ASSESSMENT OF THE EFFICACY, AVAILABILITY AND ENVIRONMENTAL IMPACTS OF BALLAST WATER TREATMENT SYSTEMS FOR USE IN CALIFORNIA WATERS

PRODUCED FOR THE
CALIFORNIA STATE LEGISLATURE

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EXECUTIVE SUMMARY

The Coastal Ecosystems Protection Act (Act) of 2006 expanded the Marine Invasive Species Act of 2003 to more effectively address the threat of nonindigenous species introduction through ballast water discharge. The Act charged the California State Lands Commission (Commission) to implement performance standards for the discharge of ballast water and to prepare a report assessing the efficacy, availability, and environmental impacts, including water quality, of currently available ballast water treatment technologies. This report summarizes the Commission's findings, discusses future plans of the Commission's Marine Invasive Species Program, and offers recommendations to the Legislature regarding the implementation of performance standards for the discharge of ballast water.

Twenty-eight ballast water treatment systems were evaluated for system efficacy, availability and environmental impacts. Testing was either not performed or data was not available for eight of those systems. For many of the remaining 20, the methods used to evaluate efficacy were variable, and the results were often presented in metrics that were incompatible with California's standards. Thus, it was often impossible to compare the available data for a single system against all of the organism size classes specified by California's performance standards. On a system-by-system basis and across all testing platforms and scales (laboratory, dockside, shipboard), no single technology has yet demonstrated the capability to meet all of California's performance standards.

Since the limited available data indicate that no system demonstrates the capability to meet all seven organism size classes of California's standards, none can be clearly deemed "available" for installation. Efficacy considerations aside however, system availability will also depend on the ability of treatment companies to install sufficient systems on new build vessels, on or after 2009, before those vessels are put into operation. Several companies are, or will soon be capable of producing treatment systems commercially, and it appears that treatment systems will be available in a

commercial context. Additional considerations impacting availability include discrepancies between state, federal and international regulation of ballast water management. The demand for treatment systems, and the availability of those systems, will remain questionable until evaluation protocols are developed and legislative issues are settled.

Many ballast water treatment systems utilize “active substances” (i.e. chemicals) to inactivate organisms, requiring an additional level of review for potential environmental impacts. Though the impacts for many such systems have been, or are in the midst of, being evaluated by other governmental entities (International Maritime Organization, Washington State), none have been directly reviewed by the Commission or the State Water Resources Control Board against the water quality regulations and criteria specific to California. Clearly, these impacts should be examined critically, with substantial review from the agency/agencies with the expertise and jurisdiction to ensure that discharges of treated ballast water meet California’s water quality requirements. Establishing an evaluation procedure to assess potential water quality impacts will be as essential as the development of guidelines to assess system efficacy.

Commission staff is currently undertaking several projects to advance the implementation of the interim performance standards and assessment of treatment technologies: 1) Developing guidelines to assist technology developers and ship owners in testing and evaluating treatment systems relative to California’s performance standards; 2) Developing protocols to verify vessel compliance with the performance standards; 3) Working with appropriate California state agencies to identify applicable water quality requirements; and 4) Working with other U.S. West Coast states to align system testing and evaluation guidelines.

In summary, the ability of systems to remove or inactivate organisms from ballast water will likely be at a level to meet California’s performance standards in the near future. However, given the short time remaining before the 2009 implementation of standards for vessels with a ballast water capacity less than 5000 metric tons (MT), and the need to develop efficacy and environmental testing and evaluation procedures before a system should be utilized in California waters, it is unlikely that systems will be sufficiently available soon enough.

The Commission recommends that legislation be adopted to:

1. Change the implementation date for new vessels with ballast water capacity less than 5000 metric tons from 2009 to 2010, and require the Commission to prepare an update of this report on or before January 1, 2009.

No treatment systems currently demonstrate the capacity to meet all of California's standards either due to numerical inability to meet the standards or lack of testing results in metrics comparable to the California standards. Commission staff have begun developing guidelines for the testing and evaluation of treatment systems by technology developers and independent third-party laboratories. Simultaneously, Commission staff are developing protocols to verify vessel compliance with the performance standards and are working in conjunction with the State Water Resources Control Board to identify applicable water quality criteria and regulations. The additional time is requested to ensure that these processes will be complete.

2. Authorize the Commission to amend the ballast water reporting requirements via regulations.

Information will be needed from vessels to support the regulation and enforcement of ballast water discharge standards. As treatment systems come online, it will be important for the Commission to acquire different types of information including the timing of, and requirements for, treatment system use, deviations from suggested system operation, and certifications for operation from vessel classification societies and other organizations/agencies. The Commission should be authorized to amend ballast water reporting requirements to meet these needs.

3. Support continued research promoting technology development.

Ballast water treatment is a fledgling industry that will need to undergo significant development as California's Performance Standards are progressively implemented and as new vessel types are built. The research and development needed to meet these standards will require substantial financial resources, and should be supported by the Legislature.

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ABBREVIATIONS AND TERMS

Act	Coastal Ecosystems Protection Act
CSLC/Commission	California State Lands Commission
Convention	International Convention for the Control and Management of Ships' Ballast Water and Sediments
CWA	Clean Water Act
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
MT	Metric Ton
NEPA	National Environmental Policy Act
NIS	Nonindigenous Species
NM	Nautical Mile
NPDES	National Pollution Discharge Elimination System
NRL	Naval Research Laboratory
Panel	Performance Standards Advisory Panel
PRC	Public Resources Code
STEP	Shipboard Technology Evaluation Program
SWRCB	California State Water Resources Control Board
USCG	United States Coast Guard
UV	Ultraviolet Irradiation
WDFW	Washington Department of Fish and Wildlife

I. PURPOSE

This report was prepared for the California Legislature pursuant to the Coastal Ecosystems Protection Act of 2006 (Act). Among its provisions, the Act added Section 71205.3 to the Public Resources Code (PRC) and charged the California State Lands Commission (Commission) 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." In preparation of this report, Commission staff conducted a literature review, hosted a workshop with technical experts in ballast water treatment, and consulted a cross-interest, multidisciplinary panel (as required by Section 71205.3 and described in subdivision (b) Section 71204.9 of the PRC). This report summarizes Commission findings and makes recommendations to the Legislature regarding the status and availability of ballast water treatment technologies and the implementation of the interim performance standards for the discharge of ballast water.

II. INTRODUCTION

Nonindigenous Species and their Impacts

Also known as "introduced", "invasive", "exotic", "alien", or "aquatic nuisance species", nonindigenous species (NIS) are organisms that have been transported by human activities to a region where they did not occur historically, and have established reproducing populations in the wild (Carlton 2001). Once established, NIS can have serious human health, economic and environmental impacts in their new environment. The most infamous example is the zebra mussel (*Dreissena polymorpha*), which was introduced to the Great Lakes from the Black Sea in the mid-1980s. This tiny striped mussel attaches to hard surfaces in such dense populations that they clog municipal water systems and electric generating plants, costing approximately $1 billion a year in damage and control (Pimentel et al. 2005). In San Francisco Bay, the overbite clam (*Corbula amurensis*) is thought to have contributed to declines of fish populations in the Sacramento-San Joaquin River Delta by reducing the availability of the plankton food base of the ecosystem (Feyrer et al. 2003). The Chinese mitten crab (*Eriocheir* *sinensis*), first sighted in San Francisco Bay in 1992, clogged water pumping stations and riddled levies with burrows costing approximately $1 million in 2000-2001 for control and research (Carlton 2001). In addition, the microorganisms that cause human cholera (Ruiz et al. 2000) and paralytic shellfish poisoning (Hallegraeff 1998) have been found in the ballast tanks of ships.

In marine, estuarine and freshwater environments, NIS may be transported to new regions through various human activities including aquaculture, the aquarium and pet trade, and bait shipments (Cohen and Carlton 1995, Weigle et al. 2005). In coastal habitats commercial shipping is an important transport mechanism, or "vector," for invasion. In one study, shipping was responsible for or contributed to approximately 80% of invertebrate and algae introductions to North America (Fofonoff et al. 2003, see also Cohen and Carlton 1995 for San Francisco Bay). Of that, ballast water was a possible vector for 69% of those shipping introductions, making it a significant ship-based introduction vector (Fofonoff et al. 2003).

Ballast water is necessary for many functions related to the trim, stability, maneuverability, and propulsion of large oceangoing vessels (National Research Council 1996). Vessels take on, discharge, or redistribute water during cargo loading and unloading, as they take on and burn fuel, as they encounter rough seas, or as they transit through shallow coastal waterways. Typically, a vessel takes on ballast water after its cargo is unloaded in one port to compensate for the weight imbalance, and will later discharge that water when cargo is loaded in another port. This transfer of ballast water from "source" to "destination" ports results in the movement of many organisms from one region to the next. In this fashion, it is estimated that more than 7000 species are moved around the world on a daily basis (Carlton 1999).

Ballast Water Management

Attempts to eradicate NIS after they have become widely distributed are often costly and unsuccessful (Carlton 2001). Between 2000 and 2006, over $7 million was spent to eradicate the Mediterranean green seaweed (*Caulerpa taxifolia*) from two embayments in southern California (Woodfield 2006). Approximately $10 million is spent annually to control the sea lamprey (*Petromyzon marinus*) in the Great Lakes (Lovell and Stone 2005). From 1999-2006, approximately $6 million was spent to control Atlantic cordgrass (*Spartina alterniflora*) in San Francisco Bay (M. Spellman, pers. comm. 2006). These control costs reflect only a fraction of the cumulative cost over time as species control is an unending process. Prevention is therefore considered the most desirable way to address the NIS issue.

For the vast majority of commercial vessels, ballast water exchange is the primary preventative management technique to prevent or minimize the transfer of coastal (including bay/estuarine) organisms. During exchange, the biologically rich water that is loaded while a vessel is in port or near the coast is exchanged with the comparatively species and nutrient-poor waters of the mid-ocean (Zhang and Dickman 1999). Coastal organisms adapted to the conditions of bays, estuaries and shallow coasts are not expected to survive and/or be able to reproduce in the mid-ocean due to the differences in biology (competition, predation, food availability) and oceanography (temperature, salinity, turbidity, nutrient levels) between the two regions (Cohen 1998). Mid-ocean organisms are likewise not likely to survive in coastal waters (Cohen 1998).

Performance Standards for the Discharge of Ballast Water

Though ballast water exchange is preferable to no ballast water management, it is generally considered an interim tool because of its variable efficacy and operational limitations. Studies indicate that the effectiveness of ballast water exchange at eliminating organisms in tanks ranges widely from 50-99% (Cohen 1998, Parsons 1998, Zhang and Dickman 1999, USCG 2001, Wonham et al. 2001, MacIsaac et al. 2002), however, when performed properly, exchange is an effective tool to reduce the risk of coastal species invasion (Ruiz and Reid 2007). New research also demonstrates that the percentage of ballast water exchanged does not necessarily correlate with a proportional decrease in organism abundance (Choi et al. 2005, Ruiz and Reid 2007). Additionally, some vessels are regularly routed on short voyages or voyages that remain within 50 nautical miles (nm) of shore, and in such cases, the exchange process may create a delay or require a vessel to deviate from the most direct route. Such deviations can extend travel distances, increasing vessel costs for personnel time and fuel consumption.

In some circumstances, ballast water exchange may not be possible without compromising vessel or crew safety. For example, vessels that encounter adverse weather or experience equipment failure may be unable to conduct ballast water exchange safely. Unmanned barges are incapable of conducting exchange without transferring personnel onboard; a procedure that can present unacceptable danger if attempted in the exposed conditions of the open ocean. In recognition of these possibilities, state (California [CA], Oregon [OR], and Washington [WA]) and federal ballast water regulations allow vessels to forego exchange should the master or person in charge determine that it would place the vessel, its crew, or its passengers at risk (CA Assembly Bill: AB 433 [2003], OR Senate Bill: SB 895 [2001], WA Senate Bill 5923 [2007]). Though the provision is rarely invoked in California, the handful of vessels that use it may subsequently discharge un-exchanged ballast into state waters, presenting a risk of NIS introduction.

Both regulatory agencies and the commercial shipping industry have therefore looked toward the development of effective ballast water treatment technologies as a promising management option. For regulators, such systems could provide NIS prevention including in situations where exchange may have been unsafe or impossible. Technologies that eliminate organisms more effectively than mid-ocean exchange could provide a consistently higher level of protection to coastal ecosystems from NIS. For the shipping industry, the use of effective ballast water treatment systems might allow voyages to proceed along the shortest routes, in all operational scenarios, thereby saving time and money.

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

III. REGULATORY OVERVIEW

A thorough evaluation of the status of ballast water treatment technologies requires not only an understanding of the regulatory framework associated with the development and implementation of performance standards for the discharge of ballast water, but also knowledge of mechanisms for testing and evaluation of systems to meet those standards. Currently, no comprehensive international, federal or state program exists that includes both performance standards and a mechanism to evaluate technologies to meet those standards. California, other states, the federal government, and the international community are working toward the development of a standardized approach to the management of discharged ballast water however, at this time existing legislation, standards and guidelines vary by jurisdiction. The following is a summary of the status of performance standards regulations and treatment system evaluation as of the writing of this report.

International Maritime Organization

In February 2004 after several years of development and negotiation, International Maritime Organization (IMO) member countries adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments (Convention). Among other requirements, the Convention imposes performance standards for the discharge of ballast water (Regulation D-2) with an associated implementation schedule based on vessel ballast water capacity and status as a new or existing vessel (Tables III-1 and III-2).

The Convention will enter into force 12 months after ratification by 30 countries representing 35% of the world's commercial shipping tonnage (IMO 2005). As of September 30, 2007, only 10 countries (Barbados, Egypt, Kiribati, Maldives, Nigeria, Norway, Spain, St. Kits and Nevis, Syrian Arab Republic, and Tuvalu) representing 3.42% of the world's shipping tonnage have signed the convention (IMO 2007).

Guidelines for the evaluation and approval of ballast water treatment systems were adopted at the 53rd session of the IMO Marine Environment Protection Committee (MEPC) in July, 2005. Guideline G8, "Guidelines for Approval of Ballast Water Management Systems" (MEPC 2005a), and Guideline G9, "Procedure for Approval of Ballast Water Management Systems That Make Use of Active Substances" (MEPC 2005b), work together to create a framework for the evaluation of treatment systems by the MEPC and Flag State Administrations (i.e. the country or flag under which a vessel operates) (Figure III-3). Flag States (not the IMO) may grant approval (also known as "Type Approval") to systems that are in compliance with the Convention's Regulation D-2 performance standards based on recommended procedures (as detailed in Guideline G8) for full-scale land-based (testing involving equivalent volume and ballast flow rate as on a vessel) and shipboard testing of the treatment system.

Table III-1. Ballast Water Treatment Performance Standards

Organism Size Class	IMO Regulation D-2[1]	California[1,2]		Washington
Organisms greater than 50 µm[3] in minimum dimension	< 10 viable organisms per cubic meter	No detectable living organisms		Technology to inactivate or remove: 95% zooplankton 99% bacteria and phytoplankton
Organisms 10 – 50 µm[3] in minimum dimension	< 10 viable organisms per ml[4]	< 0.01 living organisms per ml[4]		
Organisms less than 10 µm[3] in minimum dimension		< 10^3 bacteria/100 ml[4] < 10^4 viruses/100 ml[4]		
Escherichia coli	< 250 cfu[5]/100 ml[4]	< 126 cfu[5]/100 ml[4]		
Intestinal enterococci	< 100 cfu[5]/100 ml[4]	< 33 cfu[5]/100 ml[4]		
Toxicogenic *Vibrio cholerae* (01 & 0139)	< 1 cfu[5]/100 ml[4] or < 1 cfu[[5]/gram wet weight zooplankton samples	< 1 cfu[5]/100 ml[4] or < 1 cfu[5]/gram wet weight zoological samples		

[1] See Implementation Schedule (below) for dates by which vessels must meet California Interim Performance Standards and IMO Ballast Water Performance Standard
[2] Final discharge standard for California, beginning January 1, 2020, is zero detectable living organisms for all organism size classes
[3] Micrometer – one-millionth of a meter
[4] Milliliter – one-thousandth of a liter
[5] Colony-forming-unit – a measure of viable bacterial numbers

Table III-2. Implementation Schedule for 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
< 1500 metric tons	2009	2016
1500 – 5000 metric tons	2009	2014
> 5000 metric tons	2012	2016

In addition to receiving Type Approval from the Flag State Administration, the Convention specifies that ballast water treatment systems using "active substances" must be approved by IMO based upon procedures developed by the organization (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 or deactivates species in ballast water. The IMO approval pathway for systems that utilize active substances to inactivate or kill organisms in ballast water is more rigorous 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 GESAMP-BWWG recommendation. Systems that do not use active substances do not need Basic or Final Approval, and need only acquire Type Approval (i.e. a system only using filtration would not need Basic or Final Approval).

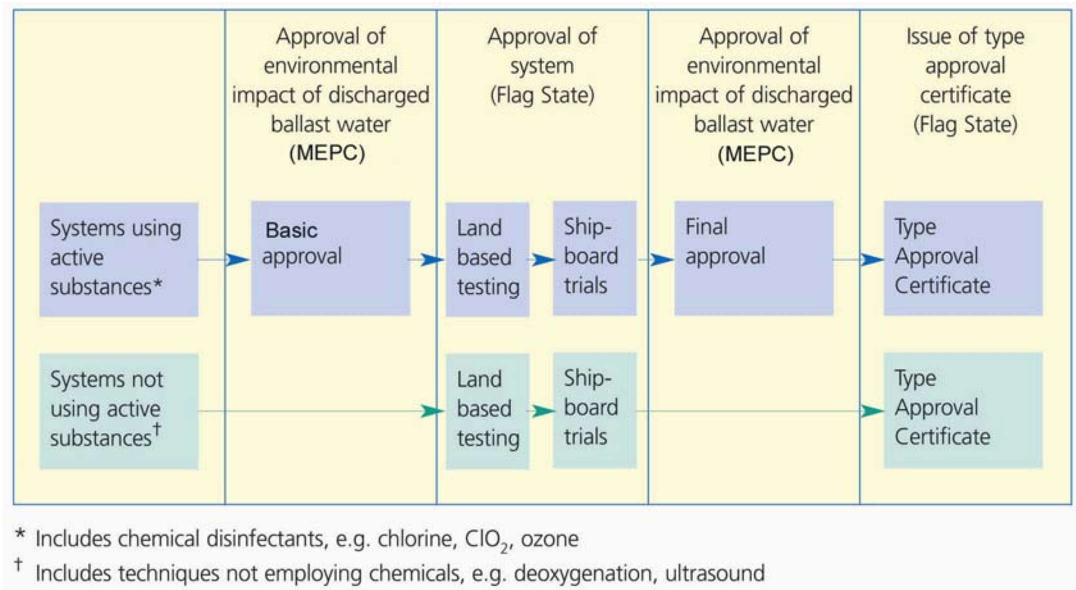

Figure III-3. Summary of IMO approval pathway for ballast water treatment systems. (Modified from Lloyd's Register (2007))

The entire IMO evaluation process (including approval for systems using active substances) has been estimated to take anywhere from six months to two years to complete (R. Everett, pers. comm. 2007, Lloyd's Register 2007). 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 for use in international waters in compliance with Regulation D-2.

The U.S. has neither reviewed nor submitted applications to IMO on behalf of any U.S. treatment technology developers thus far. Until the Convention is both signed by the U.S. and enters into force through international ratification, no U.S. federal agency has the authority (unless authorized by Congress) to manage a program to review treatment technologies and submit applications on their behalf to IMO. United States treatment developers may approach IMO through association with international companies. One U.S. technology developer has joined forces with a Korean company that has received Basic Approval under the Korean flag, and another U.S. developer has received Type Approval (the only Type Approval granted to date) through the Liberian Flag State Administration (R. Everett pers. comm. 2007). However, because the Convention has not yet been ratified, it does not have the force of international law, which draws into question the legality of IMO approvals of treatment systems. While the U.S. is actively involved in developing and negotiating the various requirements of the Convention, until the U.S. signs on, it is not party to the Convention requirements. Hence, vessels calling on U.S. ports have no right to use IMO-approved systems to meet U.S. ballast water management requirements.

Federal Legislation and Programs

The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990, revised and reauthorized as the National Invasive Species Act of 1996, provides authority to the United States Coast Guard (USCG), through the Department of Homeland Security, to regulate the management of ballast water in the United States. Included in the legislation is the authority to approve ballast water management systems that are at least as effective as ballast water exchange. As mentioned in the Introduction (Section II), the efficacy of ballast water exchange is highly variable, and thus the USCG believes the only way to consistently ensure that treatment systems are at least as effective as exchange is to set a discharge performance standard (USCG 2007). The USCG began this rulemaking process in 2002, but has yet to set a discharge standard. The lack of a federal discharge standard precludes the approval of any treatment system at the national level.

Several bills have been introduced in the House and Senate in recent years to legislatively establish a national discharge standard. In 2007 the following bills were introduced:

- The Ballast Water Management Act of 2007 (H.R. 2423, S. 1578)
- Prevention of Aquatic Invasive Species Act of 2007 (H.R. 889)
- National Aquatic Invasive Species Act of 2007 (S. 725)
- Great Lakes Invasive Species Control Act (H.R. 801)
- Coast Guard Authorization Act of 2007 (H.R. 2830)
- Great Lakes Collaboration Implementation Act (S. 791, H.R. 1350)
- Aquatic Invasive Species Research Act (H.R. 260).

These bills seek to clarify the goals and role of the federal government in ballast water management. Several of the bills introduce performance standards that would be less stringent than California's standards. More importantly, however, many of these bills also introduce language that would preempt California law and set back California's efforts to better control ballast water discharge and other ship-mediated vectors of NIS introductions. Staff will continue to follow and assess the potential impacts of any new federal legislation on ballast water management and California's program. As of November, 2007, no legislation has passed.

Two promising federal programs that are currently working proactively to support the development of experimental treatment technologies and facilitate the testing and evaluation of those systems are the USCG Shipboard Technology Evaluation Program (STEP) and the U.S. Environmental Protection Agency's (EPA) Environmental Technology Verification (ETV) program. The USCG Shipboard Technology Evaluation Program (STEP) is intended to facilitate the development of ballast water treatment technologies. Vessel owners and operators accepted into STEP may install and operate specific experimental ballast water treatment systems on their vessels for use in U.S. waters. In order to be accepted, treatment technology developers must assess: the efficacy of systems for removing biological organisms, residual concentrations of treatment chemicals, and water quality parameters of the discharged ballast water (USCG 2004). STEP provides incentives for vessel operators and treatment developers to test promising new technologies. Vessels accepted into the program may be grandfathered for operation under future ballast water discharge standards for the life of the vessel or the treatment system. However, in the three years that the program has been in existence, none of the three vessels that have applied have yet received notice of STEP approval.

The EPA Environmental Technology Verification (ETV) program is an effort to accelerate the development and marketing of environmental technologies, including ballast water treatment technologies. 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 draft protocols for verification of the performance of ballast water treatment technologies. Subsequently, the USCG established an agreement with the Naval Research Laboratory (NRL) to evaluate, refine, and validate the protocols and the test facility design required for their use. This validation project has 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 innovative research conducted by the USCG, EPA and NRL within the ETV Program and at the NRL facility is intended by the USCG to result in technical procedures for testing ballast water treatment systems for the purpose of approval and certification.

The Shifting Federal Landscape

While the USCG (including the STEP and ETV programs) is moving forward to establish performance standards and evaluate treatment technologies, the authority to manage ballast water at the federal level is currently under debate in the courts. This decision could have a major impact on the establishment of performance standards and the assessment of treatment systems both at the federal and state level. In 2003, Northwest Environmental Advocates et al., filed suit in U.S. District Court, Northern District of California, against the U.S. EPA challenging a regulation originally promulgated under the Clean Water Act (CWA). The regulation at issue, 40 C.F.R. Section 122.3(a), exempts effluent discharges "incidental to the normal operations of a vessel" from regulation under the National Pollution 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 Northwest Environmental Advocates et al. On September 18, 2006 the Court issued an order revoking the exemptive regulation (40 C.F.R. Section 122.3(a)) as of September 30, 2008. The ruling requires the EPA to develop a system, presumably as part of the NPDES permit process, which would require ballast water to be discharged under certain parameters. EPA has filed an appeal with the Ninth Circuit U.S. Court of Appeals, which is still pending.

Ultimately, this court decision will impact not only who regulates ballast water at the federal and state levels, but how they do so. The implementation of an NPDES permit process for vessel discharges may require a region by region (water basin by water basin) assessment of total allowable NIS concentrations, which could potentially result in the application of different discharge standards for different water bodies. Under such a situation, a vessel could be required to meet a different standard at each port of arrival, even within a single U.S. state. This would very likely impact ballast water performance standards currently established by states, and could also impact a vessel's selection and use of technologies to meet those standards. In practice, a vessel may have to utilize a treatment system that meets the strictest standard in effect at any port it may visit.

U.S. States

Washington

In 2001, the Washington Department of Fish and Wildlife (WDFW) established interim ballast water discharge standards to provide a target for technology developers (WAC 220-77-095). The standard requires the inactivation or removal of 95 percent of zooplankton and 99 percent of phytoplankton and bacteria in ballast water. WAC 220-77-095 also established an interim approval process for use of ballast water treatment systems in Washington waters (only USCG-approved systems may be used to meet federal requirements) which was revised by Emergency Rule (WAC 220-77-09500A), effective August 17, 2007. Systems may be approved for use on specified vessels contingent upon meeting one or more of the following criteria: 1) Previously approved by the WDFW for use in Washington waters; 2) Approved by USCG for use in national waters; 3) Enrolled in the USCG STEP; 4) Approved by the State of California for use in California waters; 5) Approved by IMO; or 6) Enrolled in the IMO approval process. Technologies are also evaluated for water quality standards as necessary.

Michigan

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

California

California's Marine Invasive Species Act of 2003 (Section 71204.9 of the PRC) 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 (SWRCB), the USCG and a technical advisory panel (Panel). The legislation also 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. Commission staff therefore convened a cross-interest, multi-disciplinary panel and facilitated discussion over the selection of standards during five meetings held during 2005 prior to preparing the report (Falkner et al. 2006) required by the Legislature.

A variety of approaches were used to guide the selection of standards: 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 each topic provided some level of insight, none could provide solid guidance for the selection of a specific set of standards. At a minimum, it was determined that reductions achieved by California's 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 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 put forward performance standards recommended by the majority of the Panel because they encompassed several desirable characteristics: 1) A significant improvement upon ballast water exchange; 2) In-line with the best professional judgment from scientific experts that participated in the IMO Convention; and 3) Approached a protective zero discharge standard. The proposed interim standards were based on organism size classes (Table III-1). The standards for the two largest size classes of organisms (>50 μm in minimum dimension and 10 – 50 μm in minimum dimension) were significantly more protective than those proposed by the IMO Convention. The majority of the Panel also recommended standards for organisms less than 10 μm including human health indicator species and total counts of all 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 standard for total living bacteria and viruses has not been considered or adopted by any other state, federal or international administration or agency. The standard will require an assessment of viability and the quantification of bacteria and viruses, and currently there are no widely accepted methods for either. The implementation schedule proposed for the interim standards was identical to the IMO Convention (Table III-2). A final discharge standard of zero detectable organisms was recommended by the majority of the Panel with an implementation deadline of 2020 added by the Commission.

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 (Falkner et al. 2006). By the fall of that same year, the Legislature passed the Coastal Ecosystems Protection Act (SB 497) 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 process in October, 2007.

In anticipation of the first implementation date of the interim performance standards in 2009 for new vessels with a ballast water capacity less than 5000 metric tons (MT), the Coastal Ecosystems Protection Act also directed the Commission to review the efficacy, availability and environmental impacts of currently available ballast water treatment systems. The initial review (this report) must be submitted to the State Legislature by January 1, 2008. Additional reviews must also be completed 18 months before the implementation dates for other vessel classes, and also 18 months prior to the implementation of the final discharge standard on January 1, 2020 (see Table III-2 for full implementation schedule). During any of these reviews if it is determined that existing technologies are unable to meet the discharge standards, the report must describe why they are not available.

As of the writing of this report, Commission staff is in the midst of developing two sets of guidelines/protocols: 1) Treatment technology testing and evaluation guidelines, and 2) Procedures for the verification of compliance with the performance standards. The treatment technology testing and evaluation guidelines will be a set of preferred methods for system assessment that technology developers and third-party laboratories may use to test their systems for potential compliance with California's standards. The Commission does not intend to pre-approve technologies for use in California waters. Instead, these guidelines will allow developers to self-certify that their systems will meet

California's requirements. While testing according to these guidelines will not be legally required, the guidelines will help to support quality product testing and evaluation. Self-certification by technology developers will assure vessel owners and operators that they are investing in a system that will meet California's discharge requirements. Testing conducted under the Commission's guidelines will also help Commission staff assess the efficacy and future availability of treatment systems to meet California's standards. Staff expects these guidelines to be completed in 2008.

Staff is also developing protocols to verify vessel compliance with the discharge standards. These will be used by inspectors to fulfill Section 71206(a) of the PRC, requiring the Commission to sample ballast water from at least 25% of vessels for compliance with the law. The development of these protocols will involve consideration of the best available sampling techniques and technologies, ease of use, cost effectiveness, accuracy and precision. Commission staff is working with the USCG, the Smithsonian Environmental Research Center, the NRL Ballast Water Treatment System Test Facility, and others on the development of verification protocols. Prior to implementation, the protocols will need to be codified through the rulemaking process, and Staff expects this to be completed in late-2008.

Though Staff continues to develop and implement guidelines and procedures to evaluate treatment system performance and compliance, the outcome of the Federal EPA/Clean Water Act court case will likely impact the administration of ballast water management. The potential impacts on California's ballast water program are currently unclear. The SWRCB is the state agency responsible for implementing the federal CWA including activities such as setting water quality standards, developing water quality control plans and issuing NPDES permits. However, under California's Coastal Ecosystems Protection Act, no state agency can impose requirements, "pertaining to the discharge or release of ballast water and other vectors of nonindigenous species from a vessel regulated pursuant to this division," unless mandated by Federal law (PRC Section 71207(a)). Should the SWRCB determine that the EPA court ruling constitutes a federal mandate, they could attempt to regulate ballast water discharges under the State's NPDES program. As a result, the Commission's Marine Invasive Species Program will be affected, with the potential that the program could be partially or wholly discontinued, with the SWRCB implementing its own, potentially unfunded, program. Legislation may be required to clarify how the programs will operate within the new legal environment. Despite the uncertain legal situation, the Marine Invasive Species Program will continue to move forward to fulfill its mandates under the Coastal Ecosystems Protection Act.

IV. TREATMENT TECHNOLOGY ASSESSMENT PROCESS

Public Resources Code (PRC), Section 71205.3 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." In accordance with the law, the Commission shall consult with, "the State Water Resources Control Board, the United States Coast Guard, and the stakeholder advisory panel described in subdivision (b) of Section 71204.9" of the PRC. This panel provided guidance in the development of the performance standards report to the California Legislature (Falkner et al. 2006).

The Commission conducted an exhaustive literature search of available scientific papers, gray literature (i.e. a study or report not published in a peer-reviewed journal), white papers including reports that describe and discuss the complex process of treatment technology evaluation (USCG 2004, PSMFC 2006), and company promotional materials related to ballast water treatment technologies. Staff also contacted treatment technology developers in order to gather additional information about system development and testing. Commission staff summarized available information on treatment systems and developed a treatment system matrix (see Tables V-1, VI-1, VI-3, VI-4, and Appendix A). Prior to consulting with the larger stakeholder advisory panel, Staff received input from a small technical workgroup.

Commission staff invited a small group of technical and scientific experts to participate in a half-day workshop in May 2007 to assess the current availability of treatment systems, their ability to meet the California performance standards, the efficacy of these systems, and environmental and water quality impacts. This group included individuals with expertise in ballast water treatment technology development, water quality and biological testing, naval architecture, naval engineering, and technology efficacy testing (see Appendix B for list of workshop participants).

In preparation for the workshop, participants were asked to review several tables summarizing relevant treatment system information and be prepared to address the following questions:

- What is the efficacy of existing treatment systems? Can any system meet California's performance standards? If not, why not?
- What is the availability of existing treatment systems? Have any treatment systems been approved at the state, federal or international level? Are any systems commercially available? If they are not ready now, when?
- What are the environmental impacts, if any, of existing systems? Are there standard testing protocols to assess environmental impacts? Have any systems undergone rigorous testing, including system safety testing? What agencies have jurisdiction/expertise over testing?

Workshop consensus (see Appendix B for workshop summary) regarding the biological efficacy was that most treatment systems, particularly those using biocides, would be capable of meeting California's performance standards. However, two major challenges associated with assessing treatment efficacy need to be addressed: 1) The lack of available results demonstrating treatment system performance at appropriate vessel-size scale, and 2) The lack of standardized tests and procedures necessary to determine whether or not treated ballast water meets the performance standards. Additional challenges identified included: the lack of sufficient toxicological testing; the lack of comprehensive cost data for system purchase, installation and operation; and the limited numbers of treatment technologies evaluated.

Additional input was received from the larger stakeholder advisory panel (see Appendix C for list of Panel members), SWRCB and USCG. The Advisory Panel met in October, 2007 (see Appendix C for meeting participants and notes), and discussions and areas of agreement were then considered by Staff to help guide the development of the final report.

V. TREATMENT TECHNOLOGIES

The goal of ballast water treatment is to remove or inactivate organisms entrained in ballast water. While this may appear simple given societal experience with waste water treatment technologies, the design and production of ballast water treatment systems can be difficult and complex in practice. A system must be effective under a wide range of challenging environmental conditions including variable temperature, salinity, nutrients 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 tanks). Treatment systems must be capable of eradicating a wide variety of different organisms ranging from viruses and microscopic bacteria to free-swimming plankton, and must operate so as to minimize or prevent impairment of the water quality conditions of the receiving waters. The development of effective treatment systems is further complicated by the variability of vessel types, shipping routes and port geography.

Two general platform types have been explored for the development of ballast water treatment technologies. Shoreside ballast water treatment occurs at a shore-based facility following transfer from a vessel. Shipboard treatment occurs onboard operating vessels through the use of technologies that are integrated into the ballasting system. While shipboard treatment systems are attractive because they allow more flexibility to manage ballast water during normal operations, there continues to be some interest in the development of shoreside treatment options for ballast water.

The similarity of shoreside treatment to waste water treatment makes it seem like an appealing option, however, it poses several challenges for treating vessel ballast water. Current wastewater treatment plants are not equipped to treat saline water (SWRCB 2002, S. Moore pers. comm.). If existing municipal facilities are to be used for the purposes of ballast water treatment, they will need to be modified, and a new extensive network of piping and associated pumps will 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 be complex and costly in California port areas. Shoreside treatment is not feasible for vessels that must take on or discharge ballast water while underway, for example, if the vessel must adjust its draft to navigate through a shallow channel or under a bridge. The retrofit of vessels including pumps, piping and valves necessary to discharge ballast to a shoreside facility at a flow rate that prevents vessels delays might also be cost prohibitive (CAPA 2000). Shoreside treatment should be considered for unique terminals, those with limited but dedicated vessel calls (such as cruise ships).

To date only limited feasibility studies have been conducted for the shoreside treatment option (see references in Falkner et al. 2006). One study specific to cruise ships indicated that due to the operational practices of cruise ships and the current regulatory requirements in California and the Port of San Francisco there is little demand at this time for shoreside treatment except in emergency situations (Bluewater Network 2006). Additional studies are necessary to determine shoreside demand for other vessel types across the state as a whole.

The majority of time, money, and effort in the development of ballast water treatment technologies during recent years has been focused on shipboard treatment systems. Further study of onshore treatment would be helpful to assess its future potential role in solving California's ballast water problem. This may include assessments by those involved in the wastewater treatment sector on whether existing technologies could meet California's performance standards. However, because all prototype technologies to date have been ship-based, we focus solely on shipboard systems for the remainder of this report.

Shipboard systems allow for greater flexibility during vessel operations. Vessels may treat and discharge ballast while in transit, and thus will not need to coordinate vessel port arrival time with available space and time at shoreside treatment facilities. As with shoreside treatment, however, shipboard treatment systems face their own set of challenges. They must be engineered to conform to a vessel's structure, ensure crew safety, and withstand the vibrations and movements induced by the vessel's engine or rough seas. Additionally, shipboard systems must be effective under transit times that range from less than 24 hours to several weeks, and must ensure that treated water meets all water quality requirements in recipient regions upon discharge.

The timing and location of shipboard ballast water treatment can be varied according to the needs of the treatment system and the length of vessel transit. Ballast water may be treated in the pipe during uptake or discharge (in line) or in the ballast tanks during the voyage (in tank). While mechanical separation (such as filtration) generally occurs during ballast uptake in order to remove large organisms and sediment particles before they enter the ballast tanks, other forms of treatment may occur at any point during the voyage. Some treatment systems treat ballast water at multiple points during the voyage, such as during uptake and discharge.

Because of this wide range of variables associated with shipboard ballast water treatment, the identification of a single treatment technology for all NIS, ships, and port conditions is unlikely. Each technology will meet the objective of killing or deactivating NIS in a slightly different manner and each could potentially impact the waters of the receiving environment through the release of chemical residuals or alterations to water temperature, salinity, and/or turbidity. Thus a suite of treatment technologies will undoubtedly need to be developed to treat ballast water industry-wide and across all ports and environments.

Treatment Methods

The development of ballast water treatment systems that are effective, environmentally friendly and safe has been a complex, costly and time consuming process. At the root of many of treatment systems are methods that are already in use to some degree by the waste water treatment industry. A preliminary understanding of these treatment methods forms the basis for more detailed analysis and discussion of ballast water treatment systems. The diverse array of water treatment methods currently under development for use in ballast water treatment can be broken down into four major categories: mechanical, chemical, physical, and combined.

Mechanical Treatment

Mechanical treatment traps and removes mid-size and large particles from ballast water. Mechanical treatment typically takes place upon ballast water uptake in order to limit the number of organisms and amount of sediment that may enter ballast tanks. Options for mechanical treatment include filtration and hydrocyclonic separation.

Filtration works by capturing organisms and particles as water passes through a porous screen or filtration medium, such as sand or gravel. The size of organisms trapped by the filter depends on the mesh size in the case of screen or disk filters, and on the size of the interstitial space for filtration media. In ballast water treatment, screen and disk filtration is more commonly used over filter media, however, there has been some interest in the use of crumb rubber as a filtration medium in recent studies (Tang et al. 2006). Typical mesh size for ballast water filters ranges from 25 to 100 µm (Parsons and Harkins 2002, Parsons 2003). Most filtration-based technologies also use a backwash process that removes organisms and sediment that become trapped on the filter, and can discharge them at the port of origin before the vessel gets underway. Filter efficacy is a function not only of initial mesh size, but also of water flow rate and backwashing frequency.

Hydrocyclonic separation, also known as centrifugation, relies on density differences to separate organisms and sediment from ballast water. Hydrocyclones create a vortex that cause 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 in use in ballast water treatment trap particles in the 50 to 100 µm size range (Parsons and Harkins 2002). One challenge associated with hydrocylone use, however, is that many small aquatic organisms have a density similar to sea water and are thus difficult to separate using centrifugation.

Chemical (Biocide) Treatment

A variety of chemical biocides are available to kill or inactivate organisms in ballast water. Biocides may be used during ballast uptake, vessel transit, or discharge. Biocides can be classified into two major categories: oxidizing and non-oxidizing. Oxidizing agents (e.g. chlorine, chlorine dioxide, bromine, hydrogen peroxide, peroxyacetic acid, ozone) are commonly used in the waste-water treatment sector and work by destroying cell membranes and other organic structures (NRC 1996, Faimali et al. 2006). Non-oxidizing biocides, including Acrolein®, gluteraldehyde, and menadione (Vitamin K3), are reported to work like pesticides by interfering with neural, reproductive or metabolic processes (NRC 1996, Faimali et al. 2006).

As with any biocide, the ultimate goal of these products is to maximize killing efficacy while minimizing environmental impact. Environmental concerns surrounding biocide use in ballast water focus on chemical residuals that may be present in ballast water at the time of discharge. The effective use of biocides in ballast water treatment requires a balance between the amount of time required to achieve deactivation of organisms, with the time needed for biocides to degrade, or for residuals to be treated, to environmentally acceptable levels. Both of these times vary as a function of ballast water organic content and sediment load. As a result, certain biocides may be more effective than others based on ballast volume, voyage length, and water quality conditions. Additional concerns about biocide use specific to shipboard operation include corrosion, safety (personnel and ship safety), and vessel design limitations that impact the availability of space onboard for both chemical storage and equipment for chemical dosing.

Physical Treatment

Physical treatment methods include a wide range of non-chemical means to kill or deactivate organisms present in ballast water. Like chemical treatment, physical treatment may occur on ballast uptake, during vessel transit or during discharge. Examples of physical treatment of ballast water include heat treatment, ultraviolet irradiation, and ultrasonic energy.

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 or inactivate unwanted organisms during vessel transit. However, it would be difficult to heat ballast water to a sufficient temperature to kill all species of bacteria due to lack of sufficient surplus energy/heat on a vessel (Rigby et al. 1999, Rigby et al. 2004). Ultrasound (ultrasonic treatment) kills through high frequency vibration that creates microscopic bubbles that rupture cell membranes (Viitasalo et al. 2005). The efficacy of ultrasound varies based on the intensity of vibration and length of exposure. Ultraviolet (UV) irradiation is another method of sterilization that is commonly used in waste water treatment. UV damages genetic material and proteins which disrupts reproductive and physiological processes. UV irradiation can be highly effective against pathogens (Wright et al. 2006).

Combined Treatment

Several treatment methods deactivate organisms by combining aspects of mechanical, chemical and/or physical treatment processes. Deoxygenation, while mainly a physical process involving the displacement of oxygen with another inert gas such as nitrogen or carbon dioxide, also has a chemical component - the addition of carbon dioxide produces a reduction in pH that enhances killing efficacy (Tamburri et al. 2006). Electrolytic or electrochemical oxidation processes combine electrical currents with necessary reactants in order to produce a wide array of killing agents. Electrolytic oxidation can produce hydroxyl radicals, capable of damaging cell membranes, or similar oxidative compounds such as ozone and sodium hypochlorite (chlorine). The degree of chemical residual formation is highly variable and dependent on the specific oxidative process being used.

Treatment Systems

Based on the methods described in Section IV (Treatment Technology Assessment Process), Commission staff compiled and reviewed information on 28 currently available shipboard ballast water treatment systems representing nine countries (Table V-1). Seventeen of these systems utilize two or more treatment methods. Multi-method systems commonly pair initial mechanical separation with a secondary chemical, physical or combined process. The systems reviewed here can be classified into four categories based on the primary treatment technology: 1) Oxidants/oxidative technologies, 2) UV systems, 3) Deoxygenation systems, and 4) Other.

Aside from mechanical separation, the most common method of treatment used in ballast water treatment systems is oxidation. Of the 28 systems reviewed, 18 use a chemical oxidant or oxidative process as the primary form of treatment (Table V-1). Specifically, six systems use chlorine or chlorine dioxide to treat ballast water, four systems use ozone, one uses ferrate, and seven use electrochemical oxidation technologies that can generate an array of oxidants including bromine, chlorine, and/or hydroxyl radicals. Of the treatment systems that have received Basic Approval for active substances from IMO thus far, all use chemical oxidants or oxidation technology to treat ballast water (Table V-1).

The second most commonly used method of ballast water treatment amongst the 28 systems reviewed is UV irradiation. Four treatment systems use UV as the primary means to kill or deactivate organisms found in ballast water. All of these systems pair UV treatment with either filtration or hydrocyclonic mechanical separation methods.

The last two categories of treatment systems reviewed by Staff include deoxygenation systems, and systems that did not fit into any of the preceding categories (“other”). Three technologies use deoxygenation as a major form of treatment, and three technologies use various methods including a non-oxidizing biocide, a heat treatment technology, and one technology using a combination of coagulation and magnetic separation (Table V-1).

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

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
Alfa Laval	Sweden	PureBallast	combination	filtration + advanced oxidation technology (hydroxyl radicals)	IMO Basic and Final
Degussa AG	Germany	Peraclean Ocean	chemical	biocide (peracetic acid and hydrogen peroxide)	IMO Basic
Ecochlor	USA	Ecopod	chemical	biocide (chlorine dioxide)	
Electrichlor	USA	Model EL 1-3 B	chemical	biocide (sodium hypochlorite)	
Environmental Technologies Inc.	USA	BWDTS	combination	ozone + sonic energy	
Ferrate Treatment Technologies	USA		chemical	ferrate	
Greenship	Netherlands	Sedimentor + chlorination	combination	hydrocyclone + electrolytic chlorination	
Hamann AG	Germany	SEDNA System	combination	hydrocyclone + filtration + biocide (Peraclean Ocean)	IMO Basic (Peraclean)
Hi Tech Marine	Australia		physical	heat treatment	
Hitachi	Japan		physical (?)	coagulation + magnetic separation + filtration	
Hyde Marine	USA	Hyde Guardian, HBWTS	combination	filtration + UV	WA Conditional
Japan Assoc. Of Marine Safety	Japan	Special Pipe	combination	mechanical treatment + ozone	IMO Basic
JFE Engineering Corp.	Japan	JFE BWMS	combination	filtration + biocide (sodium chlorine) + cavitation	
L. Meyer GMBH	Germany		combination	filtration + disinfection liquid	

Table V-1 (Continued). Ballast Water Treatment Systems Reviewed by Commission Staff

Manufacturer	***Country***	***System Name***	***Technology Type***	***Technology Description***	***Approvals***
MARENCO	USA		combination	filtration + UV	WA General Approval
Maritime Solutions Inc.	USA		combination	centrifugal separation + UV or biocide (Seakleen)	
MH Systems	USA	BW treatment system	combination	deoxygenation + carbonation	
Mitsubishi Heavy Industries	Japan	Hybrid System	combination	filtration + electrolytic chlorination	
NEI	USA	Venturi Oxygen Stripping (VOS)	combination	deoxygenation	Type Approval (Liberia)
NKO	Korea		chemical	ozone	IMO Basic
Nutech 03 Inc.	USA	SCX 2000, Mark III	chemical	ozone	
OceanSaver	Norway	OceanSaver	combination	filtration + nitrogen saturation + cavitation	
OptiMarin	Norway	OptiMar	combination	hydrocyclone + UV	
Resource Ballast Technologies	South Africa	RBT Reactor	combination	cavitation + ozone + sodium hypochlorite	
RWO Marine Water Technology	Germany	CleanBallast!	combination	filtration + advanced electrolysis (EctoSys)	IMO Basic (EctoSys)
SeaKleen	USA	SeaKleen	chemical	biocide (menadione)	
Severn Trent DeNora	USA	BalPure	chemical	electrolytic generation of sodium hypochlorite	
Techcross Inc.	Korea	Electro-Clean	combination	electrochemical oxidation	IMO Basic

VI. ASSESSMENT OF TREATMENT SYSTEMS

The Coastal Ecosystems Protection Act required the adoption of regulations to implement performance standards for the discharge of ballast water. Since the beginning of the California ballast water program in January, 2000, forty-three percent (2649) of the 6090 unique vessels that have visited California ports have reported never discharging ballast in California waters. These vessels meet the performance standards simply by not discharging ballast. Vessels that do discharge but use nontraditional sources for ballast water (such as freshwater from a municipal source or treated grey water) will likely meet the discharge standards without the need for onboard treatment systems. Vessels that utilize coastal or ocean water as ballast will require ballast treatment prior to discharge. For these vessels, the assessment of treatment systems efficacy, availability, and environmental impacts (as required by Section 71205.3(b) of the PRC) is an important step towards understanding if systems will be available prior to the implementation of the interim performance standards beginning in 2009.

Efficacy

Evaluating ballast water treatment system efficacy is challenging due to a number of reasons. Testing methodologies in use by developers vary from system to system and occasionally between tests for a single system. The results generated from this wide array of tests differ in scale (pilot vs. full-scale) and location (laboratory vs. dockside vs. shipboard; see Appendix A). Additionally, system test results are often presented in metrics that do not lend themselves to evaluation against the California performance standards. For example, Staff encountered examples of system testing that presented results as counts of certain species per unit volume with no reference to organism size (as required in the California performance standards) and even mass of pigments per unit volume. Results presented in metrics inconsistent with the standards were noted but not included in the overall evaluation of system efficacy because it could not be determined if they met the standards. Staff expects that testing results for additional systems will emerge in metrics compatible with the California standards over time and as the standards become more widely known, now that they have been adopted through the California rulemaking process. Evaluation of system efficacy was further complicated by the overall limited availability of testing results for many systems, and the apparent lack of rigorous review of testing methods and results conducted by some companies. Without an independent and standardized approach to testing, evaluation and presentation of results, direct comparison between systems is not possible.

Despite the lack of available information, Staff reviewed all literature and numerical testing results for system potential to meet the performance standards (see Table III-1 for performance standards). The limited availability of shipboard results of system efficacy required Staff to include results from dockside and laboratory studies in their analysis. Not all studies presented test results according to organism size class (the classification system used in the California performance standards). In an effort to standardize results, Staff evaluated any data on zooplankton abundance as representative of the largest size class of organisms (greater than 50 µm in size), and phytoplankton abundance was evaluated on par with organisms in the 10 – 50 µm size class (these substitutions were solely for the purpose of this report and will not be applicable to future compliance verifications). Results presented as percent reduction in organism abundance or as concentration of pigments or biological compounds associated with organism presence were noted, but these metrics were not comparable to the performance standards.

Of the 28 technologies reviewed, specific data on system efficacy were available for only 20 (Table VI-1, Appendix A). All available information, regardless of testing location or scale, is included in this assessment.

Table VI-1. Summary of systems with available results for assessment of efficacy

Manufacturer	> 50 µm		10 - 50 µm		< 10 µm[1]		*E. coli*		Enterococci		*V. cholerae*		Source[6]
	IMO	CA	IMO	CA	IMO	CA	IMO	CA	IMO	CA	IMO	CA	
Alfa Laval	Y	Y	Y	N	N/A	Unknown	Y	Y	Y	Y			1,54
Degussa AG	Y[2]	Y[2]	Y	Y	N/A	Unknown	Y	Y					24,26,89
Ecochlor	Y	Y	Y	Y	N/A	Unknown	Y	Y	Unknown		Y	Y	50,63
Electrichlor													
ETI			Y	N	N/A	N							46,47,48,49
Ferrate Treatment Tech.								N	Y	N	N	N	15
Greenship	Y	Y	Y	Y	N/A	Unknown	Y	Y	Y	Y			16,77
Hamann AG	Y	Y	Y	Y	N/A	N							28,89
Hi Tech Marine	Unknown		Unknown		N/A								31
Hitachi													
Hyde Marine	Y	Y	Unknown		N/A	Unknown	Y	Y	Unknown				43,44,99
JAMS	Y	N	Y	Unknown	N/A	Unknown	Unknown		Unknown		Unknown		35,37,38
JFE Engineering Corp.													
L. Meyer GMBH													
MARENCO	Y	Y	Y	N	N/A	Unknown							39,40,96
Maritime Solutions Inc.													
MH Systems	Unknown				N/A						Unknown		32
Mitsubishi Heavy Ind.													
NEI	Y	Y	Y	Unknown	N/A	Unknown	Y	Y	Y	Y	Y	Y	80,81,82
NK0													
Nutech 03 Inc.	Y	Y	Unknown		N/A	Unknown							30,68
OceanSaver	Y	Y			N/A								3
OptiMarin	Y	N	Unknown		N/A	Unknown[3]							7,36,95
Resource Ballast Tech.													
RWO Marine Water Tech.	Y[4]	Y[4]	Y[5]	Y[5]	N/A								56
SeaKleen	Y	Y	Y	Y	N/A	Unknown	Y	Y	Unknown				4,14,26,44
Severn Trent DeNora	Y	Y	Y	Y	N/A	Unknown							29
Techcross Inc.	Y	Y	Y	Y	N/A	Unknown	Unknown		Unknown		Unknown		55,84

[1] Results for total bacteria count only unless indicated otherwise
[2] Peraclean Ocean concentration 200 ppm
[3] Sampling included counts of Virus Like Particles
[4] *Artemia* cysts only
[5] *Tetraselmis suecica* only
[6] Numbered sources can be found in Literature Cited section

In the largest organism size class (organisms greater than 50 μm in size), 18 systems were reviewed and 14 demonstrated potential, in at least one testing replicate, to meet the required standard of no detectable living organisms per cubic meter of discharged ballast water (Table VI-2, Appendix A1). Similar results were seen in the 10 – 50 μm size class where 17 systems were reviewed, with eight providing data for at least one test replicate that indicated compliance with the requirement of less than 0.01 living organisms per ml (Table VI-2, Appendix A2).

The results of testing on organisms less than 10 μm (bacteria and viruses) and bacterial species specific to human health standards (*Escherichia coli*, intestinal enterococci and *Vibrio cholerae*) are limited. Fifteen systems presented results of the bacterial quantification, but the majority were in a metric not comparable to the California standards and the rest did not meet the standard (Appendix A3). The lack of widely accepted methods for assessing bacterial (and viral) counts is a stumbling block to the implementation of the full suite of interim performance standards. Ten systems tested for the presence of *E. coli* in treated ballast water (Appendix A4). Eight presented results comparable to the standard and seven show potential to meet the standard. Nine systems tested for the presence of intestinal enterococci, and three systems demonstrated potential compliance (Appendix A5). Finally, six systems examined treated ballast water for toxicogenic *Vibrio cholerae* and only two systems demonstrated potential compliance with the California performance standard (Appendix A6). Results for the number (counts) of viruses in ballast water samples either pre- or post-treatment were only available for two systems examined (Appendix A7).

Table VI-2. Summary of Potential Treatment System Performance with Respect to California Performance Standards

	Organisms Greater than 50	Organisms 10 – 50	Organisms less than 10	*Escherichia coli*	Intestinal enterococci	*Vibrio cholerae*
Total Systems with Results to Review[1]	18	17	Bacteria: 15 Viruses: 2	10	9	6
Number Systems that Meet Standard[2]	14	8	Bacteria: 0 Viruses: 0	7	3	2

[1] Of out of the 28 total systems assessed in this report, only 20 had testing results available for review. Not all 20 covered testing under each of the organism size classes. The total number of systems with results in a given size class is indicated in this category.
[2] This category reflects the number of systems with at least one replicate of system testing in compliance with the California performance standards (see Table III-1 for standards).

The lack of available results demonstrating shipboard treatment system performance was a major hindrance to assessing ballast water treatment system efficacy under real-world conditions. Of the 28 treatment systems reviewed, only 10 presented results from sea trials onboard vessels (Appendix A). Even within the shipboard results, however, testing varied in scale and method. Some systems have been tested using only one or two of the many available ballast tanks onboard a vessel. Other technologies have tested system efficacy across multiple ballast tanks, but only on a single voyage. A thorough investigation of system efficacy should examine ballast water treatment system performance over multiple voyages encompassing different seasons and water quality conditions.

Overall, only 20 treatment systems had results available for analysis of system efficacy; the potential for the remaining 8 systems to meet the California standards is not clear at this time. For those systems with results, four systems demonstrated potential to meet 4 out of seven performance standards size classes, two systems met 3 size classes, five systems met 2 size classes and three systems met just 1 size class (Table VI-1, Appendix A). Current law states that upon implementation of the California performance standards, discharged ballast water must meet all organism size class requirements. Treatment systems currently exist that are demonstrably capable of and/or have the potential to meet at least some of the organism size classes of the California performance standards, but at this time no systems meet all size classes.

Availability

An assessment of the availability of ballast water treatment systems requires knowledge of many elements including market demand, government approval of systems, the number of vessels impacted by the performance standards, and commercial availability. These issues are inextricably linked. Commercial availability is not simply a function of whether or not a system is available for purchase; it is also dependent on the sufficient production of systems to meet demand and the availability of customer support. System availability is also influenced by the presence of an available market (i.e. demand) to purchase treatment systems. This market, in turn, will depend upon the development of mechanisms for systems approval, particularly at the federal and international levels, as vessel operators may be hesitant to purchase systems without government assurance that such systems will meet applicable standards. Ultimately, however, the availability of treatment systems is linked to the capability to meet the standards. The aforementioned elements impacting system availability apply only to systems that demonstrate compliance.

Industry Demand

The California performance standards have a phased implementation schedule that mirrors that of the IMO Convention (see Table III-2). The phased implementation provides greater time for existing vessels to plan and execute retrofits to existing structures and machinery. All new vessels built on or after January 1, 2009 with a ballast water capacity less than 5000 MT that discharge in California waters must meet the performance standards. The number of new vessels that must meet the performance standards beginning in 2009 will greatly influence how strongly treatment developers will have to push to have their systems available for sale. New vessels with a ballast capacity greater than 5000 MT must comply by 2012. Lloyd's Register (2007) estimates that in 2009, construction will commence on 540 new vessels worldwide with a ballast capacity of less than 5000 MT. Exactly how many of those vessels will ultimately operate and discharge ballast in California waters is difficult to determine, however the numbers are expected to be relatively small. Examination of the number of vessels that have previously discharged in California provides some insight. Between January 1, 2000 and June 30, 2007, nearly 900 unique vessels with a ballast water capacity less than 5000 MT arrived in California and only 324 of those discharged ballast into California waters (Figure VI-1). Presuming a 20-year vessel replacement cycle, approximately 5% (45) of these almost 900 vessels may be replaced by new vessels and be required to meet the performance standards in 2009, and an even smaller number will discharge in California waters and require treatment system usage (K. Reynolds, pers. comm.). In the class of vessels with a ballast water capacity greater than 5000 MT, approximately 5250 unique vessels arrived, and 3167 discharged, in California waters between January, 2000 and June, 2007 (Figure VI-1). Again, a small percentage of these will also likely be replaced with new vessels and will be required to meet the performance standards beginning in 2012. Clearly, a much smaller number of new vessels will be required to meet the standards beginning in 2009 than in 2012; however, the precise number is less clear.

Because of the phased implementation schedule, existing vessels are affected by the performance standards much later than are newly built vessels. Existing vessels in the 1500-5000 MT size class must meet the standards in 2014, and all others must meet the standards in 2016. The specific number of existing vessels that will be subject to the standards beginning in 2014 is difficult to determine at this time. Traffic to California ports is on the rise (Falkner et al. 2007), but many older vessels may be scrapped in the intervening years before the standards take effect for existing vessels. Determining industry demand is further complicated by purchase timing (i.e. when a vessel chooses to purchase a treatment system). Many vessels, particularly existing ones with later implementation dates, may choose to purchase a system earlier than required so that installation dovetails with drydock and repair schedules. In this case, estimates of demand based solely on the standards implementation dates are likely inaccurate.

Commission staff will continue to follow trends in vessel visits to California and treatment system purchase and installation, particularly as the performance standards are implemented for newly built vessels, and will reassess system availability for existing vessels in future reports.

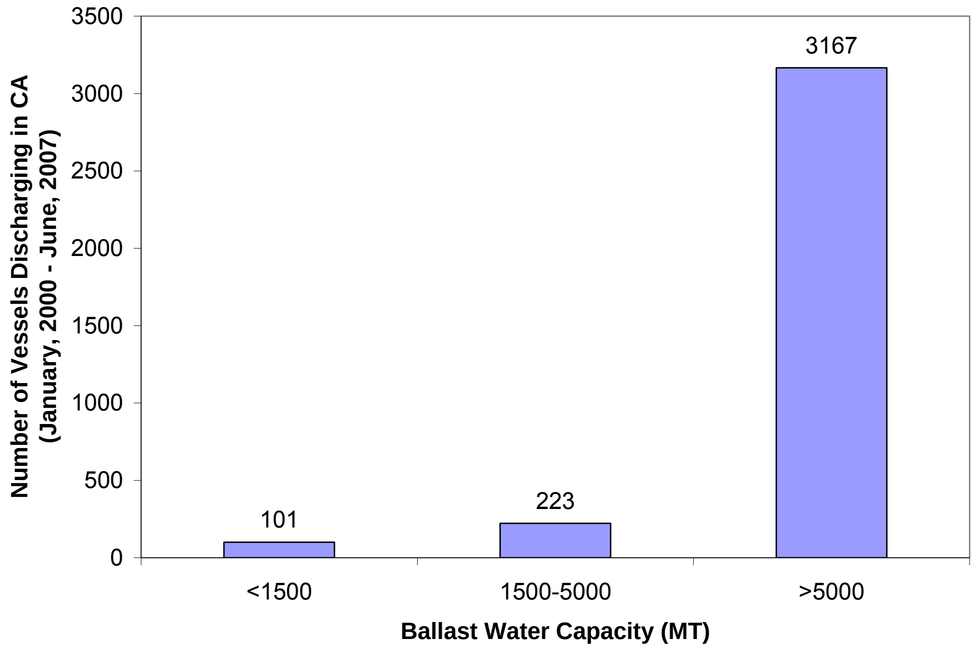

Figure VI-1. Number of vessels discharging in California waters between January, 2000 and June, 2007 as a function of ballast water capacity (MT).

Commercial Availability

System developers will need to have systems commercially available by the time the initial interim performance standards take effect in 2009. Twenty treatment technology developers provided Lloyd's Register (2007) with an actual or anticipated date of commercial availability. One company reported commercially availability in 2000. Of the remaining 19, eight were available in 2006, five are (or expect to be) ready in 2007, three anticipate commercial availability in 2008 and three in 2009. Similar data collected by Commission staff indicate at least five technologies are commercially available now and another four may be ready for commercial release by 2008, well ahead of the 2009 implementation date.

Treatment developers will also need to produce sufficient quantities of systems to meet market demand. Several of the large, multinational technology developers already produce many other products for the maritime industry and have a pre-existing infrastructure in place that may be modified to globally produce and support ballast water treatment systems (K. Reynolds, pers. comm. 2007). However, it is more difficult to gauge the ability of small technology developers to meet projected needs, or if collectively, all treatment developers will be able to meet the needs of the shipping fleet. Treatment developers may be able to space out delivery of systems for new vessels with a ballast capacity less than 5000 MT over a couple of years while infrastructure and production are brought up to speed, as even the largest marine corporations require significant lead time for existing marine product lines (K. Reynolds, pers. comm. 2007). While vessels in this size class are subject to the standards as of 2009, the construction of large commercial vessels can take several years, and many of those vessels may not actually be ready for treatment system installation and operation until 2010 or later.

System support is equally 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 support for onboard machinery whether their vessel is in Los Angeles, Shanghai, or somewhere in between. In the Glosten Associates (2006) assessment of five treatment developers, three were prepared to offer worldwide support, while plans for service were under development for the remaining two. The Lloyd's Register (2007) report does not address the issue of after-purchase support of systems. The initial influx of systems into the marketplace will no doubt challenge developers to provide adequate service. Larger companies entrenched 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 developers may face an initial period to ramp up service and access replacement parts. It is currently unclear if system support service will be adequate as the first of California's performance standards is implemented in 2009, and if a lack of service could impact system availability.

Commercial availability should not, however, at any time be confused with the capability of systems to meet the standards. Systems that may be deemed commercially available and ready for sale by technology developers must demonstrate system efficacy to vessel operators who will purchase those systems and to regulatory government agencies.

Market Availability

The availability of ballast water treatment systems is not only a function of commercial availability but also of market demand to purchase those technologies. Previous discussions addressed one aspect of demand - the numbers of vessels that will be required to meet the performance standards beginning in 2009. However, demand may also be influenced by the availability of systems that have received government approval to operate in a given water body.

In the U.S., the lack of a regulatory framework for the approval of ballast water treatment systems at the federal level is a major hindrance to the demand for systems. While California law requires initial compliance with the interim performance standards in 2009, shipping companies may be hesitant to purchase treatment systems with little or no assurance that the system will be permitted to operate in federal waters. Unless the USCG approves treatment systems prior to 2009, a vessel intent on discharging ballast in California arriving from outside of the 200 nm Exclusive Economic Zone will need to conduct a mid-ocean exchange to comply with federal ballast water management requirements and will additionally be required to treat that water to meet California requirements. This conflict in ballast management regulation between federal and state governments will no doubt cause confusion and temper demand to install treatment systems on vessels. Other states have begun to address the approval of treatment systems despite the lack of federal guidance. Washington and Michigan have preliminary approval processes for treatment systems in place. These states will encounter the same conflict between state and federal requirements until such time that the Federal government develops standards and approves technologies to meet those standards. The Commission supports the adoption of California's standards by other states and the Federal government and hopes that the USCG will accept technologies that meet the California standard as sufficient to meet USCG requirements.

Despite the potential conflict between federal and state requirements, Staff has begun developing guidelines (see Section III for initial discussion of guidelines) for treatment technology developers, in conjunction with third-party independent testing laboratories, to self-certify that their systems will meet California standards. These guidelines may serve as a template for use by developers or third-party independent laboratories to test systems that may be sold for use on vessels operating in California waters. In turn, vessel operators will have assurance that the systems they purchase have been evaluated specific to the California standards. The development of the testing guidelines has been initiated by Commission staff with a projected completion date of late-2008.

The development of testing guidelines by Commission staff is an important step to assist with the assessment, purchase and installation of treatment technologies for vessels that will operate in California, however, the guidelines will do little to facilitate the market for treatment systems at the federal or international level. Shipping companies may be unwilling to spend million of dollars purchasing and installing systems without knowledge that those systems meet federal and international requirements, and the demand for treatment technologies will likely remain sluggish until certification and legislative issues are settled.

Environmental Impacts

The assessment of environmental impacts associated with the release of treated ballast water will require agreed upon whole effluent testing procedures and criteria and mechanisms to evaluate potential impacts on designated beneficial uses (e.g. recreation, fisheries, fish/wildlife habitat) in the State's receiving waters. The development of these procedures will require cooperation amongst local, state, and federal agencies with water quality jurisdiction and expertise. Thus far such involvement has been limited in California. However, as a beginning point, many of the active substances/biocides used in ballast water treatment systems are already in use in other waste water and industrial applications. Therefore, assessment of treatment technologies for toxicological impacts may be eased by an initial examination of current discharge criteria. Furthermore, the IMO and State of Washington have developed procedures to assess the environmental impacts of chemicals in treatment systems, and a review of these programs may provide additional insight into the safety of some treatment systems. Ultimately however, California must develop methods to assess potential environmental and water quality impacts of discharging treated ballast which appropriately address applicable water quality objectives (including criteria for chemical residuals, water temperature, salinity, level of entrained sediments, and organic content) for California's receiving waters.

International Maritime Organization

As discussed in Section III (Regulatory Overview), the IMO has established an approval process for treatment technologies using active substances (i.e. chemicals) to ensure systems are safe for the environment, ship, and personnel. The two-step approval process is comprised of initial "Basic Approval" utilizing laboratory test results to demonstrate basic environmental safety followed by a Final approval process to evaluate the environmental integrity of the full-scale system. For California, examination of the IMO active substance approval process may provide an initial assessment of a treatment system's broad-scale environmental safety prior to the development of testing methods specific to State water quality requirements.

The Guideline G9 of the Convention requires applicants to provide information identifying: 1) Chemical structure and description of the active substance and relevant chemicals (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 tests results and a characterization of risk (MEPC 2005b). 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 2005b).

Federal

No formal evaluation of ballast water treatment systems currently occurs at the federal level. Experimental testing and evaluation of systems proceeds through the USCG Shipboard Testing and Evaluation Program (STEP; see Section III, Regulatory Overview for more information). Environmental compliance requirements associated with STEP participation include: 1) Compliance with the National Environmental Policy Act (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 presenting a risk to the vessel or human health will be withdrawn from the program (USCG 2006). Systems that use novel, proprietary chemicals not currently in use in large-scale applications will require Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) registration through EPA and a full toxicological impact analysis before assessment can progress.

State of Washington

The Washington State Department of Ecology developed a framework for the evaluation of effluent from ballast water discharge in 2003 and revised it in 2005. The "Laboratory Guidance and Whole Effluent Toxicity Test Review" (Washington Department of Ecology 2005) discusses information and procedures related to whole effluent toxicity testing regulations, test review, species and test conditions, and includes appendices relevant to particular cases and or situations (e.g. Appendix H: Establishing the Environmental Safety of Ballast Water Biocides). These tests are based on EPA toxicity testing procedures and require reporting in line with EPA toxicity testing manuals.

The results of the toxicity testing are used to set system discharge conditions such as maximum concentration or minimum degradation time (R. Marshall, pers. comm. 2007).

Following toxicity testing, systems are examined by the Washington Department of Fish and Wildlife, in conjunction with the Department of Ecology, for their ability to remove unwanted organisms under the conditions established as toxicologically safe (R. Marshall, pers. comm. 2007). Thus far, four systems have completed toxicity testing in accordance with Washington requirements (Table VI-3).

California

California does not have a formal review process for water quality impacts associated with ballast water treatment technologies. Staff has reviewed toxicity studies on treatment technologies that have been provided to the IMO, the State of Washington and the Commission. These reviews have provided initial indicators of potential environment impacts. Treatment systems wishing to operate in California waters must ultimately demonstrate compliance with all applicable water quality requirements as determined by the SWRCB. At this time, Commission staff are consulting with the SWRCB to identify all appropriate water quality standards and control plans.

The current court case addressing the regulation of vessel discharges (including ballast water) under the Clean Water Act may impact the criteria for evaluation of treated ballast water in California (see Section III, Regulatory Overview for summary of EPA vs. Northwest Environmental Advocates et al.). If EPA loses its appeal, SWRCB may attempt to regulate ballast water discharges. In that situation, SWRCB would also evaluate water quality impacts associated with treated ballast water under the State's NPDES program beginning as early as September 30, 2008. Until such time that jurisdiction over ballast water is settled, however, Staff will continue to consult with SWRCB staff to identify applicable water quality requirements and develop a review process for ballast water treatment systems.

Environmental Assessment of Treatment Systems

Staff has compiled environmental assessment reports and toxicity studies reported to the IMO and State of Washington, including any additional toxicity work as made available to the Commission, to assess the treatment systems for environmental impacts. While these studies provide an initial indicator of system environmental safety, they have not been conducted with California regulations and requirements in mind and a formalized environmental review may still need to occur when all appropriate California water quality requirements are identified.

Of the 28 treatment systems reviewed, 21 use an active substance (biocide) in the treatment process, and will thus require toxicological testing to ensure environmental safety before the systems can be used in State waters (Table VI-3). Systems that do not use active substances (such as those using UV) will not require toxicological testing to operate in California, however, these systems must still be reviewed for efficacy and ship and personnel safety.

Toxicity testing results for four systems were submitted to the Washington Department of Ecology for review, and three were recommended for conditional approval (which must be granted by the Washington Department of Fish and Wildlife) within specified limits for discharge concentration. One additional system was recommended for approval for the purposes of one onboard experiment (Table VI-3). Eight systems that use active substances to meet the IMO performance standards have applied for Basic Approval and six of those systems have been approved by MEPC based on recommendations from the GESAMP-BWWG (Tables V-1 and VI-3). Only one system has applied and was granted Final Approval by the MEPC thus far. Application for environmental review of system toxicity through the IMO and State of Washington is not mutually exclusive. To date, one system has been reviewed and approved by both administrations.

Table VI-3. Summary of toxicity testing for treatment systems that use active substances. Grey fill denotes systems that do not utilize active substances.

Manufacturer	***Toxicity Testing Conducted?***	***Toxicity Related Approvals***
Alfa Laval	√	IMO Basic, IMO Final
Degussa AG	√	IMO Basic, Rec. for WA Conditional[1]
Ecochlor	√	Rec. for WA Conditional[1]
Electrichlor		
Environmental Technologies Inc.		
Ferrate		
Greenship		
Hamann AG	√	IMO Basic (Peraclean)
Hi Tech Marine	N/A	N/A
Hitachi		
Hyde Marine	N/A	N/A
Japan Assoc. Marine Safety	Incomplete	IMO Basic
JFE Engineering Corp.		
L. Meyer GMBH		
Maritime Solutions Inc.		
MARENCO	N/A	N/A
MH Systems	N/A	N/A
Mitsubishi		
NEI	N/A	N/A
NK0[2]	√	IMO Basic
Nutech 03 Inc. [2]	√	
OceanSaver	N/A	N/A
OptiMarin	N/A	N/A
Resource Ballast Technologies	√	
RWO Marine Water Technology	√	IMO Basic (EctoSys)
SeaKleen	√	WA Single Test[3]
Severn Trent DeNora	√	Rec. for WA Conditional[1]
Techcross Inc.	√	IMO Basic

[1] The Washington Department of Ecology Water Quality Program has recommended Conditional Approval of this system to the Washington Department of Fish and Wildlife. As of the writing of this report, approval has not been granted.
[2] NKO and Nutech 03 Inc. have partnered (NK03) and any joint status of their technology approvals was not known at the writing of this report.
[3] SeaKleen was given a one-time approval to conduct a single test of their system.

In total, 12 of the 21 systems that use active substances have submitted information on toxicological testing to the IMO, the State of Washington, or both. Ten of those systems have received some form of approval as of August 2007. Treatment technology developers wishing to operate in California waters will still need to demonstrate compliance with applicable California water quality standards and regulations, and at this time the procedures to assess environmental impacts are still under development.

Economic Impacts

An assessment of the economic impacts associated with the implementation of performance standards and the use of treatment technologies requires consideration not only of costs associated with the purchase, installation and operation of treatment systems, but also the impacts associated with the control and/or eradication of NIS if performance standards are not met. As discussed in the Introduction (Section II), the U.S. 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). The rate of new introductions is increasing (Cohen & Carlton 1998, Ruiz & Carlton 2003) which suggests that economic impacts will likely increase as well.

California had the largest ocean economy in the U.S. in 2004, ranking number one for employment, wages and gross state product (NOEP 2007). California’s natural resources contribute significantly to the coastal economy. For example, in 2005 total landings of fish were over 440 million pounds, bringing in $116 million (NOEP 2007). Squid, the top revenue-generating species in 2005, brought in almost $31.5 million (NOEP 2007). The health of coastal natural resources are also closely tied to the tourism and recreation industries, accounting for almost $12 billion in California’s gross state product in 2004 (NOEP 2007). NIS pose a threat to these and other components of California’s ocean economy including commercial fisheries, aquaculture, sport and recreational fisheries, tourism and recreation, and education.

The use of ballast water treatment technologies to combat NIS introductions will involve economic investment on the part of ship owners. This investment in treatment systems 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 are strongly linked to vessel-specific characteristics including ballast water capacity, ballast pump rates, normal operational needs, and available space. Additionally, the retrofit of vessels already in operation (existing vessels) with 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 be broken into pieces and mounted individually; 3) Relocation of displaced equipment; and 4) The time associated with lay-up (K. Reynolds 2007, pers. comm.). Nonetheless, the use of these treatment technologies will likely help minimize or prevent future introductions of NIS and may relieve some of the future economic impacts associated with new introductions.

Many treatment technology developers are hesitant to release costs at this point because system prices represent research and development costs and do not reflect the presumably lower costs that would apply once systems are mass produced. In a 2007 report assessing the status of ballast water treatment technologies by Lloyd's Register, only 11 of 24 technologies profiled provided estimates of system capital expenditures (equipment and installation) and half (12) provided estimates of system operating expenditures (parts, service, and energy usage; Table VI-4). 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 $135,000 and $650,000 with an average of cost of $274,200 (Lloyd's Register 2007). A 2000 m^3/h capacity system ranges from $165,000 to $1,175,000 with an average cost of $542,500 per system (Lloyd's Register 2007). Operating costs range from $0.005 m^3/h of treated ballast to $0.20 per m^3/h with an average of $0.032 per m^3/h (Lloyd's Register 2007).

Relative to the cost of a newly built vessel, treatment systems may increase the cost of a vessel by 1-2%. For example, a new 8500 TEU (twenty-foot equivalent unit) container ship built by Seaspan Corporation costs approximately $132.5 million per vessel (Seaspan Corporation 2007). Installation of the most expensive currently available treatment system at $1.175 million (as indicated in Table VI-4) would increase the cost of that vessel by less than one percent. Many treatment technology developers claim that their systems will last the life of the vessel, so the capital costs of treatment systems should be a one-time investment.

Table VI-4. Summary of capital and operating cost data for select treatment systems. Unless otherwise denoted with **, source of data was Lloyd's Register 2007, Ballast Water Treatment Technology – Current Status.

Manufacturer	**Capital Expenditure** *(Equipment & Installation)*			**Operating Expenditure**
	200 m3/h *($ in thousands)*	**2000 m3/h** *($ in thousands)*	**Other** *($ in thousands)*	*($ per m3/h, unless otherwise noted)*
Alfa Laval				0.015/m^3**
Ecochlor	260	400		0.08/MT**
Electrichlor	350			0.019
ETI		500		0.005
Greenship	147	1175		
Hamann AG				0.2
Hi Tech Marine			16.5 – 300** *(equipment only)*	0.003/MT**
Hitachi				
Hyde			174 – 503**	0.01
JFE Engineering				0.04
MARENCO	135	165		0.1
MH Systems	650	950		0.06
Mitsubishi				
Japan Assoc. Marine Safety			100** *(installation only)*	0.15
NEI	150	400		0.05
Nutech 03				
OceanSaver				0.06
OptiMarin	400			
Resource Ballast Technologies	150	250		
RWO Marine				
Severn Trent	350	500		0.02
Techcross	150			0.03/MT**

**Denotes data that was found in references other than the 2007 Lloyd's Register report.

While the economic investment by the shipping industry in ballast water treatment technologies is not negligible, it is clear that damages from NIS are extremely costly in the U.S. Experts suggest that, when compared to the major costs to control and or eradicate NIS, the costs to treat ballast water may be minimal. Treating 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.

VII. CONCLUSIONS

Treatment systems that remove or inactivate organisms from ballast water will likely meet California's performance standards in the near future. However, given the short time remaining before the first implementation date for vessels with a ballast water capacity less than 5000 MT, and the need for the development of efficacy and environmental testing procedures before a system should be utilized in California waters, it is unlikely that systems will be available by 2009.

On a system-by-system basis no single technology demonstrated the capability to meet more than four (out of seven) of California's performance standards. Information for 28 different treatment technology systems was evaluated for their efficacy, availability and environmental impacts. Testing was either not performed or data were not available for 8 systems. For the remaining 20, it was often impossible to compare the available data for a single system against all of the organism size classes specified by California's performance standards because the methods used to evaluate efficacy were variable. In addition, only 10 technologies for which data was available have been tested onboard vessels during sea trials. Clearly, standardized testing and evaluation guidelines should be developed so results are in an appropriate format, particularly for the <10 μm size class. Standardized protocols will allow all systems to be evaluated on an even playing field.

Efficacy considerations aside, several companies are, or will soon be capable of producing treatment systems in a commercial context. Five to seven companies claim their systems are already commercially available, and an additional four to six claim that they are poised to launch systems commercially by 2009. At least three appear equipped to offer worldwide troubleshooting support for systems, and two additional companies will soon have service support in place.

In application, however, the issue of availability is dependent on a sequence of events for which the timing of each is unclear. Protocols must be standardized so systems are tested adequately, equitably, providing results that are comparable against California's performance standards. A process must also be in place to evaluate environmental impacts. A treatment system must then prove to meet the standards while operating within acceptable environmental limits. Once a system demonstrates efficacy, availability hinges on companies being able to install sufficient functioning systems for the quantity of vessels constructed on or after 2009.

Though the environmental impacts for many systems have been, or are in the midst of being evaluated by the IMO and/or Washington State, and many borrow from established wastewater treatment technologies, none have been evaluated specifically against the water quality criteria and regulations in California. The only environmental impact data currently available were for those systems seeking approval through the IMO or for use in Washington waters. Though several of these systems utilize technologies that have been deemed acceptable for wastewater treatment, their appropriateness for California waters has not yet been evaluated against the State Water Resources Control Board's and Regional Water Quality Control Board's water quality control plans and regulations. The establishment of an evaluation procedure or process for environmental impacts is as essential as protocols to assess efficacy, particularly for systems that use active substances (i.e. chemicals). Clearly, the environmental and water quality impacts from these treatment systems should be examined critically, with substantial review from the agency/agencies with the expertise and jurisdiction to ensure that discharges of treated ballast water meet California's water quality requirements.

VIII. LOOKING FORWARD

The infancy of the field of ballast water management, specifically related to treatment system development is apparent. As stated previously, the lack of performance standards has often been cited as a primary factor impeding the progress of technology development. Internationally, performance standards were only adopted in early-2004 and they have yet to be ratified. California's much stricter standards were only adopted by legislation in late-2006 and codified in regulation in October, 2007. The federal government has yet to adopt performance standards. So while the issue of NIS and ballast water management has been regulated to some degree since 1996, adoption of numeric standards is very recent.

As required by the Coastal Ecosystems Protection Act (Section 71205.3a of the PRC), Commission staff has adopted regulations governing interim and final performance standards for the discharge of ballast water. This report reviews the efficacy, availability and environmental impacts of currently available technologies and fulfills the requirements for the initial report assessing ballast water treatment technologies (Section 71205.3b of the PRC). The Act has strengthened the ability of the Commission to prevent NIS introductions and has increased agency responsibilities, specifically in regards to treatment technology assessment and the verification of vessel compliance with the performance standards.

The Marine Invasive Species Program staff is currently engaged in the following activities in order to continue to fulfill the Commission's legislative directive to, "move the state expeditiously toward the elimination of the discharge of nonindigenous species into the waters of the state".

1. Develop guidelines to assist treatment technology developers and independent third-party laboratories with the testing and evaluation of treatment systems relative to California's performance standards.

Standardized testing guidelines will assist and encourage developers and independent laboratories to use appropriate methods when evaluating their treatment systems against California's performance standards. Treatment developers may then self-certify that their systems will meet California's requirements. This would provide ship owners with information and some assurance regarding which treatment technologies would best meet their needs. In this review, the full potential for many systems to meet the performance standards could not be determined because data were not presented in metrics consistent with the performance standards. Guidelines for the testing of systems will provide a suggested template for the testing of treatment systems and may increase the demand for systems that are certified by treatment developers. These guidelines are expected to be made available to industry in mid- to late-2008.

2. Develop verification protocols to assess vessel compliance with the performance standards.

Staff must develop protocols to verify vessel compliance with the performance standards. This process will be enhanced by the use of the best available methods for organism enumeration in terms of ease of use, cost effectiveness, accuracy, precision and acceptance by the scientific community. The lack of widely used and accepted methods for counting organisms in the less than 10 μm size class will be particularly problematic.

Additional procedures will be required for on-site sampling, the handling of samples between vessel and testing laboratory (chain of custody), mechanisms for the identification and approval of independent laboratories to conduct the sample analysis, and requirements for reporting of compliance from laboratory to the Commission. The development of the verification protocols and the associated rulemaking process is expected to be completed in late-2008.

3. Work in consultation with the SWRCB to identify applicable water quality requirements for ballast water treatment technologies and provide technology developers with a guidance document to ensure system compliance with applicable California laws.

Twenty-one of the 28 technologies reviewed in this report utilize active substances to kill or inactivate ballast water organisms. As specified in the California Coastal Ecosystems Protection Act of 2006, it is important that such systems be reviewed for environmental impacts, including effects on water quality. As the state agency with the authority and expertise to evaluate and enforce water quality requirements under the Clean Water Act, the State Water Resources Control Board plays an integral role in this regard. The SWRCB and the Commission will work to identify the California water quality requirements that are applicable to ballast water treatment systems. This information will be incorporated into a guidance document and passed on to treatment developers so that they may ensure that their systems will be in compliance with California's water quality requirements.

4**. Support the alignment of testing and evaluation guidelines amongst all U.S. West Coast states.**

Commercial shipping is an international industry; any single ship may operate throughout several regions of the world. Ideally, performance standards should align both at the federal and international level and is preferable to a patchwork of standards adopted by individual states. Barring uniformity at larger scales, standards aligned along the U.S. West Coast would be beneficial for both industry and participant states. Even in cases where performance standards differ, it may still be possible to use the same testing and evaluation procedures to assess the effectiveness of treatment technologies. If all West Coast states encouraged technology developers to use the same testing and evaluation procedures, it would provide more uniform and useful information to ship owners.

While Staff will continue to work with Oregon, Washington, other states, and the federal government on the alignment of performance standards and treatment technology testing and evaluation guidelines and protocols, the Commission will proceed as required to fulfill its mandates under the Coastal Ecosystems Protection Act.

IX. RECOMMENDATIONS TO THE LEGISLATURE

1. Change the implementation date for new vessels with ballast water capacity less than 5000 metric tons from 2009 to 2010, and require the Commission to prepare an update of this report on or before January 1, 2009.

It appears that treatment systems should be able to meet most of California's performance standards in the near future, however, none currently demonstrate the capacity to meet all of the standards. Commission staff have begun developing guidelines, which are expected to be completed in late-2008, for the testing and evaluation of treatment systems by technology developers and independent third-party laboratories. This should aid in the testing process and provide treatment developers with a mechanism to self-certify that their system meets the California discharge standards. Simultaneously, Commission staff will require time to develop protocols to verify vessel compliance with the performance standards and identify laboratories and prepare them for the process of analyzing compliance sampling on vessel discharges. These verification protocols are expected to be completed and approved through the California rulemaking process by late-2008. While efforts will be made to keep industry appraised of the development of these guidelines and protocols as they progress, the period of time remaining for testing before the 2009 deadline would be prohibitively short. Additionally, the state must have time to identify and make industry aware of any and all applicable water quality criteria and regulations governing the discharge of treated ballast water. It is unlikely that all of this could be completed prior to the initial implementation date in 2009.

2. Authorize the Commission to amend the ballast water reporting requirements via regulations.

Section 71205(D) of the PRC currently requires reporting of ballast water management information needed to support regulation via ballast water exchange or alternative ballast water management methods. As treatment systems come online, it will be important for the Commission to acquire different types of information including the timing of and requirements for treatment system use, deviations from suggested system operation, and certifications for operation from vessel classification societies and other organizations/agencies. An expansion of the vessel reporting requirements may be necessary for Commission staff to gather information and generate future recommendations regarding the implementation of the performance standards and the evaluation and use of ballast water treatment systems. The Commission should be authorized to amend ballast water reporting requirements to meet these needs.

3. Support continued research promoting technology development.

Ballast water treatment is a fledgling industry that will need to undergo significant development as California's Performance Standards are progressively implemented and as new vessel types are built. In 2012, the standards will go into effect for new vessels with the largest ballast water capacity (over 5000 MT), and technologies will need to be able to effectively inactivate organisms under high volume and pump rate conditions. Existing vessels built before 2009 will need to be retrofitted for approved treatment systems by 2014 or 2016 (depending on ballast water capacity). Those technologies must be installable under limited space conditions, and must be able to integrate with the existing engineering of ships (piping, electrical, computer, etc.). While several of the systems evaluated in this report meet or come close to meeting many of California's Standards, many were not installed and tested on ships. It is not clear if they can be viably installed on existing vessels. Finally, as the zero discharge deadline approaches in 2020, treatment technologies must be available that kill or inactivate all organisms, in all size classes, or vessels must be operated/constructed so that they do not need to discharge ballast water. The research and development needed to reach these goals under these timelines will require substantial financial resources, and should be supported by the Legislature.

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XI. APPENDICES

APPENDIX A

Ballast Water Treatment System
Efficacy Matrix

Twenty-eight ballast water treatment systems were reviewed by Commission staff for compliance with the California performance standards. Only 20 systems had data on system efficacy available for review. System data was examined closely for results comparative to each of the organism size classes. The comparison of results against the performance standards was difficult because of the wide variety of testing procedures and methods of reporting results by treatment system developers. In this initial review, Commission staff was lenient in their assessment of systems that meet the standards. The limited availability of shipboard results of system efficacy required Staff to include results from dockside and laboratory studies in their analysis. In an effort to standardize results, Staff evaluated any data on zooplankton abundance as representative of the largest size class of organisms (greater than 50 μm in size), and phytoplankton abundance was evaluated on par with organisms in the 10 – 50 μm size class. Results presented as percent reduction in organism abundance or as concentration of pigments or biological compounds associated with organism presence were noted, but these metrics were not comparable to the performance standards.

In the following tables, systems with at least one testing replicate in compliance with the performance standard are scored as meeting California standards. Testing results that had no testing replicates in compliance with the standard are scored as not meeting California standards Systems that presented data for a given organism size class but presented the results in metrics not comparable to the standards are classified as "Unknown." For example, a system that presented results of system effect as percent reduction of zooplankton abundance could not be compared against the California standards, and thus ability of the system to comply with the standards is unknown. Open cells indicate lack of testing or results for a given organism size class. The source(s) of the data for each system can be found in the Literature Cited section of this report.

Appendix A1 Organisms > 50 µm

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/cubic meter	Methods	Reference
Alfa Laval	Laboratory	1	0	-	-	Unk (% Reduction)	Visual Assesment	54
	Dockside	2	1	3	Y	0 - 11	Visual Assesment	1
	Shipboard	1	1	1-3	N	0	Visual Assesment	54
Degussa AG	Laboratory	2	2	Y	Y	0	Visual Assesment	24, 89
	Dockside	1	0	Y	Y	Unk (% mortality)	Visual Assesment	24
	Shipboard	-	-	-	-	-	-	-
Ecochlor	Laboratory	2	2	2	Y	0 - $3.5x10^5$	Visual Assesment, Neutral Red	63
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	3	Y	0-5	Visual Assessment	50
Electrichlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-		-	-	-
ETI	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ferrate Treatment Tech.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Greenship	Laboratory	-	-	-	-	-	-	-
	Dockside	5	5	Y	Y	0	Visual Assessment	77
	Shipboard	-	-	-	-	-	-	-
Hamann AG	Laboratory	-	-	-	-	-	-	-
	Dockside	6	6	Y	Y	0	Visual Assesment	28, 89
	Shipboard	-	-	-	-	-	-	-
Hi Tech Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	2	0	-	-	Unk (% mortality)	-	31
Hitachi	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hyde Marine	Laboratory	1	0	Y	Y	-	Visual Assessment	43
	Dockside	4	2	Y, N	Y	0 (100% Mortality)	Visual Assessment	44
	Shipboard	4	0	3	Y	3 - 161	Visual, Neutral Red	99
JAMS	Laboratory	-	-	-	-	-	-	-
	Dockside	4	0	3-5	Y	BD, $2 x10^5$ - $1.4x10^6$	Visual Assessment	37, 38
	Shipboard	1	0	-	Y	8	Visual Assessment	35
JFE Engineering Corp	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
L. Meyer GMBH	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MARENCO	Laboratory	-	-	-	-	-	-	-
	Dockside	3	2	Y, N	Y	0 - 1.57	Visual Assessment	39, 40, 96
	Shipboard	-	-	-	-	-	-	-

Appendix A1 Organisms > 50 μm

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/cubic meter	Methods	Reference
Maritime Solutions Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MH Systems	Laboratory	1	0	3	N	Unk (No Units)	Visual Assessment	32
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Mitsubishi Heavy Ind.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
NEI	Laboratory	-	-	-	-	-	-	-
	Dockside	2	1	Y	Y	0, Unk (% Survival)	Visual Assessment	80, 81
	Shipboard	2	1	Y	Y	0 - 7	Visual Assessment	82
NKO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Nutech O3 Inc.	Laboratory	3	0	4	Y	$1.2x10^2$ - $1.2x10^4$	Visual Assessment	68
	Dockside	3	1	Y	Y	Unk (% Live)	Visual Assessment	30
	Shipboard	-	-	-	-	-	-	-
OceanSaver	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	9	1	-	Y	0 - 9720	Visual Assessment, Unknown	3
OptiMarin	Laboratory	1	0	-	Y	> 0	Visual Assessment	93
	Dockside	1	0	-	Y	Unk (% Reduction)	Visual Assessment	7
	Shipboard	7	0	Y	Y	1.4 - ~5500, Unk (% Reduction)	Visual Assessment	7, 95
Resource Ballast Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
RWO Marine Water Tech	Laboratory	1	1	-	-	0	Visual Assessment	56
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
SeaKleen	Laboratory	1	1	Y	Y	0	Visual Assessment	14, 26
	Dockside	2	2	3	Y	0	Visual Assessment	44
	Shipboard	1	1	3	Y	0	Visual Assessment	4
Severn Trent	Laboratory	-	-	-	-	-	-	-
	Dockside	5	3	3-4	Y	0 - $\sim4x10^5$	Visual Assessment	29
	Shipboard	-	-	-	-	-	-	-
Techcross Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	Y	Y	0	Unk	84

Unk = Unknown

BD = Below Detection Limits

Appendix A2 Organisms 10 - 50 µm

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/ml	Methods	Reference
Alfa Laval	Laboratory	1	0	-	-	Unk (% Reduction)	Visual Assesment	54
	Dockside	2	0	3	Y	0.2 - 0.7	Visual Assesment	1
	Shipboard	1	0	1-3	N	0.407 - 0.943	Visual Assesment	54
Degussa AG	Laboratory	3	3	Y	Y	0 (100% Mortality)	Visual Assessment, Sytox Green	24, 26, 89
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ecochlor	Laboratory	2	0	2	Y	<0.1 - >60, Unk ([Chl a])	Visual Assessment, MPN, [Chl a]	63
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	3	Y	0-81	Visual Assessment, [Chl a]	50
Electrichlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
ETI	Laboratory	-	-	-	-	-	-	-
	Dockside	3	0	2-3	Y	1 - 1.5	Growout (+, -), Flowcam	47, 48, 49
	Shipboard	-	-	-	-	-	-	-
Ferrate Treatment Tech.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Greenship	Laboratory	-	-	-	-	-	-	-
	Dockside	5	3	Y	Y	0 - 7	Total Counts	77
	Shipboard	-	-	-	-	-	-	-
Hamann AG	Laboratory	-	-	-	-	-	-	-
	Dockside	6	5	Y	Y	0	FCM	28, 89
	Shipboard	-	-	-	-	-	-	-
Hi Tech Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	2	0	-	-	Unk (% Mortality)	-	31
Hitachi	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hyde Marine	Laboratory	1	0	Y	Y	26 - 210	Visual Assessment, Coulter, MPN	43
	Dockside	4	0	Y	Y	Unk ([Chl a])	[Chl a]	44
	Shipboard	5	0	3	Y	Unk (% of controls, [Chl a])	Visual Assessment, [Chl a]	99
JAMS	Laboratory	-	-	-	-	-	-	-
	Dockside	4	0	3-5	Y	BD, 206.6 - 387.4, Unk	Visual Assessment (20 - 50um)	37, 38
	Shipboard	1	0	-	Y	BD	Visual Assessment	35
JFE Engineering Corp	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
L. Meyer GMBH	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MARENCO	Laboratory	-	-	-	-	-	-	-
	Dockside	3	0	Y	Y	0.05 - 0.186	MPN, [Chl a], ^{14}C, PAM	39, 40, 96
	Shipboard	-	-	-	-	-	-	-

Appendix A2 Organisms 10 - 50 µm

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/ml	Methods	Reference
	Laboratory	-	-	-	-	-	-	-
Maritime Solutions Inc.	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
MH Systems	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
Mitsubishi Heavy Ind.	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
NEI	Dockside	3	0	Y	Y	Unk	[Chl a]	80, 81
	Shipboard	2	0	Y	Y	443 - 593	Total Counts (Preserved), [Chl a], Regrowth	82
	Laboratory	-	-	-	-	-	-	-
NKO	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	3	0	4	Y	Unk	[Chl a]	68
Nutech O3 Inc.	Dockside	2	0	Y	Y	22 - 190	Total Counts (Preserved)	30
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
OceanSaver	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	1	0	-	Y	26 - 210	MPN, Coulter	93
OptiMarin	Dockside	1	0	-	Y	Unk (% Reduction)	[Chl a], Counts, Growout	7
	Shipboard	10	0	Y	Y	Unk ([Chl a], % Reduction)	[Chl a], HPLC, PAM, Counts, Growout	7, 95
	Laboratory	-	-	-	-	-	-	-
Resource Ballast Tech	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	1	1	-	-	0	Visual Assessment	56
RWO Marine Water Tech	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	2	1	Y	Y	0, Unk (Unitless)	Epifluorescence, Hemacytometer, Sytox Green	14, 26
SeaKleen	Dockside	2	0	3	Y	Unk ([Chl a])	[Chl a]	44
	Shipboard	1	1	3	Y	0	Visual Assessment, [Chl a], Growout	4
	Laboratory	-	-	-	-	-	-	-
Severn Trent	Dockside	5	2	3-4	Y	0.002 - 10, BD ([Chl a])	MPN, [Chl a]	29
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
Techcross Inc.	Dockside	-	-	-	-	-	-	-
	Shipboard	2	2	Y	Y	0	Unk	84

Unk = Unknown
BD = Below Detection Limits
MPN = Most Probable Number

Appendix A3 Organims < 10 µm

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Alfa Laval	Laboratory	1	0	-	-	Unk (% Reduction)	Visual Assesment	54
	Dockside	2	0	3	Y	$4x10^3$ - $4x10^8$	Visual Assesment	1
	Shipboard	-	-	-	-	-	-	-
Degussa AG	Laboratory	2	0	Y	Y	$3.8x10^7$ - $4.6x10^7$	Plate Counts, PicoGreen	89
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ecochlor	Laboratory	2	1	2	Y	0,Unk (% of control, % Plate cover)	Plate Counts, ^{3}H-leucine	63
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	0	3	Y	BD	Plate Counts, ^{3}H-leucine	50
Electrichlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
ETI	Laboratory	1	0	3	Y	-	Plate Counts, BacLight	46
	Dockside	3	0	2-3	Y	$5x10^7$ - $1x10^9$	Growout (+, -), FCM/PicoGreen	47, 48, 49
	Shipboard	-	-	-	-	-	-	-
Ferrate Treatment Tech.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Greenship	Laboratory	-	-	-	-	-	-	-
	Dockside	5	2	Y	Y	0 - 6000	Unk	77
	Shipboard	-	-	-	-	-	-	-
Hamann AG	Laboratory	-	-	-	-	-	-	-
	Dockside	1	0	Y	Y	$3.8x10^7$ - $4.6 x 10^7$	PicoGreen	89
	Shipboard	-	-	-	-	-	-	-
Hi Tech Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hitachi	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hyde Marine	Laboratory	1	0	Y	Y	~5000 - 7000	Plate Counts	43
	Dockside	2	0	Y	Y	Unk	Plate Counts, AODC	44
	Shipboard	4	0	3	Y	Unk	Plate Counts	99
JAMS	Laboratory	-	-	-	-	-	-	-
	Dockside	2	0	3	Y	BD, Unk	Plate Counts	37
	Shipboard	1	0	-	Y	BD	Plate Counts	35
JFE Engineering Corp	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
L. Meyer GMBH	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MARENCO	Laboratory		-	-	-	-	-	-
	Dockside	3	1	Y	Y	0 - ~$5x10^8$	Plate Counts, Membrane Filtration	39, 40, 96
	Shipboard	-	-	-	-	-	-	-

Appendix A3 Organims < 10 µm

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Maritime Solutions Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MH Systems	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Mitsubishi Heavy Ind.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
NEI	Laboratory	-	-	-	-	-	-	-
	Dockside	2	0	Y	Y	$> 1x10^8$	FCM	80, 81
	Shipboard	2	0	Y	Y	$7.3x10^7 - 7.9x10^7$	FCM	82
NKO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Nutech O3 Inc.	Laboratory	3	3	4	Y	$\leq 10^1 - 10^8$	Plate Counts, Membrane Filtration	68
	Dockside	3	3	Y	Y	$3x10^{-1} - 3x10^2$	Plate Counts, Membrane Filtration	30
	Shipboard	-	-	-	-	-	-	-
OceanSaver	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
OptiMarin	Laboratory	2	0	-	Y	$\sim 5x10^3 - \sim 7x10^3$	Plate Counts	93
	Dockside	1	0	-	Y	Unk (% Reduction)	Plate Counts	7
	Shipboard	10	0	Y	Y	$<10^3 - 10^4$, Unk (% Reduction)	Plate Counts, SYBR Gold	7, 95
Resource Ballast Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
RWO Marine Water Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
SeaKleen	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	0	3	Y	Unk (Unitless)	Plate Counts	4
Severn Trent	Laboratory	-	-	-	-	-	-	-
	Dockside	5	3	3-4	Y	$<1 - 10^{10}$	Plate Counts, Membrane Filtration	29
	Shipboard	-	-	-	-	-	-	-
Techcross Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	2	2	Y	Y	0	Unk	84

Unk = Unknown
AODC = Acridine Orange Direct Counts
FCM = Flow Cytometer

Appendix A4 ***E. Coli***

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls used	# Organisms/100 ml	Methods	Reference
Alfa Laval	Laboratory	1	0	-	-	Unk (% Reduction)	-	54
	Dockside	2	2	3	Y	0.3 - 800	-	1
	Shipboard	-	-	-	-	-	-	-
Degussa AG	Laboratory	1	1	Y	-	0	Plate Counts	26
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ecochlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	3	Y	0 - ~21	Indexx Labs Colilert	50
Electrichlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
ETI	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ferrate Treatment Tech.	Laboratory	1	0	-	-	300	Indexx Labs QuantiTray MPN	15
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Greenship	Laboratory	1	1	-	Y	>1000 - 3000	Plate Counts	16
	Dockside	5	5	Y	Y	0 - 1	Unk	77
	Shipboard	-	-	-	-	-	-	-
Hamann AG	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hi Tech Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hitachi	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hyde Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	4	4	3	Y	0	Indexx Labs Colisure	99
JAMS	Laboratory	-	-	-	-	-	-	-
	Dockside	2	0	3	Y	BD, Unk	Plate Counts	37
	Shipboard	-	-	-	-	-	-	-
JFE Engineering Corp	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
L. Meyer GMBH	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MARENCO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-

Appendix A4 ***E. Coli***

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls used	# Organisms/100 ml	Methods	Reference
	Laboratory	-	-	-	-	-	-	-
Maritime Solutions Inc.	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
MH Systems	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
Mitsubishi Heavy Ind.	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
NEI	Dockside	1	1	Y	Y	10 - 160	Indexx Labs MPN Kit	80, 81
	Shipboard	1	1	Y	Y	<100	Indexx Labs MPN Kit	82
	Laboratory	-	-	-	-	-	-	-
NKO	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
Nutech O3 Inc.	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
OceanSaver	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
OptiMarin	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
Resource Ballast Tech	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
RWO Marine Water Tech	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	1	1	Y	Y	0	Culture Growth	26
SeaKleen	Dockside	-	-	-	-	-	-	-
	Shipboard	1	Unk (0 in control)	3	Y	0 (treatment & control)	Idexx Labs Colisure	4
	Laboratory	-	-	-	-	-	-	-
Severn Trent	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
	Laboratory	-	-	-	-	-	-	-
Techcross Inc.	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	Y	Y	0	Unk	84

Unk = Unknown

BD = Below Detection Limits

Appendix A5 Intestinal Enterococci

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Alfa Laval	Laboratory	-	-	-	-	-	-	-
	Dockside	2	2	3	Y	0 - 4	-	1
	Shipboard	-	-	-	-	-	-	-
Degussa AG	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ecochlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	0	3	Y	Unk	Indexx Labs Enterolert	50
Electrichlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
ETI	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ferrate Treatment Tech.	Laboratory	1	0	-	-	80	Indexx Labs QuantiTray MPN	15
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Greenship	Laboratory	-	-	-	-	-	-	-
	Dockside	5	5	Y	Y	0	Unk	77
	Shipboard	-	-	-	-	-	-	-
Hamann AG	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hi Tech Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hitachi	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hyde Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	4	Unk (0 in control)	3	Y	0 (treatment & control)	Indexx Labs Enterolert	99
JAMS	Laboratory	-	-	-	-	-	-	-
	Dockside	2	0	3	Y	BD, Unk	Plate counts	37
	Shipboard	-	-	-	-	-	-	-
JFE Engineering Corp	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
L. Meyer GMBH	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MARENCO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-

Appendix A5 Intestinal Enterococci

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Maritime Solutions Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MH Systems	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Mitsubishi Heavy Ind.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
NEI	Laboratory	-	-	-	-	-	-	-
	Dockside	1	0	Y	Y	36	Indexx Labs MPN Kit	80, 81
	Shipboard	2	2	Y	Y	<10	Indexx Labs MPN Kit	82
NKO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Nutech O3 Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
OceanSaver	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
OptiMarin	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Resource Ballast Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
RWO Marine Water Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
SeaKleen	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	Unk (0 in control)	3	Y	0 (treatment & control)	Idexx Labs Enterolert	4
Severn Trent	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Techcross Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	Y	Y	0	Unk	84

Unk = Unknown

BD = Below Detection Limits

Appendix A6 ***Vibrio cholerae***

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Alfa Laval	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Degussa AG	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ecochlor	Laboratory	2	2	2	Y	0 (% cover)	Plate Counts	63
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	0	3	Y	BD - ~1000	Unk	50
Electrichlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
ETI	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ferrate Treatment Tech.	Laboratory	1	0	-	-	108	Indexx Labs QuantiTray MPN	15
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Greenship	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hamann AG	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hi Tech Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hitachi	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hyde Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
JAMS	Laboratory	-	-	-	-	-	-	-
	Dockside	2	0	3	Y	BD, Unk	Plate Counts	37
	Shipboard	-	-	-	-	-	-	-
JFE Engineering Corp	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
L. Meyer GMBH	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MARENCO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-

Appendix A6 *Vibrio cholerae*

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Maritime Solutions Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MH Systems	Laboratory	1	0	3	N	Unk (% Reduction)	Plate Counts	32
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Mitsubishi Heavy Ind.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
NEI	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	Y	Y	0	DFA	82
NKO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Nutech O3 Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
OceanSaver	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
OptiMarin	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Resource Ballast Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
RWO Marine Water Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
SeaKleen	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Severn Trent	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Techcross Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	1	1	Y	Y	0	Unk	84

Unk = Unknown
BD = Below Detection Limits
DFA = Direct Fluorescent Antibody

Appendix A7 Virus Like Particles

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Alfa Laval	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Degussa AG	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ecochlor	Laboratory	2	1	2	Y	0,Unk (% of Control)	Plaque Forming Units	63
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Electrichlor	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
ETI	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Ferrate Treatment Tech.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Greenship	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hamann AG	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hi Tech Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hitachi	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Hyde Marine	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
JAMS	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
JFE Engineering Corp	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
L. Meyer GMBH	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MARENCO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-

Appendix A7 Virus Like Particles

Manufacturer	Location	# Tests	# Tests Met Std	Replicates	Controls	# Organisms/100 ml	Methods	Reference
Maritime Solutions Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
MH Systems	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Mitsubishi Heavy Ind.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
NEI	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
NKO	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Nutech O3 Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
OceanSaver	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
OptiMarin	Laboratory	-	-	-	-	-	-	-
	Dockside	1	0	-	Y	Unk (% Reduction)	Spiked Coliphage MS2 Exp.	7
	Shipboard	5	0	-	Y	Unk (% Reduction)	Spiked Coliphage, SYBR Gold	7, 95
Resource Ballast Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
RWO Marine Water Tech	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
SeaKleen	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Severn Trent	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-
Techcross Inc.	Laboratory	-	-	-	-	-	-	-
	Dockside	-	-	-	-	-	-	-
	Shipboard	-	-	-	-	-	-	-

Unk = Unknown

APPENDIX B

CSLC Treatment Technology Assessment Workshop
Participants and Notes
May 25, 2007
MIT, Cambridge, MA

Participants

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Summary
The workshop was convened by the California State Lands Commission Marine Invasive Species Program to assess the efficacy, availability, and environmental/water quality impacts of ballast water treatment technologies.

A variety of methods exist to treat ballast water. Filtration or mechanical separation is the primary method of separating out large particles, but filtration alone is not sufficient to meet California discharge standards. Biocides provide the means to effectively kill or inactivate all size classes and types of organisms in ballast water, but the potential for environmental impacts associated with the release of biocide treated ballast water is high if proper dosing curves and deactivation steps are not followed. The biological efficacy of these treatment methods must also be balanced against considerations for shipboard use of complete treatment systems, including: crew and vessel safety, volume and flow rate of ballast water to be treated, impact on piping system and ballast tank corrosion rates, energy requirements, integration with ships systems, and space required for treatment machinery.

In terms of biological efficacy, the general consensus was that most treatment technologies, particularly those using biocides, will be capable of meeting the California discharge standards. However, two major challenges associated with assessing treatment efficacy need to be addressed: 1) the lack of available results demonstrating treatment system performance at appropriate vessel-size scale, and 2) the lack of standardized tests and procedures necessary to determine whether or not treated ballast water meets the performance standards.

The development and installation of treatment technologies on operational vessels is not only hampered by issues of biological efficacy but also by lack of system availability. Availability may be defined as a combination of: a) commercial availability of a given system (i.e. is such system available for purchase from a treatment company?), b) the presence of an available market for treatment technologies, and c) certifications (Type Approval) for these systems. While some technologies are close to, or ready, for purchase, the treatment technology marketplace is not yet in place due, in large part, to the lack of system approval mechanisms. At this time, the IMO Ballast Water Management Convention is not ratified, and the United States is still working through the development of processes and criteria for approval of treatment technologies and new legislation regarding performance standards. Until a federal or ratified international certification process comes online, shipping companies will be hesitant to purchase treatment systems with little or no assurance that the system will be permitted to operate in US waters. The market for treatment technologies will remain on hold until the certification and legislative issues are settled, and the timing remains unclear.

The assessment of environmental impacts associated with the release of treated ballast water will require agreed upon whole-effluent testing procedures and criteria. The development of these procedures will require involvement by local, state, and federal agencies with water quality jurisdiction and expertise, and thus far, this involvement has been lacking. However, as a beginning point, many of the active substances/biocides

used in ballast water treatment systems are already in use in other waste water and industrial applications. Therefore, assessment of treatment technologies for toxicological impacts may be eased by an initial examination of current discharge criteria for industrial and storm water permits. The State of Washington also has a ballast water specific whole effluent toxicity test program. Only a few “new” chemicals not currently in use in large-scale applications will require chemical registration and a full toxicological impact analysis before assessment can progress.

Additional topics discussed during the workshop included numbers of vessels that will be impacted by the implementation schedule and the rational behind California’s performance standards.

Based upon information presented during the workshop, CSLC staff must take the following next steps to continue to assess the efficacy, availability, and environmental/water quality impacts of ballast water treatment technologies:

- Gather more detailed information on the shipboard development, installation and testing of treatment technologies
- Begin consultation with scientists regarding the development and standardization of tests and protocols to assess treatment technology efficacy relative to California discharge standards

- Continue discussion with USCG and assist where possible in the development of federal performance standards and procedures to approve treatment technologies

- Continue support of installation, testing, and monitoring of full-scaled experimental treatment technology

- Gather information from State and Regional Waterboards on industrial and storm water permits and TMDLs relevant to chemicals used in ballast water treatment technologies

Workshop Notes

Welcome and introductions

Nicole’s overview - slides

- Coastal Ecosystems Protection Act requiring performance standards –
  - Currently going through regulatory process.
  - Required to submit report by 2008 assessing treatment technologies. If not available, why not?

  - Began process of gathering information a few months ago.
  - Matrix overview, IMO docs, peer review, lab tests, ship tests, company documents. Lots of information. Not all extremely clear.

  Question (Jon): is there a component for approvals in CA laws?

  Maurya: law does not include an approval process, but in reality, we'll need regulations to assist us in determining if a system meets a standard. We have to find a process to assess if a technology meets standards. We are still working out the details of implementation.

- After submission of report, the legislature will determine what (if anything) to do about standards. CSLC has no authority to change the implementation schedule or standard, even based on this assessment.
- Assessment status
  - Matrix assembled. This is the expert panel portion of the bill. We'll meet with the TAG that put original 2006 report together. Based on all input, will put a technology review report together and submit to leg by Jan 1 2008.
- Challenges (went through bullets on slide)
- Performance Standards table slide – noted that WA has % based reductions

Question: What should we be expecting with regard to new builds?

- Kevin: In general, new construction shipyards are booked solid for the next 5 years. To get a rough estimate of the number of new builds (vessel constructed within the last one year) arriving at a given port, one could, take number of current ship calls and divide by 20. This will vary by vessel type and trade, but considers that vessels construction is on a 20 year cycle, particularly the ships calling to CA (operators are generally better, and will pull them out after 20 years service). Services such as *Fairplay* have data on ship age, new build contracts and projections, and has processed the data by type, trade, etc.
- Greg: Could do a demographic analysis on CA with Fairplay data.
- Jon: Trade is doubling (tonnage of ships) on a 10 year cycle. CA is probably the same. High price of scrap metal has fueled rapid retiring of old vessels, and an increase in new builds. This may increase the number of new builds even more.
- Rich: Have seen estimates for the number of new builds based on these data (Fairplay) that are all over the place. Doesn't know if we'll be able to analyze the data and get the information we're looking for.
- Jon: The industry will want pieces of information: Are technologies available to put on my ship? Yards want to know if they can install them on the ship. If there's a problem, is there someone who can install it or fix it for me?
- Kevin: But they can't order technologies without type approval.

- Rich: There could be class approval system (type approval), since CA isn't required to do approvals any specific way.
- Kevin: There are differences between class society requirements and environmental requirements. The American Bureau of Shipping (ABS) has indicated that they can offer a conditional approval, reviewing the mechanical, electrical, structural elements. But this approval would not consider the environmental or efficacy requirements, and would be voided when the environmental process for approval came out. Regarding implementation dates, does California use the same definition as the IMO? For example, "delivery" date is different from a "keel laid" date. Assuming an 18 month build cycle, vessels with "keels laid" in 2009 wouldn't be delivered until mid-2010. Treatment technologies would need to be delivered in the middle of the construction process. It will be a challenge for technology developers [to ramp up the infrastructure] to deliver the quantity of systems which will be needed. Implementation efforts need to consider the difference between keel laid and delivery dates, and the time it will take technology to respond to market demand.
- Jon: Asked for clarification on grandfathering in CA law.
- Maurya: Vessels accepted into either SLC or USCG programs by 2008, are good for 5 years. She noted that originally, author of bill didn't want grandfathering.

Efficacy Questions: Will any technology meet the CA standard?

- Greg: (question) What if there's a technology that meets the standard for one organism but not others? Is there anything that CSLC has to say about it?
- Maurya: would like to get input from those doing the work. In report, would like to know, so we can put in report and include considerations in report.
- Junko: How were numbers decided for bacteria and viruses?
- Greg: Current numbers of bacteria were examined in exchanged ballast water, and the standards dropped this number down several orders of magnitude. A similar process was used for all other categories. The rationale was that technologies needed to be a significant improvement on exchange. The TAG looked at concentrations of organisms with no exchange, proper exchange, and then estimates on treatment technology requirements. The discussion/selection of standards was somewhat open after those. We do not know the shape of the dose response curve, so we could not base the standards on that. A standard based on this curve would've been the "right" number, but no one can answer that question at this point.
- Tom: How were numbers chosen for viruses and bacteria? (33 or 126) They seem baseless. [Info after workshop: E. coli and enterococci numbers come from the EPA recreational contact water quality criteria. http://www.epa.gov/waterscience/beaches/rules/bacteria-rule-final-fs.htm]

- Rich: These are existing water quality standards for U.S. waters (recreational use) for indicator organisms. The bacteria IMO numbers come from EU requirements for water quality.
- Tom: We are not equipped to answer questions on why these standards were selected for microbes. We need pat answers for why these numbers were chosen for the vendors.
- Rich: Thought they came from EPA recreational contact number. The EPA standards are means, coupled with a particular sampling structure behind them – that's why they seem a bit odd. When they [means] were plugged into the IMO standard, the statistical considerations were left out, and that's where these numbers come from.
- Maurya: These were also the numbers in federal legislation at the time - SB 1224, and HB in 2005. She noted that a certain part of advisory panel wanted IMO numbers cut in half.
- Jon: If those are the numbers that can't be changed, we need to determine how to determine if an existing technology meets them. Suggests looking at 2 things: data the developers used to evaluate their systems. The question then becomes, how do you interpolate existing body of numbers to determine that anything meets it [the standard]. There's lots of water treatment techniques (more specifically chemicals) that will meet it, but will kill surrounding environment. That's a whole different question – can it meet it the way we want it to?
- Tom: The matrix here answers these questions. Over ¾ of them are the same chemical. ¼ are non-chemical filter things. Then there are a few others. There are really only a few technologies out there. If you lump these, you're really talking about a single class of compounds. Over ¾ of what you got can clearly achieve the standard. But the active substance issue puts another twist on it. Non-oxidizing chemical can meet the standards (Seakleen, etc) - coffee can do it if you use enough. Any of the biocides can do it. The filter ones won't be able to do it by themselves, given the size range of organisms involved. Almost need to answer these questions by degrees.
- Maurya: We need to consider that the reality of operating in CA will be that technologies must meet environmental requirements.
- Tom: Given CA's standards, and IMO-like standards, it's got to be an oxidant.
- Greg: Agrees that there are several gateway questions to determine efficacy: Is the system effective? Is there a technology that has been scaled up that will work at ship scale? And then there's the toxicological question for discharge and delivery. We can't really decouple [an evaluation of the] chemical from the system.
- Ted: There are mechanisms available (e.g. waste water treatment facility systems), but the question is if they can work or do work at the ship scale. The answer is yes: there are waste water treatment systems functioning on ships, not for ballast water [for sewage]. [In response to Greg's comment] Would add that the toxicological (environmental) question needs to address the ship impacts question as well.

- Maurya: That last question will be a large part of the report.
- Kevin: There are efficacy, toxicity and implementation questions. Efficacy and toxicity are a balancing act or a 2 step process. For implementation, shipboard application, technologies will need to be approved by classification societies in way of vessel and equipment safety concerns. For the few treatment systems which are in this process, these concerns are resolvable. As such, classification society construction related approval is possible and likely for most treatment systems. Part of implementation is construction concerns. For chemical application, generation onboard requires space and electrical power
- Jon: Current installations are currently generating data on these issues due to the IMO standards push.
- Greg (question): What is the extent to which pilot testing have been scaled appropriately. EX: some have been tested on only 1 tank – not sure if they can operate on a full ship scale [e.g. with all ballast tanks in use].
- Jon: There are several that have been scaled on a full ship scale, but not very many.
- Kevin [presented his revised matrix]: I would suggest a **Cost Metrics** Section. It's inaccurate to judge cost of technologies by cost per ton [of ballast water]. Need to consider vessel type. For example, some vessel classes may not typically discharge ballast in port but need a ballast treatment system for occasional or backup use. In this case, a cost per year of operations might be more accurate than cost per ton of ballast. For other vessels the best cost metric might be cost per ship call. One should also consider life cycle costs (capital dollars to install the technologies vs. operation, consumable and maintenance expenses). The life cycle process is a good way to evaluate the costs for putting a various technologies on a specific vessel class.   A cost metrics approach should identify which technologies are practical for a given vessel class. For the **Tests and Approvals** section, a checklist may help. For toxicity most testing is appropriate in lab. Nationally, if a chemical is going to be sold, it likely needs a FIFRA registration. For use in a given state, that chemical will likely need to be registered in that state (might need more input from a toxicologist). "Classification" – talking classification societies; PVA = product design assessment (looks at mechanisms – electrical, flow, etc – is it responsible shipboard considerations); MA = manufacturers assessment (Can the supplier repeatedly build the item. Periodic factory tour to review).   Completion of this Tests and Approvals checklist would result in the technology being ready for type approval (ready for sale, commercially available and approved). The **Installation Section** looks at the time it takes for vessel installation planning, equipment procurement and installation. Vessel installation plans (interface with vessel structure and systems) can take 1 – 2 months, with marine regulatory review (once new policies regarding ballast treatment systems are established) will probably be a 1 – 2 month review cycle. Lead is the time between order and delivery for equipment. This will range significantly depending on complexity of the systems. (EX: engines can take 24 to 36 months. A valve could take 4 wks -3 years based on complexity of the treatment system.) The shipyard process will vary significantly depending on what other work

is being accomplished and the complexity of the system. A simple chemical dosing system could be installed in days. A complex system (assuming no other construction efforts) could take 1-2 months.

- Jon: A big question that came up for IMO: What does “available” mean? Disagree that a small company won’t be able to meet the needed output [demand]. If you have the design and have gone through the pre-qualification process a company, a small company can have manufacturers around the world pump out thousands of technology systems pretty quickly. The real issue will be supporting them the systems after they’re delivered/installed on ships - for parts, service and resupply [e.g. for chemicals]. Availability shouldn’t mean the ability to build –that is not an issue. The real issue is after-sale support.
- Maurya: Agree with Jon for the big guys. But most companies don’t have their ducks in a row. Some of folks are doing it in their backyard
- Kevin: Even the large companies with a complete system designs will have significant effort determining who’s going to do manufacture the equipment. This will require time to get contracts, perform QA/QC, interface with designers, etc. Treatment system company representatives will need to attend the shipyard installation effort before hookup, during building and at commissioning. Can’t go from 0-1000 treatment systems just like that. Even for a simple system it’ll takes 1-2 years to get a high volume production and installation support process going.
- Maurya: Agrees - the RJ Pfeifer took 3 times [modifications] to get it right. Installation and proper operation often take more time than planned.
- Mike: There is a reluctance [amongst system developers] to consider post-treatment element (e.g. neutralize byproducts out the pipe). They (developers) should be considering post treatment consequences.
- Kevin: One difficulty is that it’s expensive. Two treatment processes [e.g. treatment and neutralization] can double the complexity of a system, making it more expensive, and more effort to install. This water quality requirement makes it difficult for companies to compete with another agency that doesn’t require it. Need to level the playing field. Techcross got basic [IMO] approval without any dechlorination. Severn Trent doesn’t have approval, but dechlorinates. How do you level the field?
- Ted: Severn hasn’t asked for approval, it’s not that they wouldn’t be approved.
- Junko: Within G9 there’s a suite of evaluation procedures for toxicology issues. Perhaps Severn Trent hasn’t done it, but there are now systems in place to evaluate this.
- Ted: All basic approval says is that a system isn’t so bad that they won’t look at you. G9 final approval is where the real approval process will occur.
- Rich: Basic approval looks only at basic literature for toxicological impacts and lab testing. For chlorine, there’s a huge existing literature, so it’s easy to evaluate and feel comfortable to be relatively sure that it is okay. Basic approval is not really an approval, as it looks only at the chemical and doesn’t look at the specific technology that a vendor will bring for approval.

- Rich: The G9 process also requires countries to apply -not the vendor. This presumes that the country's administration does a careful review of a package the vendor brings to it, and will forward on to IMO packages that they have deemed to meet the IMO G9. It's clear that many country's administrations are not doing adequate prescreening. That process does not resemble legal structures in US. The G9 is carried out under the [IMO] convention, but for legal purposes, that convention doesn't exist (has not been ratified, not enforced). Thus, the US can't do anything to meet its responsibilities under the convention. Constitutional authority issues come into play, there's no US agency to perform the functions required, until the convention is ratified. This is a problem for US developers – There's not a way to do this through the U.S. Other federal governments don't have this problem.
- Jon: 2 immediate barriers to ratification of Convention by many countries. 1) Not all relevant guidelines are finished. Many nations (UN member nations) legally unable to ratify until all guidelines are finished. Still without one guidelines (G2) – methodology incomplete. 2) Next factor, if a country hasn't ratified, most of those countries have in legal framework that they can't type approve. If they are a signatory then can type approve, but otherwise they can't approved techs without ratification. Other administrations can't ratify [technologies?] without convention ratification.
- Rich: Need to keep in mind, that because there is technically no convention, all of these G9 approvals don't have a legal basis. It only means that the system has been deemed to meet requirements specified in document. When convention actually comes into force, there will have to be a mechanism where past decisions are brought into legality. Many lawyers aren't sure how it will play out, particularly since the G9 process changes from meeting to meeting – methods and requirements change at every meeting. How they [IMO] will go back and reconcile old approvals with later ones (ex: Alfa Laval has gone through G8 tests vs. someone entering later under a substantially different approval testing process), and how IMO will level the playing field is in question. They may not.
- Kevin: So what will happen if an approved vessel (IMO) shows up in CA and wants to discharge?
- Maurya: It's very clear that it must meet CA's standard, or no discharge.
- Rich: It doesn't mean anything, especially without a convention in place. For the federal government, if there is evidence that testing was equivalent to U.S. Federal requirements, then it may be allowed. Otherwise, it's not allowable.

Break

Nicole: Where are we with these systems? Are any able to meet CA's standards? If not, what kind of time scale are we looking at?

- Jon: Need see what technologies have been installed on a ship. The other question is if it is being tested and how is it being tested? There are people that have shipboard installations of one scale or another. You'll have to work backwards. As for who's releasing info now: Alfa Laval, Ecochlor, Severn Trent – the testing is predicated on testing with STEP program.

- Lucie: There is testing for chlorine dioxide (ClO_2) on the Atlantic Compass (ro-ro/container). This is both endpoint testing and time course testing on voyages from Newark, Baltimore, Portsmouth and back to Newark. We're looking at viability at discharge – and tests so far indicate that the ClO_2 systems meets CA standard. Toxicology testing is being done also. We found that going from bench scale to ship testing was totally different. We are also looking at differences between testing in-tank and at discharge. When testing/evaluating these systems, need to consider that all tanks on a vessel will outlet at one or a few given points – this means that when testing treatments against controls, the piping system needs to be taken into consideration and you may need to flush pipes before testing, if they have not been treated. So, it's a question of logistics. Also need to keep in mind that testing a vessel brand new without sediments in tanks is ideal, but results may be different from tanks that already have sediments. Have found that tanks already having sediments, we sometimes see 'regrowth'. Treated tanks with less sediment have very good results.
- Maurya: Should it be recommended to vessel owners that they should do a thorough tank cleaning before testing?
- Kevin: In drydock, common to clean ballast tanks out anyway. Ship effects are something to consider – good example here – that will affect results. Sea chests, piping configurations, etc. other ship effects need to be considered. Usage also.
- Ted: Regardless of what data you evaluate from ships, need to focus on testing samples at discharge. CA's standard is a discharge standard. Also, we have no faith in tank sampling (at ETV). The results have been extremely variable and unpredictable, even under extremely calibrated circumstances. Focus on in-pipe sampling for a hard measure on how well technologies are working. This will be difficult, because folks have only started looking at this.
- Jon: Believe it's safe to say that the answer to question 1 (will any technology exist) is yes. It is probably not there right now, or in a quantifiable state. There's enough indicative information data wise and corporate structure wise, that they will exist. As for dates [when it will exist] it's very nebulous. Many companies are viewing ballast water as a marketplace that will boom soon, but are waiting for these kinds of decisions [performance standards, evaluation methods, certification pathways] to decide when to grab a technology and begin ramping up production.
- Nick: If you go down list of standards, believes that for 50 microns, yes – technologies can meet it. For then next one, no. The methodology to test is not agreed upon – this is the key. For the less than 10 micron category (< 10 per mil – Bacteria) there is none that meets it, because there is no "viability" clause. Particles will always be there. For viruses – there's no testing that can evaluate this, because they test at 10^7/ml [sensitivity level?]. Current methods don't get down that far. For *E. coli*: yes. I Intestinal enterocci: yes. *Vibrio*: Yes.

- Tom: There's a difference between the analytical procedures used, vs. asking the question, "can it be done". Can't imagine that there's a procedure to enumerate the viral load in ballast water. A standard like that doesn't make sense from a monitoring point of view. The bacteria standard can be done (in waste water treatment systems). If you can't measure it, the question is why it's being used anyway.
- Kevin: Do these have to be [physically] testable? Would CA approve without actually conducting a test – e.g. could it do it by reviewing information?
- Rich & Ted: you run into problems. Their statute probably wouldn't let them do that because it implies use circumstances. USCG's statute may allow that – we only have to approve.
- Rich: Agree with Nick, but doesn't agree if it tells us anything about if technologies are available. Just identifies a systemic problem [of methods/protocol development].
- Kevin: Maybe for the ones [standards] that are possible to measure, we measure. For others we evaluate through a literature/theoretical review (e.g. bacteria counts)
- Rich: It seems that CA statutory language requires CA to do the physical testing.
- Maurya: agrees
- Rich: If you implement as Kevin says, thinks you'll be in court real quick
- Greg: Thinks Nick is right on for assessing numbers [if technologies can meet the standards currently]. Don't agree that they can't be measured. The issue is that there's no accepted approach. This is not a technological barrier, but a process approval for what constitutes appropriate technology.
- Nick: Yes. Testing is achievable, but we have not agreed on how to test.
- Greg: Defaulting to the literature is not necessary. As long as the process for measuring is identified, we can do it.
- Jon: So can't California specify testing methods [protocols] that must be used?
- Maurya: Yes – we are working on protocols.
- Ted: Fears that protocols will be based on input from folks that do water testing [water quality, waste water treatment]. ETV has encountered many problems during testing. When you do it, please involve appropriate folks.
- Maurya: Will proceed with the standards numbers as is. If it comes out that these are totally untenable, we can try to get back to legislature and try to change some things – e.g. if testing for some subset of the standards are not available, can we focus on testable ones.
- Kevin: What vessels want are approved systems with instructions that show the operator that as long as they operate per instructions, they are in compliance.
- Maurya: this is something that industry really needs to push on technology developers. That is only going to happen if industry demands it of the technology guys.

- Jon: That will be a commercial/practical reality down the line. The struggle is before that – how to determine initially that the equipment works legally. The first question right now from a ship owner is “which one is approved in the U.S.?” That will make systems “available”.
- Kevin: Once that happens, a clock starts for when a technology is “commercially available”. There will be a delay between approval and availability.
- Maurya: Yes. The primary question has shifted through the years. Now that we’ve got standards, the issue we get from developers/industry is now, “we can’t develop a technology unless you tell us how to test it”. Now is the time for developers to step up to the plate that do it.
- Ted: The Navies around the world (France, UK, Turkey) are today designing BW treatment systems in their ships, and procuring, and specifying specs today. It is affordable and doable today.
- Jon: Realistic to expect that there will be systems for all vessel types. Growing pains still need to be sorted out, but this is probably not insurmountable. It’s still a timing issue for when they get through the pains.
- Kevin: If you only consider physical possibility: UV/filtration is commercially available for small vessels. Others (Nutech, Severn Trent etc.) should be commercially available in between 6 mo-2yrs. (will need 2 years to test for operational quirks), for larger ships. All will need some additional time to ramp up production to meet volume demands. As such, the IMO implementation dates look reasonable from a physical production standpoint. This evaluation is independent of efficacy review and independent of an approval process. These remaining issues [efficacy of systems & approval process] will add more time to the process.

Nicole: We’ve had difficulty getting information on toxicological impacts – Anyone have input on where we are on that?

- Jon: There’s no system working on a technique that hasn’t done at least some toxicological testing. Maybe data isn’t complete for CA purposes.   Testing has been opportunistic. There’s data to indicate that will be ecologically acceptable.
- Lucie: We need to provide information on what testing is acceptable. Look at Washington as a guide for testing – this is what is needed. Needs to be agreed upon.
- Rich: The USCG doesn’t test for toxicity and has deferred to EPA. EPA is not dealing with it yet.
- Maurya: What are you doing with the STEP evaluations and toxicity then?
- Rich: Telling them [developers] to talk to local jurisdictions about acceptability of discharges.
- Ted: There are provisions in ETV evaluations. Whole effluent testing must be conducted, but there is no information on the criteria for testing.

- Maurya: For CA, if a chemical is not on a “List” (e.g. the Ocean Plan), then there’s no guidance.
- Ted: It’ll be important to specify input water conditions before testing – existing water quality issues will influence output test results.
- Kevin: WA State’s process looks complete (from an engineering standpoint) and good – any opinions on it? (Laboratory Guidance and Whole Effluent Toxicity Test Review Criteria, Appendix H, http://www.ecy.wa.gov/pubs/9580.pdf)
- Lucie: Ecochlor has chosen to test according to WA guidelines because it was felt that the guidelines were complete and available.
- Mike: Looking at single ships with a single treatment technology is a totally different process from a type approval process. A “no significant impact” finding for STEP means only that one ship with one experimental BWT system visiting one U.S. port, say, 10 times per year, does not pose an environmental threat. This is a long way from a type approval that would include some sort of review and approval for residual discharges on a much larger and more widespread scale.
- Jon: Is there a transitional language for the CA regulations that dovetail with a Federal program if it comes into effect.
- Maurya: If a national program that is comparable to the state program comes about, we report on the comparison to the CA state legislature, and then make recommendations (e.g. CA program can go away).
- Jon: So there is a responsibility [for California] to try to bring pressure for a federal program to come into existence. A fragmented state by state program isn’t desirable. What is the status on federal level?
- Rich: USCG is doing a rulemaking and is well into it. USCG is not at a point to tell the public what the standard will be. That will occur during the announcement of proposed rulemaking. However, our standards will not preempt states form having their own programs. Really, it is up to Congress to decide if they want to change the federal landscape, and they have been unable to do this thus far. Only one bill has ever made it out of committee, of many that have been introduced.
- Jon: Do you think that what has occurred with STEP applications have clarified the questions here?
- Rich: No. We’re in the same place or less informed than CA.
- Jon: Ship owners are looking at STEP program approval as the same as a type approval, in the absence of an actual approval process.
- Rich: There is only one system that has gone through formal testing (Alpha Laval). The problem is that the only evidence available that they have met DNV type approval is a statement by DNV that “it passes” the D2. No data or scientific results have been made available on results on methods, assumptions, etc... We can’t evaluate what that means. I’ve only seen select data at Alpha Laval’s choosing – which brings forward lots of questions of validity of that testing.

- Maurya: Agree – for me, anything that hasn't met USCG or CSLC acceptance won't work in CA.
- Kevin: When Alpha Laval comes out with an announcement that they have DNV approval, many [shipping] companies will take the bite [and install their system].
- Maurya: That is why CA has been adamant that Federal approval is really important – otherwise installation won't do shippers any good.
- Tom: It's unfair to compare Alpha Laval who has the finances to move forward with technologies that might work, with small companies who don't have those resources [and are waiting for a sanctioned approval process] and will suffer. They can't move forward, because they aren't protectable against a similar competitor. Large companies don't need approval to move forward, they are moving forward regardless because they can protect themselves. It seems unfair to small companies to force them into toxicology testing, with something that's been tested all over (e.g. chlorine) through other applications (e.g. waste water treatment, power industry). From a toxicity point of view, residuals will be the same from a ship – why would they be different? Novel biocides will need testing.
- Maurya: What is the rationale for dealing with shipboard issues so differently from waste water treatment discharges?
- Tom: People in that arena (EPA) don't work in this area [with ships] – its too different, different expertise, different people. Regulation though EPA here wouldn't be manageable, or good.
- Jon: There's a perception in the media and some circles in the environmental community and in the world of traditional water treatment general trend to move away from chlorine and looking towards new technologies in the waste water treatment world. There is a stigma in some environmental circles and perception presented in the media that chlorine is a thing of the past and we should be looking towards innovation.
- Kevin: It's stationary vs. mobile sources. For stationary sources, we can model discharge effects. With a mobile source, the community that a vessel calls on doesn't have opportunity to test in the same way.
- Ted: That said, there's no aversion to chlorine in the [shipping] industry. Nor for the regulatory agencies, because regulations exist for chlorine. There are regulations in place.
- Rich: The same thing happened with IMO. There's a group that is adverse to a use of a new group of chemicals. There are separate sectors working to the same anti-chlorine perception – slowing development down.
- Jon: But it [chlorine] is one of the best documented methods for treating things. We know how it works & its quantification of negative impacts. It has been acceptable for years. For an interim solution at least, it's a good starting point.
- Maurya: The issue has been a frustration for CA – the best available technology is chlorine, but there is a huge resistance to it.

- Ryan: EPA views the NPDES process as a shield for a company's responsibility to protect water quality. When it comes to treatment systems, the agency [EPA] has the responsibility to issue NPDES permits that are protective of water quality. At that point, a citizen's suit goes after EPA, not ship owners. Until Sept 2008, ships are exempt from NPDES permits.
- Tom: Has CA considered looking at waste water treatment/industrial waste discharge standards in general, and moving them onto ships, without a permitting issue? The shipping industry is like any other industry at the dock and must follow the discharge requirements like any other industry. Look at chlorine limits for industrial waste discharges, and convert to use for ships. This approach could be a beginning point. Many [discharge standards for many constituents in waste water or industrial waste] won't be pertinent, but at least for those that are; you've got the same matrix on them.
- Kevin: Could use shipping lanes as a discharge zone.
- Tom: Discharge standards (industrial) are based on water quality standards. Can't imagine anything from a ship will affect standing water quality standards.
- Maurya: We would look at the strictest existing water quality discharge standard in CA, and extrapolate to ships.
- Jon: Clearly, these issues have already been well investigated, tested, etc…why recreate the wheel?
- Maurya: Notes that we have been getting little guidance from CA state water board.
- Ted: The toxicity thing for ships seems no big deal compared to industrial discharges.
- Rich: Does SLC have authority to regulate a discharge (toxicity) to state waters? Discharge standards exist for much greater volume. If we're suppose to pay attention to environmental effects, a good bit of logic would be to base it [ship discharges] on what's already allowed. If we maintain that standard, it won't be a significant increase on status quo. Water Board has already said what's acceptable for discharge, and you wouldn't be out of line with that.
- Maurya: Because of the lack of participation from Water board – they have offered no assistance in evaluating toxicity.
- Ryan: Look at wastewater discharge standards. Many, though not all, elements [discharge constituents] will be analogous.
- Kevin: USCG has authority over ships calling to US water for oily water discharges, & MSD levels. It would be a logical next step for U.S. Coast Guard to determine a discharge standard for ballast water toxicity. SLC could then take care of state issues starting with U.S. Coast Guard discharge standard and framework, and modify the standard as needed. This scenario follows an existing framework for regulating oily water and MSD discharges.

- Maurya: Could be helpful, but CA doesn't have the luxury to wait for the federal government to put these types of processes in place.
- Tom: But the other way [Ryan's comment], you're not dictating anything new – totally in line with existing standards.
- Rich: If discharges were administered through NPDES instead, every port may in theory have a different discharge standard [which is undesirable].
- Ryan: That is how NPDES permits work ideally [conceptually], but general permits don't in reality.

Nicole: Wrapping up – Are there any important issues we should discuss that we haven't yet?

- Nick: if there are tests that are established, have statistics been considered to determine compliance?
- Lucie: There is a difference between what Scientists consider acceptable, and what will be accepted legally. Whatever you come up with may not be accepted by all scientists. In application you'll need tests that will give you a good idea of what's happening. Scientists should be involved in this process of selection, but other components of the community should participate in the decision of what is do-able/practical and will be legally binding.
- Jon: In response to Maurya's request to be pragmatic. Given that you have to live with these discharge standards, and have some latitude on how to get there (interpretation), lets try to put it in a box in the near term, and tell the industry what [kind of information on treatment technology systems] you'd like them to bring you. Industry will package it according to the variables you ask them to. Then you will have a picture of what's available, and what has to be developed. Jon volunteered to help spearhead that effort.
- Tom: Response to Lucie's comment. As an agency, you have to have some input back into these numbers – they are non-sensical/arbitrary. There needs to be some push back by agency too.

Adjourn

APPENDIX C

California State Lands Commission
Advisory Panel Members

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California Department of Fish and Game

John Berge
Pacific Merchant Shipping Association

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Nick Welschmeyer
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Ballast Water Treatment Technology
Technical Advisory Panel
October 15, 2007
Sacramento, CA

California State Lands Commission
Marine Invasive Species Program

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**Indicates participation via conference line

DEVELOPMENT OF TREATMENT TECHNOLOGY ASSESSMENT REPORT

Per the California Coastal Ecosystems Protection Act, the California State Lands (Commission) is required to conduct an assessment of the efficacy, availability, and environmental impacts, including water quality, of ballast water treatment technologies. In preparation of the report, Commission staff conducted a literature review including scientifically reviewed literature, white papers, grey papers, and manufacturer sponsored promotional brochures and documents. Additionally Commission staff hosted a technical workshop in Boston in May following the Fifth International Conference on Marine Bioinvasions. A draft of the report was made available to the Advisory Panel on August 24. Comments were received through late-September, and on October 4 a revised draft and a response to comments was provided to the Panel.

TIMELINE

A final draft of the report, incorporating suggestions from the Advisory Panel meeting, should be completed by November 8. The final draft will be presented to the Commission on December 3 in Sacramento. The final draft will be posted on the SLC website at least 10 working days prior to the Commission meeting. Comments on the final draft can be submitted by the Panel and the general public prior to and at the December 3 Commission meeting. The Panel will be advised of when the report is posted to the website and of the details for the Commission meeting.

OVERVIEW OF TAG QUESTIONS/CONCERNS

Each Panel member was asked to voice their questions or concerns (if any) related to the draft report emailed on 10/4/2007. In summary, they fell into the following categories:

Legal Issues:

- Potential conflict between California State standards and Federal ballast water management regulations. Will technologies compliant with California law still have to exchange ballast water to meet Federal requirements? (Swanson, Schilling)
- Ballast water requirements of other countries, and information on the international nature of the issue are missing and should be included (Ward)

Water Quality Requirements and Issues:

- Particularly in light of the submitted comments from the State Water Board, and the EPA lawsuit, what will the process be for implementation and approvals for active substances (Holms, Everett, Ruiz)?
- Who will implement an approvals process, and what are the implications for the California performance standards implementation (Holms, Everett, Ruiz).
- With regard to comments made by the State Water Board regarding active substances, how will technologies that meet California's standards and water quality requirements be applied in other states or countries (Berge)
- Concerns of the State Water Board were submitted in a revised draft sent to the Panel (Ward

Onshore treatment dismissal: Premature dismissal of onshore treatment (Cohen, Ward)

Implementation delay: Basis for the one-year delay (Cohen)

System approvals and compliance protocols: Approval of equipment, and discharge testing (protocols) for verification of compliance (Cohen)

Effectiveness of interim management: Ballast water exchange (Fredrickson)

Economics: Removal of information on lack of investment as a reason why advancement of technologies have been slow (Cohen)

LEGAL ISSUES (FEDERAL/STATE CONFLICT)

Though Commission staff recognize the desire for consistent standards with the state/international community, California's standards were set by State legislation and the Commission does not have ability to change them directly. At the Federal level, several activities may impact the Marine Invasive Species Program (MISP) (bills, law suits), however, the Commission must proceed with what it has been legally mandated to do, regardless of these other activities (Gregory, Falkner, Dobroski). This point should be better asserted in the report (Bolland).

If EPA loses its appeal and NPDES system of regulation for ballast water discharge moves forward, or if any of several federal bills passes, it is unknown what will occur (Berge, Ward). The State program and State standards may go away, particularly if preemption language passes with any of the pending Federal bills (Gregory, Bolland). The EPA could dictate minimal standards, as it does with the Clean Water Act, allowing local standards to be stricter (Cohen). In that case, the State Water Resources Control Board (SWRCB) could adopt a general order directing folks to Commission standards and requirements, in which case the current program may not be eliminated (Ward). If the SWRCB and/or the Regional Boards become responsible for administering the program and/or standards, several issues would have to be resolved: Existing water quality control plans (Basin Plans) would have to be reviewed. There is a policy for implementing NPDES permits, the State Implementation Policy, that must be reviewed and taken into consideration (Feger). Possibly, a general permit could be put forward directed towards specific age and types of vessels (Ward).

Other Notes:

- (Reynolds) It may be relevant to discuss in the report how implementation may be impacted by potential federal regulations

IMPLEMENTATION DELAY (from 2009 to 2010)

The purpose for proposing a one year delay for the first implementation date was to allow time for the development protocols to verify compliance (<u>not</u> certification protocols), and to provide time for technology developers to test prototype systems against California's standards (Dobroski, Gregory). Because the standards have very recently gone through legal process (approved by the Office of Administrative Law on October 15, 2007) companies have not been testing to CA standards, but to the much weaker IMO standard (Falkner). It appears that many technologies are very close to meeting California's standards, and that a major holdup is that the standards haven't been on the radar long enough (Dobroski).

Ship owners will want to have a set of compliance testing protocols, so developers can demonstrate that a system meets the out-the-pipe standard. Only then can owners begin the process of installing systems on ships. Though they need the standard, they also need protocols for testing systems, since different testing methods can yield different results (Reynolds). Even though protocols may change through time, a consequence of not having a testing procedure in place was that Staff could not tell if any system met California standards due to the variety of testing methods/reporting used, and because most developers were testing to the IMO standard (Cohen, Falkner).

It was also noted that a delayed implementation could be well used to resolve a process (through the Commission and SWRCB) through which systems that use active substances could be deemed acceptable for use in California (Ruiz) (see notes below).

In addition, the delay would allow for the development of guidance testing protocols to assist developers as they test against California's standards, so they may "self-certify" their systems for potential buyers. These will not be used by the State of California to certify systems (Gregory). Ideally, Staff want to avoid a situation where vessels arrive to the State with treatment systems that developers claim meet the California standard, but don't. Discharges in that case could cause more harm than good (Falkner). The delay was not driven by the lack of techniques for measuring the <10 micron count standard (Dobroski).

There was concern that one year may not be adequate to complete these tasks, if compliance protocols are projected to be completed by mid-2008, and that one year delays will continually be requested/proposed (Bolland, Cohen). The IMO suggests that prototype systems be tested for 6 months to capture at least 3 seasons. Following that, a new clock starts for developers/manufacturers to conduct verification, equipment adjustments, design efforts, production, installation, shipyard availability, etc (Reynolds).

At this point, Staff believe that the desired goals can be accomplished with a one year extension for the first implementation date (Gregory). The number of vessels that come under the first implementation date is very small. Since 2000, there have been approximately 250 vessels that have entered California and discharged ballast water in this size class (<5000MT) [Note: 695 unique vessels (dischargers and non-dischargers) in this size class have called on California ports between January 2000 and June 2007.] If we assume a 20-year replacement cycle and that 5% of the vessels (695 over 6.5 years) may be replaced per year, we can expect to see approximately 6 new vessels in that size class subject to the 2009 (2010) implementation date requirements (Falkner, Reynolds). Most of these won't hit the water until 2010 or 2011. Compliance verification protocols and suggested testing guidelines for technology developers will be developed in consultation with USCG, maritime engineers (e.g. Spencer Shilling, Kevin Reynolds, etc), by 2008 (Falkner). It's unlikely that subsequent delays would be granted by the Legislature (Gregory). Both the IMO and federal bills are considering various implementation delays (Falkner, Everett). The Commission does not anticipate requesting another delay, even if the industry requests one (Holms, Gregory).

There were also many questions and concerns regarding how technologies that utilize active substances will be deemed allowable with regard to water quality issues (Ruiz, Everett, Berge). Many of the most effective/promising systems utilize active substances, but without some procedure through which developers can determine if their systems can be assessed in this regard, there was fear that technologies may not move forward, and may be another source for delay (Ruiz, Everett). Companies will not want to buy and install systems on ships unless they are guaranteed that it will meet both the biological standards and water quality requirements (Reynolds). Specific questions and points included:

- How does a discharge permit review for active substances get done, and how long will it take (Ruiz, Everett)?
- How will the State determine if someone is in compliance? (Includes verification protocols, how many tests, where is the sample taken, etc). A step by step checklist should be provided to technology developers so they may test systems, as they won't be able evaluate this through any existing documentation (e.g. California Ocean Plan). (Ruiz)

It is currently not clear how active substance discharge compliance will occur (Ward). The SWRCB and the Regional Water Quality Control Boards don't currently have a permit process in place for mobile entities like ships. Generally, Regional Boards don't prescribe specific technologies to meet specific established permit limits, but they do have dischargers self-monitor and evaluate whether they met their permit limits. Complying with permit limits for some pollutants can be difficult to achieve and some permits have been written with compliance schedules and a date by which they will comply with the limits. Applying these procedures to mobile ships would be a totally different animal, and won't be a quick issue to resolve. It should probably be a process that the Boards review, while the EPA lawsuit is being resolved (Feger).

For issues specific to ships (unpredictability of volumes of discharge, timing of discharge, etc.) it seems reasonable that the SWRCB may implement an NPDES process, as it addresses similar issues for onshore facilities. However, it is not clear how this will happen (Berge, Ward).

The USCG and California are aligning protocols for compliance testing, which should help get the word out to developers. However, since California isn't planning on doing type testing (certifications), protocols won't be aligned in that respect. For the water quality/active substance issue, however, it's not known if alignment will occur, especially if California has varying water body-specific requirements (Berge, Everett).

SYSTEM APPROVALS AND COMPLIANCE PROTOCOLS

Following much discussion with colleagues and lawyers, the Commission has decided it will not be type approving systems/equipment. The technology developer will "self-certify" compliance with California's standards. Vessel owners will be responsible for asking the developers how standards have been met. Part of this will be reflected in regulation. A separate issue will be the development of end-of-pipe testing for compliance (Gregory).

Compliance for the biological NIS performance standards is currently under the jurisdiction of the Commission who also has the ability to impose civil/criminal penalties. Currently the Commission is directed to inspect and sample at least 25% of all arriving vessels. The 2006 Coastal Ecosystems Protection Act also allows other entities to impose civil penalties (Holms, Falkner). Water quality compliance for active substances would be deferred to the State and/or Regional Boards (Berge, Gregory). Self-certification of treatment systems will be the complete responsibility of the technology developer, and will not involve the Commission (Cohen, Gregory). There will be a regulatory need to direct the certification process, but not define it. State will only develop non-regulatory, non-certification guidelines for testing (Gregory). Ideally, a 3rd party would certify testing for the technology developer (e.g. Lloyds), but would not be submitted for regulatory review by California. This is so developers can have the latitude to select who does their own testing (Reynolds, Falkner). It should be clarified that self-certification is not legally required, but is an effort to assure quality products (Cohen). It is not clear if labs will be certified to perform the testing or not (Morin, Gregory).

Other Questions & Suggestions:

- (Ward) The FDA has testing techniques to test pathogens rapidly (especially Vibrio). Also, there was no reference in the report to the California Department of Health and their capabilities. The State Water Board is teaming up with thee groups to investigate such methods.
- (Bolland) There should be an effort so the SWRCB will be actively involved in development of protocols, in anticipation of whichever way the legal situation pans out
- (Holms) Will the Commission have the capacity to implement this program or collaborate/delegate components to others? Gregory: The MISP has a staff of 19 (inspectors, scientists, database management), and the State Water Board has one person year (PY) paid through the MISP funds. There may need to be a boost with a few more scientist staff, but the resources should be there. If the SWRCB samples for active substances testing, the Commission can assist them, or get the samples for them.

OMISSION OF SHORESIDE TREATMENT

There was a concern that a review of shoreside technologies was prematurely dismissed from the current report, and that the argument that they were overly costly and not practicable for vessels that discharge before coming to port were not adequately evaluated or proven. Onshore systems can be built to meet the standards (Cohen).

The 2006 Coastal Ecosystems Protection Act required assessment of currently available technologies. All of the current prototype treatment systems are ship-based, and there has not been any prototype shore-based systems developed. Thus, the emphasis in the report was on ship-based systems, as they were the only ones currently available (Dobroski, Falkner). Shore-based systems were not included in this report because the legislative intent evaluating technologies 18 months before each implementation date was to determine what systems might be utilized by the time each implementation deadline arrives. There was no data to evaluate the effectiveness of shore-based systems (Falkner).

Evaluations have been completed for California and Seattle and overall conclusions have been that shore-based or barge-based systems would be practical for specific vessel or trade route groups. However, they are not universally applicable for a system like Puget Sound because vessels must discharge long before arriving since cargo loading rates greatly exceed deballasting rates (Reynolds). Though no technology should be dismissed, from the viewpoint of shipping companies that have vessels transiting around the world, a shoreside technology would have to be available everywhere vessels go. Companies want to be able to go anywhere and reduce invasive species discharge, including small 3rd world country ports that may not have the resources for such facilities (Berge). For future implementation of a shore-based system, it would be the ports that would have to initiate such efforts (Swanson).

Other Notes/Suggestions:

- (Holms) A couple of sentences could be included stating that shore-based might be attractive in the future.
- (Cohen) It may be good to get someone to gather information on the feasibility of onshore. This may or may not be CSLC.

EFFECTIVENESS OF INTERIM MEASURES

Justin Fredrickson (CA Farm Bureau Federation) wanted to be filled in on the effectiveness of current management measures (ballast water exchange), and if enough is being done to curb species introductions. Specifically, why there is a 55-99% range for effectiveness of ballast water exchange.

Gregory Ruiz reported the results of a recent NOAA technical report completed by the Smithsonian summarizing reasons behind the wide variance reported for exchange efficiency. Much variation results from how people have estimated how effective exchange is. Studies that report at the low end of efficacy are typically not from controlled experiments or have not looked at how organism composition has changed (e.g. how inshore organisms are replaced by offshore ones). Many of these compare average organism numbers between ships that have and have not exchanged. This method isn't very useful, because the number of organisms in a tank can vary widely, depending on how many are in the port waters at a vessel's origin, or ballast intake point. For experiments that compare control ballast tanks (unexchanged) and experimental tanks (exchanged), reported efficacy is much higher. For these, the range is between 80 to 99%. Even in these experiments, there are variations in efficacy related to the volume of water that is moved during exchanged. Generally, exchange is more efficient when a larger volume of water is involved. Bottom line is that exchange is very effective when conducted properly. Though one must keep in mind that even after a proper ballast water exchange, a fair number of organisms can remain (e.g. if you have a billion to begin with, there will still be quite a few if efficiency is 95%). (Ruiz)

Exchange efficiency is dependent on 2 components – volumetric efficiency (flushing efficiency) and organism efficiency (how many organisms remain). Even after a proper exchange, many organisms may still remain depending on the flow characteristics, or chemical kinetics of the tank, due to ballast tank shape and ballast water intake and outtake positioning/construction (Reynolds). Also, organisms are present in the open ocean, and these can be taken in during exchange (Ward).

There was some confusion over the scope of the Marine Invasive Species Act/Coastal Ecosystems Protection Act (Ward). Both pieces of legislation apply to ocean, estuarine, and fresh waters of California (Falkner).

Historically, most parties involved agreed that ballast water exchange was a good starting management measure, but a better future solution would be treatment technologies. Ideally, the long term use of technologies will lower risk of invasions in the Delta and elsewhere. The reason for moving forward with the timeframe for performance standards in California was to push forward the development of treatment technologies (Bolland).

ECONOMICS & THE SLOW ADVANCEMENT OF TREATMENT TECHNOLOGIES

Specific numbers relating to the ability of the shipping industry to bear the cost of treatment technologies were removed from the original report draft, due to comments that statistics from large companies such as APL and Maersk don't represent many in the industry as a whole. Instead, statistics comparing the costs of systems in comparison to the cost of a new vessel (an increase of 1-2%) were used (Dobroski).

It was noted that it was helpful that the report framed the costs of treatment systems with respect to the costs of environmental damage caused by NIS. Though no one knows the full costs, they are probably understated here. Conceptually the costs that the industry will bear for technologies are comparatively small (Bolland).

Andy Cohen felt that the report should state that a lack investment from the shipping industry has been a primary reason for the slow development of treatment technologies. In response, it was noted that the shipping industry, while certainly not innocent, did not have the expertise and regulatory backing to develop such systems. When investing and/or providing ship platforms for technologies, the industry needs to do it in with a state/federal/international body so there is legal credence for activities. To its credit, whenever there has been an opportunity to put a prototype system on a ship, a vessel, funds, or resources have been put forward to engage those systems (Berge). Another significant non-financial hurdle has been the inability of regulators to get permits together so the system can be used. There may be a ship and technology, but a permit still must be obtained to use it. Many projects have faltered because of this (Reynolds). It doesn't make sense for a company to put a system on a vessel if the USCG won't approve its use (Swanson). Also, it's notable that standards (IMO) have only been out for a very short while, and an amazing push in treatment technology development has occurred within the last 2-3 years in response (Falkner). Rather than point the finger, it is more useful to indicate how much technology development has cost to date, and how much is needed for the future. The issue is that more funds are needed. The simple point that investment has been lacking is worth making, however. Finger pointing is politically dangerous and not helpful (Holms).

The treatment technology realm is a huge cottage industry waiting to happen. Development companies are waiting to step in and get rolling. Eventually, the shipping companies will pay for systems and the R&D funds used to develop them, as those costs will be folded into the costs of the systems (Berge).

THANK YOU AND ADJOURN