Greetings
Alisha Dahlstrom, Coordinator, West Coast Ballast Outreach Project

Welcome to the Spring/Summer 2008 issue of Ballast Exchange, the newsletter produced by the California Sea Grant Extension Program’s West Coast Ballast Outreach Project (WCBOP). This issue’s articles include a wide range of topics that generally fit into three themes: outreach/education, invasive species reports and plans, and ballast water technology.

In support of the oft-overlooked approach, “education first,” the WCBOP is partnering with the Sea Grant programs of Oregon and Washington to develop an aquatic invasive species (AIS) curriculum. The curriculum will feature traveling kits full of specimens, videos, activities and other resources for middle and high school teachers and informal educators. Our education coordinator, Annie Pierpoint, is currently testing some of the activities in San Francisco Bay area classrooms, and we are all working to include the most relevant California and ballast-related information into the curriculum and resource guide. For more information, please see the website section, “Curriculum Resources for AIS/ballast/fouling.”

There have also been several AIS-related reports and plans released (reviewed in this issue), including “Effects of Climate Change on Aquatic Invasive Species and Implications for Management and Research,” “Assessing the Global Threat of Invasive Species to Marine Biodiversity,” and “California Aquatic Invasive Species Management Plan.” The first two provide insights and tools for global AIS management, while the California plan gives a long-awaited assessment of AIS status and management recommendations for the state.

This newsletter also contains a variety of ballast water treatment technology articles. One article features, incidentally, another report, “Assessment of the Efficacy, Availability and Environmental Impacts of Ballast Water Treatment Systems for Use in California Waters.” The report was written by the California State Lands Commission and provides an up-to-date analysis of viable treatment technologies. In that vein, “Taking the next STEP” reviews the recent movements of STEP, the U.S. Coast Guard’s program to test and implement treatment technologies. The third article describes a novel approach by “K” Line America, Inc., to reduce AIS threat: instead of treating ballast water, they hope to reduce the need for it.

As the WCBOP enters the final year of its CALFED grant, it will primarily focus on wrapping up its ballast water activities. This includes hosting seminars and panels (including one at the Coastal Society Conference in July), publishing one final newsletter in the fall, and providing general outreach and education on ballast and AIS management issues. The WCBOP also continues to update the website, as well as its ballast water/vessel fouling blog, which can be found by clicking the “In the News” link on the WCBOP’s webpage http://ballast-outreach-ucsgep.ucdavis.edu/; additional websites on AIS and ballast water can be found by navigating to the “Links” section.

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

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California Aquatic Invasive Species Management Plan Signed by Governor

Julie Horenstein, California Department of Fish and Game

On January 18, 2008, Governor Schwarzenegger signed the California Aquatic Invasive Species Management Plan, making the state eligible for federal funds administered by the Western Regional Panel (WRP) of the federal Aquatic Nuisance Species Task Force. The WRP approved the plan, pending the governor’s signature, in November 2007. This culminated a five year effort to develop a plan according to the Task Force’s guidelines. The original draft plan was developed at U.C. Davis in 2004 with input from three stakeholder workshops. It was revised and finalized between January 2006 and August 2007, through collaboration between the California Department of Fish and Game, the State Coastal Conservancy and the San Francisco Estuary Project. Additional public hearings were held to get input on the revised draft in August 2006 and a federal and state interagency steering committee also provided substantial input during the plan’s development.

The content of the plan includes background information on environmental and economic problems associated with aquatic invasive species (AIS), pathways of introduction, historic and current AIS management, a framework for collaborative management, and a draft plan for rapidly responding to new AIS introductions. The heart of the plan is 163 actions that are organized under eight objectives. The agencies and other entities likely to be associated with each action are identified, and an implementation table in the back provides a timeline plus information on current spending on AIS management projects. Appendices include information on AIS laws and regulations, the agencies responsible for their implementation, major ongoing AIS-related programs in

Drafting the California Aquatic Invasive Species Management Plan involved extensive public and stakeholder input.

Photo courtesy of Julie Horenstein.
California, and a lists of invasive animals and plants that are on current state or federal restricted or noxious species lists.

The primary purpose of the plan is to provide guidance to state agencies on how to work together to address the problem of AIS management, and also how to work with other levels of government, research institutions and interest groups on this issue. The plan can be viewed and downloaded at http://www.dfg.ca.gov/invasives/plan/.

The study found that the Northern Californian Marine Ecoregion (that includes San Francisco Bay) is the most invaded of the 232, with 83 invasive species. Hawaii came in second place with 73. In 1998, Andrew Cohen and James Carlton published a study that suggested San Francisco Bay was the “most invaded estuary in the world.” The global scope of this TNC study further solidifies this finding.

The Global AIS Threat by “Marine Ecoregion”

Annie Pierpoint, West Coast Ballast Outreach Project (WCBOP)

A recent article published in Frontiers in Ecology has been making waves in the field of aquatic invasions. The article, authored by The Nature Conservancy (TNC) and entitled “Assessing the global threat of invasive species to marine biodiversity”, contributed important new discoveries to the study of marine invasive species, and also re-confirmed findings from some previous research.

A team of scientists led by Jennifer Molnar gathered data on 329 (now over 330) invasive species worldwide from a variety of sources. This information was compiled into a database available to the public on the internet. I spent the summer of 2005 as an undergrad at UC Davis on this project—gathering information through books, websites and other databases and inputting it into MS Access. The TNC database includes information on the origin of the selected invasive species, where they have invaded, their impacts, pathways of introduction and management techniques. A “threat scoring system,” devised to rate species on a scale of one to four in four categories: Ecological Impact, Geographic Extent, Invasive Potential, and Management Difficulty. Higher numbers represented greater ecological and geographical influence, potential and difficulty in eradication.

A common theme in conservation science is that animals, plants and other life studied don’t adhere to political boundaries. Recording geographic data for species can be challenging. Molnar and her team used a geographic unit developed in a study by TNC and the World Wildlife Fund (WWF). This paper identified global Marine Ecoregions, which are defined by a relatively uniform set of species, a few dominant habitats, and a distinct difference when compared to a nearby ecoregion. There are 232 Marine Ecoregions, which comprise 62 Provinces and 12 Realms.

Molnar and her team also found that shipping (meaning ballast water and/or hull fouling) was the most commonly cited pathway for the aquatic invasive species (AIS) in the database; 228 species were transported this way. Aquaculture was also found to be a major vector for AIS on the West Coast of the United States.

One of the most interesting results of the study came from a comparison of shipping activity (e.g., number of ports and cargo volume) and numbers of AIS, using data from the 228 species transported by ships between highly documented regions, including the United States (excluding Alaska), temperate Europe, Australia, and New Zealand. A statistically significant correlation was found, which means that greater shipping activity was associated with more AIS present. Therefore, areas of the world with busy ports and few documented AIS (such as east and southeast Asia) may be underreporting the actually number of instances and require additional research and monitoring.

This study is the result of an enormous and ongoing effort. It has reaffirmed some of what we already know about the global threat of AIS, but it has also clarified additional research needs and directions for research.

For more information, visit the “In the News” section of the WCBOP website.
Assessment of Ballast Water Treatment Systems: 
A Report from the California State Lands Commission
Nicole A. Dobroski, California State Lands Commission

The California State Lands Commission (Commission) recently completed a report assessing the efficacy, availability and environmental impacts of existing ballast water treatment systems for use in California waters. The report, submitted to the California Legislature on January 1, 2008, summarizes Commission findings after an extensive review of 28 ballast water treatment systems. The report also discusses future plans of the Commission’s Marine Invasive Species Program (Program) and offers recommendations to the Legislature regarding the implementation of performance standards for the discharge of ballast water.

In California, ballast water exchange has been the primary method of managing the release of nonindigenous species from commercial vessels since 1999. Ballast water exchange, however, is variable in effectiveness and may pose a safety risk for vessels. For these reasons, exchange has always been considered an interim measure while ballast water treatment technologies are developed. With the passage of California’s Coastal Ecosystems Protection Act (Act) of 2006, the Legislature directed the Commission to implement performance standards, in consultation with an advisory panel, for the discharge of ballast water. The standards were approved in October 2007 (see Commission website for full text of regulations) and will be implemented on a graduated time schedule beginning January 1, 2009. The interim performance standards set acceptable levels of organism abundance as a function of organism size in ballast discharges. A final discharge standard of zero detectable organisms in ballast water discharge will be implemented on January 1, 2020.

For the majority of vessels that will discharge ballast in California waters, ballast water exchange will be insufficient to meet the performance standards. Thus, vessels intent on discharging in California waters will first need to treat their ballast with a ballast water treatment system prior to discharging. To keep the Legislature and interested stakeholders abreast of new developments in the field of ballast water treatment, the Act required the Commission to prepare a report evaluating currently available ballast water treatment systems to determine if any are available to meet California’s performance standards.

The report evaluates 28 ballast water treatment systems with respect to system efficacy, availability and environmental impacts. Efficacy testing was either not performed or data were not available for eight of those systems. For many of the remaining 20, the methods used to evaluate efficacy were variable, and the results were often presented in metrics that were not comparable to California’s standards. Thus, it was often impossible to compare the available data for a single system against all of the organism size classes specified by California’s performance standards. On a system-by-system basis and across all testing platforms and scales (laboratory, dockside, shipboard), no single technology has yet demonstrated the capability to meet all of California’s performance standards.

Since the limited available data indicate that no system demonstrates the capability to meet all seven size classes of California’s standards, none can clearly be deemed “available” for installation. System availability also depends on the ability of treatment companies to install systems on newly built or retrofit vessels by the date that performance standards go into effect. (The initial implementation date, for newly built vessels with a ballast water capacity of less than 5000 metric tons, is January 1, 2009). Several companies are, or will soon be capable of producing treatment systems commercially, and it appears that treatment systems will be available in a commercial context. Additional
The ability of systems to kill or remove organisms from ballast water will likely be at a level to meet California’s performance standards in the near future. However, given the short amount of time remaining before the initial implementation of standards in 2009 and the need to develop efficacy and environmental testing and evaluation procedures before a system is permitted in California waters, it is unlikely that systems will be sufficiently available soon enough.

Based on the aforementioned conclusions and, in an effort to strengthen the Program’s management of nonindigenous species, the report recommends that the California Legislature: 1) Change the implementation date for new vessels with ballast water capacity less than 5000 metric tons from 2009 to 2010, and require the Commission to prepare an update of the report on or before January 1, 2009; 2) Authorize the Commission to amend the ballast water reporting requirements via regulations; 3) Support continued research promoting technology development.

The next steps for the Commission’s Program include several projects to advance the implementation of the interim performance standards and assessment of treatment systems, specifically: 1) Developing efficacy-testing guidelines to assist technology developers and ship owners in testing and evaluating treatment systems, in a standardized fashion, relative to California’s performance standards; 2) Developing protocols to verify vessel compliance with the performance standards; 3) Working with the SWRCB to identify applicable water-quality requirements; and 4) Working with other U.S. West Coast states to align system testing and evaluation guidelines.

For more information, please visit the Commission’s website at www.slc.ca.gov or contact Nicole Dobroski, dobrosn@slc.ca.gov.
Rian Hooff: Oregon DEQ’s One-Man Ballast Band

Interview by Alisha Dahlstrom

Although the Oregon Department of Environmental Quality (OR DEQ) has technically had an Oregon Ballast Water Management Program since 2001, there was no funding for staff to run that program until 2007, when OR Senate Bill 644 passed, providing funding for a full-time OR DEQ program manager. This position was filled by Rian Hooff in November 2007.

Before joining the world of environmental policy and regulation with OR DEQ Hooff spent over ten years doing marine ecology research and teaching. His research interests focused on how changes in plankton dynamics, due to natural or anthropogenic disturbances (e.g., climate variability or nonindigenous species), may affect fish populations and other ecosystem properties. Hooff received his Master’s based on a study of the feeding behavior of an invasive copepod (Tortanus dextrilobatus) from Southeast Asia and its potential ecological effects in San Francisco Bay. He then took a position with Oregon State University at the Hatfield Marine Science Center in Newport, OR where, as part of larger project investigating biological indicators of climate change, he looked at various copepod species as indicators of changing ocean conditions. More recently, he split time between a research position at Washington State University Vancouver, and adjunct teaching at colleges around the Portland area.

Why make the switch from academia to the applied/regulatory sciences? While he enjoyed research and teaching, Hooff was eager to try the applied side of science, which can bring with it the added benefit of more stable funding. This transition has included significant challenges—Hooff inherited a program that had been without clear leadership for six years. While one staff position is better than nothing at all, Hooff became essentially the one-man band for OR DEQ’s ballast program. Faced with the daunting task of reducing biological invasions associated with commercial vessel operations in Oregon, he focused on prioritizing and setting goals in developing this new program. A significant portion of his time is devoted to monitoring vessel arrivals in Oregon to assess compliance with their ballast-management operations.

Hoof has also started a vessel-inspection program that uses a risk-based approach to determine which vessels to board. Risk calculations for a particular vessel are based on identifying non-compliant intentions on a vessel’s ballast water reporting forms or the vessel’s source water body (e.g., those arriving from conditions similar to the Columbia River pose a higher risk).

Hooff hopes to expand the OR DEQ inspection program on the Columbia River to complement efforts by the U.S. Coast Guard and Washington State, which is no small task considering Hooff is the only ship inspector for Oregon. He normally boards two to three vessels weekly, taking anywhere from 45 minutes to 1.5 hours per ship. Interestingly, one aspect of these inspections—establishing a protocol to verify ballast water exchange—may allow Hooff to get back into field research a little, which he would welcome. Rather than rely on salinity as a verification of ballast exchange (which can be inconclusive), Hooff is interested in the possible use of chromophoric dissolved organic matter (CDOM) as a more robust indicator of coastal versus oceanic waters. Although still under development, Hooff is interested in supporting the necessary field testing and data gathering in hopes that the CDOM indicator may one day be incorporated into his vessel-inspection program.

A third charge for Hooff’s position is establishing and staffing the newly created Oregon Task Force on shipping-related transport of aquatic invasive species (AIS). In addition to issues specifically related to ballast water, this task force will report to the 2009 Oregon Legislature with analyses and recommendations on multiple shipping-related AIS issues, including hull fouling and possible hull-husbandry guidelines.

Shifting gears, I asked Hooff if he had a favorite AIS success story. His answer? “No news is good news.” He explained that in a world where healthy ecosystems rarely make headlines, the absence of stories about AIS is a good thing. Many in the AIS field get frustrated or discouraged focusing on the highly-invaded ecosystems, forgetting that their hard work has yielded many silent
successes—water bodies without AIS. And while many biological invasions have occurred during the last 20 years, there has also been increasing interest and growing momentum on AIS issues.

When asked to name “the most undervalued element of fighting AIS,” Hooff replied, “Absolutely—education; in the broadest sense the public of course, but, more importantly, for policymakers and users (commercial officers and recreational users). Getting the word out to the people whose actions directly affect our natural resources is most critical.”

In addition to experiencing a career transition, Hooff’s outside interests have shifted. In years past, weekends would find him pursuing activities such as sea kayaking and back-country skiing. During the past two years, however, he has picked up activities he can enjoy with his 2-year-old daughter, in addition to renovating his 100-year-old house.

In closing, I asked Hooff which AIS he would eliminate from the Western Hemisphere, if he had one wish. Unsurprisingly, his answer included the recent scourge of the West Coast: “All freshwater mussels with byssal threads.” While it is too late to prevent Dreisseniid introductions for some West Coast states, perhaps Oregon will be different with Hooff onboard.

International Conference on Biofouling and Ballast Water Management Held in India

A three-day International Conference on Biofouling and Ballast Water Management was held at the National Institute of Oceanography in Goa, India, February 5–7. The conference provided a fresh perspective on vessel-mediated introductions of aquatic invasive species (AIS), as it included biofouling (a.k.a. vessel or hull fouling) as a vector instead of focusing strictly on ballast water, as has been the case in many past conferences. The inclusion of this vector in an international conference reflects growing interest and recognition that growth on the outside of vessels is also a significant method of AIS movement.

The conference was honored by the attendance of Secretary General of the International Maritime Organization (IMO), Efthimios E. Mitropoulos, who began the program with a history of the effort to prevent commercial vessel transfer of AIS. The range of speaker presentations was broad: Mr. A. Chatterjee (Directorate General of Shipping, India) gave a presentation on the implications of ship biofouling and ballast water management on shipping operations and economics; Dr. J. Matheickal (GloBallast, IMO, UK) discussed the second phase of GloBallast Partnerships, which aims to forge alliances at global, regional, and national levels to assist developing countries in reducing the risk of aquatic bioinvasions via ships’ ballast water. Other presentations included updates on ballast water management programs from international representatives. For more details on the conference and a list of abstracts, please visit: http://icbab.nio.org/.

Other ballast water and biofouling conferences include the 14th International Congress on Marine Corrosion and Fouling in Japan, July 2008 and the International Conference on Ballast Water Management in Singapore, October 2008.
U.S. Coast Guard: Taking the Next STEP

LCDR Brian Moore, U.S. Coast Guard

The U.S. Coast Guard (USCG) has prepared draft environmental assessments (DEAs) for three applicants seeking to participate in the Shipboard Technology Evaluation Program (STEP): Princess Cruise Lines’ Coral Princess, Atlantic Container Lines’ Atlantic Compass, and Matson Shipping’s Moku Pahu. In Federal Register notices (73FR 18544-18546) published April 4, 2008, the USCG requests comment on the environmental impacts of testing these ballast water treatment systems onboard ships. This is in accordance with the National Environmental Policy Act of 1969, which requires each system to be evaluated for localized effects on the ports and waterways where a vessel involved in the program operates. “Getting the chance to observe these prototypes in operation is a real benefit and takes another big step toward protection of our waters from further aquatic nuisance species (ANS) invasions,” said Captain Mike Blair, Chief of the Coast Guard’s Office of Operating and Environmental Standards.

STEP is a critical element of USCG programming to support development and implementation of experimental shipboard ballast water treatment systems as alternatives to ballast water exchange as treatment to prevent ANS introductions into U.S. waters. Current ballast water management regulations require most ships to conduct mid-ocean ballast water exchange. Due to the limitations of exchange however, future USCG regulations may require specific limits to the number of live organisms in discharged ballast water.

“Getting the chance to observe these prototypes in operation is a real benefit and takes another big step toward protection of our waters from further aquatic nuisance species (ANS) invasions,” said Captain Mike Blair, Chief of the Coast Guard’s Office of Operating and Environmental Standards.

In addition, under the Endangered Species Act of 1972, the USCG contacted the National Oceanographic and Atmospheric Administration’s National Marine Fisheries Office and the U.S. Fish and Wildlife Service to initiate consideration of essential fish habitats that possibly might be impacted and any potential concerns regarding endangered species.

After the public comment period ends, the USCG will incorporate any needed changes to the DEA to ensure a thorough and well-reasoned assessment of possible impacts. The assessment will then be provided to the USCG agency head, in this case probably RADM Brian Salerno, Assistant Commandant for Marine Safety, Security and Stewardship. RADM Salerno will make one of the following determinations: no significant impact from the federal action (i.e., accepting the ship into STEP and allowing treatment system operation in accordance with the approved test plan); a finding of significant impact that would require a full Environmental Impact Review; or possibly a determination that the applicant needs to mitigate some specific impacts of the system. If the finding is of “no significant impact,” the ship will begin using the treatment system to manage ALL of its ballast water, and, for USCG purposes, will be deemed to be in compliance with ballast water management regulations (33CFR151). During ensuing years, specific efficacy tests will be conducted to provide the opportunity to assess whether treatment options being proposed are capable of achieving the stated goal of protecting U.S. waters from ANS.

The draft environmental assessments and instructions for submitting comments are found at the Federal Docket Management System website at http://www.regulations.gov; the notices can be found at: http://edocket.access.gpo.gov/2008/pdf/E8-6988.pdf. Comments and related materials must reach the Docket Management Facility on or before June 3, 2008.

Additional information on the USCG’s ballast water program and the STEP application package is available at: http://www.uscg.mil/hq/g-m/msoc/step.htm. If you have questions on the DEA or would like a copy of the DEA, please contact LCDR Brian Moore, telephone 202-372-1434 or e-mail: brian.e.moore@uscg.mil
“K” Line’s New Car Carriers Feature Environmentally Friendly Design

Christian P. von Kannewurff, “K” Line America, Inc.

“K” Line, one of the largest global ocean carriers, equipped its newest car-carrier ships, the Georgia Highway and sister ship the Oregon Highway, with numerous environmentally friendly design features. Capable of carrying 6,100 standard-size cars (decks can be re-configured to carry trucks, other high-profile vehicles and/or heavy equipment as well), these ships are the largest car carriers in the “K” Line fleet. They are almost 200 meters in length, 32.25 meters at their widest width, with a gross tonnage of 56,973 tons each.

To make the ships environmentally friendly, “K” Line designed all fuel tanks to be double hulled. Essentially these double hulls are a barrier between fuel tanks and the outside water, thus insulating the tanks and reducing the risk of fuel spilling into the water in the event of an accident.

The ships also carry an extra fuel tank in order to easily comply with any coastal region low-sulfur fuel requirements. Furthermore, the ships have been equipped with smaller engines with lower fuel consumption to reduce emissions of nitrogen oxides (NOx), sulfur oxides (SOx) and carbon dioxide (CO2).

All ships need a certain amount of ballast carried low in the ship for stability. Ballast requirements change constantly and there are many factors involved in determining the right amount of ballast to be carried: the weight of cargo being carried by the ship; the location of the cargo on the ship—low versus high weight; port versus starboard cargo weight; forward versus aft weight—and amount and weight of fuel on board. Since the factors change frequently based on particular loads being carried, the ship’s officers are constantly adjusting the quantity of onboard ballast water in order to keep the ship within the legally required safe-stability range.

The Georgia Highway and the Oregon Highway have been designed to convert approximately 20% of their ballast needs to concrete ballast. Concrete is heavier than water, with a specific gravity 3.6 times higher than that of water, meaning that less concrete ballast is needed in order to achieve the same stabilizing effect. As the concrete ballast remains on board at all times, the need for deep-sea ballast water exchange is reduced, which in turn further minimizes the risk of any potential transfer of aquatic invasive species.

This environmental initiative may appear to be a step back in time to the days when sailing ships carried stones as ballast, but it is highly effective and a “new” thought for modern ships such as the Georgia Highway and the Oregon Highway. Sometimes simple ideas are very powerful.

For more information, contact Chris von Kannewurff, “K” Line America Inc., chris.vonkannewurff@us.kline.com
Aquatic Invasions: A Curriculum for West Coast Aquatic Invasive Species Education

Annie Pierpoint, West Coast Ballast Outreach Project

This coming fall, a new curriculum on aquatic invasive species (AIS) will be available for use in classrooms and informal education centers. Aquatic Invasions: A Curriculum for West Coast Aquatic Invasive Species Education is the result of collaboration among the Sea Grant Programs of California, Oregon, and Washington. In addition to my role with the West Coast Ballast Outreach Project, I have been working with Sam Chan and Tania Siemens (both from Oregon Sea Grant), and Jodi Cassell and Alisha Dahlsrom (CA Sea Grant) on this project, funded by a grant from the National Sea Grant College Program.

The curriculum is geared towards middle and high school students and is adaptable for the general public. These are two key audiences in preventing the spread of AIS—today’s students become tomorrow’s researchers, and most agree a well-informed public is crucial in the fight against AIS. It is also important to reach this audience because release of classroom “projects” or pets can serve as a potential vector for AIS introductions, such as crayfish and bullfrogs.

The final outcome of this project will be a “traveling trunk” full of specimens, videos, activities and other resources for teachers and informal educators to help spread the word about AIS. It will be linked to the state teaching standards for Washington, Oregon, and California, which is essential to fit a busy teacher’s instruction schedule. One of the most important pieces of this kit will be a full-color resource guide that profiles the major species of concern for the West Coast, including Zebra and Quagga Mussels, invasive tunicates and Spartina. The kit also includes information about vectors and what students can do to prevent invasions.

Oregon Sea Grant has a group of adventurous teachers who have been working with the curriculum since fall 2007. In addition to in-class activities, one class has created t-shirts and sweatshirts that state, “Start to Care: Stop AIS from Being There!” to promote awareness about AIS in their community.

To help generate interest in the curriculum and get input from California teachers, I have been visiting classrooms and education fairs to teach an activity called, “Design the Ultimate Invader.” Students are introduced to several AIS and vectors, and then asked to create a poster of the worst invader that comes to mind. The results have been fascinating and colorful! A group of middle school students drew a creature that hid under skateboards and created evil human clones, while adults at an education fair envisioned a large insect with a toxic body that poisoned everything it touched.

Other activities in the curriculum include a mapping project, role-playing games, case studies and a chance to participate in actual AIS research by hunting for Caulerpa sold in aquarium shops. An activity called, “Hazardous Paths to the Columbia Gorge” allows students to create their own Hazard Analysis and Critical Control Point (HACCP) plans in order to figure when AIS might be transported during an electrofishing operation.

In fall 2008, we will be holding a California educator training workshop to show teachers and informal educators all the curriculum has to offer. By then, there will be two prototypes in each of the three participating states (Washington, Oregon, and California) that can be “checked out” for teacher use.

I am very excited to be a part of this project. It is an innovative and adaptable resource, and reflects the shifts in the field toward ecosystem-based management. The activities are fun and are generating a positive response from both educators and students. Hopefully in the future we’ll see a decrease in AIS and an increase in scientists who were once inspired by Aquatic Invasions.

Any questions should be directed to Annie at apierpoint@ucdavis.edu, (925) 646-6540 ext. 217.
Climate Change, Aquatic Invasive Species and Adaptation of Management Activities†

Britta Bierwagen, U.S. Environmental Protection Agency; Roxanne Thomas*, Environmental Law Institute; Austin Kane, Environmental Law Institute

Global-change stressors, including climate change/variability and land-use change, are major drivers of changes in ecosystems. Aquatic invasive species (AIS) also cause significant changes in ecosystems and to the services they provide. However, the effects of climate change on AIS and their combined effects on ecosystems as well as how these changes vary regionally with climate and species traits — are not well understood. In some instances climate change may create additional opportunities for invasion or, conversely, create conditions unsuitable for certain invasive species. With climate change, the magnitude of ecological, economic and human-health impacts of AIS may increase, decrease, or remain the same. Although the level of uncertainty about specific effects of climate change is high, it is necessary to develop management strategies that incorporate existing climate-change information and facilitate the addition of new information.

In March 2008, the Global Change Research Program in the National Center for Environmental Assessment, part of the U.S. Environmental Protection Agency’s Office of Research and Development, released a final report, “Effects of Climate Change on Aquatic Invasive Species and Implications for Management and Research.”2 This report strove to identify the research and management intersections to jointly address climate change and AIS. Identifying climate change and management intersections provides opportunities for control and eradication under changing conditions that states could apply to ecological problems specific to their regions. Although additional research is needed to understand the full scope of the effects of climate change on AIS, there are practical steps that states can take now to adapt AIS-management plans and programs to the altered environmental conditions projected to occur with climate change (Figure 1). Initial steps are:

(1) Incorporate climate-change considerations into leadership and coordination activities;

(2) Identify new AIS threats as a result of climate change;

(3) Identify ecosystem vulnerabilities and improve methods to increase ecosystem resilience;

(4) Evaluate the efficacy of control mechanisms under changing conditions; and

(5) Manage information systems to include considerations of changing conditions.

These are modest measures that do not entail significant expenditures, and are important to our ability to achieve stated management goals in the future. Although not every state operates a comprehensive AIS program, every state does conduct various forms of AIS management, and consideration of the effects of climate change is essential to the success of these efforts. Because states’ resources for AIS management are often scarce, these resources should be used to support management activities that will prevent, control and eradicate species. Incorporating climate-change information into planning and implementing prevention, control, and eradication will help managers carry out these management actions more successfully. Adopting an adaptive management framework (a framework that tests and changes management strategies as new learning occurs) will allow states to prevent and control AIS invasions under changing conditions and will also maximize the effectiveness and efficiency of each dollar spent on such activities. This report’s initial recommendations provide a starting point for adapting management practices and additional details are described here.

(1) Incorporating climate change into leadership and coordination activities

Invasive species councils or lead state agencies can incorporate climate-change considerations into their management plans. One strategy is to conduct facilitated meetings or workshops to identify specific management goals and objectives and research needs to inform management strategies. State councils also could work with one another to share information on climate-related data across regions. Coordination and information sharing across states can also facilitate the implementation of activities that are adapted to climate-change effects.
(2) Identifying new AIS threats as a result of climate change

A first step to preventing invasions that might result from or be influenced by climate-change factors is to identify specific AIS threats, including new pathways and vectors, that may result from changes in environmental conditions such as water and air temperatures, precipitation patterns, or sea levels. In implementing this step, the initial focus should be placed on priority AIS identified by states. Coordination among states to share information on species and pathways will aid in data collection and implementation of prevention activities.

Although the link between climate change and specific pathways or vectors may not be straightforward, there are several ways in which climate change may influence AIS pathways. For example, seaways may remain open for longer periods during the year due to warming temperatures; thus, shipping and boating traffic, a major vector for species such as the zebra mussel, also may increase. In addition, completely new shipping routes may open in polar waters due to melting ice.

Comprehensive monitoring systems to detect new AIS, new impacts and range changes as a result of climate change also should be developed. Ideally, these systems should be accessible to managers between states to ensure dissemination of important information. The systems should also be designed to be easily updated as more information on AIS and climate change becomes available. They also could be linked with models projecting changes in species-range boundaries.

(3) Identifying ecosystem vulnerabilities

Effective AIS-prevention efforts must include identification of ecosystems that may be more vulnerable to invasion under changing environmental conditions. This effort should be complemented by identification of key restoration opportunities. Restoration of ecosystems is an important component of comprehensive prevention strategies, as robust habitats are less vulnerable to invasion. For these reasons, restoration should be designed to thrive under, or at least withstand, the changing temperatures, precipitation patterns, and sea-level changes that are predicted to result from climate change.

(4) Improving control measures under changing conditions

States should evaluate control measures for efficacy under the altered conditions resulting from climate change and should adjust AIS-management priorities and plans accordingly. Biological, chemical, manual and mechanical control methods may all be affected by climate change. Managers will need to coordinate with scientists to obtain existing information on different control methods and how climate-change effects, such as increased temperatures and altered precipitation patterns, may influence their efficacy. This knowledge will help states be better prepared to adapt their control programs.

(5) Managing information under changing conditions

States designing AIS information management systems should include the capacity to account for changing conditions by collecting and tracking climate-change data (e.g., water temperature, salinity levels and water chemistry). Including this information will improve robustness and accuracy of information management systems under changing conditions. This information could also be added to existing information systems.

Next steps

Although states and their partners have much to accomplish to begin to address climate change in AIS management, the steps described above can be taken now. An adaptive management framework may be the most appropriate framework for states to use to incorporate climate change information into management plans and programs. Adaptive management involves testing the effectiveness of different management methods. Testing and adaptation will be important because of the spatial and temporal uncertainties about the specific effects of climate change.

An additional, important step for states is coordination among state and regional AIS councils and state agency personnel that manage AIS. Such collaboration can facilitate information sharing on various management activities likely to be affected by climate change, including pathway identification, monitoring data and control mechanisms. In addition, agency staff and AIS coordinators would receive valuable information from reviewing current and future prevention, control and eradication activities for their potential vulnerability to climate change; identifying specific data and information needs; and modifying current strategies where feasible.

For more information, contact Britta Bierwagen, Global Change Research Program, U.S. Environmental Protection Agency, bierwagen.britta@epa.gov; 703-347-8613.
In recent years, an extensive reduction of pelagic, plankton-feeding fish populations in the upper San Francisco Estuary (SFE) has gained national attention. Monitoring studies have revealed the lowest numbers of endangered Delta smelt and striped bass (less than 1 year of age) ever recorded, while both threadfin shad and longfin smelt, recently petitioned for federal endangered status, hover near their historical minima. Understanding the potential driver(s) of this phenomenon has been listed as a priority by regulatory agencies. A University of California, Davis research team, comprised of Drs. Bernie May and Peter Moyle, fellow doctoral student, Mariah Meek, and myself, is working to investigate the potential role of a rather unusual suspect—a trio of invasive jellyfish!

Overall, jellyfish populations appear to be increasing around the world. This trend is likely in response to anthropogenic changes impacting the oceans, such as global warming, eutrophication and the over-harvesting of fish stocks. Aided by ballast-water transport and other transport vectors, and shifting temperature and salinity regimes, many species are increasing their ranges and becoming disruptive in their new habitats. Jellyfish invasions have been wreaking havoc, from the giant 400-pound Nomura’s jellyfish fouling commercial fishing gear in Japan to the mauve stinger creating painfully unpleasant vacations for beachgoers in Europe. These invasive blooms also often impact fish populations, as jellyfish can successfully compete with fish for prey and will voraciously feed upon fish eggs and larvae. Experts in this field have expressed the need for further research into the impacts of these unique predators.

Three small hydrozoan jellyfish species, Maeotias marginata, Blackfordia virginica, and a species of Moerisia, (yet to be identified), have become established in the brackish waters of the SFE. Originally from the Black Sea region, it is likely that at least one of these species was transported to California via ballast water as early as the 1950s. Today, anecdotal reports have noted increasing abundances and distributions in these populations, with seasonal blooms (typically found June–November) of Moerisia sp. reaching densities of 500 individuals/m³ in Suisun Marsh, and “tens of thousands” of M. marginata collected in the U.S. Army Corp of Engineers’ survey of the Napa River.

Our current knowledge of the basic biology and ecology of these organisms is alarmingly poor in light of both their possible negative effect on fishes and the increasing trends in jellyfish blooms around the globe. The UC Davis research program is investigating the potential effects of these species on the SFE ecosystem to determine factors allowing their successful establishment and spread, and to predict future effects and spread. This project involves three independent tasks: genetic analyses, field surveys, laboratory investigations.

In the genetic portion of this research, we will use molecular techniques to evaluate clonal diversity and mode of reproduction. Hydrozoans are novel predators in that they can reproduce both asexually and sexually. The capacity to reproduce asexually may give a strong advantage for rapid population growth; therefore it is important to gain a clear understanding of the nature of clonal diversity, its reproduction and spread.

The second task is two-fold and will be accomplished with directed field surveys in Suisun Marsh. In the first portion, we will estimate the current distributions and abundances of invasive jellies and relate these trends to water and habitat quality. The remainder of this task will involve detailed dietary analyses of patterns in feeding behavior (including predation on larval fishes), day/night activity, and diet overlap with plankton-eating fishes.

The third task will involve a suite of laboratory studies designed to obtain physiological characteristics of these species. We will quantify feeding rates upon zooplankton and larval fish prey, evaluate salinity and temperature tolerances, and determine the effects of diet and tolerances on survival and reproduction. The expected outcome of this research will be a clearer understanding of the effects of the jellyfish on the SFE ecosystem, as well as providing information to predict trends and patterns of the jellyfish populations in response to the changing SFE environment.

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What’s Growing on Down Under: Marine Biosecurity in New Zealand

Brendan Gould, Biosecurity New Zealand

While terms such as “aquatic invasive species” (AIS) are quite familiar, the term “Marine Biosecurity,” which describes the protection of unique and/or native flora and fauna and economically important biological industries against invasion by unwanted foreign organisms, remains unfamiliar to most. Marine biosecurity issues are now well-recognized as one of the major threats to the world’s oceans, as the extent of biological invasions into coastal waters has become increasingly apparent in recent years. However, our understanding of underlying patterns in marine bioinvasions remains very limited due to both the recent emergence of the marine biosecurity discipline (compared to its terrestrial counterparts), as well as the poor baseline information and lack of consistency in information gathering approaches. The large information gaps present significant challenges for the development of effective management strategies to reduce the risks associated with invasions in marine systems. Geographically isolated from continental influences and heavily reliant on shipping for trade (>90%), New Zealand is especially predisposed to marine biosecurity risks.

As with all biosecurity issues, prevention or a reduction in the risk of new introductions is the best, and likely the most effective, strategy. This is especially important in the marine environment, given the lack of hard borders and available response tools, as well as the difficulties and costs associated with control, management or eradication of marine species. But because of the size and fluid nature of the ocean, it’s inevitable that AIS will continue to arrive. This means that there will always be a need for monitoring and surveillance, post-border pest management, and response preparedness.

Because of this situation, New Zealand’s Ministry of Agriculture and Forestry (MAF) and MAF’s subdivision, Biosecurity New Zealand, have taken the lead role in the development and implementation of an effective marine biosecurity program for New Zealand, with a number of initiatives to predict, reduce and remove the number of exotic organisms in New Zealand. MAF’s operating environment can be divided into three broad categories: pre-border programs (prevention and risk assessment); border programs (detection and interception); and post-border programs (response, control, management or eradication).

Pre-border Programs (Risk Assessment and Prevention)

The pre-border program has several major projects: (1) Value Mapping; (2) Vector and Pathways Profiling; (3) Hull Fouling; and (4) Species Profiling.

Value Mapping: This is a cross-departmental government project directed towards identifying the subcomponents of marine values New Zealand seeks to protect (economic, environmental, social and cultural); geographic locations of these subcomponents; and the relative importance of each location for a given subcomponent (e.g., for known rocky reefs in New Zealand, identifying which are most valuable in terms of their economic, environmental, social and cultural values).

Vector and Pathways Profiling: This core component of the risk analysis process is a broad project focussed on assessing the potential vectors by which AIS could reach New Zealand waters. The species and pathways associated with each vector are being assessed, with ballast water and vessel biofouling currently considered the highest risk due to New Zealand’s reliance on shipping for trade, although aquarium, aquaculture, and fresh or frozen seafood imports also pose a risk.

Hull Fouling: The objective of this sampling program is to assess the biofouling load and species associations found on slow-moving vessels (e.g., barges), passenger liners, commercial vessels and recreational yacht traffic arriving from international ports. Findings from this research will help to identify the risk associated with vessel biofouling for different vessel types and where on a vessel fouling organisms are likely to be found.

Species profiling: This work seeks to identify the “next worst” list using potential invasive species’ profile characteristics, such as life history traits and environmental tolerances. This information...
will help develop preventative measures and prospective surveillance/response programs.

**Border Programs (Detection and Interception)**

An Import Health Standard governing how ocean-going vessels handle ballast water was first issued in 1998, then revised and reissued in 2005. The Ballast Water Import Health Standard now requires vessels to submit details of tanks they intend to or may discharge in New Zealand waters at least 48 hours before they arrive, including proof of open-ocean exchange. Inspectors may then give permission for the vessel to release ballast water in New Zealand waters ahead of its arrival. Vessel crews are more likely to comply with this standard if ballast exchange can be verified by testing the ballast water. To this end, MAF is jointly funding research by the U.S. Smithsonian Institute to develop a probe that can test water in a specific ballast tank to confirm whether it contains coastal or oceanic water.

Another initiative to address ballast water introductions, and ultimately biofouling, is a proposed vessel compliance information system. The system will compile records of arriving vessels and their quarantine details (including marine biosecurity aspects) and help target vessels requiring in-depth inspections. This will also build a compliance history for repeat visitors and shipping companies to assist in developing incentives for good compliance.

**Post-border Programs (Response, Control, Management or Eradication)**

The post-border program is further divided into three key areas: (1) surveillance and monitoring; (2) incursion response and preparedness; and (3) post-border (pest) management.

**Surveillance and Monitoring**

Collecting thorough baseline information on species in existence at our busiest (therefore highest-risk) entry ports and marinas underpins MAF’s system. This baseline surveying sets out to:

- improve knowledge of NZ biodiversity and pest status;
- provide baseline information against which the effectiveness of border control or other management practices can be measured; and
- allow for the detection of changes in population distribution of existing invasive species.

Following the initial baseline work, MAF created a long-term monitoring program consisting of a series of re-surveys using the same methods as the initial baseline port surveys. These provide a measure of the rate of invasion, the success of border controls, and the effectiveness of vector and pest management actions. The port baseline surveys have identified over 1140 species in ports around the country, many of which have never previously been identified anywhere in the world. The recent *Styela clava* (sea squirt) incursion (invasion) was partially detected as a result of this baseline surveying process.

Along with the port and marina baseline surveys, MAF has also undertaken a targeted surveillance program looking for a suite of unwanted marine organisms. The study was set up to research the best methods and tools to detect the unwanted species, with the ultimate goal of implementing this methodology throughout New Zealand to provide a comprehensive national active surveillance network.

A third major component of MAF’s survey activities include passive surveillance, which engages the general public and various industries and sectors that use, work in, and are familiar with the marine environment and the species that inhabit it, in reporting any suspect discoveries. Reports from this group are being encouraged through targeted communication activities designed to reach those with marine interests, arming them with the information on what to look out for and what to do if they find something suspect.
Incursion response and preparedness

Our incursion response team and investigators assess pests and unwanted organisms capable of unacceptable harm to New Zealand’s marine environment and industry interests. The incursion response team responds to any new incursions detected as part of the surveillance and monitoring activities or through public reports. Where appropriate, the team may initiate an incursion response to identify, stop or restrict the spread of, and define the distribution of, the organism. This may be followed by an assessment of management options, including control or eradication.

Post-border management

Partnership arrangements are being developed by MAF, regional government agencies and other interested parties (such as marine and aquaculture industries) to manage the wide range of marine biosecurity issues. These include the development of regional biosecurity plans (e.g., the Fiordland Biosecurity Plan and codes of practice (e.g., the Subantarctic and Chatham Islands Code of Practice).

The Future

To ensure New Zealand’s marine biosecurity program becomes increasingly effective, MAF will continue developing and implementing a wide range of initiatives such as the baseline survey/resurvey program; an effective national surveillance system; management tools for ballast water and controls on the hull fouling pathway; finalizing a hull fouling risk analysis; undertaking species risk profiling to identify high-priority pests; and continuing to support marine biosecurity research and operational development.