Ballast Exchange

Newsletter of the West Coast Ballast Outreach Project

Volume 8 Winter 2007

Greetings

Alisha Dahlstrom, Coordinator, West Coast Ballast Outreach Project

Welcome to the Winter 2007 issue of Ballast Exchange, the newsletter produced by the California Sea Grant Extension Program's West Coast Ballast Outreach Project (WCBOP). This issue includes articles on a variety of topics (from treatment technologies to Quagga mussels) and from a wide geographic range (New Zealand to Michigan and beyond). While editing the articles for this issue, however, I observed several recurring themes running through many of them: a plethora of jargon and acronyms; the difficulties associated with taxonomy and species identification; and the emerging recognition of commercial vessel fouling as an important aquatic invasive species (AIS) vector. These themes seem not to be unique to *Ballast Exchange*, but to reflect trends in the larger AIS and ballast world.

Education and outreach efforts will be most effective if we avoid difficult jargon and use clear and accessible definitions and consistent terminology. The WCBOP has created an "AIS Acronym and Vocab Guide" section in the AIS/Ballast Background and Research program link on our website to help readers understand new terms and concepts. Please contact us if you notice any missing terms. Taxonomic confusion was a second theme mentioned by several newsetter authors, that has also been emphasized at recent AIS and ballast conferences. While genetic tests and other technologies will help solve this problem, many agree that identification based on morphological characteristics will always be the fallback method – and for this, local experts are in high demand. Additional help will also come in the new edition of *The Light and Smith Manual*, a 1000-page definitive guide to invertebrates from Point Conception, Calif., to the Columbia River. And finally, while ballast water has historically received significant attention, recent research shows a stronger role for commerical vessel fouling as a vector than previously believed. Several states and countries have introduced legislation on vessel fouling; keep track of this issue via the WCBOP website's vessel fouling section.

The last six months has seen much activity and changes not only in the ballast world, but also within the WCBOP. Some highlights include the creation of an AIS/ballast water/vessel fouling blog (updated daily), which can be found by clicking the "In the News" link on the WCBOP webpage. The blog provides a professional forum for legislative, regulatory, and news updates related to AIS, ballast water, and vessel fouling.

The biggest change to the WCBOP, however, is the departure of the WCBOP Coordinator, Holly Crosson. Holly left the WCBOP to take a joint position as Interpretation Coordinator for the UC Davis Arboretum and GATEways (Gardens, Art and the Environment) Program and the Extension Outreach Coordinator for Aquatic Invasive Species with the UC Davis Department of Environmental Science and Policy. We would like to thank Holly for all her great work with the WCBOP and wish her well in her new work! Fortunately, Holly will remain on the Advisory Committee. We are pleased to announce that Annie Pierpoint has been hired as the WCBOP's new Education Coordinator *(see article on page 2)*.

We hope you enjoy this issue of Ballast Exchange and as always, we welcome your feedback at any time.

In this Issue

WCBOP Hires New Staff Member

We are pleased to welcome Annie Pierpoint to the West Coast Ballast Outreach Project. Annie graduated from UC Davis in 2007 with a major in Environmental Biology and Management, a minor in American Studies, and a love for Aggie Football. She has worked with The Nature Conservancy's Global Invasive Species Initiative and the UC Davis Botanical Conservatory, and spent three months in Costa Rica studying tropical biology. Annie is looking forward to advancing the Project's education and outreach goals from the Pleasant Hill, CA office. We're excited to have her on board! She can be reached at apierpoint@ucdavis.edu. Welcome, Annie!

Lloyd's Register releases guide to ballast water treatment technology

Lloyd's Register has released a new Guide to Ballast Water Treatment Technology that provides an independent and impartial description and appraisal of commercially available and developing technologies for ballast water treatment. It is the result of work conducted by the international Centre for Water Science at Cranfield University, UK, on behalf of Lloyd's Register.

To obtain a copy of the guide or for more information, contact: Nicholas A K Brownnicholasak.brown@lr.org

Invaders from the Sea wins top award

A documentary on aquatic invasive species (AIS) transported in ballast water has won the gold award in the category of "Best United Nations Feature" at the United Nations Documentary Film Festival. The film was produced by the International Maritime Organization (IMO), the United Nations agency responsible for the safety and security of shipping and the prevention of marine pollution by ships, in cooperation with the BBC and the shipping industry. *Invaders from the Sea* shows how harmful organisms transported in ballast water by ships have devastated biological and economic resources in many areas around the world, largely due to expanded maritime trade and traffic volume over the last few decades. The film also highlights the progress made by IMO and the maritime industry in addressing this issue and the measures that can be taken to prevent the spread of harmful organisms.

Invaders from the Sea is now available from IMO Publishing at: http://vp.imo.org/shop/v020e

Contacts

West Coast Ballast Outreach Project
Jodi Cassell, Program Director
University of California, Cooperative Extension
75 Santa Barbara Rd.
Pleasant Hill, CA
jlcassell@ucdavis.edu
925-646-6127
925-646-6708 fax

Alisha Dahlstrom, Coordinator
California Sea Grant Extension Program
1515 Clay St., Suite 1400
Oakland, CA 94612
adahlstrom@ucdavis.edu
510-622-5048
510-622-2501 fax

Annie Pierpoint, Education Coordinator
University of California, Cooperative Extension
75 Santa Barbara Rd.
Pleasant Hill, CA
apierpoint@ucdavis.edu
925-646-6540 ext. 217
925-646-6708 fax

State Ballast Water Programs
Alaska
Tammy Davis, Alaska Dept. of Fish and Game
tammy_davis@fishgame.state.ak.us

California
Maurya Falkner, California State Lands Commission
falknem@slc.ca.gov

Hawaii
Jo-Anne Kushima, Hawaii Dept. of Land & Natural Resources
jo-anne.n.kushima@hawaii.gov

Oregon (NEW!)
Rian Hooff, Oregon Dept. of Environmental Quality
hooff.rian@deq.state.or.us

Washington
Allen Pleus, Washington Dept. of Fish and Wildlife
pleusaep@dfw.wa.gov

Coordination of Reporting between Federal and State Ballast Water Programs: A Pilot Project

Christina Simkanin, Aquatic Bioinvasion Research and Policy Institute

Ballast water and biological fouling of ship surfaces are primary vectors for transferring aquatic invasive species (AIS) around the world.[1, 2] Ballast water, because of its sheer volume and the number of organisms transferred, poses a particular threat for spreading AIS. In response to this growing threat, regulations for ballast water management (reporting, exchange, and/or treatment) have been designed and implemented at international, federal and state levels.

In the United States, both federal and state programs receive, process and analyze ballast water management reports. To promote a complementary effort in ballast water reporting between programs, the Aquatic Bioinvasion Research and Policy Institute, a Smithsonian Environmental Research Center and Portland State University collaboration, initiated a reporting pilot project in January 2005. Specifically, independent ballast water reporting activities at the federal and state (Oregon) level were coordinated to reduce the duplication of effort, increase the quality of data received, and enable quantitative comparisons of results among programs.

Commercial vessel in the Columbia River
Photo courtesy of Christina Simkanin

By working with the already-established and standardized federal data management program at the National Ballast Information Clearinghouse (NBIC), state and local agencies are able to invest (scarce) resources into increasing data quality by ensuring compliance with state reporting requirements, ground-truthing and correcting errors via follow-up interviews, and informing ship captains and agents of federal and state ballast water management requirements. Follow-up and instruction by state/local regulators may have a positive effect on federal reporting compliance and enhance overall data quality. Additionally, increased data quality and collection efficiency allows for analysis and dissemination of results that can inform policy and prevention efforts.

The pilot project, funded by the Pacific States Marine Fisheries Commission, began in January 2005 and continued through June 2007. During this time the project accomplished a number of goals.

Specifically, we:

- developed an online web-based system for viewing electronic ballast water reports submitted to the NBIC in real-time;
- established data sharing protocols which allow vetted NBIC data to be sent to state/local agencies monthly;
- demonstrated that local follow-up increases state reporting compliance and data quality, and may also increase compliance with federal regulations;
- analyzed and disseminated ballast water management data, which increased the understanding of shipping and ballast water patterns nationally and on the U.S. West Coast;
- liaised with other West Coast ballast water programs, to continue regional collaboration and maintain congruency; and
- assisted the Oregon Ballast Water Task Force and drafted a report to the legislature that led to further protection of Oregon's waterways by amending state statutes and funding a permanent Oregon Department of Environmental Quality position to staff the Oregon program (SB 644).

The approach and technologies used throughout this pilot project demonstrate that collaboration between the federal and state programs can be mutually beneficial. The protocols and tools that were developed can be used by other states to increase efficiency in their ballast water management programs through collaboration with the NBIC. Collaborative programs can reduce data entry time, increase the quantity and quality of data collected, and free resources for the dissemination of results and enforcement. Data created through this collaboration, combined with effective ballast water management, will help create strategies for reversing the trend of increasing aquatic invasions in recent decades.

References

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2. Ruiz, G.M., Carlton, J.T., Grosholz, E.D. and Hines, A.H. (1997). Global invasions of marine and estuarine habitats by non-indigenous species: mechanisms, extent and consequences. *American Zoologist,* 37: 621-63

Putting together the pieces of the AIS puzzle: Henry Lee and the EPA's Office of Research and Development

Alisha Dahlstrom, West Coast Ballast Outreach Project

Currently a research ecologist for the U.S. Environmental Protection Agency (EPA), Henry Lee II, works on several topics, including the effects of aquatic invasive species (AIS) on aquatic ecosystems. He compares the fight against AIS to putting together a puzzle – it will never be complete without all the pieces. Lee has assembled quite a few of the pieces, including collaboration, monitoring, assessment, regulation, and the creation and testing of models.

Lee joined the EPA in 1979, when he started in Newport, Oregon, as a National Research Council post-doctorate looking at the recovery of benthic communities after a stress event. Apart from a two-year period spent in San Francisco as an Office of Research and Development (ORD) Regional Scientist, serving as a liaison between regulators and the science community, he has stayed in Newport. It was in San Francisco that he recognized the growing impacts of AIS and instituted an AIS workshop series, which was the first of its kind for EPA. Out of these workshops came the first piece of the puzzle: collaboration. A small number of dedicated people from these workshops formed the Nonindegenous Species Working Group (NISWG), EPA's informal, ad-hoc group that addresses AIS (EPA has no centralized invasive species program).

Henry Lee, Research Ecologist, EPA

His second and third tools, monitoring and assessment, came into play with the Environmental Monitoring and Assessment Program (EMAP). For EMAP, he works with a team that coordinates and analyzes data collected by the states for a large-scale monitoring and assessment program for estuarine waters on the U.S. West Coast, including Hawaii, Guam and Alaska. He compares the relationship between EMAP and an ecosystem to the relationship between the GNP and an economy: it tells how well the object in question is doing, in general. Thus, the Western Coastal EMAP assesses the overall ecological condition of estuaries and coastal waters on the West Coast. This assessment can be used to determine whether or not a water body is "impaired," a classification that gives regulators the power to start working to improve the condition of the water body. For example, an impaired water body may have elevated nitrogen content, prompting regulators to examine the nitrogen sources (the "load") and start managing the worst offenders. For EMAP, the parameters analyzed include pollution measurements such as sediment contamination and fish tissue residues, measures of water quality, and quantification of the soft-bottom benthic communities (the worms and clams living in the mud and sand). While the benthic community structure has classically been used as a measure of pollution stress, Lee recognized that this EMAP data was also a rich source of AIS information for estuaries. This invited him to ask questions such as: how widespread are the invaders? Which are the most abundant? Where are they the most abundant? Besides supplying basic insights on the distribution and abundance of invaders, this information has been used in developing an index of invasion for Pacific Northwest estuaries and can be used to develop performance measures to evaluate the effectiveness of management activities to reduce invasions.

Another research effort has Lee collaborating with Deborah Reusser of the U.S. Geological Survey (USGS). Their joint project is the development of the Pacific Coast Ecosystem Information System (PCEIS), a geospatial database of the native and non-native marine and estuarine species in the Northeast Pacific. While several AIS databases exist, they tend to be either for a single waterbody (too detailed) or at too-coarse a scale to map distributions in smaller estuaries (not enough detail). Also, existing databases only report AIS, and not native species. Even though it greatly increases the workload, Lee and Reusser decided to include native species for a number of reasons, including being able to identify native species at risk from invasions, normalize the extent of invasion to native diversity, and have baseline distributions of natives to evaluate effects of global climate change. Another unique feature of PCEIS is that it includes information on the geomorphology of the Pacific Coast estuaries and land-use data on the associated coastal watersheds, which comes from another program Lee has worked on (a classification of Pacific Northwest estuaries in terms of their vulnerability to nutrient enrichment). With the combination of detailed distributional data on native and nonindigenous species and the landscape information, PCEIS can be used as a risk assessment tool for a variety of stressors, including invasions, pollution, and global climate change. PCEIS will be available to the public in six months to a year.

The PCEIS project has yielded some interesting challenges and results. Lee cites ambiguous and multiplicative taxonomic definitions as the biggest challenge in creating a database relevant to large geographic regions. For example, some species have different names in different parts of the U.S. While he sees genetics as a solution in some cases, genetic probes cannot find new species (e.g., those arriving via ballast water); he believes that anatomical structure will always be the primary tool in identification.

Another piece in solving the AIS puzzle is developing models that make risk-assessment predictions (predictions about the likelihood of future invasions) based on past invasions. Lee and Reusser are evalu-

ating an AIS theory based on biogeography (the science that deals with geographic patterns of species distribution and the processes that result in such patterns). Their theory predicts that eastern sides of oceans are more invaded than western sides. According to the theory, the western coasts of the Americas and Europe have mild climates with fairly constant water temperature (such as San Francisco Bay), which leads to "weak" native species. Conversely, the environments on the eastern coasts (Asia and the eastern U.S.) are more extreme, which leads to "tough" native species with a high environmental tolerance range. When these tough animals arrive in mild climates, they spread easily, while the wimpy animals can only invade a very small (if any) range of the opposite side of the ocean. This theory could help scientists and regulators focus more prevention efforts on high-risk (i.e., mild) environments.

Model verification is another puzzle piece: the Genetic Algorithm for Rule-set Prediction (a niche model) attempts to predict distributions of native and non-native species based on several environmental parameters such as water temperature, salinity, depth, etc. However, the accuracy of these models is rarely rigorously analyzed, which is worrisome because many of these models have terrestrial origins – and how well they apply to aquatic ecosystems is largely unknown. Using known distributions (via EMAP data), Lee and Reusser are evaluating a suite of different niche models to determine how well the predictions compare to actual distributions, and then refine the models, if necessary. For example, scientists know that mean water temperature can predict species distribution, but for coastal areas from Tijuana to Puget Sound, scientists have complete data for mean air temperature – not for mean water temperature. Lee and Reusser found that air temperature data predicts species distribution pretty well. This "shortcut" could allow scientists to make predictions with data already available, instead of losing valuable time waiting for additional data collection. But do these niche models work for aquatic predictions, in a more general sense? "They kinda work – which takes you back to the question: 'How well do we need to know the answer?'" says Lee. The answer to this question, of course, will vary case by case – but even asking the question denotes a step forward.

Lee's influence in the AIS world extends internationally as a member of the U.S. delegation to the International Maritime Organization (IMO) ballast water treaty negotiations. He provides technical assistance in the development of risk assessment guidelines that are mandated in the section that exempts ships with certain defined shipping routes from ballast water treatment requirements. The original draft guidelines included two methods of evaluating the risk of invasion – climate matching between the donor and recipient ports and detailed, species-specific risk assessments based on life history. Lee was instrumental in including a third approach in the draft guidelines, a comparison of the biogeographic overlap of native and nonindigenous species in the donor and recipient ports and biogeographic provinces. Because little is often known about the biota in the port per se compared to the larger water body the port is contained within (e.g., estuary) or biogeographic province, it is proposed that the analysis be conducted at different spatial scales. The basic approach is to compare the species present within the donor port (e.g., L.A. harbor), region (San Pedro Bay), and biogeographic province (San Diegan Province) to the species present in the recipient port (e.g., Tacoma), region (Puget Sound), and biogeographic province (West Coast Fjords). Such comparisons generate several types of information useful in assessing the potential risk of invasion from the donor port, three of which are outlined below.

1) An overlap of species between the donor and recipient biogeographic provinces is strong evidence that the overall "climate" of the two regions is sufficiently similar to allow them to share species. The greater the number of shared species, the greater the evidence for environmental matching between the donor and recipient ports/provinces. One advantage of using organisms as indicators of environmental matching (as opposed to the usually limited number of measurements of temperature and salinity) is that species distributions integrate multiple environmental parameters across ecologically relevant temporal scales (e.g., seasonal, tidal, among-year, etc.).

2) Biogeographical distributions of species in the donor biogeographic region can be used to identify high-risk species. For example, a native species in the donor region (e.g., Mediterranean) that has invaded many other regions of the world (e.g., North Sea, Northeast coast of U.S., Gulf of Mexico) demonstrates that it has "invasive" properties that allow it to colonize new areas. The next question is whether the environmental tolerances of this high-risk species overlap that of the recipient port (e.g., San Francisco), which can be evaluated by comparing the environmental conditions in the recipient port/region to those over the entire native and invaded range of the potential invader. The greater the amount of environmental overlap, the higher the likelihood the potential invader would survive in the recipient region.

3) An evaluation of the number of native species from the donor port/province that have invaded other parts of the world can be used as an indicator of the "invasion potential" of that particular biogeographic province. For example, the high percentage of invaders from the Ponto-Caspian region indicates that many species from this region of the world have high invasion potential and should be considered as high-risk invaders if there is sufficient environmental matching between the donor and recipient ports/regions.

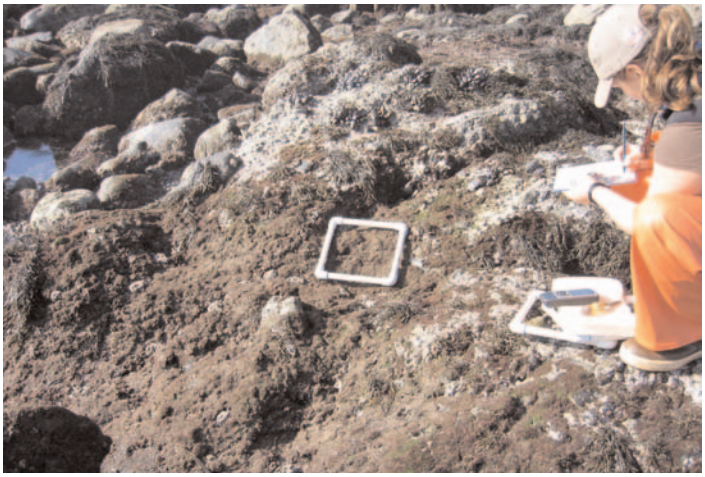
So what does a senior scientist like Lee do when he is not working on databases or attending IMO meetings? "Exploring the urban environment, attending theatre, movies, blues shows … and more database work," he joked – although this joke likely contained more than a kernel of truth, given the time- and resource-intensive nature of developing a database. And yet again the effort against AIS retains similarities to a puzzle: at times long, difficult, and frustrating, but solvable given enough hard work, strategy, and patience – qualities Lee has in abundance.

Henry Lee II can be reached at Lee.Henry@epamail.epa.gov. For more info on EMAP, visit: http://www.epa.gov/emap/

A Survey of Aquatic Invasive Species on California's Outer Coast

Steve Foss, California Department of Fish and Game

Resource managers and researchers have long known that California's ports and bays are home to many aquatic invasive species (AIS), but less well known is the extent of invasion on the outer coast. Until now, surveys for non-native species on California's outer coast have been isolated and small-scale. The recent survey by the California Department of Fish and Game's Office of Spill Prevention and Response (OSPR) represents the first comprehensive investigation of the state's open coast habitats and will help answer the question, "Have ballast water exchange initiatives been successful in slowing the rate of species invasions?"



Intertidal AIS survey. Using a square sampling frame, biologists are able to estimate the relative abundance of native and non-native species in an area.

The California Ballast Water Management Act of 1999 required the California Department of Fish and Game (CDFG) to conduct several studies to develop baseline data of AIS on the California coast. The Marine Invasive Species Prevention Act of 2003 expanded ballast water control measures to include coastwise traffic and specified that the initial baseline study conducted by CDFG should be expanded to include outer coastal habitats. The 2004 open coast study targeted prominent headlands that were in proximity to shipping lanes, as well as other locations where ballast water exchange could likely result in AIS invasions. Surveys were jointly conducted by CDFG/OSPR and Moss Landing Marine Laboratories (MLML). In all, 22 sites were sampled as part of this field investigation, which will be repeated in 2007.

At each of the 22 sites, 4 main habitat types were targeted: rocky intertidal, rocky subtidal (kelp forests if possible), sandy intertidal, and sandy subtidal. Sampling included a variety of techniques. Benthic infaunal organisms (those living within the ocean-bottom substrate) were collected from sandy intertidal and subtidal areas by sieving sediment core samples collected by a boat-mounted winch, SCUBA divers, or by hand on beaches. Epifaunal organisms (those living on the ocean's bottom substrate) were collected quantitatively from rocky intertidal and subtidal substrate by scraping and collecting from quadrats placed in areas that appeared to have high species diversity. Also, taxonomists and/or natural historians familiar with the local flora and fauna conducted qualitative visual searches for introduced species at each site. Samples were then preserved and transported to laboratories and taxonomists for identification.

Researchers identified 1,265 species from these samples, which were categorized by their introduction status: 26 were introduced, 127 were cryptogenic (not demonstrably introduced or native), and 1,112 were native to California (615 specimens could not be identified to species level and were classified as "unresolved.") Of the 26 AIS identified along the open coast, 5 were not previously known in California (all 5 were bryozoans). At least 5 additional AIS identified in this survey (2 polychaete worms and 3 bryozoans) had previously only been reported from California bays or estuarine habitats and were not known to be present on the open coast. An average of 3.3 AIS were found per site, representing an average of 1% of the total species collected from each site. There was no obvious difference in the number of AIS or percentage of AIS relative to total species between northern and southern California sites.

On a state-wide level, results from the recent outer coast field survey can be generally compared to results from the 2000-2001 bays and harbors field survey. Although far more species were identified on the outer coast (1,265) relative to the bays and harbors survey (818), introduced species accounted for a much smaller percentage of the total species identified in the outer coast (2%) than in the bays and harbors (10%). It is unknown whether the open coastal environment is more resistant (or less exposed) to invasions.

As mentioned earlier, an unusually large percentage of the total specimens were classified as unresolved (32%). The inability to adequately identify species is due to a variety of reasons, including damaged or juvenile specimens, undescribed species, and problems in the taxonomic literature. This highlights one of the difficulties facing scientists when evaluating introductions throughout the world and demonstrates the need for continued basic research on resolving taxonomy of marine species.

There appears to be little overlap between AIS observed from open coast survey sites and nearby major ports in Southern California. For example, Point Fermin, one of the open coast survey sites with the highest number of AIS, is near Los Angeles/Long Beach harbor. However, none of the 8 AIS found at Point Fermin are recorded in L.A./L.B. harbor. This lack of correspondence between AIS present within harbors and nearby open coast sites is counter-intuitive and indicates a need for investigation of mechanisms of open coast introductions.

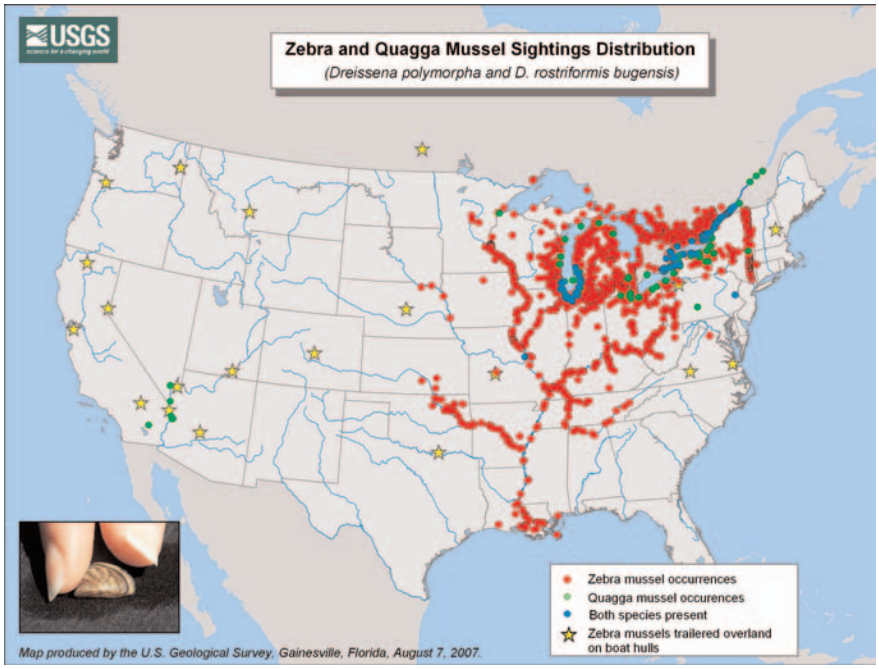
Based on literature reviews, introduction vectors have been identified for 13 of the 26 outer coast AIS found in the current survey. Only 3 probable vectors were implicated in the introduction of these species: oyster aquaculture, ballast water, and ship fouling. This suggests that shipping may play a significant role in dispersal of new species not just into California harbors and bays, but into outer coastal areas, as well.

Data from the current survey can be found in OSPR's California Aquatic Non-native Organism Database (CANOD). The database (and the MLML outer coast survey report to CDFG) is available to the public on the OSPR Web site at http://www.dfg.ca.gov/ospr/about/science/misp.html

The Quagga Quagmire: Long-term Implications of a Ballast Introduction

Paul Heimowitz, U.S. Fish and Wildlife Service

When Quagga mussels appeared in Lake Mead this past January, many fingers quickly pointed at recreational boating as the likely source of the introduction. And with good reason: recreational boats fouled by Zebra mussels (and in retrospect, probably Quagga mussels, as well) have been repeatedly intercepted within and en route to the Colorado River Basin. However, the Lake Mead situation should also make us think about the long-term implications of aquatic invasive species (AIS) introductions from commercial shipping. Obviously, a transoceanic freighter hasn't docked in the lower Colorado River recently, but most evidence indicates that ballast discharge from commercial shipping brought Quagga mussels and their more infamous cousin, the Zebra mussel, to the United States. Personal watercraft and other human vectors, as well as natural downstream dispersal, then spread these mollusks and their impacts far beyond the original site of introduction.



This ripple effect has now reached the Western United States. Since their initial discovery in Lake Mead, Quagga mussels have been found downstream in Lake Havasu and Lake Mohave. (Figure above shows distribution as of August 2007.) A recent inspection of the Colorado River Aqueduct, a critical source of water delivery to Southern California, revealed that Quagga mussels had spread 125 miles downstream of the Colorado River intake and confirmed densities at the intake nearing 500 mussels/meter^2.

Agencies have already spent a lot of money to prevent and detect further spread in the Southwest, but it's still too early to know if this new Quagga mussel introduction will lead to the severe ecological and economic impacts experienced in the Eastern United States, as Quagga mussels are pioneers in the Colorado Basin.

While Quagga mussels have been found fouling structures on Hoover Dam and other hydropower facilities, they are not yet at levels that have harmed operations. In addition to economic impacts, Quagga mussels and their filter-feeding prowess could alter the aquatic food web in the Colorado River to the detriment of imperiled fish species like the Bonytail Chub.

Can this slow-motion explosion be stopped? The 100th Meridian Initiative was launched in 1998 by the national Aquatic Nuisance Species (ANS) Task Force's Western Regional Panel (in partnership with the U.S. Fish and Wildlife Service and a multitude of other organizations) to stop the westward spread of Zebra and Quagga mussels. Despite the Colorado River setback, efforts under that initiative have redoubled to promote boater education, train law enforcement officers, and deliver other programs aimed at preventing spread. Examples of state action include California devoting new resources to operate inspection stations on key highways, Utah hiring a suite of outreach and other personnel focused on ANS, and Washington passing a new law that increases state capacity to intercept contaminated boats. Enhanced preparedness for an invasion has accompanied this boost in prevention programs, such as completion of a Zebra/Quagga mussel rapid response plan for the Columbia River Basin.

When we consider the benefits of managing transcontinental ballast water to avoid ANS introductions, we can't just think of avoiding impacts to the immediate receiving waters or even the associated coast or region. As this newest chapter in the Quagga mussel saga demonstrates, the harm caused by subsequent transport via other intracontinental pathways may be even more significant.

For more information on Quagga mussels and management efforts in the Colorado River:

100th Meridian Initiative, Lake Mead and Colorado River page
http://100thmeridian.org/mead.asp

Dreissena Species Frequently Asked Questions: A Closer Look
http://cars.er.usgs.gov/Nonindigenous_Species/Zebra_mussel_FAQs/Dreissena_FAQs/dreissena_faqs.html

Hyde Marine Ballast Water Treatment History

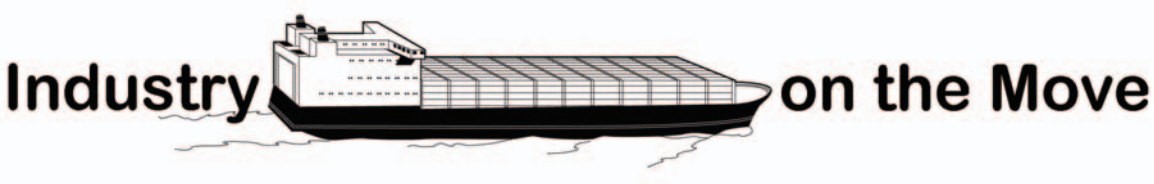
Tom Mackey, Hyde Marine, Inc.

Hyde Marine has been involved in ballast water treatment (BWT) since 1996, when it partnered with the University of Michigan to study potential BWT technologies, particularly for ships operating in the Great Lakes-St. Lawrence Seaway System. This led to Hyde's participation as the engineering contractor for one of the first BWT research programs in North America, the Great Lakes Ballast Technology Demonstration Project (GLBTDP). In 1997, Hyde was contracted by the GLBTDP to purchase the equipment being tested, design and build a mobile test facility, test the equipment, and operate it aboard a Canadian Great Lakes bulk carrier, the *Algonorth*. After a season aboard the *Algonorth*, the test equipment was transferred in 1999 to a barge in Duluth-Superior Harbor (Lake Superior), where the GLBTDP conducted additional testing of the screen filter (the original technology tested aboard the *Algonorth*), a cyclonic separator, a disk filter, and a UV disinfection system.

Hyde Guardian Ballast Water Treatment System.
Photo courtesy of Hyde Marine, Inc.

Hyde began testing and operating its own BWT equipment in 2000, when it installed its initial full-scale, first-generation system (the cyclonic separator and the UV system, manufactured by Hyde's partner, OptiMarin AS of Norway) aboard the U.S.-based cruise ship, *Regal Princess*. In 2001 Hyde installed four additional systems, two on cruise ships and one each on a container ship and chemical tanker. In 2003, after the BWT requirements were better defined, Hyde installed a state-of-the-art filtration and UV disinfection system aboard the *Coral Princess*. This system, named the Hyde Guardian, was tested extensively on land-based installations and onboard the Coral Princess in the fall of 2004. The onboard tests demonstrated the Hyde Guardian's capability to meet the IMO BWT Convention requirements, and a vessel with the Hyde system is in the final stages of review for acceptance into the U.S. Coast Guard Shipboard Technology Evaluation Program (STEP) program. In the fall of 2006, an essentially identical system was installed aboard Royal Caribbean Cruise Line's Celebrity *Mercury*. It was commissioned early in 2007, which involved checking the system's installation, starting the equipment to make sure it was operating properly, and instructing the crew in its operation and maintenance. The Hyde Guardian systems aboard the *Coral Princess* and *Mercury* were granted interim approval for use in Washington State waters by the State of Washington in 2004 and 2007, respectively. The Hyde Guardian has been commercially available since early 2003.

The Hyde Guardian has two main components – the automatic back-flushing filter and the in-line UV system. The filter ensures reliable removal of solids and larger organisms, containing several modules of "stacked-disc" filter elements that capture and store large amounts of solids. The filter is designed to automatically back-flush itself at the end of each ballasting operation and when necessary, clean one module at a time using the filtered water from the remaining modules. This allows for continuous ballast flow and discharge of the filtered material back into the ballast water source (e.g., the ocean). The



UV component uses high-output lamps perpendicular to the fluid flow, which results in superior performance and compact size. An automatic cleaning mechanism keeps the quartz sleeves that contain the UV lamps clean, ensuring consistent and reliable UV dosage. The UV treatment chamber is made of heavy-duty, 316L stainless steel for a long, trouble-free service life.

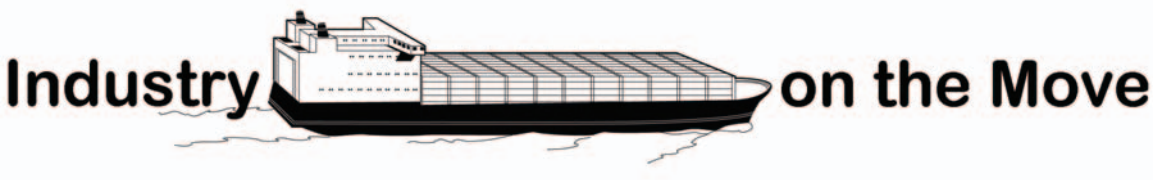
During ballasting, the flow is processed through the filter and UV system, then back to the main ballast system. During deballasting, the filter is bypassed and the water flows only through the UV system and then overboard through the discharge line. A single control panel operates the entire ballast water treatment system (filter, UV, valves and booster pump, if required). All operations and indications can be viewed via the LCD panel, and the system can easily be integrated into the ship's control system to allow for operation and monitoring in the control room.

Hyde Guardian UV Chamber.
Photo courtesy of Hyde Marine, Inc.

The system is modular in configuration so that the components can be installed separately to fit the available space on existing vessels. Hyde has also developed a complete skid-mounted Hyde Guardian system, which has been offered for several new building programs at a considerably lower installation cost. Skid-mounting uses a steel platform that forms part of the foundation for all of the BWT system components and is suited for new building applications, where it can be designed into the BWT system. The first skid-mounted system is currently under construction; completion is expected in 2007.

Hyde has over 30 years' operating experience on the seven ships fitted with its systems, and is prepared to obtain type approval for the system as soon as a facility and procedure are available to meet the IMO Convention (which could enter into force as early as January 2009), as well as the proposed U.S. regulations (they have not been released yet, but may be up to two orders of magnitude stricter than IMO guidelines.)

Hyde is also involved with the commercialization and marketing of a natural biocide for BWT called SeaKleen™. Available for commercial sale by the end of 2007, SeaKleen™ has been extensively tested using land- and ship-based installations. This past fall, SeaKleenTM was tested in a full-scale trial aboard a 45,000 DWT tanker operating on the U.S. West Coast.The ship-based tests demonstrated that SeaKleen™ meets the IMO requirements even when used in very small concentrations, as low as 1 part per million. SeaKleen™ has also been tested as a means of dealing with the no ballast on board (NOBOB) problem on the Great Lakes, as it is effective even in the presence of large amounts of sediment. Sediment in ballast tanks does not receive much attention, although many recognize it as a large, difficult-to-treat source of aquatic invasive species. Hyde Marine has worked to control sediments in ballast tanks since its predecessor company the years and is now available as a method for controlling sediment buildup in ballast tanks as required by the IMO BW Convention.



Mothball Fleet Update

Keith H. Lichten, P.E., San Francisco Regional Water Quality Control Board, and Alisha Dahlstrom, West Coast Ballast Outreach Project

In the months since the article on the U.S. Maritime Administration's (MARAD's) Suisun Bay Reserve Fleet (commonly referred to as the "Mothball Fleet") in the previous volume of Ballast Exchange (see "Hull Cleaning of the Mothball Fleet" in Volume 7), two vessels (the *Jason and Queens Victoria)* have been towed to Texas and cleaned in international waters while regulatory issues remain unresolved. MARAD administrator Sean Connaughton suspended the scrapping program to sort out pollution/regulatory concerns, reinstating it Aug. 1, 2007, when Virginia and Texas regulators accepted the status quo approach of in-water cleaning. The last article explained that the San Francisco Regional Water Quality Control Board (the Board) and the Department of Toxic Substances Control (DTSC) had initiated testing with MARAD to determine the extent of possible pollution to San Francisco Bay (the Bay). Since then, the Board has stepped up its role in dealing with three main issues: (1) discharges associated with scamping (described below); (2) peeling paint above the waterline; and (3) contaminated sediment. While the three issues (below) are still being resolved, the Board expects to know more by the end of this year.

Prior to the scrapping of an obsolete ship, the ship's hull is cleaned of invasive species in a process known as scamping. MARAD has previously conducted the scamping process in-water, discharging both invasive species and hull coatings laden with high levels of heavy metals into the Bay. Because of this, the Board required MARAD to identify alternate approaches to the current process, such as employing a capture mechanism to collect the released material, or doing the scamping work out of water. In June 2007, MARAD conducted a test run of a capture device that used a multi-layered mesh bag to capture the particlate matter removed by the scamping equipment while cleaning a ship from the James River Fleet in Virginia. California regulators are currently reviewing the information from this test to determine if (and how) a pilot may be completed in the Bay.

In addition to pollution problems occurring in-water, many of the ships in the mothball fleet also have peeling paint above the waterline. This peeling hull paint typically has heavy metal concentrations above the threshold for hazardous waste; and as it flakes off the ships, this peeling paint discharges directly into the Bay. An environmental assessment carried out in February 2007 for MARAD estimated that 21 tons of toxic metals had fallen into the Bay from above-water hulls, with another 65 tons remaining that have the potential to enter the Bay.[1] The Board and DTSC worked with MARAD to identify measures to control this hazardous waste discharge, such as preventively removing and capturing the peeling paint from the ships. MARAD was required to submit a work plan on Aug. 6, 2007, to describe how it will control this discharge; after MARAD failed to submit this work plan by the deadline, the Board has asked MARAD to submit a new plan that proposes methods and a schedule to determine the magnitude and extent of sediment impacts resulting from peeling paint off the Mothball Fleet.

The third issue arises because the Mothball Fleet has been at anchor in the Bay since World War II, and there may have been discharges from the fleet leading to a legacy of contaminated sediment. A study completed for MARAD in February 2007 that touched on this issue was not conclusive. The Board has requested a work plan from MARAD that appropriately investigates this issue and completes appropriate follow-up action.

Another new development is a proposal to dismantle the fleet at one of two historic dry dock locations; parties including members of the Bay Area Congressional delegation and the environmental group ArcEcology, are reviewing whether there are opportunities to scrap ships in the Bay Area. One option is to renovate several of the five dry-dock basins at Richmond's historic Shipyard Number 3; a second is to use the former Navy dry docks at Mare Island in Vallejo, CA; a third is using the San Francisco dry docks. Supporters of scrapping the ships in the Bay claim that doing so would have several benefits, including the creation of local jobs in an area that needs them, the elimination of AIS spread (the ships would no longer have to complete the journey south to the Panama Canal then north to Texas, during which AIS have the chance to colonize), and a reduction in towing costs (it cost $4.9 million to prepare the last 5 Suisun Bay ships for the "dead tow" to Texas).[2] Reopening the dry-docks in Richmond or Vallejo will be challenging due to the high cost of renovating such highly dilapidated facilities, expensive California labor (Texas has a lower minimum wage), the potential worker health hazards, and the disposal of large amounts of toxic materials and the possibility of air-borne pollution.[2] A final option for scrapping ships in the Bay area may be via the private sector maritime industry. For instance, BAE Systems (a private ship repair business with operational dry docks) has expressed interest in scrapping activities.

For updates on the Mothball Fleet, click the WCBOP's "In the News" link at http://ballast-outreach-ucsgep.ucdavis.edu/ or contact Keith Lichten at KLichten@waterboards.ca.gov.

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California Assembly Bill 740: Keeping Hitchhikers off the Hull

Lynn Takata and Kate Williams

In coastal environments, commercial shipping is a primary transport pathway, or "vector," for the introduction of aquatic invasive species (AIS) (Ruiz *et al.* 2000; Hewitt et al. 2004), accounting for one-half to three-quarters of introductions to North America in one study (Fofonoff *et al.* 2003). On the U.S. West Coast, ballast water management has been required over the last several years to minimize species introductions. However, studies indicate that ship fouling (aka vessel fouling, hull fouling or biofouling), another commercial shipping-related pathway, accounts for more than one-third of the shipping-related invertebrate and algal introductions to North America (Fofonoff *et al.* 2003). Despite this, there are currently no state or federal measures in place to reduce introductions through the fouling vector.

Quagga mussels growing on Sentinel Island in Lake Mead's Boulder Basin.
Photo courtesy David Kushner, National Park Service

As mandated by the 2003 Marine Invasive Species Act, the California State Lands Commission (CSLC) examined the risk of species introductions via commercial vessel fouling in consultation with a multidisciplinary advisory group. Based on research and discussions with industry representatives, scientific experts, and state and federal resource agency representatives on the advisory group, the CSLC formulated a suite of recommendations. These were submitted in a CSLC report to the California Legislature in 2006 (Takata *et al.* 2006).

Quagga mussels growing on cart retrieved from the bottom of a Lake Mead marina.
Photo courtesy David Britton, U.S. Fish and Wildlife Service.

In 2007, California State Assemblyman John Laird (Santa Cruz) introduced Assembly Bill 740, which incorporates several of the major recommendations put forward by the CSLC. The bill (which was signed into law in October 2007) proposes immediate management actions to address commercial vessels (over 300 gross registered tons) that pose an elevated risk for fouling introductions, while also proposing information collection to build a critical knowledge base that will be used to refine management measures in years to come. Toward that end, some of the key components of the legislation are:

- Broadening California's program to include the prevention of AIS introductions via commercial vessel fouling.
- Requiring the CSLC to adopt regulations governing the management of hull fouling on vessels by January 1, 2012, based on information collected on hull husbandry practices, biological research of species transfer through vessel fouling, and the development of in-water hull-cleaning technologies.
- Prior to the adoption of regulations, requiring that commercial vessels regularly, as defined in the bill, remove fouling from submerged portions of a vessel.
- Requiring annual submission to the CSLC of information on cleaning, maintenance, and antifouling measures utilized on the submerged surfaces of vessels.

Assembly Bill 740 will enhance the effectiveness of California's Marine Invasive Species Program, continuing to move it toward the long-term target of preventing AIS establishment in coastal and estuarine waters of the state. The bill has the support of the shipping industry and environmental groups. No comparable program yet exists at the national level to protect California from the adverse impacts of invasive species that may be transported through commercial vessel fouling. Assembly Bill 740 takes the first key steps towards achieving this goal. For more information on AB 740, visit the WCBOP website or go to: http://www.sen.ca.gov.

Please see page 16 for references.

Federal AIS/Ballast Legislation Update

Joy Mulinex, Great Lakes Task Force

When the Zebra mussel first invaded the Great Lakes in the late 1980s, the term "invasive species" was a fairly new term. Due in part to the $3 billion in damage to the Great Lakes region caused by the mussel from 1993-2003, however, the term has become all too familiar. Today, more than 180 aquatic invasive species (AIS) are established in the lakes, dozens of which threaten the region's ecosystem and economy. The problem is not unique to the Great Lakes; most water bodies across the country suffer from AIS introductions.

Ballast water is recognized as a leading vector for the transport of these AIS between disparate regions. While current law allows the Coast Guard to approve ballast technology with efficacy greater than or equal to ballast water exchange, but no one has been able to say exactly what that means because no federal standard for ballast water treatment has been set. As a result, no ballast technologies have been approved since Congress passed the National Invasive Species Act in 1996. Because of this lack of progress, states have begun enacting ballast treatment measures. But unless every coastal state enacts legislation that provides the same level of protection against new invaders, only federal legislation will initiate a shift from the current method of "treating" ballast water – ballast exchange – to methods that actually treat ballast water.

Policy makers on Capitol Hill know that the largest pathway for aquatic introductions is oceanic ships and thus, most action on the Hill is focused on ballast water and ships. They want a long-term solution that is more effective than ballast water exchange. A handful of bills were introduced in Congress in 2007, and they fall into three categories. The first is comprehensive legislation to address all of the following: prevention from all vectors; rapid response measures when new species are detected; screening the importation of live aquatic organisms; and research, education and outreach measures. The second category addresses ballast water and the ship as a vector, and also sets a ballast discharge standard. The last category focuses specifically on ships entering the Great Lakes system with no pumpable ballast water on board (NOBOBs).

Because comprehensive bills fall into the jurisdiction of multiple congressional committees, the coordination of which is extremely difficult, it would be difficult to pass a bill from the first category. And because all waters are plagued by some aquatic invader, there is broader interest in Congress to take national action rather than focus solely on the Great Lakes. Therefore, most believe that a ballast water bill from the second category is the most likely measure to move in 2007.

Several bills have been introduced from the second category. Representative James Oberstar, chairman of the House Transportation and Infrastructure Committee, introduced and marked up the *Coast Guard Authorization Act of 2007* (H.R. 2830). The House bill closely follows one introduced several weeks ago by Senate Commerce Committee Chairman Daniel Inouye, the *Ballast Water Management Act of 2007* (S. 1578). Both bills require ballast water treatment technology to be installed on ships that can meet a discharge standard that is 100 times more stringent than the IMO Convention, though each bill has different deadlines. Both bills allow the Coast Guard to tighten the standard if better technology becomes available.

It is unclear when either bill might be brought to the House and Senate floors for a vote, but supporters hope that legislation will move in 2007. For more information or to track the bills, please visit www.thomas.gov and type in key word "ballast" or enter the specific bill number.

Biofouling makes the IMO agenda

Naomi Parker, Biosecurity New Zealand

In addressing the risk of invasions of marine organisms in ballast water through the Ballast Water Management Convention, it is clear that we have only dealt with one of the major pathways of species movement facilitated by shipping. Another major pathway is biofouling of ships; in New Zealand and elsewhere around the world, recent incursions of biofouling species are having significant impacts on the marine environment, natural resources and industries.

Many countries are now considering how best to deal with this issue, but as with all invasive species issues, an international approach is needed. New Zealand, with the UK, Australia, the IUCN and Friends of the Earth International as cosponsors, was successful in getting biofouling on the IMO agenda at the IMO meeting in July 2007. The work to be done under this agenda item will identify the most appropriate option to further the management of biofouling at an international level, considering "softer measures" (such as guidelines) to more formal measures (such as Conventions). The work will also consider a range of different aspects of the biofouling issue and the best ways to address them, including:

- anti-fouling paint application and use;
- approaches to minimize biofouling in niche areas;
- in-water cleaning;
- documentation/certification standards for maintenance regimes; and
- design of dry dock and other vessel cleaning facilities to minimize the risk of release of biological material into the environment.

Consideration of the need for different measures for different vessel types and the need to address all vessel vectors will also be important. Because of the complexity of biofouling issues, it will take time to resolve them and work out the best ways to ensure that we minimize the risk of new invasions through this pathway.

Michigan rocks the boat with new ballast regulations

Alisha Dahlstrom, WCBOP

Although the Great Lakes are widely recognized as valuable natural assets, the existence of multiple state and international jurisdictions (eight U.S. states and two Canadian provinces claim jurisdiction over portions of the Great Lakes) makes the development of coordinated management strategies complex. Amidst the uncertainties and inaction, aquatic invasive species (AIS) have continued to spread. Michigan, however, has recently implemented the Michigan Ballast Water Act (MBWA), legislation that takes a lead in protecting the Great Lakes from AIS.

Under the new MBWA, all ocean-going vessels were required to obtain a permit before stopping at Michigan ports by Jan.1, 2007. The permit requires ships to completely refrain from discharging ballast water or treat ballast water prior to discharge using one of four approved technologies (hypochlorite, chlorine dioxide, ultraviolet light radiation, or deoxygenation).[1] This new regulation was in response to the damage to municipal, industrial, recreational, infrastructural, and ecological resources caused by AIS in Michigan, as well as to the delay by federal agencies in implementing stringent ballast regulations. There have been eight bills introduced in Congress dealing with AIS and ballast water, but nothing has been passed federally since the National Invasive Species Act in 1996 – only individual states have taken action.

Territorial waters of Michigan (shown in dark blue)
Image from Wikipedia

The regulations prohibit exchange without treatment because ballast exchange is often ineffective; studies have shown that lawful ballast exchange can remove less than 50% of organisms.[2] Even "no ballast on board" vessels (NOBOBs) pose a threat because they account for 70% of ocean traffic on the Great Lakes and carry small amounts of residual water and large amounts of unpumpable sediments; when NOBOBs take up and release Great Lakes water, organisms (including AIS) are discharged. The permit targets ocean freighters because these "salties" have had a disproportionately large effect on the Great Lakes: salties contribute to only 5% of the cargo moved in the Great Lakes, but they have imported 77% of the AIS in the Great Lakes.

Although there was an initial fear that ships would simply stop visiting Michigan ports as a result of the permit requirements, this has not been the case. The regulation's minimal effect on the Michigan shipping industry is not surprising, considering that only four of about 100 ships released ballast water within Michigan ports last year and would need to install ballast treatment technology under the new permit system. The permit cost is small, with an initial fee of $75 and a $150 annual renewal fee. However, the cost of non-compliance is high: ships without a permit will not be allowed to stop at Michigan ports – and if they do, they can face civil action and fines up to $25,000 per day.[1] Shipping groups have not been receptive to the regulations. On March 15, four shipping companies, four shipping associations, and one dock company sued the Michigan Department of Environmental Quality (MDEQ) in response to the new ballast water treatment law. The shipping companies and industry groups claimed the MBWA violates the commerce clause of the Constitution, as it is unreasonably burdensome on interstate commerce, excessive relative to local benefits, and preempted by federal regulations. A federal court judge dismissed the lawsuit on August 15, ruling that Michigan's law is constitutional. The shipping companies then appealed this decision, but the schedule for the appeal has not yet been set.

While supporting MDEQ's permit system, Great Lakes United and other conservation groups have also called for a temporary moratorium on ocean freighters until comprehensive federal regulations and appropriate treatment technology are in place. Michigan Congressional delegates are receptive to the idea, even in the face of the necessary coordination with Canada due to binational control of the St. Lawrence Seaway. This receptiveness stems, in part, from economics: according to the U.S. Army Corps of Engineers, recreational boating (which depends on clean waters and habitat) contributes $5.5 billion in national revenue, while commercial navigation on the Great Lakes accounts for $3.4 billion in national revenue.5 And most of the latter revenue is due only to within-lake traffic (which, by its nature, doesn't introduce transoceanic AIS), not oceangoing traffic. A study by Grand Valley State University found that if oceangoing vessels were eliminated from the Great Lakes, transporting the cargo from these ships via alternate methods would add only $55 million in costs, roughly 2.75% of the $3.1 billion in damage caused by the Zebra mussel alone.[6, 3]

The full value of the new regulations may not be in preventing the spread of AIS into Michigan, as AIS can invade from neighboring states without stringent regulations in place, but in the action it may prompt from federal and other state legislative bodies. So far, eight AIS- and ballast-related bills have been introduced in Congress. Many expect Congress and the USCG to act soon, and several other states, including Minnesota, Wisconsin and Indiana, are watching the situation as they consider legislation of their own. The actions of these legislative bodies will determine if Michigan's regulations stimulate or stymie future AIS and ballast programs.

Please see page 16 for references.

Ballast free and zero discharge ships – the way of the future?

Ying Mei, Herbert Engineering Corporation

Once ballast water was understood as a vector for aquatic invasive species (AIS), scientists ask whether ballast water is even necessary. The answer seems to be, ""Yes, because at least to some extent, there will always be a need to adjust trim and list for uneven cargo and fuel weights on board." However, there are ways to design and operate ships that are otherwise "ballast (water) free" and can achieve zero discharge without sacrificing cargo capacity by having internal ballast transfer or new hull designs. There are also ways to achieve "zero (coastal/port) discharge" on ships that need to carry significant amounts of ballast in their unloaded condition. Available options depend on the vessel type and trade, and also vary in their environmental impact – some result in less cargo transport efficiency (more emissions per ton-mile of cargo moved).

"Ballast Free" Designs

If we allow our definition of "ballast free" to include ships that carry only small amounts of ballast for trim/list control but never discharge that ballast, there are several possible ways to achieve the no-ballast goal through design and operation.

Internal Ballast Transfer

Conventional ship types that always have some cargo on board (i.e., containerships, RoRos, and passenger ships) can be designed with a permanent freshwater ballast system. This system allows the fresh water to be moved from tank to tank within the ship to control trim, list, stability and load distribution. Some existing containerships are able to use their saltwater ballast system in this way and achieve zero discharge. The key is a ballast system design that allows full internal transfer of water.

New Hull Forms (please see Figure 1, next page)

For ship types that regularly have an unloaded return voyage, the only way to achieve a "ballast-free" operation is to redesign the hull form so as to remove the need for large amounts of ballast water in the unloaded condition. This requires new thinking about the optimum shape of the hull and distribution of buoyancy. The goal is not only to achieve the full displacement at a normal operating draft for the loaded ship, but also to have a reasonably deep draft when unloaded so that the ship can be safely operated. Difficulties in the optimization of this new hull form arise because of the related impacts on resistance/fuel consumption, ship motions and sea loads, maintenance and increased construction costs. There are at least two new concepts being studied that take this approach: the Non-Ballast Water Ships and the Monomaran.

NOBS (Non-Ballast Water Ships)

The Shipbuilding Research Centre of Japan has developed the NOBS (Non-Ballast Water Ships) concept based on a V-shaped hull. The V-hull changes the vertical distribution of hull buoyancy allowing a deeper draft in the light condition. This provides for better vessel control and performance in heavy weather and perhaps some improvement in propulsive efficiency. By widening the beam (width of the ship), the displacement at a comparable full-load draft can also be maintained equivalent to the conventional hull.

Monomaran

A similar redistribution of the buoyancy is achieved by the Delft University of Technology (TU Delft) by removing hull volume near centerline and moving it outboard. The result is a mono-hull craft with a hint of catamaran shape, a "monomaran." The new buoyancy distribution is also shown in the sketch, Figure 1 . Delft pro poses this form with a single (or twin) podded propulsion. It has a larger wetted surface and therefore greater frictional resistance than a traditional ship, giving it higher fuel consumption. Despite this, it may be suitable for certain ship types and services.

Zero (Coastal/Port) Discharge Options

For ships that still must carry significant amounts of ballast to achieve a seaworthy condition – i.e., ships that carry cargo in bulk (bulk carriers) and tankers (crude oil carriers, product carriers, chemical carriers, and LNG carriers) – zero discharge in coastal/port areas is possible but to the detriment of cargo capacity and flexibility. For instance, a ship can retain the ballast on board in the cargo-loaded condition. Normally, ships do not have ballast onboard when the ship is completely loaded because any ballast retained onboard would subtract from available capacity for carrying cargo. This is particularly inefficient because retaining ballast can reduce the cargo carrying capacity of a ship by as much as 35%, requiring more ships to move the same amount of cargo.

There are several possible ways to improve the basic inefficiency of this approach, depending on the situation:

Within operationally safe limits and in good weather conditions, a ship could discharge part of its ballast in deep water prior to arriving in port. The remaining ballast, perhaps 10% to 15% of the cargo deadweight, is retained onboard. The ship can then load 85% to 90% of its normal cargo deadweight.

The ship owner arranges for cargo loading at two different ports and discharges ballast on the transit voyage between ports. The cargo loaded at the initial port keeps the vessel in a seaworthy state while in transit.

The ship owner arranges for some sort of back haul cargo to take the place of some of the ballast water.

A ship is designed to operate temporarily and in good weather at a deeper draft while retaining all ballast water leaving a load port with full cargo. Once out at sea, some or all of the ballast water could be discharged for the remaining transit.

Other Research

A "Ballast-Free Ship Concept" proposed by the University of Michigan looks to replace traditional double hull ballast tanks with longitudinal ballast trunks. These are flooded as the vessel discharges cargo, essentially reducing the buoyancy of the vessel and thereby retaining a suitable light draft condition. The trunks are open to the sea during the voyage and there is constant flow of seawater through the trunks driven by the vessel's forward motion. At the end of the ballast voyage, the trunks are isolated and pumped dry using a conventional ballast system in order to create the buoyancy necessary to support a full cargo load. This concept does not really meet a practical definition of "ballast free," as it relies on a continuous flow-through exchange process and normal full ballast discharge at the load port. However, it does represent some novel thinking on how to look beyond treatment as an option to avoid introducing AIS.

As the costs of ballast water treatment systems become better known and understood, there will be an incentive for ship owners to develop ballast-free designs and zero-discharge procedures. For some ship types, this will not be difficult, while for others it will require quite a change in operation or basic hull design. For large containerships, some RoRos, and some cruise ships, it is not difficult to design internal ballast-transfer systems that will provide zero-discharge performance. But for tankers and bulk carriers, the problem is much more difficult to solve without creating other detrimental effects such as higher emissions from lower transport efficiencies. The NOBS and Monomaran concepts are an attempt to eliminate the discharge without higher emissions, but they are still only in the R&D stage. But because the commercial vessels under consideration have the greatest capability to distribute AIS due to the volume of ballast water they carry, ship designers will continue to look for new ways to solve the ballast water dilemma.

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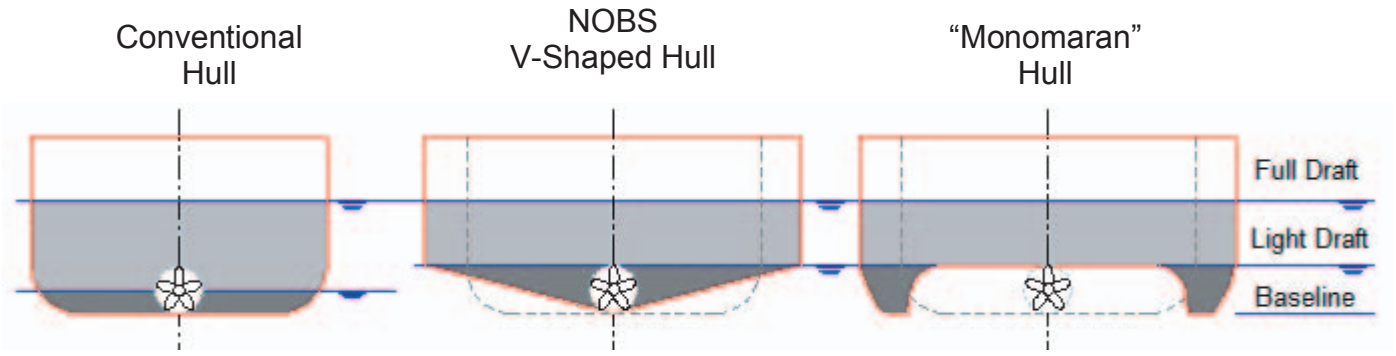

Figure 1. Comparison of Hull Section Shapes. The shaded areas show how the equivalent buoyancy can be achieved in the two primary operating drafts (full and light).

Ballast Exchange
Newsletter of the West Coast Ballast Outreach Project

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University of California
California Sea Grant Extension Program
One Shields Avenue
Davis, California 95616-8751

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Lynn Takata is a Staff Environmental Scientist for California's Marine Invasive Species Program.

Kate Williams serves as Principal Consultant for Assemblyman John Laird (D-Santa Cruz), chair of the Assembly Budget Committee and member of the Assembly Natural Resources Committee. For more information on AB 740, visit www.assembly.ca.gov/laird.

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