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Summary and Recommendations On Ballast Water Discharge Standards

From the
Ballast Water and Shipping Committee
To the
Aquatic Nuisance Species Taskforce
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Summary

Four optional approaches to setting standards for ballast water discharges are identified, along with a list of relevant issues that require further discussion. It is the recommendation of the BWSC that the options and issues be published, possibly in the Federal Register, with a request for comment by interested parties.

Introduction

The problem of how to reduce the threat of introducing foreign organisms to the waters of the U.S. via ballast water discharged from ships is complex. A number of factors contribute to the complexity of this issue, including: the relative volumes and pumping rates involved in ballasting operations; the great variability in voyage durations and routes; and the great variability in the physical, chemical, and biological make up of the ballast water carried by the vessels that operate in U. S. waters.

Under Section 1101 (a) and (b) of the Nonindigenous Aquatic Nuisance Prevention And Control Act, as amended by the National Invasive Species Act of 1996 (NISA), the Congress directed the Coast Guard to issue regulations and guidelines on ballast water management practices to prevent the introduction of nonindigenous species to U. S. waters via the discharge of foreign water from ships' ballast tanks. Specifically, these regulations (Great Lakes and Hudson River north of the George Washington bridge) and guidelines (remainder of U. S. waters) identify mid-ocean exchange of ballast water or environmentally sound alternative ballast water management methods determined by the USCG to be as effective as BWE in preventing and controlling infestations of aquatic nuisance species.

There is thus a need to develop a standard by which proposed alternative BWT technologies will be evaluated and approved. NISA explicitly directs that such alternative technologies must be "as effective as BWE". Currently, the actual "effectiveness" of BWE in reducing the threat of introductions is not well resolved. Furthermore, concerns have been voiced that exchange as a practice will be inherently difficult to quantify, and that exchange is not capable of providing a sufficient level of protection against the introduction of unwanted foreign organisms. Because current understanding of exchange is limited and a range of opinions exist concerning the basis for ballast water discharge standards, further discussion is warranted.

Ballast Water Shipping Committee

NISA directs the Aquatic Nuisance Species Task Force to advise the Coast Guard on the content of ballast water regulations and guidelines. Towards this end, the ANSTF formed the Ballast Water and Shipping Committee (BWSC), composed of public and private stakeholders. A key attribute of the BWSC is the active participation of federal agency and shipping industry representatives. The BWSC has subsequently formed two ad hoc workgroups to focus on specific issues related to alternative treatment technologies: the BWSC Working Group on

Environmental Soundness and the BWSC Working Group on Treatment Standards. The latter group has been charged with identifying a set of potential options upon which to base discharge standards for ballast water.

Review of the Effectiveness of Ballast Water Exchange and Treatment.
Studies of both ballast water exchange and treatment have been relatively few in number, and the methods used have been evolving over time. A very brief summary is included to provide a sense of where the field was at the time the Workgroup began to discuss the issue. An increasing amount of work is underway, and this summary is now almost certainly dated.

Exchange
Assuming no unpumpable residual water during an empty-refill exchange (ERE) and complete mixing during a flow-through exchange (FTE) of three full tank volumes, the theoretical efficiencies of these two methods are 100% and 95%, respectively. A limited set of empirical studies, conducted over a broad range of ballast system configurations and using salinity dilution or dye tracers to quantify the percent of water exchanged, indicate that open ocean exchange can achieve 88% to 99% effectiveness in replacing coastal water with open ocean water, with an average quite close to the theoretical efficiency of FTE.

A smaller subset of these same studies have tested the effect of BWE on the biota in ballast water. The effectiveness of exchange for reducing the abundance of biota was more varied than for water exchange, ranging from 39% to 99.9%, depending on the taxonomic groups and ships studied. At least three complicating factors make a comparison of these studies difficult. First, most of the studies have utilized comparisons between ships that did or did not conduct an exchange, rather than treatment (exchanged) and control (not exchanged) tanks. Second, a variety of methods of determining the degree of water exchange were used, including statements by ships' crew and calculations based on salinity and dye tracers. Third, a number of different taxonomic groups have been used to evaluate the exchange of biota, ranging from "all organisms" to "harmfull" dinoflagellates.

Treatment
While an increasing number of potential concepts for ballast water treatments are being proposed, to date tests have been conducted or are planned for, a limited set. The studies can be grouped into two categories. The first group (most of which are in progress) involves tests of a first phase of physical separation, either through filtration or hydrocyclonic separation, and a second phase of (usually) ultraviolet radiation. Several of these tests have been conducted on, or are planned for shipboard, while the others are barge or shore based. Some tests involve retention of treated water in ballast tanks, while others are strictly flow-through. Flow rates in most of the studies are in the range of container ships; passenger ships and Seaway sized bulk cargo carriers. The Great Lakes Ballast Technology Demonstration Project, the most extensive of these studies, has reported preliminary findings of 70% to 99% removal of microzooplankton (rotifers) and macrozooplankton, respectively, in tests of an automatic backwashing filter with a 50 um mesh screen. Phytoplankton reductions, based on total chl extraction, of 70% and 50% were observed with mesh sizes of 25 and 50 um, respectively. As expected for a treatment based on physical straining, initial analyses indicate that effectiveness varies among taxa as a function of organism size and morphological characteristics. Species with rigid spines and/or hard bodies were removed more effectively than smoother or softer-bodied taxa.

The second group of studies examined the lethality to potential ballast water organisms of various chemical and physical treatments. About half of these have been conducted as batch tests at bench-top scales, while the others have, or will involve, large-scale tests conducted dockside or on board ships. Unfortunately, most of the laboratory scale batch studies are of limited use for evaluating the potential effectiveness of operational treatments. While these studies often indicate a degree of lethality for a particular treatment, this information in and of itself does not provide much indication of the potential effectiveness of those treatments under the physical and temporal conditions encountered during ballasting operations aboard vessels.

Proposed Options for Ballast Water Treatment Standards

Following discussions within the workgroup and within the BWSC, the following options (in no order of preference) have been identified:

1. The standard should be based on the theoretical effectiveness of ballast water exchange (BWE) in replacing water (100% for ERE and 95% for FTE).

2. The standard should be set as equivalent to the measured effectiveness of BWE. This effectiveness could be expressed as an average across all vessel types and all taxa, as a specific profile across taxonomic groups within vessel types, or as some intermediate combination of these.

3. The standard should be based on the measured capabilities of the best available technology. As in #2, this level of treatment could be determined as an overall average, or within discrete groupings of vessels and taxa.

4. The standards should be based on the biological requirements, as empirically estimated or modeled, of receiving systems. The standards would be expressed as absolute concentrations of organisms from foreign waters (or dissimilar bioregions?) permissible in ballast water discharged in US waters.

Quantification of the Standard

Basing a standard on the theoretical effectiveness of BWE in replacing the water in ballast tanks allows an immediate determination of the quantitative level of treatment: 95% reduction in abundance, as theoretically possible using FTE. The other options would require varying amounts of additional effort to determine the quantitative degree of treatment.

For standards based on the measured effectiveness of exchange, the use of a coarse average could conceivably be accomplished using existing data and the results of a limited number of studies now in progress. The more finely resolved approach based on effectiveness profiles across taxonomic groups for major types of vessels would require an as yet undeveloped data set of BWE effectiveness across major ship classes and biotic groups. This approach would require a focused research effort to identify the data gaps and conduct the necessary experiments. This work would generate an operative percent removal profile for BWE in each ship class, and characterize effectiveness in terms of major taxonomic groupings and life stages (i. e., viruses, bacteria, unicellular heterotrophic and autotrophic organisms, and macrozooplankton). A hypothetical example of such a profile could be as follows: "For oil tankers, exchange (as defined operationally by regulations) achieves a minimum of 85% removal of original zooplankton; 75% removal of original phytoplankton, and 25% of toxic dinoflagellate cysts, and 25% removal of original bacteria. Standards based on the capabilities of the best available

technology will also require a significant amount of additional work, as most existing systems are still in preliminary phases of development. Significantly, for standards based on either BWE or best available technology, important decisions will need to be made concerning the specifics of standardized testing protocols.

Issues for Further Discussion

The range of potential options indicates a significant need for further discussion about the basis upon which to formulate a standard or set of standards for use in reducing the introduction of organisms in ballast water discharges. Further, a regulatory program will be required to enforce the eventual standard. Selection of a specific option for a standard will influence or even determine many aspects of the program. Important components of the regulatory program will include (but are not restricted to): the metrics by which technology performance is determined, the timing and details of phase-in periods and grandfathering provisions, the nature of exemptions, and provisions for the review and revision of the standard. To encourage input on the proposed options and the nature of the attendant regulatory program, the input of interested parties should be solicited. A Federal Register publication may maximize the opportunity for comment by the broadest suite of stakeholders.

In addition to the specific options identified above, it is the committee's opinion that the following elements would be important components of a solicitation for comment:

1. Background description of the need for and legislative context around the standard. (NISA narrative standard, IMO efforts)
2. Summary of the state-of-knowledge regarding BWE and technology effectiveness.
3. Delineation of the concept of "the standard" vis-a-vis the terms within which the standard may be applied (. i.e. required technology performance vs. grandfathering provisions, timing of the review and revision of the standard, etc.)
4. Outline fundamental approaches to setting the standard:

Approaches based on BWE, as currently specified by congress, under NISA:

a) Standard based on the theoretical effectiveness of ballast water exchange (BWE) in replacing water (100% for ERE and 95% for FTE).

b) Standard set as equivalent to the measured effectiveness of BWE. This effectiveness could be expressed as an average across all vessel types and all taxa, as a specific profile across taxonomic groups within vessel types, or as some intermediate combination of these.

Approaches not related to BWE, but which are used in other standard-setting efforts:

c) Standard based on the measured capabilities of the best available technology. As in #2, this level of treatment could be determined as an overall average, or within discrete groupings of vessels and taxa.

d) Standards based on the biological requirements, as empirically estimated or modeled, of receiving systems.

5. Solicit detailed input on the above options for standards in general, and for issues related to setting (quantifying) and implementing standards for ballast water discharges, including:

   a. Issues related to setting the standard
      - BWE as the basis for the standard, as opposed to other bases, such as best available technology or the biological capacity of the receiving systems
      - If BWE is the basis, the metric used to quantify effectiveness (i. e., the theoretical effectiveness of exchange, the water volume exchanged as estimated with physical / chemical markers, or the biological effectiveness as measured with biological markers.
      - The specificity in determining effectiveness of either BWE or best available technology (i. e., for each vessel, vessel class, or across all vessels)
      - Consideration of the probability of safe and effective BWE (including vessels declaring No Ballast On Board) in estimating the effectiveness of BWE.
      - Use of the absolute concentrations of organisms vs. the percent inactivation or removal of organisms.

   b. Issues related to implementing the standard
      - Different initial standards for existing and yet-to-be-built vessels.
      - Incremental refinements (quantitative level or taxonomic breadth) in the standard over time.
      - The period of approvals and the timing of revisions.
      - If Best Available Technology is the basis for standards, the definitions of "best" and "available".
      - The use of indicators to characterize or monitor effectiveness, such as:
        - ✓ A single organism type (like dinoflagellate cysts) that serves as a lone indicator of effectiveness.
        - ✓ A limited set of indicators representative of near-coastal zooplankton, phytoplankton and bacteria that provide a profile of effectiveness across broad taxonomic groupings
        - ✓ Physical surrogates for organisms, such as microspheres, that mimic the passive entrainment of organisms in water.
        - ✓ The percent reduction in all organisms regardless of type (as measured through ATP reduction, for example), providing a blanket estimate of system effectiveness.
        - ✓ Other methods to characterizing the effectiveness of BWM measures that could be alternatives to the above list.

6. Invite open-ended discussion of these or other issues relative to setting and implementing a standard for ballast water treatment.