CALIFORNIA STATE LANDS COMMISSION REPORT ON PERFORMANCE STANDARDS FOR BALLAST WATER DISCHARGES IN CALIFORNIA WATERS

PRODUCED FOR THE CALIFORNIA STATE LEGISLATURE

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January 2006

EXECUTIVE SUMMARY

The Marine Invasive Species Act (Act) of 2003 revised and expanded The Ballast Water Management for Control of Nonindigenous Species Act of 1999. In accordance with the Act, the California State Lands Commission (Commission) was charged with several expanded responsibilities intended to prevent or minimize the introduction of non-indigenous species (NIS) from commercial vessels. Key among those responsibilities and specific to this report, the Commission is required to recommend specific performance standards to the State Legislature, in consultation with the State Water Resources Control Board (SWRCB) and in consideration of recommendations provided by an advisory panel (Public Resources Code Section 71204.9). Commission staff convened a cross-interest, multi-disciplinary Panel, and facilitated deliberations over the selection of standards based on best available technology economically achievable and designed to protect the beneficial uses of the waters of the State.

The report summarizes the advisory panel process and the variety of approaches used to guide considerations related to the protection of beneficial uses, economic achievability, and technological feasibility. All approaches provided some foundation for the development of the recommendations, but there are many information gaps, which affected the selection and implementation schedule of performance standards for California. While questions remain regarding the effectiveness and economic achievability of technologies and there is no strong scientific evidence that argues for a specific level of treatment, the Commission believes the adoption of performance standards by the State of California is essential to move technology development forward. Furthermore, the Commission believes that by setting a technology forcing standard and mandating the review of treatment technologies as they relate to the implementation schedule, the intent of the Act "to move the state expeditiously toward the elimination of the discharge of NIS into the waters of the state," (Section 71201(d) of the Public Resources Code) can be achieved. The Commission is also recommending that efforts and progress to meet these standards be monitored so that changes to these standards or the implementation schedule can be made as necessary. Finally, the comprehensive program detailed in this report will require legislation to authorize its implementation. California lawmakers could either codify these standards in legislation or require the Commission to develop and adopt regulations to implement the Commission's report. Lawmakers should also require best achievable technology, rather than best available technology, to ensure the final performance standard is achieved.

RECOMMENDATIONS: California should:

1. *Adopt the Interim Performance Standards put forward by the Majority Panel Report.* The interim standards proposed vary by organism size class, recommending a zero detectable standard for the largest organism size class (> 50μm). It appears these interim standards will be protective of state waters and more feasible than the ultimate goal of zero discharge standards for all size classes of organisms at this time. The Panel Report was beneficial for focusing on the fundamental problem: scientific information does not exist to determine whether any standard, short of zero, will prevent new introductions.

2. *Adopt the Implementation Schedule proposed by Majority Panel Report and adopted in the IMO (International Maritime Organization) Convention for the interim standards.* The phased implementation schedule will require that all vessels meet the interim standard by 2016. This implementation schedule considered the demand for shipyard services needed to retrofit existing vessels and construction of new vessels as well as the speed of technological development.

3. *Adopt the Final Performance Standard of zero detectable for all organism size classes by 2020.* The most protective standard possible, zero detectable discharge, was the stated goal of the Advisory Panel and the Commission. All vessels operating in California waters will be required to meet the final standard by 2020. This implementation schedule considers shipyard services, operational life of maritime fleet, and technology development.

4. *Require initial and periodic reviews of treatment technologies and management practices.* A review of treatment technologies and management options in consultation with stakeholders is necessary to determine whether appropriate technologies or management options are able to achieve the proposed interim and final standards. An initial review should occur no later than January 1, 2008, in advance of the first implementation date of January 1, 2009. A review should

also occur no later than January 1, 2019, in advance of the implementation of final standards. Continued review of alternative technologies and management practices should be required and conducted every three years beginning January 1, 2011. If, as a result of these periodic reviews, technologies are identified that exceed established performance standards, strengthening of those standards should be accomplished.

5. *Grandfather vessels with existing experimental treatment technologies that have been approved by the Commission and/or the USCG (United States Coast Guard).* Provide a 5-year extension to vessels that have participated in an approved program to test promising ballast water treatment technologies prior to the date that standards become effective.

6. *Establish a testing and evaluation center that provides the industry, developers, and regulators an opportunity to take promising technologies to working prototypes.* The current State program does not have the expertise, equipment, facilities, or financial resources necessary for the testing and certification of treatment technologies. This infrastructure would substantially improve the effective implementation of performance standards and the ongoing evaluation of technologies once approved.

7. *Provide additional funding and personnel to expand biological surveys to assess the effectiveness of the State's Program.* In order to evaluate the effectiveness of performance standards or other management measures, long-term biological monitoring is needed. Such work is essential for determining how to change and enhance the Program to more effectively reduce invasions in California.

8. *Consider incentives to promote continued technology development.* Technology developers and the shipping industry are unlikely to continue development of technologies that exceed established standards. Positive inducements that are financially advantageous for the shipping industry could

serve to facilitate the advancement of technologies towards the ultimate standard of zero discharge.

9. *Remove the sunset date in the enabling legislation.* Continuation of the Marine Invasive Species Program will be necessary to ensure the development of technologies and the proper implementation of the standards in the field.

ABBREVIATIONS AND TERMS

AB	Assembly Bill
Act	Marine Invasive Species Act
CA	California
CAPA	California Association of Port Authorities
CDFG	CA Department of Fish and Game
Commission	CA State Lands Commission
EEZ	Exclusive Economic Zone
GloBallast	Global Ballast Water Management Program
HR	House Bill
ICES	International Council for the Exploration of the Sea
IMO	International Maritime Organization
MEPC	Marine Environment Protection Committee
MISP	Marine Invasive Species Program
MOA	Memorandum of Agreement
MT	Metric Ton
NAISA	National Aquatic Invasive Species Act
NIS	Non-indigenous species
nm	Nautical mile
OR	Oregon
Panel	Performance Standards Advisory Panel
PRC	Public Resource Code
R & D	Research and Development
SB	Senate Bill
SHB	Substitute House Bill
SERC	Smithsonian Environmental Research Institute
SGBOSV	Study Group on Ballast Water and Other Ship Vectors
SWRCB	State Water Resource Control Board
TOC	The Ocean Conservancy
USCG	United States Coast Guard
UV	Ultraviolet Irradiation
WA	Washington

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I. PURPOSE

This report was prepared for the California Legislature pursuant to the Marine Invasive Species Act of 2003 (Act). The Act reauthorized and enhanced the original law, The Ballast Water Management and Control for Nonindigenous Species Act of 1999. In accordance with the Act, the California State Lands Commission (Commission) was charged with several expanded responsibilities. Key among them and specific to this report is to recommend performance standards for the discharge of ballast water into the waters of the state (Section 71204.9 of the Public Resources Code (PRC)). The performance standards will be based on best available technology economically achievable and be designed to protect the beneficial uses of state waters. This report discusses the status and future plans of the Commission's Marine Invasive Species Program, as required by the Act.

II. INTRODUCTION – NON-INDIGENOUS SPECIES AND BALLAST WATER

Non-indigenous species (NIS) are organisms that have been transported by human activities into regions where they did not occur in historical time, and successfully reproduce in the wild at their new location (Carlton 2001). Once established, such species can create negative economic, ecological, and human health impacts in their new environ. In coastal environments, commercial shipping is the most important vector for invasion, in one study accounting for one half to three-quarters of introductions to North America (Fofonoff et al. 2003). Shipping related transport of NIS in ballast water, and to a lesser extent bio fouling of hulls, anchor chains and sea chests, has been an important vector since the 1800s (National Research Council 1996). Large vessels are able to transport over five million gallons of ballast water per voyage.

Ballast water is necessary for many functions related to the trim, stability, maneuverability, and propulsion of large seagoing vessels (National Research Council 1996). As ballast water is transferred from "source" to "destination" ports, so are the many organisms taken into its tanks along with the port water. In this fashion, it is estimated that some 7000 plus organisms are moved around the world on a daily basis (Carlton 1999).

Attempts to eradicate NIS after they have become widely distributed are typically unsuccessful and costly (Carlton 2001). Control is likewise extremely expensive. For example, approximately $10 million is spent annually to control the sea lamprey (*Petromyzon marinus*) in the Great Lakes (Lovell and Stone 2005); $2.3 million was spent to suppress a recurrence of the Mediterranean green seaweed (*Caulerpa taxifolia)* in southern California during 2000-2001, and $2 million was spent in Washington to control Atlantic cordgrass (*Spartinia alterniflora*) between 1999-2001 (Carlton 2001). Prevention is therefore considered the most desirable way to address the issue.

California requires vessels arriving from outside the US Exclusive Economic Zone (US EEZ) to manage their ballast water. Similar rules will become effective for vessels engaged in coastwise travel in March 2006. Management options include retention of ballast water, mid-ocean exchange, discharge to a shore-base treatment facility, or the use of an alternative treatment technology.

Ballast water exchange, the process of exchanging coastal water for mid-ocean water, is presently the most broadly applicable method for managing the risk of NIS introductions (Battelle 2003), though studies suggest that it may be of limited usefulness because its efficiency is inconsistent (Dickman and Zhang 1999, Parsons 1998, Cohen 1998) (See Section III, "The Need for Performance Standards"). During the process, biologically rich water loaded at the last port of call is flushed out of ballast tanks with the water from the open ocean, typically beyond 200 nautical miles (nm) from land. Organisms are generally less numerous in the open ocean, and it is expected that they will be poorly adapted to survive once discharged in the very different environmental conditions of a near shore port (Cohen 1998). Thus, in comparison to unmanaged ballast water, exchanged ballast is expected to reduce the risk of NIS introduction in a receiving port. Currently, ballast water exchange is the best compromise of efficacy, environmental safety, and economic practicality. The vast majority of vessels are capable of conducting exchange, and the management practice does not require any special structural modification to most of the vessels in operation.

III. THE NEED FOR PERFORMANCE STANDARDS

Currently, there are no federal or California performance standards for the discharge of ballast water. The need for standards, however, is important to provide a higher level of NIS protection, to drive the development of treatment technologies, and to facilitate commercial vessel operations. These needs are described in detail in this section.

Ballast water exchange efficiency ranges from 50-90% (U.S. Coast Guard 2001). Efficiency appears to be dependent on many factors such as ship design, ballast system configuration, and exchange location (Dickman and Zhang 1999, Battelle 2003). Due to these limitations most experts view ballast water exchange as a short-term solution, with the final resolution being a combination of treatment technologies and management options.

Current federal regulation requires that ballast water loaded outside the US EEZ be exchanged a minimum of 200 nautical miles (nm) offshore prior to discharge in U.S waters. California and other West Coast states have implemented similar requirements. Beginning March 2006 Commission approved regulations will go into effect that will require ballast water from the Pacific Coast Region (i.e., coastal waters located roughly between Cooks Inlet, Alaska and Baja California) be exchanged a minimum of 50 nm offshore before discharge in State waters. To conduct ballast water exchange at this distance offshore, a few vessels may have to modify routing on some voyages. Such deviations can extend travel distances, increasing vessel costs for personnel time and fuel consumption.

For some vessels under some circumstances, ballast water exchange can place a ship or its crew at risk (National Research Council 1996). For example, vessels that encounter adverse weather or experience equipment failure may be unable to conduct ballast water exchange safely. Some unmanned barges are incapable of conducting exchange without transferring personnel onboard; a procedure that, if attempted in the exposed conditions of the open ocean, can present unacceptable danger. 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 Substitute House Bill: SHB 2466 [2000]). Though the provision is rarely invoked in California, the handful of vessels that use it may subsequently discharge un-exchanged ballast into the state, presenting a NIS risk.

Both the regulatory community and the commercial shipping industry, therefore, look toward the development of an effective ballast water treatment technology as a promising management option. For regulators, such systems could provide NIS prevention, possibly even in situations where exchange may have been impossible. For the shipping industry, an effective ballast water treatment system might allow voyages to proceed along the shortest routes, in all operational scenarios, thereby saving time and money.

Despite these incentives, financial investment for the research and development (R&D) of ballast water treatment systems has been lacking, and the advancement of technologies has been slow. Barriers to furthering ballast water treatment technology include: the lack of protocols for testing and evaluating performance; inadequate communication between the R&D community, governments, and ship designers, builders and owners; cost of technology development; and equipment design limitations. However, the shipping industry, technology developers, and other investors point to the absence of a specific set of technology performance standards as a primary obstacle. Performance standards would set benchmark levels of organism discharge that a technology would be required to achieve for it to be deemed acceptable for use in California. Developers need these targets so they may design technologies to meet them (MEPC 49/2/1 2003). Investors are reluctant to devote financial resources towards conceptual or prototype systems without some indication that they may ultimately meet future regulations. For the same reason, vessel owners are hesitant to allow installation and testing of prototype systems onboard operational vessels. It is argued that the adoption of performance standards would address these fears, and accelerate the advancement of ballast treatment technologies.

IV. THE PERFORMANCE STANDARDS AND REQUIREMENTS OF THE MARINE INVASIVE SPECIES ACT

In response to the slow progress of ballast water treatment technology development and the need for effective ballast water treatment options, California's Marine Invasive Species Act of 2003 (Section 71204.9 of the PRC) required the California State Lands Commission to recommend specific performance standards to the State Legislature, in consultation with the State Water Resources Control Board and in consideration of recommendations provided by an advisory panel. The legislation lists three generalized criteria upon which the standards(s) shall be based:

- Protection of the beneficial uses of the waters of the state
- Best available technology
- Economic achievability

"Beneficial uses" is a term used widely in water quality plans mandated by the federal Clean Water Act and the State's Porter-Cologne Water Quality Act. In general, beneficial uses fall into four broad categories of water-related utilization: recreational, aquatic life protection, fish and shellfish consumption, and municipal and agricultural supply (Moore pers. com.). NIS presents a threat to sub-components of all of these categories (Table IV-1).

Commission staff utilized several approaches to guide considerations related to beneficial uses protection, economic achievability, and technological feasibility. All provided some foundation for the development of recommendations, but all were severely limited in the extent to which they could direct the determination of a specific set of standards. The overarching goal of this report is to present the pros, cons, and caveats of each, and therefore elucidate the rationale through which the final recommendations were selected.

- **The "dose-response" relationship (for ballast water introductions)**: Dose-Response is the predictive relationship between the number of organisms in a ballast tank and the chances of a successful invasion in a recipient port. The nature of this

Beneficial Use	NIS Carried by Ships that Impact Use (Example)
Agricultural supply	Zebra mussel
Cold freshwater habitat	Round goby
Ocean, commercial and sport fishing	Round goby, Shrimp virus
Estuarine habitat	Amur river clam *(Potamocorbula)*
Freshwater replenishment	
Groundwater recharge	
Industrial service supply	Zebra mussel
Marine habitat	Japanese shore crab
Fish migration	Chinese mitten crab
Municipal and domestic supply	Zebra mussel
Navigation	Zebra mussel
Industrial process supply	Zebra mussel
Preservation of rare and endangered species	Chinese mitten crab
Water contact recreation	Cholera, Other pathogens, Toxic dinoflagellates
Noncontact water recreation	Zebra mussel
Shellfish harvesting	Green crab, Cholera, Toxic dinoflagellates, Invertebrate pathogens
Fish spawning	Fish pathogens, Chinese mitten crab (siltation from burrowing into banks)
Warm freshwater habitat	Asian swamp eel
Wildlife habitat	Pathogens to wildlife

Table IV-1. Current and likely threats posed by non-indigenous species to beneficial uses in the San Francisco Estuary.

(From: Prevention of Exotic Species Introductions to the San Francisco Bay Estuary: A total maximum daily load report to the U.S. EPA. California Regional Water Quality Control Board, San Francisco Bay Region 2000.)

relationship is unknown, presenting a central challenge to the development of other scientifically based approaches for determining discharge standards (See Section VII, "Scientific Considerations").

- **Biological protection**: Biologically Protective based standards would reduce organism discharge from ballast water to a level that would prevent establishment of most or all NIS. The lack of knowledge on the dose-response relationship severely limits the utility of this approach (See Section VII, "Scientific Considerations").

- **Natural invasion rate**: Natural Invasion Rate based standards would reduce organism invasions from ballast water to a level that approximates a frequency of invasion that might occur in the absence of modern human forces. A rate was discussed by the advisory panel, but was based on a coarse assumption of the dose-response relationship, had not been subject to scientific peer review, and had not been academically published (See Section VII, "Scientific Considerations").

- **Improve upon the status quo (ballast water exchange)**: Standards based upon the status quo would reduce organism densities in ballast tanks to levels much lower than those observed in properly exchanged ballast water. This approach could establish a minimum threshold for performance standards, but it could not indicate what might be an acceptable upper threshold (See Section VII, "Scientific Considerations").

- **Technological availability:** Technological availability based standards evaluate the capabilities of technologies currently available. Since the development of ballast treatment technologies has been slow, very few technologies were available for examination. None have been subject to satisfactory evaluative testing that enable comparisons of their capabilities under a range of real-world conditions (See Section VIII, "Best Available Treatment Technologies").

- **Economic achievability:** Economic Achievability based standards are based on what may be economically achievable. The panel examined cost estimates of prototype shipboard technologies, cost estimates of shore-based technologies, and the economic health of the shipping industry. Available estimates were extremely coarse, limiting the utility of this information (See Section IX, “Economic Achievability”).

- **National / international consistency:** Because merchant shippers engage in worldwide trade, standards that align with national or international performance standards would be operationally preferable to a patchwork of individual standards adopted by individual states. The merits and deficiencies of proposed and existing standards were examined (See Section VI, “Summary of Other Programs with Performance Standards”).

V. PERFORMANCE STANDARDS ADVISORY PANEL PROCESS

The Act (PRC Section 71204.9) directs the Commission to consult with a Performance Standards Advisory Panel (Panel) during the development of recommendations for performance standards. Commission staff therefore convened a cross-interest, multi-disciplinary Panel, and facilitated discussions over the selection of standards. The Panel was to make recommendations to the Commission regarding the content, issuance, and implementation of ballast water performance standards.

Beginning in February 2005, Commission staff solicited invitations for Panel participants. As specifically mandated in Section 71204.9 of the PRC, representatives of the Department of Fish and Game (CDFG), State Water Resources Control Board, and the United States Coast Guard were contacted. In addition, researchers, representatives from non-government organizations, resource-related government agencies, and the maritime industry were also invited, including the United States Fish and Wildlife Service, The Ocean Conservancy (TOC), the Association of California Water Agencies, Matson Navigation, the Pacific Merchant Shipping Association, Chevron Shipping, and the Smithsonian Environmental Research Center (SERC). The USCG, as mandated by the National Invasive Species Act of 1996, is involved in efforts to establish federal standards and therefore declined to participate in the Advisory Panel. (See Appendix A for a complete list of participants).

Five meetings were held between March 7th and August 8th 2005 (See Figure V-1), during which information sharing, discussions, and deliberations took place regarding criteria for the selection of ballast treatment performance standards, and potential frameworks for their implementation. The Panel voted for a set of performance standards based on organism size class, and an implementation schedule.

Detailed information on topics discussed during Panel meetings are described in dedicated sections of this report. Major topics covered were:

- Biological data on organism concentrations in unmanaged, and properly exchanged (managed) ballast water (Section VII, "Scientific Considerations") (See Table V-1, columns 2 and 3)
- Theories on invasion rates and invasion success for NIS transported in ballast water (Section VII, "Scientific Considerations") (See Table V-1, column 8)
- Performance standards considered and/or adopted by the International Maritime Organization, other U.S. States, and proposed federal legislation (Section VI, "Summary of Other Programs With Standards") (See Table V-1, columns 4-7 and 10)
- Implementation schedules considered and/or adopted by the International Maritime Organization, other U.S. States, and proposed federal legislation (Section VI, "Summary of Other Programs with Standards")
- Current and projected capabilities of shipboard prototype ballast treatment technologies (Section VIII, "Best Available Treatment Technologies")
- Theoretical capabilities of shore-based treatment technologies (Section VIII, "Best Available Treatment Technologies")
- Estimated costs of current and future technologies, and the economic health of the shipping industry (Section IX, "Economic Achievability")

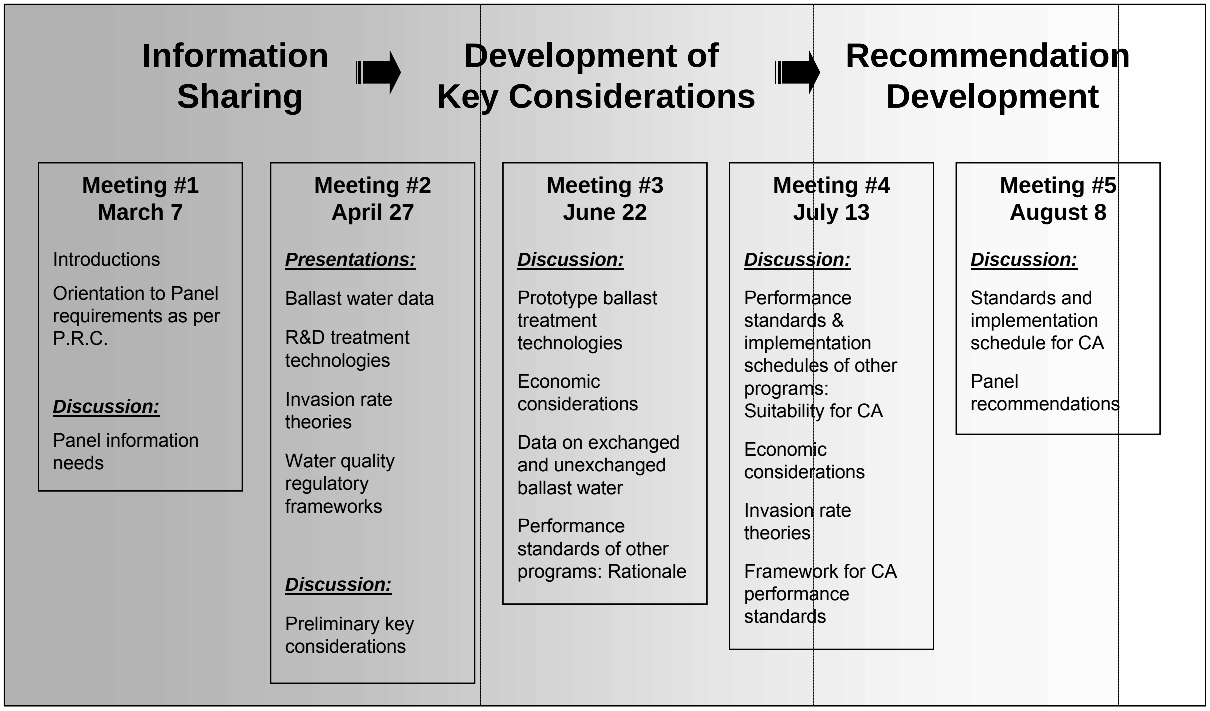

Figure V-1: Overview of major discussion areas and approximate timing during Performance Standards Advisory Panel meeting process.

The Panel agreed that the key concepts important for the development of performance standards were:

- Consistency at a national or regional level.
- At present, there is no concrete biological evidence that can guide the selection of specific performance standards beyond the efficacy of ballast water exchange.
- Because the development of ballast water treatment systems is currently in its infancy, the insight they provide for future capabilities is limited. While current technological capabilities should be kept in mind, focus should be placed on selecting standards that will drive technologies to meet them.

Panel points of majority agreement regarding an implementation framework and specific organism concentrations for standards:

- Ballast water performance standards should establish the maximum allowable number of organisms that may be discharged following treatment.

Table V-1. Comparison table of possible performance standards.

Side-by-side comparison of potential performance standards and the concentration of unmanaged and exchanged ballast water, arranged by increasing stringency from left to right. Aside from organism concentrations in ballast water (columns 2-3), columns represent standards that have been: considered or adopted internationally (columns 4 & 6); adopted by other U.S. states (columns 8 & 10); proposed in federal legislation (column 5 & 9); or considered independently by the Performance Standards Advisory Panel (column 7). Values in Columns 2 through 8 are the number of organisms per unit of water for each size class of organism. Organism size classes are measured in microns (µm), which is a unit of length equal to one millionth of a meter. Organism size class units have different units of water for each group of organisms (per m^3 = cubic meter, mL = milliliter, and 100 mL). One cubic meter (m^3) is equal to one metric ton (column 1).

1 Organism Size Class (Units)	2 Conc. in unmanaged ballast water	3 Conc. in properly exchanged ballast water [1]	4 IMO	5 U.S. Senate Bills 363/1224	6 U.S. position at IMO	7 Estimated natural invasion rate	8 Michigan	9 U.S. House and Senate Bills H.R. 1591/S.770	10 Washington
>50 µm ($/m^3$)	10^2	10^1	10	10^{-1}	10^{-2}	10^{-3}	0[2]	95%[3] 99%[4] (99.9%) Reduction	95% reduction
10-50 µm (/mL)	10	1	10	10^{-1}	10^{-2}	10^{-4}	0[2]	95%[3] 99%[4] (99.9%) Reduction	99% reduction
<10 µm (/100 mL)	10^8	10^7	250 E. coli 100 I.enterococci 1 V. cholera	126 E. Coli 33 I.enterococci 1 V. cholera	126 E. Coli 33 I.enterococci	10^3-10^4	0[2]	-	99% reduction

[1] Expected concentrations of organisms that would remain if exchange were done according to IMO guidelines
[2] No discharge of NIS or attain a permit to certify acceptable treatment preventing discharge of NIS
[3] House Bill proposes interim standards of 95% reduction for all vessels
[4] Senate Bill proposed interim standards of 99% reduction on existing vessels and 99.9% reduction for new vessels
m^3 = cubic meter, mL = milliliter

- Performance standards should reduce the number of organisms to levels much lower than those achieved by ballast water exchange.

- Concentration based standards are preferable to percent reduction based standards, given the variable protection and problematic enforcement that the latter would present.

- As the most protective standard possible, zero discharge should be the ultimate goal for ballast treatment systems, though it was unclear if this was possible in the near term.

- Given the questionable short-term feasibility of zero discharge, interim performance standards should be set with a finite implementation schedule.

- The interim standards should be periodically reevaluated and, if needed, adjusted depending on the capabilities of treatment systems available. The feasibility of a zero discharge should also be revisited during these reviews.

- Any implementation schedule should take into account that the demand for available shipyards is high, and scheduling the fleet for treatment technology installations during dry-dock will be tight.

- Once performance standards are adopted, it will be crucial to develop a standardized set of protocols whereby ballast treatment technologies may be evaluated and compared.

- Long-term biological monitoring of NIS must be continued in order to evaluate the effectiveness of performance standards and other management measures after they are implemented.

The Panel submitted recommendations to the Commission in a Majority Panel Report (Appendix A), a Minority Panel Report submitted by the shipping industry (Appendix B), and a Minority Panel Position Letter was submitted by The Ocean Conservancy (Appendix C). These recommendations were considered by Commission staff during the formulation of final recommendations (Section X, “Conclusions and

Recommendations"). Further information regarding the advisory panel can be found at: http://www.slc.ca.gov/Program_Pages/Program_Pages.htm.

VI. SUMMARY OF OTHER PROGRAMS WITH STANDARDS

The development of ballast water treatment standards has evolved significantly in the past five years. In early 2004, the International Maritime Organization (IMO) adopted a Convention on ballast water and sediment management that included performance standards (IMO 2005); the U.S. proposed standards at the same IMO Convention; federal lawmakers introduced several NIS related bills during 2005 that include performance standards; the Washington legislature adopted standards in 2000; and the Michigan legislature adopted standards in June 2005. During the development of recommendations for California, the Panel considered all accessible information related to the development of standards considered or adopted elsewhere. Tables V-1 and VI-1 summarize these standards and associated implementation schedules, which are discussed in more detail below.

Table VI-1. Summary of implementation schedules for IMO and Senate Bills 363/1224. Newly constructed vessels built by timeframes indicated in the middle column must meet standards once placed in active service. Older (existing) vessels must meet standards by deadlines indicated in the last column.

Ballast water capacity of vessel	Standards apply to new vessels in this size class constructed on or after	Standards apply to existing vessels in this size class beginning in
< 1500 metric tons	2009	2016
1500 – 5000 metric tons	2009	2014
> 5000 metric tons	2012	2016
*State of Washington requires vessels to either conduct an exchange or utilize an alternative treatment system that meets their mandated performance standard by July 1, 2007. Vessels operating in Washington can continue to utilize ballast water exchange after July 1, 2007. *State of Michigan prohibits oceangoing vessels from discharging ballast water containing NIS beginning 2007.		

International Maritime Organization Convention on Ballast Water – In February 2004 after several years of development and negotiation, IMO member countries adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments. Representatives from 74 countries, 1 associate member, 18 non-governmental organizations, and 2 intergovernmental organizations were present.

The Convention will enter into force 12 months after ratification by 30 countries that represent 35 percent of the world's commercial shipping tonnage (GloBallast 2004). The U.S. has not yet ratified the Convention.

The Convention imposes treatment standards that would limit the number of organisms that ships could discharge with their ballast water. During negotiations, the Study Group on Ballast Water and Other Ship Vectors (SGBOSV) on behalf of the International Council for the Exploration of the Sea (ICES) developed a global database on organism concentrations measured in the ballast water of commercial vessels. The information was summarized and considered during the development of ballast water standards of the Ballast Water Convention (MEPC 49/2/21 2003). A discussion of this summary is provided in Section VII, "Scientific Considerations".

The U.S. position at the IMO – In January 2004, representatives from the United States presented their recommended standards to the IMO Conference. The US delegation, in consideration of Marine Environment Protection Committee 49/2/21 urged the Conference not to settle for standards simply based on current technological capabilities. Rather, the U.S. recommended the Conference adopt environmentally sound, biologically protective, and enforceable standards that would encourage the development of technologies and management practices. The U.S. detailed rationale for protective ballast water discharge standards and made specific recommendations to the Conference (BWM/CONF/14 2004) (Table V-1).

Proposed federal legislation – Congressional attention towards invasive species, ballast water management, and associated performance standards is currently very intense. Four bills were introduced during the 2005 session: Senate Bills 363, 770, and 1224 and House Bill 1591.

U.S. Senate Bill S. 363 (proposed Ballast Water Management Act of 2005) and U.S. Senate Bill 1224 (proposed National Oceans Protection Act of 2005) contain identical performance standards that are more protective than those adopted by IMO, while adopting the implementation schedule of the IMO Convention (Tables V-1 and VI-1).

The standards proposed were a result of consultation with the US negotiation team for the IMO conference and in consideration of the Marine Environment Protection Committee (MEPC) scientific findings (Fraenkel pers.com.). Both bills are currently under discussion in the Senate's Committee on Commerce, Science, and Transportation. These bills include a preemption of state law regarding performance standards that would affect future California action on this issue.

The National Aquatic Invasive Species Act, (NAISA) of 2005, was introduced into the Senate (S. 770) and House (H.R. 1591) on April 13, 2005. There are subtle differences regarding proposed performance standards between these bills. While both propose adoption of final standards via regulations and interim standards based on a percent reduction metric, the House version proposes interim standards of 95% reduction of organisms for all vessel types within 18 months, whereas the Senate version proposes an interim standard of 99% reduction for existing vessels and a 99.9% reduction for new vessels. Neither bill proposes different standards for organism size classes, nor do they propose standards for bacteria, viruses, or virus-like particles.

Washington - Washington Department of Fish and Wildlife established interim ballast water discharge standards to provide a target for technology developers (WAC 220-77-095). The inactivation or removal of 95 percent of zooplankton and 99 percent of phytoplankton and bacteria in ballast water is required. The Washington law states that after July 1, 2007, discharge of ballast water is allowed only if there has been an open sea exchange or the ballast water has been treated to meet the standards.

Michigan – Michigan passed legislation in June 2005 that would prohibit the discharge of any waste or waste effluent into the waters of the state unless a permit is obtained beginning January 2007. For oceangoing vessels, the law prohibits the discharge of NIS unless an environmentally sound technology has been utilized by the vessel that both prevents the discharge of NIS and has been approved by the State (Michigan SB 332).

VII. SCIENTIFIC CONSIDERATIONS

In order to ensure that recommendations were based on the best available science, several biological/ecological concepts were considered by the Panel and the Commission staff. Field data and theories on ballast water organism densities and invasion patterns were examined. Considerations focused on the merits, drawbacks, and limitations of each for determining potential performance standards. Every concept provided some degree of guidance; however, none could point to a single standard.

Ballast water treatment standards can be established via one of two measurement methodologies: a percent reduction, or a specific concentration. A percent reduction scenario poses several problems. The density of organisms varies depending on source port; therefore, a percent reduction requirement would produce varying discharge concentrations for any given vessel depending on the characteristics of the source water (Figure VII-1). For similar reasons, percent reduction standards are not practicably enforceable. Samples of both the initial source water concentrations as well as discharge concentrations would be needed to verify a specific removal rate. Percent reduction is not based on either biological (level of protection to reduce/prevent introductions) or technical grounds (detection limits of sampling equipment).

Concentration based standards, in contrast, would specify a specific concentration of organisms that could be discharged following treatment, regardless of source port concentrations (Figure VII-1). Concentration based standards allow for the consideration of both a protection level to reduce risk, as well as technical consistency, such as detection limits. California laws also use concentration-based standards to protect water and air quality. The Panel and the Commission therefore support the adoption of performance standards that are concentration based (a certain number of organisms per unit of water), rather than percent reduction based (e.g. 99% removal).

Based on the scientific reports developed for the IMO Convention and subsequent consultation with scientific experts, the Panel determined that organism concentration standards should be established according to organism size classes. A size class framework provides a technical balance between biological protection and the necessary practicability of compliance monitoring. The size categories established by the IMO roughly separate ballast water organisms into biological types: macrozooplankton, (>50 µm) (very small, free-floating or drifting animals, e.g. jelly fish), phytoplankton (10-50 µm) (very small, free-floating or drifting plants, e.g. blue-green algae), and bacteria and virus-like particles (<10 µm) (See Table V-1 in Section V, "Performance Standards Advisory Panel Process").

The Panel agreed that at a minimum, reductions achieved by California's performance standards should improve upon the current status quo, and decrease the discharge of viable ballast organisms to a level below quantities observed following proper ballast water exchange. To better understand and consider this minimal threshold, data on organism concentrations in both unmanaged and properly exchanged ballast were examined. As part of a nearly identical information gathering effort during the development of IMO performance standards, ballast water data from a variety of studies around the world were gathered and standardized by Dr. Gregory Ruiz, director of the Smithsonian Environmental Research Center, Marine Invasions Laboratory (MEPC 49/2/1 2003) (Appendix A). Dr. Ruiz provided a summary of this data, with organism concentrations converted from the biological classifications originally presented by the Marine Environment Protection Committee, to size classes as considered by the advisory panel. Based on his research on the efficacy of ballast water exchange, Dr. Ruiz also noted that exchanged ballast water results in an average tenfold reduction in organism concentrations (Minton et al. 2005) (Figure VII-2 and Table V-1, columns 2 and 3).

Beyond the minimal threshold of ballast water exchange, there was no scientific evidence that could direct the selection of standards to establish a predictable level of protectiveness. The inability of science to pinpoint precise performance standards beyond ballast water exchange stems from a central information gap: the relationship between the numbers of organisms exposed to a location (i.e. port, region, or state) and the resultant likelihood of a non-native organism becoming established. Aside from the logical observation that zero organism discharge would equate to no risk, and that increasing numbers of organisms would equate to increasing risk, the shape of this "dose-response" curve is unknown (Ruiz and Carlton 2003) (Figure VII-3).

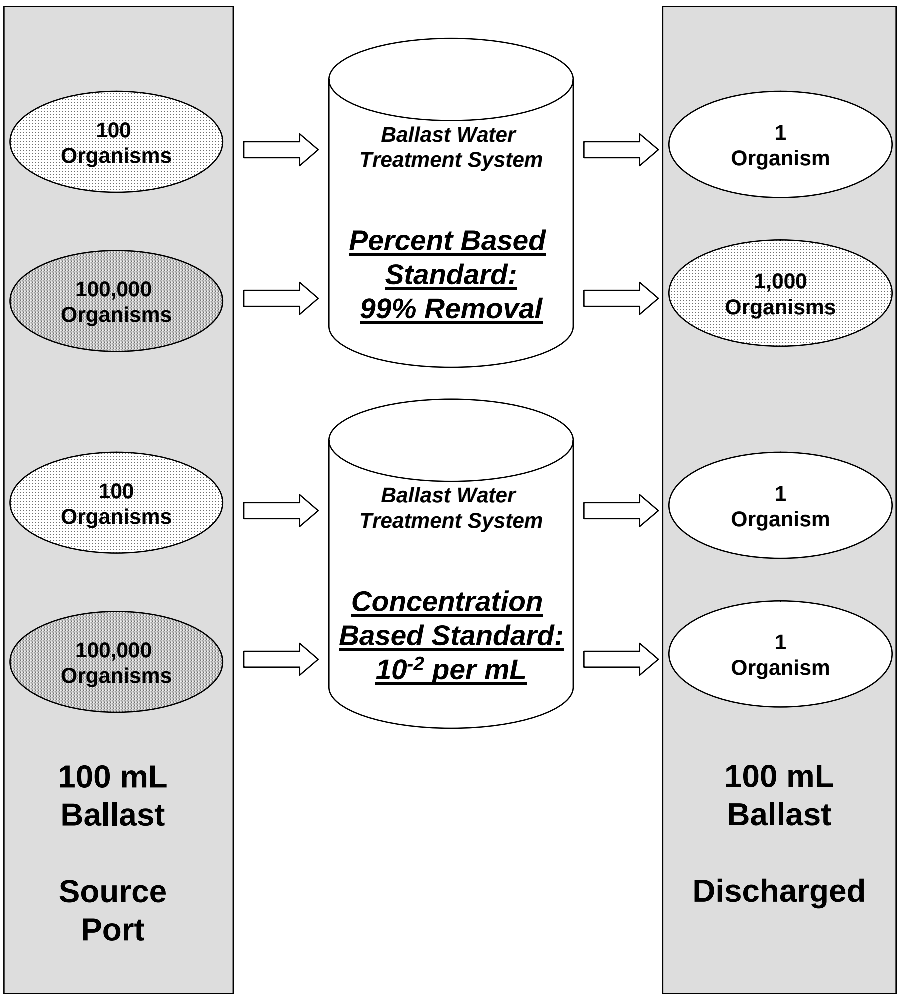

Figure VII-1. Illustrations of percent based (upper half) and concentration-based (lower half) standards.

Note: For percent based standards, the number of organism discharges is highly dependent upon the density of organisms at the source port. Thus, adoption of a percent based standard can result in widely varying numbers of organisms that are discharged.

Thus, a specific invasion risk cannot be approximated for a particular quantity of organisms discharged (MEPC 49/2/1 2003). Consequently, it is not possible to conclusively determine how much more stringent standards must be in comparison to exchange for adequate protection. It is also not possible to perform a risk-benefit analysis whereby performance standards may be selected that maximize protection, while minimizing time and financial investment needed to develop a ballast water treatment system sophisticated enough to meet it.

Given the lack of knowledge of the actual dose-response curve, the selection of standards becomes somewhat arbitrary above the efficacy of ballast water exchange.

Faced with this dilemma during deliberations over the designation of an IMO standard, two groups of technical experts (biological, engineering, environmental) recommended standards based on their best scientific judgment. The International Study Group on Ballast Water and Other Ship Vectors recommended a minimum 100-fold (10^2) improvement over exchange for both zooplankton and phytoplankton (0.4 zooplankton per m^3, 0.0133 phytoplankton per mL)(MEPC 49/2/21 2003). Based on information from the international study group and from a workshop organized by the USCG (MEPC 49/INF.31 2003), the United States recommended at least a 1000-fold (10^3) improvement over exchange for zooplankton (0.01 per m^3), a standard similar to the SGBOSV for phytoplankton (0.01 per mL), and human health-based standards for indicator bacteria (BWM/CONF/14 2004).

The dose-response curve does include a single known point: zero exposure to NIS would present no invasion risk. Based on this logic, the only potential standard that is unarguably "biologically protective" would be zero viable organism discharge. Since the ability to measure a complete absence of organisms is beyond the detection limits of modern sampling equipment, such a standard could be practically applied as a zero "detectable" organism discharge. In practice, confirmation that a treatment technology achieves and continues to maintain a zero detectable discharge target would translate to actual discharge levels that register at the lowest detection limits possible using the best sampling equipment and methodologies available.

Some vessels do not need to discharge ballast water due to their operational procedures or because of vessel design. Clearly, such vessels meet a zero target, and are preferable for both the industry and regulators. For those vessels that must discharge ballast water, however, the current and future ability of ballast treatment technologies to meet such a zero detectable standard presents a technical challenge. Prototype technologies show some potential for achieving a near zero discharge for larger ballast organisms but it is not clear if or when they will be able to reach a zero detectable target, or if a similar target is possible for smaller organisms (Section VIII, "Best Available Treatment Technologies").

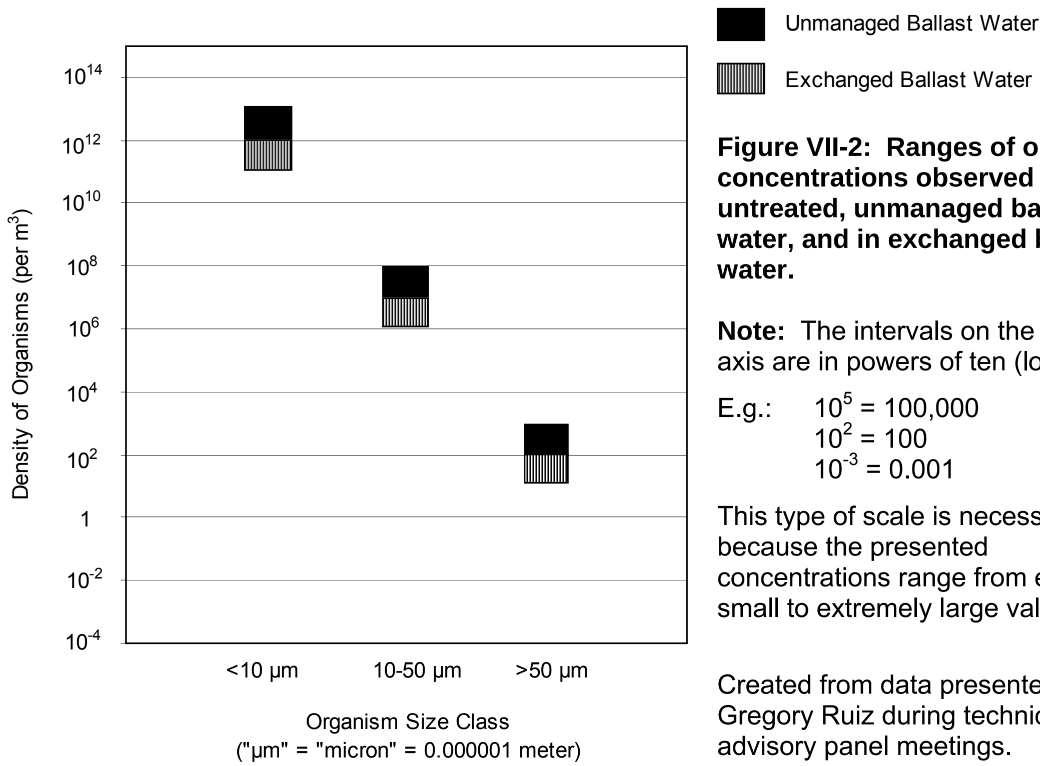

Figure VII-2: Ranges of organism concentrations observed in untreated, unmanaged ballast water, and in exchanged ballast water.

Note: The intervals on the vertical axis are in powers of ten (log scale).

E.g.: $10^5 = 100{,}000$
$10^2 = 100$
$10^{-3} = 0.001$

This type of scale is necessary because the presented concentrations range from extremely small to extremely large values.

Created from data presented by Dr. Gregory Ruiz during technical advisory panel meetings.

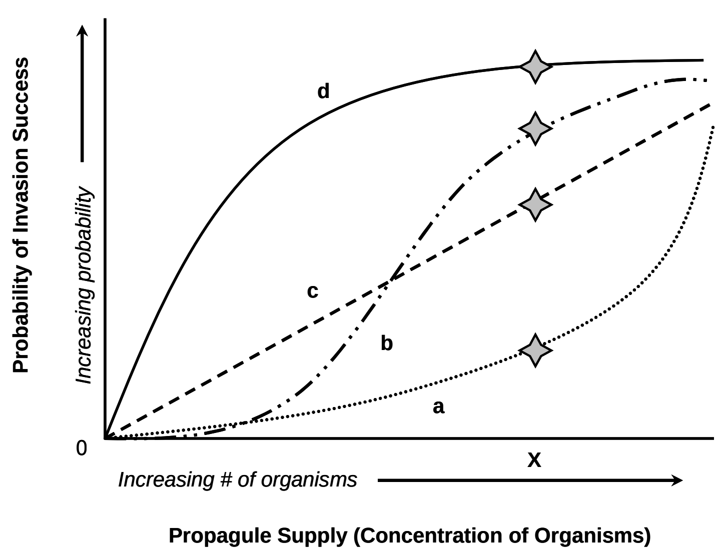

Figure VII-3: Hypothetical dose-response relationship curves. The true shape of the relationship is unknown. Note that depending on the shape of the curve (a-d), an organism concentration of X can result in widely different probabilities for invasion success, as denoted by the gray stars. Hence, without knowledge of the shape of the curve, it is not possible to accurately predict the probability of invasion success for a given organism concentration.

Modified from Ruiz G.M. and J.T. Carlton 2003. Invasion vectors: a conceptual framework for management. In: Invasive Species, Vectors and Management Strategies. Ruiz G.M. and J.T. Carlton (Eds). Washington D.C.: Island Press. 459-504.

As noted earlier, the evaluation methodologies will also need to be advanced. For example, a treatment technology that kills organisms but does not remove them from a tank will require evaluation beyond simple counts, and current methods for discerning some living and dead ballast organisms are not well developed. These hurdles, however, should not preclude the adoption of treatment standards that will serve to drive technologies and evaluation methodologies to meet them.

Dr. Andrew Cohen of the San Francisco Estuary Institute suggested a “natural invasion rate” as a basis for a standard. The goal of such a standard would be to reduce ballast discharges of organisms to a concentration that results in an invasion rate near those that would have been observed in the absence of human forces. Dr Cohen estimated that this rate is 50 species each million years (Table V-1 column 8). However, this approach is based on numerous assumptions that create a high level of uncertainty for its application to performance standards that will have regulatory impacts. The rate is based upon unpublished estimates of natural invasions for a limited number of organism groups, in a single region, during a relatively narrow time period (2-5 million years). There is no evidence how the rate might vary if extrapolated to the large number of unaddressed organisms, to other geographic areas or other prehistoric periods. The conversion from a “natural invasion rate” to a discharge standard (a concentration of organisms) was based on an assumption that the “dose-response” curve was linear (Figure VII-3, curve c), though the true shape of the curve is unknown. The proposed approach had been neither published nor peer reviewed and was thus not known or widely accepted by the scientific community.

Though limited, the guidance provided by the scientific data provides a range, albeit an extremely wide range, within which performance standards could be selected. At a minimum, standards should significantly reduce organism discharge observed following a proper ballast water exchange. At a maximum, the most “biologically protective” standard would be zero discharge. Beyond these limits, the best available science could not conclusively indicate where a performance standard should fall.

As discussed earlier, this problem was mirrored in the recommendations presented to the IMO by internationally recognized scientific experts in the field. When obligated to select specific standards in the absence of strong scientific guidance, these groups chose 100-fold and 1000-fold improvements over ballast water exchange, based on the non-specific rationale that standards should be biologically protective, should greatly reduce organism concentrations to levels much lower than unexchanged ballast, and should challenge developing technologies.

VIII. BEST AVAILABLE TREATMENT TECHNOLOGIES

Commission staff compiled and evaluated information on alternative treatment technologies designed to remove or inactivate organisms entrained in ballast water. The following summarizes that effort.

Treatment technologies must be effective under variable water quality conditions (temperature, salinity, nutrients, suspended solids, etc.), and must be designed to operate so as to minimize or prevent impairment of the water quality conditions of the receiving waters. Treatment technologies must also be effective under conditions such as high flow-rates, large volumes, and ballast water residence times (time water is held in tanks). They must be capable of inactivating a diversity of organisms ranging from microscopic bacteria and viruses to free-swimming plankton visible to the naked eye. Effective treatment technology is further complicated by the variability of vessel types, shipping routes and port geography. Because of these difficulties, the identification of a single treatment technology for all NIS, ships, and port conditions is unlikely. Rather a suite of treatment technologies will undoubtedly need to be developed to treat ballast water. Two general approaches are currently under development to attempt to meet these challenges: shipboard (onboard operational vessels), and shoreside (treatment occurs at a shore based facility following transfer from a vessel).

A number of candidate treatment technologies have been identified as possible solutions to preventing or reducing the introduction of NIS via ballast water discharge (National Research Council 1996, SWRCB 2002, GloBallast 2004). Many borrow from the wastewater treatment industry and include mechanical, physical, and chemical processes. They range from filtration and cyclonic separation to ultraviolet irradiation (UV), ultrasound, electro-ionization, deoxygenation, heat, ozone, and chemical biocides. The evaluation of treatment possibilities is at an early stage and no alternative treatments have been yet approved by state, regional, or federal regulatory authorities. Shipboard treatment systems to date have generally combined one or more type of treatment to address the different sizes of organisms found in ballast water. Most of these systems have been tested only in laboratories. A select few have been installed onboard operational vessels. Several promising shipboard treatment systems are in the conceptual or experimental testing stages.

One such system installed onboard a large passenger vessel and a container ship treats ballast water with a two-step process. A cyclonic separation chamber first disposes of larger particles and organisms, before exposing the remaining ballast water to ultraviolet irradiation for the treatment of smaller organisms. Structural modifications were necessary onboard both vessels to resolve operational issues before either system could be tested for effectiveness (Wright 2004, Matson Navigation 2005). The system removed organisms to a greater extent than unmanaged ballast water on both vessels, but did not meet the proposed IMO standards for every size class of organisms. The number of microbial and zooplankton organisms decreased over time during three different evaluation voyages (Welschmeyer et al. 2004). UV exposure produced near instantaneous effects on phytoplankton with no signs of viable recovery during the experiments.

Another promising treatment system utilizes ozone gas to treat ballast water that contains NIS. The system was installed on a tank vessel in 2000 and studies were carried out to: determine the efficacy of the system to remove coastal organisms compared to ballast water exchange; assess possible environmental risks of discharging ozone-treated ballast water; and to obtain operational experience with the system in order to implement future system improvements.

This work represented a “proof of concept” phase for the ozone treatment system, and as such, the results are limited to a few trials from one port system. This study indicates that ozonation can remove many coastal organisms and may compare favorably with ballast water exchange. The experiments suggest possible residual toxicity from bromine over time. It suggested that bromine was the ozone-producing oxidant responsible for organism mortality and that it may persist at toxic concentrations in ballast water for 1-2 days following treatment (Cooper et al. 2002). Further testing for residual effects of bromine, crew safety, corrosion, vessel modification, and costs is ongoing.

Other treatment technologies are undergoing shipboard testing with promising initial results. The first of these treats ballast water by de-oxygenation. This system uses low-sulfur inert gas to displace oxygen in ballast tanks creating a hypoxic (low oxygen concentration) environment that significantly decreases the survival of NIS. This system also claims an added benefit of reducing corrosion within ballast water tanks under certain operating conditions. A full-scale system has been installed on a bulk carrier and studies designed to evaluate the efficacy of this system as well as operational issues are scheduled to begin in mid-2006.

Another technology uses chlorine dioxide to treat NIS in ballast water. Chlorine dioxide has been effectively used for over 50-years in industrial and municipal applications. Initial studies of this treatment technology were carried out in 2002. Results show this technology effectively treats zooplankton, phytoplankton, and some microorganisms. Further research is needed, and the Commission is contracting with Matson Navigation Corp., to assist in the installation and evaluation of the chlorine dioxide treatment system onboard an integrated tug barge. Installation of the system was completed in October 2005 and testing will begin in early to mid-2006.

One more technology combines mechanical filtration and UV to treat NIS in ballast water. The filtration is provided by an auto-backflush disc filtration unit fitted with 100 μm disks, though the vendor claims the system can be fitted with 50 μm disks. Disinfection is accomplished with a medium pressure cross-flow/inline UV system. The system was installed on a large passenger vessel in 2004. Preliminary testing began in 2004, but results have not been made available.

Additional alternative technologies have been installed and tested onboard vessels. The Global Ballast Water Management Programme (GloBallast), a program that assists developing countries to implement measures to control the introduction of NIS, maintains a research and development directory. The directory lists alternative treatment technologies that have been installed and tested onboard vessels, but results from these studies are not available and little or no commercial application has occurred.

Before any type of shipboard treatment system can be made commercially available, more shipboard evaluations will be necessary. All ship-based treatment systems must be engineered to conform to a vessel's structure, ensure crew safety, and must be able to withstand the vibrations and movements induced by the vessel's engine or rough seas. Additionally, numerous biological parameters must be measured to evaluate effectiveness, and consistent, reproducible testing protocols need to be established.

While shipboard treatment systems are attractive because they allow more flexibility to manage ballast water during normal operations, there continues to be interest in the shoreside treatment of ballast water. However, utilization of shore-based treatment for ballast water poses several challenges. Current wastewater treatment plants are not equipped to treat saline water (SWRCB 2002, Moore pers com.). Municipal facilities will need to be modified for the purposes of treating ballast, or new facilities will have to be established. The acquisition and development of new ballast water treatment facilities will be difficult and costly in California port areas. Additionally, onshore treatment is not feasible for vessels that must take on or discharge ballast water while underway. Regardless, shore based ballast water treatment should be considered for unique terminals, those with limited but dedicated vessel calls, and as an option for older vessels nearing the end of their service life. To date only limited feasibility studies have been conducted for the onshore treatment option.

One such study was conducted by URS/Dames & Moore (2000), commissioned by the California Association of Port Authorities (CAPA). The study was to conceptually assess the technical and operational feasibility of onshore ballast water treatment at public port facilities. The study looked at four conceptual onshore ballast water treatment facilities with four different treatment capacities. The study report describes the initial requirements of land for each facility, construction and operation costs, as well as vessel and wharf retrofitting for onshore transfers and ballast water storage. The report concluded that, if standards used in existing wastewater facilities are adopted and costs are not a factor, shore-side treatment is feasible in California. Since costs are a factor, the report recommends that more thorough studies be conducted to better estimate costs for onshore treatment (URS/Dames & Moore 2000).

Another study was prepared for the Port of Seattle and in association with the Washington Department of Fish and Wildlife, under the Pacific Ballast Water Treatment Pilot Project. It assessed the technical feasibility and associated capitol costs of transferring ballast water to and from vessels through fixed shoreside, truck-mounted, and barge-mounted ballast transfer services. Six vessel types that frequent Puget Sound ports were examined. Five vessel surveys were conducted to identify the level and costs of modifications required to assist ballast water transfer. Modification costs calculated for each vessel type assumed that universal deck connections are installed, and that modifications to allow transfer would result in minimal impact to normal operations. The study concluded that in all cases, vessels would require modifications to their existing ballast system in order to be able to transfer ballast with minimal impact to current operations. The study concluded that while it is technically feasible to transfer ballast to and from ships through a transfer service, assessing the full economic feasibility requires additional study (The Glosten Associates 2002).

Finally, a study of the feasibility of shoreside treatment of ballast water at a cruise ship terminal in San Francisco is currently being sponsored by Bluewater Network, San Diego BayKeepers, Surfrider Foundation, and The Sierra Club. The objectives of this study are to assess the technical, environmental, and economic feasibility and benefits of shoreside ballast water treatment and re-use for cruise ships (Bluewater Network 2005). The project is expected to be complete in late 2005, early 2006.

As further studies are completed and revised, more information is expected to become available regarding the application of alternative treatment technologies. It is argued that the development of performance standards will help to facilitate the further development of technologies. Continued research and development will likely be necessary once performance standards are in place to verify if technologies meet or exceed those standards. Standards and technology will need to be dynamic because ballast water management is in its infancy.

IX. ECONOMIC ACHIEVABILITY

Establishment of performance standards requires the consideration of related economic impacts. There are many ways to evaluate the current and projected economic impacts of performance standards. Areas considered were the substantial costs associated with the control and or eradication of NIS, potential losses to California's ocean economy as a result of NIS introductions, the costs of treatment technologies, as well as effects to the overall economic health of the maritime industry as a result of adopting performance standards.

Once a problematic NIS becomes established, eradication efforts are generally unsuccessful, and costs associated with attempting to control problematic species are extremely high. The US has suffered major economic losses as a result of controlling NIS (aquatic and terrestrial). Estimated economic damage associated with NIS, including control measures are nearly $120 billion a year, with at least $1 billion spent annually on controlling just six aquatic species (Pimental 2004). Nationwide, $1 billion dollars per year was spent in the early 80's to control and mitigate damage caused by the Asian clam (*Potamocorbula amurensi*s) (Lovell and Stone 2005; Pimental 2004). The cost to control and conduct research on the Chinese mitten crab (*Eriocheir siensis*) was $1 million in 2000-2001 (Carlton 2001). The rate of new introductions is increasing (Cohen & Carlton 1998, Ruiz & Carlton 2003); which suggests that economic impacts will likely increase as well.

California has the largest ocean economy in the U.S., ranking number one for both employment and gross state product (Kildow and Colgan 2005). California's natural resources also contribute significantly to the coastal economy. For example, in 2000 total landings of fish were over 500 million pounds, bringing in nearly $140 million. Squid, the top revenue-generating species in 2002, brought in $16.5 million. The fishing industry directly contributed more than $400 million to California's economy in 2000 (Kildow and Colgan 2005). NIS presents a threat to these and other components of California commercial fisheries, as well as to aquaculture, sport fisheries, and recreational fisheries.

The realized and potential cost of NIS introductions, and the limited effectiveness of current ballast water management options (e.g. mid-ocean exchange) (Section III, "The Need for Performance Standards"), has led to increased attention and research on alternative ballast water treatment technologies. The use of these technologies will involve economic investment on the part of ship owners, and likely relieve the economic impacts of control and eradication of NIS. The cost of these alternative treatment technologies warrants review when considering the development of performance standards.

As described in Section VIII, general information on prototype shipboard technologies is limited. The few studies available provide a glimpse at the potential cost of implementing alternatives to mid-ocean exchange (Table IX-1), but only reflect costs associated with research and development. While other studies have been completed beyond those listed in Table IX-1 (see GloBallast at http://globallast.imo.org), results from those studies have not been widely reported and no commercial applications have been developed.

Table IX-1 shows cost information for a subset of treatment technologies that have been installed onboard operational vessels. The costs listed are only representative of technologies installed under research and development conditions, and are expected to decrease as they become commercially available. Equipment costs are for the purchase of the technology or system. The installation costs include but are not limited to labor and materials, which varied depending on the geographic location where the work was performed.

Table IX-1 – Cost information for specific vessels with systems installed (in thousands)
The following technologies are still in the R&D stage, as such, costs will likely be reduced once commercial applications are developed.

Technology/Vessel	Equipment Cost	Installation (Labor/materials)	Operation costs	Testing (Per voyage)
Hydrocyclone + UV				
Container Vessel	$200	$220	$6	$67
Passenger Vessel	$105	$15	$20	NA
Passenger Vessel	$135	$65	$15	$67
Passenger Vessel	$128	$19	NA	NA
100 µm Filter + UV				
Passenger Vessel	$173	NA	$20	$63
Chlorine Dioxide				
Integrated Tug-Barge	$237	$157	$75	$80
Deoxygenation				
Integrated Tug-Barge	$300	$50	$12	$100
Container Vessel	$290	$170	$12	$100

NA – data were not available

For example, shipyard labor costs in China are generally much lower than labor costs here in the United States. Operational costs are associated with the long-term use and maintenance of the system. Because all technologies are still in the research and development stage, costs for testing are included.

In addition to the vessel-specific technology applications listed above, Commission staff consulted with technology developers in order to compile generic cost estimates for the retrofit or new build for different vessel types (e.g. bulk carrier, tank vessel, container vessel). According to the technology developers, estimates provided are strongly linked to vessel-specific characteristics and associated engineering issues and technology. For example, the cost of any given system is highly dependent on ballast water capacity, ballast pump rates, normal operational needs, and available space. Therefore, the estimates provided to retrofit were extremely coarse. For example, the estimated costs to retrofit ranged from $200,000 for a bulk carrier to $5 million for a tank vessel (Gallopo pers. com., Perlich pers. com.). Developers were unable to provide estimates for technologies that might be installed onboard newly built vessels.

While ship-based treatment of ballast water is considered the most flexible method to control NIS, Commission staff compiled and considered available economic information for onshore treatment of ballast water. The URS/Dames & Moore (2000) report described key findings that though shore-side treatment may be technically feasible, it will require heavy financial investment. Several assumptions used in the report (e.g. generic vessel-type, minimal vessel delays, all right-of-ways available, treatment to waste-water standards) will likely increase the costs. The Port of San Francisco alone would face capital costs of at least $16.6 million for onshore treatment. The piping (from berth to treatment facility) would be $6.4 million and storage tanks would cost $6.3 million. If the eleven major port-complexes located in California were to be fit with shore-side treatment capabilities, capital costs would range from $7.6 million to $49.7 million per port. Annual operation and maintenance of the facilities would cost between $142,000 and $223,000 for each port in California (URS Corporation/Dames & Moore 2000).

A major cost associated with shore-side treatment is associated with the transfer of ballast water from a vessel to shore or to a storage unit. A study by The Glosten Associates (2002) demonstrates that these costs are highly dependent on vessel-specific characteristics. For example, the costs to retrofit vessels with transfer systems ranged from over $100,000 for a bulk carrier to nearly $2 million for a tank vessel (The Glosten Associates 2002). These estimates apply only to mechanical connection between a vessel and a hypothetical shoreside facility, and do not include the cost associated with constructing or maintaining a shore-side facility.

More detailed studies are recommended to assess the economic achievability of shore-side treatment (URS/Dames and Moore 2000; The Glosten Associates 2002). The two completed studies make several major assumptions that greatly simplify the complex operational realities of ports and the vessels that visit them. Many important site-specific details that would result in significantly varying costs were not addressed. For instance, the operating costs of transferring ballast water to shore should consider the costs for vessel delays, which may be significant. Additionally, studies state that mobile transfer services will be required for shore-side treatment to be feasible, yet neither study addresses this issue or incorporated these services into their cost estimates.

Based on the limited information available for both shore-based and ship-based treatment of ballast water, it is difficult to clarify the economic achievability for any particular type of treatment. So far, available cost estimates suggest the capital costs of shore-side treatment will exceed the capital costs for shipboard treatment.
While further studies are needed regarding costs of alternative treatment technologies, the industry's ability to pay for these technologies warrants consideration. Since, information regarding specific company revenues and net earnings was not available, Commission staff considered the overall economic trends of the maritime industry.

All data sources suggest that the maritime industry has been growing steadily over the past decade. The Port of Los Angeles was ranked as the top U.S. international freight gateway in 2003 (U.S. Bureau of Transportation 2005). Two of the top five U.S. ports, ranked by dollar value of foreign trade in 2003, were located in California (Navigation Data Center 2004). According to figures from the ports of Oakland and Long Beach, tons of cargo transported since 1990 has been increasing through 2003 (Port of Oakland 2005; Port of Long Beach 2005). Data from the US Maritime Administration and the US Army Corps of Engineers show a steady increase in cargo imports and exports from 1992 through 2001 (Figure IX-1). The overall economic status of the maritime industry in California appears to be in good condition.

Regardless of the economic condition of the maritime industry, experts suggest that, when compared to the major costs to control and or eradicate NIS, the costs to treat ballast water are minimal. Although a thorough analysis was not performed, the continued economic impacts of controlling NIS will likely exceed the capital and operational costs of ballast water treatment (Gotsch pers. com., Costello pers. com.).

It is clear that damages from NIS are extremely costly in the US. Treating ballast water with alternative treatment technologies will help to prevent further introductions that would also lower control and eradication costs. Unfortunately, the actual economic

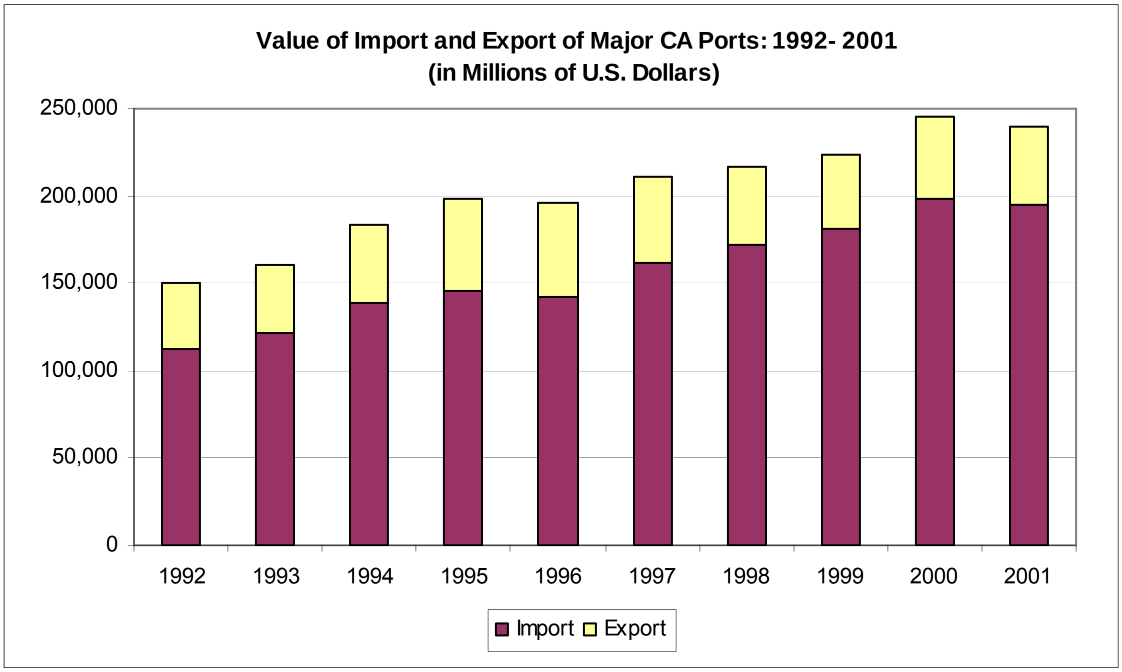

Figure IX-1: Major California ports, 1992-2001 values of imports and exports
From: Kildow and Colgan, 2005

impacts from treating ballast water will remain unclear until further research is conducted. The shipping industry appears to be healthy and therefore, it should be able to tolerate the costs of ballast water treatment within reasonable economic limits.

X. CONCLUSIONS AND RECOMMENDATIONS

Consideration of Panel Recommendations

Majority Panel Report - The Majority Panel Report recommended standards and an implementation schedule, summarized in Tables X-1 and X-2. The standards recommended are more stringent than any other national and international standards proposed for ballast water treatment (e.g. IMO, SB 363). It appears that these interim standards will be protective of state waters and more feasible than the ultimate goal of zero discharge standards for all size classes of organisms at this time. However, the best available science could not conclusively indicate if these conclusions are correct. Furthermore, these standards come with several logistical challenges, which will need to be addressed.

The Majority Panel Report recommendation that systems meet a zero-detection standard for all organisms >50 μm in size by 2009 may not be feasible because treatment technologies are still in their infancy. The Majority Panel Report describes studies, which show filtration systems can eliminate organisms of this size. While advances in manufacturing technology enable these filtration systems to remove particles greater than 50 μm, and engineering designs allow these systems to be small and simple to operate, the filtration technologies that have undergone evaluation were not designed to meet specific performance standards. Furthermore, limited shipboard studies have been conducted and no data are currently available on the efficacy of these systems under normal conditions onboard a vessel. Therefore, while these technologies show promise, the Commission cannot assure that these filtration systems will prove feasible and effective across a wide array of vessel types and environmental conditions during the time allotted in the recommendations.

It may be difficult to verify if systems meet the recommended standards due to the limitations of sampling methodologies to measure zero or very small organism concentrations in any size class, and to determine if they are living or dead. While it is possible to count zooplankton in the largest size class (>50 μm), current methods for the live/dead determination are coarse. For protists and phytoplankton, primarily in the middle size class (10-50 μm), methods that can determine both quantity and live/dead status are still being developed. Likewise, while methods for counting colonies (colony forming units) of human health pathogens are developed, methods for counting individual, non-specific bacteria and virus cells in the smallest size class (<10 μm) have not been fully developed. While these limitations should not preclude the Legislature from adopting the performance standards, they must be considered. As treatment technologies are developed to meet these standards, evaluation methods, sampling protocols and technology to test treatment systems for effectiveness will also need to be developed.

Minority Panel Report - Representatives of the shipping industry submitted a Minority Panel Report. The Report recommended standards that align with either the IMO Convention or future USCG standards in order to maintain international and/or national consistency (Table X-1). These Panel members felt that adopting standards consistent with other national and international programs would help to propel the development of technologies more effectively. The Report acknowledges that although the IMO convention standards may not be as stringent, they would facilitate technologies to meet stricter standards more quickly.

The shipping industry operates in a worldwide market, and vessels operating for any single company generally visit a number of countries. Consequently, the industry favors international or national consistency of treatment performance standards, over a patchwork of varying standards across states or nations. In practice, any single vessel will be forced to meet the standards of the strictest nation/region it visits. The performance standards recommended by the Majority Panel Report would be the most stringent of any adopted or proposed elsewhere, and the industry contends that it would be unreasonable to expect special investment for the adoption of an individual state's standards. Shipping industry representatives on the Panel therefore advocate that California's standards align with the standards adopted at the IMO Convention. Alternatively, they advocate that the standards align with the anticipated January 2006 release of USGS proposed federal standards.

Reports submitted as part of the IMO Convention suggest that the standards adopted by IMO would only be a marginal improvement on current management practices of ballast water exchange for the largest organisms (>50 μm) and may be similar to unmanaged ballast water for the smaller organisms (<50 μm) (Table V-1, MEPC 49/2/1 2003) (Section VII "Scientific Considerations"). Furthermore, the timeframe during which the USCG will propose to adopt U.S. federal performance standards is uncertain. The stated legislative intent of the Marine Invasive Species Act is to move California expeditiously toward the elimination of the discharge of NIS. As such, Commission staff does not believe the standards adopted by IMO or a reliance on uncertain future federal action meets this intent.

Minority Panel Position Letter - A minority position letter was submitted by The Ocean Conservancy. The position letter encourages the adoption of interim standards outlined in the Majority Panel Report as a starting point with an approach that permits the improvement of the standards that is consistent with improving technology over time (Table X-1). The Ocean Conservancy advocates setting a specific date for achieving a zero discharge standard with benchmarks for reviewing the feasibility of zero as the date approaches. Although the achievability of a zero discharge standard may not be possible at this time, Commission staff does agree with setting a specific date for achieving a zero discharge standard with specific timelines to review technological and economic feasibility as the date approaches, as well as further scientific research.

Table X-1: Summary of Advisory Panel recommendations on performance standards by organism size class.

Organism Size Class (Units)	Majority Panel Recommendations	Minority Panel Recommendations	Minority Panel Position [3]
> 50 μm (/m^3)	No detectable living organisms	10 organisms	No detectable living organisms
10 - 50 μm (/mL)	10^{-2} organisms	10 organisms	10^{-2} organisms
< 10 μm (/100 mL)	10^3 for bacteria 10^4 for viruses Public health protective limits [1]	Public health protective limits [2]	10^3 bacteria 10^4 viruses Public health protective limits [1]

[1] 126 colony-forming-units per 100 milliliters of Escherichia coli, 33 colony-forming-units per 100 milliliters of Intestinal enterococci, 1 colony-forming-unit per 100 milliliters or 1 colony-forming-unit per gram of wet zoological samples for Toxicogenic Vibrio cholerae (serotypes 01 and 0139)

[2] 250 colony-forming-units per 100 milliliters of Escherichia coli, 100 colony-forming-units per 100 milliliters of Intestinal enterococci, 1 colony-forming-unit per 100 milliliters or 1 colony-forming-unit per gram of wet zoological samples for Toxicogenic Vibrio cholerae (serotypes 01 and 0139)

[3] The Ocean Conservancy supports the Majority Panel Report's long-term standard of zero, however advocates setting a date for achieving a zero discharge standard with benchmarks for reviewing the feasibility of zero as the date approaches.

Table X-2: Recommended implementation schedule for interim performance standards. Newly constructed vessels built by timeframes indicated in the middle column must meet standards once placed in active service. Older (existing) vessels must meet standards by deadlines indicated in the last column.

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

Commission Recommendations and Rationale

Commission staff considered the majority and minority positions submitted by the Panel in addition to reviewing the most current research and data available. As described throughout this report, there are many information gaps, which affect the selection and implementation schedule of performance standards for California.
There is no strong scientific evidence that argues for a specific level of treatment. Additionally, questions remain regarding the effectiveness and economic achievability of technologies. Regardless, the Commission believes that by setting technology forcing standards and mandating the review of treatment technologies as they relate to the implementation schedule, the intent of the Act to move the state expeditiously toward the elimination of NIS can be accomplished.

Commission staff used the Panel recommendations and rationale, as well as other information in creating its final recommendations to the Legislature:

1. The State of California should adopt the Interim Performance Standards put forward by the Majority Panel Report.

No single approach (i.e., biological, technical, economic, uniformity) provides certainty regarding the determination of performance standards. Though limited, the scientific data provides an extremely wide range, within which performance standards could be selected. At a minimum, standards should reduce the number of organisms discharged below those observed following a proper ballast water exchange and should function without introducing chemical or physical constituents into the treated ballast water that may result in an adverse water quality impact on the receiving waters. At a maximum, a standard should dictate a zero discharge of organisms in ballast water. Beyond these limits, and contrary to the statements made in the Majority Panel Report, the best available science could not conclusively indicate where a performance standard should fall. As discussed in Section VII, Scientific Considerations, the Majority Panel's rationale for recommending these standards is questionable. However, the proposed standards encompass several other desirable characteristics: they are significantly better than ballast water exchange, they are in-line with the best professional judgment from the scientific experts participating in the IMO Convention, and they do approach a protective zero discharge standard. As such, the proposed interim standards do meet the intent of the Act.

Clearly, the fewer organisms that are discharged from a vessel, the lower the risk that an invasion will occur. The question remains, "How much better than exchange is protective enough?" An ideal standard would maximize biological protection, facilitate the rapid development and installation of effective technologies, and minimize the economic burden placed on the shipping industry. Current information regarding biological protection, technological feasibility, and economic achievability is ambiguous at best.

Despite the many unknowns, Commission staff believes the codification of performance standards is essential to move technology development forward. Stakeholders have argued that the lack of movement on technology development is a direct result of no clear set of standards. Industry has contended that it needs "a target" to aim for. Standards are clearly needed sooner rather than later, to act as a catalyst.

Though the Commission agrees that national consistency regarding performance standards is preferable to a patchwork of rules, the protection of California waters from NIS is critical. Commission staff does not believe that the IMO standards would adequately protect California waters. A small percentage of vessels would meet the >50 μm IMO standard simply through ballast water exchange, and some could meet it even without exchanging ballast water. The IMO standards therefore, could not be considered performance standards that are significantly better than ballast water exchange.

The Commission supports nationally implemented standards that are protective of California waters and believes that adoption of the standards recommended in the report can help lead the national standards into becoming as protective as possible. The USCG has been working on this ballast water issue for several years and may release their proposed standards in early 2006 in the form of a rulemaking package, but the actual numeric standards are not available for consideration at this time.

Additionally, several pieces of federal legislation were introduced in 2005. The passage and implementation of this legislation is not assured. Therefore, Commission recommends that the State of California adopt the Majority Panel Report recommendations on concentration-based, organism size class interim performance standards.

2. The State of California should adopt the Implementation Schedule proposed by Majority Panel Report and adopted in the IMO Convention for the interim standards.

The implementation schedule for compliance with any adopted performance standards is important for the success of any law or rule. In 2004, California ports received over 14000 vessel calls by nearly 2000 different vessels. Since July of 2001, over 5000 different vessels have operated in State waters. Depending on the nature of effective emerging technologies, installation of some systems may only be possible in shipyards. Currently, the demand for shipyard services exceeds supply, and scheduling typically occurs years in advance. Therefore, implementation timeframes must be appropriate not only in terms of the speed of technological development, but also shipyard availability for the retro-fit of existing vessels and construction of new vessels.

Based on Commission data, the majority of vessels (>4400) operating in California since July 1, 2001 have ballast water capacities exceeding 5000 metric tons (MT). A sizable percentage of these vessels are over 10-years old and will presumably be nearing the end of their operational lifespan by the time a treatment system would be required to be installed. The vast majority of vessels will have approximately ten years to identify appropriate technologies, schedule necessary shipyard time, and install technology (Figure X-1). The Commission recommends the State of California support the adoption of the implementation schedule proposed in the Majority Panel Report and adopted in the IMO Convention.

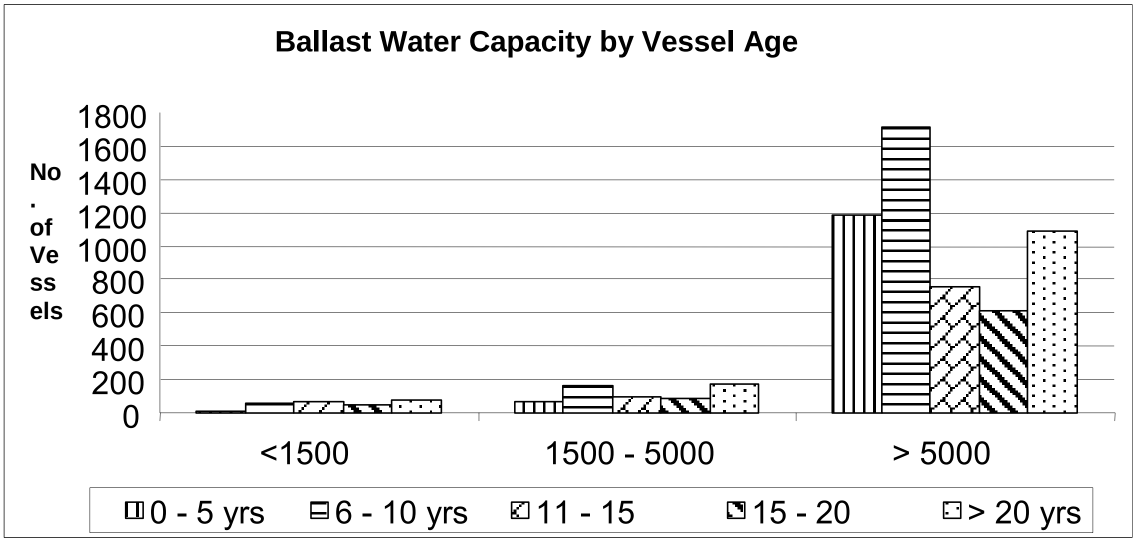

Figure X-1: Ballast water capacity by vessel age
Source: California State Lands Commission-Marine Invasive Species Program database

3. Adopt the Final Performance Standard of zero detectable for all organism size classes by 2020.

The Advisory Panel and Commission support the long-term standard of zero detectable discharge of living organisms. Based on the operational lifespan of vessels, the availability of shipyard access, and expected technological advancements, establishing a final zero discharge standard for all vessels by 2020 is likely feasible.

4. The State of California should mandate an initial and periodic review of treatment technologies and management practices.

The Commission recommends periodic reviews of treatment technologies and management options to determine whether appropriate technologies or management options are able to achieve or exceed the proposed interim and final standards. Assessment of technologies should consider biological effectiveness, safety, environmental soundness, potential water quality impacts and consideration of methods to minimize or prevent such outcomes, practicability, and cost effectiveness. Marine Environment Protection Committee 53/2/2 provides an appropriate template for these reviews.

The first review should be conducted no later than January 1, 2008, one year before the first implementation date of January 1, 2009. Another review, regarding the feasibility of the final zero standard, should be conducted no later January 1, 2019. These reviews would inform the State of California as to whether sufficient technology is available to meet the adopted standards and allow time to modify the schedule if necessary.

This review should consider systems that are commercially available or technologies that are close to being available. The following questions need to be asked: Are components widely available (geographic limitations, availability of replacement parts)? Can the system be used on any vessel or are there constraints related to ballast water capacity (flow rates, time to process ballast water) and operations (voyage duration, temperature and humidity impacts on system)? Is the infrastructure related to ballast water treatment available (sufficient manufacturing, shipyard capacity) for new ships and retrofit of existing vessels?

In addition to the initial review, review of existing and upcoming technologies and management practices should be conducted every three years beginning January 1, 2011. If, as a result of these reviews, technologies are identified that exceed established performance standards, strengthening of those standards should be accomplished.

The reviews should also examine whether industry is making good faith efforts to comply with the standards. If not, the State may want to consider alternative requirements or forms of support for technology development and implementation.

5. The State of California should support the "Grandfathering" of vessels with existing experimental treatment technologies that has been approved by the Commission and/or the USCG.

The implementation schedule recommended by the Panel addresses the retrofitting of existing vessels as well as standards required for future vessel construction. Another important, though very small group of vessels that should be considered, are those whose owners have elected to install prototype treatment technologies in advance of established performance standards. The IMO Convention addresses these vessels (Regulation D-4), by giving a 5-year extension to vessels that participate in an approved program to test promising ballast water treatment technology prior to the date that standards become effective. Under this scenario, a vessel with ballast water capacity greater than 5000 MT that had an experimental treatment system installed in advance of the adoption of California performance standards would be allowed to use that system until 2021. At which time it must comply with the adopted performance standards. In general, these vessels' owners have worked closely with state, federal, and international entities, adding to our understanding of ballast water treatment technology onboard operational vessels.

6. The State of California should support the establishment of a testing and evaluation center that provides the industry, developers, and regulators an opportunity to take promising technologies to working prototypes.

Mandating performance standards must take into account the certification, and subsequent verification of treatment technologies. The current State program does not have the expertise, equipment, facilities, or financial resources necessary for the testing and certification of treatment technologies. This infrastructure would substantially improve the effective implementation of performance standards and the ongoing evaluation of technologies once approved.

The USCG has recently established a testing and evaluation center in Key West, Florida. However, this single facility will only be able to consider three or four systems annually, once testing and verification protocols are established. Discussions between Commission staff and USCG have identified the need for additional testing and evaluation centers. The Commission staff has proposed the establishment of a center in the San Francisco Bay area that would compliment the USCG's Florida facility. A San Francisco-based facility could offer a testing scenario under rigorous conditions that are widely different from those of Key West. Complementary California and Key West facilities could subject technologies to an array of environmental conditions that may be more reflective of the range of conditions vessels encounter during the course of international trade. The budget to establish such a facility, including capitol start-up cost, personnel, operating expenses and equipment is estimated at approximately $10 million over three years. To date, funding for such a center has not been identified.

7. The State of California should appropriate additional funding and personnel to expand biological surveys to assess the effectiveness of the State's Program.
The only way to evaluate the effectiveness of performance standards or other management measures is through long-term biological monitoring. Such work is essential in determining how to change and enhance the Program to more effectively reduce invasions in California. As mandated by the Act, the California Department of Fish and Game administers a statewide monitoring program for NIS within California's estuaries and along its coast.

Under the existing study plan, each monitoring site will be revisited about every 3 years, allowing for at least two sampling events at each site before the sunset date of the program (established in the Act). This monitoring schedule was dictated by time and resource limitations, and will provide only limited data with which to assess whether any new introductions have occurred. The sheer size of the California coastline and the lag time involved for new species to become established necessitates monitoring over a much longer time horizon. It's easy to 'miss' a species on any one visit to a site. The more visits, the greater likelihood that a complete inventory is developed and new introductions are spotted.

One of the resource limitations of these studies has been the availability of taxonomists to do the species identification work. Currently, there are a limited number of taxonomists familiar with the wide variety of species being collected in the surveys. Moreover, because many of the species are introduced from other regions, they may never have been seen by taxonomists working locally. More detailed taxonomic analysis, including genetic identification, would help to resolve the very important questions regarding an organism's pathway of introduction and region of origin. Genetic identification can more accurately determine whether a species is new to this continent or just new to the area of California where it is currently found. With such information it will be easier to assess if the introduction is from a ship vector, which would mean that existing control programs have not been fully effective, or may show that there are other sources of introduction that need to be addressed through other regulatory means.

At a minimum, it is critical that financial resources continue that allow the CDFG to continue its present efforts for the long term, at the very least through the end of the implementation dates established by this report. The Commission recommends that the CDFG be provided additional funding and personnel to expand the frequency and geographic coverage of surveys for a more complete data timeline.

8. The State of California should consider incentives to promote continued technology development.

Technology developers and the shipping industry are unlikely to continue development of technologies that exceed established standards. California should consider various incentive programs (fee reduction, tax credits, etc.) to continue technology development even after technologies are able to meet the adopted performance standards. Positive inducements that are financially advantageous for the shipping industry could serve the advancement of technologies towards the ultimate standard of zero discharge.

9. The Legislature should remove the sunset date in the enabling legislation.

The Marine Invasive Species Act of 2003 includes a sunset date of January 1, 2010; which is well before many of the implementation dates recommended in this report. Continuation of the Marine Invasive Species Program will be necessary to ensure the development of technologies and the proper implementation of the standards in the field.

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XII. APPENDICES

APPENDIX A

MAJORITY REPORT AND RECOMENDATIONS
OF THE
CALIFORNIA ADVISORY PANEL
ON
BALLAST WATER
PERFORMANCE STANDARDS

BALLAST WATER DISCHARGE STANDARDS

REPORT AND RECOMMENDATION OF THE CALIFORNIA ADVISORY PANEL ON BALLAST WATER PERFORMANCE STANDARDS

SUMMARY OF ADVISORY PANEL RECOMMENDATION

The Advisory Panel recommends that the State of California adopt the ballast water discharge standards described below in order to reduce the introduction of harmful exotic species into California's coastal waters. The recommended standards are more stringent than those proposed in either the International Maritime Organization (IMO) Convention or in legislation introduced in the U.S. Senate because the Panel has determined that those standards are inadequate to prevent the introduction of new exotic species that could have significant damaging impacts on California's aquatic ecosystems and on its economy.

Existing technologies are capable of achieving the recommended standards. The primary challenge is to adapt these technologies for application to the conditions and operational requirements of ballast water discharges. To accomplish this in an orderly and economical manner, the Panel recommends a phased and tiered implementation approach consistent with other proposals.

The Panel's recommendation was adopted by a majority of the Panel members. Members representing the shipping industry stated that they recommend alignment with State and federal standards so the shipping industry does not have to deal with different discharge requirements in different parts of the country. They therefore felt they could not endorse the majority recommendation because it differs from standards contained in pending Senate legislation. (Minority opinions are included in the Appendix.)

The Panel did not have time or resources to consider many key aspects of implementing discharge standards, including program funding, monitoring of discharges, environmental monitoring and assessment of program effectiveness. It would be helpful to either reconvene this Panel or to convene a new independent panel of appropriate expert and stakeholder parties to make recommendations on these issues.

LEGISLATIVE AUTHORITY

California Public Resources Code §71204.9 directed the State Lands Commission (Commission) to convene an Advisory Panel to make recommendations to the Commission regarding the content, issuance and implementation of performance standards for the discharge of ballast water into the waters of the state, or into waters that may impact waters of the state. The standards are to protect the beneficial uses of affected and potentially affected waters, based on the best available technology economically achievable. The State Lands Commission is to consider the Advisory Panel's recommendations in submitting recommendations on ballast water standards to the Legislature by January 31, 2006.

The Advisory Panel consisted of representatives from the shipping industry, from stakeholder industries that are affected by exotic species introduced in ballast water discharges, from environmental organizations, scientific experts, and representatives from state and federal agencies (Appendix 1). The Panel met five times in the spring and summer of 2005.

BRIEF OVERVIEW OF THE CHALLENGE

It is not necessary here to revisit in detail the nature of the ecological and socio-economic problems caused by invasive aquatic organisms. The impacts of those invasions have been well documented and demand an effective response. It became clear during panel deliberations that an unacceptable level of invasions will continue over the coming years unless more effective measures of prevention are implemented. Due to inherent limits on its effectiveness, ballast water exchange or retention (which are the basis for California's current regulatory approach) cannot prevent new invasions from occurring.

The question therefore became, what is the standard of treatment needed to reduce the number of viable organisms in ballast water discharges to a level that lowers the risk of invasion to an acceptable threshold? The Panel and State Lands Commission staff assembled data and consulted experts to guide the Panel's consideration of this question.

ADVISORY PANEL RECOMMENDATION

The Advisory Panel recommends that California adopt the discharge standards in Table 1 in order to reduce the risk of introduction of new exotic species to an acceptable level. The Interim Standards should be phased in according to the schedule in Table 2, which is the same implementation schedule as contained in the IMO Convention and in pending Congressional legislation. The Long-term Standard of no detectable discharge of living organisms should undergo a technical review by 2016 to determine if this goal can reasonably be achieved and recommend an appropriate implementation schedule.

It is expected that private industry will play the main role in developing effective technologies once standards are adopted; and that industry will be given broad leeway to determine what technologies to use as long as the chosen method complies with the standards and all other applicable regulatory requirements. The Panel's shipping industry representatives expressed interest in having the State certify technologies that achieve the applicable standards.

Table 1. Recommended ballast water discharge standards

	Organism type or size class	Discharge standard
Interim Standards	*Environmentally-protective limits*	
	Organisms greater than 50 microns in minimum dimension:	No detectable living organisms
	Organisms 10-50 microns in minimum dimension:	No more than 10^{-2} living organisms per milliliter
	Organisms less than 10 microns in minimum dimension:	No more than 10^{3} colony-forming-units of bacteria per 100 milliliters
		No more than 10^{4} viruses per 100 milliliters
	Public health-protective limits	
	Escherichia coli:	No more than 126 colony-forming-units per 100 milliliters
	Intestinal enterococci:	No more than 33 colony-forming-units per 100 milliliters
	Toxicogenic *Vibrio cholerae* (serotypes O1 and O139):	No more than 1 colony-forming-unit per 100 milliliters
		No more than 1 colony-forming-unit per gram of wet zoological samples
Long-term Standard	All size classes	No detectable living or culturable organisms

Table 2. Recommended Implementation Schedule for Interim Standards

Ballast capacity of vessel	Applied to vessels in this size class that are constructed in or after	Applied to other vessels in this size class starting in
<1500 metric tons:	2009	2016
1500-5000 metric tons:	2009	2014
>5000 metric tons:	2012	2016

RATIONALE FOR THE RECOMMENDED STANDARDS

After some discussion, the Panel agreed to consider standards that set limits on organism concentrations in ballast water discharges within the organism size classes and on the implementation schedule used in the IMO Convention and in the current drafts of two bills pending in the U.S. Senate (S. 363 and S. 1224). As noted by the Panel's shipping industry representatives, this implementation schedule takes into account the limited availability of dry-dock facilities and provides a workable time frame for scheduling vessels for retrofit. Adopting this framework also provides a measure of consistency with national and international efforts to set ballast water discharge standards.

Within this framework, the Panel considered a range of concentration standards including the proposed IMO standards, the standards in the pending Senate bills, the standards advocated by the U.S. representatives to the IMO conference, a standard based on reducing the rate of invasion due to ballast water discharges to a level approximating the natural invasion rate, and various forms of zero discharge standards. The Panel compared these, on an order-of-magnitude basis, to the mean and median values for organism concentrations in untreated ballast water discharges, as determined from various studies. These figures are shown in the first table in Appendix 2.

<u>Biological Basis for Standards</u>

The Panel was unable to find any written or reported explanation of the biological rationale for the concentration standards in the IMO Convention, the standards in the pending Senate bills, or the standards advocated by U.S. representatives at the IMO Convention. While these standards appear to have been derived in part from technical workshops convened by the U.S. Coast Guard or IMO, the published materials from these workshops do not give any explanation or indication of the effect that these standards are expected to have on the rate of invasions due to ballast water discharges (USCG 2002; MEPC 2003). In some cases, it's not clear if these standards would result in a significant reduction from current, untreated discharge levels (*e.g.* compare the IMO standard for the 10-50 micron size class with untreated concentrations, in Appendix 2, Table 1).

The scientific basis for a standard of discharging no exotic organisms is that exotic organisms, unlike conventional chemical pollutants, can reproduce and increase over time, persist indefinitely and spread over large regions. Thus, very large, widespread and long-term impacts could potentially result from the discharge of a small number of individual organisms—in some cases as few as a single mated pair, or in the case of asexually-reproducing species, a single individual. From this perspective, the only biologically safe standard is no discharge of exotic organisms. The Panel noted that in practice "zero discharge" might refer to a variety of distinct standards, including no detectable discharge of organisms, no discharge of viable organisms, and no discharge of ballast water. Additional information on zero discharge standards is provided in the memo in Appendix 3.

One biologically-based standard that is less stringent than zero discharge is a "natural invasion rate standard," which would reduce the discharge of organisms in ballast water to a level where the rate of invasion due to these discharges is approximately equal to the natural invasion rate. The calculation of concentration limits to meet this standard starts with estimates of the concentration of organisms in untreated and unexchanged ballast water (Appendix 4), and reduces these by the ratio between the natural invasion rate and the rate of invasion due to ballast water discharges (Appendix 5). The Panel's scientist members offered different estimates of the natural invasion rate, and the Panel considered the range of these estimates in developing its recommendations (Appendix 6).

Technical and Economic Considerations

The basic task involved in meeting ballast water discharge standards is to remove or kill organisms contained in a tank of water. Several technologies are available to achieve this, including methods used by municipalities to disinfect large quantities of water and wastewater. These technologies need to be adapted to work on the variety of organisms present in ballast water, over the range of physical and chemical parameters that are characteristic of ballast water, and to function in a shipboard setting or onshore system in a manner that is consistent with ship operational requirements.

Relative to the quantity of water and wastewater that is routinely disinfected by municipal and other treatment plants, the volume of ballast water discharged in California is quite small. For example, the total ballast water discharge in California in 2004 (7.8 million m^3—Falkner *et al.* 2005) is less than 0.25% (one-quarter of one percent) of the volume of wastewater that is annually treated and discharged into the San Francisco Bay Estuary (Gunther *et al.* 1987). If it were gathered together in one place, all the ballast water discharged in California could be treated in one small treatment plant.

The Panel was able to consider some limited information regarding the shipping industry's ability to finance the investment in new ballast water treatment technologies. Preliminary cost estimates for ballast water treatment range from less than $10 million to $50 million per year to treat all the ballast water discharged into California (see page 2 of the memo in Appendix 7). One study commissioned by the California Association of Port Authorities estimated total capital and operating costs of $8.1 million/year to collect and treat all ballast water discharges in California in onshore plants built specifically for that purpose (URS/Dames & Moore 1998). The study found that the pipes and tanks needed to transport and store the ballast water on shore formed the major part of these costs, with the treatment plants themselves accounting for 7% of the total.

In comparison, the existing capital and operating costs for a single ship are estimated at $10,000-$53,000 per day (≈$4-19 million/year) and the profits for a single ship at $3,000-$38,000/day ($1-14 million/year); a federally-subsidized dredging project at the Port of Oakland is estimated to provide $156-229 million/year in net direct benefits to the ships using that port; and the cargo handled by California ports is valued at over a quarter of a trillion dollars each year (Appendix 7, page 3). The California shipping industry is currently undergoing an expansion related to globalization and the ongoing growth in international trade, with the industry as a whole yielding record-high profits (Appendix 7, pages 3-4). Thus, economic indicators suggest that the shipping industry may have the financial capacity to provide high levels of ballast water treatment, and that the timing may be appropriate for such investment.

The economic indicators cited here and in the Appendix were compiled by Panel members and State Lands Commission staff from literature and internet searches and discussions with economists. More comprehensive financial information on the industry may be available, which would allow for a more detailed comparison between the estimated costs for treating ballast water discharges and the industry's capacity to pay these costs. This information was not available to the Panel.

Recommended Standard for Organisms >50 Microns in Minimum Dimension

A treatment system using 50-micron filters would eliminate all or virtually all organisms with a minimum dimension greater than 50 microns. Filters of this size have been used and performed reliably in several ballast water treatment studies and are expected to be a component of various ballast water treatment systems planned for shipboard use (Appendix 3). Some ballast water studies and proposed treatment systems have involved 10-micron to 25-micron filters, but the performance and compatibility of these finer filters with ship operational requirements is not yet clear. The USCG and IMO technical workshops recommended that standards of complete removal or inactivation, no discharge, or no detectable discharge of organisms >50 microns in minimum diameter (or in some cases, even smaller organisms) be put into effect by 2006, and one workshop recommended that a further standard of no detectable discharge of organisms >10 microns in minimum diameter be put into effect by 2015 (Appendix 3). The Panel found that a standard of no detectable discharge of organisms >50 microns in minimum diameter is feasible, and therefore recommended that this be adopted as an Interim Standard for implementation between 2009 and 2016.

Recommended Standard for Organisms 10-50 Microns in Minimum Dimension

Based on the information noted in the preceding paragraph, the Panel was uncertain whether a standard of no detectable discharge of organisms 10-50 microns in minimum diameter is feasible in the short term. Instead, the Panel determined that a feasible short-term standard could be based on the less stringent end of the range of estimates of a natural invasion rate standard (Appendix 5). The Panel therefore recommended that an Interim Standard for this organism size class of no more than 0.01 living organisms per milliliter of ballast water discharge be implemented between 2009 and 2016, and that the State evaluate by 2016 when a Long-term Standard of no detectable discharge could be implemented. The Panel noted that the recommended Interim Standard for this organism size class is the same as the standard advocated by the U.S. representatives to the IMO conference.

Recommended Standard for Organisms <10 Microns in Minimum Dimension

While 0.2-micron membrane filters have been used in drinking water treatment systems, filter systems for removing organisms <10 microns in minimum dimension from ballast water have not been tested and are unlikely to be feasible in the short-term for widespread ballast water treatment. Instead, the Panel determined that a feasible short-term standard for this size class could be based on a 10^5-fold reduction in the concentration of organisms relative to their mean concentration in untreated and unexchanged ballast water, consistent with the middle of the range of estimates of a natural invasion rate standard (Appendix 5). The Panel noted that implementing this level of reduction over the next decade seems reasonable relative to the 10^3-fold or 10^4-fold reductions in microbe concentrations required by the federal Safe Drinking Water Act, which have been in place and successfully implemented for decades. The Panel therefore recommended that an Interim Standard of no more than 10^3 bacteria and no more than 10^4 viruses per 100 milliliters of ballast water discharge be implemented between 2009 and 2016, and that the State evaluate by 2016 when a Long-term Standard of no detectable discharge could be implemented.

<u>Recommended Standard to Protect Public Health</u>

The Senate bills (S. 363 and S. 1224) contain concentration limits for certain pathogens and pathogen indicator species. These are based in part on the U.S. EPA water quality criteria for water contact recreation (standards for *Escherichia coli* and intestinal enterococci), and in part on evidence that ballast water has transported epidemic strains of the bacterium that causes cholera (standards for *Vibrio cholerae*). Although one Panel member argued that the water contact recreation criteria were insufficiently protective of public health, the Panel found that the public health protective standards in these Senate bills were reasonable and feasible and recommended that they be adopted as an Interim Standard.

CONCLUSION

The Advisory Panel strove to identify an approach to reduce the risk of harmful invasions of exotic species that was scientifically based, effective and reasonable. The recommended approach is the same as recently proposed federal and international approaches in terms of implementation schedule, organism size classes, health indicator organisms, allowable technologies and application to various classes of ships. It differs from other approaches in that it proposes more stringent limits on the number of viable organisms that would be allowed in ballast water discharges. The Panel recommends these more stringent limits because it concluded that other adopted and proposed standards would fail to accomplish the objective of preventing the introduction of potentially harmful organisms. Because the environmental and socio-economic impacts of invasive species have been so significant to date, the Panel believes that strong standards are essential to the success of a preventive strategy.

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LIST OF APPENDIXES

APPENDIX 1: ADVISORY PANEL MEMBERS

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APPENDIX 2: COMPARISON OF POTENTIAL STANDARDS

Table 1. Order-of-magnitude comparison of organism concentrations in ballast water and potential discharge standards

Organism Size Class	Units	Concentration in untreated, unexchanged ballast water	Standard in IMO Convention	Standard in Senate Bills	US position at IMO conference	Standard based on natural invasion rate	Zero discharge standard
>50 µm	$/m^3$	10^2-10^3	10	10^{-1}	10^{-2}	10^{-3}-10^{-2}	0
10-50 µm	/mL	10-10^2	10	10^{-1}	10^{-2}	10^{-4}-10^{-3}	0
<10 µm	/100 mL	10^8-10^9	–	–	–	10^3-10^4	0

Table 1 compares the organism concentrations in untreated ballast water discharges and a range of potential concentration standards for ballast water discharges.

Columns 1-2: The organism size classes and units are those used in the IMO Convention and in the current drafts of two bills in the U.S. Senate (S. 363 and S. 1224). The organism size classes refer to the minimum dimensions of the organisms.

Column 3: The concentrations in untreated and unexchanged ballast water are order-of-magnitude estimates based on statistical summaries of a range of studies, which are described further in Table 2 below. For the >50 micron and 10-50 micron organism size classes, the ranges approximate the median and mean values for zooplankton and phytoplankton respectively; for the <10 micron size class, the range approximates the mean values for bacteria and virus-like particles, respectively.

Columns 4-6: The IMO Convention, Senate bills and the standards advocated by the U.S. representatives at the IMO conference include public health protective standards that limit the concentration of certain pathogenic and pathogen indicator species that are less than 10 microns in minimum dimension, but do not contain any general restriction on the discharge of organisms in this size class to protect the environment from invasions. The full standards in the IMO Convention and Senate bills are given in Table 3 below.

Column 7: The ranges given for a standard based on the natural invasion rate are based on a 10^5-fold reduction from the range of concentrations given for untreated, unexchanged ballast water. Scientists on the Panel or consulted by Panel members estimated that the appropriate reduction could be between 10^4-fold and 10^6-fold, based on their range of estimates of the natural invasion rate. This range could raise or lower the figures in Table 1 by one order of magnitude.

Column 8: Several types of zero discharge standard were discussed by the Panel, including no discharge of ballast water, no discharge of living organisms, and no detectable discharge of living organisms.

Table 2. Organism concentrations in untreated and unexchanged ballast water

Type of Organism	Number of Ships Sampled	Median Concentration	Mean Concentration
Zooplankton	429	0.4/liter	4.64/liter
Phytoplankton	273	13,300/liter	299,202/liter
Bacteria	11		8.3×10^{8}/liter
Virus-like Particles	7		7.4×10^{9}/liter

Table 2 shows the IMO's statistical data on organism concentrations in ships' ballast water (MEPC 2003). These data were the basis for the order-of-magnitude concentrations given in Column 3 of Table 1, and were derived from studies that sampled ballast water of coastal origin with a broad range of ages that had not been exchanged or treated. MEPC (2003) suggested that median values are a useful frame of reference for considering ballast water standards (the definition of median is that half the tanks had higher concentrations than the median value, and half had lower.)

Table 3. IMO Convention and Senate Bill standards for permissible concentration limits in ballast discharges

Organism Type or Class	IMO Convention	S. 363 and S. 1224
Living organisms >50 microns in minimum dimension	10/m^3	0.1/m^3
Living organisms 10-50 microns in minimum dimension	10/mL	0.1/mL
Colony-forming units of *Escherichia coli*	250/100 mL	126/100 mL
Colony-forming units of intestinal enterococci	100/100 mL	33/100 mL
Colony-forming units of toxicogenic *Vibrio cholerae* (serotypes O1 & O139)	1/100 mL	1/100 mL
Colony-forming units of toxicogenic *Vibrio cholerae* (serotypes O1 & O139)	1/gram wet weight of zoological samples	1/gram wet weight of zoological samples

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APPENDIX 3: MEMO ON ZERO DISCHARGE STANDARDS

Subject: **Background and Possible Basis for a Zero Discharge Standard**
To: Ballast Water Treatment Standards Committee
From: Andrew Cohen
Date: August 4, 2005

Various standards might be considered zero discharge standards, including:

- no detectable discharge of living organisms
- zero discharge of living organisms
- no discharge of ballast water

The scientific basis for a zero discharge standard is that exotic organisms, unlike conventional chemical pollutants, can:

1) reproduce and increase over time:
2) persist indefinitely: and
3) spread, sometimes in high concentrations, over very large and even continental distances once they have been discharged to a new continent.

Such invasions can result from a single pair of mated organisms, or in the case of asexually-reproducing species, a single individual. An example of the latter is the tropical seaweed *Caulerpa taxifolia*, whose invasion over thousands of acres in the Mediterranean Sea and in two bays in California consists of a single clone, and thus derives from a single individual.[1]

In 1998, the San Francisco Bay Regional Water Quality Control Board (Region 2) proposed and the State Water Resources Control Board approved listing exotic species discharged in ballast water as a priority pollutant impairing the waters of San Francisco Bay, under Clean Water Act §303(d) (SFBRWQCB 1998). In subsequently considering how to set a total maximum daily load (TMDL), Region 2 concluded (at least informally) that zero-discharge of exotic organisms was the only scientifically-supported standard available.

The U.S. Coast Guard convened two technical workshops on Ballast Water Treatment Standards in the spring of 2001, bringing together experts in the fields of ballast water treatment, invasion biology and standards development. The East Coast Workshop recommended a long-term (within 5 years) standard of 100% removal or inactivation of coastal holoplankton, meroplankton, and demersal organisms (including all life stages) and photosynthesizing organisms (including phytoplankton, cysts and algal propagules), which

[1] The import and sale of *Caulerpa taxifolia*, dubbed the "Killer Alga," was banned in the U.S. in response to a petition from over 100 scientists who were alarmed at its impacts in the Mediterranean. It was subsequently discovered growing in two small bays in California, where its eradication (which is nearly complete after 4 years of effort) probably cost over $10 million (Raloff, 1998, 2000; Jousson *et al.* 2000).

includes a variety of organisms down to 2 μm in size. The West Coast Workshop recommended a short-term (within a few years) standard of zero discharge for organisms >50 μm and a long-term (within 10 years) standard of zero discharge for all organisms (USCG 2002a).

Based on these workshops, meetings of the Ballast Water and Shipping Committee of the Aquatic Nuisance Species Task Force, and an IMO GloBallast workshop, the U.S. Coast Guard published an Advance Notice of Proposed Rulemaking in the spring of 2002 (USCG 2002b). This notice listed alternative short-term standards, including removing, killing or inactivating all organisms >100 μm, and no discharge of organisms >50 μm; and alternative long-term goals, including no discharge of zooplankton and photosynthetic organisms (including holoplanktonic, meroplanktonic, and demersal zooplankton, phytoplankton, and propagules of macroalgae and aquatic angiosperms), inclusive of all life-stages.

An International Workshop on Ballast Water Discharge Standards was held by the State Department and the U.S. Coast Guard at NSF headquarters on Feb. 12-14, 2003. Participants included IMO representatives and technical experts from 7 IMO member states. Of the Workshops three working groups, Group 1 recommended an initial standard of no detectable organisms >50 μm; and Group 3 recommended an initial standard of no detectable organisms >100 μm to go into effect by 2006, no detectable organisms >50 μm to go into effect by 2009, and no detectable organisms >25 μm to go into effect by 2015. A synthesis of the groups' recommendations was suggested, which included a standards of no detectable organisms >50 μm to go into effect by 2006, and no detectable organisms >10 μm to go into effect by 2015 (MEPC 2003).

Several assessments and studies of ballast water treatment have employed filtration either as the initial or sole treatment process. The filter sizes used in these assessments range from 150 μm to 50 μm or less,[2] suggesting that zero detectable discharge of organisms above these sizes would be routinely achieved by these treatments.

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[2] Some examples of ballast treatment systems using filtration that have been investigated include:
• *filtration to 150 μm*: a single-pass 150 μm wedgewire strainer on ballasting at 1,250 and 2,500 m^3/hr (Pollutech 1992); a single-pass 150 μm wedgewire strainer on ballasting at 2,500 m^3/hr and UV at 420 mW-S/cm^2 (Pollutech 1992); a recirculating system with 150 μm wedgewire strainer and UV at 420 mW-S/cm^2 (Pollutech 1992);
• *filtration to 100 μm*: a continuous deflective separation unit operated at normal ballast pump flow rates filtering to 50-100 μm (Victoria ENRC 1997); 100 μm filtration at 270 and 1,800 m^3/hr, with UV, thermal or ultrasonic treatment (Battelle 1998); a self-cleaning 100 μm filter at 135 m^3/hr (Röpell & Voight 2002);
• *filtration to 50 μm*: a single-pass 50 μm wedgewire strainer on ballasting at 1,250 and 2,500 m^3/hr (Pollutech 1992); a single-pass 50 μm wedgewire strainer on ballasting at 2,500 m^3/hr and UV at 210 mW-S/cm^2 (Pollutech 1992); an in-line 50 μm stainless steel strainer with automatic backwash (AQIS 1993); 50 μm filtration during ballasting (Dames & Moore 1999); continuous backwash filtration to remove particles and organisms down to 50 μm size (URS/Dames & Moore 2000); a 50 μm filter screen at 340 m^3/hr with and without a prefilter (Cangelosi & Harkins 2002); a self-cleaning 50 μm filter at 135 m^3/hr (Röpell & Voight 2002); a self-cleaning 50 μm screen at 340 m^3/hr (Waite & Kazumi 2004);
• *filtration to 25 μm*: a self-cleaning 25 μm woven mesh screen filter at 1,000 m^3/hr (Carlton *et al.* 1995); 25 μm filtration at 270 and 1,800 m^3/hr, with UV, thermal or ultrasonic treatment (Battelle 1998); a 25 μm filter screen at 340 m^3/hr with and without a prefilter (Cangelosi & Harkins 2002);
• *filtration to 20 μm*: 20 μm filtration during ballasting (Dames & Moore 1999); 20 μm filtration and cyclone during ballasting (Dames & Moore 1999).

Until 1992, the largest containerships built were of the Panamax type, with widths no greater than the 106' maximum that is permitted to pass through the Panama Canal. As containerships tried to carry greater numbers of containers per ship, containers were stacked progressively higher on the decks through the 1980s, with correspondingly increasing amounts of ballast water needed to provide stability. Beamier Post-Panamax containerships, which increasingly dominate the fleet,[3] are inherently more stable and carry and discharge much less ballast water per voyage—on the order of a few hundred tons rather than several thousand tons for Panamax ships (Herbert Engineering 1999)—while carrying much larger numbers of containers. Some can also shifting ballast internally to adjust the ship's list and trim. Ship designers are considering further modifications to ships' piping systems that would eliminate the discharge of ballast water in port (Herbert Engineering 1999; Schilling 2000). This may also be feasible for a few other types of vessels, such as passenger ships (Schilling 2000).

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Dames & Moore (1999) concluded that on-board filtration systems appear "potentially viable with filter sizes between 20 and 50 μm". Oemcke (1999) noted that self-cleaning stainless steel screens can filter down to 10-20 μm without flocculants, and that membrane filters to filter surface waters down to 0.2 μm cost 35-49¢ per m^3 of filtrate in 1990 (*i.e.* $2.7-3.8 million to filter the 7.8 million m^3 of ballast water discharged in California in 2004), but that costs had been dropping as technology improved and market share increased.

3 The Port of Oakland projects that Post-Panamax sized containerships, which accounted for 10% of port visits in 1996, will account for 75% of port visits in 2010 (Port of Oakland 1999).

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APPENDIX 4: CONCENTRATIONS OF ORGANISMS DELIVERED IN SHIPS' BALLAST WATER IN THE ABSENCE OF ANY TREATMENT: ESTABLISHING A BASELINE FOR CONSIDERATION OF TREATMENT EFFICACY –

A report submitted to the Marine Environmental Protection Committee (MEPC) of the International Maritime Organization (IMO) by the ICES/IOC/IMO Study Group on Ballast Water and other Ship Vectors, on behalf of the International Council for the Exploration of the Sea (ICES), based on data assembled from Study Group members by Dr. Greg Ruiz of the Smithsonian Environmental Research Center.

INTERNATIONAL MARITIME ORGANIZATION

IMO

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MARINE ENVIRONMENT PROTECTION COMMITTEE
49th session
Agenda item 2

MEPC 49/2/21
23 May 2003
Original: ENGLISH

HARMFUL AQUATIC ORGANISMS IN BALLAST WATER

Comments on draft Regulation E-2
Concentrations of organisms delivered in ships' ballast water in the absence of any treatment: Establishing a baseline for consideration of treatment efficacy

Submitted by the International Council for the Exploration of the Sea (ICES)

SUMMARY

Executive summary:	This document has been submitted by the Chairmen of the ICES/IOC/IMO Study Group on Ballast Water and other Ship Vectors (SGBOSV), Stephan Gollasch (Germany) and Steve Raaymakers (IMO GloBallast Programme Co-ordination Unit), on behalf of the International Council for the Exploration of the Sea (ICES). This submission is based on the meeting of SGBOSV, held in March 2003 in Vancouver, Canada. The Study Group discussed the basis of the bracketed numbers in the draft Regulation E-2 and developed a database of known organism concentrations in ballast tanks, so as to guide the scientific determination of ballast water management standards. These data establish a current baseline level or threshold of organism delivery, against which treatment and management efficacy should be measured. The proposed ballast water treatment/ management should result in a substantial reduction below the current baseline level of organism concentrations delivered in untreated ballast tanks. The full meeting report of the 2003 meeting of SGBOSV will soon be available at www.ices.dk. The content of this submission does not necessarily represent the views of ICES.
Action to be taken:	Paragraph 12
Related documents:	MEPC 48/2; MEPC 48/2/1; MEPC 49/2/3

Introduction

1 Mr. Michael Hunter (United Kingdom), Chairman of the Ballast Water Working Group convened during MEPC 48, requested scientific input to provide a scientific reasoning for the individual numbers in draft Regulation E-2.

2 The second Intersessional Meeting of the Ballast Water Working Group (IBWWG) discussed Regulation E-2 and recommended a new format for consideration at MEPC 49:

> "Ships conducting Ballast Water Management in accordance with this Regulation shall discharge no more than [25] viable individuals per litre of zooplankton greater than [10]µm in size; and no more than [200] viable cells per ml of phytoplankton greater than [10]µm in size; and discharge of a specified set of indicator microbes shall not exceed specified concentrations".

3 The Ballast Water Working Group concluded that there was not sufficient time and scientific resources at the MEPC-IBWWG to determine the specific size and concentration in brackets. Some concern was expressed that the individual numbers in brackets for both, total phytoplankton and zooplankton abundance may not provide meaningful protection of species invasions (MEPC 49/2/3, paragraphs 2.63 to 2.65).

4 SGBOSV agreed that the finalisation of this standard is vital so as to provide the R&D community with a clear benchmark to aim for in developing alternative treatment technologies. It was also made clear that organism concentration values currently inserted in the draft standard are subject to negotiation. Expert scientific input is urgently required to inform this process and ensure that scientifically defensible and environmentally meaningful values are adopted in the Convention.

5 Identification of specific standards for ballast water treatment remains unresolved. It is certain that removing all organisms from ballast water would prevent associated invasions. It is also clear that reducing organism concentrations will reduce the likelihood of invasions. However, the specific level of reduced invasion risk achieved with each incremental reduction in organism concentration is presently not known.

6 As a minimum standard, to achieve any reduction in invasion risk, ballast water treatment must result in a substantial reduction in the concentrations of organisms compared to untreated ballast water. In particular, treatment should reduce the concentrations of coastal organisms, which can colonize and significantly impact coastal (including marine, brackish and freshwater) ecosystems.

7 This document summarizes data on the concentrations of viable organisms that arrive in ballast water that has not undergone any treatment or management. This is intended to characterize the current level of delivery against which treatment and management efficacy (standards) should be considered.

Executing Institutions

8 The Study Group on Ballast Water and Other Ship Vectors (SGBOSV) is a joint activity of ICES, IMO and IOC. The SGBOSV is composed of an international group of scientists, with extensive knowledge about the biology of ship-mediated transfers and invasions. The SGBOSV strives to advance scientific understanding of biological invasions associated with ships that is needed to guide management and policy decisions.

9 At the 2003 meeting of SGBOSV in total 41 participants from Australia, Belgium, Canada, France, Germany, Ireland, Italy, the Netherlands, New Zealand, Norway, Russia, Sweden, the United Kingdom, the United States of America and the GloBallast Programme (GloBallast), International Maritime Organization (IMO) attended (Annex 4). The Chairman of

the IMO Ballast Water Working Group, Mr. Michael Hunter, who also attended the 2003 meeting of SGBOSV, appealed to the Study Group to provide advice and input, in time for consideration by MEPC 49. Responding to the need for scientific input, and as requested by Mr. Hunter, SGBOSV discussed the bracketed individual numbers in draft Regulation E-2.

Methodology

10 Study Group member Dr. G. Ruiz of the Smithsonian Environmental Research Center, United States volunteered to take the lead in developing a global database on organism concentrations based upon data provided by Study Group members. A questionnaire addressing concentrations of organisms measured in the ballast water of commercial vessels was sent to the members of SGBOSV shortly after the meeting.

11 The information provided was summarized and is attached as annex 1 to this document. SGBOSV hopes that the datasets will support the development of ballast water standards of the Ballast Water Convention.

Action requested of the Committee

12 The Committee is requested to take the data provided in the annexes to this document into account and comment, as it deems appropriate.

***

ANNEX 1

1 The ICES/IOC/IMO SGBOSV discussed the basis of the bracketed numbers in the draft Regulation E-2 and agreed that it is necessary to consider the concentrations of organisms in ballast tanks. This provides an important framework to understand the transfer of biota and to guide the development of ballast water treatment standards.

2 The SGBOSV has developed a database to characterize the concentrations of organisms measured in ballast tanks.

3 The information of this database is summarized here and intended to provide a baseline measure of what arrives in ballast water without any treatment, to better inform discussions at IMO.

Methodology

4 Data were included only for ballast water of coastal origin (< 100 km offshore) that was not exposed to ballast water exchange or an alternate treatment. These data included ballast water sampled from multiple vessel types (tankers, bulk carriers, container vessels, etc.) and with a broad range of ages.

5 The concentrations of organisms were summarized according to four general taxonomic groups: zooplankton, phytoplankton, bacteria, and virus-like-particles. These data derive from multiple studies, conducted at various ports, encompassing all seasons. The sources of data, and details of methods, are shown in annex 2.

6 These data are restricted to the ballast water only and do not include estimates for sediments or biofilms.

7 Summary statistics were calculated for each taxonomic group, to characterize the concentration of organisms present in untreated ballast water.

Results

8 For ***zooplankton***, summary statistics are based upon n=429 ballast tanks sampled (see Annex 3), mostly from individual vessels (i.e., a single tank at the end of independent vessel voyage), as follows:

(a) The median was 0.4 individuals per litre, indicating that half of the samples had concentrations above this value and the other half below this value.

(b) The mode was 0.1 individuals per litre. The mode is simply the individual value (concentration) most commonly observed among all samples, compared to any other single value.

(c) The mean number of zooplankton was 4.64 individuals per litre (standard error =0.708).

(d) The range of concentrations was 0 - 172 individuals per litre.

(e) These values are a conservative estimate of concentrations because samples were collected with nets with mesh openings that ranged from 55-80 μm and so only zooplankton larger than the mesh size were collected.

(f) The frequency distribution of zooplankton concentrations is shown in Figure 1 (annex 3).

9 For ***phytoplankton***, summary statistics are based upon n=273 ballast tanks sampled (see annex 3), mostly from individual vessels (i.e., a single tank sampled at the end of independent vessel voyages), as follows:

(a) The median was 13,300 phytoplankton cells per litre, indicating that half of the samples had concentrations above this value and the other half below this value.

(b) The mode was 1.0 phytoplankton cells per litre. The mode indicates the individual value most commonly observed among all samples, compared to any other single value.

(c) The mean number of phytoplankton was 299,202 phytoplankton cells per litre (standard error = 183,637).

(d) The range of concentrations was 1 - 49,716,400 phytoplankton cells per litre.

(e) These values are a conservative estimate of concentrations for phytoplankton above 10 μm, because samples were sieved with mesh sizes that ranged from 0-10 μm (0 means samples were not concentrated).

(f) The frequency distribution of phytoplankton concentrations is shown in Figure 2 (annex 3).

10 Fewer data were available for concentrations of ***bacteria*** and ***virus-like-particles*** in ballast water, limiting characterization in a similar fashion to zooplankton and phytoplankton. Instead, we simply report mean values and ranges.

(a) The mean number of bacteria from n=11 ballast tanks was 8.3×10^8 cells per litre (standard error = 1.7×10^8), ranging from 2.4×10^8 to 1.9×10^9 cells per litre.

(b) The mean number of virus-like particles (VLPs) from n=7 ballast tanks was 7.4×10^9 VLPs per litre (standard error = 2.3×10^9), ranging from 0.6×10^9 to 14.9×10^9 VLPs per litre.

Conclusions & Recommendations

11 Considerable variation exists in the concentrations of organisms arriving in unexchanged/untreated ballast water among vessels. Some of this variation is explained by (a) season and (b) voyage duration. Several studies also indicate that considerable variation exists among ballasting events, within the same port and season, which undoubtedly contribute to the observed variation.

12 The median concentrations of organisms estimated by this analysis for unmanaged ballast water provide a useful frame of reference in consideration of ballast water standards.

(a) The median is one approach to characterize the distribution of concentrations observed in unmanaged ballast water, as it presently arrives.

(b) By definition, 50% of all ballast tanks sampled in this analysis had concentrations below the median value and the other 50% had concentrations above the median.

(c) A significant risk of invasions still exists at the observed median concentrations.

13 To significantly reduce the risk of invasions associated with ballast water beyond the present situation, permissible discharge concentrations identified by any treatment/management standards should fall greatly below the median values observed presently in untreated / unmanaged ballast water.

14 Any standard should strive to reduce the transfer of organisms to the maximum extent possible, to minimize the likelihood of invasions, as it is clear that the risk of invasion (a) exists with any organism transfer and (b) increases with increasing concentrations of organisms.

15 Recognizing the inherent risk with any discharge, and the current concentrations delivered in untreated ballast water, SGBOSV recommends standards at least 3 orders of magnitude below the observed median concentrations for zooplankton and an equivalent or higher level of reduction for phytoplankton.

(a) **Zooplankton**

The median was 0.4 individuals per litre (see above) what is equivalent to 400 individuals per cubic meter. A three orders of magnitude reduction results in 0.4 individuals per cubic meter.

(b) **Phytoplankton**

The median was 13,300 phytoplankton cells per litre (see above). A three orders of magnitude reduction results in 13.3 individuals per litre.

***

ANNEX 2

Source of data compiled in database and used in analyses. Sample size refers to number of ballast tanks sampled.

Organism Type	Source	Number of Samples	Sieve Size (μm)	Geographic Region	Ship Types
Zooplankton					
	S. Gollasch	101	55	Germany	Container, Ro-Ro, Tanker
	G. Ruiz et al.	205	80	Eastern U.S.	Bulker
	G. Ruiz et al.	123	80	Alaska	Tanker
Phytoplankton					
	S. Gollasch	61	10	Germany	Container, Ro-Ro, Bulker
	T. McCollin	105	0 (not sieved)	Scotland	Bulker, Cargo, Tanker
	T. McCollin & I. Lucas	107	0 (not sieved)	England & Wales	Bulker, Container, Ro-Ro, Tanker
Bacteria					
	G. Ruiz, F. Dobbs, & L. Drake	11	0 (not sieved)	Eastern U.S.	Bulker
Viruses					
	G. Ruiz, F. Dobbs, & L. Drake	7	0 (not sieved)	Eastern U.S.	Bulker

***

ANNEX 3

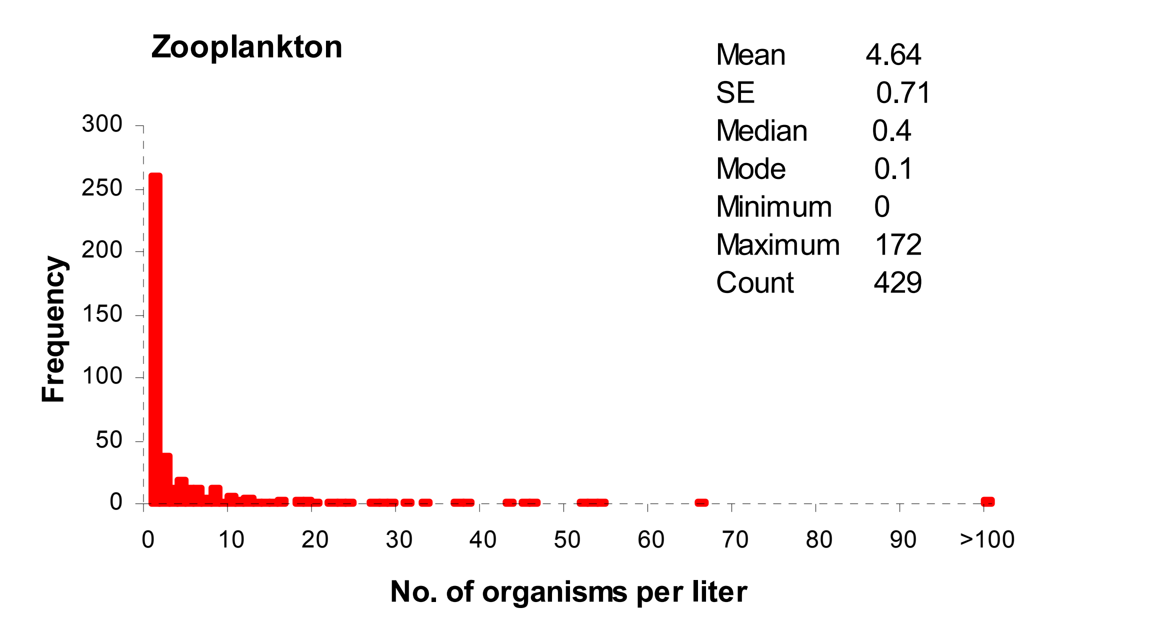

Figure 1. Frequency of zooplankton concentrations in ballast water. Shown is the frequency of zooplankton concentrations (no. per litre) measured in samples from ballast tanks (n=429).

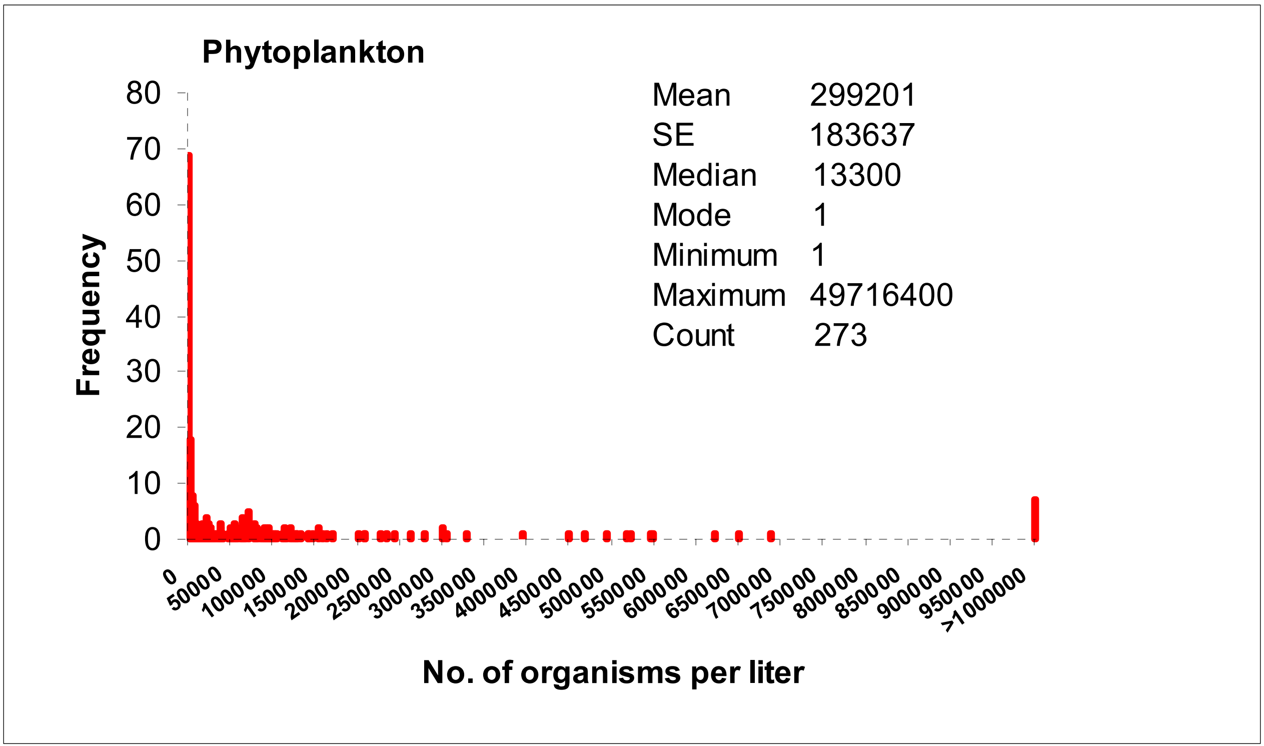

Figure 2. Frequency of phytoplankton concentrations in ballast water. Shown is the frequency of phytoplankton concentrations (no. per litre) measured in samples from ballast tanks (n=273).

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ANNEX 4

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APPENDIX 5: MEMO ON A NATURAL INVASION RATE STANDARD

Subject: **Basis for a Standard Based on the Natural Rate of Invasion**
To: Ballast Water Treatment Standards Committee
From: Andrew Cohen
Date: August 7, 2005

Biological Rationale for a Standard Based on the Natural Invasion Rate

Biological invasions of marine ecosystems are natural, at least in the sense that on rare occasions a coastal organism must have by accident drifted or rafted across the ocean and established an isolated colony on the other side. However, human activities—prominently including the transport and discharge of ballast water—have greatly increased the rate at which such colonies are established, creating a novel level of rapid alteration of ecosystems and (because a portion of these species have harmful impacts on economic or recreational activities or public health), elevated the stresses on human communities.

A performance standard that reduced the rate of invasion due to ballast water discharges to around the average rate of invasion under natural conditions would implicitly allow a doubling of the natural invasion rate as a result of ballast discharges alone. However, in contrast with a standard that allowed a 10x or 100x increase in the invasion rate,[1] this is still reasonably close to the natural rate and possibly within the normal range of variation, and would thus be reasonably protective of the environment. Because it would entail a substantial decrease in the current rate of invasion, it would also reduce the impacts on human uses. Such a standard would thus be reasonably protective of the various environmental, recreational and economic beneficial uses of California's waters.

Calculation of a Standard Based on the Natural Invasion Rate

To a first approximation, in order to reduce the rate of invasions due to ballast water to roughly the average natural invasion rate, we need to reduce the concentration of living organisms in ballast water discharges by the ratio between the natural invasion rate and the invasion rate due to the discharge of untreated and unexchanged ballast water.[2] We'll call this ratio the Reduction Factor:

1 Based on the calculations below, the standards in S. 363 and S. 1224 represent about a 10x-100x increase over the natural invasion rate for organisms >50 microns, and about a 100x-1,000x increase for organisms in the 10-50 micron size class. The standards in the IMO Convention represent about a 1,000x-10,000x and about a 10,000x-100,000x increase over the natural invasion rate for >50 micron and 10-50 micron organisms, respectively.

2 This approximation implicitly assumes that the Discharge/Invasion Curve is roughly linear, that is, that an X% increase or decrease in the number of organisms discharged during a period of time will

(1) Reduction Factor = $\frac{\text{Natural invasion rate}}{\text{Invasion rate due to untreated and unexchanged BW}}$

Then, the concentration standard for living organisms in ballast water discharges that will meet this goal is:

(2) Concentration Standard = $\frac{\text{Concentration of organisms in}}{\text{untreated \& unexchanged BW}}$ X Reduction Factor[3]

Estimate of concentration in ballast water: Order-of-magnitude estimates of the concentration of living organisms in untreated and unexchanged ballast water at the end of transoceanic voyages are:

- for organisms >50 microns in width 10^2-10^3 per m^3
- for organisms 10-50 microns in width 10-10^2 per mL
- for organisms <10 microns in width 10^8-10^9 per 100 mL

These estimates are derived from statistical data on studies that sampled ballast water of coastal origin that had not been exchanged or treated. Specifically, the concentration

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produce about an X% increase or decrease in the number of invasions that occur during that time as a result of those discharges. We don't, in fact, know the shape of this curve and a variety of shapes are theoretically possible, but the assumption of linearity is both the simplest possible assumption and consistent with standard regulatory practice. For example, the US EPA routinely makes the precisely analogous assumption when assuming that the Dose/Response Curves for a variety of suspected carcinogens and other toxins are linear in order to extrapolate responses from rodent bioassays conducted at high dose levels to chronic human exposures projected at low dose levels.

3 In reality, it's not the *concentration* of organisms in ballast water that needs be reduced by the Reduction Factor, but rather the *rate* at which organisms are discharged. This is equal to the concentration of organisms times the rate of ballast water discharge. If C_{BW} = the concentration of organisms in untreated, unexchanged ballast water, D_1 = the rate of ballast discharge during the baseline period that corresponds to C_{BW}, and D_2 = the rate of ballast discharge during the future period when the Concentration Standard is in effect, then:

$$\text{Concentration Standard} \times D_2 = C_{BW} \times D_1 \times \text{Reduction Factor}$$

If $D_1 = D_2$, then this equation reduces to Equation (2). If the rate of ballast water discharge is decreasing over time ($D_1 > D_2$), then Equation (2) will calculate a Concentration Standard that is too low (*i.e.* too stringent), and if it's increasing, it will calculate a standard that is too high (too lenient). For the container fleet, the increasing number of Post-Panamax ships, which carry and discharge less ballast water per ship while carrying more containers suggests that the rate of ballast water discharge could decline (Herbert 1999). For example, the Port of Oakland (1998) projected that while the number of containerships arriving at the Port and the amount of cargo carried by them would increase from 1996 to 2010, the amount of ballast water they discharged would decrease by 42%. On the other hand, for other types of vessels such as bulk carriers and tankers, significant decreases in the amount of ballast water discharged per ton of cargo are unlikely (Herbert 1999). The larger volumes of ballast water carried by these ships, and the projected increases in cargo tonnage handled by California ports suggests that the overall rate of ballast discharge will increase. In neither case, however, is the change likely to approach an order of magnitude, and so Equation (2) seems reasonable as a first approximation.

ranges for >50 micron and 10-50 micron organisms are based on the mean and median values for zooplankton and phytoplankton samples, respectively, and the concentration range for <10 micron organisms is based on the mean values for bacteria and virus-like particles. More detail on these data is provided in Table 2 of "Attachment F: Comparison of Potential Standards" which SLC sent to the Committee before the July meeting, in Greg Ruiz's presentation at the April meeting, and in MEPC (2003).

Estimate of natural invasion rate: A natural marine invasion is defined as a marine organism that is transported across an ocean by drifting, rafting or some other natural, irregular and rare transport mechanism and becomes established initially as a disjunct, isolated population in waters on the other side. It excludes organisms that have a continuous range that includes both sides of the ocean (such as, in the Pacific, organisms that have a continuous range from northern Japan and Siberia across to Alaska and British Columbia by way of the Bering Strait or the Aleutian Islands), organisms that have regular, natural genetic exchange between populations on opposite sides of the ocean (such as may occur with pelagic organisms that regularly migrate across the ocean, or organisms with teleplanic larvae that are regularly advected across the ocean), and organisms occurring in disjunct, transoceanic populations that are relics of formerly genetically-continuous populations. The natural, one-way invasion rate (*i.e.* from one side of the ocean to the other) can be estimated as:

$$(3) \quad \text{Natural invasion rate} = \frac{0.5 \times \text{The number of species common to both sides of the ocean that are thought to result from natural invasion}}{\text{The length of time it takes for isolated populations to become morphologically distinct}}$$

Based on a review of the biogeographical literature and other relevant data, the number of species of invertebrates and fish[4] common to both sides of the Pacific Ocean that are thought to be the result of natural invasions is estimated as ≤10 (J. Carlton estimate) or ≤100 (A. Cohen estimate). The length of time that it takes for isolated populations of invertebrates or fish to become morphologically distinct (*i.e.* such that they would be considered separate species based on morphological evidence) is estimated as 1-3 million years.[5] If we conservatively[6] estimate the number of naturally invaded

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4 The available biogeographical data for other types of organisms, including protozoans, fungi, bacteria and viruses, are too poor to provide a basis for even a rough estimate of the natural invasion rate.

5 For example, closely-related populations of marine organisms on either side of the Panamanian isthmus, which have been separated for about 2.8 million years, are variously considered by taxonomists to have morphologies that range from being very similar but capable of being distinguished (and therefore are considered separate species) to being so similar that they cannot be distinguished (and therefore are usually identified as the same species).

In the July meeting, Greg Ruiz noted that Vermeij (1991) reported that 11 gastropod species from the western Pacific had invaded the eastern Pacific in the last 18 million years. This rate of 0.6 invading gastropods per million years seems reasonably consistent with an estimate of ≤100 fish and invertebrates per million years.

6 In this memo, "conservative" is taken to mean supporting a smaller reduction from the concentration of organisms in untreated discharges and a less-stringent standard. Here, for example, it means using the numbers—out of the range of reasonable estimates—that produce the highest estimate of natural invasion rate. If the calculation instead used 10 for the number of common species and 3 million years for the period, the natural invasion rate would be less than 2 species per million years.

invertebrate or fish species common to both sides of the ocean to be 100, and the relevant period to be 1 million years, then the natural invasion rate from the western to the eastern Pacific shore for species in these two categories of organisms is 50 species per million years, or 5 x 10^{-5} species per year.

Estimate of invasion rate due to unexchanged, untreated ballast water: The Federal law that first set up a voluntary program of mid-ocean ballast water exchange was passed in 1996, and the California law that required mid-ocean ballast water exchange was passed in 1999. Data from a period immediately prior to the passage of these laws would therefore be appropriate for estimating the rate of invasion resulting from the discharge of unexchanged and untreated ballast water.

From 1961-1995, the rate of invasion into the San Francisco Bay and Delta was one species every 14 weeks, or 3.7 species per year; with the rate increasing over time to 5.2 species per year in 1991-95 (Cohen & Carlton 1997).[7] The fraction introduced by ballast water also increased over time. For invertebrates and fish, the rate was 2.9 species per year in 1961-1995, with ballast water responsible for introducing 0.7-1.7 species per year (24-59% of the total); in 1991-1995 the rate was 4.2 invertebrate and fish species per year, with ballast water responsible for 1.6-3.2 (38-76% of the total).

These figures probably substantially underestimate the true number of invasions, by missing exotic species that (a) haven't been collected, (b) have been collected but not identified, or (c) have been identified but whose status as exotic or native has not yet been resolved (cryptogenic species). These missing species could raise the total by probably 50-100%.[8] In addition, these figures refer only to species established in the San Francisco Bay/Delta system; if species established elsewhere in California are included, the total could rise by at least another 50-100%.[9] When these factors are taken into account, ballast water is estimated to be responsible for introducing 2-7 exotic invertebrates and fish into California waters each year if 1961-95 is used as the baseline for the estimate, and 4-13 invertebrates and fish if 1991-95 is used as the baseline.

Calculation of Reduction Factor and Concentration Standards: Using the above estimates and Equation (1), the Reduction Factor is:

- for the 1961-95 baseline: 0.7-2.5 x 10^{-5}
- for the 1991-95 baseline: 0.4-1.3 x 10^{-5}

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7 The invasion numbers discussed in this section are based on the date of discovery (first observation or collection) of the invading species.

8 For example, Cohen & Carlton (1998) reported 234 exotic species and at least 125 cryptogenic species established in the San Francisco Bay and Delta (cryptogenics equal to 53% of the number of exotics). Ashe (2002) reported (a) 360 exotic species, (b) 247 species considered cryptogenic but "most likely introduced," and (c) 126 taxa not identified to species but considered by researchers to most likely be introduced, in California coastal waters (categories (b) and (c) equaling 104% of the number of exotics).

9 For example, Ashe (2002: Figure 5) reported 190 exotic and 43 cryptogenic species in San Francisco Bay, but 360 exotic and 247 cryptogenic species statewide, or 89% and 474% over the San Francisco Bay numbers.

To an order of magnitude, the Reduction Factor is 10^{-5}.[10] The corresponding Concentration Standards are:

- for organisms >50 microns in width 10^{-3}-10^{-2} per m^3
- for organisms 10-50 microns in width 10^{-4}-10^{-3} per mL
- for organisms <10 microns in width 10^3-10^4 per 100 mL

References

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[10] Steve Moore (San Francisco Bay RQWCB) noted that this is reasonably close to the reductions in organism concentrations that have been achieved for decades under the Safe Drinking Water Act, where the EPA criteria set reductions of 10^{-3} or 10^{-4} for different types of microbes.

APPENDIX 6: ADDENDUM TO THE MEMO ON A NATURAL INVASION RATE STANDARD

Footnote 5 incorrectly reported data from Vermeij (1991). Vermeij actually stated that 11 gastropod species from the Line Islands in the Central Pacific had invaded the eastern Pacific in the last 2 million years, or a rate of about 5.5 invading gastropods per million years. At the August 2005 Advisory Panel meeting, after some discussion of technical issues related to the records in this paper and other paleontological data, Greg Ruiz stated that he was more comfortable with a natural invasion rate estimate of ≤1,000 fish and invertebrates per million years. Thus, three invasion biologists provided the Panel with different estimates of the natural invasion rate, corresponding to calculations of different Reduction Factors and concentration limits, as follows:

Biologist	Estimate of natural invasions of invertebrates and fish per million years	Reduction Factor	Concentration limits for organisms >50 microns	Concentration limits for organisms 10-50 microns	Concentration limits for organisms <10 microns
J. Carlton	≤10	10^{-6}	10^{-4}-10^{-3}	10^{-5}-10^{-4}	10^{2}-10^{3}
A. Cohen	≤100	10^{-5}	10^{-3}-10^{-2}	10^{-4}-10^{-3}	10^{3}-10^{4}
G. Ruiz	≤1,000	10^{-4}	10^{-2}-10^{-1}	10^{-3}-10^{-2}	10^{4}-10^{5}

The Panel considered the wider range of concentration limits indicated by this range of estimates as potentially pertaining to a natural invasion rate standard.

APPENDIX 7: MEMO ON TECHNICAL FEASIBILITY, TREATMENT COSTS AND ECONOMIC INDICATORS

Subject: **Some Data on Treatment Costs and Economic Indicators**

To: Ballast Water Treatment Standards Committee

From: Andrew Cohen

Date: August 7, 2005

Technical Feasibility and Scale

The basic task to be achieved is to remove or kill organisms that are trapped in a tank of water.

Relative to the volumes handled by existing programs to remove or kill organisms in water or wastewater, the amount of ballast water to be treated is modest. Less than 7.8 million cubic meters of ballast water were discharged into California waters in 2004 (Falkner *et al.* 2005). In contrast, over 3.2 *billion* cubic meters of wastewater are treated and discharged to the San Francisco Bay Estuary each year (Gunther *et al.* 1987)[11], or more than 150 times the volume of ballast water discharged to the entire state. Each year, 24 different wastewater treatment plants in the Bay Area each treat more than the total volume of ballast water discharged to the entire state. Two Bay Area plants each treat more than 23 times the total volume of ballast water discharged to the entire state.

Comparable or even larger volumes of water are treated by the Bay Area's water districts.

From the perspective of water or wastewater treatment, treating all of California's ballast water is a small-scale project — the volume equivalent of a single small water treatment plant for the entire state.

[11] These data are from a 1987 review, based on wastewater treated in 1984-86. With 20 years of rapid population growth, the volume of wastewater treated in the Bay Area is no doubt substantially larger today.

Estimated Treatment Costs for all Ballast Water Discharged into California

The figure below from URS/Dames & Moore 1998 is from a study commissioned by the California Association of Port Authorities that included site-specific cost estimates for essentially all ports in the state. The other figures were developed by multiplying per metric ton costs derived from the cited sources by the State Lands Commission's data on the total amount of ballast water discharged into California waters in 2004 (7.8 million metric tons—Falkner *et al.* 2005). For the most part, these studies estimated the major, identifiable costs but did not necessarily estimate all costs. Costs given in Australian or Canadian dollars were converted to US dollars using recent exchange rates. Costs were not inflated to current dollars.

	$million/year
Filtration & UV (onshore)	
AQIS 1993	2-5
Pollutech 1992	3-9
URS/Dames & Moore 1998	8
Chlorine (500 ppm)	
Pollutech 1992	13
Rigby *et al.* 1993	19
Filtration & UV (shipboard)	
Pollutech 1992	22
Schilling 2002	32
Hydrocyclone & UV (shipboard)	
Schilling 2002	27
Glutaraldehyde	
Lubomudrov, Moll	32-48
Glycolic Acid	
RNC Consulting	50

Shipping Industry - Economic Indicators

CALIFORNIA-WIDE INDICATORS

- Cargo handled by California Ports
  - $260 billion in 2003 (DOT Statistics 2003)
  - $300 billion/year (ILWU)

- Revenues, Costs & Profits of California Shipping Industry (rough calculation based on comparison with Jones Act Fleet data)
  - Revenues ≈$14 billion/yr
  - Capital & Operating Costs ≈$12.5 billion/yr
  - Profits ≈$1.5 billion/yr

PORT/REGION INDICATORS

- Bay/Delta ports: $34 billion in foreign trade in 1992 (Port of Oakland 1998a, b)
- Annualized net direct benefit of -50' dredging project to ships using the Port of Oakland:
  - $156-229 million/year (Port of Oakland 1998a)
- Federal subsidy for Port of Oakland's -50' dredging project:
  - $82.5 million (Port of Oakland 1998b)

PER VESSEL INDICATORS

- Capital & Operating Costs per Vessel

Containerships:	$10,000-15,000/day – new 1,000-3,500 TEU (OCS 2004)
	$42,000/day while in port, $53,000/day while at sea – 73,000 DWT containership (Port of Oakland 1998c)
Bulk Carriers:	$11,000-19,000/day – various ages & sizes (OCS 2004)
	$24,000/day – 10-year-old Capesize (Stopford)
Tankers:	$32,000-43,000/day – new VLCC (OCS 2004)

- Profits per Vessel

Containerships:	$3,000-27,000/day – 300-3,500 TEU (OCS 2004)
Bulk Carriers:	$15,000-38,000/day – various sizes (OCS 2004)
Tankers:	$9,000-32,000/day – various sizes (OCS 2004)

- Average Tanker Freight Rates
  - $19,000-$55,000/day (2002-2004) (Naval Institute 2005)

OTHER

- Shipping Industry – Net Profit Margin of 28.0%, the 2nd highest of 212 industries listed (2nd only to Healthcare Re-insurers) (Yahoo Finance, accessed Aug. 5, 2005).
- Shipping Industry – Return on Equity of 33.6%, the 9th highest of 212 industries listed (Yahoo Finance, accessed Aug. 5, 2005).

Shipping Industry - Growth Trends

<u>Los Angeles/Long Beach harbors</u>
In 1995, Long Beach Harbor and Los Angeles Harbor were the 2nd and 3rd busiest container ports in the US, after New York/New Jersey Harbor (Port of Oakland 1998c).

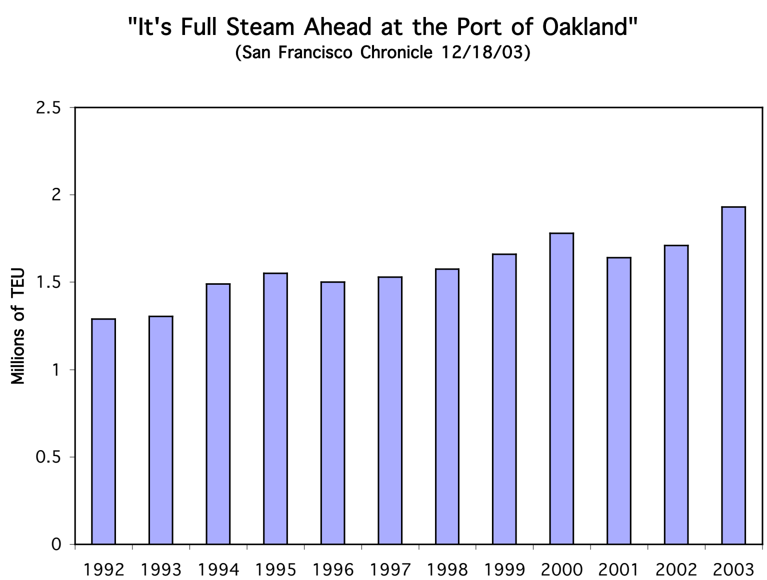
The number of containers handled at Long Beach Harbor more than doubled between 1994 and 2004, from 2.6 million to 5.8 million, for an average growth of 8.35% per year (data from "Attachment B: Economic Trends" in the materials provided by SLC for the July meeting).

Container traffic at Los Angeles/Long Beach harbors is expected to rise 13% this year, according to the Pacific Maritime Association (San Francisco Chronicle, July 15, 2005).

<u>Port of Oakland</u>
In 1995, the Port of Oakland was the 4th busiest container port in the US and the 19th busiest container port in the world (Port of Oakland 1998c).

Cargo tonnage at the Port of Oakland has grown 8.3%/yr over the past 5 years (Port of Oakland 1998c).

Projected growth is from 1.4 million TEU in 1996 to 3.4 million TEU in 2007. Future growth is projected at 7-8% per year (Jordan Woodman Dobson 1998).



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APPENDIX 8: MINORITY REPORT FROM PANEL MEMBERS REPRESENTING THE SHIPPING INDUSTRY

PMSA

June 15, 2005

Suzanne Gilmore
Marine Facilities Division
California State Lands Commission
100 Howe Avenue, Suite 100 South
Sacramento, CA 95825

<u>Re: California Public Resources Code – Ballast Water Performance Standards</u>

Dear Suzanne:

Pursuant to the SB 433 (Nation – statutes of 2003), the State Lands Commission (Commission) has convened and consulted with an advisory panel to develop a report to the Legislature with recommendations on specific performance standards for the discharge of ballast water. The undersigned companies, representing many of the vessels calling in California's ports, appreciate the opportunity to participate in this process. We have worked closely with one another in an effort to ensure that the maritime industry's concerns and interests are adequately expressed within the framework of the advisory panel and more broadly, within the statute. We would like to offer the following recommendations to the panel as guidelines for the development of these standards.

The development of performance standards for discharge of ballast waters is one of the most important steps to take in the development of treatment technology. Although many public and private sector efforts have been made, and are currently underway to develop and analyze treatment technologies, establishing a standard for removal or destruction of invasive species will provide a benchmark for further development and refinement. However based on the data presented in previous panel meetings, the quantification of open water exchange efficiency as well as development of alternative treatment technologies are still in the infancy stages. Data on the correlation of microorganism concentrations in ballast water and the introduction of invasive species are also scarce. Therefore, we recommend caution in developing performance standards without sound scientific testing and analysis. We fully support provisions that will allot CSLC the necessary funding to develop the data needed to make defensible decisions regarding ballast water performance standards.

Efforts to develop standards are taking place in the international arena, through the International Maritime Organization (IMO) as well as nationally through both federal legislation and research being done by the United States Coast Guard (USCG). Our industry applauds the efforts by the Commission to coordinate and align the California ballast water statutes and regulations with the USCG and the IMO. As the majority of ocean going vessels entering California waters operate throughout the world, the adoption of harmonious regulations results in greater ease of application, less disruption to industry and most importantly - greater compliance. In the case of ballast water management, the shipping industry has been exposed to a variety of state and local requirements that, in some cases, have varied from international and federal requirements. Continuing this patchwork-quilt approach would be catastrophic for the environment and the industry and undermine the progress that we can make on this issue by the establishment of a strong, uniform federal program. Although California's major ports are some of the largest in the world, it is unrealistic to assume that capital investment will be put toward technology to treat ballast water to a standard different from the rest of the world. We can not foresee multiple treatment systems on-board vessels, each treating to a different standard.

For this reason, our suggestion to the advisory panel is to await the development of standards from the USCG or the IMO and consider those standards as guidelines for a recommendation to the Legislature. We realize that such standards may not be available for review prior to the January 31, 2006 deadline established under AB 433, however our understanding is that work is already being done on these and any delay should be minor. We also believe the Commission has the ability to provide the Legislature with an interim recommendation to await national or international standards and to act upon those standards once in place.

We will be happy to discuss this recommendation further with the advisory panel.

Sincerely,

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John Berge – Pacific Merchant Shipping Association

____

Lisa M. Swanson – Matson Navigation Company

____

Bradly Chapman – Chevron Shipping Company

APPENDIX 9: SUPPLEMENTAL REPORT FROM THE OCEAN CONSERVANCY

Advocates for Wild, Healthy Oceans

Pacific Regional Office
116 New Montgomery St.
Suite 810
San Francisco, CA 94105

415.979.0900 Telephone
415.979.0901 Facsimile
www.oceanconservancy.org

Formerly the Center for
Marine Conservation

The Ocean Conservancy

September 9, 2005

Lt. Governor Cruz Bustamante
California State Lands Commission
100 Howe Ave Suite 100 South
Sacramento, CA 95825-8202

Dear Lt. Governor Bustamante and Members of the Commission:

At the outset, The Ocean Conservancy would like to thank the State Lands Commission for convening this Committee, and its staff for their skillful facilitation of the Committee's activities. Although The Ocean Conservancy supports many of the Majority Report's recommendations, we write separately to highlight a few points.

(1) California Should Adopt A Rigorous, Technology-Forcing Approach.

As the Majority Report indicates, the Committee selected more-or-less fixed "interim" standards that are achievable given technologies that are available today. Simultaneously, the Committee selected an implementation schedule – one that is aligned with other federal programs – that gives the industry years before any substantive improvement must be made. During the Committee's work, TOC sought higher standards because the existence of such standards – combined with a competitive marketplace for ballast water treatment products – would motivate the rapid development of technology appropriate for meeting them.

The Clean Water Act has been termed a technology-forcing statute because of the rigorous demands placed on those who are regulated by it to achieve higher and higher levels of pollution abatement under deadlines specified in the law. The general statutory scheme is that in any given category or subcategory of industry, dischargers are to meet technology-based performance standards, based on the capability of available treatment technology. In other words, as technology develops and more effective pollution control tools become available, the requirements for dischargers are ratcheted up. Technology-based standards are the principal vehicle for setting pollution control levels, yet water quality standards were retained as a basis for assessing the need for even more stringent discharge controls where necessary to protect the uses of a stream, including human health. Accordingly, the Act specifically envisions **better** pollution control than "Best Available Technology Economically Achievable" in circumstances where water quality is impaired.

The interim standards selected by the Committee are as strong or stronger than any existing standards that we are aware of. However, they are fixed, inflexible and based on technologies available today, rather than flexible, forward-looking and adaptive. The Ocean Conservancy encourages the State Lands Commission to take the interim standards as a starting point, and to consider an approach that permits improvement of the standards – consistent with improvement in technology – over time.

(2) The Long-Term Discharge Standard of Zero Should Be Firmer.

The Ocean Conservancy supports the Majority Report's long-term standard of zero detectable discharge of living organisms because implementation of this standard is the only means of eliminating all risk of invasion. However, no date is set for achieving this standard, and the technical review conducted in 2016 will evaluate only **if** this standard can be met.

California must set a date for achieving the zero discharge standard, and establish benchmarks for reviewing the feasibility of the standard as it approaches. This approach would create incentives for developing technology as quickly as possible, without creating unmanageable compliance burdens for the industry.

(3) California Should Lead the National Battle Against Invasive Species By Adopting the Strongest Possible Standards.

California ports handle between $200 billion and $300 billion in cargo annually, and the estimated gross revenues of California shippers are in the range of $14 billion a year. California is the 6th largest economy in the world. In other words, the assertion that shippers will avoid California ports if California's ballast water performance standards are too stringent is a scare tactic. Moreover, it is a scare tactic that has a long history.

California's air quality legislation predates the federal Clean Air Act, and set higher standards that persist today. California's water quality legislation predates the federal Clean Water Act, and controls pollution from a wider variety of sources even today. California's pesticide regulation predates federal insecticide controls, and even today, California's pesticide regulations are the most comprehensive in the nation. These are just a few examples of California's environmental leadership, but they are sufficient to highlight the fact that strong environmental regulation has never caused industry to flee from this state. Despite tough rules, our economy continues to grow.

* * * * *

In sum, TOC encourages the State Lands Commission to continue its pattern of national leadership in addressing the threat of invasive species in United States waters. The recommendations of the Ballast Water Performance Standards Advisory Committee are strong, but could be made significantly stronger, as we outline above. Most importantly, California should not wait for the emergence of national standards that are heretofore unsettled. Instead, it should do as it has historically done: lead the way, and encourage the rest of the nation to follow.

Sincerely,

Sarah G. Newkirk
California Water Quality Programs Manager

APPENDIX B

MINORITY REPORT AND RECOMENDATIONS
OF THE
CALIFORNIA ADVISORY PANEL
ON
BALLAST WATER
PERFORMANCE STANDARDS

BALLAST WATER DISCHARGE STANDARDS

REPORT AND RECOMMENDATION OF THE CALIFORNIA ADVISORY PANEL ON BALLAST WATER PERFORMANCE STANDARDS

MINORITY REPORT

SUMMARY OF ADVISORY PANEL RECOMMENDATION

Representatives of the Shipping industry are submitting the following as a minority report. We are attempting to incorporate the Majority Panel report within and highlight the differences in our opinion in order to facilitate the ease in which SLC is able to submit their final report.

In most cases we concur with the findings and "collective memory" of events that unfolded during the meetings. However, in a number of instances contained within the Majority Report minority opinions are expressed. We have amended or deleted these instances to better reflect the opinion of the Panel.

The Majority of the Advisory Panel recommends that the State of California adopt the ballast water discharge standards described below in order to reduce the possible introduction of harmful nonindigenous aquatic species into California's coastal waters. The recommended standards are more stringent than those proposed in either the International Maritime Organization (IMO) Convention or in proposed Congressional legislation (SB-363). A majority on the Panel has decided that those standards are inadequate to sufficiently reduce the risk of introduction of new nonindigenous aquatic species that could have significant damaging impacts on California's aquatic ecosystems and on its economy. The industry representatives are recommending alignment with proposed IMO standards and USCG standards based on work currently underway, or alternatively those found in SB-363 should it be signed into law. The shipping industry supports global regulations which they feel will facilitate reduction of invasions globally and facilitate development of treatment technologies in a timelier manner. This opinion is further explained in the letter in Attachment 1.

Existing technologies are capable of achieving the recommended standards in a land-based wastewater treatment setting. The primary challenge is to adapt these technologies for application to shipboard conditions and operational requirements of ballast water discharges. It should also be noted that unlike shoreside waste water treatment systems which are designed for specific tasks, ballast water treatment systems will need to handle millions of possible unknown species, silt and debris, saltwater, etc. To date, there have been only a few demonstrations of ballast water treatment systems onboard ships. To help in facilitating the proposed requirements, the Panel recommends a phased and tiered implementation approach consistent with timelines proposed by IMO and USCG.

The Panel did not have time or resources to consider many key aspects of implementing discharge standards, including program funding, monitoring of discharges, environmental monitoring and assessment of program effectiveness. It would be helpful to either reconvene this Panel or to convene a new independent panel of appropriate expert and stakeholder parties to make recommendations on these issues in the future as the program matures, economically proven technology is developed and studies are completed.

LEGISLATIVE AUTHORITY

California Public Resources Code §71204.9 directed the State Lands Commission (SLC) to convene an Advisory Panel to make recommendations to the Commission on the content, issuance and implementation of performance standards for the discharge of ballast water into the waters of the state, or into waters that may impact waters of the state. The standards are to protect the beneficial uses of affected and potentially affected waters, based on the best available technology economically achievable. SLC is to consider the Advisory Panel's recommendations in submitting recommendations on ballast water standards to the Legislature by January 31, 2006.

The Advisory Panel consisted of representatives from the shipping industry, from stakeholder industries that are affected by nonindigenous aquatic species introduced in ballast water discharges, from environmental organizations, scientific experts, and representatives from state and federal agencies (Appendix 1). The Panel met five times in the spring and summer of 2005.

BRIEF OVERVIEW OF THE CHALLENGE

It is not necessary here to revisit in detail the nature of the ecological and socio-economic problems caused by nonindigenous aquatic species. The impacts of some invasions have been well documented and necessitate an effective response. Due to inherent limits on its effectiveness, ballast water exchange and retention (which are the two viable management techniques under California's current regulatory approach) cannot completely prevent the introduction of nonindigenous species into state waters.

The question therefore becomes what is the standard of treatment needed to reduce the number of viable organisms in ballast water discharges to a level that lowers the risk of invasion to an acceptable threshold? The Panel and SLC staff assembled data and consulted experts to guide the Panel's consideration of this question.

ADVISORY PANEL RECOMMENDATION

The Majority Advisory Panel recommends that California adopt the discharge standards in Table 1 in order to reduce the risk of introduction of new nonindigenous aquatic species. The Interim Standards should be phased in according to the schedule in Table 2, which is the same implementation schedule as contained in the IMO Convention and in pending Congressional legislation. The Long-term Standard of no detectable viable organisms in the discharge should be subjected to a technical review to be conducted no later than 2016. The review should determine if this goal can reasonably be achieved and recommend an appropriate implementation schedule.

It is expected that private industry will play the main role in developing effective technologies once standards are adopted; and that industry will determine which technologies to use based on their ship and voyage characteristics, as long as the method chosen satisfies the standards and all other applicable regulatory requirements. The Panel's shipping industry representatives expressed interest in having the State certify technologies that achieve the applicable standards.

Table 1. Recommended ballast water discharge standards

	Organism type or size class	Discharge standard
Interim Standards	<u>*Environmentally-protective limits*</u>	
	Organisms greater than 50 microns in minimum dimension:	No detectable living organisms
	Organisms 10-50 microns in minimum dimension:	No more than 10^{-2} living organisms per milliliter
	Organisms less than 10 microns in minimum dimension:	No more than 10^{3} colony-forming-units of bacteria per 100 milliliters
		No more than 10^{4} viruses per 100 milliliters
	<u>*Public health-protective limits*</u>	
	Escherichia coli:	No more than 126 colony-forming-units per 100 milliliters
	Intestinal enterococci:	No more than 33 colony-forming-units per 100 milliliters
	Toxicogenic *Vibrio cholerae* (serotypes O1 and O139):	No more than 1 colony-forming-unit per 100 milliliters
		No more than 1 colony-forming-unit per gram of wet zoological samples
Long-term Standard	All size classes	No detectable living or culturable organisms

Table 2. Recommended Implementation Schedule for Interim Standards

Ballast capacity of vessel	Applied to vessels in this size class that are constructed in or after	Applied to other vessels in this size class starting in
<1500 metric tons:	2009	2016
1500-5000 metric tons:	2009	2014
>5000 metric tons:	2012	2016

RATIONALE FOR THE RECOMMENDED STANDARDS

After some discussion, the Panel agreed to consider standards that set limits on organism concentrations in ballast water discharges within the organism size classes and on the implementation schedule used in the IMO Convention and in the current drafts of two bills pending in the U.S. Senate (S. 363 and S. 1224). As noted by the Panel's shipping industry representatives, this implementation schedule takes into account the limited availability of dry-dock facilities, time for private industry to develop technology, and provides a workable time frame for scheduling vessels for retrofit.

Within this framework, the Panel considered a range of concentration standards, including the IMO standards, the standards in the Senate bills, the standards that were recommended to the U.S. representatives to the IMO conference, and various forms of zero discharge standards. The Panel compared these, on an order-of-magnitude basis, to the mean and median values for organism concentrations in untreated ballast water discharges, as determined from various studies. These figures are shown in the first table in Appendix 2.

Biological Basis for Standards

The Panel was unable to find any written or reported explanation of the biological rationale for the concentration standards in the IMO Convention, the proposed standards in the Senate bills, or the standards advocated by U.S. representatives at the IMO Convention. While these standards appear to have been derived in part from technical workshops convened by the U.S. Coast Guard or IMO, the published materials from these workshops do not give any explanation or indication of the effect that these standards are expected to have on the rate of invasions due to ballast water discharges (USCG 2002; MEPC 2003). In some cases, it's not clear if these standards would result in a significant reduction from current, untreated discharge levels (*e.g.* compare the IMO standard for the 10-50 micron size class with untreated concentrations, in Appendix 2, Table 1).

The basis for a zero detectable living organism discharge standard is that nonindigenous aquatic species, unlike conventional chemical pollutants, can reproduce and increase over time, persist indefinitely and may spread over large regions. The actual mechanisms of invasion for the large universe of potential nonindigenous aquatic species are currently not known. From this perspective, the only biologically perfect standard is no discharge of nonindigenous aquatic species. The Panel noted that in practice "zero discharge" might refer to a variety of distinct standards, including no detectable discharge of viable organisms, no discharge of organisms, no discharge of viable organisms and no discharge of ballast water. Additional information on zero discharge standards is provided in the memo in Appendix 3.

It should be noted that panel members representing regulatory agencies stated the ability to detect a “zero discharge standard” is problematical as the ability to detect “zero” changes as new detection technologies are developed. In addition it is often very difficult with current technology to determine if organisms are “alive”.

One biologically-based standard that is less stringent than zero discharge is a "natural invasion rate standard," which would reduce the discharge of organisms in ballast water to a level where the rate of invasion due to these discharges is approximately equal to the natural invasion rate. The calculation of concentration limits to achieve this is described in Appendices 4 and 5 which were prepared by one member of the Panel. As stated by a Panel member representing the scientific community, it should be noted that these calculations are based on data with a great deal of uncertainty and were omitted from the IMO convention for this reason. The minority has left this information in this report to acknowledge that the topic was discussed but would like to emphasize it was not supported by the Majority of the Panel and to state there was significant disagreement between the scientists that were on the Panel.

Technical and Economic Considerations

The basic task involved in meeting ballast water discharge standards is to remove or inactivate organisms contained in a tank of water. The size, voyage duration and configuration of ballast water tanks on vessels vary greatly. Several land based technologies could potentially be used for this purpose, including methods that are routinely used to disinfect quantities of water and wastewater, but these need to be adapted to work on the variety of organisms present in ballast water, over the range of physical and chemical parameters that are characteristic of ballast water, and to function in a shipboard or onshore system in a manner that is consistent with ship operational requirements. Many treatment systems cover many acres of land and require hundreds of employees to maintain them. With this in mind it is important to note that the development of ballast water treatment technologies is still in its infancy and very few technologies have been tested onboard ships. Unfortunately, the efficiency of these few tested systems has not been adequately evaluated due to the fact that uniform testing protocols have not been established. Due to these uncertainties, we encourage the Commission to adopt IMO or Federal standards. In addition, it should be noted that the few treatment systems that have been installed on vessels do not meet the standards as proposed in the majority panel recommendation. Finally, land based technologies depend heavily on chemical treatment, such as chlorine, which has not been deemed acceptable in ballast water discharges into state waters and impacts adversely with structural integrity of steal and coatings within ballast tanks.

The Majority report includes language by the author as a minority opinion with regard to the shipping industry’s ability to finance the investment in new ballast water treatment technology. The topic of industry profits or losses did come up on a few occasions but the Panel was reminded this was beyond their purview. The legislation states "best available technology economically achievable". It is not the responsibility of the shipping industry to fund research and development of the technology. Once proven technology is available for shipboard installation the question of industry profits and losses to determine what is "economically achievable" can be discussed. Normal market forces will dictate directions for technology development that will naturally accommodate the economics of the maritime industry.

Recommended Standard for Organisms >50 Microns in Minimum Dimension

Most Panel members feel that a standard of no detectable discharge of organisms >50 microns in minimum diameter is feasible, and therefore recommended that this be adopted as an Interim Standard for implementation between 2009 and 2016. In the majority report it refers to filtration technology. The panel consistently stated that specific types of treatment systems were not to be part of the Panels recommendation, but rather let private industry develop the technology to meet the standards.

Recommended Standard for Organisms 10-50 Microns in Minimum Dimension

Most of the Panel recommended that an Interim Standard for this organism size class of no more than 0.01 living organisms per milliliter of ballast water discharge be implemented between 2009 and 2016, and that the State evaluate by 2016 if a Long-term Standard of no detectable discharge could be implemented.

Recommended Standard for Organisms <10 Microns in Minimum Dimension

Most of the Panel recommended that an Interim Standard of no more than 10^3 bacteria and no more than 10^4 viruses per 100 milliliters of ballast water discharge be implemented between 2009 and 2016, and that the State evaluate by 2016 if a Long-term Standard of no detectable discharge could be implemented.

Recommended Standard to Protect Public Health

The Senate bills (S. 363 and S. 1224) contain concentration limits for certain pathogens and pathogen indicator species. These are based in part on the U.S. EPA water quality criteria for water contact recreation (standards for *Escherichia coli* and intestinal *enterococci*), and in part on evidence that ballast water has transported epidemic strains of the bacterium that causes cholera (standards for *Vibrio cholerae*). Although one Panel member argued that the water contact recreation criteria were insufficiently protective of public health, the Panel found that the public health protective standards in these Senate bills were reasonable and feasible and recommended that they be adopted as an Interim Standard.

CONCLUSION

The Advisory Panel strove to identify an approach to reduce the risk of preventing harmful introduction of nonindigenous aquatic species that was scientifically based, effective and reasonable. The recommended approach is similar to other proposed approaches in terms of implementation schedule, organism size classes, health indicator organisms, allowable technologies and application to various classes of ships. It differs from other approaches in that it proposes more stringent limits on the number of viable organisms that would be allowed in ballast water discharges. The Panel majority recommends these more stringent limits because it concluded that other adopted and proposed standards would be less effective in accomplishing the objective of preventing the introduction of potentially harmful organisms. Because the environmental and socio-economic impacts of nonindigenous aquatic species have been so significant to date, the Panel Majority believes that strong standards are essential to the success of a preventive strategy.

The Panel Minority who work on this issue in global terms are aware of the impacts that may occur due to invasions. We feel that through support and alignment with International and Federal regulations, treatment systems will more quickly be developed and installed. Ultimately this will facilitate better treatment systems that will be able to more quickly meet more stringent standards. California continually prides itself on leading the world in many environmental areas. Industry feels that by differentiating itself from this global problem, California may actually cause delays in solving it. Less than 10% of the world's vessels will ever call in California ports. In addition there are in excess of 5000 vessels that come to California for the first time each year and many of these may never return or return on an infrequent basis. Vessel owners that have a committed trade to California will install treatment systems that meet the requirements proposed in the Majority Report (assuming there is such a treatment system available) but operators that only have to meet International or Federal standards will purchase and install the least expensive option that covers anticipated trade. By implementing differing standards the potential for significant negative economic impacts to the multibillion dollar goods movement in California is likely to occur We also feel that it is premature to adopt standards based on a natural invasion rate that has been calculated based on questionable data. We strongly encourage CSLC to support additional research that can be used to evaluate ballast discharge standards with defensible scientific methodologies.

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APPENDIX 1: ADVISORY PANEL MEMBERS

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June 15, 2005

Suzanne Gilmore
Marine Facilities Division
California State Lands Commission
100 Howe Avenue, Suite 100 South
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Re: California Public Resources Code – Ballast Water Performance Standards

Dear Suzanne:

Pursuant to the SB 433 (Nation – statutes of 2003), the State Lands Commission (Commission) has convened and consulted with an advisory panel to develop a report to the Legislature with recommendations on specific performance standards for the discharge of ballast water. The undersigned companies, representing many of the vessels calling in California's ports, appreciate the opportunity to participate in this process. We have worked closely with one another in an effort to ensure that the maritime industry's concerns and interests are adequately expressed within the framework of the advisory panel and more broadly, within the statute. We would like to offer the following recommendations to the panel as guidelines for the development of these standards.

The development of performance standards for discharge of ballast waters is one of the most important steps to take in the development of treatment technology. Although many public and private sector efforts have been made, and are currently underway to develop and analyze treatment technologies, establishing a standard for removal or destruction of invasive species will provide a benchmark for further development and refinement. However based on the data presented in previous panel meetings, the quantification of open water exchange efficiency as well as development of alternative treatment technologies are still in the infancy stages. Data on the correlation of microorganism concentrations in ballast water and the introduction of invasive species are also scarce. Therefore, we recommend caution in developing performance standards without sound scientific testing and analysis. We fully support provisions that will allot CSLC the necessary funding to develop the data needed to make defensible decisions regarding ballast water performance standards.

Efforts to develop standards are taking place in the international arena, through the International Maritime Organization (IMO) as well as nationally through both federal legislation and research being done by the United States Coast Guard (USCG). Our industry applauds the efforts by the Commission to coordinate and align the California ballast water statutes and regulations with the USCG and the IMO. As the majority of ocean going vessels entering California waters operate throughout the world, the adoption of harmonious regulations results in greater ease of application, less disruption to industry and most importantly - greater compliance. In the case of ballast water management, the shipping industry has been exposed to a variety of state and local requirements that, in some cases, have varied from international and federal requirements. Continuing this patchwork-quilt approach would be catastrophic for the environment and the industry and undermine the progress that we can make on this issue by the establishment of a strong, uniform federal program. Although California's major ports are some of the largest in the world, it is unrealistic to assume that capital investment will be put toward technology to treat ballast water to a standard different from the rest of the world. We can not foresee multiple treatment systems on-board vessels, each treating to a different standard.

For this reason, our suggestion to the advisory panel is to await the development of standards from the USCG or the IMO and consider those standards as guidelines for a recommendation to the Legislature. We realize that such standards may not be available for review prior to the January 31, 2006 deadline established under AB 433, however our understanding is that work is already being done on these and any delay should be minor. We also believe the Commission has the ability to provide the Legislature with an interim recommendation to await national or international standards and to act upon those standards once in place.

We will be happy to discuss this recommendation further with the advisory panel.

Sincerely,

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John Berge – Pacific Merchant Shipping Association

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Lisa M. Swanson – Matson Navigation Company

____

Bradly Chapman – Chevron Shipping Company

APPENDIX 2: COMPARISON OF POTENTIAL STANDARDS

Table 1. Order-of-magnitude comparison of organism concentrations in ballast water and potential discharge standards

Organism Size Class	Units	Concentration in untreated, unexchanged ballast water	Standard in IMO Convention	Standard in Senate Bills	US position at IMO conference	Standard based on natural invasion rate	Zero discharge standard
>50 µm	/m^3	10^2-10^3	10	10^{-1}	10^{-2}	10^{-3}-10^{-2}	0
10-50 µm	/mL	10-10^2	10	10^{-1}	10^{-2}	10^{-4}-10^{-3}	0
<10 µm	/100 mL	10^8-10^9	–	–	–	10^3-10^4	0

Table 1 compares the organism concentrations in untreated ballast water discharges and a range of potential concentration standards for ballast water discharges.

Columns 1-2: The organism size classes and units are those used in the IMO Convention and in the current drafts of two bills in the U.S. Senate (S. 363 and S. 1224). The organism size classes refer to the minimum dimensions of the organisms.

Column 3: The concentrations in untreated and unexchanged ballast water are order-of-magnitude estimates based on statistical summaries of a range of studies, which are described further in Table 2 below. For the >50 micron and 10-50 micron organism size classes, the ranges approximate the median and mean values for zooplankton and phytoplankton respectively; for the <10 micron size class, the range approximates the mean values for bacteria and virus-like particles, respectively.

Columns 4-6: The IMO Convention, Senate bills and the standards advocated by the U.S. representatives at the IMO conference include public health protective standards that limit the concentration of certain pathogenic and pathogen indicator species that are less than 10 microns in minimum dimension, but do not contain any general restriction on the discharge of organisms in this size class to protect the environment from invasions. The full standards in the IMO Convention and Senate bills are given in Table 3 below.

Column 7: The ranges given for a standard based on the natural invasion rate are based on a 10^5-fold reduction from the range of concentrations given for untreated, unexchanged ballast water. Scientists on the Panel or consulted by Panel members estimated that the appropriate reduction could be between 10^4-fold and 10^6-fold, based on their range of estimates of the natural invasion rate. This range could raise or lower the figures in Table 1 by one order of magnitude.

Column 8: Several types of zero discharge standard were discussed by the Panel, including no discharge of ballast water, no discharge of living organisms, and no detectable discharge of living organisms.

Table 2. Organism concentrations in untreated and unexchanged ballast water

Type of Organism	Number of Ships Sampled	Median Concentration	Mean Concentration
Zooplankton	429	0.4/liter	4.64/liter
Phytoplankton	273	13,300/liter	299,202/liter
Bacteria	11		8.3×10^8/liter
Virus-like Particles	7		7.4×10^9/liter

Table 2 shows the IMO's statistical data on organism concentrations in ships' ballast water (MEPC 2003). These data were the basis for the order-of-magnitude concentrations given in Column 3 of Table 1, and were derived from studies that sampled ballast water of coastal origin with a broad range of ages that had not been exchanged or treated. MEPC (2003) suggested that median values are a useful frame of reference for considering ballast water standards (the definition of median is that half the tanks had higher concentrations than the median value, and half had lower.)

Table 3. IMO Convention and Senate Bill standards for permissible concentration limits in ballast discharges

Organism Type or Class	IMO Convention	S. 363 and S. 1224
Living organisms >50 microns in minimum dimension	$10/m^3$	$0.1/m^3$
Living organisms 10-50 microns in minimum dimension	10/mL	0.1/mL
Colony-forming units of *Escherichia coli*	250/100 mL	126/100 mL
Colony-forming units of intestinal enterococci	100/100 mL	33/100 mL
Colony-forming units of toxicogenic *Vibrio cholerae* (serotypes O1 & O139)	1/100 mL	1/100 mL
Colony-forming units of toxicogenic *Vibrio cholerae* (serotypes O1 & O139)	1/gram wet weight of zoological samples	1/gram wet weight of zoological samples

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APPENDIX 3: MEMO ON ZERO DISCHARGE STANDARDS

Subject: **Background and Possible Basis for a Zero Discharge Standard**
To: Ballast Water Treatment Standards Committee
From: Andrew Cohen
Date: August 4, 2005

Various standards might be considered zero discharge standards, including:

- no detectable discharge of living organisms
- zero discharge of living organisms
- no discharge of ballast water

The scientific basis for a zero discharge standard is that nonindigenous aquatic organisms, unlike conventional chemical pollutants, can:

1) reproduce and increase over time:
2) persist indefinitely: and
3) spread, sometimes in high concentrations, over very large and even continental distances once they have been discharged to a new continent.

Such invasions can result from a single pair of mated organisms, or in the case of asexually-reproducing species, a single individual. An example of the latter is the tropical seaweed *Caulerpa taxifolia*, whose invasion over thousands of acres in the Mediterranean Sea and in two bays in California consists of a single clone, and thus derives from a single individual.[1]

In 1998, the San Francisco Bay Regional Water Quality Control Board (Region 2) proposed and the State Water Resources Control Board approved listing nonindigenous aquatic species discharged in ballast water as a priority pollutant impairing the waters of San Francisco Bay, under Clean Water Act §303(d) (SFBRWQCB 1998). In subsequently considering how to set a total maximum daily load (TMDL), Region 2 concluded (at least informally) that zero-discharge of nonindigenous aquatic organisms was the only scientifically-supported standard available.

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1 The import and sale of *Caulerpa taxifolia*, dubbed the "Killer Alga," was banned in the U.S. in response to a petition from over 100 scientists who were alarmed at its impacts in the Mediterranean. It was subsequently discovered growing in two small bays in California, where its eradication (which is nearly complete after 4 years of effort) probably cost over $10 million (Raloff, 1998, 2000; Jousson *et al.* 2000).

The U.S. Coast Guard convened two technical workshops on Ballast Water Treatment Standards in the spring of 2001, bringing together experts in the fields of ballast water treatment, invasion biology and standards development. The East Coast Workshop recommended a long-term (within 5 years) standard of 100% removal or inactivation of coastal holoplankton, meroplankton, and demersal organisms (including all life stages) and photosynthesizing organisms (including phytoplankton, cysts and algal propagules), which includes a variety of organisms down to 2 µm in size. The West Coast Workshop recommended a short-term (within a few years) standard of zero discharge for organisms >50 µm and a long-term (within 10 years) standard of zero discharge for all organisms (USCG 2002a).

Based on these workshops, meetings of the Ballast Water and Shipping Committee of the Aquatic Nuisance Species Task Force, and an IMO GloBallast workshop, the U.S. Coast Guard published an Advance Notice of Proposed Rulemaking in the spring of 2002 (USCG 2002b). This notice listed alternative short-term standards, including removing, killing or inactivating all organisms >100 µm, and no discharge of organisms >50 µm; and alternative long-term goals, including no discharge of zooplankton and photosynthetic organisms (including holoplanktonic, meroplanktonic, and demersal zooplankton, phytoplankton, and propagules of macroalgae and aquatic angiosperms), inclusive of all life-stages.

An International Workshop on Ballast Water Discharge Standards was held by the State Department and the U.S. Coast Guard at NSF headquarters on Feb. 12-14, 2003. Participants included IMO representatives and technical experts from 7 IMO member states. Of the Workshops three working groups, Group 1 recommended an initial standard of no detectable organisms >50 µm; and Group 3 recommended an initial standard of no detectable organisms >100 µm to go into effect by 2006, no detectable organisms >50 µm to go into effect by 2009, and no detectable organisms >25 µm to go into effect by 2015. A synthesis of the groups' recommendations was suggested, which included a standards of no detectable organisms >50 µm to go into effect by 2006, and no detectable organisms >10 µm to go into effect by 2015 (MEPC 2003).

Several assessments and studies of ballast water treatment have employed filtration either as the initial or sole treatment process. The filter sizes used in these assessments range from 150 µm to 50 µm or less,[2] suggesting that zero detectable discharge of organisms above these sizes would be routinely achieved by these treatments.

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2 Some examples of ballast treatment systems using filtration that have been investigated include:
• *filtration to 150 µm*: a single-pass 150 µm wedgewire strainer on ballasting at 1,250 and 2,500 m^3/hr (Pollutech 1992); a single-pass 150 µm wedgewire strainer on ballasting at 2,500 m^3/hr and UV at 420 mW-S/cm^2 (Pollutech 1992); a recirculating system with 150 µm wedgewire strainer and UV at 420 mW-S/cm^2 (Pollutech 1992);

Until 1992, the largest containerships built were of the Panamax type, with widths no greater than the 106' maximum that is permitted to pass through the Panama Canal. As containerships tried to carry greater numbers of containers per ship, containers were stacked progressively higher on the decks through the 1980s, with correspondingly increasing amounts of ballast water needed to provide stability. Beamier Post-Panamax containerships, which increasingly dominate the fleet,[3] are inherently more stable and carry and discharge much less ballast water per voyage—on the order of a few hundred tons rather than several thousand tons for Panamax ships (Herbert Engineering 1999)—while carrying much larger numbers of containers. Some can also shifting ballast internally to adjust the ship's list and trim. Ship designers are considering further modifications to ships' piping systems that would eliminate the discharge of ballast water in port (Herbert Engineering 1999; Schilling 2000). This may also be feasible for a few other types of vessels, such as passenger ships (Schilling 2000).

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• *filtration to 100 µm*: a continuous deflective separation unit operated at normal ballast pump flow rates filtering to 50-100 µm (Victoria ENRC 1997); 100 µm filtration at 270 and 1,800 m^3/hr, with UV, thermal or ultrasonic treatment (Battelle 1998); a self-cleaning 100 µm filter at 135 m^3/hr (Röpell & Voight 2002);
• *filtration to 50 µm*: a single-pass 50 µm wedgewire strainer on ballasting at 1,250 and 2,500 m^3/hr (Pollutech 1992); a single-pass 50 µm wedgewire strainer on ballasting at 2,500 m^3/hr and UV at 210 mW-S/cm^2 (Pollutech 1992); an in-line 50 µm stainless steel strainer with automatic backwash (AQIS 1993); 50 µm filtration during ballasting (Dames & Moore 1999); continuous backwash filtration to remove particles and organisms down to 50 µm size (URS/Dames & Moore 2000); a 50 µm filter screen at 340 m^3/hr with and without a prefilter (Cangelosi & Harkins 2002); a self-cleaning 50 µm filter at 135 m^3/hr (Röpell & Voight 2002); a self-cleaning 50 µm screen at 340 m^3/hr (Waite & Kazumi 2004);
• *filtration to 25 µm*: a self-cleaning 25 µm woven mesh screen filter at 1,000 m^3/hr (Carlton *et al*. 1995); 25 µm filtration at 270 and 1,800 m^3/hr, with UV, thermal or ultrasonic treatment (Battelle 1998); a 25 µm filter screen at 340 m^3/hr with and without a prefilter (Cangelosi & Harkins 2002);
• *filtration to 20 µm*: 20 µm filtration during ballasting (Dames & Moore 1999); 20 µm filtration and cyclone during ballasting (Dames & Moore 1999).

Dames & Moore (1999) concluded that on-board filtration systems appear "potentially viable with filter sizes between 20 and 50 µm". Oemcke (1999) noted that self-cleaning stainless steel screens can filter down to 10-20 µm without flocculants, and that membrane filters to filter surface waters down to 0.2 µm cost 35-49¢ per m^3 of filtrate in 1990 (*i.e.* \$2.7-3.8 million to filter the 7.8 million m^3 of ballast water discharged in California in 2004), but that costs had been dropping as technology improved and market share increased.

[3] The Port of Oakland projects that Post-Panamax sized containerships, which accounted for 10% of port visits in 1996, will account for 75% of port visits in 2010 (Port of Oakland 1999).

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APPENDIX 4: MEMO ON A NATURAL INVASION RATE STANDARD

Subject: **Basis for a Standard Based on the Natural Rate of Invasion**
To: Ballast Water Treatment Standards Committee
From: Andrew Cohen
Date: August 7, 2005

Biological Rationale for a Standard Based on the Natural Invasion Rate

Biological invasions of marine ecosystems are natural, at least in the sense that on rare occasions a coastal organism must have by accident drifted or rafted across the ocean and established an isolated colony on the other side. However, human activities—prominently including the transport and discharge of ballast water—have greatly increased the rate at which such colonies are established, creating a novel level of rapid alteration of ecosystems and (because a portion of these species have harmful impacts on economic or recreational activities or public health), elevated the stresses on human communities.

A performance standard that reduced the rate of invasion due to ballast water discharges to around the average rate of invasion under natural conditions would implicitly allow a doubling of the natural invasion rate as a result of ballast discharges alone. However, in contrast with a standard that allowed a 10x or 100x increase in the invasion rate,[1] this is still reasonably close to the natural rate and possibly within the normal range of variation, and would thus be reasonably protective of the environment. Because it would entail a substantial decrease in the current rate of invasion, it would also reduce the impacts on human uses. Such a standard would thus be reasonably protective of the various environmental, recreational and economic beneficial uses of California's waters.

Calculation of a Standard Based on the Natural Invasion Rate

To a first approximation, in order to reduce the rate of invasions due to ballast water to roughly the average natural invasion rate, we need to reduce the concentration of living

1 Based on the calculations below, the standards in S. 363 and S. 1224 represent about a 10x-100x increase over the natural invasion rate for organisms >50 microns, and about a 100x-1,000x increase for organisms in the 10-50 micron size class. The standards in the IMO Convention represent about a 1,000x-10,000x and about a 10,000x-100,000x increase over the natural invasion rate for >50 micron and 10-50 micron organisms, respectively.

organisms in ballast water discharges by the ratio between the natural invasion rate and the invasion rate due to the discharge of untreated and unexchanged ballast water.[2] We'll call this ratio the Reduction Factor:

$$(1) \qquad \text{Reduction Factor} = \frac{\text{Natural invasion rate}}{\text{Invasion rate due to untreated and unexchanged BW}}$$

Then, the concentration standard for living organisms in ballast water discharges that will meet this goal is:

$$(2) \qquad \text{Concentration Standard} = \begin{array}{c}\text{Concentration of organisms in}\\ \text{untreated \& unexchanged BW}\end{array} \times \text{Reduction Factor}$$[3]

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[2] This approximation implicitly assumes that the Discharge/Invasion Curve is roughly linear, that is, that an X% increase or decrease in the number of organisms discharged during a period of time will produce about an X% increase or decrease in the number of invasions that occur during that time as a result of those discharges. We don't, in fact, know the shape of this curve and a variety of shapes are theoretically possible, but the assumption of linearity is both the simplest possible assumption and consistent with standard regulatory practice. For example, the US EPA routinely makes the precisely analogous assumption when assuming that the Dose/Response Curves for a variety of suspected carcinogens and other toxins are linear in order to extrapolate responses from rodent bioassays conducted at high dose levels to chronic human exposures projected at low dose levels.

[3] In reality, it's not the *concentration* of organisms in ballast water that needs be reduced by the Reduction Factor, but rather the *rate* at which organisms are discharged. This is equal to the concentration of organisms times the rate of ballast water discharge. If C_{BW} = the concentration of organisms in untreated, unexchanged ballast water, D_1 = the rate of ballast discharge during the baseline period that corresponds to C_{BW}, and D_2 = the rate of ballast discharge during the future period when the Concentration Standard is in effect, then:

$$\text{Concentration Standard} \times D_2 = C_{BW} \times D_1 \times \text{Reduction Factor}$$

If $D_1 = D_2$, then this equation reduces to Equation (2). If the rate of ballast water discharge is decreasing over time ($D_1 > D_2$), then Equation (2) will calculate a Concentration Standard that is too low (*i.e.* too stringent), and if it's increasing, it will calculate a standard that is too high (too lenient). For the container fleet, the increasing number of Post-Panamax ships, which carry and discharge less ballast water per ship while carrying more containers suggests that the rate of ballast water discharge could decline (Herbert 1999). For example, the Port of Oakland (1998) projected that while the number of containerships arriving at the Port and the amount of cargo carried by them would increase from 1996 to 2010, the amount of ballast water they discharged would decrease by 42%. On the other hand, for other types of vessels such as bulk carriers and tankers, significant decreases in the amount of ballast water discharged per ton of cargo are unlikely (Herbert 1999). The larger volumes of ballast water carried by these ships, and the projected increases in cargo tonnage handled by California ports suggests that the overall rate of ballast discharge will increase. In neither case, however, is the change likely to approach an order of magnitude, and so Equation (2) seems reasonable as a first approximation.

Estimate of concentration in ballast water: Order-of-magnitude estimates of the concentration of living organisms in untreated and unexchanged ballast water at the end of transoceanic voyages are:

- for organisms >50 microns in width 10^2-10^3 per m^3
- for organisms 10-50 microns in width 10-10^2 per mL
- for organisms <10 microns in width 10^8-10^9 per 100 mL

These estimates are derived from statistical data on studies that sampled ballast water of coastal origin that had not been exchanged or treated. Specifically, the concentration ranges for >50 micron and 10-50 micron organisms are based on the mean and median values for zooplankton and phytoplankton samples, respectively, and the concentration range for <10 micron organisms is based on the mean values for bacteria and virus-like particles. More detail on these data is provided in Table 2 of "Attachment F: Comparison of Potential Standards" which SLC sent to the Committee before the July meeting, in Greg Ruiz's presentation at the April meeting, and in MEPC (2003).

Estimate of natural invasion rate: A natural marine invasion is defined as a marine organism that is transported across an ocean by drifting, rafting or some other natural, irregular and rare transport mechanism and becomes established initially as a disjunct, isolated population in waters on the other side. It excludes organisms that have a continuous range that includes both sides of the ocean (such as, in the Pacific, organisms that have a continuous range from northern Japan and Siberia across to Alaska and British Columbia by way of the Bering Strait or the Aleutian Islands), organisms that have regular, natural genetic exchange between populations on opposite sides of the ocean (such as may occur with pelagic organisms that regularly migrate across the ocean, or organisms with teleplanic larvae that are regularly advected across the ocean), and organisms occurring in disjunct, transoceanic populations that are relics of formerly genetically-continuous populations. The natural, one-way invasion rate (*i.e.* from one side of the ocean to the other) can be estimated as:

$$(3)\qquad \text{Natural invasion rate} = \frac{0.5 \times \text{The number of species common to both sides of the ocean that are thought to result from natural invasion}}{\text{The length of time it takes for isolated populations to become morphologically distinct}}$$

Based on a review of the biogeographical literature and other relevant data, the number of species of invertebrates and fish[4] common to both sides of the Pacific Ocean that are thought to be the result of natural invasions is estimated as ≤10 (J. Carlton estimate) or

[4] The available biogeographical data for other types of organisms, including protozoans, fungi, bacteria and viruses, are too poor to provide a basis for even a rough estimate of the natural invasion rate.

≤100 (A. Cohen estimate). The length of time that it takes for isolated populations of invertebrates or fish to become morphologically distinct (*i.e.* such that they would be considered separate species based on morphological evidence) is estimated as 1-3 million years.[5] If we conservatively[6] estimate the number of naturally invaded invertebrate or fish species common to both sides of the ocean to be 100, and the relevant period to be 1 million years, then the natural invasion rate from the western to the eastern Pacific shore for species in these two categories of organisms is 50 species per million years, or 5×10^{-5} species per year.

Estimate of invasion rate due to unexchanged, untreated ballast water: The Federal law that first set up a voluntary program of mid-ocean ballast water exchange was passed in 1996, and the California law that required mid-ocean ballast water exchange was passed in 1999. Data from a period immediately prior to the passage of these laws would therefore be appropriate for estimating the rate of invasion resulting from the discharge of unexchanged and untreated ballast water.

From 1961-1995, the rate of invasion into the San Francisco Bay and Delta was one species every 14 weeks, or 3.7 species per year; with the rate increasing over time to 5.2 species per year in 1991-95 (Cohen & Carlton 1997).[7] The fraction introduced by ballast water also increased over time. For invertebrates and fish, the rate was 2.9 species per year in 1961-1995, with ballast water responsible for introducing 0.7-1.7 species per year (24-59% of the total); in 1991-1995 the rate was 4.2 invertebrate and fish species per year, with ballast water responsible for 1.6-3.2 (38-76% of the total).

These figures probably substantially underestimate the true number of invasions, by missing invasive species that (a) haven't been collected, (b) have been collected but not identified, or (c) have been identified but whose status as invasive or native has not yet

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5 For example, closely-related populations of marine organisms on either side of the Panamanian isthmus, which have been separated for about 2.8 million years, are variously considered by taxonomists to have morphologies that range from being very similar but capable of being distinguished (and therefore are considered separate species) to being so similar that they cannot be distinguished (and therefore are usually identified as the same species).

In the July meeting, Greg Ruiz noted that Vermeij (1991) reported that 11 gastropod species from the western Pacific had invaded the eastern Pacific in the last 18 million years. This rate of 0.6 invading gastropods per million years seems reasonably consistent with an estimate of ≤100 fish and invertebrates per million years.

6 In this memo, "conservative" is taken to mean supporting a smaller reduction from the concentration of organisms in untreated discharges and a less-stringent standard. Here, for example, it means using the numbers—out of the range of reasonable estimates—that produce the highest estimate of natural invasion rate. If the calculation instead used 10 for the number of common species and 3 million years for the period, the natural invasion rate would be less than 2 species per million years.

7 The invasion numbers discussed in this section are based on the date of discovery (first observation or collection) of the invading species.

been resolved (cryptogenic species). These missing species could raise the total by probably 50-100%.[8] In addition, these figures refer only to species established in the San Francisco Bay/Delta system; if species established elsewhere in California are included, the total could rise by at least another 50-100%.[9] When these factors are taken into account, ballast water is estimated to be responsible for introducing 2-7 invasive invertebrates and fish into California waters each year if 1961-95 is used as the baseline for the estimate, and 4-13 invertebrates and fish if 1991-95 is used as the baseline.

Calculation of Reduction Factor and Concentration Standards: Using the above estimates and Equation (1), the Reduction Factor is:

- for the 1961-95 baseline: $0.7\text{-}2.5 \times 10^{-5}$
- for the 1991-95 baseline: $0.4\text{-}1.3 \times 10^{-5}$

To an order of magnitude, the Reduction Factor is 10^{-5}.[10] The corresponding Concentration Standards are:

- for organisms >50 microns in width $10^{-3}\text{-}10^{-2}$ per m^3
- for organisms 10-50 microns in width $10^{-4}\text{-}10^{-3}$ per mL
- for organisms <10 microns in width $10^{3}\text{-}10^{4}$ per 100 mL

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Herbert Engineering. 1999. Ballast Water Management for Containerships: Implications for the Port of

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8 For example, Cohen & Carlton (1998) reported 234 exotic species and at least 125 cryptogenic species established in the San Francisco Bay and Delta (cryptogenics equal to 53% of the number of exotics). Ashe (2002) reported (a) 360 exotic species, (b) 247 species considered cryptogenic but "most likely introduced," and (c) 126 taxa not identified to species but considered by researchers to most likely be introduced, in California coastal waters (categories (b) and (c) equaling 104% of the number of exotics).

9 For example, Ashe (2002: Figure 5) reported 190 exotic and 43 cryptogenic species in San Francisco Bay, but 360 exotic and 247 cryptogenic species statewide, or 89% and 474% over the San Francisco Bay numbers.

10 Steve Moore (San Francisco Bay RQWCB) noted that this is reasonably close to the reductions in organism concentrations that have been achieved for decades under the Safe Drinking Water Act, where the EPA criteria set reductions of 10^{-3} or 10^{-4} for different types of microbes.

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APPENDIX 5: ADDENDUM TO THE MEMO ON A NATURAL INVASION RATE STANDARD

Footnote 5 incorrectly reported data from Vermeij (1991). Vermeij actually stated that 11 gastropod species from the Line Islands in the Central Pacific had invaded the eastern Pacific in the last 2 million years, or a rate of about 5.5 invading gastropods per million years. At the August 2005 Advisory Panel meeting, after some discussion of technical issues related to the records in this paper and other paleontological data, Greg Ruiz stated that he was more comfortable with a natural invasion rate estimate of ≤1,000 fish and invertebrates per million years. Thus, three invasion biologists provided the Panel with different estimates of the natural invasion rate, corresponding to calculations of different Reduction Factors and concentration limits, as follows:

Biologist	Estimate of natural invasions of invertebrates and fish per million years	Reduction Factor	Concentration limits for organisms >50 microns	Concentration limits for organisms 10-50 microns	Concentration limits for organisms <10 microns
J. Carlton	≤10	10^{-6}	10^{-4}-10^{-3}	10^{-5}-10^{-4}	10^{2}-10^{3}
A. Cohen	≤100	10^{-5}	10^{-3}-10^{-2}	10^{-4}-10^{-3}	10^{3}-10^{4}
G. Ruiz	≤1,000	10^{-4}	10^{-2}-10^{-1}	10^{-3}-10^{-2}	10^{4}-10^{5}

The Panel considered the wider range of concentration limits indicated by this range of estimates as potentially pertaining to a natural invasion rate standard.

APPENDIX 6: MEMO ON TECHNICAL FEASIBILITY, TREATMENT COSTS AND ECONOMIC INDICATORS

Subject: **Some Data on Treatment Costs and Economic Indicators**

To: Ballast Water Treatment Standards Committee

From: Andrew Cohen

Date: August 7, 2005

Technical Feasibility and Scale

The basic task to be achieved is to remove or kill organisms that are trapped in a tank of water.

Relative to the volumes handled by existing programs to remove or kill organisms in water or wastewater, the amount of ballast water to be treated is modest. Less than 7.8 million cubic meters of ballast water were discharged into California waters in 2004 (Falkner *et al.* 2005). In contrast, over 3.2 *billion* cubic meters of wastewater are treated and discharged to the San Francisco Bay Estuary each year (Gunther *et al.* 1987)[1], or more than 150 times the volume of ballast water discharged to the entire state. Each year, 24 different wastewater treatment plants in the Bay Area each treat more than the total volume of ballast water discharged to the entire state. Two Bay Area plants each treat more than 23 times the total volume of ballast water discharged to the entire state.

Comparable or even larger volumes of water are treated by the Bay Area's water districts.

From the perspective of water or wastewater treatment, treating all of California's ballast water is a small-scale project — the volume equivalent of a single small water treatment plant for the entire state.

[1] These data are from a 1987 review, based on wastewater treated in 1984-86. With 20 years of rapid population growth, the volume of wastewater treated in the Bay Area is no doubt substantially larger today.

Estimated Treatment Costs for all Ballast Water Discharged into California

The figure below from URS/Dames & Moore 1998 is from a study commissioned by the California Association of Port Authorities that included site-specific cost estimates for essentially all ports in the state. The other figures were developed by multiplying per metric ton costs derived from the cited sources by the State Lands Commission's data on the total amount of ballast water discharged into California waters in 2004 (7.8 million metric tons—Falkner *et al.* 2005). For the most part, these studies estimated the major, identifiable costs but did not necessarily estimate all costs. Costs given in Australian or Canadian dollars were converted to US dollars using recent exchange rates. Costs were not inflated to current dollars.

	$million/year
Filtration & UV (onshore)	
AQIS 1993	2-5
Pollutech 1992	3-9
URS/Dames & Moore 1998	8
Chlorine (500 ppm)	
Pollutech 1992	13
Rigby *et al.* 1993	19
Filtration & UV (shipboard)	
Pollutech 1992	22
Schilling 2002	32
Hydrocyclone & UV (shipboard)	
Schilling 2002	27
Glutaraldehyde	
Lubomudrov, Moll	32-48
Glycolic Acid	
RNC Consulting	50

Shipping Industry - Economic Indicators

CALIFORNIA-WIDE INDICATORS

- Cargo handled by California Ports
  - $260 billion in 2003 (DOT Statistics 2003)
  - $300 billion/year (ILWU)

- Revenues, Costs & Profits of California Shipping Industry (rough calculation based on comparison with Jones Act Fleet data)
  - Revenues ≈$14 billion/yr
  - Capital & Operating Costs ≈$12.5 billion/yr
  - Profits ≈$1.5 billion/yr

PORT/REGION INDICATORS

- Bay/Delta ports: $34 billion in foreign trade in 1992 (Port of Oakland 1998a, b)
- Annualized net direct benefit of -50' dredging project to ships using the Port of Oakland:
  - $156-229 million/year (Port of Oakland 1998a)
- Federal subsidy for Port of Oakland's -50' dredging project:
  - $82.5 million (Port of Oakland 1998b)

PER VESSEL INDICATORS

- Capital & Operating Costs per Vessel

Containerships:	$10,000-15,000/day – new 1,000-3,500 TEU (OCS 2004)
	$42,000/day while in port, $53,000/day while at sea – 73,000 DWT containership (Port of Oakland 1998c)
Bulk Carriers:	$11,000-19,000/day – various ages & sizes (OCS 2004)
	$24,000/day – 10-year-old Capesize (Stopford)
Tankers:	$32,000-43,000/day – new VLCC (OCS 2004)

- Profits per Vessel

Containerships:	$3,000-27,000/day – 300-3,500 TEU (OCS 2004)
Bulk Carriers:	$15,000-38,000/day – various sizes (OCS 2004)
Tankers:	$9,000-32,000/day – various sizes (OCS 2004)

- Average Tanker Freight Rates
  - $19,000-$55,000/day (2002-2004) (Naval Institute 2005)

OTHER

- Shipping Industry – Net Profit Margin of 28.0%, the 2nd highest of 212 industries listed (2nd only to Healthcare Re-insurers) (Yahoo Finance, accessed Aug. 5, 2005).
- Shipping Industry – Return on Equity of 33.6%, the 9th highest of 212 industries listed (Yahoo Finance, accessed Aug. 5, 2005).

Shipping Industry - Growth Trends

Los Angeles/Long Beach harbors

In 1995, Long Beach Harbor and Los Angeles Harbor were the 2nd and 3rd busiest container ports in the US, after New York/New Jersey Harbor (Port of Oakland 1998c).

The number of containers handled at Long Beach Harbor more than doubled between 1994 and 2004, from 2.6 million to 5.8 million, for an average growth of 8.35% per year (data from "Attachment B: Economic Trends" in the materials provided by SLC for the July meeting).

Container traffic at Los Angeles/Long Beach harbors is expected to rise 13% this year, according to the Pacific Maritime Association (San Francisco Chronicle, July 15, 2005).

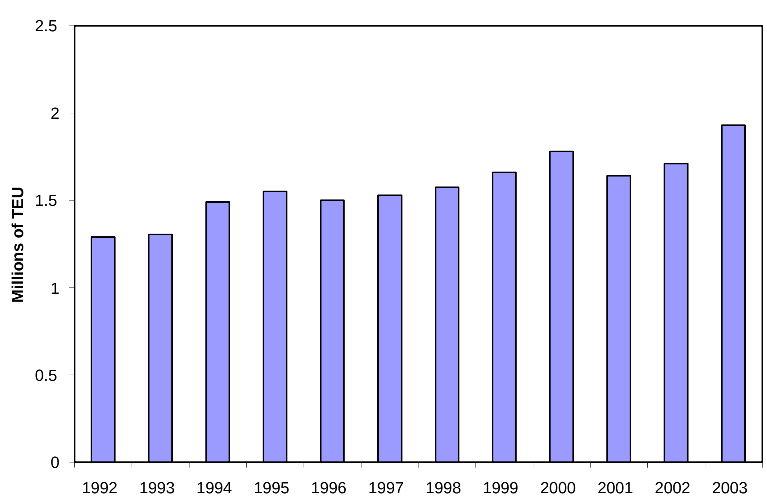
Port of Oakland

In 1995, the Port of Oakland was the 4th busiest container port in the US and the 19th busiest container port in the world (Port of Oakland 1998c).

Cargo tonnage at the Port of Oakland has grown 8.3%/yr over the past 5 years (Port of Oakland 1998c).

Projected growth is from 1.4 million TEU in 1996 to 3.4 million TEU in 2007. Future growth is projected at 7-8% per year (Jordan Woodman Dobson 1998).

"It's Full Steam Ahead at the Port of Oakland"
(San Francisco Chronicle 12/18/03)



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APPENDIX C

MINORITY POSITION LETTER
SUBMITTED BY
THE OCEAN CONSERVANCY

Advocates for Wild, Healthy Oceans

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September 9, 2005

Lt. Governor Cruz Bustamante
California State Lands Commission
100 Howe Ave Suite 100 South
Sacramento, CA 95825-8202

The Ocean Conservancy

Dear Lt. Governor Bustamante and Members of the Commission:

At the outset, The Ocean Conservancy would like to thank the State Lands Commission for convening this Committee, and its staff for their skillful facilitation of the Committee's activities. Although The Ocean Conservancy supports many of the Majority Report's recommendations, we write separately to highlight a few points.

(1) California Should Adopt A Rigorous, Technology-Forcing Approach.

As the Majority Report indicates, the Committee selected more-or-less fixed "interim" standards that are achievable given technologies that are available today. Simultaneously, the Committee selected an implementation schedule – one that is aligned with other federal programs – that gives the industry years before any substantive improvement must be made. During the Committee's work, TOC sought higher standards because the existence of such standards – combined with a competitive marketplace for ballast water treatment products – would motivate the rapid development of technology appropriate for meeting them.

The Clean Water Act has been termed a technology-forcing statute because of the rigorous demands placed on those who are regulated by it to achieve higher and higher levels of pollution abatement under deadlines specified in the law. The general statutory scheme is that in any given category or subcategory of industry, dischargers are to meet technology-based performance standards, based on the capability of available treatment technology. In other words, as technology develops and more effective pollution control tools become available, the requirements for dischargers are ratcheted up. Technology-based standards are the principal vehicle for setting pollution control levels, yet water quality standards were retained as a basis for assessing the need for even more stringent discharge controls where necessary to protect the uses of a stream, including human health. Accordingly, the Act specifically envisions **better** pollution control than "Best Available Technology Economically Achievable" in circumstances where water quality is impaired.

The interim standards selected by the Committee are as strong or stronger than any existing standards that we are aware of. However, they are fixed, inflexible and based on technologies available today, rather than flexible, forward-looking and adaptive. The Ocean Conservancy encourages the State Lands Commission to take the interim standards as a starting point, and to consider an approach that permits improvement of the standards – consistent with improvement in technology – over time.

(2) The Long-Term Discharge Standard of Zero Should Be Firmer.

The Ocean Conservancy supports the Majority Report's long-term standard of zero detectable discharge of living organisms because implementation of this standard is the only means of eliminating all risk of invasion. However, no date is set for achieving this standard, and the technical review conducted in 2016 will evaluate only **if** this standard can be met.

California must set a date for achieving the zero discharge standard, and establish benchmarks for reviewing the feasibility of the standard as it approaches. This approach would create incentives for developing technology as quickly as possible, without creating unmanageable compliance burdens for the industry.

(3) California Should Lead the National Battle Against Invasive Species By Adopting the Strongest Possible Standards.

California ports handle between $200 billion and $300 billion in cargo annually, and the estimated gross revenues of California shippers are in the range of $14 billion a year. California is the 6th largest economy in the world. In other words, the assertion that shippers will avoid California ports if California's ballast water performance standards are too stringent is a scare tactic. Moreover, it is a scare tactic that has a long history.

California's air quality legislation predates the federal Clean Air Act, and set higher standards that persist today. California's water quality legislation predates the federal Clean Water Act, and controls pollution from a wider variety of sources even today. California's pesticide regulation predates federal insecticide controls, and even today, California's pesticide regulations are the most comprehensive in the nation. These are just a few examples of California's environmental leadership, but they are sufficient to highlight the fact that strong environmental regulation has never caused industry to flee from this state. Despite tough rules, our economy continues to grow.

* * * * *

In sum, TOC encourages the State Lands Commission to continue its pattern of national leadership in addressing the threat of invasive species in United States waters. The recommendations of the Ballast Water Performance Standards Advisory Committee are strong, but could be made significantly stronger, as we outline above. Most importantly, California should not wait for the emergence of national standards that are heretofore unsettled. Instead, it should do as it has historically done: lead the way, and encourage the rest of the nation to follow.

Sincerely,

Sarah G. Newkirk
California Water Quality Programs Manager