plasma BWTS	combination	filtration + plasma + UV	IMO Basic and Final, Type Approval (Korea)

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Samsung Heavy Industries Co., Ltd.	Korea	Purimar™ BWMS	combination	filtration + electrolysis + neutralization (sodium thiosulfate)	IMO Basic and Final, Type Approval (Korea)
Samsung Heavy Industries Co. Ltd.	Korea	Neo-Purimar™ BWMS	combination	filtration + electrolysis + neutralization (sodium thiosulfate)	IMO Basic and Final
Sea Knight	USA	INSITU BWMS	combination	deoxygenation + biological augmentation	
Severn Trent De Nora	USA	BALPURE® BP-500	chemical	filtration + electrochlorination + neutralizing agent (sulfur-based reduction)	IMO Basic and Final, STEP[1], Type Approval (Ger.)
Siemens	Germany	SiCure™	combination	filtration + electrochlorination	IMO Basic and Final
Shanghai Cyeco Environmental Technology Co., Ltd.	China	Cyeco™ BWMS	combination	filtration + UV	Type Approval (China)
STX Metal Co. Ltd.	Korea	Smart Ballast BWMS	chemical	electrolysis + neutralization (sodium thiosulfate)	IMO Basic and Final

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Sumitomo Electric Industries, Ltd.	Japan	Ecomarine™	combination	filtration + UV	
SUNBO Industries Co., Ltd.	Korea	Blue Zone™ BWMS	chemical	ozone + neutralization (thiosulfate)	IMO Basic
Sunrui Marine Environment Engінerring Co., Ltd.	China	BalClor™ BWMS	combination	filtration + electrochlorination + neutralizing agent (sodium thiosulfate)	IMO Basic and Final, Type Approval (China)
Techcross Co. Ltd.	Korea	Electro-Cleen™ System	chemical	electrolysis + neutralizing agent (sodium thiosulfate)	IMO Basic and Final, Type Approval (Korea)
Van Oord B.V.	Netherlands	Van Oord BWMS	chemical	chlorine + neutralization (sodium bisulfite)	IMO Basic
Wärtsilä Corporation	Finland	Marinex UV BWMS	combination	filtration + UV	
Wärtsilä Hamworthy	Netherlands	AQUARIUS® EC BWMS	combination	filtration + electrolysis + neutratlization (sodium bisulfite)	IMO Basic and Final
Wärtsilä Hamworthy	Netherlands	AQUARIUS® UV	combination	filtration + UV	Type Approval (Netherlands)

Table VII-1. Shipboard Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Wuxi Brightsky Electronic Co. Ltd.	China	BSKY™ BWMS	combination	filtration + UV	IMO Basic and Final, Type Approval (China)

[1] STEP is a USCG experimental use approval that applies to the combination of one vessel and one treatment system. While STEP enrollment includes a rigorous technical and environmental screening, it is not a type approval process.

Note: Based on MEPC 59/24 – Administrations may determine if shipboard ballast water treatment systems that make use of UV light produce active substances. Any system that makes use of an active substance must be reviewed according to the G9 Guidelines (see MEPC 2008e).

Efficacy

Shipboard ballast water treatment system performance, or efficacy, is defined for purposes of this report as the extent to which a system removes or kills organisms in ballast water. Commission staff focused on the ability of available treatment systems to meet California's performance standards for the discharge of ballast water (see Table III-1 for performance standards). This report specifically targets existing vessels, those constructed prior to January 1, 2010, with a 1500–5000 metric ton ballast water capacity which will be required to comply with the California discharge standards as of January 1, 2014. However, the ballast water treatment efficacy findings stated here may be considered to apply to all vessel sizes, and for immediate consideration, this would include qualifying newly built vessels with a ballast water capacity of less or equal to 5000 metric tons that began construction on or after January 1, 2010 and vessels with a ballast water capacity of greater than 5000 metric tons that began construction on or after January 1, 2012. The findings in this report supersede and replace earlier reported finding regarding efficacy of systems for vessels of all ballast water capacities.

Since the first technology assessment report was submitted to the California Legislature in 2007, Commission staff has seen rapid growth in the availability and quality of system performance testing data, the most reliable of which are generated by independent, scientific testing organizations. These independent reports generally provide the most robust and comprehensive review of shipboard treatment system performance and environmental acceptability. Commission staff continues to work with vendors and testing organizations to encourage further standardization of data analysis and presentation.

In the current report, Commission staff provides the California Legislature and interested stakeholders with third-party data from land-based and shipboard testing of shipboard ballast water treatment systems. Additional data collected by treatment vendors and at the laboratory scale are available but not included in this report (please contact Commission staff). To determine the proportion of successes and failures for each system at treating water to California's standards, only third-party data were used. In all instances, citations are provided for the original data sources. This information is provided in summary form as many of the third party test reports are confidential in nature and not yet publically available. Commission staff encourages treatment system vendors to make all data available to the public.

Due to the limitations of available data, and the variable conditions present in the "real world," this report presents whether or not systems have demonstrated, on a limited basis, the ability to comply with California's performance standards. Positive assessment for the purpose of this report does not guarantee system compliance during operation in California, nor does the report suggest or imply system approval. The Commission and its staff do not have the practical ability to test and approve shipboard treatment systems for operation in California waters. Vessel owners and operators are ultimately responsible for complying with California's performance standards for the discharge of ballast water.

Commission staff was able to collect efficacy data for 37 of the 75 shipboard treatment systems reviewed in this report. With the exception of the evaluation of system performance for inactivating *Vibrio cholerae*, laboratory data were not used for evaluation purposes in this report because of the large difference in scale between the laboratory, land-based, and shipboard investigations. As in the Commission's 2011 technology update (Dobroski et al. 2011), this report differentiates between data collected for research and development (R&D) and data collected by independent third-parties for Type Approval purposes, as much as possible.

The EPA SAB report (SAB 2011) notes that not all data can be considered “reliable,” and defines reliable data as consisting of both methods and results from land-based and shipboard tests. Commission staff agree with this definition, and thus this report only consider systems that can provide methods and results of third-party tests gathered as part of the type approval process when evaluating system success rates. Of the 37 systems with any data available for review, only 24 systems had data that was determined to be reliable, and not all systems were tested for all organism size classes (see Table VII-2).

As discussed in Section IV. Treatment Technology Assessment Process, Commission staff faces multiple challenges in assessing system performance relative to California’s standards. No methods are currently available, and no treatment system are being tested, to assess total living virus concentrations in ballast water samples, and thus this standard is not included in the data analysis for this report. Bacteria concentrations are assessed using total culturable heterotrophic bacteria, which allow Staff to have confidence that the bacteria are living, but only represent a subset of all bacteria species. In the case of California’s standard in the 10–50 micron size category (0.01 living organisms per milliliter), the detection limits of the best available methods cannot yet reliably attain the required level of accuracy/sensitivity. This means that no available data can confirm a system’s ability to meet California’s standards, although staff can determine when a system does not meet the standard. Finally, many of the naturally occuring concentrations of human health indicator species (*E. coli*, intestinal enterococci, and *Vibrio cholerae*) are zero or non-detectable in coastal waters near ballast water treatment technology testing facilities, which makes it difficult to guage system performance, even though the IMO and USCG testing protocols consider these tests valid for type approval purposes.

Because of the aforementioned challenges with data availability and limits of detection for certain organism size classes, at this time it is not possible to determine if any ballast water treatment system is available to meet the full suite of California's performance standards. It is important to make a distinction here between measurability and the inability to meet a standard. As evidenced below (see Table VII-2) many systems face challenges with meeting California's performance standards on a consistent basis, but determining if systems can meet California's standards is further complicated by the limits of detection (measurability) of existing data - existing data are not sensitive enough to confirm if the standards can be met for the 10-50 micron size class and are not available for viruses.

Nevertheless, it is important to document progress in shipboard ballast water treatment system development and present the available data on treatment system performance. Shipboard ballast water treatment systems are able to meet some of California's standards (*E. coli*, intestinal enterococci, *Vibrio cholerae*, organisms >50 microns, bacteria (as measured by culturable bacteria)) (see Table VII-2). The information presented below reflects the most recently available data on whether or not ballast water treatment systems are available to meet, on a limited basis, any of California performance standards. Data used to generate these tables comes from testing using protocols to determine withether treatment systems can meet the IMO D-2 and/or USCG/EPA discharge standards.

For Table VII-2, the total number of tests performed on a system under land-based or shipboard test conditions is given as a denominator. The number of land-based or shipboard tests for which a system demonstrated the ability, on a limited basis, to meet California's discharge standards is given in the numerator. For the 10-50 micron size class, the limits of detection preclude confirmation of the availability to meet the California standard. The number of tests with results that appear consistent with the standard are shown as “lim. det (x)” to alert the reader to the limits of detection issue. Furthermore by presenting the number of tests that appear consistent with the standard, the reader can determine how many tests clearly did not meet the standard, which is important for knowledge of system reliability.

Many systems did not demonstrate the same compliance rates in land-based tests as in shipboard tests. This should be of interest both in light of any type approvals that will be given at the federal level, and in informing the discussions between vendors and anyone wishing to purchase a treatment system. Commission staff believes that shipboard tests are more indicative of the performance of a system under real-world conditions, as would be experienced by vessels operating in California waters. Land-based tests are the most rigorous available, however, and so it is important that land-based testing results are included inTable VII-2.

Table VII-2. Shipboard treatment systems with reliable third-party collected land-based or shipboard test results from type approval or other third-party testing, for which success rates could be generated. The number of tests, averaged across replicates, that demonstrated, on a limited basis, the ability to meet California's standards is presented in the numerator, and the total number of tests performed is presented in the denominator. Data that cannot be confirmed as meeting the California standards due to the limits of detection of existing sampling methods are indicated by "lim det." ***See Section IV for discussion of challenges associated with data analysis and reasoning behind presentation of the data as seen.***

Manufacturer	>50 µm		10 – 50 µm		<10 µm (bacteria)		*E. coli*		Enterococci		*Vibrio*		Literature Cited[2]
	Land	Ship	Land	Ship	Land	Ship	Land	Ship	Land	Ship	Land	Ship	
Alfa Laval[1]	4/10	1/4	lim det (3/10)	lim det (1/4)	0/10	2/2	10*/10	4*/4	10*/10	4*/4	10*/10	4*/4	147 , 149 , 152
Auramarine	0/11	-	lim det (5/11)	-	0/11	-	11*/11	-	11*/11	-	11*/11	-	153
BIO-UV	0/4	-	0/4	-	1/4	-	4*/4	-	4*/4	-	4*/4	-	134
DESMI	5/11	2/3	0/11	Unk/3	11/11	-	11/11	3*/3	11/11	3*/3	11/11	3*/3	26,27
Ecochlor	8/15	3/3	lim det (9/11)	lim det (3/3)	8/11	-	10/10	3/3	11/11	3/3	1/1 (lab)	3*/3	44 , 141
ERMA First	5/12	0/2	lim det (9/12)	lim det (2/2)	0/Unk[3]	-	10*/10	2*/2	10/10	2/2	-	2*/2	45, 46, 145
Hyde	1/10	3/3	lim det (4/10)	lim det (1/3)	5/10	3/3	10*/10	3*/3	10*/10	3*/3	-	3*/3	142, 196
JFE	6/11	3/6	lim det (11/11)	lim det (5/6)	3/11	4/6	11*/11	6/6	11/11	6/6	11*/11	6*/6	39, 150, 57
MAHLE	1/11	4/4	lim det (4/11)	lim det (4/4)	11/11	4/4	11/11	4/4	11/11	4/4	-	4/4	41, 18
Marenco	3/4	-	0/1	-	2/3	-	-	-	-	-	-	-	68, 69, 194
MSI	0/5	-	0/5	-	3/5	-	5/5	-	5/5	-	5*/5	-	131,
NEI	1/5	1/2	0/1	Unk	0/2	0/2	0/1	2*/2	0/1	Unk	-	2*/2	177, 178
NK-03	5/14	1/5	lim det (9/14)	lim det (4/5)	0/14	1/1	10*/10	5*/5	10*/10	5*/5	10*/10	5*/5	60, 62
Nutech	0/3	2/3	0/2	0/3	3/3	2/2	-	3*/3	-	3*/3	-	3*/3	52, 198
OceanSaver	0/11	1/3	Unk/11	lim det (1/3)	0/10	-	11*/11	3*/3	11*/11	3*/3	11*/11	3/3	155, 182, 183

Table VII-2. Shipboard treatment systems with reliable third-party collected land-based or shipboard test results from type approval or other third-party testing, for which success rates could be generated. The number of tests, averaged across replicates, that demonstrated, on a limited basis, the ability to meet California's standards is presented in the numerator, and the total number of tests performed is presented in the denominator. Data that cannot be confirmed as meeting the California standards due to the limits of detection of existing sampling methods are indicated by "lim det." ***See Section IV for discussion of challenges associated with data analysis and reasoning behind presentation of the data as seen.***

Manufacturer	>50 µm		10 – 50 µm		<10 µm (bacteria)		*E. coli*		Enterococci		*V. cholorae*		Literature Cited[2]
	Land	Ship	Land	Ship	Land	Ship	Land	Ship	Land	Ship	Land	Ship	
OptiMarin	8/12	0/8	lim det (6/12)	lim det (2/8)	2/12	-	12*/12	8*/8	12*/12	8*/8	12*/12	8*/8	146, 148
Panasia	5/11	0/3	lim det (6/11)	lim det (2/3)	-	-	10*/11	3/3	11/11	3/3	11*/11	3/3	61, 63
Qingdao	4/13	3/3	lim det (8/13)	lim det (3/3)	9/13	3/3	13*/13	3*/3	13*/13	3*/3	13*/13	3*/3	151, 159
Resource Ballast Technologies	2/2	2/3	lim det (1/2)	0/3	-	-	2/2	3*/3	2/2	3/3	2/2	3*/3	2, 43
RWO	0/13	4/5	lim det (6/13)	lim det (3/3)	7/13	-	13*/13	5*/5	13*/13	5/5	13*/13	5*/5	42, 154
Severn Trent	9/16	2/4	lim det (13/16)	0/3	10/11	2/4	16*/16	4/4	16/16	4/4	5*/5	4*/4	143, 40, 132
Siemens	0/10	-	lim det (5/10)	-	0/10	-	10/10	-	7/10	-	10*/10	-	133, 49
Techcross	8/11	4/4	lim det (9/11)	lim det (3/4)	5/5	1/1	11/11	4/4	11/11	4*/4	11*/11	4*/4	64, 65, 66, 67
Wartsila Hamworthy (Aquarius UV)	-	0/2	-	lim det (2/2)		-	-	2/2	-	2*/2	-	2*/2	47,48

[*] **Concentration at intake was unknown, non-detectable, or zero in at least one test. As discussed in Section IV, the IMO G8 Guidelines and ETV protocols for assessing ballast water treatment system performance have no minimum influent concentration requirements to conduct system performance tests for these organisms.**

[1] These data include land-based testing of system v. 2.0 and shipboard testing of system v. 1.0. DNV did not require shipboard testing of v. 2.0. Additional testing was conducted at Great Ships Initiative in 2010 but is not summarized here because the system was a hybrid between versions 1 and 2 and not a system currently on the market. For more info see GSI (2011).

[2] Numbered references can be found in the Literature Cited section.

[3] Unknown - minimum, and maximum values provided, but not the total number of tests.

The review of available data indicates that treatment systems are meeting some of California's performance standards. However, the reliability of meeting any individual standard within California's performance standards varies greatly depending on the treatment system, the organism size class being tested, and the testing scale (land-based vs. shipboard). It is not possible to determine at this time if systems can meet the 10–50 micron organism size class due to the lack of measures with sufficient sensitivity for California's standards. Furthermore, there are no tests available at this time to assess total living viral concentrations in ballast water.

Therefore, based on the analysis of the available data, Commission staff has determined that no ballast water treatment systems are currently available to meet all of California's performance standards for the discharge of ballast water.

Additional Considerations Regarding System Efficacy

One significant problem with the implementation of performance standards and the use of ballast water treatment systems is that there are currently no protocols in place (international, federal, or state) to assess vessel ballast water discharges for compliance with relevant standards. Systems need to be type approved using existing protocols, but unless we know the conditions under which that system will be operated, and what compliance regime it will be subject to, it is difficult, if not impossible, to ensure that the type approval testing will be done to reflect those conditions.

For these reasons, Commission staff is in the process of developing protocols to assess vessel compliance with California's standards. The establishment of the protocols will give direction to treatment vendors and vessel operators as to how Commission staff will assess organism concentrations in vessel discharges for compliance assessment purposes. These protocols will address ballast water sample volumes, sampling sensitivity issues, and take into account both scientific rigor and practicality for shipboard inspections of ballast water discharges. The establishment of compliance protocols is particularly important to define California's standard for organisms greater than 50 microns which is defined as "no detectable living organisms." The greater than 50 micron standard requires definition by protocol to ensure appropriate volumes of water are collected during compliance testing to establish limits of detection and to calculate statistical confidence. Additionally, the protocols will define the best available methods to assess discharge concentration in the 10–50 micron size class, as well as all other organism size classes except viruses in California's standards. Commission staff continues to work with scientists, engineers, and the regulated industry on the development of these protocols.

Availability

As noted in the Efficacy section, based on the existing data, no shipboard ballast water treatment systems are currently available to meet all of California's performance standards for the discharge of ballast water. Nevertheless, many factors play into system availability, in addition to efficacy, and warrant discussion, including industry demand (i.e. how many ships need to buy systems) and commercial availability (i.e. are there enough systems being manufactured/sold to meet industry demand and are resources available to install these technologies on new and existing vessels).

Based on statute, existing vessels with a ballast water capacity between 1500–5000 metric tons will be required to meet California's ballast water discharge standards as of January 1, 2014. This vessel size class represents about 8 percent of the fleet arriving to California ports between January 2000 and March 2012 (Figure VII-2). While commercial availability and industry demand are two important components of this assessment of availability, the specific purpose of this report is to assess the availability of retrofit-capable treatment systems for existing vessels with a ballast water capacity between 1500–5000 metric tons, although as noted throughout the report, the broad conclusions discussed herein can be applied to all size classes of vessels and the retrofit information should be applied to all existing vessels, regardless of ballast water capacity.

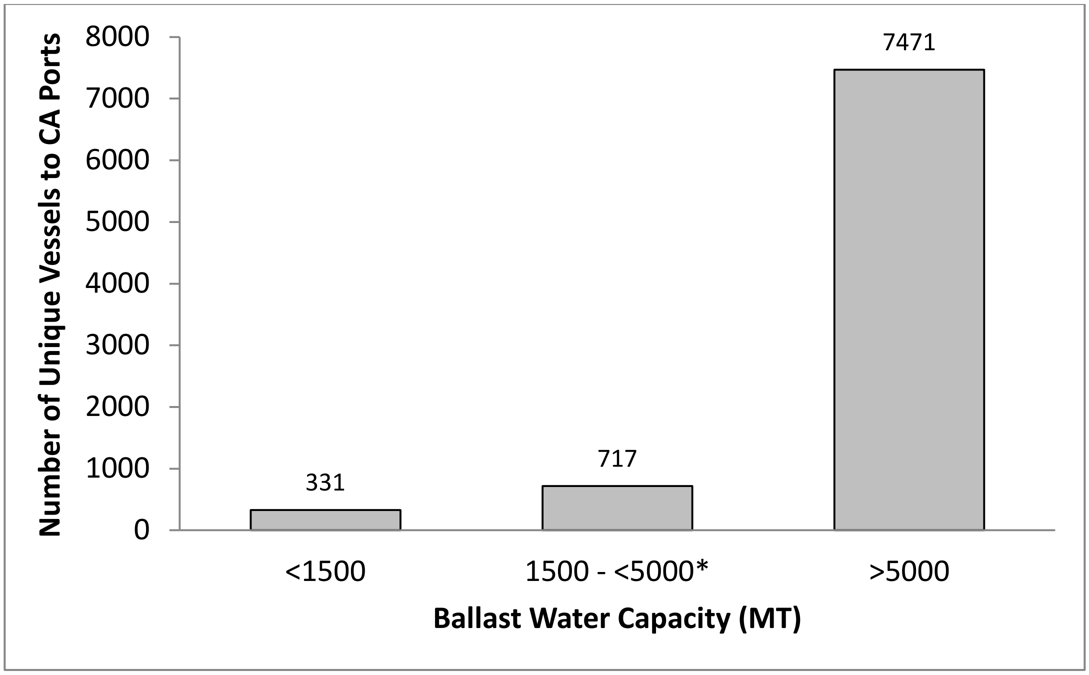

Figure VII-2. Vessels arriving to California ports between January 2000 and March 2012. Vessels are categorized by ballast water capacity in metric tons (MT). * = Existing vessels in this size class will be required to comply with ballast water discharge standards as of January 1, 2014.

Between January 2000 and March 2012, 717 unique vessels with a ballast water capacity between 1500–5000 metric tons arrived at California ports (Figure VII-2). These vessels will be required to meet the performance standards as of January 1, 2014. Less than 20 percent of voyages, on average, discharge ballast in California waters (Takata et al. 2011), and so these vessels will not always have to discharge ballast. However, any one vessel might need to discharge ballast water on a single voyage due to safety or operational concerns, in which case the vessel may need to have a shipboard treatment system installed or be prepared to discharge to a reception facility. It is not yet clear whether shipboard system vendors will be able, or whether shore-based facilities will be available to meet this demand, particularly in light of the fact that many more vessels exist worldwide that may not call on California ports, but will need to install ballast water treatment systems on a similar timetable to meet IMO and U.S. federal discharge standards. One vendor that Commission staff has had contact with has plans to retrofit 101 vessels with its ballast water treatment system in the next one to two years. Further research is required to determine if other vendors of shipboard treatment systems will be able to increase production to meet projected demands.

As part of assessing the availability of treatment systems for the existing vessel size class with 1500–5000 MT ballast capacity for this report, Commission staff compiled data regarding the retrofit capability of shipboard ballast water treatment systems by contacting vendors directly and asking them to complete a retrofit questionnaire (see Appendix B for copy of questionnaire). This questionnaire was developed by Commission staff to address engineering concerns regarding system retrofits on vessels with a variety of space, power, and schedule constraints (new build vessels should encounter fewer engineering and logistical obstacles to system installation). Commission staff also contacted select marine engineers to discuss challenges encountered during retrofitting existing vessels. Fifteen treatment system manufacturers returned the retrofit questionnaire (see Table VII-3).

Table VII-3. Summary of shipboard ballast water treatment systems vendor responses to retrofit questionnaire supplied by Commission staff in March 2012. "Max flow rate retrofit" refers only to the maximum flow rate system that has been previously retrofit on a vessel. Vessel types are abbreviated as follows: a = auto, b = bulker, c = container, g = general, p = passenger, t = tanker, ba = barges. Blank cells indicate that no information was available.

Manufacturer	System Name	Retrofits Completed (#)	Retrofit Orders (#)	Vessel Types Retrofit	Max Flow Rate Retrofit (m3/h)	Max Power (kW)	Drydock Required	Explosion Hazard Protections[2]
Alfa Laval	PureBallast	14	13	t, p, c, g, p	1000	37 - 433	no	yes
Auramarine	CrystalBallast	2	0	b, p	1000	38 - 462	no	in develop.
Ecochlor	Ecochlor BWTS	2	0	c, b	1250	7 - 43	case specific	
Hyde Marine	Hyde Guardian	12	6	p, g, o, c	1000	15 - 114	no	yes
MAHLE	Ocean Protection Sys.	3	0	p, c, a		varies	no	no
N.E.I.	Venturi Oxygen Stripping Sys.	9		b	4400			
NK-03	NK-03 System	2	101	c, t	2200	725.4	no	
OceanSaver	OceanSaver BWTS	1	9	a	500		case specific	
OptiMarin	Optimarin Ballast Sys.	3	6			varies	case specific	no

Table VII-3 continued. Summary of shipboard ballast water treatment system vendor responses to retrofit questionnaire supplied by Commission staff in March 2012. "Max flow rate retrofit" refers only to the maximum flow rate system that has been previously retrofit on a vessel. Vessel types are abbreviated as follows: a = auto, b = bulker, c = container, g = general, p = passenger, t = tanker, ba = barges. Blank cells indicate that no information was available. Unk = unknown.

Manufacturer	System Name	Retrofits Completed (#)	Retrofit Orders (#)	Vessel Types Retrofit	Max Flow Rate Retrofit (m3/h)	Max Power (kW)	Drydock Required	Explosion Hazard Protections[2]
Panasia	Glo-En Patrol	1	Unk	g	6000	720	no	Unk
RWO	CleanBallast	1	0	c	500	salinity depend	no	no
SunRui	BalClor	1	5	b	1000	300	no	
Severn Trent	BalPure	1	1	t	1500	varies	case specific	
Wartsila/Trojan Marinex	Trojan BWTS	1	1	c	500		no	
Techcross	Electro-Cleen	5	0	c, b		salinity depend	case specific	yes
Wartsila Hamworthy	Aquarius[1]	2		t, p			case specific	In develop.

[1] Wartsila Hamworthy produces two Aquarius systems, Aquarius UV and Aquarius EC.
[2] Explosion hazard protections are primarily of concern for retrofits onboard tankers.

Ballast treatment systems must be able to treat all ballast on a vessel prior to discharge. For systems that treat on uptake and/or discharge, the total volumetric capacity of the vessel is not the determining factor. Instead, the treatment system must be able to keep pace with the flow rate of the vessel's ballast water pumps. Commission staff analyzed data on the number of ballast water pumps and the maximum pump rates for the fleet of vessels that call on California ports. It is difficult to pinpoint an average system treatment rate necessary for these vessels because, depending on a vessel's piping configuration, a vessel may need one system per pump or may have one system to treat water coming in or out from all pumps. The pump rate capacities of treatment systems are of particular relevance to oil tankers and bulk carriers which must load and discharge cargo rapidly.

Figure VII-3 illustrates the range of ballast water pump rates on vessels that operate in California waters. The figure includes both vessels that have discharged and have not discharged ballast in California waters, because all vessels have the potential to discharge ballast at some point either due to cargo operations or safety concerns. Figure VII-3 also shows the maximum single pump rate per vessel, and the average maximum combined pump rate per vessel. Average maximum flow rates for vessels between 1500–5000 metric tons ballast capacity fall within the pump rate capacity of available BWTS that have been retrofit on vessels in Table VII-3, though some vessels may have to slow ballasting/deballasting operations under some circumstances depending on the treatment system selected. Figures VII-4 and VII-5 provide a more detailed summary of the pump rates of unique vessel that arrived to California ports from January 2000 – March 2012. Figure VII-4 summarizes the average maximum ballast pump rates, and Figure VII-5 summarizes single maximum ballast pump rates. Most unique vessels that arrived to California during this time have a combined and/or single pump rate maximum of below 2000 m^3/hr., and thus fall within the pump rate capacity of available shipboard ballast water treatment systems. For vessels with greater than

5,000 MT ballast water capacity, pump rate requirements can be much greater and require a more robust treatment system capability. It is important to note that treatment system pump rates can vary based on the age of system components as well as the quality of water to be treated.

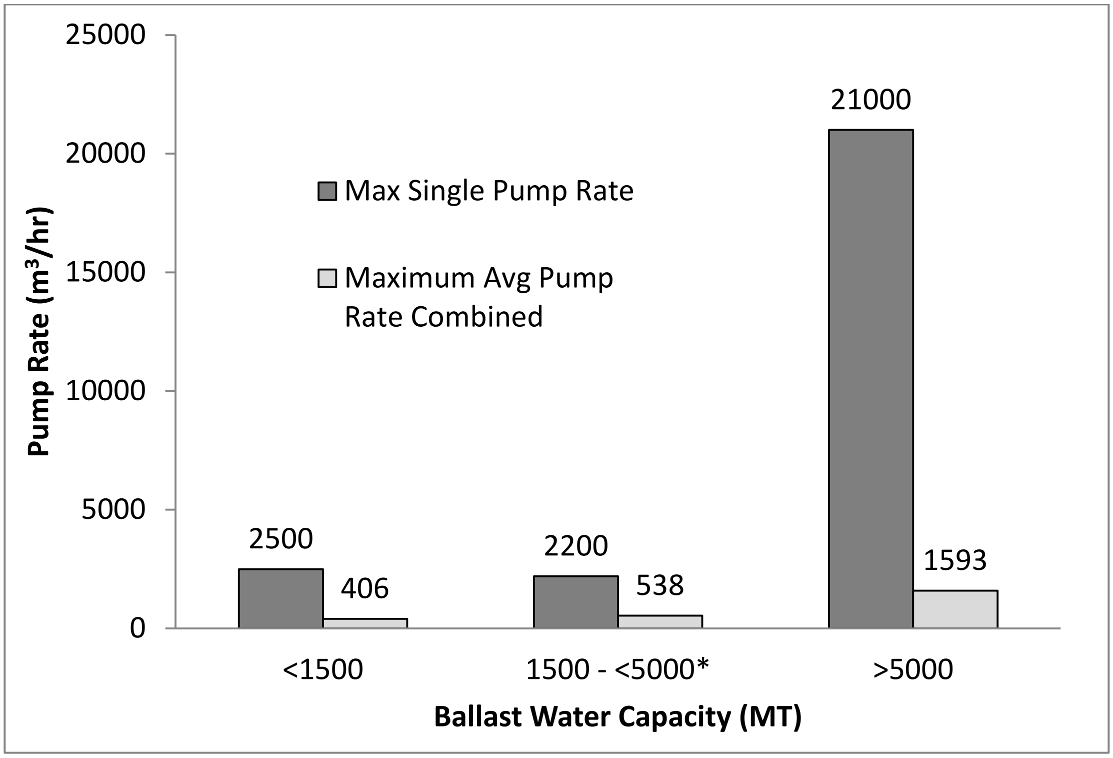

Figure VII-3. Vessels that have visited California ports and their average maximum single and average maximum combined ballast water pump rates (m^3/h). Data were collected from January, 2000 – March 2012. * = existing ships with this ballast water capacity will be subject to the 2014 implementation date for California's performance standards.

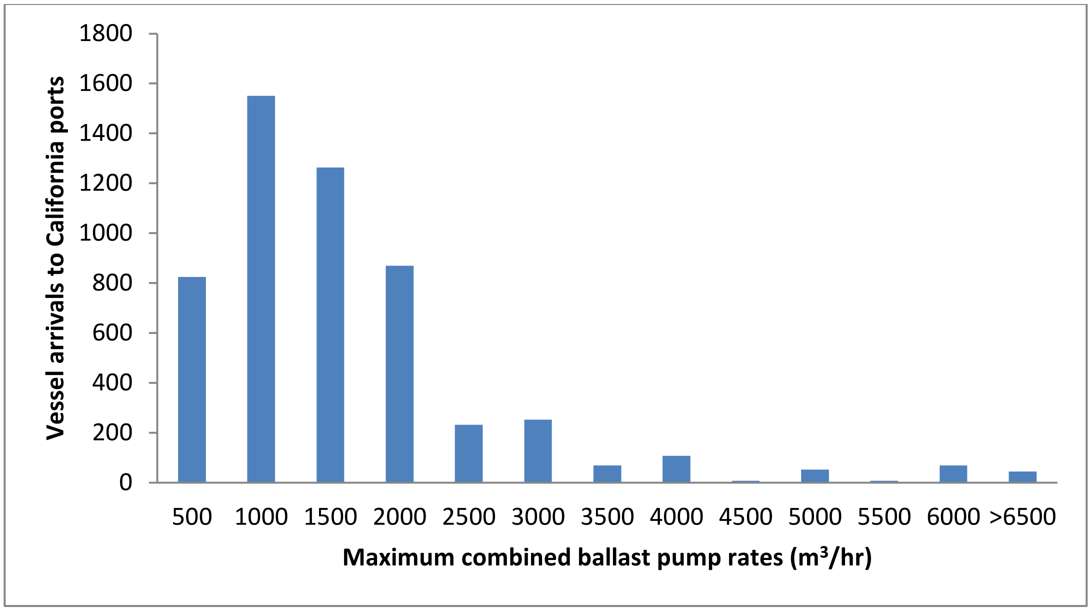

Figure VII-4. Frequency distribution of combined pump rate capacities for vessels that arrived to California ports from January 2000 – March 2012.

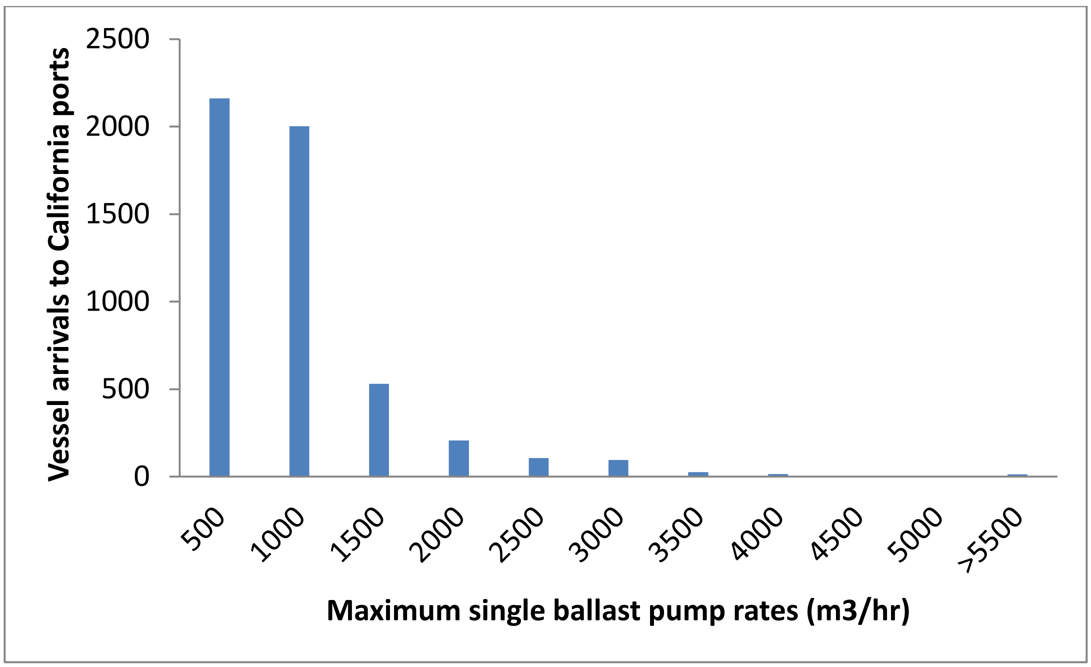

Figure VII-5. Frequency distribution of single ballast pump rate capacities for vessel arrivals from January 2000 – March 2012.

System support is as important as commercial availability. Following installation, system developers will need to have personnel and infrastructure in place to troubleshoot and fix problems that arise during system operation. Maritime trade is a global industry and vessel operators will need to have global support for onboard machinery. Larger companies established in the maritime logistics or equipment industries may already be prepared to respond to technological challenges and emergencies as they arise, but smaller ballast water treatment vendors may face an initial period to ramp-up service and access to replacement parts. Vendors claim that service will be available worldwide. Only time will tell, how support networks can deal with this influx of new machinery, and if system support services will be adequate as California, federal, and international performance standards are implemented.

Environmental Regulation and Impact Assessment

An effective shipboard ballast water treatment system, or shore-based reception facility, must comply with both performance standards for the discharge of living organisms in ballast water and with applicable environmental safety and water quality laws, regulations and permits. The discharge of treated ballast water should not impair water quality such that it impacts the beneficial uses of the State's receiving waters. The IMO, federal government, and state governments have developed specific limits for discharge constituents and/or whole effluent toxicity evaluation procedures in order to protect the beneficial uses of waterways from harmful contaminants. Commission staff has drawn on the environmental review of shipboard ballast water treatment systems and active substance constituents from all levels of government (state, federal, and international) in the assessment of environmental risk for the 75 treatment systems reviewed in this report.

International

As discussed in Section III (Regulatory Overview), the IMO has established an approval process through the Guideline G9 for treatment technologies using active substances (i.e. chemicals) to insure that systems are safe for the environment, ship, and personnel. The IMO two-step approval process is comprised of initial

“Basic Approval” utilizing laboratory test results to demonstrate basic environmental safety, followed by “Final Approval” based upon evaluation of the environmental integrity of the full-scale system. Guideline G9 of the Convention requires applicants to provide information identifying: 1) Chemical structure and description of the active substance and relevant chemical byproducts; 2) Results of testing for persistence (environmental half-life), bioaccumulation, and acute and chronic aquatic toxicity effects of the active substance on aquatic plants, invertebrates, fish, and mammals; and 3) An assessment report that addresses the quality of the test results and a characterization of risk (MEPC 2008e). Systems that apply for Basic and Final Approval are reviewed by the IMO Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) – Ballast Water Working Group (BWWG) in accordance with the procedures detailed in Guideline G9. The Guideline does not address system efficacy, only environmental safety (MEPC 2008e) and is a voluntary guideline for the Convention which has not yet gone into effect.

Federal

The USCG will approve ballast water treatment systems based on biological efficacy and operational safety, and has signed a Memorandum of Understanding with the U.S. EPA to share data relevant to implementation of the Vessel General Permit (VGP) and to cooperate regarding enforcement measures. The U.S. EPA regulates discharges for adherence to Clean Water Act (CWA) water quality standards. The USCG also approves systems for use in the Shipboard Technology Evaluation Program (STEP), and in doing so and must consider potential environmental impact under the National Environmental Policy Act (NEPA). Vessels that participate in the STEP must comply with the U.S. EPA’s Vessel General Permit (VGP) and additionally conform to the environmental compliance requirements associated with STEP participation, including: 1) Compliance with the NEPA process; 2) Due diligence by the applicant in providing requested biological and ecological information and obtaining necessary permits from regulatory agencies; and 3) A provision that systems found to have an adverse impact on the environment or present a risk to the vessel or human health will be withdrawn from the program (USCG 2006).

The current 2008 VGP contains requirements for total residual chlorine (TRC; instantaneous maximum = 100 micrograms(µg)/liter (l)) levels in effluents from vessel operations, and the 2013 VGP contains requirements for TRC and four other chemical residuals (ozone, chlorine dioxide, hydrogen peroxide, peracetic acid). The effluent limits and best management practices described in the VGP are specific to those treatment systems that make use of biocides. Under the permit, all biocides that meet the definition of a "pesticide" under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA; 7 U.S.C. § 136 et seq.) must be registered for use with the EPA. Biocides generated onboard a vessel solely through the use of a "device" (as defined under FIFRA) do not require registration. Systems that use biocides or produce derivatives which lack applicable EPA Water Quality Criteria must conduct whole effluent toxicity testing to determine chronic toxicity levels. Systems that do not meet the Water Quality Criteria or chronic toxicity limits may be required to cease discharging and must apply for coverage under an individual National Pollutant Discharge Elimination System permit.

The 2013 VGP requires monitoring of ballast water treatment system discharges for chemical residuals. Numeric limits are included in the 2013 VGP for TRC (100 µg/l), chlorine dioxide (200 µg/l), ozone (100 µg/l, detected as total residual oxidizers or TRO), peracetic acid (500 µg/l), and hydrogen peroxide (1000 µg/l). For systems that utilize or generate other residuals, acceptable levels in ballast water discharges must meet standards in the EPA 1986 Quality Criteria for Water (the Gold Book) and subsequent updates to these levels. The Gold Book and its updates can be accessed at http://water.epa.gov/scitech/swguidance/standards/criteria/library_index.cfm.

States

As discussed in Section III, several states established ballast water management programs and performance standards requirements through section 401 certification of the VGP. This certification also provides states a mechanism to set water quality criteria for ballast water discharges. Chlorine was a toxicant of concern for many states, particularly those located on the Great Lakes. Several states chose to establish limits for Total Residual Chlorine (TRC) in ballast discharges that were substantially more stringent than the limit established by the VGP (of 100 µg/l). Massachusetts for example, set a TRC limit of 10 µg/l in discharges from experimental treatment systems. Several states also established conditions requiring evaluation of acute and chronic impacts from treated discharges.

Washington State

The State of Washington's evaluation of environmental impacts from the discharge of treated ballast water has proven an invaluable resource. The Washington State Department of Ecology developed a framework for "Establishing the Environmental Safety of Ballast Water Biocides" in 2003, and revised it in 2008 to be included as Appendix H in the *Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria* manual (Washington State Department of Ecology 2008, available at http://www.ecy.wa.gov/pubs/9580.pdf). Two systems have completed toxicity testing in accordance with Washington requirements (Table VII-4).

California

Vessels that discharge ballast water in California waters must comply with the applicable provisions of the EPA's VGP including any California-specific conditions added by the State Water Resources Control Board (Water Board) through the Clean Water Act section 401 certification process. California's section 401 certification requires that vessel discharges contain no hazardous wastes as defined in California law or hazardous substances as listed in the 401 certification letter (see Water Board 2009). Discharges may not contain an oily sheen or noxious liquid substance residues, and detergents may not be used to disperse hydrocarbon sheens. Regulation of Total Residual Chlorine (TRC) in ballast water discharges in California occurs through the VGP and the Water Board's section 401 certification. The Water Board has adopted amendments to the California Ocean Plan that will bring current state law for vessel discharges under the purview of the Ocean Plan. Total residual chlorine would not be allowed to exceed 60 µg/l in ocean waters (or 20 µg/l in freshwater or in enclosed bays such as San Francisco Bay), as delineated in California's section 401 certification of the draft 401 VGP. All vessels that discharge ballast in California waters must comply with the conditions of California's 401 certification of the EPA VGP, which contains limits for TRC. Vendors and vessel owners/operators must consult with the Water Board and EPA to ensure that vessel discharges comply with all other applicable effluent requirements. More information is available at http://www.swrcb.ca.gov/water_issues/programs/index.shtml. A section on vessel discharges under the clean beaches/ocean programs is listed at this website.

Environmental Assessment of Treatment Systems

Commission staff has compiled environmental assessment reports and water quality data reported to the IMO, as well as information made available to the State of Washington and Commission staff, to assess available treatment systems for potential environmental impacts to California waters. The IMO active substance approval documents, in particular, have proved to be a valuable resource to assess a treatment system's broad-scale environmental safety prior to comparison of specific system effluent constituents to the VGP and California water quality objectives.

Of the 75 treatment systems evaluated for this report, 46 have received either IMO Basic or IMO Basic and Final approvals as of May 2013. Forty-eight systems utilize active substances, including ozone gas, free radicals generated by system operation, sulfur-based reducing compounds, and chlorinated and brominated compounds. Of systems that utilize or generate active substances, Commission staff was able to acquire water quality and toxicity testing information on 34 of those systems. Active substances, approvals, and compliance with California limits for Total Residual Chlorine (TRC) residuals for these active-substance systems are summarized in Table VII-4. An assessment of all of the potential impacts from all possible chemicals and residuals associated with the use of these treatment technologies is beyond the scope of this report and is the purview of the California Water Board and the EPA.

Table VII-4. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA TRC 60 µg/l compliant?	CA TRC 20 µg/l compliant?	Literatue Cited
Alfa Laval	free radicals	Y	IMO Basic and Final	Y	N	50, 147, 149, 152
AQUA Eng. Co. Ltd.	sodium hypochlorite	Y	IMO Basic and Final	Insufficient data	Insufficient data	108, 112
Aquaworx ATC Gmbh	n/a (UV, cavitation bubble)	Y	IMO Basic			94
ATLAS-DANMARK	hyplochlorous acid, ozone, hydrogen peroxide, chlorine dioxide, hydrogen, sodium hydroxide	N	denied insufficie nt data, conceptual in nature			112, 106
Auramarine Ltd.	n/a (UV)	Y				3
BIO-UV	n/a (UV)					
Brillyant Marine LLC	n/a (electric pulse)					
Coldharbour Marine	n/a (deoxygenation)					
COSCO	n/a (UV)	Y	IMO Basic			118
Dalian Maritime University Environment Engineering Institute (DMU-EEI) DMU -OH BWMS	hydroxyl radicals, ozone, hydrogen peroxide and HOBr in equilibrium with OBr	Y	IMO Basic			122
DESMI Ocean Guard A/S	hydroxyl radical, ozone	Y	IMO Basic and Final	Y	N	26, 98

Table VII-4 continued. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA TRC 60 µg/l compliant?	CA TRC 20 µg/l compliant?	Literatue Cited
Dow Chemical Pacific Ptd. Ltd.	ozone					
Ecochlor	chlorine dioxide	Y	IMO Basic and Final, USCG STEP, Rec WA Cond.[1]	Y	Y	88
EcologiQ	n/a (deoxygenation)					
Electrichlor	sodium hypochlorite					
ETI	ozone	Y				77
Envirotech and Consultancy Pte. Ltd. (BlueSeas BWMS)	sodium hypochlorite hypochlorous acid/hypochlorite	Y	IMO Basic			116
Envirotech and Consultancy Pte. Ltd. (BlueWorld BWMS)	sodium hypochlorite	Y	IMO Basic			117
ERMA First ESK Engineering Solutions SA	sodium hypochlorite	Y	IMO Basic and Final			122
Ferrate Treatment Tech.	ferrate					
GEA Westfalia (BallastMaster ultraV)	OXIDAT hypochlorous acid	Y	IMO Basic			111, 117

[1] WA Dept. of Ecology Water Quality Program has recommended Conditional Approval of the system to WA Dept. Fish and Wildlife. As of the writing of this report, approval has not been granted.

Table VII-4 continued. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA 60 µg/l compliant?	CA 20 µg/l compliant?	Literatue Cited
GEA Westfalia (BallastMaster ecoP)	n/a (UV + ultrasonic)		IMO Basic			
Hanla IMS Co., Ltd. (EcoGuardian	sodium hypochlorite	Y	IMO Basic and Final			128
Headway Tech (OceanGuard™ BWMS)	hydroxyl radical, hypochlorous acid, hypochlorite, hydrogen peroxide	Y	IMO Basic and Final	Y	Y	109, 105, 151
Hi Tech Marine (SeaSafe-3)	n/a (heat)		New South Wales EPA			78
Hitachi Plant Technologies (ClearBallast)	triiron tetraoxide, poly aluminum chloride, poly acrylamide sodium acrylate	Y	IMO Basic and Final			96, 85, 93
HWASEUNG R&A Co., Ltd. (HS Ballast)	sodium hypochlorite	Y	IMO Basic			125
HyCa Technologies (HyCator®: BWT Reactor System)	sodium hypochlorite, hypochlorous acid, hypochlorite ion	Y				130
Hyde Marine (Hyde Guardian)	n/a (UV)	Y	UCSG STEP			
Hyundai Heavy Ind. (EcoBallast)	n/a (UV)	Y	IMO Basic and Final			85, 86

Table VII-4 continued. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA TRC 60 µg/l compliant?	CA TRC 20 µg/l compliant?	Literatue Cited
Hyundai Heavy Ind. (HiBallast)	chlorine, bromine, sodium hypochlorite, sodium hypobromite, hypochlorous acid, hypobromous acid	Y	IMO Basic and Final	Detection limit of tests above EPA std.	Detection limit of tests above EPA std.	99, 103
JFE Eng. Corp. (JFE BallastAce)	sodium hypochlorite	Y	IMO Basic and Final	Insufficient data	Insufficient data	39, 100, 150
	sodium hypochlorite (granular)	Y	IMO Basic and Final	Insufficient data	Insufficient data	39, 100, 150
Jiujiang Institute (OceanDoctor BWMS)	hydroxyl radical	Y	IMO Basic and Final			130
Knutsen Ballastvann AS (KBAL BWMS)	n/a (UV)					
KT Marine Co., Ltd. (KTM-BWMS)	sodium hypochlorite	Y	**IMO Basic**			121, 124
Kuraray (MICROFADE™ BWMS)	calcium hypochlorite	Y	IMO Basic and Final			120 Annex 44
Kwang San Co. Ltd.	Cl_2, hypochlorous acid, hypobromous acid, sodium hypochlorite, sodium hypobromite	Y	IMO Basic		Detection limit of tests above EPA std.	104

[1] WA Dept. of Ecology Water Quality Program has recommended Conditional Approval of the system to WA Dept. Fish and Wildlife. As of the writing of this report, approval has not been granted.

Table VII-4 continued. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA TRC 60 µg/l compliant?	CA TRC 20 µg/l compliant?	Literatue Cited
MAHLE Ind. GmbH	n/a (UV)		IMO Basic and Final			
Mexel Industries	yes, unknown					
MARENCO	n/a (UV)		WA Conditional[1]			
Maritime Solutions Inc.	n/a (UV)					
MH Systems	n/a (deoxygenation)					
Mitsui Engineering (SPO-SYSTEM)	Peraclean Ocean	Y	IMO Basic			110
Mitsui Engineering (FineBallast MF)	(n/a) filtration					

Table VII-4 continued. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA TRC 60 µg/l compliant?	CA TRC 20 µg/l compliant?	Literatue Cited
Mitsui Engineering (FineBallast OZ)	Ozone	Y	IMO Basic and Final	N	N	82
NEI	n/a (deoxygenation)	Y	USCG STEP			177, 178
NK Co. Ltd.	ozone, total residual oxidant	Y	IMO Basic and Final	Y	Y	89
Ntorreiro	yes, unknown					
Nutech 03 Inc.	ozone	Y		N	N	52, 198
OceanSaver	free and total residual oxidant	Y	IMO Basic and Final	Y	Y	86, 155, 158
OptiMarin	n/a (UV)	Y				146
Panasia Co. (GloEn-Patrol)	n/a (UV)	Y	IMO Basic and Final			60, 62
Panasia Co. (GloEn-Saver)	sodium hypochlorite neutralization using sodium thiosulfate	Y	IMO Basic			123
REDOX Maritime	Ozone sodium thiosulfate	Y	IMO Basic			127

Table VII-4 continued. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA TRC 60 µg/l compliant?	CA TRC 20 µg/l compliant?	Literatue Cited
Resource Ballast Tech (Resource BWTS)	ozone, sodium hypochlorite	Y	IMO Basic and Final			84, 95
RWO Marine Water Tech.	hydroxyl radicals, free active chlorine	Y	IMO Basic and Final	Insufficient data	Insufficient data	42, 83, 92, 154
Samkun Century Co.	ozone, atomic oxygen, nitric oxide, superoxide radicals produced during disinfection	Y	IMO Basic and Final			107
Samsung Heavy Industries, Co., Ltd. (Purimar)	sodium hypochlorite	Y	IMO Basic and Final			113
Samsung Heavy Industries (Neo-Purimar)		Y	IMO Basic and Final			114
Sea Knight						
Severn Trent De Nora	sulfur-based reducing compounds	Y	IMO Basic and Final, USCG STEP	Y	Y	83, 92
Siemens	sodium hypochlorite, sodium hypobromite, oxygenated species, oxygen, hydrogen	Y	IMO Basic and Final	Y	Y	133
Shanghai Cyeco	n/a (UV)					
STX Metal Co., Ltd.	Hypochlorite	Y	IMO Basic and Final			115,

Table VII-4 continued. Environmental testing and approvals for 75 shipboard ballast water treatment systems reviewed by Commission staff. Blank cells indicate that data were not available. In California, total residual chlorine may not exceed 60 µg/l for discharges to ocean waters, and may not exceed 20 µg/l for discharges to enclosed bays and inland waters. N/A = not applicable, Insufficient data = TRC data were received, are not sufficient to determine whether CA TRC limits were met.

Manufacturer	Active Substance	Toxicity Testing Conducted	Environmental Related Approvals	CA TRC 60 µg/l compliant?	CA TRC 20 µg/l compliant?	Literatue Cited
Sumitomo Electric Industries, Ltd.	n/a (UV)					
SUNBO Industries (Blue ZoneTM BWMS)	ozone	Y	IMO Basic			129
Sunrui	hypochlorite, hypobromite, chloramines, bromamines	Y	IMO Basic and Final			102,
Techcross Inc.	hypochlorite, hypobromite, ozone, hydroxyl radicals, hydrogen peroxide	Y	IMO Basic and Final	Insufficient data	Insufficient data	81, 87
Van Oord B.VI	sodium hypochlorite	Y	IMO Basic			126
Wartsila (Marinex)	n/a (UV)					
Wartsila Hamworthy Aquarius UV	n/a (UV)					
Wartsila Hamworthy Aquarius EC	sodium hypochlorite	Y	IMO Basic and Final			124 annex 6
Wuxi Brightsky Electronic Co. Ltd.	n/a (UV)		IMO Basic and Final			119

Of the shipboard treatment systems outlined in this report, 32 utilize or generate chlorine or chlorinated compounds. Several shipboard treatment systems provided data demonstrating that TRC (sometimes measured as TRO = Total Residual Oxidants) was neutralized by an adaptable and automated neutralization step. Other biocides used for ballast water treatment may fall under the “pesticide” registration requirement under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). FIFRA does not, however, apply to chemicals that are generated and used solely onboard a vessel. Most treatment systems using biocides generate that chemical through onboard electrochemical processes, and thus will not be subjected to FIFRA registration. This exception provides significant leeway for systems to operate in U.S. waters without any kind of federal biocide regulation except as provided by the VGP. The EPA and USCG have signed a Memorandum of Understanding that provides for data sharing and collaboration regarding informal enforcement documents for the VGP such as notices to ship operators of deficiencies.

The marine coatings industry has expressed concern over systems that utilize chlorine or chlorine compounds in regards to the impact of high chlorine concentrations on ballast tank coatings. These coatings are not anti-fouling coatings and contain no biocides. They are applied to prevent ballast tank corrosion, and contain organic materials that can be degraded by high concentrations of chlorine. Further research is needed to accurately determine the maximum levels of chlorine and chlorine compounds that such coatings can withstand. Vessels that have already installed chlorine-based or chlorine-generated systems should be approached for initial qualitative information on treatment system effects on ballast tank corrosion-prevention coatings.

Economic Impacts

An assessment of the economic impacts associated with the implementation of performance standards and the use of treatment technologies requires consideration of the costs of NIS introductions to California and the U.S. if performance standards are not met. The specifics of treatment system costs in this section refer to shipboard ballast water treatment systems, but the economic impacts of species introductions are broadly applicable.

As discussed in the Introduction (Section II), California has suffered major economic losses as a result of attempts to control and eradicate NIS (aquatic and terrestrial; Carlton 2001, Lovell and Stone 2005, Pimentel et al. 2005), and these costs are projected to increase. California was also the entry point for 79 percent of existing NIS on the west coast of North America (Ruiz et al. 2011), impacting the economies of California's regional and international partners and requiring control and eradication of NIS that arrived first to California.

Vector control (i.e. controlling the pathways by which NIS enter California waters) is the most effective solution to the problem of NIS (Crooks and Soule 1999, Carlton et al. 2005, Davidson et al. 2008). For each NIS that has established in California and caused harm to California's economy, environment, and public health, California spends thousands to tens of millions of dollars per year in control and eradication (Cardno-Entrix and Cohen 2011). Taken together, this means that NIS severely impact the California economy.

Once established, NIS can cause direct economic losses by reducing yield (i.e. aquaculture and fisheries), reducing the value of commodities, increasing health care costs, or by reducing tourism-based revenues. For example, evidence strongly indicates that a toxigenic strain of *Vibrio cholerae* was transported via ships from South America to the U.S. Gulf coast in 1991, resulting in the closure of Mobile Bay (Alabama) shellfish beds. Economic damages for the short-term localized closure are estimated at over $700,000 (Lovell and Drake 2009). Prince Edward Island oyster operations in Canada lose approximately $1.5 million annually due to mortality caused by the nonindigenous seaweed *Codium fragile* (Colautti et al. 2006). The rate of new introductions is increasing (Cohen and Carlton 1998, Ruiz and Carlton 2003), which suggests that economic impacts will likely increase as well.

As of 2009, California had the second largest ocean-based GDP in the U.S., and ranked number one for employment and second in wages (NOEP 2012). California's natural resources contribute significantly to the coastal economy. For example, in 2010 total landings of fish were almost 438 million pounds, valued at more than $176 million (NOEP 2012). Squid, the top revenue-generating species in 2010, brought in more than $71 million (NOEP 2012). Millions of people visit California's coasts and estuaries each year, spending money on recreational activities that are directly related to the health of the ecosystem. Annually, over 150 million visits are made to California's beaches: approximately 20 million for recreational fishing, over 65 million for wildlife viewing, and over 5 million for snorkeling or scuba diving (Pendleton 2009). Direct expenditures for recreational beach activities alone likely exceed $3 billion each year (Kildow and Pendleton 2006). In total, the tourism and recreation industries accounted for almost $15 billion of California's gross state product in 2009 (NOEP 2012). NIS pose a threat to these and other components of California's ocean economy including fish hatcheries and aquaculture, recreational boating, and marine transportation.

The use of ballast water treatment technologies to combat NIS introductions will involve significant economic investment on the part of ship owners. This investment reflects not only initial capital costs for the equipment and installation, but also the continuing operating costs for replacement parts, equipment service and shipboard energy usage. Cost estimates for shipboard ballast water treatment systems are strongly linked to vessel-specific characteristics including ballast water capacity, ballast pump rates and available space. Additionally, the retrofit of vessels already in operation (existing vessels) with shipboard ballast water treatment technologies may cost significantly more than installation costs for newly built vessels due to: 1) The necessity to rework existing installations (plumbing, electric circuitry); 2) Non-optimal arrangement of equipment that may require equipment modules that can be mounted individually; 3) Relocation of displaced equipment; and 4) Time associated with lay up (Reynolds, K., pers. comm. 2007). Nonetheless, the use of these treatment technologies will help minimize or prevent future introductions of NIS and relieve some of the future economic impacts associated with new introductions.

Many shipboard treatment system vendors are hesitant to release costs because system prices still represent research and development costs and do not reflect the presumably lower costs that would apply once systems are in mass production. In the 2010 Lloyd's Register report, the most recent report available with system cost information, only 22 of 41 technologies profiled provided estimates of system capital expenditures (equipment and installation) and half (20) provided estimates of system operating expenditures (parts, service, and energy usage; Table VII-5). Commission staff has also acquired some data on capital and operating costs. Capital expenditure costs are dependent on system size. A 200 cubic meters per hour (m^3/h) capacity system may require an initial capital expenditure between $20,000 and $630,000 with an average cost of $291,000 (Lloyd's Register 2007, Lloyd's Register 2010, Commission data from technology vendors 2007–2008) – down $96,500 from 2009 (see Dobroski et al. 2009a). A 2000 m^3/h capacity system ranges from $50,000 to $2,000,000 with an average cost of $892,500 per system (Lloyd's Register 2007, Lloyd's Register 2010, Commission data from technology vendors 2007–2008). The average cost of the large capacity systems has not changed since Dobroski et al. (2009a). Operating costs range from negligible, assuming waste heat is utilized, to $1.50 per m^3 with an average of $0.07 per m^3 (Lloyd's Register 2007, Lloyd's Register 2010, Commission data from technology vendors 2007–2008)—down \$0.06 per m^3 since 2009 (when it was \$0.13 per m^3) (see Dobroski et al. 2009a). Staff has not been able to update these numbers, as Lloyd's (2010) is still the best and most complete reference for cost data. As more systems are sold, costs will likely decrease.

Treatment systems will likely increase the cost of a new vessel by 1–2 percent. For example, a new 8200 TEU (twenty-foot equivalent unit) container ship built by Hyundai Samho Heavy Industries costs approximately \$120 million per vessel (Pacific Maritime 2010). Installation of the most expensive treatment system currently available at \$2.0 million (as indicated in Table VII-5) would increase the cost of that vessel by 1.7 percent. Many treatment technology developers claim that their systems will last the life of the vessel, so the capital costs for treatment systems should be a one-time investment per vessel, assuming that the system will remain compliant with respective regulations and requirements throughout the world.

While the economic investment by the shipping industry in ballast water treatment technologies will be significant, when compared to the total costs to control and/or eradicate NIS, the costs to treat ballast water may be negligible. Control efforts are multi-year and represent tens of millions of dollars already spent by the State of California. Managing ballast water with treatment technologies will help to prevent further introductions and lower future costs for control and eradication. Additional studies will be necessary to obtain actual economic impacts associated with treating ballast water.

Table VII-5. Summary of capital and operating cost data for select shipboard treatment systems. Unless otherwise noted, source of data is Lloyd's Register (2010).

Manufacturer	Capital Expenditure *(Equipment & Installation)* 200 m^3/h *($ in thousands)*	2000 m^3/h *($ in thousands)*	Other *($ in thousands)*	Operating Expenditure *($ /m^3)*
21st Century Shipbuilding				
Alfa Laval				0.015[1]
Aquaworx ATC				
atg UV Technology				
ATLAS-DANMARK	180	850		
Auramarine Ltd.				0.040
Brillyant Marine LLC	300	2000		
Coldharbour Marine				
COSCO/Tsinghua Univ.				
DESMI Ocean Guard				
Ecochlor	500	800		0.080
EcologiQ			<50[1]	1 - 1.50[1]
Electrichlor	350			.019
ETI		500		cost of power
Hamworthy Aquarius UV				
Hi Tech Marine	150	1600	16.5 – 300[1] *(equipment)*	nil[2]
Hitachi/Mitsubishi		400		
Hyde Marine	250	1200	174 – 503[1]	<.020
Hyundai Heavy Industries (1) – Ecoballast				
Hyundai Heavy Industries (2) – HiBallast				

[1] Source: Communications with technology vendors (2007-2008).
[2] Assumes waste heat utilized

Table VII-5. Summary of capital and operating cost data for select shipboard treatment systems. Unless otherwise noted, source of data is Lloyd's Register (2010).

Manufacturer	Capital Expenditure *(Equipment & Installation)* 200 m^3/h *($ in thousands)*	2000 m^3/h *($ in thousands)*	Other *($ in thousands)*	Operating Expenditure *($ /m^3)*
JFE Eng. Corp.				0.053
Kwang San Co. Ltd.				
MAHLE				
MARENCO	145	175		0.0006 - 0.001
Maritime Solutions				
Mexel Industries	20	50		
MH Systems	500	1500		0.06
Mitsui Engineering			100[1] *(installation)*	0.15[3]
NEI	249	670		0.13
NK Co. Ltd.	250	1000		0.007
Ntorreiro				
Nutech 03 Inc.	250	450		0.32
OceanSaver	288	1600		0.06[3]
OptiMarin	290	1280		
Panasia Co. Ltd.				
Pinnacle Ozone Solutions	200	500		0.013
Qingdao Headway Tech.				0.0018
Resource Ballast Tech.	275	700		
RWO Marine Water Tech.				
Severn Trent De Nora	630	975		0.020
Siemens	500	1000		0.0085 - 0.010
Sunrui CFCC				
Techcross Inc.	200	600		0.003
Wartsila				

[3] Source: Lloyd's Register (2007)

VIII. DISCUSSION AND CONCLUSIONS

California's performance standards are set in statute (Pub. Resources Code § 71205.3) and are being implemented on a graduated time schedule based on a vessel's year of construction and ballast water capacity. On paper, vessels have several options available to them to comply with California's performance standards, including: 1) retention of all ballast water on board; 2) use of potable water as a ballast water source; 3) discharge to a shore-based ballast water treatment facility; and 4) treatment of all ballast prior to discharge by a shipboard ballast water treatment system. However, in practice, this report has demonstrated that vessels have very few options available at this time to comply with California's performance standards. While a large proportion (over 80%) of voyages to California waters retain all ballast water on board, a vessel may still need to discharge ballast on 20% of its voyages for either operational or safety purposes, and thus will need a method of ensuring that any discharged ballast is in compliance with the standards. Potable water is not an option for many vessels due to cost and the volume of water needed for ballasting purposes. There are currently no shore-based facilities to treat NIS in ballast water in the United States. Shipboard ballast water treatment systems are under development and testing worldwide, however given the limitations of existing data (i.e. detection limit issues for the 10-50 organism size class, lack of data for the viral organism class), and the lack of data indicating consistent performance at meeting California's standards in land-based and shipboard testing for the other organism size classes , the Commission concludes that no shipboard ballast water treatment systems are currently available to meet all of California's performance standards for the discharge of ballast water.

The lack of options available to the shipping industry with which to comply with California's performance standards at this time is a significant obstacle to implementation of the standards. The Commission therefore recommends that the California Legislature amend PRC section 71205.3 to delay implementation of

California’s performance standards for the discharge of ballast water for all vessel size classes until such time that technologies are determined to be available. Because the performance standards have already been implemented for newly built vessels (vessels constructed after January 1, 2010 with a ballast water capacity less than or equal to 5000 MT and vessels constructed after January 1, 2012 with a ballast water capacity greater than 5000 MT), per existing statute, any delay in implementation will need to be retroactive for these vessels.

The Commission continues to work closely with the regulated community and other interested parties to develop a plan for implementation of the standards that takes into account the availability of options to meet California’s performance standards while recognizing that the Commission must continue to strive to meet its mandate to “eliminate the discharge of nonindigenous species into the waters of the state.” A delay in implementation of the standards will provide Commission staff with time to conduct research and gather data on novel shipboard ballast water treatment systems and options for shore-based ballast water treatment facilities. Commission staff is currently securing the services of a third party manager to develop a request for proposals to conduct a study to assess the feasibility of shore-based treatment in California. This study, along with additional research on shipboard ballast water treatment system performance and availability, will help direct the implementation of California’s performance standards into the future.

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X. APPENDICES

APPENDIX A

Ballast Water Treatment Technology Vendor Retrofit Questionnaire (Delivered Electronically February 13, 2012)

Dear Ballast Water Treatment Technology Vendors:

The California State Lands Commission staff is gathering information on the retrofit capability of any and all treatment systems to be included in the 2012 ballast water treatment technology assessment report. We request that you answer the following 9 questions as completely as possible so that we may gather accurate information about current industry-wide retrofit capabilities. Please use as much typing space as needed to completely answer each question. The information you provide will also let potential clients know specifics about retrofitting existing vessels with your company's ballast water treatment system (BWTS).

This form can be filled out electronically and returned via email to amanda.newsom@slc.ca.gov. Please return this form by **Monday, March 12** to have your BWTS retrofit information included in the Commission's 2012 report.

Thank you for your participation in the Commission's 2012 technology assessment. Please do not hesitate to contact me at the email address provided above with any questions about this survey or how the information may be used.

Regards,

Amanda Newsom, PhD
SeaGrant Fellow
California State Lands Commission
Marine Invasive Species Program

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1) Has your company ever retrofit its BWTS to one or more existing vessels? If so, please indicate the number (i.e. quantity) and types (e.g. tankers, cruise ships) of vessels retrofit and the maximum pump capacity of the systems installed.
Type response here.

2) Do you have any orders for future retrofits? If so, please indicate the quantity and types of vessels to be retrofit and an estimate of when these retrofits will be completed.
Type response here.

3) What are the footprint and vertical clearance requirements of your company's BWTS? If your company manufactures both small and large BWTS, please specify footprint and vertical clearance for each available size.

Type response here

4) Does your company's BWTS break down into components that could be retrofit as space allows? If so, how many components and how much space (footprint and vertical clearance) is required for each component?

Type response here

5) What are the power requirements for your company's BWTS?

Type response here.

6) Are there any limitations on your company's ability to retrofit an existing vessel with a BWTS (example: explosion hazard for oil tankers)? If so, are these limitations for certain vessel types or for all vessels?

Type response here.

7) Does a vessel have to be in drydock to be retrofit with your company's BWTS?

Type response here.

8) Are any estimates available regarding the cost (US$) of retrofitting your company's BWTS to existing vessels for the categories (a-d) written below? This estimate can be stated as a range, as we are aware these costs will be different for each vessel.

a) installation/labor

b) parts

c) cost of the system (capital equipment costs)

d) energy usage

Type response here.

9) Please use the space below to include additional information regarding retrofitting your company's BWTS.

Type response here.

APPENDIX B

California State Lands Commission
Marine Invasive Species Program
2012 Ballast Treatment Technology Assessment Report
Technical Advisory Group Meeting Notes
April 11, 2012

Participants

Amanda Newsom – CSLC
Chris Scianni – CSLC
Chris Brown – Smithsonian Environmental Research Center
Shuka Rastegarpour – California State Water Resources Board
Sonia Gorgula – Hawaii State Department of Land and Natural Resources*
Karen McDowell – San Francisco Estuary Partnership*
Jackie Mackay – CSLC*
Enrique Galeon – CSLC*
Steve Morin – Chevron Shipping*
Maurya Falkner – CSLC*
Nick Welschmeyer – Moss Landing Marine Laboratories*
Abigail Blodgett – San Francisco Baykeeper*
Sharon Shiba – DFG/OSPR*
Rian Hooff- Oregon Department of Environmental Quality*
Ryan Albert – US Environmental Protection Agency*
Lisa Swanson – Matson Navigation*
Andrea Fox – California Farm Bureau*
John Berge – Pacific Merchant Shipping Association*
John Stewart – International Maritime Technology Consultants, Inc.*
* = participated by phone

Meeting Notes

Amanda Newsom – Purpose of meeting

1. The purpose of this meeting is to discuss the Treatment Technology Assessment Report itself. This is not to discuss the standards, which are set in law. We will welcome comment on how clearly the standards are discussed within the context of the report.

2. Provide regulatory updates from the International, Federal and State levels. Highlights include the IMO convention now being ratified by 33 countries (26% world shipping tonnage). Convention goes into effect when 35%.is reached. USCG put out final rule on discharges (Phase 1 standard). EPA has released draft 2013 VGP which consist of ballast discharge standards.
3. Efficacy and availability – SLC is asking members/industry for concrete numbers of systems being used now. It will give an indication of the methodology of systems in the market and how reliable these systems are. Thirteen systems have demonstrated potential to comply with CA discharge standards in either shipboard or land-based tests (in 1 test). Six systems showed potential compliance in 50% of tests. Currently, there are three (3) systems that show compliance in 100% of tests.
4. Environmental Impacts/standards – In order to legally operate in CA, treatment technologies also have to meet state and federal environmental standards. Seven out of the 13 systems that showed potential to comply with the EPA's VGP limit of total residual chlorine. Five systems use technology other than chlorine; e.g.MAHLE uses a UV system that does not fall under VGP. All top performing systems are either VGP compliant or utilize non-chemical technology.
5. Recommendations – Move forward with 2014 implementation date for all vessels in the 1,500 to 5,000 MT size class.
6. Report timeline – Would like final comments by April 20, 2012. Report submitted to Commissioners during July meeting.
7. Points for discussion: Commission needs – Regulatory development and insight. Would like additional information on the impacts of aquatic invasive species to the environment. Also, need concrete data on the additional cost of installation and retrofit of systems on vessels. Thoughts on conclusions and recommendations in the report.

Pressing questions, concerns about the report – Roundtable discussion to collect initial comments and ideas regarding report for a later discussion

"bullet point" denotes person initiating comment

- Sharon – The introduction to the 2012 draft report could use more concrete examples about actual occurrences and economic impacts of BW-mediated NIS introductions specific to California. Even the information we have is sparse. Should show how serious the problem is. There was some mention of pelagic organism decline, which could be augmented more, since it is an ecological effect.

- Shuka – No comments at this time.

- Chris B. – No comments at this time.

- Abigail – Did not have time to review complete draft thoroughly. Concerned with enforcement of the standards. How often will samples be taken and how long will it take?

  Amanda – That's a discussion to be had when discussing tthe Article 4.7 rulemaking, since it is still in the public comment period.

- Andrea – Concerned about the availability of TS that will be able to do what it needs to do to meet the standard. Are there TS out there?

  Amanda – The systems reviewed in the report that showed the potential to comply are commercially available. Many of them have been retrofitted to vessels already.

- Karen – No initial comments.

- Nick W. – What are the criteria used to determine compliance? Are there categories or one category? Is it one test to meet all regulatory standards or a particular standard? Are you endorsing the top vendors?

  Chris S. – It is stated in the report that there is no endorsement, just showing they are compliant, given the data we have seen. Don't want to hold any information back so we are putting it all out there.

  Nick W. – As an innocent listener that is what I heard since you are calling them the "top" systems.

- Ryan A. – No comment.

- Sonia – No comment.

- Steve – Sent in detailed comments. I'm baffled as a member of industry that the Feds and other States are backing off on advanced standards beyond D2. But, CA is remaining with standards that, according to everyone else, can't be met or verified.

  Amanda – This is a conversation that would be more fair for you to have with the Legislature since we aren't the sole authority on the standards. We can only report what they are.

Chris S. – We want to try and keep this from becoming a conversation about the standards themselves.

Steve – But the report is all about the standards and if your standards are so hard that nobody can meet them then your report is moot.

Chris S. – The data we will be presenting shows, we feel, that our standards can be met.

Steve – I find those statements very debatable, not only that systems are meeting compliance but that there is a way to verify it.

Maurya – That's why compliance protocols have been developed.

Steve – But these are CA protocols, there's no federal protocols.

Maurya – We're not the feds.

Steve – I know, but is there a scientifically approved/backed protocol for all the class sizes and tests?

Amanda – That is within the purview of Article 4.7 and is in its public commentary period.

- John B. – There is concern whether systems can meet the standard. Based on IMO D2 testing VGP, pg 82. EPA states CA data "Do not have test efficacy beyond the limits of D2". So, can this data your being provided actually be used to determine compliance with the more stringent CA standards? Echolor, when they commented on the VGP, noted that tthe scientific methods cannot quantify standards at a high enough resolution. That is a major concern. At the September commission meeting, there was skepticism about the standards to verify by a third party before implementation dates resulting in putting the cart before the horse. I understand the protocols are in the rulemaking process but it may be premature to assume everything will work out accordingly. The report would be remiss if it didn't mention the adoption of CG rule. Vessels might be forced to install a system to meet CA standards only to have to rip it out a few years later since it wasn't approved by CG. Have seen a couple IMO type approved systems pulled off the market since they couldn't even meet D2.

Amanda –I'm familiar with the comments on the ETV protocols and we were actually able to get the numbers and used those data to determine efficacy. If we couldn't get the numbers, we did not report on efficacy. Does anyone have additional insight on the CG comment?

Maurya – CG has a two pronged approach. They will be looking at systems installed on existing vessels and they will be submitting an alternative management application along with their type approval application. They will be accepting those applications within the next couple of months. Systems must be shown to be at least as good as exchange. CG working on policy to accept applications and should be out in the next week.

Amanda – To be considered reliable data for the report, the methodologies had to accompany the numbers. For the most part, IMO is using a similar methodology.

John B. – Is CA essentially using IMO D2 standard?

Amanda – No, it's more stringent.

- Steve – refer back to you comment that the top three companies were compliant 50% of the time. Industry needs to meet compliance 100% of the time, so a 50-60% compliance rate does us no good. The systems that passed 100% of shipboard tests did not pass land based tests.

Amanda – Compliance will be based on shipboard operation conditions.

Sharon – Why are the number of tests per unit so low?

Amanda – The availability of lab testing can be difficult and costly.

Maurya – Nick has done a lot of this work, any insight why difference in shipboard vs lab based testing?

Nick W. – Land based is more stringent test, ship board test a bit more sloppy and easier to pass since the challenge concentrations for ship-board testing are tremendously lower than that for land based. The conditions for land based require additive to be added to the sea water to make it more organic in particulate constituents and use augmented organism counts. In ship board you get what Mother Nature gave you.

John S. – Also lot of variety in the way ship board testing is conducted since it is more opportunistic in nature. There's a lot more room for interpretation on how the tests were conducted. High amount of variability in sampling based on who's doing it. Large amount of samples can be collected and picked to pass. Adds some value questions to ship board data.

Amanda – No way to verify the systems have given us all the information. We reported everything we were given.

Nick W. – For the systems that passed the CA standard, does the report give the data score? Does the reader get to see the numbers or do we take your evaluations as presented?

Amanda – The body of the report is a summary of the data that will be found in Appendix A. The reader can go back to the appendix for further information. References to those data are also included.

Nick W. – In imagining what some of the data look like it probably said "ND" not detected.

Amanda – If that is the case than ND would be noted in the appendix and the methodology used and the data reference would be in the appendix.

Nick W - How can we pass compliance? What is the number? We can make the test happen the way you want it to and engineer a test to get zero, but does that mean non-detectable? Can we pass a non-detectable standard?

Amanda – It's left to the reader to go to the appendix to evaluate the methodology used.

Nick W. – The data do not always appear as numbers, but can be non-detectable meaning we didn't find any and I believe under CA that would be passable.

Amanda – Passes under a certain methodology if the rulemaking goes through. It's the criteria we're using since it's the closest thing we have.

- Andrea – What is the availability of TS that meets CA standard? Are they commercially available so that the people being regulated by the standards can actually meet those standards? Companies can't bring in all their ships at once to be retrofitted. It is a huge process for retrofit. Is there technology available to do the job and is it readily available.

  Amanda – Refer to draft report table VI-4, pg. 69. Bolded systems are compliant in greater than 50% in compliance tests. Columns show retrofits completed and retrofits ordered. All bolded systems have completed retrofits which seems to say the technology is available now.

  Chris S. – Important to remember is this report focuses on existing vessels of BW capacity of 1500-5000 MT, it is a small group that represents about 0.1% of the fleet.

  Amanda – Refer to pg. 67-68. Within that vessel size class 20% of voyages discharges ballast into CA waters which equals about 140 vessels that would be required to install by Jan 2014. Vessels discharging once must install TS, but there are caveats to the rule. Not every of those vessels meets the profile. Distributed among the 13 vendors which showed compliance, would equate to approx. 12 retrofit systems per vendor, which is the likely demand. Part of how we addressed availability.

John B. – Even though the report is focusing on the 1500-5000MT size class, all new builds under construction now over 5000 MT, a vast majority of vessels, will have to comply as well, so CA is addressing only a small percentage of the fleet that will need retrofitting. At last Commission meeting, the Commissioners expressed skepticism about ships being built now meeting CA standards and it is remiss to ignore those concerns.

Amanda – To clarify, this is about new builds that are still having to have BWT installed while being built complying with CA standards. This will create greater strains to retrofitting demands?

John B. – Yes, certainly a much greater population of ships than the 1500-5000 vessel class.

Maurya –We should look at language from the last report that was approved by the Commissioners in September and incorporate that language into this report regarding availability of systems.

John B. – Commissioners did not approve that report, not an action item on that agenda. They expressed concerns during the presentation.

Maurya – Correct. They approved the larger class size in the 2010 report. 2011 report is an update, which is not legislatively mandated and so doesn't need approval. Make recommendation to look at 2010 report and incorporate the language.

Lisa S. – I give support to John B. and Steve. We're concerned about measuring the standard and what it means to the report.

- Amanda – Will look at the 2010 report and issues brought up by industry. Regarding Nick's question, top systems language does not appear in the report, but do you have any advice regarding the framing of the language in the report based on the systems that are being used.

Steve – I'd like to direct you to pg 62, next to last sentence, line 8, where "top performing" is used.

Nick W. – This all takes us back to the same questions/criticisms as with the2010 report, are we overly optimistic with these systems? Can vendors actually achieve these standards? I will go back and look at the numbers. We are in a fuzzy area saying systems can comply with CA standards currently, but not knowing if the tests were sensitive enough to test to standards, without knowing tests. Gives a one foot on ice, one foot on banana peel scenario because numbers are not appearing very well. Certainty in statements comes with backpedalling to re-explain how the test was actually performed. Need to make sure that the top performing systems arrived at results based on real numbers and not on assumptions.

Amanda – Will look again at the data and be more critical in the evaluation.

Nick W. – We talked about this in 2007 and again in 2010. It is now 2012 and it is not going away.

Ryan A. – EPA supports Nick's question as a consumer of these results as well. One caution when considering this language, we are only looking at the shipboard results and not looking at land based. Even though I fully appreciate that you will have a fully ship based protocol, much like we do at EPA, I'm worried about not taking advantage of quality control available in land based testing where there can often be lower detection limits. Such strong perceived be best for long term.

John S. – I work with a lot of tech developers, and I don't always defend them. In this case I can't defend them. As I read this from a non-regulatory perspective I would recommend just taking out the "top performer" language on systems. This language and information is being abused in the market place. We have to be careful of the language that is suggestive, where this data creates a perception of compliance with a standard in and of itself. It reads as an endorsement and it should not become an endorsement. Need to be really careful in framing the language so we aren't perpetuating the thought and use of the report as endorsement for these systems.

- John B. – Is the data that's being assessed based on IMO D2 testing protocols? Is that data appropriate for testing CA's more stringent standard?

Ryan A. – Good question. As a consumer of data, I believe, as do many on the regulating community, that there are definite shortcomings in current testing approaches under the 2004 ballast water convention. Improvements are being looked at, such as the ETV protocols. We discuss CA discussion on their analysis of data and how to look at it through a BAT approach. From our perspective we are looking at 2 different lenses and we aren't going to say whether IMO or CA approach is better other than they are fundamentally different, both with their own strengths and weaknesses. CA has done a very good job expressly noting the potential to apply doesn't guarantee performance.

As detection limits improve the effective CA limit will be better, but they are currently limited by current detection approaches.

John B. – For the 10-50 size class, where it is 1,000 times more stringent than (IMO), is it appropriate to use the data in report to determine compliance with the CA standard?

Ryan A. – Would not use type approval for 10-50 um. Need to look at these differently. We've determined that the existing G8 protocols using a BAT standard doesn't give us adequate resolution. But again, we are looking through a different lens than the potential to comply lens.

John B. – We will have to comply, that is the concern.

- Steve M. – Report suggests compliance with the CA standard, isn't that the purpose of the report, to indicate there are systems out there that can meet the standard?

Amanda – The purpose of the report is to determine if there are systems that meet the standard. All we can do is report the data.

Steve M. – So now you're saying there are systems that can meet your standard?

Amanda – That is our determination at this point, yes. We can't approve anything, all we can do is report the data.

Nick W. – You are having to back pedal each time the question comes up. I agree with John Stewart. Vendors will take advantage of the test and there will be abuses in the marketplace. A no detect is a stringent level and vendors will be able to say they met it if they set up their experiments in such a way to get zeros. Some will take advantage of it and it's an uncomfortable position.

Sharon – Wasn't there some reference in the text about a non-dimensional limit?

Amanda – That's for the non-detectable being a non-dimensional limit and refers only to 10-50 um size class.

Nick W. – CA standard for organisms 10-50 is .01/ml, IMO = 10/ml. ETV says we will sample 1ml and concentrate 6 times. Scouring through that 1 ml and counting what is found. You will have a better than average chance of not seeing an organism in 1 ml. ETV recognized this and recommends not looking through 1ml but 1,000ml. If one looks through 1ml and finds a zero, well a Zero is zero no matter how you cut and dice it up and they will think they passed for CA.

- Amanda – Going back to Sharon’s comment regarding how we can add more details on invasions in CA.. We need additional information on economic and health impacts on CA. We are definitely always looking for more impact data for CA.

  Andrea – Check with CA invasive species advisory committee, who are currently funding an impacts study. Pose questions to committee and they will provide more information. One of our members is currently conducting a study on invasive species pathways within CA.

  Chris B. – Report should be available in August. Vector impact analysis report should augment information.

- John S. – Is it conceivable this report could not reflect the names of companies? Just report data of what technologies are capable of and are available, but not report a particular brand? Could have a misinterpretation of data. May help to avert some of the problems associated with the perceived endorsement. Appropriate to name names rather than keep it general to technologies?

  Amanda – Interesting question, this is something staff will discuss.

  Maurya – From historical perspective, it was done in the original report. EO/Commissioners would like to go that way, but agreed we should revisit the question, especially given the potential misuse of the report.

- John B. – The Invasive Species Fund pays for one person at the State Water Board to collaborate with CSLC. Can we get information from Water Board on what their VGP certifications are and whether it will have any implications on the standard?

  Chris S. – Waterboard will work with us to discuss any regulatory updates.

- Amanda – Are there any additional additives at the Federal, International level? Cost? Numbers? We have used Lloyd’s Register, but it may be out of date. Please email me any updates you may have.

  Maurya – Any contact with vendors?

  Amanda – Yes, they are very helpful. Especially those with retrofit issues.

- Amanda – Any closing comments?

John B. – I will be submitting written comments to the group.

Amanda – Submit comments by email. If you would like to expand more on what was said here or add additional comments, please do.

End of meeting.