Coastwise ANS: Assessment of Coastwise Traffic Patterns and Management of Aquatic Nonindigenous Species Risk on NOBOBs and Coastwise Vessels of the Great Lakes and East Coast of the United States and Canada

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Overview

Ships that engage in strictly coastwise traffic patterns (e.g., along the coast of the eastern US and among the ports of the Great Lakes) do not have to undergo treatment of ballast water or treat NOBOB tanks under U.S. law. Preliminary analysis indicates that coastwise shipping patterns and ballast water discharges pose a significant risk for facilitating the secondary spread of nonindigenous species among the freshwater and estuarine habitats along both the east coast and in the Great Lakes. Yet coastwise shipping activities have not been studied nor assessed with respect to ANS risk.

In this project we will expand upon previous work (Reid 08- NOBOB-S) to explore the efficacy of salinity-based treatments of residual organisms (especially low-salinity tolerant organisms) in ballast tanks, including those in NOBOB condition. We will focus on coastal organisms in Great Lakes and other coastal estuarine habitats of the North American Atlantic coast that are interconnected via coastwise shipping patterns and will use a detailed analysis of coastwise traffic to guide us in a risk assessment of the potential for transfer of low salinity organisms between these ecosystems/habitats. These data and assessments are required to make informed predictions and recommendations for the best combination of management strategies of ballast water exchange and brine exposures for preventing the secondary coastal spread of nonindigenous species into the freshwater and estuarine habitats of the United States. Input will include experimental and published data on salinity tolerances, coastwise and Great Lakes shipping patterns, and environmental compatibility between Great Lakes and U.S. east coast ports.

Proposed Work

Coast-wise traffic patterns of ships along eastern and Gulf Coasts of the United States were analyzed from data in the National Ballast Water Clearinghouse. The most significant ports that supply ballast water to the Great Lakes region were identified:

Houston, TX; Baton Rouge, LA; Baltimore, MD; Long Island Sound (COTP Zone), Port Everglades, FL; Portland, ME; New York, NY; Wilmington, DE; Albany, NY; Claymont, DE; and Philadelphia, PA.

Of these ports with significant ballast water transport into the Great Lakes, those considered predominantly or significantly low salinity (Houston, Baton Rouge, Baltimore, Philadelphia-Claymont, and Wilmington) were further investigated and port environmental profiles were developed.

A multi-year study of the efficacy of high-concentration sodium chloride (brine) solutions as a rapid-acting biocide for treating non-compliant NOBOB residuals was completed. We tested the efficacy of concentrated sodium chloride brine solutions as an additional treatment for eradicating halotolerant taxa often present in the ballast tanks of NOBOB ships. The lowest brine treatments (30 ppt for 1 h) caused 100% mortality in several species of cladocerans and copepods collected from oligohaline habitats. However, several brackish-water peracarid crustaceans, including some that can also survive in freshwater, required higher brine concentrations and longer exposure durations (45-60 ppt, 3-24 h). The most resilient animals were widely-introduced peracarid crustaceans that generally prefer mesohaline habitats, but do not tolerate freshwater (required brine treatments of 60-110 ppt for 3-24 h). Brine treatments (30 ppt) also required less time to cause 100% mortality for eight taxa than treatments using 34 ppt seawater. Based on these experiments and published data, we proposed appropriate treatment strategies for ballast tank biota often associated with NOBOB vessels entering the Great Lakes region. We estimate the lethal dosage of brine for 95% of the species in our experiments to be 110 ppt (95% confidence limits of 85-192 ppt) when the exposure time is 1 h and 60 ppt (95% confidence limits of 48-98) when the exposure duration is 6 h or longer.

Preparations of instruments for shipboard brine treatments with moored conductivity-temperature sondes to track the dispersion of brine added as a treatment to residual ballast in NOBOB tanks were completed. Actual experiments were delayed pending identification of cooperating vessels. Initial NOBOB-treatment experiments have been planned to take place during late fall 2008 aboard a tanker, and due to safety requirements, the sondes will not be useable for those experiments. Plans for experiments on ballasted vessels are not yet complete, but will likely not start until spring 2009.

Scientific Rationale

Ships that engage in strictly coastwise traffic patterns (e.g., along the coast of the eastern US and among the ports of the Great Lakes) do not have to undergo treatment of ballast water or treat NOBOB tanks under U.S. law. Preliminary analysis indicates that coastwise shipping patterns and ballast water discharges pose a significant risk for facilitating the secondary spread of nonindigenous species among the freshwater and estuarine habitats along both the east coast and in the Great Lakes. Yet coastwise shipping activities have not been studied nor assessed with respect to ANS risk.

In this project we will expand on previous work (Reid 08- NOBOB-S) to explore the efficacy of salinity-based treatments on coastal organisms in Great Lakes and other coastal estuarine habitats of the North American Atlantic coast that are interconnected via coastwise shipping patterns and will use a detailed analysis of coastwise traffic to guide us in a risk assessment of the potential for transfer of low salinity organisms between these ecosystems/habitats. These data and assessments are required to make informed predictions and recommendations for the

best combination of management strategies using ballast water exchange and brine exposures for preventing the secondary coastal spread of nonindigenous species into the freshwater and estuarine habitats of the United States. Input will include experimental and published data on salinity tolerances, coastwise and Great Lakes shipping patterns, and environmental compatibility between Great Lakes and U.S. east coast ports.

We propose to develop information and a predictive model to assess the risk of nonindigenous species introductions or spread among ports in the freshwater and estuarine habitats along the U.S. and Canadian Atlantic coasts and the Great Lakes via coastwise trade. Ports will be targeted based on analyses of coastwise vessel traffic and ballast patterns obtained from the National Ballast Water Clearinghouse (NBIC). Management strategies based on ballast water exchange and brine exposures for preventing such spread will be evaluated based on direct experiments as well as data culled from the scientific literature on salinity tolerances of key species from these ecosystems, and environmental compatibility among the targeted ports.

Our modeling approach will be inclusive of both novel experimental data on the environmental tolerances of both ‘successful’ and ‘failed’ introduced species as well as previously published data on their abundance, salinity tolerance, species relationships, and habitat preferences. We will also apply the Ballast Water Risk Assessment Model developed by the GloBallast Program to examine environmental compatibility between ports of interest and for comparison with the model approach described above.

Special attention will be given to two well-known heavily invaded regions, the Great Lakes and Chesapeake Bay. These regions share invasion threats from similar species groups that are tolerant of freshwater and oligohaline habitats. Estuarine systems such as the Chesapeake Bay are general receptive to diverse species groups with wide environmental tolerances, however the Great Lakes has the added barrier of a constant freshwater environment. This will allow us to compare the importance of several stepwise environmental barriers in the degree of coastal and intra-continental spread of invasive species.

To better understand the ballast tank environment, we previously moored instrument sondes in ballast tanks of selected commercial cargo ships. Under this project, several of those sondes will be used to understand and test the spread of high-concentration NaCl brines in ballast tanks during one or more shipboard treatments on commercial cargo ships in the Great Lakes, the latter to be planned and conducted by Canada DFO.

Objectives

1. Quantify the traffic and ballast water discharge patterns of coastwise shipping between estuarine ports of the United States, Canada, and the Great Lakes region.
2. Characterize the salinity and biota of ballast water entering the Great Lakes from coastwise traffic.
3. Test the efficacy of full salinity exposure to prevent the transfer of low salinity organisms by ships in coastwise trade.
4. Test the efficacy of brine solutions for preventing the introduction of environmentally tolerant fish (gobies) and invertebrate species (peracarids) into the Great Lakes.

5. Create a predictive model based on their environmental tolerances, abundance, and life history characteristics that discriminates between those species that have been successful versus unsuccessful at spreading among low salinity habitats along the eastern US and the Great Lakes Region.

Governmental/Societal Relevance

The invasive-species risk posed by vessel operations to the Great Lakes ecosystem resulted in rapid policy changes over the last several years. Ships that engage in strictly coastwise traffic patterns (e.g., between ports along the Atlantic coast of the US and Canada and in the Great Lakes) do not undergo treatment of ballast water under U.S. law. Preliminary analysis indicates that coastwise shipping patterns and ballast water discharges may pose a significant risk for facilitating the secondary spread of nonindigenous species among the freshwater and estuarine habitats along both the east coast and the Great Lakes. Yet coastwise shipping activities have not been studied nor assessed with respect to ANS risk. This could represent a significant gap in the protection of the Great Lakes (in particular) and Atlantic coastal ecosystems.

In this project we will expand upon previous work (Reid 08: NOBOB-S) to explore the efficacy of salinity-based treatments of residual organisms (especially low-salinity tolerant organisms) in ballast tanks, including those in NOBOB condition. We will focus on coastal organisms in Great Lakes and other coastal estuarine habitats of the North American Atlantic coast that are interconnected via coastwise shipping patterns and will use a detailed analysis of coastwise traffic to guide us in a risk assessment of the potential for transfer of low salinity organisms between these ecosystems/habitats. These data and assessments are required to make informed predictions and recommendations for the best combination of management strategies of ballast water exchange and brine exposures for preventing the secondary coastal spread of nonindigenous species into the freshwater and estuarine habitats of the United States. Input will include experimental and published data on salinity tolerances, coastwise and Great Lakes shipping patterns, and environmental compatibility between Great Lakes and U.S. east coast ports.

This project continues previous collaboration on this subject involving NOAA's Great Lakes Environmental Research Laboratory, the Smithsonian Environmental Research Center, and the University of Michigan Cooperative Institute for Limnology and Ecosystems Research. In addition, collaboration with the Canada Department of Fisheries and Oceans (DFO) and Transport Canada will provide, at no-cost (in-kind participation), enhanced analysis of vessel traffic patterns for the Atlantic coast of North America and the Great Lakes, focusing on both coastwise trade and internal Great Lakes domestic (U.S. and Canada) routes.

Relevance to Ecosystem Forecasting

This project will produce a predictive model based on the environmental tolerances, abundance, and life history characteristics of species and environmental characteristics of key Atlantic and Great Lakes ballast-related ports. It will discriminate between those species that have been successful versus unsuccessful at spreading among low salinity habitats along the eastern US and the Great Lakes Region. If successful, it will provide an additional tool towards reduction of

risk of new species introductions, thus serving to enhance the protection and integrity of the Great Lakes ecosystem.

Products

Publications

Santagata S., K. Bacela, D.F. Reid, K. Mclean, J.S. Cohen, J.R. Cordell, C. Brown, T.H. Johengen, and G.M. Ruiz. Eradicating ballast-tank organisms with sodium chloride treatments. *Environmental Toxicology & Chemistry*, In Press.