Report from the

Great Lakes Ballast Water Collaborative Meeting: Toronto

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Prepared for: The Great Lakes Ballast Water Collaborative

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Great Lakes Ballast Water Collaborative Meeting: Toronto

Introduction

The goals of this meeting were for participants to:

1. Gain a better understanding of the ballast water treatment system (BWTS) testing process and technology-verification procedures by discussing uncertainty.
2. Continue discussions about BWTS technology, research, and policies.

An unprecedented number of people (over 74) attended the intense daylong (8 a.m. – 5 p.m.) meeting of the Great Lakes Ballast Water Collaborative on January 19, 2011, in Toronto. This was the fourth meeting of the Collaborative, which gathered for the first time in Detroit, Michigan, on September 24, 2009. The Collaborative formed to facilitate the exchange of information and cultivate relationships among academia, the shipping industry, policy makers, and other stakeholders in the ongoing challenge to support industry while preventing invasive species from entering North American waters, specifically the waters of the Great Lakes. This meeting precedes the imminent release of three important documents:

- The EPA's Science Advisory Board Report (expected in early summer 2011).
- The National Academies' National Research Council Report, (expected in early summer 2011).
- The US Coast Guard's final Ballast Water Discharge Standard rulemaking, (expected in spring 2011).

Terry Johnson of the Saint Lawrence Seaway Development Corporation (Seaway) explained that the Collaborative has been helpful for state regulators and that industry has benefited enormously from the dialogs. "We've all come to realize the importance of science in informing legislation," he said, pointing specifically to the recent ballast water management recommendations in Wisconsin and those being refined in California. "Unless we have a firm grounding in science, we (as regulators) are not doing our job properly."

Mark Burrows of the International Joint Commission (IJC) commented on the growth in sharing of science through the Collaborative. “I’m looking forward to seeing some action on harmonizing ballast water regulation throughout the Great Lakes,” he said. “I have a lot of hope that we’ll get this job done.”

The IJC and the Seaway facilitated this meeting of the Collaborative. Dale Bergeron, University of Minnesota Sea Grant Program, and David Reid, a retired research scientist now a science consultant for the Seaway, facilitated the meeting, which Craig Middlebrook of the Seaway coordinated. Other major contributors included the State of Wisconsin (via Susan Sylvester, chief, Permits Section, Bureau of Watershed Management, Department of Natural Resources), the Canadian Shipowners Association (via Bruce Bowie, president), the American Steamship Company (via Noel Bassett, vice-president of operations), The Northeast Midwest Institute (via Allegra Cangelosi, senior policy analyst, ecosystem team), and the Great Lakes Fishery Commission.

Collaborative reports and some associated presentations are posted online at:

http://www.greatlakes-seaway.com/en/environment/ballast_collaborative.html

They are also available from:

Saint Lawrence Seaway Development Corporation
U.S. Department of Transportation
1200 New Jersey Avenue, S.E.
Suite W32-300
Washington, D.C.
USA 20590
Tel: 800-785-2779 or 202-366-0091

Various publications, reports, and websites referenced in presentations given throughout the day are compiled and cited at the end of this report. Handouts distributed at the meeting are appended.

PART 1: Update on Ballast Water Collaborative Activities

Canadian Federal Regulatory Update

(Transport Canada: Chris Wiley, joined by Paul Topping)

Transport Canada is updating Canada's 2006 regulations for ballast water management (Phase 1: mid-ocean ballast water exchange) to combine existing requirements under the authority of the Canada Shipping Act, 2001. The updated proposed regulations, published on 18 December 2010 in the Canadian Gazette, introduced no substantive policy changes or additional text.

Phase 2 is expected in 2011 and will include language acknowledging that Canada ratified the International Maritime Organization (IMO) International Convention for the Control and Management of Ships Ballast Water and Sediments and will likely reflect the science discussed at the Great Lakes Ballast Water Collaborative meetings. The IMO Convention is poised to come into force in 2012 and Canada is preparing to proceed to meet the Convention's standards with a third phase of ballast water regulations. Colin Henein, a policy advisor from Transport Canada, said that Canada not only ratified the IMO Convention, but it is particularly active in the IMO ballast water discussions (Chris Wiley chairs the IMO Ballast Water Working Group) and supports aquatic invasive species science. "The fact that we are all here indicates how complicated the issues have become," said Henein.

Transport Canada does not have a timeline for Phase 3 regulations but Collaborative discussions will influence the trajectory. Phase 3 rules will incorporate Department of Fisheries and Ocean information and input. Canada will likely require ships entering the St. Lawrence Seaway to practice the mid-oceanic exchange of ballast water in addition to using BWTSs. BWTS measures will evolve as technology evolves.

Paul Topping, manager of environmental protection for Transport Canada, said, "We're looking to this Collaborative for consultation and discussion as we develop Phase 2 and Phase 3 regulations."

Chris Wiley, manager of environmental issues for Transport Canada, commented on international sampling and what is actually possible with regard to type-testing BWTSs. Referencing documents produced by the Bulk Liquids and Gases Subcommittee of the IMO (www.imo.org) he said, "If you read those documents, you will see that it is not easy to take samples in a consistent way onboard ships."

Anticipated challenges regarding ships transporting non-native species include vessels with biofouled hulls, particularly as ships come out of layup as global economic conditions improve. Also, there is uncertainty about handling ships without BWTSs onboard when the IMO Convention goes into effect. Future ballasting might involve solid ballast, no ballast, and a move toward ballasting with potable water.

Wiley reported that the IMO is convening a "flag state implementation meeting" toward the end of February 2011. Wiley co-authored a document on the sampling process flag states might use to evaluate compliance (i.e. if the BWTS used chlorine, regulators could check that vessel personnel were monitoring of the amounts of chlorine used). He said the next stage would be to conduct indicative sampling and then enforcement sampling.

Currently the IMO has type-approved 13 BWTSs and anticipates that 2 more will be type-approved by spring 2011; only 3 have been tested in fresh water. Hyundai Heavy Industries made a recent splash with a new faster BWTS. Wiley said Canada is hoping to test freshwater systems in partnership with Germany and that there isn't yet a BWTS proven to meet IMO standards in fresh water. "Two things are driving this discussion," he said, "science and politics." Wiley said Canada is exploring ballast water management science and politics with California to examine what combination of the two will yield ballast water that would be considered safe (non-toxic and devoid of viable organisms) to release into harbors.

Following Transport Canada's report, there was a discussion about the rationale of continuing to require ballast water exchange after the IMO convention goes into effect (i.e. when vessels will be required to have a type-approved BWTS onboard). Canadian officials see a benefit to keeping the ballast water exchange policies. Jon Stewart, technology advisor with International

Maritime Technology Consulting, felt that requiring exchange and BWTSs would be a "double whammy to shippers."

For details concerning Canada's ballast water regulations, see:

Canada's Ballast Water Program

http://www.tc.gc.ca/eng/marinesafety/oep-environment-sources-ballastwater-1722.htm

A Guide to Canada's Ballast Water Control and Management Regulations TP 13617 E

http://www.tc.gc.ca/eng/marinesafety/tp-tp13617-menu-2138.htm

U.S. Federal Regulatory Update

(United States Coast Guard (USCG): CDR Gary Croot joined by Ryan Albert of the U.S. Environmental Protection Agency (EPA))

Dr. Albert reported that the EPA solicited comments for improving the Vessel General Permit (VGP) in order to inform the next (2013-2018) VGP. He said two other studies, the EPA's Science Advisory Board (SAB) study (a report on the status of ballast water treatment technologies…efficacy, and interpretation of treatment designs), and the National Academies' National Research Council (NRC) study (a report on methods to evaluate risks associated with the number of organisms in ballast) will also influence the next VGP.

A draft of the EPA's Science Advisory Board report is available at:

http://yosemite.epa.gov/sab/sabproduct.nsf/0/9e6c799df254393a8525762c004e60ff!OpenDocument&TableRow=2.2#2.

Public comments will be rolled into a report due by May 31, 2011 and the associated "glossy report" will come out later in the summer.

When questioned about the numerical limits for water quality, Albert said the EPA's water quality effluent limits were in the permits and that numerical limits are pending.

Fielding questions about whether EPA and USCG timelines will match, Dr. Albert said, "Not everything may be perfectly in sync but we have a mandate to develop standards and meet implementation deadlines."

CDR Gary Croot agreed saying that the USCG will try to harmonize regulations across political boundaries and agency mandates when it issues a final rule (*Standards for Living Organisms in Ships' Ballast Water Discharged in U.S. Waters*). The USCG received over 2000 comments related to the final rule during the public comment period. Great Lakes interests were well represented in these comments (including states, non-government organizations, environmental groups, and shippers). Croot said the type-approval process would be the cornerstone of the USCG final rule because detecting organisms at low concentration levels in the field is difficult. "We need to be sure that systems do what they are suppose to do before putting them on a ship," he said. He anticipates that the second iteration of the BWTS-specific VGP will rely heavily on the EPA's SAB and the NRC reports.

The USCG is using the Environmental Technology Verification (ETV) Program Ballast Water Protocol developed by the EPA, "Generic Protocol for the Verification of Ballast Water Treatment Technology," to set verification procedures and standards. The final Protocol was published in September 2010 after a 4 - 5 year comprehensive research and review process. Croot said, "We believe we have a robust protocol. It's a bit different from the IMO's G8 guidelines for type approval. It's more refined." The U.S.'s type-approval process (based on the ETV protocol) will have requirements for independent laboratories with specific reference to quality assurance and quality control.

There are provisions in USCG's proposed final rule to give systems tested by other nations a "leg-up" in getting type-approval in the U.S. The USCG expects to issue its first type-approval for a BWTS in 2014. BWTSs that have foreign flag state approval might be approved more quickly than 2014, but the USCG can't say more than that at this time.

Georges Robichon of Fednav, Ltd., voiced an assumption that the USCG must be going with the IMO ballast water discharge standard if the expectation is to type-approve a BWTS by 2014.

Gary Croot responded that Phase 1 would probably adopt the IMO standard, but that Phase 2 could be more stringent. Beyond that, he was not at liberty to comment. Croot said that it is difficult to know when the IMO Convention will be fully ratified and that the U.S. is not ready to ratify it at this time.

A Collaborative participant asked whether a BWTS on a vessel would require more than a foreign flag state type-approval, such as STEP enrollment. Croot replied that there would likely be allowances made for certain parts of foreign flag state dossiers, depending on the quality assurance and quality control documents during testing and the testing facility's adherence to ETV protocols. As far as whether the USCG will issue a list of promising BWTSs to guide shippers as they prepare to purchase BWTSs, Croot said that there could possibly be a list based on a case-by-case review of technology, but not by flag administration.

Allegra Cangelosi reminded the group that the Great Ships Initiative's freshwater BWTS testing facility is available to prospective BWTSs for testing.

STEP Update: Acceptability of vessels accepted in STEP by Great Lakes States
(United States Coast Guard: CDR Gary Croot)

Note: an informal discussion about STEP occurred in Toronto a day prior to the Collaborative meeting and highlights were summarized during this portion of the meeting.

Carriers should note that when the USCG final rule comes out, carriers will lose the "grandfather clause" that applies to BWTSs on ships enrolled in STEP. The "grandfather clause" allows ships supporting early-versions of BWTSs to use that BWTS for the life of the ship as long as the BWTS is working and remains safe. Before the anticipated final rule, the USCG will accept partially completed applications as placeholders so as not to discourage enrollment in STEP.

Carriers wanted clarification as to whether they should enroll their ships in STEP before the final rule, even though they won't know what systems will be approved for installation. The

conundrum remains that shippers are reluctant to install BWTSs prior to USCG type-approval and before individual states accept or reject the grandfather clause associated with STEP.

Croot said that although the USCG encourages shippers to install systems, they're sensitive to the fact that none have been approved. He said that since the grandfather clause is a policy, the USCG could change it. A shipper suggested that regulators consider an interim policy in the face of "a chicken-and-egg situation" regarding individual state rulings and the state of BWTS technology. Middlebrook pointed out that "although the final rule may do away with the grandfather clause, it doesn't do away with the value of going through the STEP program."

Jeff Stollenwerk, of the Minnesota Pollution Control Agency, mentioned that most states are interested in getting BWTSs on ships as soon as possible. "I understand frustration of ship owners not knowing how states will respond to issues like the grandfather clause and life of ships," he said. He suggested that it would be helpful if states knew what ship owners were doing to address BWTS and the rationale for those actions. "We need to know where you're headed and why you think it's appropriate," he said.

Policy makers in the Great Lakes and coastal states are looking forward to the next iteration of the VGP and USCG decisions. While some may disagree with some of the conclusions, California State Lands Commission reviewed BWTSs for the state's legislature (*2010 Assessment of the Efficacy, Availability and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters*) and the tables in that document could be useful in making informed BWTS decisions.

CDR Croot reported that verification testing is being carried out at independent labs and by the USCG on the *Golden Bear* in California. Currently, an inter-calibration study is being conducted to ensure that the three U.S. BWTS testing facilities are testing to ETV protocols (see below, Part 2: Different BWTS Testing Facilities, Same Results?). Researchers are also comparing their results to those documented in reports for BWTSs that have been type-approved by a foreign flag state.

The USCG views STEP as a segue for type-approval in the U.S. When ballast water treatment standards are ratcheted up, there will be another round of STEP opportunities for ship owners. Croot said the USCG believes evaluating different systems in different conditions on different ships is valuable. He went on to explain that STEP started about 7 years ago with three goals:

1. To encourage ship owners to volunteer ships as test facilities (with the idea that the installed BWTS would be approved for the life of the system or ship, unless it grossly malfunctioned or polluted the water).
2. To give BWTS manufacturers a platform for perfecting their systems.
3. To give the USCG data from which they could evaluate BWTSs for type-approval.

Since ships in the Great Lakes fleets treat huge volumes of water compared to smaller ballast systems on ocean fleets, and the life of a Great Lakes ship is long, the grandfather clause in STEP is appealing. Kirk Jones of Canada Steamship Lines said the financial incentive to enroll in STEP is hinged around the grandfather clause. Another shipping representative said that in order to obtain a loan sizable enough to purchase BWTSs, there needs to be a firm recognition of the process.

Carolyn Junemann from the U.S. Maritime Administration (MARAD) responded by saying that MARAD can help offset cost of installation for ships in STEP. "We work with USCG and we have obligated funds in place to help," she said. "The Great Lakes are a special situation and we want to encourage the participation of Great Lakes fleets."

At this time for ships enrolled in STEP, ship owners pay for the BWTS, MARAD can pay for design and installation, and the USCG will pay up to $400,000 for the first year of BWTS testing.

Wisconsin: Dissemination and Discussion of Technology Feasibility Report

(Wisconsin Department of Natural Resources: Susan Sylvester)

Susan Sylvester, chief of the Wisconsin Department of Natural Resources (WDNR) Permits Section of the Bureau of Watershed Management presented an update on Wisconsin's ballast water treatment feasibility assessment. She explained that the WDNR issued a general permit proposal in November 2009 that would require ships to meet ballast water treatment standards 100 times more stringent than the IMO standards (100 x IMO). The state issued this strict proposal in response to pressure from non-governmental organizations asking for these higher-than-IMO-standards and that ballast water regulations included lakers.

To make the required feasibility determination by 31 December 2010, the WDNR involved stakeholders and sought expertise through the Great Lakes Ballast Water Collaborative. The main questions were:

- Are BWTSs approved for installation and reliability, and are they commercially available for 100 x IMO?
- Can treatment systems be installed on vessel by the implementation date?
- Is it possible to tell if the system is working properly and to conduct compliance monitoring for 100 x IMO?

The feasibility report, "Wisconsin Ballast Water Treatment Feasibility Determination," was issued on December 21, 2010 and was also distributed at the Collaborative meeting, and is available online. The key information that was used to support the determination included the meetings and reports of the Collaborative (Montreal and Duluth), the EPA SAB meetings, the NRC meetings and various reports, Great Ships Initiative discussions, and the fact that there is no national ballast water discharge standard.

Sylvester said the WDNR is excited about the USCG final rule, and the reports being produced by the SAB and NRC. She finds the STEP process encouraging and would like to see ships get treatment systems earlier rather than later. "Ballast water exchange provides a benefit and should

be continued regardless of the USCG requirement or sunset of this condition," she said referencing preliminary research by Dr. Sarah Bailey (Fisheries and Oceans Canada) and the Great Ships Initiative. She said non-governmental organizations are heavily commenting on the public notice (December 14, Feasibility Determination Report 12-22-10) and that a public hearing is set for January 26 in Superior, Wisconsin. Comments are being accepted until February 4, 2011 and the permit modification should be issued in the spring of 2011.

Sylvester commented that working with vessel owners in STEP continues to be important and that there needs to be a national standard upon which the EPA and USCG agree. "We need to keep the discussions within the Collaborative moving forward for a solution," she said. "The public still wants a higher standard. We feel that treatment plus exchange will satisfy our public."

Allegra Cangelosi of the Northeast Midwest Institute asked, "What if a BWTS shows that it exceeds IMO standards; would the vessel still need to exchange its ballast water mid-ocean? Sylvester replied that exchange is a best management practice that Wisconsin would probably keep. "We're disappointed that USCG is proposing to sunset this (ballast water exchange) practice."

New York Update

(New York Department of Environmental Conservation: Dave Adams)

Dave Adams, a regulatory coordinator for the Office of Invasive Species, said that New York's ballast water team is certifying VGPs with 6 conditions related to ballast water management. The conditions were based on four documents available at the time when decisions were being made. The most significant conditions are that the New York VGP requires:

1. Ships continue ballast water exchange and flushing
2. By 2012, ships must reach ballast water discharge standards 100 x IMO
3. By 2013, new vessels must reach ballast water discharge standards 1000 x IMO

New York received 1400 requests from shippers for a time extension for reaching the state's ballast water discharge standards. Adams expressed disappointment that many of these requests were form letters. Agency staff would have preferred letters from shippers showing evidence of design and engineering efforts. As the result of November's elections, there is a new incoming administration in New York. Although the ballast water team is ready to send replies to the shippers, they are giving the new administration an opportunity to make changes to the replies.

The New York VGP proposal does not include STEP because of language constraints in the current VGP. The state is interested in working with vessel operators via the STEP process, however.

Minnesota Update

(Minnesota Pollution Control Agency: Jeff Stollenwerk)

Like New York, Minnesota has a new state administration which Jeff Stollenwerk, supervisor of Industrial Water Quality Permits, said makes it difficult to give an update about where the state's ballast water regulations are heading. Stollenwerk's hope is that, just as states cooperated on VGP comments with respect to water quality limits, they can do the same for ballast water discharge standards. He expressed the general frustration states face in association with the EPA's *Clean Water Act Section 401 Water Quality Certification*'s numeric-based water quality limits and suggested asking the EPA for water quality limits that could be applied nation-wide before requiring 401 Certification. A state can wave 401 Certification if it can prove that ballast water discharges meet state standards.

Interim Measures Update

(American Steamship Company: Noel Bassett)

Noel Bassett, vice-president of operations, American Steamship Company, presented PowerPoint slides to support a discussion about technology development through a partnership between the

American Steamship Company and the National Park Service (Phyllis Green). Bassett said that Great Lakes ships are challenging because of the huge amounts of water they can carry and their high rates of discharge. "At least from my chair," he said, "there are no systems that can manage our pumping rates. Maybe the new Hyundai system could but I'd bet every dollar in Gary Croot's wallet that system won't fit on a laker."

Lakers load and unload up to 10,000 tons an hour. Bassett said that operating at slower rates would bring the Great Lakes maritime system to its knees and that, although they are large, lakers can get in and out of ports quickly.

Dye tests were conducted to evaluate the efficacy of potential interim treatment methods for ballast water management. Several experimental systems were fitted on the ship *Indiana Harbor* to conduct passive (nothing to enhance mixing within a ballast tank) mixing studies. Bassett showed a graph indicating that dye concentrations were almost uniform in 24 hours and uniform at about 38 hours after the dye was added. Basset then showed a chart indicating that a 10-foot-long scale model involving active mixing achieved near-uniform concentrations of dye in 45 minutes. The model used a pump to bubble air through the water to create flow and circulate water rapidly within the tank.

Skid-based equipment may be practical for interim treatment. The partners' intent is to prototype a skid-mounted system for applying biocides (sodium hydroxide or sodium hypochlorite) to ballast water in 2011.

After applying one of the two biocides to reach lethal pH levels of 11 or 12, the ballast water pH will be neutralized with carbon dioxide (CO_2) before it is discharged. The Great Ships Initiative and the USGS have tested the neutralization process. CO_2 will likely be carried in liquid form onboard ships. Bassett suggested that since ships generate CO_2, maybe scrubbers could capture it while the ship is underway and then pump it through the ballast tanks.

In-tank mixing methods could influence treatment solutions but it was felt that mixing can be done quickly and well even in a complex ship. Bassett described the pumping rates through a ship's 3-foot wide pipes as "incredible." "Sometimes four pumps are going at one time," he said.

In response to a question about the potential damage a biocide like sodium hydroxide could do to the uncoated lining of a Great Lakes ship's ballast tanks, Bassett said that sodium hydroxide actually has a beneficial side effect of prolonging the life of steel. Most other chemicals have opposite effects. Bassett said, "The technology is promising enough that we're continuing with this research. Frankly we don't see any other options."

PART 2: Verification and Risk Evaluation

The goals of this session were to share information on tools and statistical approaches to validate and verify that ballast water treatment systems are meeting a given discharge standard.

The presentations given during the mid-day session were rooted in discussions that started during the Great Lakes Ballast Water Collaborative meeting in Duluth (summer 2010). Collaborative members sought clarity about the statistical aspects of verifying that ballast water treatment systems are as effective as they aim and claim to be.

Two Regulatory Philosophies

(Jeff Stollenwerk, Minnesota Pollution Control Agency)

Stollenwerk presented a PowerPoint slideshow to support a review of two ballast water regulatory approaches:

1. Technology-based regulations (broad in applicability, cost and feasibility factored in).
2. Environmentally based regulations (specific form of environmental protection).

"We need to approach ballast water treatment with both philosophies, but we need to account for the weaknesses in both approaches," he said. He explained that the forthcoming technology-based USCG regulations and EPA's VGP generate questions about providing enough protection. On the other hand, environmentally based regulations, like state 401 Certification for the VGP, raise questions about how achievable the goals are. Stollenwerk said actual solutions need to be both protective and achievable.

Colin Henein of Transport Canada said that although the states' 401 regulations could be characterized as environmental, they're set with reference to the IMO's technology-based standard. Stollenwerk responded saying, "We put ballast water management policies forth as a water quality regulation even though it is derivative of IMO technology-based standard." He said

that rules could be based on technology and what can be achieved, or based on the science, or based on results. Paul Topping, Transport Canada, said the rules start with what we need to do to protect the environment and then what needs to be done to get there. "The IMO 2004 Ballast Water Regulation was considered an aspirational standard," Topping said. "It is ironic we are here today having this discussion."

Reid thought that the IMO standards could be characterized based on size criteria; that large organisms are regulated using environmentally based standards and small organisms are regulated using technology-based standards. Croot thought the regulations were in the middle of the continuum, not all technology-based or all environmentally based. He defined risk as: Risk = (probability of an event) x (amount of impact). "What degree of risk are we willing to live with?" he asked? "If answer is zero then there is no shipping in the Great Lakes."

Cangelosi commented that before the days of ballast water management, some ships were full of organisms and others carried very few. She said the IMO's standards for ballast water discharge reflected ships at the "very few" end.

Risk and Uncertainty

(Dale Bergeron, Minnesota Sea Grant)

Bergeron presented a PowerPoint slideshow to help clarify regulatory philosophies and the ensuing discussion of risk. He illustrated how terms and work choice matter by quoting Donald Rumsfeld:

> *There are known knowns. These are things we know that we know. There are known unknowns. That is to say, there are things that we know we don't know. But there are also unknown unknowns. There are things we don't know we don't know.*

Great Lakes Ballast Water Collaborative participant Ray Vandenbosch, Ontario Ministry of Transport, added to the quote: "There are things we don't know we know. There are little pieces of knowledge here that maybe we haven't tapped into yet."

Bergeron defined two terms:

Risk - unknown outcome, but known underlying outcome distribution.

Uncertainty - unknown outcome, unknown underlying outcome distribution.

He said risk and uncertainty are on opposite ends of a continuum where statistical probability is in the middle. "We need to talk about the statistical probability that treatment systems will achieve what we need them to achieve," he said. "We're going to be talking about verification of efficacy, not a level of protection."

Reid suggested viewing risk as a formed threat that moves into uncertainty. He said the problem is to figure out if your solution is meeting your goals.

Sampling Effort and Statistical Power at Threshold Ballast Water Discharge Densities (IMO-D2 Standard for "zooplankton")

(Dr. Whitman Miller, Smithsonian Environmental Research Center)

Miller presented a PowerPoint slideshow to support a lecture on statistics, concentrating mainly on sampling error. His manuscript (in revision for the journal "Environmental Science and Technology") served as the basis for the lecture.

He quoted Ben Franklin, "*In this world nothing can be said to be certain, except death and taxes.*" And a quote sometimes credited to Mark Twain, "*There are three kinds of lies: lies, damned lies, and statistics.*"

Miller used a sports analogy to explain distribution and variance. He talked about how the height and weight of baseball players differed from Formula-1 racecar drivers in a way that made the two groups distinguishable by their distribution and variance. In contrast, hockey and baseball players exhibited a similar distribution and variance making differentiating between hockey and baseball players problematic.

In a similar way, Miller said ballast water management poses a problem. “How do we assess the sampling effort necessary to reliably differentiate zooplankton size in ballast water?” He referenced many potential sources of error, including inadequate sample volume, non-random distribution of organisms, and loss of organisms. Such sources of error necessitate increasing the sample volume required to draw conclusions with a reasonable degree of confidence.

Miller’s hypothesis was that a particular BWTS works, saying, “I use a constitutional approach to regulatory philosophy: innocent until proven guilty.” He focused the discussion on a two-stage Poisson sampling model:

1. BWTS compliance would be based on a single sample and this level of sampling would be expected to be effective if the degree of non-compliance was large.
2. BWTS testing could combine samples to assess compliance and this level of sampling would be expected to improve discrimination when the actual concentrations of organisms hovered around the ballast water treatment standard.

The model assumes:

1. Ballast water is sampled interactively from the discharge pipe to control for the spatial structure of organisms.
2. A time-integrated sample represents a single sample.
3. The total concentrated sample volume is processed so that all live organisms equal to or greater than 50 microns in diameter that were captured are detected.

Note: The **Poisson distribution** models the probability that a certain number of events occur within a certain period of time. The events need to be unrelated to each other. They also need to occur with a known average rate. Examples of this distribution are:

- The numbers of cars that pass on a certain road in a certain time.
- The number of light bulbs that burn out (fail) in a certain amount of time.

Miller explained the value of increasing sample size by showing a graph that made it visually clear that as the sample size increased, the variance bars did not overlap as much. When variance becomes more distinct, it will be easier to determine when a BWTS moves out of compliance.

Miller asked, “If you have more than one organism in one cubic meter of water are you out of compliance? If you have less, does that mean you’re in compliance?” He said a Type 2 statistical error is the most environmentally concerning; a false positive; falsely believing the ballast water discharge standard was achieved. Setting a non-compliance threshold at 95% means there could be more than 84 zooplankton in a 7 cubic meter sample of ballast water before the water can be considered non-compliant.

Miller said that the number of false alarms and false negatives can be managed by adjusting statistical power, but in the end arbitrary decisions will likely set compliance rules. He showed an important slide regarding detecting exceedance compared to true concentration, the conclusion being that, again, as sample volume increases the result becomes more powerful, more trustworthy.

Dr. Melanie Frazier, an EPA ecologist and co-author of *Density Matters: Review of Approaches to Setting Organism-Based Ballast Water Discharge Standards* (Lee et al. 2010), when asked for a comment said through a telephone connection, “Thanks to Whitman for covering everything I would have said.”

Dr. Sarah Bailey, Fisheries and Oceans Canada, asked Miller if his work could be extended to more of an indicative sampling process. Miller said, “You’ll never have 100% confidence. No data are correct, the question is how incorrect are they? The issue is whether the sample you are taking is a representative sample? Is it large enough? There is not a right answer, but whatever you do, there are tools to characterize your methods.”

Statistical Assumptions, Real Distributions, Alternative Sampling Strategy

(Dr. Raymond Vaughan, New York's Attorney General's Office)

Vaughan continued the discussion of statistics and sampling strategy with a PowerPoint slideshow. As Vaughan talked about confidence as a function of sample volume and organism concentration, he referenced Lee et al.'s (2010) *Density Matters: Review of Approaches to Setting Organism-Based Ballast Water Discharge Standards,* which he said assumes a Poisson distribution of organisms.

Vaughan said that organisms in real ballast tanks would generally not be expected to exhibit a Poisson distribution and could be aggregated. If organisms were aggregated, much larger sampling volumes would be needed to achieve the same level of confidence that a BWTS is achieving a particular discharge standard.

An alternative sampling strategy, which Vaughan said would avoid issues associated with aggregated organisms, would be to collect a representative quantity of ballast water by configuring a separate sampling ballast tank. Both the real and the sample tanks would need to remain equally full. The strategy would require discharging the entire contents of the sample tank through the BWTS into a clean container and then counting organisms as usual.

He said that discussions are still needed regarding conducting no-ballast-on-board (NOBOB) sampling. He wondered if it could be possible to conduct occasional compliance monitoring in Montreal or at Detroit/Windsor or the lakehead ports on Lake Superior.

Vaughan concluded his presentation by reiterating the fact that if organisms are not randomly distributed in ballast water (i.e. they aggregate), sampling volume becomes problematic. He said sampling volume wouldn't be such a problem if a representative sample is collected in a separate sampling tank and 100% of this sample is tested. He suggested that this method is analogous to composite samplers that are widely used for land-based applications that are programmed to collect samples at specified intervals based on time, flow, or events.

Cangelosi cautioned that if a smaller sample tank were installed, it may not be representative of conditions experienced by organisms in bigger tanks since the surface-to-volume ratio would be different. Vaughan suggested selecting a median surface-to-volume ratio target and pursuing other work-around solutions. “It is important not to let problems overwhelm potential solutions,” he said.

When Jon Stewart, International Maritime Technology Consulting, asked what the sample volume would need to be if the ballast water treatment standard were set at 100 x IMO. Vaughan answered that it would need to be 30 cubic meters to achieve 95% confidence. He explained that Whitman Miller was talking about statistical power, and that he was talking about statistical confidence. He said that although the regulatory system seems slanted against technology vendors, states are obliged to protect water quality, making this slant a necessity. Vaughan said, “There’s not a fair way to follow up with compliance, though. Probably the best we can do is find gross violators.”

Rick Harkins of Keystone Shipping Company challenged Dr. Miller and Dr. Vaughan. “I ask you to help us come up with a way of sampling that will be meaningful,” he said, explaining that the pump might be 1000 feet away from the ballast water tank and a ship might have 18 different ballast tanks with 18 different configurations.

Miller acknowledged the unique spatial structure of various ships but said, “We’re not so concerned with what is in the ballast tank; we’re concerned about what is in the discharge pipe. There may be a way to simplify how we view the problem.” Harkins agreed with Miller, saying, “What is in ballast tank #1 on starboard and what is in ballast tank #10 will be different.”

It remains unclear who will monitor BWTS compliance once a BWTS has been type-approved by the USCG. The USCG will not be taking ongoing compliance samples. Practicality remains important.

Different BWTS Testing Facilities, Same Results?

(Allegra Cangelosi, Northeast Midwest Institute)

Cangelosi asked, "How similar would test outcomes be in different facilities? Is standardization sufficient to eliminate disparities between outcomes among the Great Ships Initiative (GSI), Maritime Environmental Resource Center (MERC), and *Golden Bear* trials? Are the results the same, even if we import scientists? Will the results hold true in Singapore?" She went on to say that one of the uncertainties being addressed at GSI is how well a land-based facility can predict BWTS efficacy on a working ship.

When GSI and MERC tested the same BWTS (Siemens' SiCURE System) the results were equivalent. However, another system that was recently tested at NIVA (Norwegian Institute for Water Research) had very different test results at the GSI facility. IMO guidelines were used for testing at both facilities, but NIVA and GSI approached the tests differently. NIVA added organisms to the test water that were not particularly challenging to the filter in question. GSI used ambient harbor water from a freshwater system, which overwhelmed the filter and the system failed to meet the IMO standard. The level of standardization in testing remains unclear, as does the approach to analysis said Cangelosi. "As Whitman suggested, there is no substitute for replicates! Sorry folks."

Cangelosi expressed the importance of understanding what difference fresh, brackish, and salt water makes to BWTS efficacy. "We are at the high variability of Whitman's graph in terms of testing," she said. "It's not helpful if every system gets a 'no'." She said that testing a BWTS in different facilities would improve the confidence that a system works.

Nicole Dobroski, California State Lands Commission, called in from California. She asked, "How are we, as regulators, taking the statistical information into account as we move forward? It is clear that we don't have protocols to test beyond IMO at this time. The challenge is to protect waters while knowing that no BWTSs are USCG type-approved."

In California, the state statute dictates a ballast water discharge standard that is 1000 more stringent than IMO for organisms larger than 50 microns. Changing this standard would require a change in legislation. Dobroski said making a list of the best available technology for managing ballast would be helpful but even that would need to be supported with changes in legislation. She suggested making amendments so ships could be compliant to verification protocols that would change over time. Such an alternative wouldn't require legislative change but would require rules.

The Ballast Water Advisory Group and the California government are not advocating for changing their ballast water discharge standard. Dobroski said, "The standard could be anything, the rub is how you measure it." She suggested moving away from the 50 micron classification. "If we look to smaller organisms, we don't need to process as much water and smaller class organisms are much more abundant." California researchers will be working with the 10-50 micron size class of organisms this spring, taking samples from a ballast water discharge line.

In a discussion facilitated by Dr. David Reid, Dr. Jeff Ram, Wayne State University, invited Collaborative participants to "stay tuned" to research he was conducting, funded by the Great Lakes Restoration Initiative, to study microorganisms.

Issues that came up included water quality compliance when discharging treated ballast water since as one participant said, "You need a way to control the discharge before it hits the water." A shipping representative said he was starting to get hypertension thinking about eight different states and eight different verification laboratories. A BWTS manufacturer asked, "How do you envision a process that can deal with all the different flow rates and designs?"

Cangelosi said that interested parties should be looking for consistency between laboratory, land-based, and shipboard testing. She said the best role for ship-based studies would be to look for fundamental parameters for verifying the BWTSs are working on an ongoing basis since the federal government is investing in type-approval testing (verifying that a BWTS will work properly and safely on a ship).

Miller commented on the differences between biological testing and physical testing. “Once initial testing is complete, maybe we could step back and do more intermittent testing,” he said.

Reid wrapped up by congratulating the Collaborative for entering into another realm of understanding BWTS verification challenges.

Potential Ballast Water Treatment Options

(Phyllis Green, superintendent, Isle Royal National Park)

Green referenced three documents:

- The Great Lakes Protection Puzzle: A request for Collaborative review of potential ballast treatment systems research and implementation strategies designed to fit maritime industry needs. (Handout, see supporting documents at the bi-national Seaway website).
- Interim Treatment: Mapping a Road to success. (Handout, see above).
- Emergency Response Guide for Handling Ballast Water to Control Non-Indigenous Species. 2010. The National Park Service, Isle Royale National Park.

She asked Collaborative participants to read and comment on the handouts. In particular, Green asked for input on implementing interim strategies for managing ballast water in the Great Lakes using a skid-mounted system for taking on and off ships with cranes. One strategy kills organisms in ballast water with sodium hydroxide, and the other involves sodium hypochlorite. She said portable or port-side skid-mounted treatment systems would be something to use while freshwater BWTS technology was developing, to use if a BWTS fails, or to use in emergency de-ballasting situations.

Cangelosi remarked that GSI found no red flags associated with treating ballast water with a lye process. She said that at a bench-scale, they are working out minor issues but they have not encountered major issues.

Green showed a chart of aquatic invasive species in Lake Superior produced by Minnesota Sea Grant to illustrate interim treatment targets. Acknowledging invasion timelines, the disappearance of diporeia (an important invertebrate) in Lake Michigan and the 75 million visitors coastal parks receive each year, Green reiterated the importance of stopping aquatic invasive species from spreading. She said that she appreciated ABS's Ballast Water Treatment Advisory (2010) and used it to help inform Park Service intentions to install a permanent 4-hour BWTS on its Isle Royale boat, *Ranger III*; 4-hours is the transit time between Michigan's Copper Harbor and Isle Royale National Park.

Isle Royale National Park staff are currently treating the *Ranger III's* ballast water dockside with a biocide added to a level that will kill the veligers of invasive mussels. The mixing technology study discussed by Bassett (see Part I, Interim Measures Update) helped park officials develop confidence that they could manage emergency events, like grounding.

Green suggested moving from emergency treatment to interim treatment by identifying high-risk vessels and setting a technology standard (a target biocide dose known to kill target organisms). She said that to stop the transit of AIS at Welland Canal, skid-mounted interim BWTSs could be operating onboard a ship during the ship's 11-hour passage through the locks. "This transit time would give the biocide 11-hours of soak time," she said.

Green pointed out that 38% of the world's ships can't conduct mid-ocean ballast water exchange. Another Collaborative participant pointed out that these ships don't come into the Great Lakes but might visit U.S. saltwater ports.

Green thanked the American Steamship Company for advancing ballast water management with their studies of sodium hydroxide and mixing. Scott Smith, ecology section chief of USGS Western Fisheries Research Center, urged the Collaborative to participate in efforts to develop interim treatments for managing ballast water discharge in the Great Lakes. He cooperated on developing the handout, *The Great Lakes Protection Puzzle*, and again invited Collaborative members to read and comment on it. Smith said, "We're learning about what options might work

but we need lots of help from the regulatory agencies and shipping industry to make treatments applicable."

Part 3: Understanding risk and exploring measures to mitigate the spread of AIS by existing Great Lakes vessels

The goals of this session were to establish a working group to evaluate the risks and consequences of species-specific movements, to produce a common understanding of risk mitigation, and to explore new technologies or operational strategies.

The session started out with an acknowledgement that harmonious regulations between Canada, the U.S. federal government, and U.S. state governments are "still off in the distance" and with the hope that participants would "examine what is possible now."

Bruce Bowie, president of the Canadian Shipowners Association introduced a proposal to form a working group to assess the risk of transfer attributable to Great Lakes vessels and to define and examine available ballast water management options to mitigate this risk. The industry is interested in engaging the BWC on approaches and potential risk mitigation efforts. He reiterated previous Collaborative observations that finding technologies that work in Great Lakes conditions (extremely cold, fresh water, short trips, high pump rates, vessel space and power constraints) is challenging. Although he was clear that he thought the industry must do what is feasible and practical to stop moving AIS, he also noted that researchers need to look into the relative risk of moving AIS through ballast water compared to other vectors.

Risk Assessment Methods and Models

(Dr. Sarah Bailey, Fisheries and Oceans Canada)

Bailey talked about how risk assessments could be applied to predict and prevent aquatic invasions. She mentioned the history of invasion biology beginning with Elton (1958), which identified species-poor and disturbed and island habitats as being vulnerable to invasion. She referenced Lodge's (1993) list of potential Great Lakes invasive species, and Williamson's (1996) review of factors that influenced invasion success, including:

- Propagule pressure as measured by the number of introduction events, the number of propagules, and the health and condition of those organisms.
- The organisms' physical and chemical requirements.
- The organisms' biological requirements.

Bailey's work focuses on prediction and analyzing vectors and pathways. "Can it get there and can it survive?" she asks. She defined two terms:

Vector - physical means of transportation.

Pathway - the route by which an invader travels.

She then gave a brief "Risk Assessment 101" lecture, based on research conducted through the Centre of Expertise for Aquatic Risk Assessment (CEARA), which is part of Fisheries and Oceans Canada. "Risk analysis," she said, "is a procedure to identify threats and vulnerabilities." She showed the following formula:

Risk analysis = risk assessment + risk management + risk communication

To conduct a risk assessment, Bailey said one would need to identify the *likelihood* that a threat would be realized or a vulnerability would be tapped, and then analyze the threat to assess the magnitude of its consequences. A risk approach evaluates the likelihood and severity of an undesirable event. It uses probability to describe the chance that an event will occur. Bailey said the objective of management is to develop recommendations and describe uncertainty, and then to make decisions.

She gave the following formula for a Biological Risk Assessment for AIS:

Risk assessment = $P_{(introduction)} \times P_{(impact)}$

Where $P_{(introduction)} = P_{(arrival)} \times P_{(survival} \times P_{(establishment)} \times P_{(spread)}$

$P_{(arrival)}$: Evaluate vectors and pathways, measure propagule pressure. (See Grigorovich et al., 2003, Ricciardi 2006.)

$P_{(survival)}$: Conduct an "Environmental Similarity Analysis," which looks at the biological tolerances of species and the habitat similarities to other places it occupies. (See Herborg et al., 2007.)

$P_{(establishment)}$: Consider long-term population establishment needs. (For example, remember a flounder may be able to live in fresh water but it requires salt water for reproduction.)

$P_{(spread)}$: Evaluate connectivity and pathways through which an AIS might spread after becoming established.

Uncertainties in ranking the potential impacts of an invasive species are important to acknowledge. "Is outcome relative (based on expert opinion) or absolute (based on hard data)?" Bailey suggested asking.

Bailey said the most common type of AIS risk assessment is a **species risk assessment**, which is typically based on biology with the impact predicted from biological studies and/or invasion history. A **pathway risk assessment** is driven by a vector analysis involving multiple species and possibly unknown impacts. Challenges for pathway risk assessment are that they are only plausible at a coarse scale, and that they need to incorporate current species information, biological data to calibrate risk levels, and data to inform mathematics.

The Port of Duluth-Superior might be viewed as high-risk for new AIS because of the number and volume of ballast water discharges it receives. Conversely, Hamilton Port might be viewed as low-risk because only a few ballast discharges are made there. This kind of assessment is very subjective. A formal risk assessment would help to prioritize research efforts, create early detection and rapid response strategies, identify species at risk and paths of secondary spread, and create mechanisms for making and analyzing regulations.

Two studies characterize the role lakers have in introducing non-native species to new areas in the Great lakes. The Lake Transit Study (Rup et al., 2010) focused on 90 vessels and the relative ballast water discharge on the Great Lakes of lakers and salties. The study showed that there was

much more water moving among the Great Lakes in the ballast tanks of lakers than there was coming into the lakes from overseas ports.

Rup, M. P.; Bailey, S. A.; Wiley, C. J.; Minton, M. S.; Miller, A. W.; Ruiz, G. M.; MacIsaac, H. J. 2010. Domestic ballast operations on the Great Lakes: potential importance of Lakers as a vector for introduction and spread of nonindigenous species. Canadian J. Fish. Aquatic Sci. 67(2): 256-268.

Abstract:

Ballast water is recognized globally as a major vector of aquatic nonindigenous species (NIS) introductions; domestic ballast water transfers, however, have generally been considered low risk in North America. We characterize ballast operations of domestic ships in the Great Lakes-St. Lawrence River system (Lakers) during 2005-2007 to examine the risk of primary and secondary introductions associated with ballast water transfers over short distances. Results indicate that Lakers transported at least 68 million tonnes of ballast water annually. Approximately 71% of ballast water transfers were interregional, with net movement being from lower to upper lakes. A small proportion of ballast water discharged in the Great Lakes (<1%) originated from ports in the St. Lawrence River that may serve as sources for new NIS. These results indicate that domestic ballast water transfers may contribute to NIS introductions and are likely the most important ballast-mediated pathway of secondary spread within the Great Lakes. Future efforts to reduce invasion impacts should consider both primary and secondary introduction mechanisms.

The other, an unpublished biological study, focuses on what species are being transported and what risks they pose. Looking at organisms that are 50 microns or larger in diameter, researchers identified 97 zooplankton taxa in ballast water carried by lakers. Seven non-indigenous species of zooplankton have been reported from all five of the Great Lakes.

Bailey summarized by saying that CEARA expects to release a Great Lakes Risk Assessment in June 2011 and a National Risk Assessment should be ready by December 2011. The National Risk Assessment will be limited due to its breadth. Only the busiest three ports for each pathway/region will be included; $P_{(arrival)}$ will be based on data from secondary sources; it will be a snapshot study using up to three years of shipping data; it will not evaluate potential management strategies.

After Bailey's presentation, Jon Stewart said he was "suffering from vector confusion." He wondered about the value of determining risk for transporting AIS in ballast water if other vectors for moving AIS are not addressed simultaneously.

CSA Risk Model and Preliminary Risk Assessment Results

(Azin Moradhassel and Mira Hube)

Note: Moradhassel's and Hube's presentations had common elements, making it logical to put them together for the ease of reading this Collaborative report. At the meeting, the two presentations were separated by Dr. Chadderton's presentation and a facilitated discussion.

Azin Moradhassel, director of Environment Policy and Issues, Canadian Shipowners Association (CSA), reminded Collaborative participants of the CSA proposal to advance solutions to the challenges facing ballast water management on existing vessels while BWTS are being developed. The proposal's objectives, she said, were to:

- improve shared knowledge on transfer risk,
- prioritize the risk and impacts,
- identify measures to address these risks,
- undertake pilot projects.

Following the Duluth meeting, researchers, the CSA, and U.S. carriers developed an aggregated inventory of the movement of ballast water over the Great Lakes and further developed a preliminary risk assessment model. Moradhassel added to Bailey's risk assessment concept:

Mitigated Risk = (potential risk) – (mitigation results)

She talked about the methods for cross-referencing the movement of ballast water around the Great Lakes to the presence of AIS to identify donor and receiver ports. Using the Canadian Steamship Line's study as a platform (see the Duluth Collaborative Report), the CSA completed an understanding of the port-to-port movement of ballast water for the CSA fleet in 2009 and a similar compilation is being developed for U.S. participants.

Moradhassel identified risk mitigation options (ballasting protocols, best management practices, and vessel modification technologies) before sharing preliminary results of the CSA study of ballast water movement in the Great Lakes. She said the CSA documented more than 1800 voyages over almost 300 unique trade routes in the Great Lakes and the St. Lawrence River. The

traffic moved more than 23 million metric tons of ballast water. Nearly half of the activity occurred between ports in the same body of water, and 70% of it occurred within the Great Lakes (i.e. it did not involve ports from the St. Lawrence River). Top donor ports for CSA ballasting were: Hamilton, Sorel, Quebec, and Toledo. Top ports receiving ballast water were Duluth, Goderich, Thunder Bay, and Ashtabula.

Moradhassel said the sub-workgroup of the Collaborative is also compiling a list of known AIS in the Great Lakes and the St. Lawrence River, focusing on trade routes involving multiple bodies of water and the St. Lawrence River. They have also identified a potentially useful database (contact: Yves de Lafontaine, Section Head - Aquatic Ecosystems Analyst, Environment Canada) and are looking into environmental similarities and species profiles. She noted that NOAA's Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS; http://www.glerl.noaa.gov/res/Programs/glansis/glansis.html) species factsheets are being updated to provide impact information in a standardized format.

Moradhassel said the preliminary model indicates that 85% of the species with a potential to transfer along the CSA trade routes could be captured using a ballast water filtering system. She prompted the Collaborative to "keep pursuing 'Made in the Great Lakes' solutions" for addressing aquatic invasive species.

Bailey commented that Fisheries and Oceans Canada is collaborating with the CSA and a postdoctoral researcher (Andrew Drake) to examining vectors and pathways for AIS in the Great Lakes beyond maritime activities. "Our main goal is to be prepared for what comes in next," she said, "regardless of the vector or pathway of entry."

Mira Hube, director of Environmental Services for Seaway Marine Transport and chair of the CSA ballast water working group, spoke about the Great Lakes risk model the CSA and its partners are developing. She said that they expect to have 90% of the ballast water movement in the Great Lakes documented in the near future and that the working group is focusing on four tasks:

1. "Complete" risk assessment model by the target date of May 1, 2011 ("Complete" is in quotations because the group recognizes that the model will continue to be refined as more and different information becomes available.) A panel of AIS scientists is advising the model on assumptions, methods, data sources, impact/survivability, and individual species.
2. Apply the risk assessment to the movement and behavior of select species by the target date of May 15, 2011. The group's hope is to be able to report the results at the next Collaborative meeting proposed to be held in conjunction with the Marine Tech meeting in Chicago at the end of May.
3. Explore technologies and practices to mitigate the potential risk identified by the target date of May 15, 2011. Concurrent with tasks 1 and 2, a panel of AIS scientists, technology developers, and vessel owners aim to develop interim measures to mitigate ballast water treatment.
4. Develop a report of the working group's findings in time for the May 27, 2011, Green Marine Green-Tech Conference in Chicago. The report will include the results of the risk assessment, inventory of technologies and practices, and recommendations for consideration by federal and sate regulators on risk mitigation options.

Workgroup participants include scientists, regulatory agencies, industry representatives (vessel owners, technology developers), and environmental non-government organizations. Although it is not clear where risk assessment will fit into regulatory schemes, Hube reiterated that it is important to explore a variety of paths and that industry is clearly interested in cooperating in a solution.

Bassett commented that the 2009 data the work group is using represents an atypical shipping season. "2010 is more representative of what we normally do," he said. Hube replied that the group would definitely look at the 2010 data because they recognize that 2009 was not fully representative.

AIS Research Initiatives

(Lindsay Chadderton, The Nature Conservancy)

Chadderton talked about several projects he is involved with that focus on four major pathways leading aquatic invasive species into the Great Lakes. The pathways are:

- maritime shipping
- trade in live organisms
- canals
- trailered boats and associated recreation activities

Chadderton is partnering on a University of Notre Dame project funded by The Great Lakes Protection Fund that is germane to the Collaborative, which is summarized as:

(From The Great Lakes Protection Fund Website) The project team, led by experts in the fields of invasive species biology, molecular ecology, and nanotechnology, will partner with Canadian and U.S. agencies to: build five species specific molecular probes for four potentially invasive species – Chinese mitten crab, killer shrimp, golden mussel and the predatory water flea – and one probe to detect zebra mussels; develop a ship-scale, laboratory independent detection platform that can be used onboard or in port; and, establish an end user network to communicate the technology's progress and application. The proposed work will produce a novel detection technology for the "next set" of invasive species in the Great Lakes. In addition, this early investment will build a new industry for the detection of freshwater ecosystem threats. If successful, the proposed work will equip decision makers with the tools necessary to know the invasive species threat posed by a particular vessel within 2 hours from obtaining a ballast water sample.

The team is in the pilot phase of using genetic tools to detect the presence or absence of green crabs, golden mussels, quagga mussels, and Chinese mitten crabs. With these tools, they can detect animal presence, but not necessarily if it is dead or alive.

Chadderton spoke of another research project funded by the Great Lakes Protection Fund that aims to identify areas that pose the greatest risks of moving invasive species to the Great Lakes. Researchers from the University of Notre Dame and the U.S. Forest Service are creating a similarity report for areas within North America.

In September, NOAA awarded $2.5 million to the University of Notre Dame and its partners to predict the next wave of invasive species likely to enter the Great Lakes and to identify cost-effective countermeasures. Chadderton shared a world map showing color-coded regions that have similar aquatic habitats. Through this visualization, Chadderton said, the researchers surmised that killer shrimp and golden mussels had the potential to be the Great Lakes' next invaders.

Chadderton said that NOAA (Center for Sponsored Coastal Ocean Research) support and Great Lakes Restoration Initiative funding are allowing researchers to make scientifically-based predictions about risk, answering such questions as:

- Which pathways are AIS using?
- What species are likely to be successful?
- Where will they live? (Use GIS layers to model where species are likely to do well)
- How will they spread?
- What are the likely impacts?
- What are the regional economic impacts?
- What are the most cost-effective management strategies to avoid, remedy, or mitigate impacts?

Chadderton showed a chart comparing the environmental distance of aquatic habitats and the number of AIS arriving from those areas. He explained that because of the similarity between habitats and the number of ships passing back and forth, European and Great Lakes ports are most likely to exchange organisms that could establish non-native populations.

Chadderton said that a University of Notre Dame researcher, Dr. David Lodge, showed how "prevention saved bunches of money in Australia" and commented that it would be money-saving activity to prevent AIS from spreading in the Great Lakes (Keller et al., 2007). He noted the abundant overlap between invasive species research and Collaborative interests and reiterated the wisdom in pursuing collaborative work.

Miller was struck by Chadderton's map of how ports were connected through shipping. He said it was important to distinguish between the number of arrivals and the amount of ballast water discharged. "If vessels don't discharge ballast water then they are not a vector," he said. "We *(Smithsonian Environmental Research Center)* are coming from a volume approach, you're coming from number of arrivals, which would be great for looking at hull-fouling."

Terry Bowles, from the St. Lawrence Seaway Management Corporation, thought that in his presentation Chadderton missed the fact that oceangoing ships exchange ballast water mid-ocean as a "best management practice." Bowles said, "I think you should be looking at what species are saltwater tolerant. We have a short window here. In five years BWTS will be in operation so the concerns will be vastly different."

Lindsay said that his research interests are focused on how organisms move around the Great Lakes regardless of the vector.

Paul Topping of Transport Canada said that in addition to inspecting all NOBOB ships, authorities undertake a physical sample of ballast water entering the Great Lakes to ensure it is of the right salinity. He noted that the flow of invasive species into the Great Lakes from foreign ports has dropped considerably.

Ray Vandenbosch of the Ontario Ministry of Transport said, "Sometimes it feels like we're just trying to boil the ocean rather than to look at what is likely to invade." He suggested taking the way species spread out of the formula for risk assessment; Bailey said that since the amount of spread contributes to the overall impact, it should stay in.

A participant observed, "You can introduce an organism 100 times and then you introduce it for the 101st and it takes off." He noted how this complicates invasion predictions and that maybe there are "windows of invasion opportunities that open and close."

After praising the shipping industry for impressively "jumping into ballast water management issues with both feet," Jeff Stollenwerk offered strategies for moving forward. With regard to

risk assessment he suggested caution about trying to figure out what is going on in the environment since this tact often ends up being an expensive and time-consuming endeavor. His point was based in the history of water quality work and where society has been successful, like in managing cholera, rivers on fire, and typhoid. "Almost all of these achievements have been based on knowing what we need to do and doing it," he said. "They haven't been based on assessing the environment. It is much harder to answer the 'how will it affect the environment' question." However, he thought that risk assessment has an important part in ballast water management discussions and that the Collaborative might use it in two ways:

1. Guide applicable technology to achieve a desired outcome. Stollenwerk said, "There has been an impressive amount of work done, but when I hear there are 78 potentially invasive species, I'm really thinking as a biologist that there are more like 700."
2. Guide performance standards to create applicable requirements that use technology while incorporating and understanding of trade routes and seasons and other relatively course levels of activity.

Adams of the New York Department of Environmental Conservation was concerned that risk assessments could take too much time away from focusing on blocking the movement of AIS through high-risk and high-traffic routes.

Jeff Ram of Wayne State University asked if pathogens or viruses were being considered in the risk assessment? Bailey said that the researchers are considering all the species, viruses included, that are on the "list." Green pointed out that NOAA's new list of 78 high-risk invasive species didn't represent the opinions of all of the people who might have contributed and that at least one expert scientist thinks this is an oversight.

The USCG reiterated concerns voiced at other Collaborative meetings about how BWTS would affect ship safety and ship construction issues. Paul Topping asked for suggestions for regulatory drafting to putting into the convention. "If your group identifies low-hanging fruit," said Topping, "let us know. The timing of this risk assessment is interesting. Keep the conversation open and ongoing."

Concluding Comments

Bergeron offered to send out an invitation to Collaborative participants to join the CSA working group. He thought that U.S. and Canadian information and capacity should be unified into integrated work plans and aligned work efforts, and that the IJC has been partnering well on this issue. He said that in the end, "the common denominator, the *Esperanto*, is dollars."

The three calls for action voiced at this meeting of the Collaborative were:

- Unify ballast water management and research efforts between Canada and the U.S. (Colin Henein, Transport Canada).
- Offer input and feedback on the meeting handout: The Great Lakes Protection Puzzle: A request for Collaborative review of potential ballast treatment systems research and implementation strategies designed to fit maritime industry needs (Phyllis Green, Isle Royale National Park).
- Participate in the risk assessment working group (Azin Moradhassel, Canadian Shipowners Association).

Craig Middlebrook closed the meeting by recognizing the behind-the-scene organizational efforts of Dr. Marvourneen Dolor. He said that the most important take-aways from these meetings are the reports, which are used by states and federal agencies to inform ballast water regulations.

Mark Burrows of the IJC asked the Collaborative to keep the sense of urgency and focus on what is applicable. He saw real value in making U.S. and Canadian standards consistent. "Keep in mind the review of the Great Lakes Water Quality Agreement that is underway that calls for the harmonization of management," he said.

Terry Johnson, Administrator of the Saint Lawrence Seaway Development Corporation urged states to synch their regulations with the USCG's final rule. "Not being in synch would drive commerce away from your ports," he said. "Take away message is that there is uncertainty with ballast water management and regulations but 'let not your hearts be troubled.' Take heart.

Sixteen months is a nano-second in the life of a government project." He then recognized the work of Craig Middlebrook in leading the Collaborative meetings.

David Reid added one endnote, recommending that for an interesting historic perspective on ballast water-related issues in the Great Lakes, people should read an article by G. H. Ferguson published in Public Health Reports in 1932. He particularly referenced the last paragraph:

> Further study was discontinued on this problem as it was felt that sufficient data had been gather for present purpose and that direct pollution of the Great Lakes waters by vessel sewage is a far more serious menace and one which should receive first attention, rather than the lesser menace of vessel ballast water. (Ferguson 1932)

Handouts

- Agenda
- Wisconsin Ballast Water Treatment Feasibility Determination (provided by Susan Sylvester of the Wisconsin Department of Resources)
- The Great Lakes Protection Puzzle: A request for Collaborative review of potential ballast treatment systems research and implementation strategies designed to fit maritime industry needs. (provided by Phyllis Green of the National Park Service, Isle Royale National Park)
- Interim Treatment: Mapping a Road to success. (provided by Phyllis Green of the National Park Service, Isle Royale National Park)

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Centre of Expertise for Aquatic Risk Assessment (CEARA), Fisheries and Oceans Canada. http://www.dfo-mpo.gc.ca/science/coe-cde/ceara/index-eng.htm

International Maritime Organization (IMO) International Convention for the Control and Management of Ships Ballast Water and Sediments (http://globallast.imo.org)

NOAA's Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) species fact sheets. www.glerl.noaa.gov/res/Programs/glansis/glansis.html

USCG's Shipboard Technology Evaluation Program (STEP). www.uscg.mil/hq/cg5/cg522/cg5224/step.asp

Journal Articles and Reports

2010 Assessment of the Efficacy, Availability and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters http://www.slc.ca.gov/spec_pub/mfd/ballast_water/Reports_Presentations.html

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Great Lakes Ballast Water Collaborative Meeting

Wednesday January 19, 2011
Fairmont Royal York, Room: Confederation 5&6
100 Front Street West
Toronto, Ontario Canada M5J IE3
(866) 540-4489

AGENDA

Morning Session (8 AM – 10:30 AM)

- 8:00 – 8:10 Introductory Remarks (IJC and SLSDC)
- 8:10 – 8: 20 Update on Ballast Water Collaborative Activities (Craig Middlebrook)
- 8:20 – 8:40 Canadian Federal Regulatory Activities Update (Paul Topping)
- 8:40 – 9:00 U.S. Federal Regulatory Activities Update (CDR Gary Croot)
- 9:00 – 9:20 STEP Update and Discussion: Acceptability of vessels accepted in STEP by Great lakes Sates.
- 9:20 – 9:40 Wisconsin Department of Natural Resources Dissemination and Discussion of Technology Feasibility Report (Susan Sylvester)
- 9:40 – 10:00 State Activities Update (Dave Adams & Jeff Stollenwerk)
- 10:00 – 10:10 Update on interim measures activities (Noel Bassett)
- 10:10 – 10:30 BREAK

Mid-day Session (10:30 AM – 1:30 PM)

Verification and Risk Evaluation Information Session

Goal: Share information on the current tools and statistical approaches to ballast water treatment system validation and verification tools and strategies.

Moderator – Dr. David Reid

Verification strategies continue to be a particularly difficult element in the overall ballast water treatment discussion because policy goals and specific standards are dependent on both issues of hard science and regulatory philosophy.

- 10:30 – 10:50 Verification vs. Risk Reduction; understanding the difference between Risk and Uncertainty (Dale Bergeron & Jeff Stollenwerk).

- 10:50 – 11:15 Current Statistical Tools and Methodologies to Evaluate Ballast Water Treatment Efficacy (Dr. Whitman Miller)
- 11:15 – 12:30 Panel Discussion: Opportunities and Obstacles to Ballast Water Validation & Verification (Each speaker will present for 10minutes followed by ~25 minutes of discussion (Allegra Cangelosi, Dr. Melanie Frazier, Dr. Raymond Vaughan, and Dr. Nicole Dobroski)
  - Options for Greater Precision & Practicability in Measurement Techniques to Support Increasing Standards.
  - Past and Present Process of Creating Assay Tools.
  - Realities of limitations of current approach and possible alternative approaches that could be developed over time.
  - Detection/Quantification of Live Organisms in Ballast Water.

- 12:30 – 1:00 Start of working lunch.

- 1:00 – 1:30 The Great Lakes Protection puzzle: a request for Collaborative review of potential ballast treatment systems, biocides and implementation strategies to guide research designed to develop treatment options that best fit maritime industry requirements (Phyllis Green and Scott Smith). 15 minutes for Presentation and 15 minutes for Questions and Discussion.

Afternoon Session (1:30 PM – 5 PM)

Risk Assessment Workshop: Understanding risk and exploring measures to mitigate the spread of AIS by existing Great Lakes vessels.

Facilitator – Dale Bergeron

- 1:30 – 1:40 Introductory remarks (Dale Bergeron)
- 1:40 – 1:50 Introduction to the project/proposal (Bruce Bowie)
- 1:50 – 2:10 Presentation on AIS Risk Assessment methodologies/models (Dr Sarah Bailey)
- 2:10 – 2:30 Presentation on Rup et al (2010) results (Dr Sarah Bailey)
- 2:30 – 2:45 Break
- 2:45 – 3:30 Explanation of CSA risk model and presentation of Preliminary Results of Risk Assessment using 2009 CSA fleet data (Mira Hube & Azin Moradhassel)
- 3:30 – 3:50 Presentation on AIS research initiatives and plans (Dr. Lindsay Chadderton)
- 3:50 – 4:20 Discussion (Facilitated)
- 4:20 – 4:35 Proposed Work Plan for BWC Working Group 4: AIS Risk Transfer Working Group (Mira Hube, Azin Moradhassel).
- 4:35 – 4:50 Discussion (Facilitated)
- 4:50 – 5:00 Wrap-up