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ICAIIS

17TH INTERNATIONAL CONFERENCE ON AQUATIC INVASIVE SPECIES

August 29 to September 2, 2010

Westin San Diego, San Diego, CA, USA



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Conference at a Glance

Sunday, August 29

12:00 PM to 6:00 PM
Conference Registration and A/V Check-in
7:30 PM to 9:30 PM
Invited Reception for Authors of Presentations and Posters, Session Chairs and Technical Program Committee

Monday, August 30

8:30 AM to 10:00 AM
Plenary Session
10:30 AM to 12:10 PM
Concurrent Sessions
12:15 PM to 1:30 PM
Luncheon (Provided)
12:45 PM
Speed Poster Presentations
1:30 PM to 5:00 PM
Concurrent Sessions
5:00 PM to 6:30 PM
Poster Session and Networking Mixer
Evening Free

Tuesday, August 31

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Concurrent Sessions
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Luncheon (Provided)
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Concurrent Sessions

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Concurrent Sessions
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Evening Free

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WEDNESDAY, SEPTEMBER 1

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Booth #1


Fluid Imaging Technologies, Inc.

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www.fluidimaging.com

Now in its 11th year, Fluid Imaging Technologies of Yarmouth, ME manufactures the FlowCAM[®], an imaging particle analyzer providing continuous photographic imaging and analysis of microscopic particles in a fluid medium. FlowCAM can be used to automatically analyze water samples for algal content, including taste and odor causing algae, cyanobacteria and invasive species. VisualSpreadsheet[®] software performs automated pattern recognition to distinguish different particles in a heterogeneous sample. With over 200 instruments now found on every continent, the FlowCAM is used worldwide to by marine and freshwater researchers to image, count, identify and classify phytoplankton and zooplankton. For more information, visit www.fluidimaging.com or contact us at (207) 846-6100.

Booth #3

Maritime Solutions Inc.
Martime Solutions, Inc.

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Maritime Solutions, Inc. (MSI) was founded in 1998 to bring advanced technologies into the marine and environmental marketplace. The Company's mission is to become the source for advanced concepts that address marine and environmental concerns by promoting new and innovative products and services resulting in more effective SOLUTIONS to traditional marine and environmental problems.

From its inception, Maritime Solutions targeted select areas of activity that demand the application of improved technology including treatment of ships' ballast water to prevent the introduction of non-indigenous marine species and the treatment of municipal and industrial water streams to prevent Zebra and Quagga mussel infestation.

Booth #2


Marrone Bio Innovations

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Marrone Bio Innovations[®] (MBI) discovers, develops, and markets effective and environmentally responsible natural products that focus on unmet needs for weed, pest, and plant disease management. Their newest offering is ZEQUANOX[™], the first and only invasive mussel control solution that is naturally sourced and ecologically compatible. Zequanox is a highly effective, microbial-based product that controls invasive zebra and quagga mussels (*Dreissena* species) that continue to invade freshwater ecosystems throughout North America. It selectively targets the invasive mussels, while leaving fish, birds, and important native aquatic species untouched. In addition to treating adult mussels, Zequanox prevents juveniles from settling. Zequanox is operationally compatible with existing chemical application equipment used for invasive mussel control, and carries low exposure risk for workers during application.

MBI is in the final stages of perfecting product formulations and treatment protocols for industrial and power facilities, open water, and irrigation systems. Zequanox will be the first and only naturally-sourced and environmentally safe method for invasive zebra and quagga mussel control in open water. US EPA has approved a Section 18 Emergency Use Exemption Permit submitted by the Bureau of Reclamation. MBI anticipated our full US EPA registration January 2011.

For more information on Zequanox, contact Sarahann Rackl (Dow), Invasive Mussel Project Manager, at 925-209-3076 or sdow@marronebio.com or to learn more about Zequanox and MBI online, go to www.MarroneBio.com

Booth #4


Wärtsilä

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Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers. In 2009, Wärtsilä's net sales totalled EUR 5.3 billion with more than 18,000 employees. The company has operations in 160 locations in 70 countries around the world. Wärtsilä is listed on the NASDAQ OMX Helsinki, Finland.

Wärtsilä's Environmental Services offering encompasses solutions for management and treatment of both air and water pollution, as well as energy and operation optimization solutions for marine propulsion installations and land-based power plants. During Autumn 2010, Wärtsilä will launch a Ballast Water Treatment system jointly developed with Trojan Technologies.

Monday, August 30 Morning

Plenary Session

8:30 am
Welcoming Remarks from the Bureau of Reclamation
Bob Quint, Deputy Commissioner – Operations (Acting), Bureau of Reclamation

9:00 am
Ocean Stewardship – a Future of Collaboration
Dr. Larry Robinson, Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy Administrator of NOAA

9:45 am
Questions and Discussion

10:00 am
Break

Concurrent Session A-1

Western Dreissenids

*Session Chair: Dana Anat
 Bureau of Reclamation*

10:30 am
Interbasin Transfer of Zebra Mussels from Lake Texoma, Oklahoma to the Trinity River Basin in Texas
Everett Laney, U.S. Army Corps of Engineers

10:50 am
Quagga/Zebra Mussels in California: A 2010 Update from the California Department of Fish and Game
Susan Ellis, California Department of Fish and Game

11:10 am
Prioritizing Zebra and Quagga Mussel Monitoring in the Columbia River Basin
Timothy Counihan and Amy Puls, United States Geological Survey; Steve Wells and Mark Sytsma, Portland State University, Center for Lakes and Reservoirs

11:30 am
The Continuing Saga of Quagga Mussels in Southern Nevada
Peggy Roefer, Southern Nevada Water Authority

11:50 am
Quagga Mussel Recruitment: Is Southern California Really Paradise for this Invader?
Carolynn Culver, California Sea Grant Extension Program; Daniel Daft, City of San Diego

12:15 pm
Luncheon

12:45 pm
Speed Poster Presentations

Concurrent Session B-1

Ecological and Ecosystem Impacts

*Session Chair: Gordon Brown
 U.S. Department of the Interior*

10:30 am
The Big Picture: Using Macroecology to Understand the Impacts of Freshwater Invasions
Anthony Ricciardi, McGill University

10:50 am
Effects of Climate Change on Native and Exotic Freshwater Mollusks in Riverine Ecosystems
Rob Leuven, Laura Verbrugge, Mark Huijbregts, Aafke Schipper and Gerard van der Velde, Radboud University Nijmegen; Abraham bij de Vaate, Waterfauna Hydrobiologisch Adviesbureau

11:10 am
Using Long-Term Monitoring to Investigate the Changes in Species Composition in the Harbour of Ghent (Belgium)
Pieter Boets, Koen Lock and Peter Goethals, Ghent University

11:30 am
Examining Ecological and Ecosystem-Level Impacts of Aquatic Invasive Species in Lake Michigan Using an Ecosystem Productive Model, LM-Eco
David Miller and Russell Kreis, Jr., U.S. Environmental Protection Agency; Xiangsheng Xia and Wilson Melendez, CSC

11:50 am
Exotic Invertebrates Alter Benthic Community in Lake Erie
Lyubov Burlakova, Alexander Karatayev and Christopher M. Pennuto, Buffalo State College

12:15 pm
Luncheon

12:45 pm
Speed Poster Presentations

Concurrent Session C-1

Education, Outreach and Scientific Data Exchange

*Session Chair: Peg Brady
 National Oceanic and Atmospheric Administration*

10:30 am
Aquatic Invasive Species Prevention: Start With Behavior
Douglas Jensen, University of Minnesota Sea Grant Program

10:50 am
Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States
Stephen Phillips and Bill Zook, Pacific States Marine Fisheries Commission

11:10 am
Watercraft Inspections Using Scent Detection Dogs: An Evaluation of the Efficacy of California Department of Fish and Game's Canines to Detect Dreissenid Mussels
Martha Volkoff and Lynette Shimek, California Department of Fish and Game

11:30 am
Regional Aquatic Invasive Species Spread Prevention Through Lake Stewardship Programs on Lake George, Lake Champlain, and in the Adirondacks
Meg Modley, Lake Champlain Basin Program; Emily Debolt, Lake George Association; Eric Holmlund, Paul Smith's College, Adirondack Watershed Institute

11:50 am
Enhancements to the Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS)
Rochelle Sturtevant, Great Lakes Sea Grant Network at NOAA's Great Lakes Environmental Research Laboratory; David F. Reid, National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory (Retired)

12:15 pm
Luncheon

12:45 pm
Speed Poster Presentations

Concurrent Session D-1

Asian Carp

*Session Chair: Becky Cudmore
 Fisheries and Oceans Canada*

10:30 am
Asian Carps Range Expansion Toward the Great Lakes: Can it be Stopped, What are We Doing and What Can be Done?
Phil Moy, University of Wisconsin Sea Grant Institute

10:50 am
Capture Efficiency of Asian Carp in the LaGrange Pool of the Illinois River Using Traditional Gear
Greg Sass and John H. Chick, Illinois Natural History Survey

11:10 am
Environmental DNA (eDNA) monitoring of the Asian Carp (*Hypophthalmichthys molitrix* and *H. nobilis*) in the Chicago Area Waterway linking the Mississippi River and the Laurentian Great Lakes
W. Lindsay Chadderton, The Nature Conservancy, Christopher L. Jerde, Andrew R. Mahon and David M. Lodge, University of Notre Dame

11:30 am
The Potential for Asian Carp Eggs and Larvae to Move in Tow Vessel Ballast and Barge Void Spaces
Phil Moy, University of Wisconsin Sea Grant Institute

11:50 am
The Effects of Visual and Acoustic Deterrents to Prevent the Upstream Movement of Asian Carps
Greg Sass and Blake C. Ruebush, Illinois Natural History Survey

12:15 pm
Luncheon

12:45 pm
Speed Poster Presentations

Monday, August 30 Afternoon

Concurrent Session A-2

Western Dreissenids

*Session Chair: Marc Maynard
Bureau of Reclamation*

1:30 pm

Quagga-Zebra Mussel Action Plan for Western U.S. Waters (QZAP)

*Susan Mangin, U.S. Fish & Wildlife Service;
Tom McMahon, Arizona Game and Fish
Department and Emily Austin, National Park
Service*

1:50 pm

Quagga Mussel Monitoring for the Central Arizona Project

*Albert Graves and T. Dewey, Central
Arizona Project; Renata Claudi and Carolina
Taraborelli, RNT Consulting, Canada*

2:10 pm

New Instrument to Detect and Identify Invasive Dreissenid Veligers Using a Continuous Imaging Particle Analyzer (Flowcam XP)

*Kent Petersen, Harry Nelson, Matthew
Duplisea and Benjamin Spaulding, Fluid
Imaging Technologies*

2:30 pm

Zebra Mussel Growth and Seasonal Reproductive Cycles in San Justo Reservoir, California, USA

*Tanya Veldhuizen and Jeff Janik, California
Department of Water Resources*

2:50 pm

Break

Concurrent Session B-2

Ecological and Ecosystem Impacts

*Session Chair: Gordon Brown
U.S. Department of the Interior*

1:30 pm

Aquatic Invaders in Dutch Coastal Waters: A World Heritage Site at Risk?

*Tom M. van der Have, Ministry Agriculture,
Nature & Food Quality; Adriaan Gittenberger,
GiMaRIS*

1:50 pm

Xenopus laevis in Golden Gate Park: A Field Study

*Steve Felt, David Chu, Antwain Howard and
Sherril Green, Stanford University School
of Medicine, Department of Comparative
Medicine*

2:10 pm

Evaluation of International Risk Assessment Protocols for Exotic Species

*Laura Verbrugge and Rob S.E.W. Leuven,
Radboud University Nijmegen, Institute for
Water and Wetland Research, Department
of Environmental Science; Wiebe Lammers,
Ministry of Nature, Agriculture and Food
Safety, Plant Protection Service; Gerard van
der Velde, Radboud University Nijmegen,
Institute for Water and Wetland Research,
Department of Animal Ecology and
Ecophysiology*

2:30 pm

Aquatic Invasive Species in the Laguna Madre/Rio Bravo Ecological Region

*Roberto Mendoza, Juanita Hernández,
Verónica Segovia, Ivonne Jasso, Nelson
Arreaga and Daniela Pérez, Universidad
Autónoma de Nuevo León, Facultad de
Ciencias Biológicas*

2:50 pm

Break

Concurrent Session C-2

Education, Outreach and Scientific Data Exchange

*Session Chair: Curt Brown
Bureau of Reclamation*

1:30 pm

Tracking Invasive Species with a Unique Tool to Set Up and Manage a Network of Observers (BIOAPP)

*Hélène Godmaire, Caroline Larivière and
Valérie Lacourse, Great Lakes United,— Union
Saint-Laurent Grands Lacs; Blaise Barrette,
Les Productions un Monde à Part*

1:50 pm

It's in the Bag – Managing the Potential Spread of AIS from Crane Testing Water Weights

*Paul Heimowitz, U.S. Fish and Wildlife Service;
Joe DiVittorio, Bureau of Reclamation; Angelo
Cimini, Imes Inc.*

2:10 pm

Invading Species Watch: A Volunteer Based Monitoring Program in Ontario's Inland Lakes

*Francine MacDonald and David Copplestone,
Ontario Federation of Anglers and Hunters*

2:30 pm

Using Risk Perception to Determine if *Didymosphenia geminata* Poses a Risk to Tasmania, Australia

*Marnie Campbell, Nicole Cliff and Chad Hewitt,
National Centre for Marine Conservation and
Resource Sustainability, Australian Maritime
College*

2:50 pm

Break

Concurrent Session D-2

Asian Carp

*Session Chair: Phil Moy
University of Wisconsin Sea Grant
Institute*

1:30 pm

Bighead and Silver Carps in the Great Lakes: Understanding the Complexities and Uncertainties

*Duane Chapman, U.S. Geological Survey,
Columbia Environmental Research Center,
Patrick M. Kovovsky, U.S. Geological Survey,
Great Lakes Science Center*

1:50 pm

Above presentation continued

2:10 pm

Development of Methods to Orally Deliver Biocides to Control or Limit Invasive Aquatic Animals

*Terence Hubert and M.P. Gaikowski,
U.S. Geological Survey, Upper Midwest
Environmental Sciences Center*

2:30 pm

Use of Pheromones to Control Invasive Asian Carp

*Edward Little and Robin D. Calfee, U.S.
Geological Survey, Columbia Environmental
Research Center*

2:50 pm

Break

Monday, August 30 Afternoon

Concurrent Session A-3

Western Dreissenids

*Session Chair: Chris Holdren
Bureau of Reclamation*

3:20 pm

The Quagga Mussel: Reclamation's Control Options for Dealing with an Invasive Species

Leonard Willett, Bureau of Reclamation

3:40 pm

Salt River Project's Invasive Mussel Outreach and Education Efforts in Phoenix, Arizona

Lesly Swanson, SRP Environmental Siting and Studies

4:00 pm

Settlement and Growth of Quagga Mussels (*Dreissena bugensis*) in Lake Mead, USA

David Wong and Shawn Gerstenberger, University of Nevada Las Vegas; Wen Baldwin and Bryan Moore, National Park Service

4:20 pm

Interagency Monitoring Action Plan (I-MAP): Quagga Mussels in Lake Mead National Recreation Area

Kent Turner, National Park Service, David Wong and Shawn Gerstenberger, University of Nevada Las Vegas

4:40 pm

From Sink to Source? An Overview of Zebra Mussel (*Dreissena polymorpha*) Population Dynamics in Reservoirs of the South-Central USA

Chad Boeckman and Joseph Bidwell, Oklahoma State University; Jason Goeckler, Kansas Department of Wildlife and Parks; Everett Laney, U.S. Army Corps of Engineers

Concurrent Session C-3

Education, Outreach and Scientific Data Exchange

*Session Chair: Douglas Jensen
University of Minnesota Sea Grant Program*

3:20 pm

Reducing the Risks of Schools, Science Curricula and Biological Science Suppliers as Potential Pathways for Spreading Aquatic Invasive Species: Turning a "Home Town" Problem into Education and Prevention Opportunities of Bi-National Scope: Phase 1 and 2

Samuel Chan, Tania Siemens, Denise Lach, Tim Miller-Morgan and Skye Root, Oregon State University; Robin Goettel and Pat Charebois, Illinois Indiana Sea Grant; Matthias Herborg, BC Ministry of Environment; Jeff Brinsmead, Ontario Ministry of Natural Resources; Charles Jacoby, University of Florida; Susan Zaleski and Kevin Moua, University of Southern California Sea Grant; Rochelle Sturtevant, NOAA; Wei-Ying Wong, Connecticut College; Helen Domske, Cornell University; Jeff Adams and Julian Olden, University of Washington

3:40 pm

Live Organisms in the Classroom: Value and Implications for Invasive Species Management

Wei Ying Wong, Connecticut College; Samuel Chan and Tania Siemens, Oregon Sea Grant; Charles Jacoby, St. Johns River Water Management District; Jeff Brinsmead, Ontario Ministry of Natural Resources; Matthias Herborg, British Columbia Ministry of the Environment; Tim Miller-Morgan, Denise Lach and Skye Root, Oregon State University; Kevin Moua and Susan Zaleski, University of Southern California Sea Grant; Robin G. Goettel, Patrice Charlebois; Kristin TePas and Terri Hallesy, Illinois-Indiana Sea Grant Program

4:00 pm

"AIS in the Classroom" Pathway: How do Biological Supply Houses Factor in?

Patrice Charlebois and Kristin TePas, Illinois-Indiana Sea Grant/Illinois Natural History Survey; Samuel Chan and Tania Siemens, Oregon Sea Grant; Wei Ying Wong, Goodwin-Niering Center for Conservation Biology & Environmental Studies; Charles Jacoby, University of Florida; Jeff Brinsmead, Ministry of Natural Resources; Denise Lach, Oregon State University; Robin Goettel and Terri Hallesy, Illinois-Indiana Sea Grant

4:20 pm

Citizen Scientists Contribute to the First Verified Discovery of the Colonial Tunicate (*Didemnum vexillum*) in Oregon: Education and Management Lessons Being Learned

Samuel Chan, Sea Grant Extension, Oregon State University; Rick Boatner, Oregon Department of Fish and Wildlife; Lorne Curran, Volunteer Scientific Diver, REEF and Oregon Coast Aquarium; Bruce Hansen, U.S. Department of Agriculture Forest Service, PNW Research Station

4:40 pm

Enhancing Surveillance for Marine Pests in Northern Australia by Engaging Indigenous Marine Rangers

Helen Cribb, Department of Resources, Northern Territory Government, Australia

Concurrent Session D-3

Asian Carp

*Session Chair: Becky Cudmore
Fisheries and Oceans Canada*

3:20 pm

Placing Control of Asian Carps in a Spatially Explicit Context

James Garvey, Southern Illinois University

3:40 pm

Summary Remarks and Discussion

Becky Cudmore, Fisheries and Oceans Canada

Monday, August 30, 5:00 pm to 6:30 pm

Poster Session

BIOAPP: A Unique Tool to Set Up and Manage a Network of Observers

Blaise Barrette, Les Productions un Monde à Part Inc.

Nonindigenous Copepods and Plankton Dynamics of the Lower Columbia River Estuary

Stephen Bollens, Joanne Breckenridge, Gretchen Rollwagen Bollens and Olga Kalata, Washington State University, School of Earth and Environmental Sciences; Jeffery Cordell, University of Washington, School of Aquatic and Fishery Sciences

Patterns of Aquatic Macrophyte Richness and Aquatic Invasive Species Across Europe and the Mediterranean Region

Eglantine Chappuis, Esperança Gacia, Enric Ballesteros, Centre d'Estudis Avançats de Blanes

One-Stop-Shop for AIS Regulations: A National Database of State and Federal Laws

Patrice Charlebois and Kristin TePas, Illinois-Indiana Sea Grant & Illinois Natural History Survey; Nicole Furlan, and Angela Archer, Illinois-Indiana Sea Grant

The Devastating Effects of an Invasive Fish, Roach (*Rutilus rutilus*), on the Flesh Colour of a Wild Brown Trout (*Salmo trutta*) Population in an Irish Lake Over a Ten Year Period (1999 – 2009)

Ronan Cusack, Western Regional Fishery Board; Frances Lucy, Institute of Technology, Sligo; Martin O'Grady, Central Fishery Board; Greg Forde, Liam Gavin and Frank Reilly, Western Regional Fishery Board; Vaughan Lewis, Wild Brown Trout Trust

Aquatic Disease Biosecurity: Moving Away from an Approach Based on Pathogens

Marty Deveney, South Australian Research and Development Institute; Ramesh Perera, Biosecurity Australia; J. Jones, Department of Fisheries

Oxygen Depletion Events Control the Invasive Golden Mussel (*Limnoperna fortunei*) in a Tropical Floodplain

Márcia Divina de Oliveira and Débora F. Calheiros, Embrapa Pantanal; Stephen K. Hamilton, Michigan State University, Kellogg Biological Station and Department of Zoology

California Department of Fish and Game's Invasive Species Program

Holly Gellerman and Susan Ellis, California Department of Fish and Game

Multiple Introductions and Invasion Pathways for the Invasive Ctenophore *Mnemiopsis leidyi* in Eurasia

Sara Ghabooli, Aibin Zhan, Melania Cristescu and Hugh MacIsaac, University of Windsor; Tamara Shiganova, Russian Academy of Sciences, P. Shirshov Institute of Oceanology; Peyman Eghtesadi-Araghi, Iranian National Center for Oceanography

Educators and the Erie Canal: An Effective Partnership for AIS Training

Michael Goehle, U.S. Fish & Wildlife Service; Helen Domske, New York Sea Grant – Cornell University

Interdicting Aquatic Nuisance Species through Emergency Treatment of Ballast Water: A Management Perspective

Phyllis Green, National Park Service

Evaluation of a Habitat Suitability Model for the Invasive European Green Crab (*Carcinus maenas*) Using Species Occurrence Data from Western Vancouver Island, British Columbia

Jodi Harney, Coastal and Ocean Resources Inc; Linda Shaw, NOAA National Marine Fisheries Service

Zebra and Quagga Mussel Monitoring in the California State Water Project

Jeff Janik and Tanya Veldhuizen, California Department of Water Resources

Rancho California Water District's Pioneering Effort to Achieve 100% Prevention of Quagga Mussels with Self-Cleaning Screen Filtration Systems for Vail Lake

Nicole Murphy and Sunny Huang, Kennedy/Jenks Consultants; Corey Wallace, Rancho California Water District; Renata Claudi, RNT Consulting

Performance of Anti-Fouling and Foul-Release Coatings Exposed to Zebra Mussels, San Justo Reservoir, California, USA

Dan Salyers, Tanya Veldhuizen and Jeff Janik, California Department of Water Resources

Monitoring of Invasive Alien Species in Constanta Harbor

Cristina Preda and Marius Skolka, Ovidius University of Constanta

Managing Aquatic Invasive Species in Ocean and Coastal National Parks

Chenier Prudhomme, Rita Beard, Eva DiDonato and Julia Brunner, National Park Service

Creating Tools for Invasive Species Decision Support at a Global Scale: Distribution Maps and Models of Predicted Potential Distribution

Annie Simpson, U.S. Geological Survey

Evaluation of New Coating Products for Mitigation of Zebra/Quagga Mussel Colonization

Allen Skaja and David Tordonato, Bureau of Reclamation

Bactericidal Effect of Increased pH to Aquatic Pathogenic and Ship Ballast Environmental Bacteria

Clifford Starliper and Barnaby Watten, U.S. Geological Survey, Leetown Science Center

Salinity Tolerance of the Exotic Round Goby: Experimental Implications for Seawater Ballast Exchange

Carol Stepien, Susanne Karsiotis and Lindsey Pierce, University of Toledo; Joshua Brown, NOAA Sea Grant

How the Physical Dispersion of Ballast Water Influences the Risk of Aquatic Invasive Species Establishment – Field Observations and Modelling

Yajun Sun, University of Toronto

Rapid Assessment Surveys and Protocols for Lionfish Invasions in National Parks

Brittany Thompson, Jeffrey Cross, Eva DiDonato and Rita Beard, National Park Service

Ecosystem Impacts of Quagga Mussels in Lake Mead Arizona-Nevada, USA

Todd Tietjen and Peggy Roefer, Southern Nevada Water Authority; G. Chris Holdren, Bureau of Reclamation

Response to the Invasion of *Undaria pinnatifida* in San Francisco Bay, CA, USA

Chela Zabin, Smithsonian Environmental Research Center and University of California, Davis; Vanessa Guerra, Smithsonian Environmental Research Center, University of California, Davis and California State Lands Commission; Jonathan Thompson, U.S. Fish & Wildlife Service; Christopher Scianni and Nicole Dobroski, California State Lands Commission; Chris Brown and Gail Ashton, Smithsonian Environmental Research Centre; Edwin Grosholz, University of California, Davis

Tuesday, August 31 Morning

Plenary Session

Session Chair: Sharon Gross, U.S. Geological Survey

8:30 am

Addressing Aquatic Invasive Species at the Bureau of Reclamation

Michael Gabaldon, Director of Technical Resources, Bureau of Reclamation

9:00 am

The Way Forward - A Strategic Plan to Preclude the Establishment of Asian Carp in the Great Lakes

Bill Bolen, Senior Advisor, U.S. Environmental Protection Agency

9:30 am

Questions and Discussion

10:00 am

Break

Concurrent Session A-4

Industrial Control Technologies

*Session Chair: Renata Claudi
RNT Consulting Inc.*

10:30 am

Mexel Efficiency Study – Results of Year-long Pilot Study at American Electric Power’s DC Cook Nuclear Plant

Doug Bronicki, American Electric Power, DC Cook Nuclear Plant, Thomas Armon, H-O-H Water Technology

10:50 am

Developing Use Pattern for Potential Open-Water Application of Zequanox™ – A Microbial-Based Technology for Selective Control of Invasive Dreissenid Mussels

Mark Heilman, Tyler Koschnick and Brad Franklin, SePRO Corporation; Sarahann Dow and Dustin Ottman, Marrone Bio Innovations

11:10 am

Evaluating Zebra Mussel (*Dreissena polymorpha*) Response to Desiccation at a Central California Water Supply Reservoir

Ned Gruenhagen and Michelle Chapman, Bureau of Reclamation

11:30 am

Demonstration Trials at DeCew II Generating Station at Ontario Power Generation Using Zequanox

Tony Van Oostrom, Ontario Power Generation; Kelly Peterson, ASI Group; Sarahann Dow, Marrone Bio Innovations

11:50 am

Surveillance, Maintenance, Instrumentation and Monitoring of Underwater Infrastructure; with Focus on Dreissenid Mussels

Robert Clarke, ASI Group Ltd.; Albert Graves, Central Arizona Project

12:15 pm

Luncheon

Concurrent Session B-4

Molecular Techniques and Applications to AIS Monitoring and Detection

*Session Chair: Doug Mountfort
Cawthron Institute*

10:30 am

Towards “Next Generation” Molecular Detection Methods for the Surveillance and Monitoring of Marine Pests in New Zealand

Douglas Mountfort, Cawthron Institute, Kirsty Smith, Susie Wood, Lesley Rhodes and Marek Kirs; Graham McBride and Graeme Inglis, National Institute of Water & Atmospheric Research

10:50 am

Modeling and Estimating Uncertainty in Environmental DNA Surveillance of Invasive Asian Carps

Cameron R. Turner, Derryl J. Miller, Christopher L. Jerde, Andrew R. Mahon, Matthew A. Barnes and David M. Lodge, University of Notre Dame, Center for Aquatic Conservation; W. Lindsay Chadderton, The Nature Conservancy

11:10 am

Using Two Robotic Platforms Developed at the Monterey Bay Aquarium Research Institute (MBARI) for Molecular Detection and Monitoring of Marine Invertebrate Larvae and Major Copepod Groups *in situ*

Julio B. J. Harvey, Roman Marin III, John P. Ryan, Nilo Alvarado, Shannon B. Johnson, Chris Preston, Christopher A. Scholin and Robert C. Vrijenhoek, Monterey Bay Aquarium Research Institute

11:30 am

Nucleic Acid Probes for Detection and Management of Marine Pests: Applications and Capabilities, Prospects and Limitations in a Genomic Era

Jawahar Patil, CSIRO

11:50 am

Unique RT-PCR test for Replicating VHS Virus with Internal Controls

Carol Stepien, Lindsey Pierce, James Willey, Erin Crawford and Douglas Leaman, University of Toledo

12:15 pm

Luncheon

Concurrent Session C-4

Shipping: Testing Treatment Systems and Management Practices

*Session Chair: Sarah Bailey
Fisheries and Oceans Canada*

10:30 am

Evaluation of Ballast Water Treatment Systems: Programmatic Overview of U.S. Coast Guard Research and Development Efforts

Richard A. Everett, U.S. Coast Guard, Environmental Standards Division

10:50 am

U.S. Coast Guard R&D Center Ballast Water Research Program: Parsing the Problem

Penny Herring, Gail Roderick and Marion Lewandowski, U.S. Coast Guard R&D Center

11:10 am

A Statistical Treatment of Ballast Water Discharge Sampling for the Evaluation of Treatment Efficacy and the Implications for Regulatory Purposes

Edward Lemieux, Kevin Burns and Lisa Drake, Naval Research Laboratory

11:30 am

Ballast Water Discharge Sampling: Approximating Zooplankton Retention Efficiencies Using Microbeads

Lisa Drake, Mia Steinberg, Stephanie Robbins and Scott Riley, Science Applications International Corporation; Tim Wier, EXCET, Inc.; Wayne Hyland, Azimuth Technical Consultants; Edward Lemieux, U.S. Naval Research Laboratory

11:50 am

Quantifying Viability in Protists Discharged in Ballast Water Using Two Fluorescent Vital Stains

Mia Steinberg, Scott Riley, Stephanie Robbins, Edward Lemieux and Lisa Drake, Naval Research Laboratory; Bruce Nelson, Battenkill Technologies

12:15 pm

Luncheon

Concurrent Session D-4

Policy and Programs

*Session Chair: Mark Burrows
International Joint Commission*

10:30 am

Early Detection of Invasive Alien Aquatic Species in the St. Lawrence River and Estuary through a Commercial Fisherman Network: A Three-year Experiment Evaluation.

Guy Verreault, Genevieve Bourget, Anne-Marie Pelletier, Réhaume Courtois and Anouk Simard, Ministère des Ressources naturelles et de la Faune, Quebec

10:50 am

From Paper to Practice: Launching the World’s Most Stringent Ballast Water Standards

Nicole Dobroski, Christopher Scianni, Lynn Takata and Maurya Falkner, California State Lands Commission

11:10 am

(Re)thinking Aquatic Nonindigenous Species Impact Assessment

Alisha Dahlstrom, Marnie Campbell and Chad Hewitt, University of Tasmania, Australian Maritime College

11:30 am

Rapid Response Planning for Aquatic Invasive Species in the Lake Champlain Basin

Meg Modley, Lake Champlain Basin Program

11:50 am

Bi-National, Economic Considerations in Co-Managing Invasive Species and Water Quality for California and Baja California Coastal Boats

Leigh Johnson, University of California and Linda Fernandez, University of California, Riverside

12:15 pm

Luncheon

Tuesday, August 31 Afternoon

Concurrent Session A-5

Industrial Control Technologies

*Session Chair: Tony Van Oostrom
Ontario Power Generation*

1:30 pm

pH and Calcium – Natural Limits in Zebra Mussel Spread

Frances Lucy, Institute of Technology, Sligo; Sergey Mastitsky, University of Heidelberg, Department of Bioinformatics; Renata Claudi, RNT Consulting

1:50 pm

Adjustment of pH as Method of Control for Dreissenid Mussels

Albert Graves, Central Arizona Project; Renata Claudi, Robert Prescott and Carolina Taraborelli, RNT Consulting

2:10 pm

Novel Approaches for Management of Invasive Quagga Mussels in a Large Water Supply System

Ricardo De Leon, William Taylor, Paul Rochelle, Sun Liang, Anthea Lee, Metropolitan Water District of Southern California

2:30 pm

Macrofouling Control of Invasive Species: A Critical Evaluation of Current Methods, Efficacy and Shortcomings

Sanjeevi Rajagopal and Gerard van der Velde, Radboud University Nijmegen; Vayalam Venugopalan, BARC Facilities; Henk Jenner, KEMA Power Generation and Sustainables

2:50 pm

Break

Concurrent Session B-5

Molecular Techniques and Applications to AIS Monitoring and Detection

*Session Chair: Doug Mountfort
Cawthron Institute*

1:30 pm

Toward Practical, PCR-based Detection Methods for the Surveillance of Marine Pests from Australian Ports and Waterways

Nathan Bott, Alan McKay, Kathy Ophel-Keller and Marty Deveney, South Australian Research and Development Institute

1:50 pm

Identification of Ballast Sediment Invertebrate Species Using Resting Eggs and Mitochondrial Markers

Hugh MacIsaac, University of Windsor, Elizabeta Briski and Melania Cristescu, University of Windsor, Sarah Bailey, Fisheries and Oceans Canada

2:10 pm

Zebra Mussels – Bioindicators for Seasonal Trends in Cryptosporidiosis

Frances E. Lucy and Declan Feeney, Institute of Technology, Sligo; Thaddeus K. Graczyk, Leena Tamang and Talia E. Abbott Chalew, Johns Hopkins Bloomberg School of Public Health; Theo de Waal, Annetta Zintl and Marzieh Ezzaty Mirhashemi, University College Dublin

2:30 pm

Something Old and Something New: Tracking AIS Incursions through Space and Time Using Molecular Data from Established Populations

Sharyn Goldstien and David Schiel, University of Canterbury; Graeme Inglis, NIWA; Neil Gemmell, University of Otago

2:50 pm

Break

Concurrent Session C-5

Shipping: Testing Treatment Systems and Management Practices

*Session Chair: Peg Brady
National Oceanic and Atmospheric Administration*

1:30 pm

Automated Analyses of Ballast Water Samples for the Enumeration of Viable Organisms in the $\geq 50 \mu\text{m}$ Size Class

Bruce Nelson, Battenkill Technologies; Mia Steinberg, Scott Riley, Stephanie Robbins, Edward J. Lemieux, Penny Herring, and Lisa A. Drake, Naval Research Laboratory

1:50 pm

Flow-through Discharge Sampling: Design and Validation

Timothy Wier, EXCET Inc.; Lisa Drake and Edward Lemieux, Naval Research Laboratory; Jonathan Grant, Battenkill Technologies

2:10 pm

An Automation and Control System Specification for Verification of Ballast Water Treatment Systems

Jonathan Grant, Battenkill Technologies, Inc.; Timothy Wier, Excet, Inc.; Edward Lemieux, U.S. Naval Research Laboratory

2:30 pm

Intercomparison of U.S. Ballast Water Test Facilities

Lisa Drake, Science Applications International Corporation; Tim Wier, EXCET, Inc.; Jonathan Grant, Battenkill Technologies, Inc.; Edward Lemieux, Naval Research Laboratory

2:50 pm

Break

Concurrent Session D-5

Policy and Programs

*Session Chair: Victor Serveiss
International Joint Commission*

1:30 pm

Plan to Eradicate Invasive Spartina from the West Coast

Mark Sytsma, Portland State University

1:50 pm

Lake Superior Aquatic Invasive Species Complete Prevention Plan

Roger Eberhardt, Michigan Department of Environmental Quality; Susan Greenwood, Ontario Ministry of Natural Resources; Amy Thomas, Battelle; Elizabeth LaPlante, United States Environmental Protection Agency; Nancy Stadler-Salt, Environment Canada

2:10 pm

Management of Marine Pests in the Australian Context: Biofouling Policy Development

Sonia Gorgula, Australian Government Department of Agriculture, Fisheries and Forestry

2:30 pm

Binational Aquatic Invasive Species Rapid Response Assessment and Planning International Joint Commission Work Group Activities

Mark Burrows, International Joint Commission Great Lakes Regional Office

2:50 pm

Break

Tuesday, August 31 Afternoon

Concurrent Session A-6

Industrial Control Technologies

*Session Chair: Michelle Chapman
Bureau of Reclamation*

3:20 pm

Assessing the Efficiency and Safety of the Antifouling MXD-100 for Control of Invasive Species *Limnoperna fortunei* (Dunker, 1857) in Power Plants

Carlos Alberto Dias and Frederico Augusto Ribeiro da Mata, Maxclean Ambiental e Química S/A; Fabiano Alcísio e Silva, Mônica de Cássia Souza Campos and Fábio de Castro Patrício, Fundação Centro Tecnológico de Minas Gerais

3:40 pm

The Use of Barriers in Combination with Chemical Treatment to Eradicate the Fatal Atlantic Salmon (*Salmo salar*) Parasite *Gyrodactylus salaris*

Jarle Steinkjer, Directorate for Nature Management

4:00 pm

Evaluation of Zequanox™ for Adult Invasive Mussel Treatment and Settlement Prevention at Davis Dam

Sarahann Dow and Carolyn Link, Marrone Bio Innovations, Frederick Nibling and Joseph Kubitschek and Leonard Willett, Bureau of Reclamation;

4:20 pm

Evaluation of Auto-Backwash Filters in an Irrigation System to Control Dreissenid Mussels

Garry Smythe, Shaw Environmental and Infrastructure Inc.; Gary Osminski, Huron County

4:40 pm

Evaluation of New Coating Products for Mitigation of Zebra/Quagga Mussel Colonization

Allen Skaja and David Tordonato, Bureau of Reclamation

5:00 pm

Mussel Eradication: A Portable Option

Dan Butts, ASI Group

5:20 pm

Two New Coatings for Preventing Biofouling of Zebra Mussels and Algae

Erik W. Edwards, Ramanathan S. Lalgudi, Craig Bartling, and Henry Pate, Battelle Memorial Institute, Advanced Materials Applications

Concurrent Session B-6

Molecular Techniques and Applications to AIS Monitoring and Detection

*Session Chair: Doug Mountfort
Cawthron Institute*

3:20 pm to 4:30 pm

Questions and Discussion

Concurrent Session C-6

Shipping: Testing Treatment Systems and Management Practices

*Session Chair: Christopher J. Wiley
Fisheries and Oceans Canada/Transport Canada Marine*

3:20 pm

U.S. Coast Guard Experience with Implementation of a Prototype Ballast Water Management Equipment Evaluation Program

LCDR Brian Moore and Richard Everett, United States Coast Guard

3:40 pm

Assessment of Plankton Density in Ballast Water Samples Using a High Resolution Laser Optical Plankton Counter and FlowCAM®

Jocelyn Gerlofsma and Sarah Bailey, Fisheries and Oceans Canada

4:00 pm

Verification Trial of IMO Type Approved Ballast Water Management Systems

Peter Neimanis, Australian Quarantine and Inspection Service

Concurrent Session D-6

Policy and Programs

*Session Chair: Mark Burrows
International Joint Commission*

3:20 pm

Prevention and Detection of Quagga Mussels (*Dreissena bugensis*), Zebra Mussels (*Dreissena polymorpha*), and Other Aquatic Invasive Species at Aquaculture Facilities

Martha C. Volkoff, California Department of Fish and Game

3:40 pm to 4:40 pm

Workshop

Using the Bureau of Reclamation Equipment Inspection and Cleaning Manual

Joseph DiVittorio, Bureau of Reclamation

Wednesday, September 1 Morning

Plenary Session: Risk Analysis in a Changing World

Session Chair: Joseph DiVittorio, U.S. Bureau of Reclamation

8:30 am

California's Marine Invasive Species Program: Merging Stakeholder Involvement, Politics and Good Science

Maurya Falkner, California State Lands Commission

9:00 am

The National Invasive Species Council: An All Taxa Approach

Chris Dionigi, Assistant Director for Domestic Policy, National Invasive Species Council

9:30 am

Questions and Discussion

10:00 am

Break

Concurrent Session A-7

Aquatic Plants

Session Chair: Linda Nelson
U.S. Army Corps of Engineers

10:30 am

Integrating Landscape-Level Strategies and Tools to Manage Invasive *Egeria densa* in the Sacramento-San Joaquin Delta, California, USA

Lars Anderson, U.S. Department of Agriculture-ARS; Tyler Koschnick and Scott Shuler, SePRO Corporation; Scott Ruch, RuchLogic; Marica Carlock, California Department of Boating and Waterways; Maria J. Santos, University of California, Davis; Susan L. Ustin, Center for Spatial Technologies and Remote Sensing

10:50 am

New Data on the Reproductive Phenology of the Introduced Kelp *Undaria pinnatifida* (Phaeophyceae, Laminariales) in Port Phillip Bay (Victoria, Australia)

Carmen Primo, Marnie L. Campbell and Chad L. Hewitt, Australian Maritime College – University of Tasmania

11:10 am

Understanding the Lifecycle and Morphology of the Invasive *Lagarosiphon major* in Lough Corrib, Ireland, in Order to Develop Effective Control Practices

Michael Millane, Stephanie Evers, Joseph M. Caffrey, Helen Moran and Shireen Sayed, Central Fisheries Board

11:30 am

Control of *Lagarosiphon major* and Restoration of Indigenous Communities Using a Biodegradable Geotextile to Exclude Light

Joseph M. Caffrey, Stephanie Evers, Michael Millane, Helen Moran and Shireen Sayed, Central Fisheries Board; M. Butler, Western Regional Fisheries Board

11:50 am

Genetic Population Structure of an Invasive Aquatic Weed, *Elodea canadensis*, in Finland – One or Multiple Invasions?

Tea Huotari, Helena Korpelainen, Elina Leskinen, University of Helsinki; Kirsi Kostamo, Finnish Environment Institute

12:15 pm

Luncheon

Concurrent Session B-7

Crustaceans

Session Chair: Gerard van der Velde
University of Neijmegen

10:30 am

Habitat Use and Dispersal Capacity of the Nonindigenous Isopod *Cirolana harfordi*

Denise Bunting, University of Sydney; Ross Coleman, Will Figueira, University of Sydney; Sebastian Holmes, University of Sydney; School of Biological Sciences Emma Johnston, The University of New South Wales

10:50 am

Distribution and Habitat Preferences of the Invasive Crustacean *Hemimysis anomala* in the Great Lakes

Kelly Bowen, Jocelyn Gerlofsma and Marten Koop, Fisheries and Oceans Canada; Tim Johnson, Ontario Ministry of Natural Resources

11:10 am

A Quick Test to Establish the Predation Capacity in Exotic and Native Gammaridean Species

Gerard van der Velde, Bart Stoffels, Jeroen Tummers and Rob Leuven, Radboud University Nijmegen; Dirk Platvoet, University of Amsterdam

11:30 am

Genetic Admixture Dynamics Reveal Dispersal Patterns in a Coastal Marine Invasion

John Darling, U.S. Environmental Protection Agency; April Blakeslee, Smithsonian Environmental Research Center; Joe Roman, University of Vermont; Cynthia McKenzie, Fisheries and Oceans Canada; Jeb Byers, University of Georgia; Jamie Pringle, University of New Hampshire

11:50 am

Potential Impact of Chinese Mitten Crab (*Eriocheir sinensis*) on Turbidity and Submerged Vegetation in Lake Zuidlaardermeer, Northern Netherlands

J.H. Wanink, R. Bijkerk and M.J.J.E. Loonen, Koeman en Bijkerk bv, Ecological Research and Consultancy; M.L.C. Heukels and R.W. de Jong Van Hall Instituut, Department of Animal Management; Van Hall Instituut, Department of Animal Management; P.P. Schollemma and H. Wanningen, Water Board Hunze en Aa's

12:15 pm

Luncheon

Concurrent Session C-7

Shipping: Risk, Policy and Programs

Session Chair: Richard Everett,
U.S. Coast Guard

10:30 am

Patterns of Compliance, Geography and Management of Ballast Water in California

Lynn Takata, Chris Scianni, Nicole Dobroski and Maurya Falkner, California State Lands Commission

10:50 am

An Analysis of the Fouling-Related Practices of Commercial Vessels in California

Christopher Scianni, Nicole Dobroski, Lynn Takata and Maurya Falkner, California State Lands Commission

11:10 am

Minimizing the Spread of Marine Nonindigenous Invasive Species Through Application of Boat Hull Antifouling Strategies: To Clean or Not to Clean?

Leigh Johnson and Carolyn Culver, University of California; Henry Page and Jenifer Dugan, University of California, Santa Barbara

11:30 am

Elements of Marine Biofouling Risk

Chad Hewitt, Marnie Campbell and Alisha Dahlstrom, University of Tasmania, Australian Maritime College; Ashley Coutts and Derek Shields, Aquenal, Joe Valentine, Hobart

11:50 am

National Risk Assessment of Ship-mediated ANS Introductions to Canada's Four Coasts

Sarah Bailey, Johanna Bradie, Matthew Deneau, Nathalie Simard, Cynthia McKenzie, Kim Howland, Jennifer Martin and Terri Sutherland Fisheries and Oceans Canada; Farrah Chan, University of Windsor

12:15 pm

Luncheon

Wednesday, September 1 Afternoon

Concurrent Session A-8

Aquatic Plants

Session Chair: Linda Nelson
U.S. Army Corps of Engineers

1:30 pm

Alien Attack – Invasion of *Alternanthera philoxeroides* (Mart.) Griseb (Alligator weed) in Wular Lake of Kashmir, India

Ather Masoodi and Fareed Khan, Aligarh Muslim University,
Jonathan Newman Centre for Ecology and Hydrology

1:50 pm

Caulerpa taxifolia in South Australia and Queensland: Parallel Histories

Marty Deveney, Keith Rowling, Kathryn Wiltshire and
Jason Tanner, South Australian Research and Development
Institute; Dana Burfeind, Griffith University, Australia;
James Udy, The University of Queensland

2:10 pm

Research and Testing of a System for Precision Littoral Zone Application of Aquatic Herbicides

Thomas McNabb and Thomas Moorhouse, Clean Lakes, Inc.;
Bruce Sabol, U.S. Army Engineer Research and Development
Center

2:50 pm

Break

Concurrent Session B-8

Crustaceans

Session Chair: Rob Leuven
University of Neijmegen

1:30 pm

Introduction of the European Common Barnacle *Balanus perforatus* Brugière (Crustacea, Cirripedia) into Korean Waters

Il-Hoi Kim, Kangnung National University, Department
of Biology; Jae-Sang Hong, Inha University, Department
of Ocean Sciences

2:50 pm

Break

Concurrent Session C-8

Shipping: Risk, Policy and Programs

Session Chair: Christopher J. Wiley
Fisheries and Oceans Canada and Transport Canada,
Ontario Region

1:30 pm

Canada's Ballast Water Program – Science, and Risk Supporting Internationally Based Regulatory Regime

Paul Topping and David Yard, Transport Canada

1:50 pm

Fresh Water; Neglected in Shipboard Ballast Water Treatment Testing and Approval – A Potential Solution

Christopher J. Wiley, Transport Canada – Ontario Region

2:10 pm

Establishing a Scientific Foundation for Numeric Concentration of Living Organisms in Ballast Water Discharge Limits under U.S. EPA's Vessel General Permit (VGP)

Ryan Albert and Henry Lee II, U.S. Environmental Protection
Agency

2:30 pm

Can We Sample Ships to Assess Compliance with Ballast Water Management Standards?

Stephan Gollasch, GoConsult; Matej David, University
of Ljubljana

2:50 pm

Break

Wednesday, September 1 Afternoon

Concurrent Session A-9

Marine Invaders

Session Chair: Susan Pasko
National Oceanic and Atmospheric Administration

3:20 pm

Marine Invasive Species in the Greater Gulf of Maine/ Gulf of St. Lawrence Ecoregion – an Information Perspective

David G. Oliver, Skylark Information Systems Ltd.

3:40 pm

Celtodoryx ciocalyptoides: The First Record of a Sponge Species Transferred from One World Ocean into Another by Human Activity

Daniela Henkel, Forschungsinstitut und Naturmuseum
Senckenberg

4:00 pm

Investigating the Microbiology of an Invasive Marine Oyster: Gulf of Eilat vs. the Eastern Mediterranean Sea

Dror Zurel, Uri Gophna and Yehuda Benayahu, Porter School for
Environmental Studies, Tel Aviv University, Department
of Molecular Microbiology and Biotechnology

4:20 pm

How to Kill Over 100,000 Wild Pacific Oysters in One Day: Research and Experiences from a Successful Control Exercise Over 25km of Infested Intertidal Reef in South Australia

Michael T. Sierp, Department of Primary Industries
and Resources SA

Concurrent Session B-9

Workshop

Session Chair: Alisha Dahlstrom
National Centre for Marine Conservation
and Resource Sustainability

3:20 pm to 5:20 pm

Understanding and Describing Impacts of Aquatic Non-indigenous Species

Understanding and describing impacts of aquatic nonindigenous species (ANS) is a difficult task. Significant challenges include: the paucity of impact data regarding many ANS; the uncertainty often surrounding the existing data; the variety and relevance of different data types, many of which are observational or anecdotal in nature; and the lack of common descriptors for impact magnitude and type. Resolving these issues in order to accurately assess ANS impacts is critical given the increasing frequency of invasions and the associated legislative and regulatory decisions that require reliable descriptions of species' impacts.

This interactive workshop will present resource managers and others with responsibility in the marine environment with a suite of non-indigenous species, with directed discussion and the opportunity for the participants to provide their assessment of the impacts. The outcomes of this workshop will assist efforts to develop a comprehensive framework to describe the types and magnitudes of impacts to environmental, economic, social, cultural, and human health values, and how to proceed in situations with scarce, uncertain, or non-experimental data.

While all backgrounds and experience levels are welcome, this workshop also involves a short, online exercise to be completed several weeks before the conference.

Please contact Alisha Dahlstrom at alishad@amc.edu.au by July 19 for more information or if you are interested in participating.

Concurrent Session C-9

Shipping: Risk, Policy and Programs

Session Chair: Mark Burrows
International Joint Commission

3:20 pm

Ballast Water Management Study for Halifax Class Frigates

Christopher J. Wiley, Transport Canada Marine - Ontario Region

3:40 pm

Refinement of a Hydroxide Stabilization Process for Treatment of Ballast: Effect of Relative Headspace Volume, Ventilation Rate and Liquid Phase Mixing on pH Depression

Barnaby Watten and Philip Sibrell, U.S. Geological Survey,
Leetown Science Center; Scott Smith, U.S. Geological Survey,
Western Fisheries Research Center

4:00 pm

Tales from the Crypt: Instrument Records from Inside Operating Ballast Tanks

David Reid, National Oceanic and Atmospheric Administration,
Great Lakes Environmental Research Laboratory (retired,
Emeritus); Thomas Johengen, University of Michigan-
SNRE; Tony Wang, University of Windsor; Sarah Bailey and
Christopher Wiley, Fisheries and Oceans Canada/Transport
Canada; Philip Jenkins, Philip T. Jenkins & Associates, Ltd.;
Hugh MacIsaac, University of Windsor

4:20 pm

On-board Ship Tests in the Great Lakes Measured the Efficiency of Basic Dosing Methods for Treating Ballast Tanks

Noah Adams, Barnaby Watten and Scott Smith, U.S. Geological
Survey; Kevin Reynolds, The Glosten Associates; Phyllis Green,
National Park Service

4:40 pm

Computational Analysis of Reagent Mixing in Ballast Tanks

Wesley Wilson, Naval Surface Warfare Center – Carderock
Division; Barnaby Watten, U.S. Geological Survey, Leetown
Science Center

Thursday, September 2 Morning

Concurrent Session A-10

Fishes

Session Chair: Paul Heimowitz
U.S. Fish & Wildlife Service

8:30 am

Developmental Plasticity and Successful Fish Invasions

Vladimír Kováč, Comenius University

8:50 am

Do Long-time and Recently-established Populations of Topmouth Gudgeon (*Pseudorasbora parva*) Follow Different Ontogenetic Trajectories and Life-histories?

Eva Záhorská and Vladimír Kováč, Comenius University

9:10 am

Morphological Variability of Non-native Black Bullhead *Ameiurus melas* Populations in Four European Countries

Andrea Novomeská and Vladimír Kováč, Comenius University, Department of Ecology; Stanislav Katina, Comenius University, Department of Probability and Mathematical Statistics, and University of Glasgow, Department of Statistics; Gordon H. Copp, Centre for Environment Fisheries and Aquaculture Science (CEFAS); G. Pedicillo and M. Lorenzoni, Università di Perugia, Dipartimento di Biologia Cellulare e Ambientale

9:30 am

Fathead Minnow *Pimephales promelas* in Europe: Preliminary Results on the Environmental Biology of a Feral Population of 'Rosy Reds' in Northern England

Michael Godard, Robert Britton and Gordon Copp, Bournemouth University and Centre for Environment, Fisheries and Aquaculture Science; Grzegorz Zięba, University of Łódź

9:50 am

Break

Concurrent Session B-10

Drissenids

Session Chair: Frances E. Lucy
Institute of Technology, Sligo

8:30 am

A New Mention for an Aquatic Invasive Species at the Northern Limit of its Range: Dynamics of an Asiatic Clam Population in Association with a Power Plant

Anouk Simard, Annie Paquet, Yves Robitaille and Courtois Réhaume, Ministère des Ressources naturelles et de la Faune du Québec; Charles Jutras and Pierre Blier, Université du Québec à Rimouski; André Martel, Musée canadien de la nature

8:50 am

Integrating an Emerging Tool into Native Freshwater Mussel Protection and Recovery Efforts

Denise A. Mayer, Michael J. Gaylo and Daniel P. Molloy, New York State Museum, Division of Research and Collections; Mark P. Gaikowski and Terrance D. Hubert, U.S. Geological Survey, Upper Midwest Environmental Sciences Center; Douglas B. Aloisi, James A. Luoma and Nathan L. Eckert, U.S. Fish & Wildlife Service, Genoa National Fish Hatchery

9:10 am

Assessment of the Invasion of *Limnoperna fortunei* in the Lower Paranaíba River and its Tributaries of the Right Bank – the Stretch Between São Simão (GO) and Paranaíba (MS)

Mônica de Cássia Souza Campos, Fabiano Alcísio e Silva and Pedro Henrique Rolin Benini, Fundação Centro Tecnológico de Minas Gerais

9:30 am

Environmental Aspects of the Invasion of *L. fortunei* in the Upper Parana River (Minas Gerais, Goiás, Brazil)

Mônica de Cássia Souza Campos, Fundação Centro Tecnológico de Minas Gerais; Maria Edith Rolla, Helén Regina Mota and Fabiano Alcísio e Silva, Companhia Energética de Minas Gerais - CEMIG

9:50 am

Break

Concurrent Session C-10

Shipping: Testing Treatment Systems and Management Practices

Session Chair: David F. Reid
National Oceanic and Atmospheric Administration (Emeritus, retired)

8:30 am

Ballast Water Treatment Systems; Current Status and Future Perspective

Marcel Veldhuis, Cato ten Hallers, Frank Fuhr, Peter Paul Stehouwer, Isabel van de Star, Cees van Slooten and Etienne Brutel, Royal Netherlands Institute for Sea Research

8:50 am

Influences on Aquatic Micro-organisms when Qualifying Ballast Water Treatment Systems

Isabel van der Star, Frank Fuhr, Govert van Noort, Peter Paul Stehouwer and Marcel Veldhuis, Royal Netherlands Institute for Sea Research

9:10 am

Influence of Species Composition and Organism Density of Zooplankton on Land-based Testing of Ballast Water Treatment Systems

Frank Fuhr, Isabel van der Star, Jan Finke and Marcel Veldhuis, Royal Netherlands Institute for Sea Research

9:30 am

The Role of Microbial Regrowth in the Remineralization of PERACLEAN® Ocean

Cees van Slooten, Peter Paul Stehouwer, Josje Snoek, Eveline Garritsen and Marcel Veldhuis, Royal Netherlands Institute for Sea Research

9:50 am

Break

Thursday, September 2 Morning

Concurrent Session A-11

Fishes

Session Chair: Paul Heimowitz
U.S. Fish & Wildlife Service

10:20 am

Potential Freshwater Fish Invaders to the North American Arctic

Ross Tallman and Kimberly Howland, Fisheries and Oceans Canada

10:40 am

Food Web Changes Following Introduction of Nile Perch (*Lates niloticus*) into Lake Victoria

J.H. Wanink, M. Kische-Machumu and F. Witte, University of Leiden, Institute of Biology Leiden

11:00 am

Status of Two North-American *Ameiurus* Species (Ictaluridae) in Flanders (Belgium) with Preliminary Genetic Screening of Specimens from Belgium, France and The Netherlands

Hugo Verreycken, Claude Belpaire and Koen De Gelas, Research Institute for Nature and Forest

11:20 am

Invasive Fishes in the Aral Sea Basin, Central Asia

Ernest Khurshut, Uzbek Academy of Sciences

Concurrent Session B-11

Dreissenids

Session Chair: Frances E. Lucy
Institute of Technology, Sligo

10:20 am

Population Genetic History of the Dreissenid Mussel Invasion: Expansion Patterns Across North America

Carol Stepien, University of Toledo; Joshua Brown, National Oceanic and Atmospheric Administration

10:40 am

Invasion Paradox: Why *Dreissena rostriformis bugensis*, Being Less Invasive, Outcompete *D. polymorpha*?

Alexander Karatayev, Lyubov Burlakova, Sergey Mastitsky, Buffalo State College; Dianna Padilla, Stony Brook University; Edward Mills, Cornell Biological Field Station

11:00 am

Using GARP to Investigate the Present and Future Distribution of Zebra Mussel in Europe

Belinda Gallardo, University of Cambridge, Department of Zoology

Concurrent Session C-11

Shipping: Testing Treatment Systems and Management Practices

Session Chair: Christopher J. Wiley
Fisheries and Oceans Canada and Transport Canada, Ontario Region

10:20 am

Re-growth of Algae and Bacteria after Treatment with UV- or Chemical-based Ballast Water Treatment Systems

Peter Paul Stehouwer, Isabel van der Star, Josje Snoek, Eveline Garritsen and Marcel Veldhuis, Royal Netherlands Institute for Sea Research

10:40 am

Identification of Potential Invasive Phytoplankton Species in Re-growth Experiments after UV-based Ballast Water Treatment

Viola Liebich, Peter Paul Stehouwer and Marcel Veldhuis, International Max Planck Research School for Maritime Affairs

11:00 am

Quantifying the Likelihood of Invasion by Global Shipping

Hanno Seebens and Bernd Blasius, University of Oldenburg, Institute for Chemistry and Biology of the Marine Environment

Ocean Stewardship – a Future of Collaboration

Dr. Larry Robinson

Assistant Secretary of Commerce for Oceans and Atmosphere and Deputy Administrator of NOAA

This abstract was unavailable at the time of printing

NOTES

Interbasin Transfer of Zebra Mussels from Lake Texoma, Oklahoma to the Trinity River Basin in Texas

*Everett Laney
U.S. Army Corps of Engineers*

Lake Texoma is a U.S. Army Corps of Engineers lake located on the Red River between the Oklahoma/Texas border. It is also fed by the Washita River from Oklahoma. The 74,686 surface acre lake has 580 miles of shoreline and had approximately 6.4 million visitors in 2009. An adult zebra mussel was found on a private structure in April 2009 on the south (Texas) shoreline approximately 1.25 miles upstream of the dam. By late summer they were being found at various locations on the lake. The North Texas Municipal Water District (NTMWD) pumps water from Lake Texoma to Sister Grove Creek which flows into Lake Lavon at the headwaters of the Trinity Water Basin. Three adult mussels were found in Sister Grove Creek below the NTMWD outfall structure in August 09. The Trinity River is 710 miles long and flows to Galveston Bay. Its watershed is 17,965 sq. mi. and serves as a primary water supply to more that 6 million people in the upper region (DFW) and another 5 million in the lower region (Houston).

Lake Texoma is managed by the Tulsa District (SWT), Corps of Engineers, but the Trinity River Basin is within the Fort Worth District (SWF). The NTMWD intake facilities on the lake are permitted by the SWT Regulatory Branch. A stipulation in the permit is that NTMWD "shall monitor the inter-basin transport of viable fish and invertebrates from Lake Texoma to Lake Lavon." Additionally, "In the event that the results of monitoring ... indicate that unacceptable adverse impacts are occurring, or likely to occur, as a result of ... operation of facilities covered in this permit, modifications to plant features and/or operation of such facilities to avoid, reduce, or otherwise mitigate adverse impacts shall be required."

This presentation will describe the coordination and regulatory issues faced by the two Corps Districts and the NTMWD in developing a response to prevent the transfer of zebra mussels into the Trinity River Basin.

NOTES

Quagga/Zebra Mussels in California: A 2010 Update from the California Department of Fish and Game

Susan Ellis

California Department of Fish and Game

Since the 2007 and 2008 discovery of quagga and zebra mussels (*Dreissenid* mussels) in California, the Department of Fish and Game (DFG) has led the state response and management of these species. Efforts have been coordinated among federal, state, and local agencies, and emphasized prevention, containment, education and outreach, and early-detection monitoring.

DFG continues to convene meetings with partner agencies to coordinate efforts, update others on accomplishments, and identify future needs. In addition, DFG contributes to national efforts via the Aquatic Nuisance Species Task Force and Western Regional Panel on Aquatic Nuisance Species. At the local level, DFG staff throughout the state coordinate with local agency efforts, including training, prevention, education and outreach, and monitoring.

State laws enacted since 2007 require managers of infested waters to prepare plans to control and/or eradicate *Dreissenid* mussel infestations, and managers of uninfested reservoirs to develop programs to prevent the introduction of *Dreissenid* mussels. In addition to early-detection monitoring at these uninfested reservoirs, partners throughout the state are implementing early-detection monitoring programs. DFG has established laboratory facilities to analyze plankton samples collected by DFG staff and local agencies using both PCR and cross-polarized light microscopy.

DFG and its partners continue to identify and address potential vectors that have the potential to further introduce or spread *Dreissenid* mussels, including unregulated points of entry along state borders, aquaculture, fire fighting equipment and operations, among others.

Nearly four years since the discovery of quagga mussels, DFG is encouraged that our partnership's efforts have contributed to minimization of the spread of *Dreissenid* mussels in California. With the growing recognition of the need for action, a concerted, multi-state effort will make an additive contribution to our ongoing efforts.

NOTES

Prioritizing Zebra and Quagga Mussel Monitoring in Columbia River Basin

Timothy Counihan and Amy Puls

U.S. Geological Survey, Western Fisheries Research Center, Columbia River Research Laboratory

Steve Wells and Mark Sytsma

Portland State University, Center for Lakes and Reservoirs

In 2007, dreissenid mussels (*Dreissena polymorpha*, zebra and *D. bugensis*, quagga mussels) were found to have established populations west of the Rocky Mountains. The proximity of these new infestations indicates that the risk posed by dreissenid mussels to the Pacific Northwest has increased. The Columbia River Basin (CRB) Team of the 100th Meridian Initiative has developed and tested a rapid response protocol that can be implemented if mussels are detected, but its efficacy is dependent upon effective detection of new infestations, which requires an effective monitoring strategy. To address this need, Portland State University partnered with the U.S. Geological Survey to produce a regional assessment of the risk of introduction and establishment posed by *D. polymorpha* and *D. bugensis* to individual lakes, reservoirs, and rivers within the Columbia River Basin (CRB), and the surrounding areas in Oregon, Washington, California, Nevada, Idaho, Utah, and Wyoming. Our goal in this effort was to develop a comprehensive prioritized list of water bodies to target for early detection dreissenid mussel monitoring. The risk of dreissenid establishment has been shown to be influenced by environmental parameters such as dissolved calcium, pH, water temperature, salinity, dissolved oxygen, and suitable substrate. Dissolved calcium concentrations and pH are hypothesized to be the most limiting environmental parameter to dreissenid establishment in the CRB and Greater Northwest. Multiple sources were queried to collect water quality and boater use data. For water quality data, the US Environmental Protection Agency STORET database (<http://www.epa.gov/storet>), and USGS National Water Information System database (<http://waterdata.usgs.gov>) were the primary sources for water quality data. Once we had exhausted existing sources of water quality data, waterbodies that lacked data were identified. During this process, we assessed the presence or absence of pertinent boater use and water quality data at over 700 lakes, reservoirs, and rivers. Using the data we compiled, we then developed a Kriging model (e.g., Fitted Surface Models, Universal Kriging maps), to predict regional trends in calcium based on the existing water quality data. Based on the model output we then identified waterbodies with no water quality data that were most likely to have water quality suitable for dreissenid mussel establishment and prioritized the field collection of water quality data. We then evaluated several potential methods for characterizing the risk of dreissenid establishment and introduction to individual water bodies in the CRB and Greater Northwest region. We will present the results of our assessment and discuss some of the challenges that exist when conducting a regional assessment at the individual water body scale.

NOTES

The Continuing Saga of Quagga Mussels in Southern Nevada

Peggy Roefer
Southern Nevada Water Authority

On January 6, 2007 a small striped mussel was discovered on a cable by divers at the Las Vegas Boat Harbor in Boulder Basin of Lake Mead. Experts from the U.S. Fish and Wildlife Service positively identified this as a quagga mussel (*Dreissena bugensis*), a close relative of zebra mussels. This invasive species had somehow “jumped” from the Great Lakes to Lake Mead. This was the first recorded occurrence of quagga mussels in the western U.S. Managers and scientists from the Southern Nevada Water Authority (SNWA) are active participants in all local activities due to the potential risk to drinking water intake facilities in Lake Mead. SNWA is the drinking water wholesaler for the Las Vegas valley. Eighty percent of drinking water used in Las Vegas is withdrawn from Lake Mead at Saddle Island in Boulder Basin. Short and long term responses to quagga mussels are being developed in order to protect the SNWA mission to supply quality drinking water to southern Nevada. SNWA and other agencies are also conducting monitoring to determine the status of the invasion and determine growth trends. This presentation will focus on the response by Southern Nevada Water Authority to the introduction and spread of this invasive species as well as monitoring results from Lake Mead. It will discuss the proactive steps taken to protect the SNWA assets, cooperation with other stakeholders on Lake Mead and future plans for quagga mussel control.

NOTES

Quagga Mussel Recruitment: Is Southern California Really Paradise for this Invader?

Carolynn Culver

California Sea Grant Extension Program

Daniel Daft

City of San Diego

The quagga mussel, *Dreissena bugensis*, is world renown as a devastating aquatic invasive species that causes significant economic and ecological impacts on water delivery systems and fresh water ecosystems. When this invader arrived in Southern California, predictions of its impacts were dire in light of what had occurred elsewhere and the belief that it would readily reach high densities due to the favorable environmental conditions of the area. While the quagga mussel is certainly present and going to stay in Southern California, its impacts at some locations have been less than expected thus far. To begin to explore reasons for this, we investigated spatial and temporal patterns of recruitment of the quagga mussel in Lake Miramar, San Diego, California. We used passive plastic mesh collectors (scrubbing pad; Tuffy®) to assess recruitment of mussels just settling out of the water column. Recruitment was measured at 3m intervals between 3m and 24m. Collectors were retrieved once a month for a year. We also measured water temperature and transparency to explore the potential relationship of these variables with patterns of mussel recruitment.

Our results indicated great variability in recruitment of *D. bugensis* in space and time. Mussel recruitment was heterogeneous among water depths, being significantly higher at shallower depths; 6m and 9m, followed by 3m and 12m. Little to no recruitment was detected at the deepest depths (21m and 24m). We also found little to no mussel recruitment during several months of the year; November through May. Similar to areas with more extreme environmental conditions, recruitment occurred almost exclusively during the summer and early fall, sharply increasing in June and July and tapering off from August through October. Settlement of *D. bugensis* in the shallower water depths was unexpected. Based on the negative phototactic behavior of this species, we thought mussel settlement would occur in darker waters between the bottom of the average Secchi disk readings (~9.5 m) and the top of the hypolimnion (19 m). The variation in mussel recruitment over time was also surprising, as the water temperatures were more than adequate to support continued reproduction and larval development. Additionally, water containing veligers was continually pumped into the reservoir from the aquaduct throughout the year.

Our findings suggest that southern California is not the overall paradise once thought for the quagga mussel. Recruitment limitations may, in part, explain the lower than expected densities of mussels in the area. Other factors such as mussel predation by fish and diving ducks, the trophic state of the water body and the development of a thermocline which leads to anoxic condition in the hypolimnion also likely influence mussel densities. Based on our data, early detection and monitoring efforts and application of control strategies in California and elsewhere may be best implemented over a few months in late spring/early summer within shallow depths (<12m) thereby targeting the time and area of highest mussel recruitment. However, additional studies are needed to determine whether the patterns of mussel recruitment documented at Miramar Reservoir are similar throughout the region.

NOTES

The Big Picture: Using Macroecology to Understand the Impacts of Freshwater Invasions

Anthony Ricciardi
McGill University

Many freshwater invasions appear to have relatively minor ecological consequences, whereas others cause dramatic disruptions to biodiversity and food webs. Under the influence of a heterogeneous environment, impacts vary across time and space; for example, the same invader that causes the loss of native species from one area may co-exist with native species in other areas. As a result of this context-dependent variation, few generalizations of impact exist and, consequently, managers lack risk assessment tools to forecast and prioritize the most important invasion threats.

I contend that while experiments are necessary to understand the effects of invaders, they are insufficient by themselves to reveal generalities. The context-dependent nature of invasions requires analysis of large-scale patterns, i.e. a macroecological approach. I demonstrate the utility of this approach by exploring three research topics: 1) the relationship between the impact and the phylogenetic distinctiveness of an invader relative to the invaded community; 2) the relationship between the number of high-impact invaders and colonization pressure (the number of species introduced to a system); and 3) the identification of correlates of impact for specific invaders that have a documented history of effects across multiple invaded areas. In each case, statistical patterns emerge that suggest generalities of the effects of invaders that can enhance our predictive understanding of impact.

NOTES

Effects of Climate Change on Native and Exotic Freshwater Mollusks in Riverine Ecosystems

*Rob Leuven, Laura Verbrugge, Mark Huijbregts, Aafke Schipper and Gerard van der Velde
Radboud University Nijmegen*

*Abraham bij de Vaate
Waterfauna Hydrobiologisch Adviesbureau*

Climate change strongly affects the abiotic conditions in riverine ecosystems by altering water temperature regimes, increasing peak discharges and periods of drought, and in coastal areas also by enhancing salt water intrusion due to sea level rise. We analyzed the effects of changes in water temperature and salinity on the species pools of native and exotic freshwater mollusks in the river Rhine. Species sensitivity distributions (SSDs) for temperature and salinity tolerances were constructed of both native and invasive species. These were used to determine the potentially not occurring fractions (PNOF) of regional and local species pools due to water temperature and salinity levels corresponding with future climatic conditions. In general, PNOFs will be higher for native than for invasive mollusk species. However, the potential effects will remarkably differ between various sections of the river-estuary continuum. Implications of our results will be discussed with respect to riverine ecosystem functioning.

NOTES

Using Long-Term Monitoring to Investigate the Changes in Species Composition in the Harbour of Ghent (Belgium)

Pieter Boets, Koen Lock, Peter L.M. Goethals

Ghent University, Laboratory of Environmental Toxicology and Aquatic Ecology

Unintentional intercontinental transport via ballast water and hull fouling of ships are key introduction vectors of aquatic species. In addition, the construction of canals, connecting previously separated biogeographic regions, eases the spread of exotic species. In the present study, the macroinvertebrate community of the harbour of Ghent was studied by analysing 135 samples taken at different locations from 1990 until 2008. In this way, the influence of exotic species and a changing water quality on the macroinvertebrate species composition was investigated. In total, seven exotic and four indigenous crustacean species were found, three of them (*Gammarus tigrinus*, *Palaemon macrondactylus* and *Rhithropanopeus harrisi*) represented on average more than 63% of the total crustacean abundance. Mollusc diversity was higher, with a total of 14 species, four of which are exotic. The abundance of indigenous Mollusca fluctuated strongly, while the abundance of the invasive molluscs gradually increased since their first occurrence in 1995. Before 1993, no exotic macroinvertebrates were present in the harbour of Ghent. Afterwards, the number of exotic taxa increased, whereas the number of native taxa remained stable. The improvement of the chemical water quality and the simultaneous increase in total number of species was also reflected in an increase of the Multimetric Macroinvertebrate Index Flanders. Macroinvertebrate diversity was very low at the beginning of the 1990s, but increased due to the improvement of the chemical water quality achieved by sanitation and stricter environmental laws. This is reflected by the dissolved oxygen, which increased from an average of 2 mg/L to an average of 9 mg/L, allowing more sensitive species to establish. Although lab studies are often used to get insight in the behaviour and feeding habits of exotic species, in this study, a different approach was used. Analysis of the stomach content of species collected in the field was performed to obtain information about the diet of different crustaceans. Stomach analysis revealed that *G. tigrinus* and *Dikerogammarus villosus* have an omnivorous diet, *P. macrondactylus* and *R. harrisi* predated mainly on other macroinvertebrates, whereas the indigenous *Asellus aquaticus* could be categorized as a detritivore. This study indicated that the precise impact of invasive crustaceans on the local macroinvertebrate community is difficult to determine because it is hard to assess the diversity that could have been reached in the absence of exotic species. Due to intensive international boat traffic and the low species diversity, the harbour of Ghent is especially vulnerable for invasions. Stronger regulations and a better understanding about the contribution of shipping, shortcuts via artificial water ways, habitat degradation and environmental pollution are required to reduce the further spread of exotic species.

NOTES

Examining Ecological and Ecosystem-Level Impacts of Aquatic Invasive Species in Lake Michigan Using an Ecosystem Productive Model, LM-Eco

David Miller and Russell Kreis, Jr.

U.S. Environmental Protection Agency, O.R.D., N.H.E.E.R.L., M.E.D.

Xiangsheng Xia and Wilson Melendez

CSC

Ecological and ecosystem-level impacts of aquatic invasive species in Lake Michigan were examined using the Lake Michigan Ecosystem Model (LM-Eco). The LM-Eco model includes a detailed description of trophic levels and their interactions within the lower food web of Lake Michigan. The LM-Eco modeling construct has been applied in two phases to investigate ecosystem-level responses and effects corresponding with aquatic invasive species. The first phase includes examining the effect of the invasive species *Bythotrephes longimanus* on individual zooplankton species based upon extensive field data collected at multiple locations in Lake Michigan. Field data collected at 15 sampling stations within Lake Michigan over a series of 8 sampling cruises throughout a 2 year period demonstrated that over 65% of zooplankton species exhibited a decline with the occurrence of *Bythotrephes* in the sample. The LM-Eco model was successfully applied to simulate the trends of *Bythotrephes* and zooplankton abundance as observed in the collected field data. A second phase of the LM-Eco modeling construct focuses on benthic organisms including the invasive dreissenid mussels, zebra mussel (*Dreissena polymorpha*) and quagga mussel (*Dreissena bugensis*), as well as the native amphipod *Diporeia*. Application of the second phase of the model allows for investigation of trends for interaction between nutrients, dreissenids, *Diporeia*, zooplankton and phytoplankton dynamics. Model simulations allowed for examination of interactions between the invasive and native species on a resolution of 5km by 5km locations throughout Lake Michigan. Analysis was completed as a time series specific to individual field sampling locations within the lake, and also on a lake wide scale.

NOTES

Exotic Invertebrates Alter Benthic Community in Lake Erie

Lyubov E. Burlakova, Alexander Y. Karatayev and Christopher M. Pennuto
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Lake Erie, due to its warm and shallow waters and large propagule pressure, is often one of the first among Great Lakes to be colonized by a new invader, and is considered as the most vulnerable to new invasions. European stream valvata (*Valvata piscinalis*) was probably the first benthic exotic mollusc that colonized Lake Erie over 110 years ago, while New Zealand mudsnail (*Potamopyrgus antipodarum*) was discovered only 4 years ago and could be considered among the most recent invaders. To estimate the role of exotics in benthic community, we collected 125 benthic samples in Lake Erie in summer of 2009 from different depths in all three lake basins, and compared these data to the results of benthic survey done in 1979 (Dermott 1994). In this pre-dreissenid year, 3 exotic species (gastropod *Bithynia tentaculata*, and oligochaetes *Branchiura sowerbyi* and *Potamothenix vejovskyi*) added < 1% to the total density of the lake, and >2% to the total biomass. Oligochaetes, mollusc *Pisidium* and amphipod *Diporeia* dominated the pre-invasion community in terms of density, and chironomids, oligochaetes, *Sphaerium*, *Diporeia*, and *Pisidium* – in biomass. Thirty years later we found eight live exotic species, including molluscs *Dreissena r. bugensis*, *D. polymorpha*, *Sphaerium corneum*, *Cipangopaludina chinensis*, *Potamopyrgus antipodarum*, *Valvata piscinalis*, oligochaete *B. sowerbyi*, and amphipod *Echinogammarus ischnus*, as well as numerous shells of *B. tentaculata*. Invaders were disproportionately abundant among molluscs, and were completely absent from the most diverse group of native invertebrates (insects). Currently benthic invaders comprise 17% of total benthic diversity (oligochaetes were not identified), 40% of density, and over 95% of the total benthic wet biomass in the whole lake. Community structure and dominant complex changed significantly since 1979, and benthic community is currently dominated by exotic species.

NOTES

Aquatic Invasive Species Prevention: Start With Behavior

Douglas Jensen

University of Minnesota Sea Grant Program

Recreational boaters, anglers, and others continue to spread aquatic invasive species (AIS). AIS public outreach can fail when behavior determinants for those audiences are not clearly understood, articulated, or activated. Often, very different and sometimes contradictory approaches take aim at influencing behavior. Natural resource managers typically employ conventional “education” loosely in an effort to “get the word out.” Not surprisingly, this inadequate approach rarely influences behavior resulting in a perceived outcome that “the public doesn’t get it.” Consequently, natural resource professionals resolve to fall back heavily upon laws and regulations in an attempt to force compliance. They may also consider using fear to influence behavior. Fear can be a good motivator in the short term; however, its use is short-sighted and a poor long term motivator.

More importantly, common reasons why AIS outreach does not reach behavior goals is that it rarely takes into account values, beliefs and attitudes of the target audience(s). Using proven approaches by educators and psychologists can help guide the design of public AIS communication and education efforts. Educators generally relate pedagogy to knowledge and demonstration of skills, whereas many psychologists base behavior on values, motivations, and self-image. As one model, these elements modulate behavior through an individual’s beliefs, attitudes, norms, skills, efficacy, and other factors. Another approach for application in AIS outreach is community-based social marketing (CBSM). Concepts used in CBSM provide a framework for natural resource managers and educators to target and sustain behavior intervention concerning AIS. Integration of CBSM can help uncover barriers and benefits, provide insights into forming commitments that tap into motivations, support approaches to develop personal and social norms, and use prompts strategically as reminder tools.

This presentation will describe how these complementary education and psychological behavioral intervention approaches can be applied using the *Stop Aquatic Hitchhikers!*™ campaign.

NOTES

Uniform Minimum Protocols and Standards for Watercraft Interception Programs for Dreissenid Mussels in the Western United States

*Stephen Phillips and Bill Zook
Pacific States Marine Fisheries Commission*

Recreational watercraft is the primary vector for range expansion of zebra and quagga mussel populations within the western US. The adoption of region-wide uniform minimum protocols and standards for watercraft interception and decontamination programs is considered essential by nearly all state, federal, tribal and local agencies and organizations involved in this effort. To address this issue, the Pacific States Marine Fisheries Commission, at the request of the Western Regional Panel (WRP) on Aquatic Nuisance Species, developed the “living” document Recommended Uniform Minimum Protocols and Standards (UMPS) for Watercraft Interception Programs for Dreissenid Mussels in the Western United States. This document was adopted by the WRP at its September 2009 annual meeting in Seattle, WA. While the protocols and standards recommended in this document are directed at preventing the inadvertent transfer of quagga/zebra mussels from areas where they are currently present to unaffected waters on trailered watercraft and equipment, their application will help prevent the spread of other Aquatic Nuisance Species (ANS) as well. The UMPS document has recommendations for three program levels as well as protocols and standards for screening interviews, watercraft/equipment inspection, decontamination, quarantine, exclusion, and certification and serves as a ‘best practices’ manual for watercraft/equipment interception and training programs in the western US.

NOTES

Watercraft Inspections Using Scent Detection Dogs: An Evaluation of the Efficacy of California Department of Fish and Game's Canines to Detect Dreissenid Mussels

*Martha Volkoff and Lynette Shimek
California Department of Fish and Game*

The primary mode of overland transport of *Dreissenid* mussels has been identified as trailered watercraft. To address this pathway, the California Department of Fish and Game (DFG) has made a substantial investment in training both DFG personnel and stakeholders in watercraft inspection. Managers at a growing number of waterbodies that allow watercraft have implemented inspection programs at considerable effort and expense.

Concurrent with watercraft inspection training, DFG's Law Division developed a Canine Program. The olfactory sensitivity of canines has been long recognized, and more recently successfully utilized to perform a variety of services. DFG's canines, all trained in scent detection, are partnered with wardens, who retain their full suite of enforcement duties. DFG's canines are used to detect mussels, among other scents, in the course of those enforcement activities.

Local agencies currently rely on humans to inspect watercraft. These inspections are laborious and time consuming, and alternative tools that would make the task of inspecting faster and/or more effective are desired. Scent detection dogs have been identified as a means to improve the speed and accuracy of existing inspection programs, however validation of the utility and effectiveness of canines for this application is necessary. In addition, it is important for DFG to know how effective their canines are at detecting mussels under field conditions.

In the Fall of 2009 and Spring of 2010 DFG conducted staged watercraft inspections to evaluate 1) Are canines more effective than humans at detecting mussels on watercraft?; 2) Do canines take less time than humans to inspect watercraft?; and 3) Among DFG's canines, how accurate are they at detecting *Dreissenid* mussels? The results of this research will be used to make recommendations to local agencies about watercraft inspection programs, as well as support the utility and effectiveness of the Department's Canine Program.

NOTES

Regional Aquatic Invasive Species Spread Prevention through Lake Stewardship Programs on Lake George, Lake Champlain, and in the Adirondacks

Meg Modley

Lake Champlain Basin Program

Emily Debolt

Lake George Association

Eric Holmlund

Paul Smith's College

Regional lake stewardship programs that have been implemented in the Lake Champlain region are aimed to reduce the spread of aquatic invasive species through boat launch steward programs. The Paul Smith's College Adirondack Watershed Institute has developed a Watershed Stewardship Program that has been running for the past 10 years that places stewards at boat access areas in the Adirondacks to inform and involve the public in taking actions to prevent the spread of aquatic invasive species. The program was adopted by Lake Champlain and Lake George, where programs begin their fourth season in 2010.

Paul Smith's College, the Lake George Association, and Lake Champlain Basin Program have proved that boat launch steward programs are effective at AIS spread prevention. Results show that over 4% of surveyed boats launching or retrieving from Lake Champlain had aquatic organisms attached to their boats, trailer, or equipment. Paul Smith's College's Watershed Stewardship Program conducted a study between the years of 2003-2005 to determine the impact of boat launch stewards' message on watercraft operators. Findings indicate that watercraft operators exposed on prior visits to short interpretive messages presented by watershed stewards had significant improved knowledge of Eurasian watermilfoil ecology and reproduction. There continues to be a growing interest and demand for both paid and volunteer steward programs in the region. Stewards from all programs collect survey data to better understand what types of lake users visit their lakes, which bodies of water the vessels have previously visited, and if boat launch users take measures to prevent the spread of aquatic invasive species. These programs are collecting data that has led to better targeting of spread prevention messages, tracking where visitors are coming from, and beginning to track boat launch user spread prevention measure behavior changes.

NOTES

Enhancements to the Great Lakes Aquatic Non-indigenous Species Information System (GLANSIS)

Rochelle Sturtevant

Great Lakes Sea Grant Network at NOAA's Great Lakes Environmental Research Laboratory

David F. Reid

National Oceanic and Atmospheric Administration, Great Lakes Environmental Research Laboratory (retired, Emeritus)

The Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS – <http://www.glerl.noaa.gov/res/Programs/ncrais/glansis.html>) is a Great Lakes specific node of the USGS Nonindigenous Aquatic Species (NAS) system. GLANSIS has been selected as the backbone for AIS information reporting for the Great Lakes region under the Great Lakes Restoration Initiative. Significant enhancements to GLANSIS – such as implementation of point mapping capability – have been achieved in the last year and more are forthcoming. These include listing and addition of information for range expansion and high risk species (potential future invaders), revision of impact data to better support risk assessment and inclusion of a new field for management information. Mechanisms for submitting sightings and receiving alerts via the USGS partnership will be highlighted along with the recent and planned enhancements.

NOTES

Asian Carps Range Expansion Toward the Great Lakes: Can it be Stopped, What are We Doing and What Can be Done?

Phil Moy

University of Wisconsin Sea Grant Institute

Since about 2002 residents in the midwest have been exposed to dramatic videos of bighead and silver carps leaping from the surface of the Illinois River, hitting boaters as they sped across the river. These large fish quickly became the focus of prevention efforts in the Chicago Sanitary and Ship Canal. This focus has recently brought to light new sampling methods, new approaches to invasive species control and renewed concerns about the potential for establishment of these species in the Great Lakes basin. The papers in this session will discuss new detection techniques, new approaches for control and management and we will consider the potential for, hurdles to and impacts of establishment of Asian carps in the Great Lakes.

NOTES

Capture Efficiency of Asian Carp in the La Grange Pool of the Illinois River Using Traditional Gear

Greg G. Sass

*Illinois River Biological Station, Illinois Natural History Survey, Institute of Natural Resource Sustainability,
University of Illinois at Urbana-Champaign*

John H. Chick

*Great Rivers Field Station, Illinois Natural History Survey, Institute of Natural Resource Sustainability,
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Catchability of invasive fishes using traditional gears may vary by species, density, and habitat preferences. For example, catchability is often positively correlated with invasive species density such that early detection monitoring of invasive fishes at low densities with traditional fishing gears may not be representative of the population at large. Species-specific avoidance behaviors to traditional gears may also hinder such efforts. In the specific case of invasive Asian carp (bighead carp *Hypophthalmichthys nobilis*, silver carp *H. moltrix*) in the upper Illinois River, environmental DNA detections suggest the presence of Asian carp; however, traditional fishing gears (e.g., electroshocking, trammel netting) have been unsuccessful in determining physical presence. In order to better understand the relationship between effort, catchability, and fish densities, we used a mark-recapture population estimate for silver carp and a block net/rotenone/electrofishing study to test for a trend among catch per unit of effort and ambient Asian carp densities. Our results suggest that catchability of Asian carps with traditional gears is low even in locations of high Asian carp abundance. Therefore, traditional fishing gears may not be useful for early detection monitoring where Asian carp are presumed to be at low abundances, such as in the upper Illinois River. Future survey efforts aimed to confirm the physical presence of Asian carps must therefore be creative and may require more non-traditional freshwater fisheries gears, such as large purse seines and lift nets.

NOTES

Environmental DNA (eDNA) Monitoring of the Asian Carp (*Hypophthalmichthys molitrix* and *H. nobilis*) in the Chicago Area Waterway Linking the Mississippi River and the Laurentian Great Lakes

W. Lindsay Chadderton

*The Nature Conservancy, Great Lakes Project
and*

Center for Aquatic Conservation, Department of Biological Sciences, University of Notre Dame

Christopher L. Jerde, Andrew R. Mahon and David M. Lodge

Center for Aquatic Conservation, Department of Biological Sciences, University of Notre Dame

Effective research and management of invasive species commonly relies upon the ability to detect and monitor low densities of patchily distributed non-indigenous species. But detecting rare species in aquatic ecosystems can be particularly challenging, where even large organisms can be difficult to directly observe or capture. Most existing methods (nets, traps, divers, electric fishing, underwater video, sonar) are only effective in a narrow range of habitats, principally shallow water, with slow water velocities or swell, or moderate to high visibility. This detection and delimitation problem is further exacerbated when the target species are present at low abundance of an incipient invasion. Genetic based sampling methods have the potential to overcome many of the constraints posed by traditional aquatic monitoring and detection gear. Here we present results of an ongoing surveillance effort using environmental DNA to delimitate the spread of bighead and silver carps (*Hypophthalmichthys nobilis* and *H. molitrix*) from the Illinois River through the Chicago Area Waterway System to Lake Michigan. Repeated detection of Asian carp DNA above an electric barrier in 2009 and 2010, indicate that some individuals of silver carp may already have escaped into Lake Michigan and invasion by bighead carp is imminent. No evidence exists that an established population of either species exists in Lake Michigan. Our results indicate that monitoring for the presence of environmental DNA of high risk species has potential to provide a sensitive early detection surveillance method in aquatic environments.

NOTES

The Potential for Asian Carp Eggs and Larvae to Move in Tow Vessel Ballast and Barge Void Spaces

Phil Moy

University of Wisconsin Sea Grant Institute

With the discovery of bighead and silver carp DNA and at least one physical specimen upstream of the electric barrier there has been renewed interest in the possible mechanisms by which these fish could get past the electric field intended to stop their upstream range expansion. One possibility is spread in the ballast of barges and tow vessels. This study examines the potential for young Asian carps to survive in the ballast water of tow boats and barges and be carried across the electric barrier reach. The study examines the frequency of barge hull damage which results in a rupture, the physical conditions within the void and ballast spaces and assesses the effectiveness of current operational regulations to address this vector.

NOTES

The Effects of Visual and Acoustic Deterrents to Prevent the Upstream Movement of Asian Carps

Greg G. Sass and Blake C. Ruebush

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Bighead (*Hypophthalmichthys nobilis*) and silver (*Hypophthalmichthys molitrix*) carps have invaded the Mississippi River Basin and have successfully established populations in the La Grange reach of the Illinois River. The invasion of Asian carps in the Illinois River has negatively influenced native fish populations and they now pose an imminent threat to invading Lake Michigan through the Chicago Sanitary and Ship Canal (CSSC). Sound Projector Array Bio-Acoustic Fish Fence (i.e., sound-bubble-strobe light barrier) technologies may have the ability to slow or eliminate Asian carp range expansions. In 2005, sound-bubble barrier technologies were shown to be 95% effective at deterring adult bighead carp passage in hatchery raceways. However, in order to use this technology for Asian carps management, barrier effectiveness trials must be conducted at an ecosystem-scale. We tested the effectiveness of sound-bubble-strobe light barriers at repelling Asian carps and native fish passage in the fall of 2009 within Quiver Creek, a tributary to the Illinois River. To test barrier effectiveness, Asian carps and native fishes were removed from upstream of the barrier. The upstream portion of Quiver Creek above the barrier is pooled by a lowhead dam preventing fishes from moving further upstream. All captured fishes were measured for length, weight, and received a floy-tag prior to being released downstream of the barrier. Barrier effectiveness was determined by upstream recaptures. Our preliminary results suggest 100% effectiveness at repelling silver carp passage and 97% effectiveness against passage by native fishes. If further testing concludes that this system is effective at repelling Asian carps passage, sound-bubble-strobe light technologies could be used as a redundant technology in the CSSC in addition to the current electric barriers and in locations where Asian carps have not yet invaded, but pose a threat.

NOTES

Quagga-Zebra Mussel Action Plan for Western U.S. Waters (QZAP)

Susan Mangin

U.S. Fish & Wildlife Service

Tom McMahon

Arizona Game and Fish Department

Emily Austin

National Park Service

Quagga and zebra mussels are among the most economically and ecologically damaging aquatic nuisance species and are spreading into the West. Infestation of invasive mussels into western regions, such as the Lake Tahoe Region, could have devastating effects on the regional economy. The Aquatic Nuisance Species Task Force (ANSTF) asked its Western Regional Panel (WRP) to develop a plan to address the growing threat of these invasive mussels in the West. As a result, the WRP developed QZAP. In November 2009, QZAP was conditionally approved by the ANSTF, pending changes. The changes were incorporated into the final document, dated February 2010. Since QZAP was finalized, federal and state agencies and their partners have worked actively to implement it. Efforts supporting QZAP implementation will be discussed.

NOTES

Quagga Mussel Monitoring for the Central Arizona Project

Albert Graves and T. Dewey
Central Arizona Project

Renata Claudi and Carolina Taraborelli
RNT Consulting

The Central Arizona Project (CAP) is designed to bring about 1.5 million acre-feet of Colorado River water per year to service areas in central Arizona. It is a 336-mile long system of aqueducts, tunnels, pumping plants and pipelines and is the largest single resource of renewable water supplies in the state of Arizona. Faced with the knowledge that quagga mussels had infested the CAP source of water, the CAP launched an extensive monitoring program to determine where the mussels would likely impact CAP’s system. The monitoring began in December, 2008 and continues today. This paper will present an overview of the results of the monitoring and will explore why quagga mussels do not thrive within the CAP system.

NOTES

New Instrument to Detect and Identify Invasive Dreissenid Veligers Using a Continuous Imaging Particle Analyzer (Flowcam XP)

*Kent Peterson, Harry Nelson, Matthew Duplisea and Benjamin Spaulding
Fluid Imaging Technologies*

In the summer of 2008 Fluid Imaging Technologies, Inc. (FIT) expanded the use of their imaging particle analyzer - FlowCAM® - by providing for the capability of the instrument to detect the natural birefringence of mussel veligers through the use of cross-polarized light. Equipping a standard FlowCAM with cross-polarizing filters provided the FlowCAM user with a method to rapidly detect, identify and enumerate *Dreissenid* veligers through the use of imaging technology along with image analysis software. Fluid Imaging has since demonstrated the efficacy of the technology in third-party tests, as well as with the user community responsible for the monitoring of Z/Q mussels, as a number of western (U.S.) organizations adopted the technology for use in the monitoring of Z/Q mussels during 2009.

Realizing the importance of providing a proven and a reliable method for the task of early detection, identification and enumeration of Z/Q mussels, FIT has taken the technology and adopted it for the specific application of the detection of Z/Q veligers. By focusing solely on the task of detecting and imaging Z/Q veligers – both birefringent and standard monochrome images – FIT has been able to significantly reduce the cost of the instrument while at the same time enhancing the application.

An overview of the technology will be presented along with field data from the user community.

NOTES

Zebra Mussel Growth and Seasonal Reproductive Cycles in San Justo Reservoir, California, USA

Tanya Veldhuizen and Jeff Janik

California Department of Water Resources, Aquatic Nuisance Species Program

The zebra mussel (*Dreissena polymorpha*) was first reported in San Justo Reservoir, a small (40 ha), warm monomictic impoundment in the central coast region of California, in January 2008. The discovery occurred nearly one year after the quagga mussel (*D. bugensis*) was found in Lake Mead (Nevada-Arizona, USA) and rapidly spread to the lower Colorado River reservoirs and into southern California's extensive water distribution system. Following the discovery, San Justo Reservoir was quarantined and closed to public access. The Bureau of Reclamation (owner) and San Benito County (operator) are jointly preparing environmental documents for eradication activities. This impoundment presently supports the only known California population of *D. polymorpha* and dreissenid mussels (*D. bugensis* or *D. polymorpha*) not connected to the Colorado River aqueduct distribution network. The Sacramento – San Joaquin Delta is the source for water conveyed by the Central Valley Project (CVP) and the State Water Project (SWP) to the reservoir. The SWP is the largest state-built and operated multipurpose water and power system in the United States. The 700 miles of canals and pipelines provide drinking water for 23 million people and irrigation for 750,000 acres of farmland. *D. polymorpha* presence in San Justo Reservoir provided an opportunity to study zebra mussel biology under similar water quality and climatic conditions found in the SWP.

Studies by California Department of Water Resources staff were initiated in June 2008 to measure seasonal veliger abundance and settlement rates. Veliger sampling (63 micron mesh, 500L) occurred at weekly to monthly intervals over 3 spawning seasons. Veligers occurred in low numbers (<5 veligers/L) from March through November, peaked in June (>100 veligers/L) and were not detected November through February. Surface tows (1 x 40m) yielded consistently higher veliger densities than vertical tows (2 x 20m).

Mussel settlement and biomass accumulation rates were examined on various materials, including anti-fouling coatings and other materials commonly used in the SWP. Colonization of these surfaces was documented over time using high resolution photography. Biomass was determined by weighing colonized substrates with a hanging scale. Few anti-fouling coatings were both durable and resistant to zebra mussel colonization.

Additional studies were implemented in May 2009 to measure juvenile and adult zebra mussel growth and mortality both spatially and temporally. Mussels from five size classes (3-6mm, 10-12.6mm, 12.6-19mm, 19-25mm, and 25mm+) were harvested from the reservoir and incubated in mesh bags throughout the epilimnion and hypolimnion for one year. Mussels were removed from the water each month to measure maximum shell length, volume, and mortality, and then returned to the same treatment bag for redeployment. Shell length was determined by photographing mussels on graph paper with high resolution photography and measuring the images with measurement software. Volume was measured in the field using volumetric displacement in a graduated cylinder. Mussels deployed in the epilimnion grew faster and had higher survival than mussels deployed in the hypolimnion.

Zebra and quagga mussels pose a serious threat to water delivery systems in California. In response, the California Department of Water Resources (DWR) has implemented a mussel management program. The program includes early detection monitoring, rapid response planning, and development of biofouling control measures prior to mussel establishment within the SWP. The results of these studies directly aided in the refinement of program components, and provided a better understanding of overall implications to future management and control of dreissenid mussels in the SWP.

NOTES

Aquatic Invaders in Dutch Coastal Waters: A World Heritage Site at Risk?

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Ministry Agriculture, Nature & Food Quality

Adriaan Gittenberger

GiMaRIS

The Netherlands has a long history of shipping, fishing, aquaculture and coastal waterworks. At least partly as a result of this, there is considerable impact of invasive species on biodiversity, economy and safety. Dutch coastal waters have the highest number of alien species in North Sea region. The Dutch Delta area (e.g., Oosterschelde estuary in the southern province Zeeland) is a regional hot spot: with over 100 alien species. The Dutch Wadden Sea in the north of The Netherlands has a much lower alien diversity in macrofauna and macroflora with about 65 alien species.

Aquaculture and shipping form the major pathways for introductions of non-native species into the Dutch Delta. The settlement of these species is further aided by the relative high abundance of non-native, artificial habitats like rocky dikes there. The Wadden Sea, a World Heritage Site, is characterised by intertidal areas dominated by soft sediments. The international importance is partly the result of scale. The Wadden Sea has seen repeated loss of major habitats over several centuries: oyster banks, seagrass beds, sabellaria reefs and brackish zones. Other important habitats that have declined include the intertidal mussel beds which are now being replaced by Japanese oyster reefs. Recent decades are characterised by declines in viable fish populations (e.g., herring, groundfish, migrating fish and shellfish (oyster, whelk), and an increasing number of invasions: *Spartina*, *Crassostrea* and related pathogens and parasites (*Mytilicola*, *Bonamia*) and predators (oyster drills), *Mya* and *Ensis*. These new invasions are a result of economic transition (aquaculture replacing bottom fisheries), coastal development (creating hard substrate stepping stones) and recreational shipping (marina's), which impose new risks to the international Wadden Sea.

Several general trends are apparent: Low biodiversity and brackish habitats have higher prevalence of marine alien species. Shipping ports, marina's and aquaculture are hot spots for further dispersal. Pathogens and parasites have high impact on biodiversity and economy. Major shifts have occurred recently in abundance and distribution of invasive alien species. EU and national policy is briefly discussed as well as new developments in the management cycle: intensifying monitoring, rapid assessment, risk assessment, prevention and eradication.

NOTES

***Xenopus laevis* in Golden Gate Park: A Field Study**

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A healthy feral population of the invasive non-native aquatic amphibian *Xenopus laevis* has been established in a small man-made pond in Golden Gate Park, San Francisco, CA since ~2001. We have followed this population from July 2004-2006 and visited again in the spring of 2009 with the goal of monitoring the relative abundance, reproductive effort/efficiency, disease and parasite load, as well as diet. Specimens were collected by dip netting and trapping. Over 500 *Xenopus laevis* were collected and necropsied. Ovaries were visually inspected and collected for histopathology, and water quality tests (pH, temperature, conductivity, ammonia, nitrate, nitrite, free and total chlorine, monochloramine, copper and dissolved oxygen) were performed on samples collected from the pond. During the winter months of January and February, water temperature ranged from 6.1-10.6°C, and ~19 of the females examined during those months were anovulatory (i.e. had fewer egg sacs and/or egg sacs that lacked primordial germ cells). Anovulatory frogs tended to be the older, larger frogs with average snout-to-vent lengths (SVL) and body weights of 10.1cm (~2-3 years of age) and 97.1g respectively. Fecund frogs were smaller with average SVLs and weights of 9.1cm and 72.1g, respectively. During summer months, when water temperature reached 20.8°C, another peak in the number of anovulatory females (26.3%) was observed. Parasite load consistently included rotifers, copepods, cladoceres, chironmids, and mosquito larva. Stomach contents included and juvenile *Xenopus* and *Xenopus* eggs. There was no evidence in this population of fungal disease (*Batrachyium dendrobatidis*) or of mycobacteriosis. Water pH declined to 5.5 in the winter months and the chlorine levels reached as high as 0.58 mg/L without physical evidence of illness in the frogs. In conclusion, this feral fecund population of *Xenopus laevis* is healthy and free of disease and has readily adapted to Northern California climates.

NOTES

Evaluation of International Risk Assessment Protocols for Exotic Species

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Wiebe Lammers

Ministry of Nature, Agriculture and Food Safety, Plant Protection Service

Gerard van der Velde

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In the last decade various risk assessment procedures for exotic species have been developed. We evaluated seven national and international developed risk assessment procedures using criteria related to invasion stages, impact categories, data requirements, scoring methods, uncertainties, policy compliance, user friendliness and assessment time. In addition, risk classifications resulting from the use of various protocols in different countries were compared. Overall, two different approaches for risk characterization could be distinguished: 1) qualitative listing methods using formalized questions to assign high-risk species to a Black List, and 2) (semi)-quantitative scoring methods, using the sum of the scores for various evaluation criteria as indicator for a high, medium or low risk. The majority of the protocols give little explanation or quantification as to what actually qualifies a significant (harmful) ecological effect. Different risk classifications may occur due to differences in species-climate or species-environment match in countries or biogeographical regions, data availability, and experience of risk assessors. Differences in species-environment match between various countries stress the need for regional specific risk assessments of exotic species.

NOTES

Aquatic Invasive Species in the Laguna Madre/Rio Bravo Ecological Region

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Universidad Autónoma de Nuevo León, Facultad de Ciencias Biológicas

Within the Strategic Plan for North American Cooperation in the Conservation of Biodiversity the Commission for Environmental Cooperation identified the Laguna Madre/Rio Bravo Ecological Region (LM/RB) as one of the 14 regions of prime importance for focused North American attention, based on biological and ecological continental significance and high levels of threat. A major environmental problem that is just beginning to be considered at a bi-national level (Mexico-US) is the presence of invasive species in shared ecosystems. An analysis of aquatic invasive species occurring in the LM/RB region was performed in order to gain understanding of this driver of change in biodiversity. According to several databases, reports and scientific articles, there are 373 exotic species (100 plants, 85 invertebrates, 162 fishes, 10 amphibians, 4 reptiles 1 mammal and 1 fungus, 2 protozoans, 4 bacteria and 4 viruses) present or reported in neighboring states to the LM/RB region. An index to categorize the invasiveness of species was developed and a pathway analysis for the region was made. Two models were used to construct bioclimatic envelopes for each species: Maximum entropy (Maxent) and Genetic Algorithm for Rule-Set Prediction (GARP).

The most important source region for exotic plants was Asia, followed by the American continent. A great number of plants were associated with dry ballast, probably as seeds, and hull fouling. Fishes were the most important exotic species group in LM/RB region (more than 40% of all taxa). The majority is native to the American continent and a great number are native transplants of the Atlantic slope. The major pathway of fish introductions was the intentional stocking for sport fishing and the pathways associated with this activity (fish used as bait and aquaculture). The group of amphibians and reptiles was represented by few species, all native to the American continent, with a great majority from North America, chiefly from the Atlantic slope. For this group pet-aquarium was the most important pathway. The American continent was also the main source region for exotic invertebrates in LM/RB region. This group differs from the rest, because it was the only group where species of marine and brackish origin were more important than those of freshwater origin. Invertebrates were mostly introduced by ballast water and hull fouling. The introduction of bacteria and viruses was associated to aquaculture of commercial species, particularly from countries of the Asian continent. Only one mammal associated to freshwater was found to be exotic to the LM/RB region.

According to the invasiveness index developed for this study 94 species were scored as critical invasive species (50 species of plants, 23 invertebrates, 15 fish, 2 amphibians, 1 reptile, 1 mammal, 1 bacteria and 1 virus).

NOTES

Tracking Invasive Species with a Unique Tool to Set Up and Manage a Network of Observers (BIOAPP)

*Hélène Godmaire, Caroline Larivière and Valérie Lacourse
Great Lakes United, – Union Saint-Laurent Grands Lacs*

*Blaise Barrette
Les Productions un Monde à Part*

Horticulture is an important vector for the introduction and spread of invasive plants in Canada. In an effort to protect wetland biodiversity and integrity, Great Lakes United has launched a three year outreach plan to short-circuit the horticulture chain. For the past three years, Great Lakes United has run a campaign to inform professional and amateur gardeners of the risks that exotic invasive plants pose, and to provide them with the knowledge to make sound, wetland-friendly, choices. In addition, a school program dedicated to horticulture and landscaping schools has been developed and implemented. This program focuses on the importance of prevention and promotes voluntary codes of conduct. Now, after disseminating a prevention message among gardeners and the public, Great Lakes United is focusing on the early detection of invaders. Thus, the third phase introduces the Plant Watch Monitoring Network, which involves a diversity of actors such as gardeners, anglers, hunters, bird-watchers, boaters, hikers, and other groups and individuals that frequently visit the outdoors and wetlands. Available on line, this tool will help detect new invaders and the spread of new invasions. It will bridge knowledge gaps on the distribution of targeted invasive species, their population dynamics and the risks they represent to the ecosystem. Education strategies, tools, results and perspectives will be presented with a focus on the Monitoring Network's operation and the possibility and transferability it offers.

NOTES

It's in the Bag – Managing the Potential Spread of AIS from Crane Testing Water Weights

Paul Heimowitz
U.S. Fish and Wildlife Service

Joe DiVittorio
Bureau of Reclamation

Angelo Cimini
Imes Inc.

Beyond major AIS pathways such as recreational boating and ballast water, managers also need to consider lesser-known vectors. Crane testing water weight bags have recently surfaced on the AIS management radar screen. Water weight bags are used by the crane industry as an alternative to fixed solid weights for lift testing. These large foldable bags are transported to a crane work site, filled with water to specified volumes that equal a precise weight, emptied after crane testing operations have concluded, and transported to another work site. If raw water is used for bag filling (e.g., a remote site where potable water is not available), and bags are not thoroughly dried or decontaminated, there is potential that remnant water will be transported to the next work site, which could be thousands of miles away. Any AIS retained in the remnant water, such as quagga mussel veligers, could be inadvertently moved in the process. Water weight industry leaders have been working proactively to evaluate and eliminate AIS risks from this pathway, using techniques such as fan-assisted drying and freezing. Further work is needed to validate and refine decontamination methods for a variety of AIS and pathogens. Outreach is needed to inform the rest of the industry, as well as agency contract managers, regarding risks from this pathway and associated risk management methods. Third party certification and processes like Hazard Analysis and Critical Control Point planning can serve to verify bag disinfection. Strategies to address this pathway will provide a model for management of other mobile water-based equipment.

NOTES

Invading Species Watch: A Volunteer Based Monitoring Program in Ontario's Inland Lakes

Francine MacDonald and David Copplestone
Ontario Federation of Anglers and Hunters

Created in 1998, the Invading Species Watch program is a volunteer based monitoring program for the detection of zebra mussel veligers (*Dreissena polymorpha*) and spiny water flea (*Bythotrephes longimanus*) in Ontario's inland lakes. This program relies on a network of volunteers from across the province as well as a team of summer staff to coordinate volunteer efforts. Since the program's inception, well over 300 volunteers have collected 2850 samples from 530 lakes. Their efforts have dramatically improved our knowledge of zebra mussel and spiny water flea distribution in Ontario.

In addition to this knowledge, and of equal importance, is the local awareness that is raised by the Invading Species Watch program. By engaging local citizens to participate in monitoring efforts, making presentations at various events during the summer, and distributing educational materials, staff and volunteers work to prevent the spread of invasive species.

In this presentation we will describe to history of the program, its successes, lessons learned, and plans for the future.

NOTES

Using Risk Perception to Determine if *Didymosphenia geminata* Poses a Risk to Tasmania, Australia

Marnie Campbell, Nicole Cliff and Chad Hewitt

National Centre for Marine Conservation and Resource Sustainability, Australian Maritime College

For the management of introduced species to be successful it must engage stakeholders and educate the plebs. This is particularly important in a border context where we rely on people to “do the right thing.” However, altruistic behaviour relies on people’s perception of the risk nature of an event and whether they perceive their actions as contributing to the risk event. In a biosecurity context, often people are unaware that their actions pose a risk and hence improving public awareness of introduced species via risk communication is a strategy that is often employed by quarantine agencies.

Within Australia, Tasmania is considered a ‘pristine’ environment and is marketed on its ‘green’ image, which attracts national and international travellers. It’s an island and as such its State quarantine regulations are similar to the National level regulations, with the aim being to prevent introduced species from entering this environment. A critical component of this border management is to ensure that travellers are aware of the risks they pose to the State and to manage their activities with regards to transporting species across borders. We decided to investigate how aware people are of introduced species and then to test the potential leakiness of the border by undertaking a risk assessment that would examine whether the freshwater, non-indigenous diatom, *Didymosphenia geminata*, poses a risk to Tasmania.

Didymosphenia geminata is not present in Australia, but it was introduced to New Zealand in late 2004, and since this incursion Tasmania was placed on high alert. Tasmania and New Zealand are linked socially (people that travel between the two regions to undertake recreational activities) and environmentally (similar environments and ecological niches). At present, airport travellers entering Tasmania pass through quarantine posts that contain awareness information about *D. Geminata*. Information about *D. geminata* is also provided to recreational fishers that pay for fishing licences.

Our risk assessment has a quarantine endpoint (to prevent the entry of a species across the Tasmanian border) and used quantitative data on traveller’s patterns and recreational users risk perception (concern and behaviour). The process included determining: 1) the likelihood that *D. geminata* could arrive in Tasmania; 2) the consequence of this entry; and 3) the derived risk. Data were collected using a survey instrument with face-to-face interviews. We targeted travellers at the Launceston airport, and gathered consequence data by targeting trout fishing, hiking, and kayaking recreational user groups.

In total, we surveyed just under 400 people, with a response rate of ~80%. We surveyed 194 people entering Launceston airport and found that the likelihood of *D. geminata* entering Tasmania was rare. 200 recreational users were then surveyed with consequences (respondents level of concern and changes in their behaviour) ranging from moderate to catastrophic. Thus, *D. geminata* poses a low-medium risk to Tasmania. Some interesting statistical trends were detected and will also be discussed within this presentation.

NOTES

Bighead and Silver Carps in the Great Lakes: Understanding the Complexities and Uncertainties

Duane Chapman

U.S. Geological Survey, Columbia Environmental Research Center

Patrick M. Kocovsky

U.S. Geological Survey, Great Lakes Science Center, Lake Erie Biological Station

Much attention has been focused on the threat of bighead and silver carp invasion to the Laurentian Great Lakes. Predictions of the effects of an invasion range from the complete collapse of the Great Lakes fisheries to failure of the invading fish to survive in the Great Lakes ecosystems, and some have expounded a great deal of confidence in a particular outcome. However, there remains a great deal of uncertainty regarding the outcome of any invasion. Proposed factors that may limit or allow the invasion include temperature, availability of planktonic or alternative food resources, propagule pressure, and water hardness. We address each of these factors, and describe the uncertainty where appropriate. Also, we address the potential rate of any expansion of a bighead or silver carp population in the Great Lakes, based on existing risk assessments and on early rates of bighead and silver carp population expansion in rivers of the central United States and in the Caspian Sea.

NOTES

Development of Methods to Orally Deliver Biocides to Control or Limit Invasive Aquatic Animals

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Aquatic invasive organisms are a serious problem throughout the United States, causing billions of dollars in losses to economies that depend on aquatic resources. Natural resource managers consistently list the lack of chemical tools to control aquatic invasive species as one of their top concerns. Currently, only four chemicals, the general piscicides antimycin and rotenone and the lampricides 3-trifluoromethyl-4-nitrophenol and niclosamide are registered with the U.S. Environmental Protection Agency for control of aquatic pests. Though Asian and common carp, as well as most other invasive fish species, are sensitive to antimycin or rotenone, the current formulations do not offer selective control of these species. Applications of antimycin or rotenone are thus limited only to those aquatic systems where a complete fish kill may be tolerated. Present application methods, which rely on dissolution of a piscicide in the water column, limit management applications to small aquatic habitats of limited volume. This limitation effectively permits invasive aquatic animals to move unchecked through large aquatic systems such as the Great Lakes, Mississippi River, or other large water bodies. The development of targeted delivery systems to deliver bioactive agents to specific invasive aquatic animals could facilitate the development of integrated pest management programs. Developing alternative delivery systems presents a unique opportunity to enhance the selectivity of general piscicides and substantially reduce effects on non-target species.

NOTES

Use of Pheromones to Control Invasive Asian Carp

Edward E. Little and Robin D. Calfee

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Bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*H. molitrix*), inadvertently introduced to the Mississippi River in the 1970s -1980s are now abundant throughout the lower Missouri, the Mississippi, and Ohio Rivers. The carp are highly efficient pelagic feeders, have high fecundity, and likely pose a threat to endemic species. The use of species-specific repellants and lures based on natural pheromones may increase the effectiveness of conventional eradication methods. Carp have been suggested to have a “chemical language” that is effective in turbid environments for predator defense and reproduction. During avoidance/attractance tests juvenile carp significantly avoided aqueous extracts prepared from the skin of injured conspecifics. The avoidance response was associated with species-typical anti-predator responses, including cessation of ongoing activities, freezing, school formation, and movement from the area. The avoidance response persisted for as long as the stimulus was applied, thus the skin extract “alarm substance” may be effective in repelling carp from critical habitat. In contrast, juvenile carp were initially attracted to chemical stimuli of water in which small schools of carp were held suggesting a potential chemical lure. The context of these chemosensory stimuli is likely important in sustaining the avoidance/attractance responses, reflecting the strength of the stimulus, proximity of the organism to the plume, orientational cues, presence of conspecifics, and motivational factors such as hunger, acclimation, and experience with the predator. Thus, the initial state of vigilance would likely subside in the absence of pertinent visual and auditory stimuli such as the presence or motion of a predator or schooling conspecifics. Future studies will consider attractive lures based on chemical feeding stimuli, and substances associated with sex pheromones.

NOTES

The Quagga Mussel: Reclamation's Control Options for Dealing with an Invasive Species

Leonard Willett

Bureau of Reclamation, Hoover Dam Water Treatment Group Manager, Lower Colorado Dams Office

Quagga mussels were discovered in Lake Mead on January 6, 2007. Since then, they have been found throughout the lower Colorado River as well as in water bodies in California, Arizona, Nevada, and Colorado. This presentation will focus on the already observed as well as anticipated impacts of this invasive species on the Colorado River, on the water storage, diversion and delivery infrastructure along the river, and what the Bureau of Reclamation and other key water management agencies are doing to address the threat the mussels present.

NOTES

Salt River Project's Invasive Mussel Outreach and Education Efforts in Phoenix, Arizona

Lesly Swanson

Salt River Project, Environmental Siting and Studies

Quagga and zebra mussels are spreading throughout the southwestern United States. In Arizona, Salt River Project (SRP) manages a system of six dams and reservoirs and over 1300 miles of canals and laterals in the Phoenix area and one dam and reservoir in northern Arizona. These southwestern reservoirs are located within easy driving distance of existing mussel populations. The SRP reservoirs provide a source of water recreation for the local cities and towns and habitat for a number of wildlife species. They are the primary source of water for the metropolitan Phoenix area, serving cities, Indian communities, irrigation districts, homes and agricultural enterprises.

SRP is a multi-purpose federal reclamation project responsible for delivering nearly 1 million acre feet of water annually to its service area in central Arizona. SRP also receives water from the infested portion of the Colorado River via an aqueduct managed by the Central Arizona Project (CAP). The CAP canal is directly connected to SRP's canal system.

Electricity is supplied by SRP to about 946,000 customers in the metropolitan Phoenix area. Some of the generating stations responsible for supplying power take water directly from SRP's system of canals, canals which are being fed by infested waters. Hydroelectric generation from SRP's dams and three low flow hydro plants on the canal system also provide SRP customers with power. A coal fired power plant operated by SRP draws water from Lake Powell, located upstream of current established infestations on the Colorado River.

All of the SRP reservoirs are currently free of quagga and zebra mussels. Regular monitoring is being done and an active outreach and education campaign has been evolving since Quagga mussels were found in Lake Pleasant in December 2007. SRP feels that one of the key components to keeping SRP reservoirs mussel free is public education.

It is important that SRP reservoirs and dams remain mussel free. SRP's education and outreach effort is a complicated task due to the vast number of stakeholders and the close proximity of Lake Pleasant. It is possible for a boater to travel from Lake Pleasant to one of the SRP reservoirs in the same day, potentially acting as a vector spreading quagga veligers. Also, boaters visiting infested Lakes on the Lower Colorado River or in neighboring states could also stop at an SRP reservoir.

This presentation will describe the outreach and education efforts SRP has undertaken to reach the public stakeholders ranging from anglers, water recreationists, water customers, power customers, marinas and State and Federal agencies. SRP is involved in the daily operations of the dams and reservoirs but does not have regular contact with water recreationist. Thus, working with other agencies and marinas has been a key component to outreach efforts. SRP feels it is important to play an active role in helping to contain the spread of zebra and quagga mussels in the desert southwest. Not only will this protect SRP infrastructure and water and power delivery, it will also benefit all stakeholders in the southwestern United States.

NOTES

Settlement and Growth of Quagga Mussels (*Dreissena bugensis*) in Lake Mead, USA

David Wong and Shawn Gerstenberger
University of Nevada Las Vegas

Wen Baldwin and Bryan Moore
National Park Service

Settlement and growth of quagga mussels (*Dreissena bugensis*) was monitored in Lake Mead, NV, USA, where the first dreissenid occurrence was confirmed in the western United States. To measure the settlement rate of these invasive mussels, seven acrylonitrile butadiene styrene (ABS) pipes were attached to a line in shallow water (7.7 m) since November 23, 2007; additionally, eight ABS pipes were placed in another line in deep water (13.4 m) since January 3, 2008. Quagga mussels were sampled from these pipes on March 19, May 21, July 9, and October 20, 2009, respectively. Active settlement of quagga mussels veligers were recorded in all sampling events. The settlement rates of quagga mussels did not differ among the two lines but a significant difference was found among seasons, with the highest settlement rate recorded from July 9 to October 20. The higher settlement rate in October corresponded to higher abundance of veligers in the water column in the Boulder Basin of Lake Mead. Alternatively, early July's high veliger abundance in the water column did not correspond with higher settlement on the ABS substrates. One explanation may be the percentage of competent veligers, in terms of the ability to settle, usually peaks during fall and is less in the spring and summer. There was no significant difference in mussel density between the two experimental depths. However, significantly higher number of mussels was recorded on October 20, 2008 than other sampling time, which indicated that new mussels were still settling and growing on these ABS pipes.

Shell length data of different cohorts collected from the above experiment were also used to estimate the growth of quagga mussels. The patterns of quagga mussel growth from the two lines were quite similar. The growth rates of newly settled juveniles from spring to early summer were about 50 to 100 $\mu\text{m}/\text{day}$ and decreased to 10 to 40 $\mu\text{m}/\text{day}$ from summer to early fall. Analysis of covariance revealed that the growth in spring was significantly higher than growth during summer or early fall. Length frequency data on two natural populations of quagga mussels collected in 2007 showed that there were four distinct cohorts that established in Sentinel Island and Indian Canyon Cove of Boulder Basin, Lake Mead. The estimated growth rates of these two populations decreased significantly as mussel size increased. A Von Bertalanffy growth model was used to show that the maximum mussel shell length in Sentinel Island and Indian Canyon Cove were 22.7 and 25.8 mm, respectively, which agreed well with the field observed shell length (i.e., 22.0 and 24.0 mm) in these two locations. Caged mussels at 7.5 m depth in Las Vegas Boat Harbor in Boulder Basin of Lake Mead were also used to estimate growth of quagga mussels. Mussels less than 10 mm were held individually in a cage from July 31, 2007 to March 19, 2008. The shell length measurements from the cage experiment also indicated that smaller mussels grew faster than larger ones. The information on settlement and growth of quagga mussels from this study can help understand their population dynamics in the western United States.

NOTES

Interagency Monitoring Action Plan (I-MAP): Quagga Mussels in Lake Mead National Recreation Area

Kent Turner
National Park Service

David Wong and Shawn Gerstenberger
University of Nevada Las Vegas

Quagga mussels (*Dreissena bugensis*) found on January 6, 2007 in Lake Mead were the first confirmed occurrence of dreissenid mussels (quagga and zebra mussels) in the western United States. These invasive mussels not only clog pipelines and other public facilities, but also have profound and permanent impacts on water quality and the ecosystem. Upon discovery of this emerging issue, the National Park Service (NPS), Bureau of Reclamation (BOR), U.S. Fish and Wildlife (USFWS), Southern Nevada Water Authority (SNWA), Nevada Department of Wildlife (NDOW), and other agencies expressed concern about protecting drinking water quality, water delivery infrastructure, ecosystem health, endangered species, and recreational activities, and identifying ways to reduce the spread of this invasive species. To address these issues, a small working group was established shortly after quagga mussels were discovered and has grown rapidly to include about 80 individuals representing over 25 federal, state, regional, and local agencies in the Lower Colorado River basin. Significant progress has been made by combining efforts of the different agencies.

The results of these efforts have been compiled and integrated into an interagency monitoring action plan (I-MAP). The goal of I-MAP is to develop a standardized, long-term, cost-effective, and consistent monitoring plan for quagga mussels in Lake Mead to gain efficiencies from shared operations and information. The plan attempts to build upon current monitoring activities and capabilities, identifies the next steps that can occur within existing capabilities, and, finally, outlines gaps and areas of future need. The first step prescribed by the I-MAP is to identify key needs, questions, and projects related to the objectives associated with (1) infestation of quagga mussels and (2) the basic biology and ecology of quagga mussels. This approach is cost-effective in using statistically determined minimum numbers of sampling stations that can represent the entire lake and an appropriate sampling frequency that will best estimate recruitment and growth of quagga mussels in Lake Mead. For monitoring adult mussels, we primarily focus on 13 transects at different depths covering both silty and rocky sediments in Lake Mead and a sampling frequency of quarterly to annually; for monitoring veligers, 28 stations are set up with a sampling frequency of weekly to monthly and 1 extra station is sampled at different depths each week. Standardized methods of monitoring are critical to the success of this plan. For veliger monitoring, plankton net (with size of 63/64 μm) tow is recommended; diving and PONAR grab are used to monitor adult mussels in the hard and soft sediments, respectively. This program is being implemented by lake managers and stakeholders to scientifically monitor the long-term quagga mussel development and its potential impacts on water quality and food webs in Lake Mead. This multiple agency project can be used as an example for other interagency groups in locations infested by dreissenid mussels, especially areas in the western United States.

NOTES

From Sink to Source? An Overview of Zebra Mussel (*Dreissena polymorpha*) Population Dynamics in Reservoirs of the South-Central USA

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Jason Goeckler
Kansas Department of Wildlife and Parks

Everett Laney
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Early in the zebra mussel colonization of North American waters, debate existed as to how successful the new invader would become in the more southern latitudes of the U.S. By 1993 zebra mussels had colonized the McClelland-Kerr navigational system in Oklahoma and were probably introduced by barge traffic from the Mississippi River. However, it was not until 2003 that zebra mussels were found outside the navigation channel, with the discovery of individuals in Oologah Reservoir, OK, and in El Dorado Reservoir, KS. Routine population monitoring in these two systems revealed significant increases in peak veliger density until 2006 in Oologah and 2007 in El Dorado, when a large-scale population die-off occurred, bringing veliger densities from $>300/L$ to less than $1/L$ in both systems. Zebra mussels have not been fully extirpated from these reservoirs and their densities are slowly increasing annually. At least seven other reservoirs in Kansas (Winfield, Cheney, Marion, Perry, Milford, Wilson, and Lake Afton), and another five reservoirs in Oklahoma (Kaw, Keystone, Sooner, Texoma and Hudson) currently contain populations of zebra mussels. Additionally, polymerase chain reaction (PCR) survey samples suggest the possibility of even more infestations in Oklahoma. At Sooner Reservoir, OK (a thermally modified impoundment) annual die-offs of zebra mussels occur during June and July in the warmest region of the lake, but there has been no evidence of a large-scale reduction as had occurred in Oologah and El Dorado Reservoirs. Furthermore, at Texoma Reservoir, on the OK-TX border, a recently discovered population of zebra mussels has lead to curtailed water withdraws in an effort to prevent new infestations into Lavon Reservoir and the Trinity Basin, TX. Current and future work is aimed at determining upper thermal tolerances of zebra mussels from this region, specifically comparing individuals from Sooner Reservoir with the Kansas populations. If zebra mussels from this region have an enhanced physiological ability to cope with warm summer water temperatures, continued spread into Texas is likely.

NOTES

Reducing the Risks of Schools, Science Curricula and Biological Science Suppliers as Potential Pathways for Spreading Aquatic Invasive Species: Turning a “Home Town” Problem into Education and Prevention Opportunities of Bi-National Scope: Phase 1 & Phase 2

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Wei-Ying Wong
Connecticut College

Helen Domske
Cornell University

Jeff Adams, Julian Olden
University of Washington

The distribution, use and disposition of live organisms by biological supply houses, science curricula, and schools is an important, but until recently, often overlooked and not well- studied pathway for the introduction and spread of invasive species that threaten our ecosystems, human health, and economy. This session will describe a bi-national USA and Canadian study that aims to elucidate and find solutions to the “invasive species in classrooms” pathway as a potential vector for the introduction of invasive species into the wild by: a) formally defining the pathway through surveys and interviews with schools, biological science supply houses, curriculum specialists and curriculum developers, b) gaining input on effective solutions from all the stakeholders in the pathway through formal focus groups and interviews and c) developing pilot outreach and education tools for invasive species prevention based on input from stakeholders.

We will share our latest findings on the route by which organisms arrive in the classrooms, how the organisms are used in classrooms, what happens to them and stakeholder-based ideas and solutions including those from biological science supply companies. Teachers are often reluctant to euthanize live creatures used for classroom projects and many give them to students, let them die naturally in the classroom or release to the wild. Few teachers euthanize them or return them to the supplier. In addition to biological science supply houses, we learned that pet stores are also an important source of animals used in the classroom. Researchers also met with biological supply house representatives to understand their business and operational processes (see presentation by Charlebois et al) as it relates to schools, invasive species and collaborative ways to minimize this pathway as a source of AIS.

We are learning that solutions to this pathway have to be acceptable to all the stakeholders (educators, curriculum developers and biological science supply houses). Because of the reach that schools have and the highly integrated nature of curricula with biological science supply houses, addressing this pathway, provides a mechanism for education about invasive species that would otherwise not be possible.

Live Organisms in the Classroom: Value and Implications for Invasive Species Management

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Robin G. Goettel, Patrice Charlebois, Kristin TePas and Terri Hallesy
Illinois-Indiana Sea Grant Program

Live organisms are an important component of the classroom environment. Live specimens and pets routinely enter and leave the classroom. In a series of focus groups with teachers across the US and Canada, we have found that live organisms do not merely serve as specimens for study nor as spectacle objects. Teachers spoke extensively and passionately about the use of live organisms to model stewardship, responsibility, and ethics. Teachers also cite the importance of live organisms in their work with special needs students as well as youth at risk.

Our research also indicates that students and educators commonly take live organisms home and/or intentionally release organisms into the wild. The classroom then represents a potentially important *pathway* for the introduction of invasive species (IS) into the environment. But it also represents a promising *opportunity* to work with educators to close this pathway while educating students about the issue of invasive species.

While it may seem that the most expedient ways of eliminating the classroom as a pathway for introduction of IS into the environment may be to put a stop to the use of live organisms or to encourage the use of euthanasia on live organisms, such an approach would likely meet with resistance given the value of live organisms for in- and out-of classroom teaching. How should we balance the importance of mitigating introduction of IS with preserving the roles that live organisms play in education?

NOTES

“AIS in the Classroom” Pathway: How do Biological Supply Houses Factor in?

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The distribution and use of live organisms by biological supply houses, science curricula and schools is a relatively new and heretofore not well-studied pathway for the introduction and spread of aquatic invasive species (AIS). In our research on this pathway, we have learned that 1) students commonly take live organisms home, which creates the potential for these new “pets” to escape or be released, and 2) schools and teachers often intentionally release organisms into the wild. These findings indicate that the use of live organisms in the classroom is a consequential pathway through which AIS can be introduced into the environment.

Live organisms regularly are obtained for classroom use through a Biological Supply House (BSH). Some of the live organisms available through BSHs are documented AIS including red swamp crayfish (*Procambarus clarkii*), rusty crayfish (*Orconectes rusticus*), Brazilian elodea (*Egeria densa*), American bullfrog (*Lithobates catesbeianus*) and mosquito fish (*Gambusia affinis*). Thus BSHs can serve as distribution centers for these potential invaders, which are frequently shipped outside their natural range for classroom use. While having live organisms in the classroom provides a valuable learning experience for students, threats associated with this pathway need to be addressed.

To help us better identify and address these threats, we analyzed the role of BSHs in this multi-faceted pathway. To do this, we conducted phone interviews with the leading supply houses. Through these interviews we gained a better understanding of how BSHs operate including how they obtain their live specimens, how they determine what organisms to sell, what management practices are in place regarding AIS, and what information they provide to customers regarding live-organism purchases. These data were then used to identify opportunities for collaboration with BSHs on preventing the introduction and spread of AIS through the use of live organisms in classrooms.

NOTES

Citizen Scientists Contribute to the First Verified Discovery of the Colonial Tunicate (*Didemnum vexillum*) in Oregon: Education and Management Lessons Being Learned

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Sea Grant Extension, Oregon State University

Rick Boatner

Oregon Dept. of Fish and Wildlife

Lorne Curran

Volunteer Scientific Diver, REEF and Oregon Coast Aquarium

Bruce Hansen

U.S. Department of Agriculture Forest Service, PNW Research Station

Didemnum vexillum, a colonial tunicate was discovered y for the first time in both Oregon and Alaska through separate citizen science efforts during the first-half of 2010. Infestations of *D. vexillum* have been reported in California, Washington and Province of British Columbia as early as the years 1990's through 2007, but not in Oregon and Alaska until 2010. The first verified discovery of *D. vexillum* in Oregon was made by volunteer scientific divers associated with the Oregon Coast Aquarium and REEF Environmental Education Foundation during February, 2010 in Winchester Bay on a rock jetty and on some mooring lines and stringers associated with an oyster farm close to the jetty. A second Oregon discovery occurred in April 2010 in Coos Bay during inspections of tires and VEXAR substrate samplers by a university marine biology class. In June, 2010, *D. vexillum* was discovered in Sitka, Alaska during a large-scale and well-organized citizen science based "bioblitz" event led by agencies and non-profit organizations. This paper focuses on lessons being learned in Oregon that can help guide, improve and accelerate early detection, rapid response and prevention efforts associated with *D. vexillum* and other invasive tunicates. We also acknowledge the important role of volunteers (e.g. scientific divers), collaborative coordination efforts led efforts by the Oregon Invasive Species Council and engaging and working with stakeholders impacted by the discovery.

Occurrence of the *D. vexillum* on rock outcrops and jetties at the mouth of a bay in Winchester Bay, Oregon poses management challenges and will require creative adaptive management-based control solutions. In just 3 months, volunteer scientific divers have recorded 2-3 (from ~0.1m² to 0.3m²) fold area expansion of the individual colonies of *D. vexillum* on the rock jetty in Winchester Bay. Rapid response in Oregon is pending the completion of a statewide invasive tunicate (marine invasive invertebrate)management plan, site specific risk analyses, delimiting surveys and microsite specific sources of environmental data such as salinity and temperature needed to understand *D. vexillum* establishment and reproduction.

NOTES

Enhancing Surveillance for Marine Pests in Northern Australia by Engaging Indigenous Marine Rangers

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With a remote and largely inaccessible coastline, surveillance for invasive marine species in the Northern Territory (NT) has historically been focussed in and around major population centres. More recently, however, surveillance efforts in remote areas have been enhanced through the involvement of Indigenous Marine Rangers.

Whilst no invasive marine species are currently known in Territory waters, biofouling on vessels is a significant and increasingly important vector for the transport of invasive marine species by vessels of all classes. Although most commercial vessel activity is concentrated in port environments, remote areas of the NT coastline are also threatened by biofouling particularly on yachts and illegal and unregulated vessels. In such areas, an introduced pest is likely to go unnoticed until it is well established, greatly reducing the chances that control and eradication activities would be successful.

In light of such risks a project commenced in 2007 to enhance surveillance efforts in remote areas. Marine pest training, educational materials, support and resources were provided to a small number of Indigenous Marine Ranger groups to conduct coordinated marine pest monitoring activities. Training was conducted 'on country' over a series of visits by Fisheries' staff who also accompanied rangers on patrol.

Marine pest surveillance has been enthusiastically embraced by the ranger groups who see it as a contribution to the management of their sea country. Building on the success of the project, and in order to maintain long term involvement, surveillance training has now been incorporated into an accredited course designed specifically for the Rangers. The Certificate II in Fisheries Compliance was developed to increase knowledge and skills in identifying and reporting fishing and maritime related incidents to NT and Federal agencies. With Fisheries providing ongoing financial support to eight ranger groups on a fee-for-service basis, the long term involvement of the rangers looks certain.

Indigenous Marine Rangers across the NT are now actively involved in marine pest monitoring activities, whether through the regular inspection and collection of artificial settlement surfaces, or the incorporation of marine pest inspections into current activities such as marine debris surveys, beach walks and shore searches. Training of rangers will continue, with formal training planned to occur on an annual basis and a Certificate III level course already being developed.

NOTES

Placing Control of Asian Carps in a Spatially Explicit Context

James Garvey

Southern Illinois University, Fisheries and Illinois Aquaculture Center

Carps of the genus *Hypophthalmichthys* are established in the Mississippi River drainage and expanding their range. Currently, these species have increased in the Upper Mississippi River System (UMRS), threatening to invade Lake Michigan and potentially harm its multibillion-dollar commercial and recreational fishery. Pre-emptive action has been taken - a permanent electrical barrier plus discrete piscicide releases near a potential entry point at the Chicago Sanitary and Ship Canal will reduce movement of adults into the Great Lakes. However, as population densities continue to build in the UMRS and tributaries adjacent to the Great Lakes, the probability of dispersal and establishment via multiple alternate pathways will increase. Given that these carp species are valued economically throughout much of the world and also have unrealized market value in the United States, developing a commercial fishery is possible. A rarity in fisheries, the goal would be to build the fishery to levels sufficiently large to control population growth and reduce standing biomass. Recent spatially explicit research on interactions between carp recruitment dynamics and lock-dam complexes within the UMRS suggests that recruitment may vary with the intensity and frequency of flooding. Thus, a climatically induced series of poor-recruitment years coupled with intense fishing may effectively reduce population density and therefore relax the risk of invasion into the Great Lakes. Because eradication by fishing is the goal, alternative economic opportunities for native fisheries and aquaculture in the UMRS must be developed in parallel with the carp commercial fishery.

NOTES

Poster Presentations

BIOAPP: A Unique Tool to Set Up and Manage a Network of Observers

Blaise Barrette

Les Productions un Monde à Part Inc.

Horticulture is an important vector for the introduction and spread of invasive plants in Canada. In an effort to protect wetland biodiversity and integrity, Great Lakes United has launched a three year outreach plan to short-circuit the horticulture chain. For the past three years, Great Lakes United has run a campaign to inform professional and amateur gardeners of the risks that exotic invasive plants pose, and to provide them with the knowledge to make sound, wetland-friendly, choices. In addition, a school program dedicated to horticulture and landscaping schools has been developed and implemented. This program focuses on the importance of prevention and promotes voluntary codes of conduct. Now, after disseminating a prevention message among gardeners and the public, Great Lakes United is focusing on the early detection of invaders. Thus, the third phase introduces the Plant Watch Monitoring Network, which involves a diversity of actors such as gardeners, anglers, hunters, bird-watchers, boaters, hikers, and other groups and individuals that frequently visit the outdoors and wetlands. Available on line, this tool will help detect new invaders and the spread of new invasions. It will bridge knowledge gaps on the distribution of targeted invasive species, their population dynamics and the risks they represent to the ecosystem. Education strategies, tools, results and perspectives will be presented with a focus on the Monitoring Network's operation and the possibility and transferability it offers.

NOTES

Non-indigenous Copepods and Plankton Dynamics of the Lower Columbia River Estuary

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and

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As part of a multi-year field study to investigate plankton dynamics in the lower Columbia River estuary, we conducted monthly sampling at a station near Astoria, Oregon. We sampled hydrography, chlorophyll, nanoplankton, microplankton, and mesozooplankton. In addition to the description of seasonal variation in the plankton community and relationships to environmental predictors, we sought to better understand the linkages between different taxonomic groups, trophic levels, stages, and size classes of plankton, and especially, the role of native vs. non-indigenous copepods. To do this we performed group-specific ordinations and cluster analyses that related community composition to both environmental and biological variables. All plankton communities displayed strong seasonal cycles and were strongly correlated to freshwater discharge and salinity. However, preliminary analyses also suggested large inter-group differences. Unlike heterotrophic communities (micro- and mesozooplankton), the diatom community was not strongly associated with a temperature gradient. Both diatom and microzooplankton communities were strongly related to predator forcings, particularly to total copepod nauplii, copepodite, calanoid copepod, and rotifer abundances. Conversely, the mesozooplankton community lacked strong relationships with potential prey groups, with the exception of total nanoplankton. The copepod community was numerically dominated by *Eurytemora affinis*, *Coullana canadensis*, and *Pseudodiaptomus forbesi*. The non-indigenous *P. forbesi* dominated during autumn when temperatures were high and river flow minimal. During this period we also saw peak abundances of *Limnoithona tetraspina*, another non-indigenous copepod. These results indicate that plankton communities in the lower Columbia River estuary are strongly influenced by both biological (e.g., trophic interactions) and physical processes (e.g., river discharge), with the relative importance of these processes varying between different groups of plankton. On-going analyses will include examination of potential relationships between specific size classes of nano- and microplankton and mesozooplankton community composition, particularly with respect to native vs. non-indigenous copepods.

NOTES

Patterns of Aquatic Macrophyte Richness and Aquatic Invasive Species Across Europe and the Mediterranean Region

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Are aquatic plant richness patterns the same as terrestrial plant? Is the Mediterranean area a biodiversity hot spot for aquatic plants? Are these patterns related to invasive species? To answer these questions we studied the aquatic macrophyte checklist of 44 countries. We determined species presence or absence based on citations from two on-line databases: CWRIS (The PGR Forum Crop Wild Relative Information System) and GBIF (Global Biodiversity Information Facility). Specific information on invasive species was obtained from DAISIE (Delivering Alien Invasive Species Inventories for Europe) database. We compiled 5297 citations representing 283 different aquatic macrophyte species (vascular helophytes and hydrophytes) and 52 families. Greatest species richness was found in France and Spain (227). Richness was associated with latitude, with medium values at high latitudes, high values at mid latitudes and low values at low latitudes (this is partly due to information gaps for N-African and E-Asian countries). Similar richness patterns were seen for helophytes and hydrophytes. Richness is also correlated with the total freshwater resources of the country, with some exceptions. For example, countries with greater richness than average are Denmark, Netherlands, Spain or France. On the contrary, Belarus and Turkey had poorer than the average richness. 40% of the studied species are invasive somewhere in Europe, but this percentage is much lower when focusing on invasive species coming from outside Europe. A greater percentage of helophytes (51%) are invasive compared to hydrophytes (34%). Even in aquatic habitats having fewer invasive species compared with terrestrial habitats, these represent a greater percentage of the total richness of these habitats. Patterns of invasive aquatic plants richness by country differ from those found for aquatic macrophytes.

NOTES

One-Stop-Shop for AIS Regulations: A National Database of State and Federal Laws

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Illinois-Indiana Sea Grant*

Shipment of live organisms to individuals by commercial entities such as biological supply houses (BSHs) is an avenue through which AIS can be introduced and spread. To illustrate this, consider that some of the live organisms available through commercial entities in the U.S. are documented AIS including rusty crayfish (*Orconectes rusticus*), Brazilian elodea (*Egeria densa*), mosquito fish (*Gambusia affinis*) and parrotfeather (*Myriophyllum aquaticum*). Commercial entities often ship these potential invaders outside their natural range where they can be released into local ecosystems by uninformed individuals.

Many commercial entities will not ship organisms to states in which they are regulated. However, this practice is effective in preventing the introduction and spread of AIS only if a commercial entity's information is comprehensive and up-to-date. Through discussions that we have had with BSHs, we have learned that it is difficult for them to find and keep current on regulations for states to which they ship. They have indicated that state regulatory information is often 1) difficult to find, 2) hard to interpret, 3) distributed among more than one agency, and 4) changed as new species are added to state "regulated" or "prohibited" lists. This task of keeping current on state regulations is especially onerous considering that commercial entities may ship nationwide. Based on our discussions with BSHs, our impression is that commercial entities want to do "what's right" and would abide by AIS regulations if they were made manifest.

To help make AIS regulations more easily accessible to commercial entities, we developed a searchable, online database of all relevant state and federal regulations. The database is accessible via a user-friendly interface that allows commercial entities (as well as private individuals) to easily obtain information based on their needs (e.g., states in which a given species is regulated, all species regulated within a given state). In addition, all regulations in the database were reviewed by each state's AIS coordinator (or equivalent) and the relevant federal agencies to ensure that they were accurate and up-to-date. By having easy access to timely information regarding which species are regulated and where, commercial entities such as BSHs can avoid distributing prohibited species, and thereby reduce the risk that their activities will enable the introduction and spread of AIS.

NOTES

Rapid Assessment Surveys and Protocols for Lionfish Invasions in National Parks

*Jeffrey Cross, Eva DiDonato and Rita Beard
National Park Service*

Lionfish, now prevalent throughout the southeastern coast of the United States, have been sighted in the vicinity of Florida and Caribbean National Parks. The status of the Indo-Pacific lionfish within these coral reef parks is poorly understood. The lionfish have the potential to cause significant ecological impacts and injuries to park visitors and staff. Lionfish pose a two-fold threat because they are voracious predators that can alter native reef communities and because they contain venomous spines that can inflict serious harm to swimmers, fishers, and divers. Lionfish has already been found at Biscayne NP and may also be present at Buck Island, Salt River Bay, Virgin Islands and Dry Tortugas National Parks. The status of lionfish needs to be confirmed in order for the National Park Service to respond appropriately to this increasing threat. The National Park Service has developed and implemented a protocol which samples marine habitats within and nearby Biscayne National Park and Buck Island to assess lionfish abundance and distribution. Marine habitats within and around these parks are sampled using standardized underwater survey methods to obtain estimates of population abundance in representative habitat types. When found, lionfish are collected by trained staff for population management and genetic testing. Park staff are working with National Oceanic Atmospheric Administration, the Reef Environmental Education Foundation, United States Geologic Survey and other agencies to maximize information extracted from collected specimens. The National Park Service has taken this first step, of inventorying and monitoring, to effectively manage lionfish within park boundaries.

NOTES

The Devastating Effects of an Invasive Fish, Roach (*Rutilus rutilus*), on the Flesh Colour of a Wild Brown Trout (*Salmo trutta*) Population in an Irish Lake Over a Ten Year Period (1999 – 2009)

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Central Fishery Board

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Western Regional Fishery Board

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In 2009, a fisheries research project explored the possible effects of an invasive fish species, roach (*Rutilus rutilus*) on an indigenous brown trout (*Salmo trutta*) population in Lough Mask, the third largest lake in Ireland.

Lough Mask is a 22,000 acre limestone lake located in the west of Ireland. It is approximately 7 x 15 Kilometres and has a maximum depth of 70 meters.

Roach were first discovered in Lough Mask by the fishery authority in 1996 while carrying out stock management survey work on the Lake.

Six sample sites were selected on the lake to examine the diversity and abundance of macroinvertebrates available to trout and roach as a food source. Stomach samples were also collected from both fish species in order to establish their feeding habits and diet.

A questionnaire was circulated among 100 anglers to capture their observations on the changes in flesh colour of trout caught in Lough Mask.

The research shows an indisputable correlation between the change in trout diet subsequent to the roach invasion, and the deterioration in flesh colour of the trout in Lough Mask.

This is shown mainly through the study of the trout and roach diet, and the distinct low level of crustacean element in the trout stomach samples in comparison to a relatively high level in the roach diet.

NOTES

Aquatic Disease Biosecurity: Moving Away from an Approach Based on Pathogens

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Systems used to manage the risk of disease spread through trade in aquatic commodities are based on terrestrial models, despite fisheries and aquaculture production encompassing many more taxa and species, lower levels of knowledge about aquatic hosts and their pathogens, far more frequent emergence of previously unknown diseases and a lower likelihood of containment or eradication of aquatic diseases once established. The complexity and uncertainty associated with diseases of aquatic organisms make dependence on risk assessment approaches based on specific pathogens, as used for terrestrial based commodities, risky at best. International transboundary spread of aquatic animal diseases has been common, although the relative lack of effort in applying controls may be as responsible for this as the underestimation of risks associated with trade in aquatic commodities compared to their terrestrial counterparts.

Here, we present an alternative approach using a simple risk scoring method, to assess risks associated with a range of aquatic animal product types generically (i.e. not on a pathogen specific basis) with recommended best practice guidelines to complement existing pathogen based IRA processes in the international standards.

NOTES

Managing Aquatic Invasive Species in Ocean and Coastal National Parks

Eva DiDonato, Rita Beard and Julia Brunner
National Park Service

Stemming from the 2006 NPS developed the Ocean Park Stewardship Action Plan; the National Park Service has developed a national focus on management of coastal parks. Invasive species, sea level rise and increased park visitation pose unprecedented challenges to management of these unique resources. At a recent Ocean and Coastal workshop natural resource managers from across the country identified the need for: development of prevention practices for park visitors, development of policies and regulations to guide management of these areas, increased partnership with state and federal agencies, and, management of invasive species in and around National Parks. Parks have historically managed invasive plants in coastal areas but are now expanding to invasive species in waters beyond the coastline.

NOTES

Oxygen Depletion Events Control the Invasive Golden Mussel (*Limnoperna Fortunei*) in a Tropical Floodplain

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Embrapa Pantanal

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Over the past 10 years the golden mussel (*Limnoperna fortunei*), an exotic species native to eastern Asia, has become widespread and abundant in the Pantanal Wetland, Brazil. Oxygen concentrations are often low in rivers and floodplain waters of the Pantanal and oxygen depletion events can last for several weeks during the rising water phase. Although mortality of *L. fortunei* has been documented during oxygen depletion events, its tolerance to hypoxic and anoxic conditions is poorly understood, in part because changes in oxygen availability are accompanied by other changes such as decreased pH. We analyzed interannual variation in densities of adults and juveniles in relation to varying oxygen conditions, and tested the tolerance of *L. fortunei* to oxygen depletion events in a floodplain lake and in the laboratory. Mussels died after 5 days of an oxygen depletion event in a floodplain lake, and a population established there in 2005 was extirpated in 2006 owing to hypoxic conditions. Laboratory tests confirmed that mussels died more quickly in water from the oxygen depletion event. Annual oxygen depletion events must control the density of the invasive golden mussel in the Pantanal, maintaining low densities and periodically extirpating them from some habitats. Financial support: CNPq (PELD and CTHIDRO programs), Michigan State University, Embrapa Pantanal.

NOTES

California Department of Fish and Game's Invasive Species Program

Holly Gellerman and Susan Ellis
California Department of Fish & Game

The Invasive Species Program is a statewide program within the California Department of Fish and Game's Habitat Conservation Planning Branch. Our mission is to reduce the negative impacts of non-native invasive species on the wildlands and waterways of California. The Invasive Species Program has developed in recent years to include twelve staff at state headquarters and regional offices. The majority of these staff, including all regional staff, work solely on controlling the spread of quagga and zebra mussels. Of personnel remaining, one staff member is dedicated to invasive species issues throughout the San Francisco Bay-Delta, and one staff covers issues California-wide. The Program also provides staff support to the California Invasive Species Council and Advisory Committee. Given the limited resources and personnel compared to the size of the invasive species problem in California, the Invasive Species Program must prioritize and plan projects strategically.

The California Aquatic Invasive Species Management Plan, approved by the Western Regional Panel of the Aquatic Nuisance Species Task Force and signed by the Governor in 2008, guides much of our work. This Plan provides a framework for how state agencies will coordinate with one another on aquatic invasive species issues and also addresses coordination with federal agencies, research institutions, and stakeholders. It identifies and prioritizes 163 specific actions organized under the following eight objectives for the management of aquatic invasive species in California: coordination and collaboration, prevention, early detection and monitoring, rapid response and eradication, long-term control and management, education and outreach, research, and laws and regulations. The majority of our work however involves leading quagga mussel response and management in California.

NOTES

Multiple Introductions and Invasion Pathways for the Invasive Ctenophore *Mnemiopsis leidyi* in Eurasia

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The introduction and spread of non-indigenous species (NIS) in marine ecosystems accelerated during the 20th century owing to human activities, notably international shipping. Genetic analysis has proven useful in understanding the invasion history and dynamics of colonizing NIS and identifying their source population(s). Here we investigated sequence variation in the nuclear ribosomal Internal Transcribed Spacer (ITS) region of the ctenophore *Mnemiopsis leidyi*, a species considered as one of the most invasive globally. We surveyed four populations from the native distribution range along the Atlantic coasts of the United States and South America, as well as six populations in the introduced range from the Black, Azov, Caspian and Baltic Seas. Allelic and nucleotide diversity of introduced populations were comparable to those of native populations from which they were likely drawn. Introduced populations typically exhibited the same or less genetic differentiation (lower F_{ST} values) than native populations. Population genetic analyses supported the invasion of Eurasia from at least two different pathways, one from the northern part of the native distribution range (e.g., Narragansett Bay) to the Baltic Sea, the other from the Gulf of Mexico (e.g., Tampa Bay) to the Black Sea and thence to the Caspian Sea. The relatively high genetic diversity observed in introduced populations is consistent with large inocula and/or multiple invasions, both of which are possible given ballast water transport and the extensive native distribution of the ctenophore in the Atlantic Ocean.

NOTES

Educators and the Erie Canal: An Effective Partnership for AIS Training

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U.S. Fish & Wildlife Service

Helen Domske

New York Sea Grant – Cornell University

Since 2000, the U.S. Fish and Wildlife Service and New York Sea Grant have successfully held 21 invasive species workshops, reaching over 370 educators in New York State. Using the New York State Canal System as a basis for learning, educators across the state have learned about the role of canals as vectors for AIS, how to identify some of the prominent species of concern, detection, monitoring and control methods used by biologists, and how to infuse this information into existing school curricula. Workshops have been held across the mainstem Erie Canal at Lockport, Brockport, Spencerport, and at the Montezuma National Wildlife Refuge. This has encouraged participation from teachers across New York State and established many excellent partnerships. While science teachers are the targeted participants, the inclusion of folklore and canal history also enables teachers of social studies, music, English, and other disciplines to walk away with meaningful lessons for their classes. They also receive a new-found knowledge of AIS. While the instruction stops at the conclusion of the workshop, the learning continues. Participants walk away with agency contacts who then continue to provide educational materials, preserved specimens, and other resources for the teachers and their students. This “train the trainer” approach enables young adults to learn something that isn’t part of their state-mandated curriculum, but adds to the overall ability to manage and hopefully prevent new introductions.

NOTES

Interdicting Aquatic Nuisance Species through Emergency Treatment of Ballast Water: A Management Perspective

Phyllis Green
National Park Service

Ballast continues to be one of the principle vectors for aquatic nuisance species internationally. National Parks and marine sanctuaries require the highest level of protection from accidental introduction. The interdiction methodology discussed offers an opportunity to treat a ship when the ship is out of compliance with exchange requirements or current regulation.

This paper will summarize shipboard research evaluating mixing properties of emergency response techniques to deliver biocides into ballast tanks. A guidebook has been developed by the National Park Service in collaboration with United States Geological Service scientists, naval architects and marine industry leaders to enable implementing interdiction when conditions warrant it. Case studies of interdictions will be presented, and access to interdiction information under emergency time-lines and conditions discussed.

NOTES

Evaluation of a Habitat Suitability Model for the Invasive European Green Crab (*Carcinus maenas*) Using Species Occurrence Data from Western Vancouver Island, British Columbia

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Coastal and Ocean Resources Inc.

Linda Shaw
NOAA National Marine Fisheries Service

A habitat suitability model constructed for the European green crab (*Carcinus maenas*) identifies potentially suitable habitats for the invasive species in coastal Alaska, British Columbia, and Washington on the basis of attributes recorded in the ShoreZone Coastal Habitat Mapping database (Harney 2007; report available online at www.coastalandoceans.com). ShoreZone data consist of along-shore coastal units and across-shore components into which the geomorphic and biologic features of the shoreline are mapped.

In the habitat suitability model, nested queries of the ShoreZone database identify shoreline units possessing habitat attributes that are critical to green crab colonization: protected or semi-protected wave exposure, mud or sand flats in the intertidal, eelgrass in the subtidal, and salt marsh vegetation in the supratidal. Each along-shore coastal unit is rated (0-4) with respect to habitat suitability for the green crab on the basis of the number of critical habitat attributes that co-occur within a single along-shore unit. In this manner, highly-suitable habitat sites, on the order of tens to hundreds of meters in shoreline length, are identified from more than 50,000 km of coastal attribute data in Washington, British Columbia, and Southeast Alaska.

In this study, 15 green crab occurrence sites on the west coast of Vancouver Island are compared to habitat suitability model predictions for the area. All 15 sites have a rating of at least 2 of 4 (wave exposure and at least one other attribute). Three sites have a habitat rating of 3, and four sites have a habitat rating of 4.

With respect to the individual habitat attributes at these sites:

- Protected or semi-protected wave exposure categories are mapped at all 15 sites (100%).
- Protected exposures alone account for 80% of the sites.
- Eelgrass is mapped in 7 of the 15 sites (47%).
- Salt marsh vegetation is mapped in the supratidal zone of 10 of the 15 sites (67%).
- Sand or mud flats are mapped in 7 of the 15 sites (47%). When flats are present, eelgrass also occurs 50% of the time. When flats are present, salt marsh vegetation also occurs 70% of the time. Bare tidal flats lacking either eelgrass or salt marsh vegetation do not occur at any of the green crab occurrence locations.

Applications of suitable habitat predictions include site selection for monitoring and modeling efforts. Using the highest-rated site predictions generated by the ShoreZone model (rated 4 of 4), highly suitable green crab habitat locations can be identified from thousands of kilometers of shoreline attribute data in British Columbia and Southeast Alaska, even in the absence of other data or information.

NOTES

Zebra and Quagga Mussel Monitoring in the California State Water Project

Jeff Janik and Tanya Veldhuizen

California Department of Water Resources, Aquatic Nuisance Species Program

Zebra and quagga mussels, *Dreissena polymorpha* and *D. bugensis*, cause enormous negative economic and environmental impacts. These macrofouling mussels pose a serious threat to water delivery systems in California. California's economy depends in large part on the State Water Project (SWP) which transports large quantities of water across very long distances through a complex and vulnerable system of canals, pipes, reservoirs, hydropower plants, and pumping stations. In January 2007, quagga mussels were discovered in Lake Mead and rapidly spread through the lower Colorado River and the Colorado River Aqueduct and associated reservoirs. In January 2008, zebra mussels were discovered in San Justo Reservoir in San Benito County. In response, the California Department of Water Resources (DWR) played an active role in the multi-agency response effort and developed and implemented a mussel monitoring program for the SWP. Until mussels become established within the SWP or associated watershed, this program acts as an early warning system. Once mussels are established, the program will guide the selection and application of control measures and enable evaluation of control measure effectiveness.

The monitoring program consists of four elements: 1) plankton tows to detect veligers (larval mussels) and spawning events, 2) settlement plates to detect mussel settlement and to quantify mussel densities and growth rates, 3) flow-through bioboxes to monitor mussel settlement and growth rates within each facility, and 4) inspection of infrastructure during routine maintenance shutdowns. Depending upon the method, samples are analyzed using either polymerase chain reaction (PCR), cross-polarized light microscopy (CPLM), or visual enumeration. As mussels are not yet established in the SWP, samples are currently analyzed for the presence/absence of mussels. Once mussels become established, a quantified approach will be used. Monitoring stations are located throughout the SWP from the upper Feather River in Northern California to terminal reservoirs in Southern California. Most locations are monitored on a weekly to monthly basis.

NOTES

Rancho California Water District's Pioneering Effort to Achieve 100% Prevention of Quagga Mussels with Self-Cleaning Screen Filtration Systems for Vail Lake

*Nicole Murphy and Sunny Huang
Kennedy/Jenks Consultants*

*Corey Wallace
Rancho California Water District*

*Renata Claudi
RNT Consulting*

Recent California regulations (Assembly Bills #1683 & 2065) require water agencies to prevent the transmission of quagga mussels (*Dreissena rostriformis bugensis*) into uninfested water bodies. Rancho California Water District (RCWD) is currently in the construction phase of the Vail Lake Transmission Main & Pump Station (VLT&PS) in Temecula, Riverside County, California, which will be used to pump up to 80 cfs of surplus Metropolitan Water District of Southern California (MWD) raw water via a 48-inch CML&C steel pipe to Vail Lake for storage on a seasonal basis. Vail Lake has an operating volume of ~15,000AF and is currently supplied by local runoff. Since MWD's raw water from the Colorado River contains quagga mussel veligers and Vail Lake is currently uninfested, RCWD authorized Kennedy/Jenks Consultants (Kennedy/Jenks) to study how to prevent the spread of quagga mussel into Vail Lake when VLT&PS is operational. Study efforts have evolved into the current VLPS Quagga Mussel Screen Filtration Pilot Testing Project.

Based on initial analysis of quagga mussel treatment/filtration alternatives and water quality testing recommended by the screen filter manufacturers, a pilot test of several automatic, self-cleaning screen filtration system suitable for pressure pipeline installations was recommended. The pilot test was conducted to meet two main objectives: 1) to determine the frequency of backwash for automatic, self-cleaning screen filtration systems; and 2) to determine the effectiveness of such screen filtration systems to prevent 100% passage of all quagga mussels under baseline and elevated turbidity conditions.

This pilot test is a pioneering effort in quagga mussel control because it is the first to study the use of automatic, self-cleaning screen filters for **100% prevention** of passage of all quagga mussel organisms.

Self-cleaning screen filters from three different manufacturers were tested. The pilot system design consisted of three 200 gpm parallel trains, each from a single manufacturer. Each train consisted of a 2-stage screen filtration system arrangement, with a 200µm nominal rated screen filter (to reduce the load and backwash frequency of the 25 µm by removing larger particulates, such as quagga mussel shells and raw water debris) followed by a 25 µm absolute rated screen filter (to prevent the passage of all quagga mussels including fertilized eggs and larvae <40 micron). A common header supplied MWD raw water to each train.

The pilot study was conducted over a 5 week period from June 7, 2010 through July 9, 2010. Performance monitoring for quagga mussel removal was conducted over a 3-day period during the fourth week of testing. Test runs included unspiked and artificial turbidity spiked runs. Available data, analyses and results will be presented.

NOTES

Performance of Anti-Fouling and Foul-Release Coatings Exposed to Zebra Mussels, San Justo Reservoir, California, USA

Dan Salyers, Tanya Veldhuizen and Jeff Janik

California Department of Water Resources, Division of Operations and Maintenance

Zebra and quagga mussel biofouling poses a serious threat to water delivery systems in the West. In response to this threat, the California Department of Water Resources (DWR) implemented a comprehensive mussel management program in the State Water Project (SWP), the largest state-built and operated multipurpose water and power system in the United States. The SWP provides drinking water for 23 million people and irrigation for 750,000 acres of farmland in California. The program includes early detection monitoring, rapid response planning, and development of macrofouling control measures. One component of this program was to evaluate anti-fouling and foul-release coatings in a reservoir that supports a zebra mussel (*Dreissena polymorpha*) population and has similar water quality to the SWP.

The use of anti-fouling and foul-release coatings is a potential solution to macrofouling for some components of SWP facilities. We examined zebra mussel settlement and biomass accumulation rates on about 20 different anti-fouling and foul-release coatings and other materials commonly used in the SWP. Colonization of these surfaces was documented for more than one year using high resolution photography. Biomass was determined by weighing colonized substrates. Mussel biofouling resulted in a 500 to 580% increase in weight for unprotected test plates. Few coatings were both durable and resistant to zebra mussel colonization. Silicone-based foul-release coatings were the most resistant to biofouling, while proprietary paints and high solids epoxy corrosion-prevention coatings were least resistant. This study was conducted in San Justo Reservoir, a small (40 ha), warm monomictic impoundment in the central coast region of California.

Study results will aid in the selection of effective coatings, assessment of biofouling on current load capacity of hoists and cranes, and development of infrastructure retrofit plans to manage dreissenid mussels in the SWP.

NOTES

Monitoring of Invasive Alien Species in Constanta Harbor

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Ovidius University of Constanta

Constanta Harbor is the largest port in the Black Sea region and represents a major gateway for alien species. In December 2008 we started a monthly monitoring program from three sampling points along a gradient from the inner part towards the outer part of the port. The fouling community was dominated by mussels (*Mytilus galloprovincialis*) which formed a bed with a thickness of 5-15 cm. The mussel bed offers both a substrate for epibiota and interstitial volume for other mobile organisms. The samples of the fouling communities of macro- and meio-invertebrates from mussel beds had an average species richness of 30-40 species/sample, with little variation in space and time. The observed species richness was lower when compared with natural substrate communities. Alien species represented about 10%, with few in higher densities *Balanus improvisus*, *Rithropanopeus harrisi*, *Doridella obscura*, *Haliplanella lineata*. Some alien species appear only occasionally – *Blackfordia virginica*, *Ficopomatus enigmaticus*, while others, frequently mentioned in fouling communities on ships' hulls (e.g., *Balanus amphitrite*, *Sphaeroma walkeri*, *Musculista senhousia*), did not develop self sustaining populations. The relative stable structure in time and space of the species richness of mussel beds suggests a stable, complex community less permissive to new incoming alien species. We estimate the cost of a simple monitoring program of the fouling communities on hard substrate for the rapid detection of potential invasive alien species to cost between 10,000-15,000 € per year.

NOTES

Creating Tools for Invasive Species Decision Support at a Global Scale: Distribution Maps and Models of Predicted Potential Distribution

Annie Simpson
U.S. Geological Survey

Global levels of expertise in invasive species information management are extremely diverse, ranging from complex information systems that are Web enabled, such as the DAISIE (Delivering Alien Invasive Species Inventories for Europe) to the simplest method of writing data on paper and filing it on a shelf (done by many research scientists). For data to be effectively shared, it must be made freely available in formats that are either standardized or tagged for standardized retrieval. The Global Invasive Species Information Network (GISIN) was formed to provide a platform for sharing invasive species information at a global level, via the Internet and other digital means. This presentation will describe: 1) the results of a GISIN needs assessment administered to members of the invasive species information management community, 2) various methods to submit data to the GISIN system, which offers a federated search among diverse online databases, 3) recently developed distribution maps and models of potential predicted distributions, and 4) additional decision support tools being made accessible through the GISIN.

NOTES

Evaluation of New Coating Products for Mitigation of Zebra/Quagga Mussel Colonization

Allen Skaja and David Tordonato
Bureau of Reclamation

Coatings research is part of an ongoing interdisciplinary program being conducted by the Bureau of Reclamation to reduce invasive mussel impacts to hydraulic structures. In May 2008, a project was initiated to evaluate the efficacy of commercially available technologies in preventing mussel attachment to underwater infrastructure. Selected products were tested *in situ* at Parker Dam on the lower Colorado River where quagga mussel colonization has become extensive. Products were selected based on previous research by others, such as the U.S. Army Corps of Engineers, and manufacture recommendations.

The testing is ongoing and currently includes antifouling and foul-release coatings, conventional polymer coatings and metalized coatings. Newer commercially available products are the main focus of the research. Over the course of the 17 months, several coatings and metal alloys have been installed and evaluated including 4 copper metal alloys, three zinc plated steels, two epoxy coatings, three zinc rich primers, six antifouling coatings, seven foul release coatings, one asphaltic coatings, one aluminum ion additive product, one polyurea coating, one fusion bonded nylon, one vinyl ester, and five fluorinated powder coatings. Panels and grates were coated and deployed in both static and dynamic conditions.

From the initial set of 18 products, only three products were found to exhibit satisfactory performance after 18 months of freshwater exposure. The remaining samples were heavily fouled with mussels. Foul release coatings were effective in resisting mussel attachment, especially under dynamic conditions. The primary advantage of foul-release products is that they are nontoxic. However, durability has been found in all cases to be a significant limitation. As such, the focus on foul release coatings is to find products with greater durability. Additional coatings which are expected to exhibit greater durability were added to the testing program in 2009. The results for tests of these coatings are currently pending.

NOTES

Bactericidal Effect of Increased pH to Aquatic Pathogenic and Ship Ballast Environmental Bacteria

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Barnaby Watten

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Ship ballast (water) is a well-recognized conveyer of non-indigenous aquatic-borne species to the United States. Aquatic environmental bacteria, for example, not only survive in water or on substrata in water, but those that are pathogenic to animals are horizontally transmitted via the water column. The International Maritime Organization developed international legislation (D2 Standards) that specifies maximum numbers of indicator microorganisms that may be released via ballast water (Lloyd's Register, 2007). Ships constructed during, and after 2009 must decontaminate ballast on board and prior to release, and conform with the new D2 Standards. Three of the five indicator microorganisms are bacteria (the other two are plankton); the bacteria and the maximum allowable viable cells are: *Vibrio cholera* (≤ 1 cfu/100mL), *Escherichia coli* (< 250 cfu/100mL), and intestinal (i.e. mammalian source) Enterococci (< 100 cfu/100mL). We are evaluating the feasibility of increased pH (i.e., hydrated lime, sodium hydroxide) for use as a ballast decontaminant to meet the D2 Standards. We developed controlled, in vitro studies to determine endpoint treatment parameters (of 1- pH 10-12 and 2- duration of treatment up to 72h) necessary to achieve our target 100 % bactericidal (i.e., killing) activity. Optimal bacterial growth parameters were utilized to ensure maximum growth of control, non-pH treated cultures. Standard curves were developed with sterile-filtered 2N and 5N NaOH vs. two bacteriological media, TSB and #2 developmental media. Pure bacterial cultures were grown in 50 mL medium volumes on a rotary shaker (100-120 rpm) at optimal incubation temperatures (16-30°C, depending on the bacterium). We employed viable cell counting techniques to determine the efficacy of increased pH treatments. About 86 bacterial isolates were tested, a variety of Gram-negative and Gram-positive bacteria, including potential human pathogenic coliforms, environmental pollution indicators including the three species in the D2 Standards, horizontally transmitted (via water) fish pathogenic bacteria, and 50 environmental bacteria that we recovered from water from a 1.26 mil gal ballast tank on a 1,000 ft bulk cargo ship used in the Great Lakes. All control cultures grew, most to 1×10^9 cfu/mL or greater, and although the maximum pH and treatment duration endpoints required for 100 % killing varied for each bacterium, we demonstrated 100 % killing to all bacteria tested within pH 12.0 for 72h. Many of the bacteria were killed within 4h at pH 10.0. Results for the D2 Standard bacteria were: one isolate of *V. cholera* was killed within 4h at pH 10.0; 4 isolates of *E. coli* were killed within 12h at pH 10.0; and one isolate of *Enterococcus faecalis* (a Gram-positive) was killed within 72h at pH 12.0. In addition to excellent bactericidal efficacy, increased pH offers other advantages, namely, anti-rust properties, and favorable delivery and mixing processes, economics, and pH neutralization applications.

NOTES

Salinity Tolerance of the Exotic Round Goby: Experimental Implications for Seawater Ballast Exchange

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Joshua Brown
NOAA Sea Grant

The Eurasian round goby *Neogobius melanostomus* invaded the North American Great Lakes in 1990 via ballast water introduction from the Black Sea area (0-15 ppt salinities), and since spread throughout watersheds and adjacent riverine systems. Legislation now requires oceanic ballast water exchange of vessels entering the Great Lakes, whose salinity effects are unknown on gobies. We tested 230 round gobies (juveniles and adults) in salinity tolerance experiments with 20 per treatment at 0 (control), 5, 10, 15, 20, 25, 30, 35, and 40 ppt - with 32 ppt being average oceanic conditions – in immediate immersion versus longer-term acclimation experiments (increasing 5 ppt every 3 days). Immersion experiments yielded 95-100% survivorship at 0-10 ppt, 70-80% for 15-20 ppt, 20% at 25 ppt, and 0% in 30-40 ppt. Acclimation experimental results were 95-100% survival in salinities of 0-20 ppt, 80% in 25 ppt, and 0% at 30 ppt. In long-term experiments, Lake Erie round gobies lived at salinities to 20 ppt for 4 months. Thus, round gobies readily tolerate and acclimate to estuarine conditions, and are unlikely to be affected by oceanic ballast water exchange. We predict that the round goby will spread to estuaries along North American coasts, where their success will be enhanced by their native mytilid mussel prey.

NOTES

How the Physical Dispersion of Ballast Water Influences the Risk of Aquatic Invasive Species Establishment – Field Observations and Modelling

Yajun Sun
University of Toronto

Ballast water discharge is held responsible for most of the successful invasions of non-indigenous species into the Great Lakes. The probability of post-discharge establishment of an alien species depends upon the rate at which the density of the population decreases due to physical dilution compared to the biological growth rate. Observations are presented from four field experiments that measured the dispersion patterns of discharged dyed ballast water. These experiments were performed at two very different sites, the first in 2008 conducted at Goderich Harbour had a long hydraulic retention timescale, whereas a similar experiments in 2009 was conducted in the fast flowing St. Clair River. The very different flushing dynamics of these two locations are compared with the logistic population model with the Allee effect.

We find that it is important to include a hydraulic “dead zone” in order to properly simulate the dilution properties of realistic water body. These “dead zones” are sites of lowered dilution ability, making it easier for successful establishment of introduced alien species. Therefore population dynamics of organisms discharged by ballast water are described using simple box models. Risk analyses are also compared with a range of different dilution rates that are relevant to harbours around the Great Lakes.

NOTES

Ecosystem Impacts of Quagga Mussels in Lake Mead, Arizona-Nevada, USA

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Southern Nevada Water Authority

G. Chris Holdren
Bureau of Reclamation

Since their discovery in Lake Mead in 2007 quagga mussels have been identified both as adults and juvenile veligers throughout the lake. Following the initial population explosion it appears that veliger production in the lake has stabilized, while the cladoceran and copepod communities have had variable responses. Veliger abundances near Hoover Dam peaked in 2007 at 6 individuals L^{-1} , at 31 individuals L^{-1} in 2008, and at 9 individuals L^{-1} in 2009. This pattern was repeated in the open waters of Boulder Basin and Las Vegas Bay. Further up-reservoir (Virgin and Gregg Basins) veliger abundances peaked at 1-2 individuals L^{-1} during 2007 and 9-14 individuals L^{-1} in 2008. Peak abundance of cladocerans in Boulder Basin and Las Vegas Bay generally declined from 2007 (11-22 individuals L^{-1}) to 2008 and 2009 (2-9 individuals L^{-1}). In the Virgin and Gregg Basins peak cladoceran abundances increased from 2 individuals/L in 2007 to 3-4 individuals L^{-1} in 2008. Copepods followed the same general pattern as the cladocerans, though the abundances were generally 5-10 times greater. Broad measures of water quality have continued to improve, following a trajectory that pre-dates the invasion by quagga mussels. Chlorophyll concentrations have continued to decline, reaching $<1 \mu g L^{-1}$ in Boulder Basin during the summers. Total phosphorus concentrations have remained low following advanced treatment by regional wastewater operators and total organic carbon concentrations have fallen to $<3 mg L^{-1}$. Hypolimnetic volumetric oxygen demand has continued to decline, falling $2.5 mg O_2 m^{-3} day^{-1}$ since 2000. The Burn's Trophic Level Index suggests that the trophic level in Boulder Basin has declined from mesotrophic to oligotrophic over the period including the colonization and spread of quagga mussels. While Lake Mead may only now be entering the stage of the quagga mussel invasion where broad ecosystem changes are observed, the system has thus far been more strongly impacted by hydrologic manipulations, nutrient loading reductions, and unique aspects of Lake Mead limnology than the quagga mussel. It remains to be determined what the ecological impact of the quagga mussels are in this system.

NOTES

Response to the Invasion of *Undaria pinnatifida* in San Francisco Bay, CA, USA

Chela Zabin

Smithsonian Environmental Research Center and University of California, Davis

Vanessa Guerra

Smithsonian Environmental Research Center, University of California, Davis and California State Lands Commission

Jonathan Thompson

U.S. Fish & Wildlife Service

Christopher Scianni and Nicole Dobroski

California State Lands Commission

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Addressing Aquatic Invasive Species at the Bureau of Reclamation

Michael Gabaldon

Director of Technical Resources, Bureau of Reclamation

The Bureau of Reclamation is the United States largest wholesale supplier of water, operating 348 reservoirs with a total storage capacity of 245 million acre-feet that provides 1 out of 5 Western farmers with irrigation water for 10 million farmland acres that produce 60 percent of the nation's vegetables and one quarter of its fresh fruit and nut crops. It also delivers 10 trillion gallons of water to more than 31 million people each year. Reclamation is also the second largest producer of hydropower in the United States and operates 58 hydroelectric power plants that annually produced, on average, 40 billion kilowatt-hours for the last 10 years. All of this while only operating in the seventeen Western United States. Needless to say there are a lot of dams, miles of canals and pipes, generators, and other important infrastructure that can be impacted by aquatic invasive species and Reclamation is taking this challenge head-on. Reclamation is an active participant in the Aquatic Nuisance Species Task Force that brings together other governmental organizations that are concerned with the introduction and spread of aquatic nuisance species. Reclamation has developed an Equipment Inspection and Cleaning Manual that provides uniform guidelines for inspection and thorough cleaning of vehicles and equipment. It has also developed an Integrated Pest Management Manual that provides practitioners comprehensive guidelines in diagnosing and treating pest and invasive species problems including aquatic invasive species. Specifically Reclamation is working with the State of California to control Hydrilla, working with other federal, state, and local agencies to control giant Salvinia and parrotfeather in Arizona and California. But the greatest impact recently has been that of quagga and zebra mussels. Reclamation is working with a variety of partners to ensure that operations of the facilities continue despite this infestation. To ensure operations Reclamation is monitoring reservoirs throughout the west for early detection of mussel infestation, studying coatings that prevent the mussels from attaching to the infrastructure or that make it easier to remove them, and other technologies that will keep enclosed pipes free of the mussels. Reclamation is also reaching out to other agencies and sharing information on what we are learning from the research. Outreach to the public is also essential to help prevent the spread of aquatic invasive species and Reclamation has been working with its partners to ensure that all visitors clean, drain, and dry their equipment.

NOTES

The Way Forward – A Strategic Plan to Prevent the Establishment of Asian Carp in the Great Lakes

Bill Bolen

Senior Advisor, U.S. Environmental Protection Agency

The Great Lakes food web has been significantly degraded in recent decades because of aquatic invasive species (AIS). The migration of three species of carp not native to the United States (bighead, black, and silver), also known as Asian carp, into and through the Illinois and Des Plaines Rivers and the Chicago Area Waterway System (CAWS), is the most recent and most acute AIS threat facing the Great Lakes today.

The Asian Carp Control Strategy Framework (Framework) has been prepared by the Regional Coordinating Committee's (RCC) participating agencies to outline the actions that will be implemented to control Asian carp migration and prevent them from establishing a self-sustaining population in the Great Lakes.

The Framework is a dynamic document, reflecting an ever-increasing body of knowledge gathered from ongoing research and monitoring, and builds on the December 2009 deployment of Federal, State, Local, and Canadian resources to conduct an eradication effort in the Chicago Sanitary and Ship Canal (CSSC). Many actions described in this Framework, such as research and feasibility studies, are expected to provide additional data that may be included in future Framework updates.

NOTES

Mexel Efficiency Study- Results of Year Long Pilot Study at American Electric Power's DC Cook Nuclear Plant

Doug Bronicki

American Electric Power, DC Cook Nuclear Plant

Thomas Armon

H-O-H Water Technology

Mexel, a chemical product in the general classification as filming amines, has been evaluated for use as a preventative molluscicide control program at AEP's DC Cook's Nuclear Power Plant (CNP) in Bridgman, Michigan USA. Mexel is marketed as a corrosion inhibitor, dispersant, and control agent for cooling water fouling species such as mussels and hydroids. A unique on-site research facility was constructed and operated continuously for 365 days to evaluate the efficiency of Mexel to control zebra mussel infestation on cooling water intake tunnels at CNP. Standard and custom testing methods were used to determine the performance of Mexel on modeled intake tunnels using natural populations of zebra mussels trans-locators and larvae under dynamic conditions.

The findings indicate that a Mexel product dosage of 4 ppm/40 minutes per day illustrated:

- Effectiveness in preventing Zebra Mussel infestation in corrugated pipes modeled to pattern CNP intake tunnels
- Reduced sludge and silt accumulation in flowing water circuits
- No rapid detachment (sloughage) of existing mollusk colonies
- No negative impact on Great Lakes receiving waters and lake biota when discharged un-nuetralized as measured by Whole Effluent Toxicity (WET) testing.

NOTES

Developing Use Pattern for Potential Open-Water Application of Zequanox™ – A Microbial-Based Technology for Selective Control of Invasive Dreissenid Mussels

Mark Heilman, Tyler Koschnick and Brad Franklin
SePRO Corporation

Sarahann Dow and Dustin Ottman
Marrone Bio Innovations

Strain CL145A of *Pseudomonas fluorescens* (Pf) was previously isolated and shown by Dr. Dan Malloy, Director of the Cambridge Field Research Laboratory of the New York State Museum, to provide selective control of invasive freshwater mussels (zebra mussels – *Dreissena polymorpha*; quagga mussels – *Dreissena rostriformis bugensis*). Through collaborative effort with the Bureau of Reclamation and other federal, state, and international agencies, Marrone Bio Innovations continues research towards developing and demonstrating cost-effective, commercially-available Pf-based materials for invasive mussel control associated with industrial uses including hydroelectric power generation. In addition, SePRO Corporation, in collaboration with MBI, has initiated studies to examine how Pf materials can be produced, formulated, and applied for open-water mussel management to restore habitat of lakes, reservoirs, ponds, and other infested waterways. Preliminary work indicates that prototype Pf formulations have settling and re-suspension characteristics that favor delivery and exposure to mussels infesting appropriate substrate of open-water benthic habitat. Static, controlled jar testing using low quagga mussel densities and turbidity measurement as a correlate of applied product concentration indicated that at 24 hours after test treatment, 25-30% of suspended Pf formulations had been sequestered/metabolized by mussels while 46-52% of materials settled to container bottom and 17-25% remained suspended in the water column. Application of formulation prototypes directly to the bottom of test containers produced different exposure and turbidity dissipation patterns influenced by both mussel feeding behavior and product settling characteristics. Controlled laboratory trials are in progress to examine and refine dose/exposure relationships under more static hydrologic conditions to improve formulation and delivery strategies for open-water applications. These trials are addressing position of target mussels in the water column (e.g., suspended on vertical or floating surfaces versus on bottom substrate) relative to application approach and short-term dispersal patterns. They also are examining the influence of formulation choice, application design and exposure parameters on prevention of veliger settlement. Outcome of laboratory studies will be described along with results of related 2010 open-water field evaluations.

NOTES

Evaluating Zebra Mussel (*Dreissena polymorpha*) Response to Desiccation at a Central California Water Supply Reservoir

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Michelle J. Chapman

Bureau of Reclamation, Water Treatment & Research Engineering Team

Zebra mussels (*Dreissena polymorpha*; ZM) were discovered in San Justo Reservoir (SJR), San Benito County, California in January, 2008. SJR is a 10,300 acre-foot capacity water supply reservoir that is part of the Central Valley Project (CVP). The 207 surface-acre reservoir is operationally isolated from most CVP facilities and is therefore not highly likely to contribute to a ZM infestation at other CVP facilities, except by human aided transfer. A plan to treat SJR with potassium chloride for ZM eradication or control was developed following the Virginia Department of Game and Inland Fisheries' eradication effort at Millbrook Quarry. The plan proposed drawing down the reservoir pool to minimize the volume of water to be treated with potassium chloride, which would minimize cost. Unlike the Millbrook Quarry project, the potassium concentration would be diluted to a sub-lethal level as SJR was refilled following treatment. However, because SJR is significantly larger than the 12 acre Millbrook Quarry and has significant structural variation and unique features that could complicate eradication compared with the more uniform quarry, there was concern that the ZM population exposed during drawdown would survive and repopulate the reservoir upon refilling. Either the shoreline population would have to be somehow treated, or the water level would have to be kept low long enough that no mussels could survive the period of desiccation. To determine how long this might take, a desiccation study was initiated at the end of the 2009 irrigation season. It was found that after 42 days desiccation, some mussels still could not be declared dead with certainty. Consequently, the effect of desiccation on the establishment of mortality is being further investigated to resolve uncertainty

NOTES

Demonstration Trials at DeCew II Generating Station at Ontario Power Generation Using Zequanox™

Anthony Van Oostrom
Ontario Power Generation

Sarahann Dow
Marrone Bio Innovations

Kelly Murray
ASI Group

For the last 20 years the Niagara Plant Group (NPG) of Ontario Power Generation has been refining and improving chlorine treatment approaches in order to more effectively control adult zebra and quagga mussels in cooling water piping systems. During this time sodium hypochlorite usage was reduced by over 80%, effectiveness improved and significant cost savings realized. However, further improvement opportunities with sodium hypochlorite are limited.

In 2008, NPG made an application to the Ontario Environmental Leaders Program, a voluntary environmental program for industry that is administered by the Ontario Ministry of Environment. One of the nine targets set in the NPG program was to carry out the first full scale treatment trial using an environmentally safe alternative to chlorination for adult mussel control. To achieve this target, NPG began working with Marrone Bio Innovations (MBI) in August 2008 to carry out a trial using commercially viable prototypes of Zequanox™, a *Pseudomonas fluorescens* CL145A (Pf CL 145A) derived mussel control product (killed bacteria cells), at DeCew II Hydroelectric Generating Station (DeCew II). Pf CL 145A was originally discovered by Dr. Dan Molloy, Director of the Cambridge Field Research Laboratory of the New York State Museum and demonstrated to be highly effective in killing both zebra and quagga mussels. The non-target eco-toxicity studies that have been performed to date have demonstrated no negative impact to other aquatic species. MBI's task is to further develop this discovery into a commercially viable technology. Real life demonstration trials like this one at DeCew II are necessary to help refine product development and determine additional critical product operational parameters. ASI Group Ltd (ASI) was retained to help design and carry out the trials at DeCew II.

The demonstration trials at DeCew II using Zequanox™ are the first trials in which an entire cooling water system of a hydroelectric generation facility are treated for adult invasive mussels with this product. Pilot and demonstration treatment trials are also being conducted in jars and bioboxes to evaluate the product effectiveness at different times of the year and to evaluate different prototype generations. To help evaluate the effectiveness of the full scale trials, NPG has installed a unique in-line cooling system mussel mortality monitoring device. This device could be adapted and used at other facilities to help monitor the effectiveness of their treatments.

The presentation will review the results and observations from these demonstration trials including the first full scale demonstration testing carried out at DeCew II. It will also review the retrofit requirements for the existing chlorination system, ease of application of the *Pseudomonas fluorescens* product, treatment benefits and disadvantages of this product compared to chlorination as well as details of the pipe bypass mortality monitoring installation. Mussel mortality for demonstration, pilot and full scale trials will also be presented.

NOTES

Surveillance, Maintenance, Instrumentation and Monitoring of Underwater Infrastructure; with Focus on Dreissenid Mussels. Condition Surveys of Underwater Infrastructure Providing 2-D and 3-D Representation Obtained Without Interruption of Scheduled Plant Operations

Robert Clarke

ASI Group Ltd.

Albert Graves

Central Arizona Project

Inspection and maintenance is critical to the performance and longevity of underwater infrastructures. Since a complete facility must generally be taken out of service in order for these components to be inspected, any procedure that can minimize the outage interval will also minimize the loss of power and revenue generation. The use of remotely operated vehicles (ROVs) to conduct these inspections can significantly reduce the downtime. This method eliminates the time required to safely drain and flood a system and prevents unnecessary stresses to the tunnel structure by keeping the internal hydrostatic pressure and surrounding ground pore water pressure in equilibrium. Personnel can conduct the inspection from the safety of a dedicated control room while the robot is used to relay video and other sensory information from inside the tunnel to the team.

To further the minimization of facility downtime, ASI Group Ltd. has designed and built a dual-axis sonar system using scanning sonar as the basis for development that is capable of operating in high flow conditions and provides accurate dimensional information regarding the structure and accumulated debris.

The system employs two axes of rotation aligned perpendicular, resulting in the ability to point the transponder in any direction. By calculating the distance to objects from the transponder head at multiple angular positions, a three dimensional point cloud representation of the structure and any surrounding debris may be obtained. Sensors on board the system can dynamically monitor and account for changes in temperature, pressure and salinity, used in speed of sound calculations. Changes in the attitude (roll, pitch and yaw) of the system, as a result of high flow past the system, can also be dynamically corrected.

This technology has been used to obtain a full coverage scan of a flooded surge shaft in California. The system has been used to scan the intake structure of hydro electric penstocks and the fore-bay of a nuclear plant, both while under fully operational conditions. Dimensioned maps were generated providing data regarding debris accumulation on the face of the structure, "as-built" information, and sediment deposition (bathymetric information) in the vicinity of the structure.

This paper will review projects where an ROV and dual axis sonar system were used as the primary means of inspection and cases where the information was used to assist engineers prepare for dewatering and planned maintenance work.

NOTES

Towards “Next Generation” Molecular Detection Methods for the Surveillance and Monitoring of Marine Pests in New Zealand

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Cawthron Institute*

*Graham McBride and Graeme Inglis
National Institute of Water & Atmospheric Research*

In New Zealand surveillance programmes for marine pests do not include identification of organisms in the water column. Molecular methods allow detection of dispersive forms thereby contributing to a more robust surveillance programme. Additionally, New Zealand has become a signatory to the IMO Ballast Water Convention and there is scope for developing molecular methods for detection and enumeration of viable organisms as well as species specific probes for indicator bacteria. We have developed a suite of molecular tools for surveillance and the most promising techniques so far are qPCR and/or sandwich hybridisation assay (SHA) targeting the mtCO1 and rRNA genes. However multiplexing methods such as qPCR are logistically difficult in current formats, though SHA can be transformed to low density arrays for use in environmental sampling processors (ESP's) for remote sensing. We are currently evaluating two “next generation” methods for multispecies detection (Solexa sequencing and Combimatrix array) and their potential advantages over current methods in regard to assay design, flexibility, indicative performance, capacity, cost effectiveness and ease of use will be evaluated. Prospects of a hybrid approach are considered in the context of “next generation” and current methods. Finally surveillance and compliance monitoring need to be underpinned by a sound statistical basis, and we describe progress in the development of sampling protocols and evaluate compatibility of detection and enumeration methods to these. As a result some new initiatives in detection and enumeration are proposed.

NOTES

Modeling and Estimating Uncertainty in Environmental DNA Surveillance of Invasive Asian Carps

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W. Lindsay Chadderton
The Nature Conservancy

Early detection of aquatic invasive species (AIS) is difficult because low densities of organisms are out of sight underwater. However, the medium they inhabit – water – provides a detection opportunity that environmental DNA (eDNA) surveillance can uniquely exploit. eDNA surveillance detects and identifies the genetic signal that organisms leave in water as they shed DNA-containing cellular material. As this signal spreads through the water, it expands the area and time window that can be sampled to detect an organism’s presence. eDNA surveillance is a promising tool for early AIS detection due to the ease of water sampling and the sensitivity, high-throughput, and declining costs of modern molecular methods. However, as an eDNA signal spreads it also weakens by dilution and degradation - increasing the probability of false negative detections. To better understand the factors affecting detection probability, we developed a conceptual model of the hierarchical uncertainties relating biomass of target organisms to probability of successful detection using PCR. Within the framework of this model we quantified the range of target DNA concentration in eDNA samples for invading bighead and silver carp (*Hypophthalmichthys nobilis*, and *H. molitrix*, respectively) from the Chicago Sanitary and Ship Canal (USA). We also quantified the uncertainty relating target DNA concentration to probability of PCR success. Our model and empirical results are discussed in relation to metagenomics, forensics, and ancient DNA - other established fields using low-concentration, degraded, or mixed genetic material. This work provides guidance for establishing eDNA detection limits and designing appropriate surveillance protocols.

NOTES

Using Two Robotic Platforms Developed at the Monterey Bay Aquarium Research Institute (MBARI) for Molecular Detection and Monitoring of Marine Invertebrate Larvae and Major Copepod Groups *in situ*

Julio B.J. Harvey, Roman Marin III, John P. Ryan, Nilo Alvarado, Shannon B. Johnson, Chris Preston, Christopher A. Scholin and Robert C. Vrijenhoek

Monterey Bay Aquarium Research Institute

Despite efforts to regulate marine fisheries resource use in recent years, fish stocks continue to collapse. Direct monitoring of the underlying biology supporting fisheries may therefore be of critical importance for effectively informing efforts toward stock maintenance and resource management. Molecular methods offer a rapid, accurate and repeatable way to directly monitor the production and biodiversity of zooplankton that are key elements of marine food webs supporting fish stocks. Additionally, molecular tools enable improved 'bio-security' through ecosystem monitoring for invasive species and their propagules. We currently employ two robotic platforms in a concerted effort to monitor temporally and spatially variable production of zooplankton in the Monterey bay. The Autonomous Underwater Vehicle (AUV) is a mobile, autonomous sampling device that collects a wide array of oceanographic data in addition to environmental water samples, for analysis at our shore-based laboratory. In contrast, the Environmental Sample Processor (ESP) conducts both water sampling and on-board, microarray mediated molecular analyses, *in situ*, during stationary mooring deployments of up to one month. In both cases, robust and highly sensitive sandwich-hybridization assays (SHA) are used with 18S ribosomal RNA targeted probes capable of detecting various barnacles, mussels, polychaete worms, brachyuran crabs, calanoid and podoplean copepods, and the invasive European green crab, *Carcinus maenas*. Comparison of hydrographic data plots with biological signal 'spectra' from 62 AUV and 14 ESP water samples, provides a comprehensive perspective on how biological and physical variables interact with respect to targeted zooplankton. Multivariate statistical methods are used to link the biological signals to environmental temperature, salinity, turbidity, and concentrations of oxygen, chlorophyll and nitrate. Our analyses reveal that specific hydrographic features (currents, fronts and layers) appear to entrain and provide favorable growth conditions for certain zooplankton. The current results represent a move away from previous efforts demonstrating 'proof of concept' for these technological developments and progress toward science-driven sampling aimed at addressing specific hypotheses about marine food web dynamics, larval dispersal, recruitment processes and connectivity among populations of organisms.

NOTES

Nucleic Acid Probes for Detection and Management of Marine Pests: Applications and Capabilities, Prospects and Limitations in a Genomic Era

Jawahar Patil
CSIRO

This abstract was not available at the time of printing.

NOTES

Unique RT-PCR Test for Replicating VHS Virus, with Internal Controls

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An outbreak of a unique and especially virulent strain (IVb) of viral hemorrhagic septicemia (VHS) occurred in 2005 in the Great Lakes, killing several economically prominent freshwater fishes; including yellow perch (*Perca flavescens*), muskellunge (*Esox masquinongy*), and freshwater drum (*Aplodinotus grunniens*); with additional outbreaks occurring in subsequent years. This virus poses extensive risk to the aquaculture and baitfish industries, as well as to native fisheries. Despite efforts to reduce detection time with DNA diagnostics, cell culture, which is a weeks-long laborious process, is the only currently USDA-APHIS approved diagnostic method. Our laboratories have developed a new molecular based assay, Standardized Reverse Transcriptase Polymerase Chain Reaction (StaRT-PCR), to detect VHSv, which greatly speeds time (to hours), lowers detection threshold, uniquely identifies among VHSv strains, and provides intrinsic quality control via a standardized mixture of internal standards (SMIS). Our test also has been modified to uniquely determine whether the virus is actively replicating and, therefore, transmissible to other fish. We present evaluations of our StaRT-PCR test using infected fish cell lines, wild-caught fish, and immersion and injection-challenged fish experiments [including muskellunge (in conjunction with Drs. Mohamed Faisal and Robert Kim of Michigan State University) and yellow perch (with Dr. Frederick Goetz of University of Wisconsin Milwaukee and Dr. James Winton of U.S. Geological Survey, Seattle)]. Here we compare the ability of our StaRT-PCR assay to accurately detect VHSv infection with results from current cell culture/plaque assay tests and traditional qRT-PCR. We will additionally measure and quantitatively compare viral infectivity using (A) plaque assay, (B) qRT-PCR, versus (C) StaRT-PCR to determine relative accuracy and detection threshold at varying infection levels.

NOTES

Evaluation of Ballast Water Treatment Systems: Programmatic Overview of U.S. Coast Guard Research and Development Efforts

Richard A. Everett

U.S. Coast Guard, Environmental Standards Division

The U.S. Coast Guard (USCG) is authorized and directed by Congress under the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990 as reauthorized and amended by the National Invasive Species Act (NISA) of 1996 to develop a national regulatory program to prevent and control introductions of nonindigenous aquatic organisms into U.S. waters via the operations of vessels. In addition to the current regulations and policies established between 1998 and 2004, the Coast Guard published a proposed rule on August 28, 2009, that would set a performance standard for the quality of ballast water discharged in U.S. waters. NANPCA and NISA authorize and require the Coast Guard to approve alternative ballast water management practices (BWMS) used in lieu of ballast water exchange. Ultimately, the approval of BWMS would require procedures similar to those in the Code of Federal Regulations, Title 46, Subchapter Q, to ensure that BWMS work not only in the laboratory but under shipboard conditions. In preparation for implementing a discharge standard, Coast Guard has undertaken a suite of research and development projects to identify, develop, and refine protocols, methods, and tools necessary to evaluate the performance of ballast water treatment systems. Working with partners in the Environmental Protection Agency's Environmental Technology Verification (ETV) Program, the Naval Research Laboratory's (NRL) Center for Corrosion Science and Engineering, and the U.S. Department of Transportation's Volpe National Transportation Systems Center (Volpe), Coast Guard is developing and refining protocols for testing treatment systems under land-based and shipboard circumstances. Initial work under the ETV program and in partnership with NRL has resulted in validated protocols for land-based tests of ballast water treatment systems. Protocols for shipboard testing are under development and build on the ETV protocols, along with findings and lessons from the Coast Guard's Shipboard Technology Evaluation Program (STEP). Key advances have been realized, and are continuing, in methods for representative sampling of discharges; approaches for handling significant volumes of water onboard vessels; and more objective and rapid methods for detection and enumeration of living organisms in ballast water. The research and development work has been coordinated between the Environmental Standards Division at Coast Guard headquarters and the USCG R&D Center. This presentation will summarize the overall program of research. Follow-on presentations by USCG R&D Center and NRL will progressively focus in on the suite of specific projects that have been conducted, or which are currently in-progress.

NOTES

U.S. Coast Guard R&D Center Ballast Water Research Program: Parsing the Problem

*Penny Herring, Gail Roderick and Marion Lewandowski
U.S. Coast Guard, Research & Development Center*

In support of the Coast Guard's ballast water management regulatory program, the U.S. Coast Guard Research and Development Center (RDC) is conducting a comprehensive suite of R&D projects. For administrative purposes, the ballast water management issue was divided into two separate foci: ballast water exchange (BWE) and ballast water treatment (BWT). For BWE a tracer was sought, its distribution validated, and a measurement tool developed. Coast Guard is currently conducting an operational evaluation of the ballast exchange assessment meter (BEAM), wherein selected field offices employ the BEAM during routine ballast water management exams on vessels. BWT was approached from the view of approval and use of treatment systems. A three-step approach has focused on the development of shore-based approval tests, shipboard approval tests, and methods for use in verification of compliance by vessels. Potential discharge requirements have forced careful examination of traditional methods for sampling and analysis of organisms in water, and engineering approaches for testing the performance of full scale ballast water treatment systems. This presentation will provide an overview of RDC efforts to develop and refine objective and rapid methods for assessing the efficacy of ballast water management practices, and set the stage for talks by a key partner, the Naval Research Laboratory, describing specific methods for enumeration of living organisms in ballast water.

NOTES

A Statistical Treatment of Ballast Water Discharge Sampling for the Evaluation of Treatment Efficacy and the Implications for Regulatory Purposes

Edward Lemieux, Kevin Burns and Lisa Drake
Naval Research Laboratory

Several ballast water discharge standards have either been adopted or proposed with restrictions upon the discharge organisms over a wide range. These standards propose that ballast water discharge from the ship shall not exceed 0.1-10 living organisms per metric ton for organisms larger than $\geq 50 \mu\text{m}$, while organisms between 10 and 50 μm are limited to less than 0.1-10 living organisms per milliliter. These standards have significant implications for both the testing of ballast water treatment systems for type-approval testing, but also for compliance testing as part of a comprehensive regulatory effort. While several efforts are underway to develop methods for the assessment of organism viability which allow for enumeration, a detailed statistical examination of the land based testing sampling protocols and compliance sampling has been not been considered.

The current document discusses the implications of relevant discharge standards on sample volumes and the relative confidence in sample taken over a range of sample volumes. A statistical model is proposed and validated on the basis empirical data from experiments conducted with both inorganic beads and living organisms. The model is used to provide a projection of the sample size requirements to achieve a level of precision such that the 95% upper confidence bound does not exceed the proposed standard and that the test statistic should not exceed twice the observed mean. The effects of sample concentration factors and various discharge standards are examined and recommended sample volumes are proposed.

The analysis is extended to consider the implications of this statistical effort on current and future testing protocols. Recommendations are provided to significantly revise land based testing protocols to provide for cumulative or binned samples rather than the current 1 m^3 samples in triplicate. Recommended sample sizes are significantly larger than those currently practice, with the minimum being 60 m^3 . The impact of these recommendations on the physical arrangement of current sampling protocols is also considered. Finally, the statistical model is used to provide examples of the level of confidence that may be applied when sample sizes significantly smaller than those that are recommended are utilized as may be the case in regulatory compliance sampling.

NOTES

Ballast Water Discharge Sampling: Approximating Zooplankton Retention Efficiencies Using Microbeads

*Lisa Drake, Mia Steinberg, Stephanie Robbins, Scott Riley
Science Applications International Corporation, Naval Research Laboratory*

*Tim Wier
EXCET, Inc.*

*Wayne Hyland
Azimuth Technical Consultants, Naval Research Laboratory*

*Edward Lemieux
Naval Research Laboratory*

In 2004, the International Maritime Organization adopted the International Convention for the Control and Management of Ships' Ballast Water and Sediments, which establishes standards for ballast water discharge and the performance of ballast water management systems. Among the criteria for ballast water discharge is the density of organisms $\geq 50 \mu\text{m}$ (nominally zooplankton), which is set at < 10 viable organisms m^{-3} . With respect to land-based and shipboard testing of ballast water management systems, accurate enumeration of organisms in such sparse concentrations requires large sample volumes to be concentrated and examined (see the abstract by Lemieux et al.).

The large volumes result in two challenges: adverse effects on organisms filtered through a fairly fine mesh must be minimized, and the size of the individual nets or filters must be manageable (the latter is especially relevant for shipboard testing). Traditionally, marine scientists capture organisms by filtering water through a plankton net. Alternatively, a set of filter bags enclosed in individual housings—a configuration commonly used in water-treatment facilities—can be used. In theory, the filter bags are superior to a plankton net for ballast water testing because the filter bag assembly does not require a mechanism to lift it to collect samples. Additionally, the filter bags are not open to the atmosphere, so they are less vulnerable to inclement weather than plankton nets.

Preliminary flow experiments were conducted in Key West, Florida using ambient seawater pumped through $25 \mu\text{m}$ mesh filter bags (40.6 cm long) placed in housings arranged in series. To prevent the bags from clogging and to realize low differential pressures between filter bags, it was necessary to maintain a low flow rate of 96 liters per minute.

A series of field trials was conducted to determine the efficacy of filter bags to retain zooplankton. As a proxy for plankton, red microbeads composed of a cross-linked polystyrene divinylbenzene copolymer with a diameter of $49 \mu\text{m}$ ($\text{CV} = 7.8\%$) were used. Two filter bags were arranged in series: $100 \mu\text{m}$ and $25 \mu\text{m}$ mesh bags or two $25 \mu\text{m}$ mesh bags. Microbeads were placed in the first filter bag, approximately 7000 – 10,000 liters of ambient seawater was flowed through the system, the bags were retrieved, and the beads were counted.

Initial field experiments showed low microbead recovery (28-55%), so straightforward trials were conducted in the laboratory using filter bags or sieves with fresh water. On the basis of the laboratory tests, a number of improvements was made to the experimental design; among them, the filter bags' seams were glued with a marine sealant to prevent microbeads from slipping through the relatively large holes along the seams. Microbead recovery efficiencies improved markedly: 82%-99.5%. Field experiments employing the improvements and flowing approximately 3800 l of fresh water through filter bags also showed much greater recovery efficiencies: 82%-100%. These results have implications for land-based and shipboard testing of ballast water management systems.

NOTES

Quantifying Viability in Protists Discharged in Ballast Water Using Two Fluorescent Vital Stains

Mia Steinberg, Scott Riley, Stephanie Robbins, Edward Lemieux and Lisa Drake
Naval Research Laboratory

Bruce Nelson
Battenkill Technologies, Inc.

One of the biggest challenges for testing ballast water treatment systems is enumerating live organisms in the discharge water. Only some of the taxa in the $\geq 10 \mu\text{m}$ and $< 50 \mu\text{m}$ size class are motile and demonstrate viability with movement. Appearance alone is insufficient for determining viability since organisms subjected to a ballast water treatment system may appear unharmed with intact organelles despite being dead. Additionally, any analysis must be able to enumerate a diverse assemblage of organisms originating from many geographical locations as well as evaluate large volumes of discharged ballast water with potentially very low ($< 10 \text{ organisms ml}^{-1}$) concentrations of viable organisms.

To this end, we have developed a method for analyzing protists using two vital stains, fluorescein diacetate (FDA) and CellTracker Green (CMFDA), which rely on intracellular enzymatic activity for conversion to a non-permeable, fluorescent product. These probes have different staining patterns and characteristics, and the combination of the two was ultimately shown to be the most promising indicator of viability in the $\geq 10 \mu\text{m}$ and $< 50 \mu\text{m}$ size class. Ambient organisms collected from Key West, Florida were stained and scored as moving or unmoving and stained or unstained. As a positive control, several motile algal monocultures were tested with these stains, and as a negative control, samples were heat killed before staining and analysis. Results from Key West indicated a Type I error rate of 5% and a Type II error rate of 1%.

Testing this staining technique at three other marine and brackish locations produced a Type I error rate ranging from 3-36% and a negligible Type II error rate ranging from 0-1%. The high number of false positives observed at some sites was largely predictable due to a handful of heterotrophic dinoflagellate species, and research is underway to further investigate complimentary analyses for these dinoflagellates so that this technique can be used at all sites regardless of the protist assemblage.

NOTES

Early Detection of Invasive Alien Aquatic Species in the St. Lawrence River and Estuary through a Commercial Fisherman Network: A Three Year Experiment Evaluation

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The St. Lawrence River (Québec, Canada) is at high risk from invasive aquatic alien species (IAAS). This large watershed hosts an important international commercial shipping traffic, a main vector for IAAS. In addition, the lower part of this watershed, a 500-km long stretch, is particularly attractive and suitable for almost all IAAS because it provides a wide diversity of fish habitat, including rocky, vegetated or muddy shores, with still or running waters and water salinity ranging from 0 to 30‰. A commercial fisherman Early Detection Network (EDN) for IAAS was implemented between 2007 and 2009 in the river and its estuary with the aim to detect and collect alien species. We first produced a field guide to help fishermen to identified IAAS, and we visited each of the 150 EDN participants twice a year to provide training for IAAS detection. The network was widely distributed over the region covering fresh-, brackish-, and saltwater areas. We estimated that approximately 2.5 millions fish, ranging from 10 to 2,000 mm, were sampled annually in the fishing gears. Each year, up to 150 suspected IAAS were brought to the laboratory for detailed identification, and among these, three species (up to 20 specimens/species) were positively identified as IAAS: Chinese mitten crab (*Eriocheir sinensis*), Round goby (*Neogobius melanostomus*) and European tench (*Tinca tinca*). An extension in distribution range was also noted for other species, such as the Alewife (*Alosa aestivalis*) or the Atlantic butterfish (*Peprilus triacanthus*) being caught 1000 km outward of its natural range. Although the detection network was cost-effective at collecting and identifying IAAS in the St. Lawrence, an area with one of the highest potential of establishment of exotic species in North America, the global efficiency of the EDN seemed to correlate with the level of support from experts. The overall performance of the EDN is critically reviewed after three years of operation and additional measures are suggested for long-term implementation.

NOTES

From Paper to Practice: Launching the World's Most Stringent Ballast Water Standards

*Nicole Dobroski, Christopher Scianni, Lynn Takata and Maurya Falkner
California State Lands Commission*

In an effort to curb species invasions, California's Marine Invasive Species Program (MISP) established performance standards for the discharge of ballast water in 2007. The performance standards set limits for organism concentration as a function of organism size class, and are implemented on a graduated time schedule beginning January 1, 2010, with a final standard of zero detectable living organisms in ballast water discharge by 2020.

A critical step for implementation has been the evaluation of treatment technologies to determine if any are available to meet the standards within the required timeframe. In its December 2007 report to the California legislature, the MISP determined that none of the 28 treatment systems reviewed was yet able to meet California's performance standards. A second legislative report was completed in January 2009 which showed a significant improvement in the quantity and quality of the available data on treatment system performance. Two treatment systems appeared capable of meeting California's performance standards, with several more expected to be available in the near future. A brief technology assessment update completed in October 2009 reviewed 41 technologies and raised the number of systems that had demonstrated the capability of meeting California's standards from two to seven.

In addition to assessing the availability of treatment systems to meet California's performance standards, the MISP has developed new regulations to ensure the smooth implementation of the standards. In 2009, regulations were approved requiring the installation of sampling ports on vessels discharging in California waters. These sampling ports will allow the MISP to collect ballast water samples and verify vessel compliance with the standards. In early 2010, the MISP developed reporting forms to gather information about the installation, use and maintenance of ballast water treatment systems on board vessels discharging in California waters.

These regulations and reports will be discussed, including an updated legislative report completed in July 2010 assessing the efficacy, availability and environmental impacts of treatment technologies for use in California waters. MISP staff will also discuss efforts to develop protocols to verify vessel compliance with the standards. California's proactive approach to ballast water management will limit the introduction and spread of non-indigenous species in California waterways, and serves as a model for the effective science-based management of a global challenge.

NOTES

(Re)thinking Aquatic Non-indigenous Species Impact Assessment

*Alisha Dahlstrom, Marnie Campbell and Chad Hewitt
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The increasing rate of aquatic non-indigenous species (ANS) transfers in the face of contracting resources for aquatic biosecurity management has resulted in a risk assessment approach to identify the highest risk vectors and/or ANS. Risk assessment includes two components: likelihood (probability of an event occurring) and consequence (level of impact). In an aquatic biosecurity context, impact assessment faces several challenges, including: paucity of data; high uncertainty and the different interpretations of the role of precaution in assigning impact; variety of assessment methods and frameworks; and different assumptions, threshold values, and levels of uncertainty for each value category.

While environmental and economic impact literature exists for several high-profile species, the vast majority of ANS do not have impacts adequately described or quantitatively assessed within the primary (peer-reviewed) literature. For example, environmental impacts are largely qualitatively described with few empirical assessments. Economic evaluations have been undertaken for a number of species, however these assessments are often in the form of cost-benefit analyses. In contrast, the evaluation of social, cultural and human health impacts is not undertaken for the majority of species. Yet the absence of information does not mean absence of impact. The precautionary approach would suggest managers identify missing information as a high risk. This situation is juxtaposed against a general consensus (and specific requirement made by the World Trade Organization's Sanitary and Phytosanitary Agreement) that assessment methodologies follow scientific principles and include sufficient scientific evidence to justify the outcome where the outcome will influence trade.

Several of the approaches used to assess ANS impacts partially address these issues. For example, one approach is to combine expert and stakeholder opinions with quantitative data in an effort to include both qualitative and quantitative information. The most comprehensive versions of this approach use consequence matrices across four core values (environmental, economic, social/cultural, and human health). These consequence matrices rely on exemplars of increasing levels of impact with thresholds defined by stakeholder groups. While there is no widely-accepted framework for impact description (e.g., which subcategories to use within the four core values) or impact measurement (e.g., how to choose the threshold levels that differentiate impact levels), these consequence matrices have proven useful frameworks for elucidating stakeholder perceptions of value (and impact). While differences in assumptions surrounding core values and interpretations of information will vary based on the opinions and backgrounds of assessors or experts, use of consequence matrices reduces the linguistic uncertainties between assessors.

Reconciling these challenges to interpreting, describing, and assigning ANS impacts is an important element of risk assessment. This presentation will present an innovative way to improve impact assessment in an aquatic biosecurity context.

NOTES

Rapid Response Planning for Aquatic Invasive Species in the Lake Champlain Basin

Meg Modley

Lake Champlain Basin Program

Lake Champlain Basin partners recognize the ecological, economic, and possible human health implications of the 49 known nonnative species in Lake Champlain. Protecting Lake Champlain from future aquatic invasive species invasion is a high priority. The best approach is to prevent the introduction of aquatic invasive species through early detection, monitoring, and education and outreach. However, when prevention measures fail and a new AIS is discovered, rapid response is the last line of defense. Rapid response planning was conducted in the Lake Champlain Basin to ensure a coordinated interstate and international response in which staff, expertise, equipment, and other resources may be shared. The Rapid Response Plan identifies lead agencies in each jurisdiction, provides a step by step plan, a species evaluation questionnaire (risk assessment), priority species for management, and a thorough review of all applicable permits for control options. Valuable lessons were learned by identifying gaps in policy and legislation in the review of permitting process.

NOTES

Bi-National, Economic Considerations in Co-Managing Invasive Species and Water Quality for California and Baja California Coastal Boats

Leigh Johnson
University of California

Linda Fernandez
University of California, Riverside

Efforts to prevent transport of invasive, hull-fouling species may be affected by regulatory action to protect California's coastal water quality from degradation by copper leached from antifouling paints on hulls of recreational boats. A copper regulatory program is in place for a major yacht basin in northern San Diego Bay and in process for other major, California boat basins. Regulatory trends and evidence of copper resistance among invasive, hull-fouling species suggest that copper antifouling paints, alone, will not suffice to prevent transport by boats moving among coastal harbors.

California's major ports have high numbers of invasive species. Nearby, small-craft harbors are also invaded, suggesting an important role for recreational and commercial fishing boats in coastwise transport of invasive species. Extensive boat traffic among the California coast, Sacramento-San Joaquin Delta and the Baja California peninsula increases invasive species transport risks. Thus, a bi-national approach is needed to manage invasive, marine, hull-fouling species. To create effective policies and programs, policy makers, boating businesses and boat owners need information on costs of effective fouling control measures and supply-side capacity.

The authors surveyed 30% of coastal marina, boatyard and hull-cleaning businesses on the California coast, in the Sacramento-San Joaquin Delta, and in Ensenada, La Paz and Cabo San Lucas of Baja California. Through summary statistical analyses and regressions, relationships were measured between factors such as fouling control options and costs, frequency of boat use, length of stay at marinas, location, awareness of nontoxic coatings *et alia*. For example, although length of stay in a marina varies greatly, approximately half of long-term marina tenants rarely take out their boats. These factors present specific issues related to toxic (copper and zinc) versus nontoxic (epoxy and slick) coatings and to invasive species control. Bi-national comparisons identified differences in cost profiles for supplies and services used to control fouling and maintain vessel hulls.

Awareness of nontoxic boat bottom coatings has increased among the customers of coastal marina, boatyard and hull cleaning businesses. Regressions indicate that awareness of nontoxic coatings was significantly associated with likelihood of choosing them.

Harbor, marina and yacht club managers reported homeports of overnight visitors and events that attracted them. Such data indicate major patterns of coastwise, boat traffic and motivations for travel that may influence likelihood of transporting invasive species.

The authors also surveyed 30% of United States' West Coast slip liner companies and 30% of United States' boat lift companies, as there were too few of each in California for an adequate sample. These products are available in a variety of sizes; boat lifts generally are more costly than slip liners. Some boating facilities do not permit slip liners and/or boat lifts.

NOTES

pH and Calcium – Natural Limits in Zebra Mussel Spread

Frances E. Lucy

Institute of Technology, Sligo

Sergey Mastitsky

Department of Bioinformatics, University of Heidelberg and RNT Consulting Inc.

Renata Claudi

RNT Consulting Inc.

Suitable water chemistry is essential to the successful colonisation of zebra mussels. The zebra mussel, *Dreissena polymorpha*, spread rapidly to many Irish lakes following its introduction to the Shannon system in the early 1990s. Lack of invasion to some Irish lakes may be explained by the geology of their catchments. These lakes have low pH and calcium levels due to the absence of limestone in river basins.

This presentation will summarise the status of colonised and un-colonised Irish lakes in terms of these chemical parameters.

This information is a very useful tool for water managers during the rapid spread of zebra mussels in the western United States. Essentially, the data can be used to produce a model to predict the probability of a lake becoming colonised with zebra mussels. This will facilitate the development of effective monitoring programme and will also be useful in an industrial context, as pH adjustment is gaining popularity as a form of zebra mussel control.

NOTES

Adjustment of pH as Method of Control for Dreissenid Mussels

*Albert Graves
Central Arizona Project*

*Renata Claudi, Robert Prescott and Carolina Taraborelli
RNT Consulting Inc.*

During the summer of 2009, a flow through experiment was conducted to evaluate the impact of low pH on the settlement and survival of dreissenid mussels.

Lake Ontario water was pumped into a flow through laboratory set up. The natural pH of the lake water was depressed using phosphoric acid to result in three test streams with pH of 7.3, 7.1 and 6.9. Fourth stream was unaltered lake water (pH of 8.1 to 8.4) used as control. Caged adults were introduced into each treatment for the four month duration of the experiment. The incoming lake water contained dreissenid veligers allowing for primary settlement to be monitored in each treatment.

This presentation will describe the experiment and discuss the results obtained.

NOTES

Novel Approaches for Management of Invasive Quagga Mussels in a Large Water Supply System

*Ricardo De Leon, William Taylor, Paul Rochelle, Sun Liang and Anthea Lee
Metropolitan Water District of Southern California*

The invasive mussel infestation of Western States has very high potential cost implications due to rapid growth and proliferation in the warmer and extensive waterway networks of the West. Although a number of controls for invasive mussels have been reported in the literature, current drinking water and environmental regulations limit the options available for implementation, especially in the Western United States. In response to quagga mussel infestation from the Lower Colorado River, the Metropolitan Water District of Southern California has developed a quagga mussel control plan (QMCP) incorporating enhanced detection, surveillance, and mitigation strategies. Metropolitan's approach is based on Integrated Pest Management (IPM), a strategy developed by the U.S. Department of Agriculture to provide a science based decision-making process that identifies and reduces risks from pests and pest management-related strategies. As part of the QMCP, Metropolitan is developing novel approaches for detection, control and management of mussels within its 242 mile-long aqueduct and multiple reservoirs. These novel approaches consist of: 1) new analytical and detection methodologies which include molecular-based detection of veligers in water samples and viability stain studies. Improved monitoring tools will provide additional information needed for management decisions; 2) field testing of coatings that deter the attachment of veligers; 3) laboratory breeding of mussels with the goal of obtaining a consistent source of veligers for inactivation studies with disinfectants and alternative treatments and for developing approaches for interfering with the replicative cycle of mussels, and 4) bench-scale and flow-through disinfection studies of mussels to confirm laboratory-scale results with chlorine and chloramines, coagulants and polymers, and to optimize dose and exposure time at near real-world conditions and 5) lake management studies for control of quagga mussels through manipulation of oxygen levels, flow, and enhanced predation. This presentation will provide results on each one of these novel approaches and their implementation in a large water system.

NOTES

Macrofouling Control of Invasive Species: A Critical Evaluation of Current Methods, Efficacy and Shortcomings

Sanjeevi Rajagopal and Gerard van der Velde
Radboud University Nijmegen

Vayalam Venugopalan
BARC Facilities

Henk Jenner
KEMA Power Generation and Sustainables

Cooling water systems of coastal power stations offer unique habitats for coastal sessile benthic organisms, many of which include invasive species. Constant flow of water and protection from predators create ideal conditions for development of thriving populations of biofouling organisms such as mussels and barnacles. Massive populations of such organisms colonise cooling water circuits, creating serious operational problems for utilities. Among the different organisms, invasive species can cause considerable damages and costs associated with their control can be quite substantial. However, the full extent of the costs of damages caused by invasive fouling organisms has only recently received greater appreciation. Focused studies are necessary to understand the invasive problem and provide accurate and comprehensive assessments of the benefits and costs of control alternatives. Chemical control of biofouling is generally practiced as an economically viable option for the smooth operation of the cooling water systems. Unfortunately, there are no comprehensive reviews available on the native vs invasive issue regarding macrofouling control. The present review attempts to fill this gap. Industries operating in tropical areas by virtue of their high biodiversity are particularly prone to biofouling by relatively large number of species. In this review paper, data on biofouling aspects of a typical tropical power station located on the east coast of India is presented. Chlorination regime employed to control selected species of native vs non-native is illustrated. Data on lethal and sublethal effects of chlorination on the selected organisms are presented and data gaps are mentioned. Inherent limitations of the method are highlighted and recent technological advances are indicated. It is predicted that chlorination will continue to dominate industrial biofouling control scenario until economically and ecologically viable alternatives are developed.

NOTES

Toward Practical, PCR-Based Detection Methods for the Surveillance of Marine Pests from Australian Ports and Waterways

Nathan Bott, Alan McKay, Kathy Ophel-Keller and Marty Deveney
South Australian Research and Development Institute

Accurate and rapid diagnosis of marine pest species is central to their control. The Australian *National System for the Detection and Management of Marine Pests* requires tools for the detection and monitoring of marine pests. We are currently developing a capability for the specific and sensitive quantitative Polymerase Chain Reaction (QPCR)-based detection of invasive marine pest species from the marine environment. Various projects are currently underway for the development and refinement of assays for the detection and enumeration of six marine pest species: Asian bag mussel (*Musculista senhousia*), European clam (*Corbula gibba*), green-lipped mussel (*Perna canaliculus*), European green crab (*Carcinus maenas*), wakame (*Undaria pinnatifida*) and vase tunicate (*Ciona intestinalis*). These will complement assays previously developed for giant fanworm (*Sabella spallanzanii*), Pacific oyster (*Crassostrea gigas*) and northern Pacific seastar (*Asterias amurensis*). Putative TaqMan Minor Groove Binding (MGB) QPCR assays will be rigorously screened with a wide range of heterologous controls to confirm specificity, and a range of environmental samples from various locations (both water and sediments) will be spiked with target organisms to determine detection limits. These quantitative assays will have the potential to be utilised for the detection of larval stages in environmental samples (water and sediments) as well as ship ballast water and fouling, and will allow more effective management and control strategies to be implemented. Developments in water sampling methodology and protocols for molecular analysis will be discussed. Future studies will explore the development of sensitive and specific QPCR assays for other marine pests of significance.

NOTES

Identification of Ballast Sediment Invertebrate Species Using Resting Eggs and Mitochondrial Markers

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Great Lakes Institute for Environmental Research, University of Windsor

Sarah Bailey
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The transshipment of ballast water and associated flora and fauna by cargo vessels has increased dramatically in recent decades. Invertebrate species are frequently carried in ballast water and sediment, yet their identification can be extremely problematic when only immature or diapausing eggs are present. Here we describe the application of DNA barcoding using mitochondrial cytochrome c oxidase subunit I and 16S rDNA to identification of species identities from diapausing stages found in ballast sediment of transoceanic ships. The method is applicable to a wide range of taxa, including Cladocera, Copepoda, Rotifera, Bryozoa and Ascidia. The utility of molecular identification using diapausing eggs was compared to the traditional method of taxonomic identification using individuals hatched from diapausing eggs. Molecular identification overcomes several problems posed by morphological identification such as the need to break dormancy and the inability to identify juvenile life stages. Of the 289 diapausing eggs surveyed, sufficient DNA for barcoding was obtained from 96 individuals (33%). Of these eggs, 62 (65%) were identified to species level, while 35% were identified to family/order level. Molecular identification resolved a greater number of species than traditional taxonomy (19 vs. 10 species). Molecular methodologies provide a rapid, accurate approach to identification of species from resting stages that otherwise would be very difficult to identify.

NOTES

Zebra Mussels – Bioindicators for Seasonal Trends in Cryptosporidiosis

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Cryptosporidium is one of the most important zoonotic parasites in the developed world including Ireland. Although cases are reported in Ireland throughout the year, over 60% of human cryptosporidiosis cases occur during the spring peak between March and June. While it is generally accepted that the spring peak is chiefly due to zoonotic transmission, this hypothesis is largely based on circumstantial evidence as the spring peak coincides with the main calving and lambing seasons. Moreover, since most livestock and wildlife species calf during spring time, it is unclear which host species is the most significant contributor to environmental contamination with human-infective *Cryptosporidium* oocysts. Zebra mussels (*Dreissena polymorpha*) are currently being used as an effective environmental biomonitoring tool in a two-year Irish EPA funded project. This invasive bivalve has already been used successfully in several international studies to detect *Cryptosporidium* and other human waterborne pathogens

This project aims to determine the cause(s) of the spring Cryptosporidiosis peak in Ireland. In 2009 and 2010, livestock, wildlife and the environment were screened in two waterbodies for the presence of *Cryptosporidium* oocysts. Zebra mussels were used as the environmental monitors in one lake, Lough Gill, Co. Sligo. Public health is a major issue in this study as this 14 km² mesotrophic lake is the main source of drinking water for local populations.

Zebra mussels were processed for *Cryptosporidium* using multiplexed combined fluorescent in situ hybridisation (FISH) and a direct immunofluorescent assay (IFA). Where necessary for species identification purposes, nested PCR was utilised to amplify specific sequences of DNA. Genotyping was also carried out in accordance with methods used for project' human and animal faecal samples.

The zebra mussel analysis will assist in the compilation of a project database of *Cryptosporidium* spp and subspecies that occur in humans, livestock, wildlife and the environment, which in turn will be very useful for tracing future outbreaks. This source tracking can be used to inform management policies on catchment land use and best practice measures as prescribed under the EU Water Framework Directive.

NOTES

Something Old and Something New: Tracking AIS Incursions through Space and Time Using Molecular Data from Established Populations

Sharyn Goldstien and David Schiel

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Graeme Inglis

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Neil Gemmell

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Molecular tools are now used extensively to identify and track aquatic invasive species. Many studies using these tools are limited mostly to a single sampling occasion, which provides a temporal snap-shot of the invasive populations, often years after the first incursion. From this discrete temporal sample inferences are made about founder effects and the influence of genetic diversity in the success of the invading population. At this stage of an incursion, however, much of the mixing and genetic sorting is well-established. While there is now strong recognition of the need to sample extensively throughout the species native and invasive range to make informed predictions about the path of invasions, there has been relatively little discussion of the need to sample temporally. Incorporating temporal sampling of recent incursions can provide insights into the early spatio-temporal stability of genetic patterns and can more accurately examine the success of individuals within founding or established populations. The invasion by the tunicate *Styela clava* into New Zealand waters provides an ideal case study for investigating the spatio-temporal components of recent marine incursions. *S. clava* was first noted in New Zealand in 2005 and has since expanded throughout marinas and natural habitats of the North and South Islands. Using samples collected in 2006 and 2007 we investigated spatial and temporal genetic patterns over two years and have used these data to assess the origins of new incursions of this species as they are found and removed from boat hulls and marina structures during surveillance operations. The results show that the populations are genetically differentiated spatially and temporally throughout the country. Extensive admixture occurs among marinas, with minimal post-border influence from the two major ports (Auckland and Lyttelton). Temporal patterns indicate that the populations are not yet in a stable state, and many of the new incursions to marinas around New Zealand probably have an external source, further suggesting that multiple incursions are still occurring in New Zealand waters. This work implies that the management of aquatic invasive species would benefit from temporal sampling as a measure of establishment and management success.

NOTES

Automated Analyses of Ballast Water Samples for the Enumeration of Viable Organisms in the $\geq 50\ \mu\text{m}$ Size Class

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Testing to evaluate the efficacy of Ballast Water Treatment Equipment (BWTE) requires the characterization of samples to determine the number of live organisms following treatment. With respect to organisms in the $\geq 50\ \mu\text{m}$ size class, Phase I of the U.S. Coast Guard proposed standard requires that following treatment, there be less than 10 living organisms m^{-3} . It is extremely difficult to reliably quantify a sparse assemblage of organisms in this large volume of fluid. Consequently, theoretical statistics of sparse populations strongly support relatively large samples be concentrated (60,000:1) prior to microscope evaluation. As standardized tests require that suspended solids fall within relatively high specified ranges, concentrating samples also increases the amount of suspended solids, making these samples significantly more complex to analyze, as organisms can be obscured from view by this and other sample debris.

Experimental validation of sample analysis procedures at the Naval Research Laboratory (NRL) has determined that the presence of this and other types of debris common to BWTE test samples makes it difficult to manually count simple, regular objects, such as $50\ \mu\text{m}$ – $150\ \mu\text{m}$ diameter polymer beads, in test samples using manual microscopy methods. The complexity, diversity and motility of organisms in the $\geq 50\ \mu\text{m}$ size class makes it even more challenging to accurately characterize these samples. This has provided the impetus for the optimization of microscope equipment, data collection and analysis protocols and advanced image processing algorithms for image set collection and analysis.

NRL has determined that staining samples with a combination of two vital stains (Fluorescein Diacetate, FDA; and 5-chloromethylfluorescein diacetate, (CMFDA) provides significantly increased diagnostic ability compared to the use of a single stain. To take advantage of these stains, it is desired to utilize two microscope modalities; brightfield or white light and epifluorescence. Further diagnostic ability can be gained by combining the use of stains with motility analyses. For this purpose, it is desired to collect time resolved image sets in each of these microscope modes. The image data from both modalities should be spatially correlated; therefore, image sets from brightfield and epifluorescence must be interleaved, not collected in series. Combining the two microscope modes and applying motility detection algorithms to these image sets allows the viability of a wide range of organisms in the complex samples associated with BWTE evaluations to be assessed.

NRL has developed protocols for the collection, documentation, analysis, and archiving of image data to support BWTE evaluations. This presentation will first describe the equipment and software modifications NRL has made in its microscope system to afford the rapid switching between microscope modes under computer control to generate image sets optimized for automated analyses. This is followed by descriptions of the laboratory procedures used to collect and analyze image data according to these protocols. The presentation will conclude with descriptions of the motility algorithms used for the automated assessment of the image data and will provide examples of applying these algorithms to enumerate the number of viable organisms in complex ballast water samples.

NOTES

Flow-through Discharge Sampling: Design and Validation

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EXCET, Inc.

Lisa Drake

Science Applications International Corporation

Jonathan Grant

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Edward Lemieux

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Ballast water treatment systems installed on ships will eventually have to comply with discharge standards under development by the International Maritime Organization (IMO) or the United States Coast Guard. Systems will be granted type-approval after undergoing a series of land-based and shipboard trials. As such, to ensure the discharge standards are met either in a land-based or on a ship, the water will need to be collected, concentrated, and then analyzed. Importantly, the sample will need to be representative of water being discharged. Based on the current IMO discharge standard and the statistics of sparse populations, the volume is quite large and needs to be concentrated down to a small enough sample for analysis.

Current practice for sampling ballast water normally includes the use of plankton tows using plankton nets fitted with a cod end. This presentation will explore a new flow-through sampling apparatus for sampling ballast water upon discharge, with a focus on the design of the sampling apparatus and choice of equipment used. In addition, testing and validating this sampling apparatus at the Naval Research Laboratory in Key West, FL will be discussed.

NOTES

An Automation and Control System Specification for Verification of Ballast Water Treatment Systems

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Naval Research Laboratory

Testing of ballast water treatment equipment (BWTE) to standard protocols, such as those under development by the ETV Program, is intended to provide comparable data to the maximum practical extent and ensures that consumers and other stakeholders can make informed choices in selecting a treatment system regardless of technology. Comparison of data sets requires that challenge conditions remain consistent across tests of any treatment system.

The ETV protocols for testing BWTE describe conditions and data collection requirements for land based testing through the following verification factors: biological efficacy, operations and maintenance, cost, reliability, safety, and environmental acceptability. The most complex factor to measure is biological efficacy, with prescribed minimum challenge conditions and continuous sampling. Challenge conditions include an allowed range of water quality parameters and a mix of ambient and standard test organisms. Continuous monitoring of challenge parameters and associated sampling systems is necessary to verify conditions throughout a test, and automated control of facility equipment is necessary to maintain test parameters. An automated control system facilitates generation of consistent challenge conditions to each treatment technology under test, and provides an irrefutable, legally defensible record of events that can be used to verify the treatment system performance.

The Naval Research Laboratory has developed a specification to inform ballast water test facilities (BWTF) about both general attributes and specific requirements that should be included as part of an automated control system. The discussion of the specification incorporates equipment characteristics and measurement parameters based on a set of functional requirements for testing, using the ETV Generic Protocol for the Verification of Ballast Water Treatment Technologies as a base reference for the testing protocols.

NOTES

Intercomparison of U.S. Ballast Water Test Facilities

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Testing of ballast water treatment systems for compliance with discharge standards such as those proposed by the International Maritime Organization (IMO) or the US Coast Guard is a relatively new activity. To support verification testing, the US Coast Guard and Environmental Protection Agency have partnered to develop an Environmental Technology Verification (ETV) protocol that describes procedures and system requirements for the verification of treatment systems.

To date, there are no test facilities (TF) certified as Verification Organizations in accordance with the ETV protocol, and no testing to the most recent version of the protocol has been performed. It is of interest to the overall ballast water community, and treatment system vendors in particular, for testing to occur at multiple TFs. Although the protocol allows flexibility to develop new methods, TFs must provide test conditions consistent with specified parameters and meet certain other requirements. Given the TFs are located in different geographic areas and necessarily operate under different environmental conditions, inherent variability among TFs—both with respect to physical configuration and biological and physical characteristics of challenge waters—will exist, and variations in test results are expected. Such variations in test results across facilities must be accounted for and minimized to the extent possible because they could 1) create an unfair advantage among the TFs, with manufacturers preferring a TF that gives the ‘best’ results, or 2) create an unfair advantage among manufacturers, who might be able minimize production costs by designing equipment for a specific TF where test results would be favorable, or 3) both. It is also important that any deficiencies in the protocol be identified through its implementation at multiple sites. To address these issues, NRL and USCG are developing an intercomparison approach for use among TFs to assess parity and identify discrepancies.

The project will compare TFs’ methods and results, and it will assess the degree to which TFs uniformly apply the EPA’s ETV protocol (and if possible, the IMO G8 Type Approval Guidelines). Applications will be solicited, and TFs will respond to a questionnaire that assesses their capabilities in four areas: personnel base to conduct the tests, physical capability and operational conformance to the ETV Protocol, ability to meet the test schedule in 2010 and 2011, and TF costs to support all phases of the program. Following receipt of applications, two TFs will be selected to participate in the program. Concurrently, a commercial BWTS will be selected and purchased. Ideally, the BWTS will have received Type Approval under IMO guidelines (and thus certified for ship installation), sized for treatment of $200 \text{ m}^3 \text{ hr}^{-1}$, require less than six months for manufacturing and delivery, and ship under standard Department of Transportation freight rules.

Each TF will run three biological and efficacy tests. The results will provide governmental regulatory agencies an objective view of TFs’ differences in capabilities, methods, and results; identify the major causes of variability; and recommend methods to improve consistency among facilities and increase testing efficiency.

NOTES

Plan to Eradicate Invasive *Spartina* from the West Coast

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Four species of non-native cordgrasses (genus *Spartina*) are found along the West Coast of the United States and Canada. Where established, these invaders convert estuarine mudflats and salt-marsh ecosystems into uniform *Spartina* meadows and alter estuarine hydrology through sediment accretion. Drift card studies suggest that widespread dispersal of seeds and fragments can occur along the West Coast. Therefore, eradication efforts in one area may be negated by propagule pressure from outside the area.

Through the West Coast Governors' Agreement on Ocean Health, the Governors of Washington, California, and Oregon committed to work cooperatively to eradicate non-native *Spartina* by 2018. An Action Coordination Team (ACT), or workgroup, was formed to develop a strategy to meet the 2018 goal. The ACT included representatives from the three states, federal government, tribal governments, non-governmental organizations, and the Province of British Columbia.

The Plan is divided into six elements: prevention, early detection, rapid response, eradication, restoration, and communication/public outreach. The successful eradication efforts in San Francisco Bay and Willapa Bay have required significant funding. Ongoing efforts to eradicate *Spartina* in Willapa Bay and San Francisco Bay have cost \$12 million. Early detection of new infestations is critical to economical eradication of *Spartina* on the West Coast, and the Plan focuses on early detection and rapid response as well as support of ongoing efforts.

The cost of Plan implementation over the first three years was estimated at approximately \$8 million. The total new funding required to meet the 2018 eradication goal is \$25 million dollars. The ACT will pursue this funding through a variety of sources, including state, federal, and non-governmental organizations.

NOTES

Lake Superior Aquatic Invasive Species Complete Prevention Plan

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Canada and the United States share responsibility for protecting Lake Superior from the introduction of new aquatic invasive species (AIS). To date, 88 non-native aquatic species have been found in Lake Superior. Situated at the head of the Great Lakes St. Lawrence Seaway system, a 2,342 mile long (3700 km) water navigation system connected to global trade, Lake Superior is at risk for continued invasion by non-indigenous species of aquatic plants and animals. The risk of non-native species is their potential to cause devastating economic and ecosystem effects that impart significant losses to the region in the form of damage and control costs, degraded water quality, job losses, declining property values, compromised native species, decreased biodiversity, and other negative impacts.

To address the risk of AIS, the Lake Superior Binational Program developed an AIS Complete Prevention Plan (Plan), which outlines actions that need to be implemented to close existing vectors and pathways of introduction in order to prevent new invasions from entering and becoming established in the Lake Superior ecosystem. Current vectors of AIS introduction include: maritime commerce, agency activities, illegal activities, organisms in trade, fishing and aquaculture, canals and diversions, tourism and development, and water recreation. At present, domestic shipping is considered to pose the greatest threat of spreading AIS to Lake Superior from the lower Great Lakes. The Plan proposes a comprehensive binational program of education, monitoring, and regulation (including inspection and enforcement) that recognizes the importance of shipping, port operations, and trade and commerce to both the Lake Superior region and the American and Canadian economies. Members of federal, state, provincial and tribal agencies were involved in the development of the Plan, which integrates the existing Great Lakes AIS prevention efforts of various agencies into a common plan for Lake Superior. The actions and recommendations outlined in the Plan serve as a basis for agencies and others with a role in AIS prevention to develop work plans in support of the Plan. These work plans will reflect the institutional and legislative differences between Canada and the United States but will focus on the needs of the Lake and will create the domestic decision frameworks necessary to lead to actions on the ground.

NOTES

Management of Marine Pests in the Australian Context: Biofouling Policy Development

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The impetus for the development of a National System for the Prevention and Management of Marine Pest Incursions (the National System) in 1999 in Australia was largely in response to growing concern of the potential impacts of marine pests to Australian waters.

The National System that resulted focusses on three main elements of pest management:

1. prevention, through the ballast water and biofouling vector
2. emergency response
3. ongoing management and control

Supporting elements include monitoring, communication, research and development and evaluation and review.

In relation to prevention, to date concern has typically focussed on the management of the ballast water vector. In 2001 mandatory ballast water management arrangements for international shipping were implemented in Australia. In 2005 Australia signed, subject to ratification, the International Convention on the Control and Management of Ships' Ballast Water and Sediments. The Joint Standing Committee on Treaties has recommended that Australia take binding treaty action to implement this Convention.

More recently, the focus has shifted to species that attach on the external surfaces of vessels, including commercial, fishing, and non-trading vessels such as barges, dredges, tugs and recreational yachts. These species are collectively known as biofouling.

Under the National System, progress on managing the biofouling vector includes:

1. the development of nationally agreed voluntary biofouling management guidelines for vessel sectors that provide practical advice and guidance for owners/operators within a range of marine sectors to manage for marine pest risks associated with biofouling
2. The development of marine pest identification guides for seventeen species
3. The development and launch of an industry targeted marine pest website
4. In 2005, the introduction of voluntary requirements for managing biofouling risks associated with vessels less than 25 metres in length arriving in Australia.

In the international forum, Australia is actively contributing to and supporting the development of draft Guidelines through the International Maritime Organisation for the control and management of ship's biofouling to minimise the transfer of invasive aquatic species.

However domestically, while post border marine pest detection continue to occur, there are currently no regulatory measures in place for preventing the introduction of marine invasive species into Australian waters through biofouling. Since 2005, the Australian Government has been developing biofouling management requirements to manage marine pest risks on internationally arriving vessels. This includes progress on risk assessments that characterise the biofouling risk to Australia at the species level (in the context of the international vessel traffic that Australia is exposed to), as well as a draft consultation regulation impact statement. The development and future implementation of any bio-fouling requirements are intended to be applied in a risk-return context and to close a significant gap in Australia's biosecurity arrangements.

NOTES

Binational Aquatic Invasive Species Rapid Response Assessment and Planning International Joint Commission Work Group Activities

Mark Burrows

International Joint Commission, Great Lakes Regional Office

Introductions of Aquatic Invasive Species (AIS) to the Great Lakes through a variety of vectors are a leading threat to the ecosystem. In October 2009 a collaborative work group comprised of members of the International Joint Commission's Water Quality Board, the Science Advisory Board and the Council of Great Lakes Research Managers reported on its recommended Binational Aquatic Invasive Species Rapid Response Policy Framework. This work was based on a literature review, a series of personal interviews, three species-specific case study analyses, and an "expert's workshop" employed to extract critical success factors. Public input was collected during the IJC 2009 Biennial Meeting in Windsor Ontario and also from comments received via on-line review. The report recommendations and public input will serve to inform the Commission's 15th Biennial Report to the governments of Canada and the United States. The work group report and its appendix are both available for download at the following link: <http://meeting.ijc.org>. Planning and implementation of a binational AIS rapid response network is considered essential. In addition, threat assessments and comprehensive monitoring have been identified as key elements of a rapid response plan required to guide operations to control or eradicate invasive species posing a high risk to native populations.

A comprehensive near shore assessment using new technology and biological monitoring approaches to characterize existing native and AIS distributions can provide Lakewide Management Plan (LaMP) managers with important baseline data to use to measure the effectiveness of restoration and response activities. The work group on Binational AIS Rapid Response will report on current efforts to map the distribution of both native and non-indigenous species in the Great Lakes and to assess risk. In addition, the work group will build on the recommended 2009 binational framework for AIS rapid response; to develop and pilot test a process or protocol for binational rapid response. Proposed actions will be evaluated on a species and site-specific basis. Products of this activity will serve to guide implementation actions and improve understanding of the potential impacts of rapid response measures on Great Lakes water quality.

NOTES

Assessing the Efficiency and Safety of the Antifouling MXD-100 for Control of Invasive Species *Limnoperna fortunei* (Dunker, 1857) in Power Plants

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Currently, we have information various methods of invasive mollusks population control in industries systems have been developed for the zebra mussel (*Dreissena polymorpha*). However, for the *Limnoperna fortunei* (golden mussel), no effective methods has been developed or adapted. In order to fill this gap, MAXCLEAN Environmental & Chemical S.A, through a technical cooperation agreement with the Technological Center of Minas Gerais (CETEC) and two companies of the electricity sector, CEMIG and CESP, for 7 years developed and evaluated the efficacy and safety of the antifouling product MXD-100 for control of invasive species *L. fortunei* in refrigeration systems of Power Plants. MXD-100 is a product based on plant extracts, tannins and quaternary ammonium. Different methods were applied to evaluate the product, such as assessment of MXD-100 toxicity to larvae and adult golden mussel to estimate the lowest effective concentrations for application; ecotoxicity tests with *Daphnia similis*, *Ceriodaphnia dubia*, *Pseudokirchneriella subcapitata*, *Phimephales promelas*, *Leporinus frederici*, *Prochilodus lineatus*, *Astyanax bimaculatus* and *Myleus tiete*; biodegradability; tests for risk of ingestion (LC 50), dermal irritation and eye irritation. To assess pipes corrosion risk, tests for metal corrosion levels were performed. Golden mussel larvae and adults showed LC 50 of 0.05 ppm, which was lower than the LC 50 obtained for the biomarkers evaluated. The lowest value was found for *D. similis*, 0.12 ppm, attesting a higher specificity of MXD-100 to golden mussel. Since there was a 71.5% biodegradability in 28 days, the product is considered biodegradable. Results for health risks were dermal irritation: 0.83 grade (non-irritant), eye irritation: 18.33 grade (slightly irritating) and LD 50: 5000 mg/kg of live weight. The corrosion tests showed negative results. In field tests during 2 years, a 1 ppm concentration of MXD-100 were used in the injection (expected concentration of 0.05 ppm), with an intermittent application: 3 times a day X 10 minutes. The application point was before the cooling system's raw water filter of a generating unit (GU) of CESP Power Plants Eng. Sérgio Motta e Ilha Solteira. A GU without application of the product was used as control. For monitoring, a biobox was installed in each unit, and the assessments of fouling levels and the parameters required by environmental legislation for disposal of effluents CONAMA 357, CONAMA 397 and MS 518 potability were made. The results regarding the efficiency of the system treated with MXD-100 against fouling by golden mussel were 97% compared to control. The parameters analyzed in the effluent met existing laws. The product MXD-100 proved to be a viable, safe and effective solution in the control of the golden mussel, being efficient and specific in the control of larvae and adults of *L. fortunei*, of low risk to the handling and storage, low eco-toxicity, low use dosage and not causing corrosion of pipelines. The MXD-100 is registered in ANVISA (Agência Nacional de Vigilância Sanitária).

NOTES

The Use of Barriers in Combination with Chemical Treatment to Eradicate the Fatal Atlantic Salmon (*Salmo salar*) Parasite *Gyrodactylus salaris*

Jarle Steinkjer

Directorate for Nature Management

The invasive salmon parasite *Gyrodactylus salaris* is among the worst threats to Atlantic salmon (*Salmo salar*) today. *G. salaris* is a small (0.5 – 1 mm) ectoparasitic monogenean which is found on fins and skin of Atlantic salmon in its freshwater phase. After introduction to Norway, *G. salaris* has caused epidemics that have devastated stocks of Atlantic salmon in 46 rivers. The salmon parr abundance has been reduced on an average of 86 % and the catch of salmon are reduced on an average of 87 % in infected rivers.

In an attempt to contain the damage caused by *G. salaris* the Norwegian authorities have drawn up an action plan to combat the parasite. Eradication measures consist of a combination of fish barriers to prevent upstream migration and chemical treatment. The use of physical obstacles is an important measure in rivers which are complicated to treat with rotenone due to the salmon migrating distance or the river complexity. Use of barriers is essential in rivers where salmon is migrating up into big lakes.

The principle behind migration obstacles is to prevent the salmon from entering the spawning areas. After five to seven years the river upstream the barrier will be devoid of salmon, thus also devoid of parasites, as these can not live without a host. The distribution of salmon and parasites will be limited to the areas below the obstacles. The probability of successful chemical treatment increases, and the conflict towards other environmental interests will be reduced. This method is for obvious reasons dependent on that no other fish species susceptible to *G. salaris* are distributed upstream the barrier.

Rivers are closed in various ways depending on the size, topography and any technical construction already in place in the river. In rivers where fish ladders already extend the distance the salmon may migrate upstream, closing the ladders will prevent salmon from entering the upper section. All salmon ladders in *G. salaris*-infected rivers have been closed.

Short-time barriers are used to split up the treatment area. This kind of barrier is often used to prevent salmon to migrate up into complicated tributaries. After the construction of the obstacles, the area upstream can be treated with chemical independent of the rest of the project. At this way such barriers simplify treatment of big and complex rivers.

The River Figga has been infected by *G. salaris* since 1980. There is a big lake, Lake Leksdalsvatnet (20 km²) situated in the Atlantic salmon distribution area. One condition for exterminating the parasite from this river was to prevent the salmon from migrating up into this lake. Consequently a fish barrier was built in the river downstream the lake. This fish barrier has a length of 38 meter. The water is filtered through a 4 meter wide iron grating with 5 cm openings. This obstruction has functioned satisfactorily. No salmon are registered upstream the barrier, and the area downstream the barrier is now treated with rotenone and the parasite are eradicated from this river.

NOTES

Evaluation of Zequanox™ for Adult Invasive Mussel Treatment and Settlement Prevention at Davis Dam

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Bureau of Reclamation*

*Sarahann Dow and Carolyn Link
Marrone Bio Innovations*

After confirmation of adult quagga mussel infestation and impact to Bureau of Reclamation (Reclamation) Dams along the Colorado River in 2007, Reclamation initiated a program to evaluate treatment and control technologies for invasive mussels at their facilities along the Colorado River. As part of this more comprehensive program, Reclamation is working with Marrone Bio Innovations (MBI) under a Cooperative Research and Development Agreement (CRADA) to help progress the development and demonstrate their commercially viable prototypes of Zequanox™, a mussel control product (killed bacteria cells) derived from *Pseudomonas fluorescens* CL145A (Pf CL 145A). Pf CL 145A was originally discovered by Dr. Dan Molloy of the New York State Museum and demonstrated to be highly effective in killing both zebra and quagga mussels. Reclamation is working with MBI to conduct pilot and demonstration trials to determine if Zequanox™ is a potentially economic and viable solution as part of their invasive mussel control tool box to address some of their challenges with invasive mussels.

The non-target eco-toxicity studies that have been preformed to date have demonstrated no negative impact to other aquatic species.

Both pilot and demonstration trials at Davis Dam were initiated in January 2009 and have been conducted on a monthly basis since. The pilot trials are conducted in flow through bio-boxes in which mussels are seeded into the boxes and product is injected and mixed. Biobox trials are being conducted to test both the efficacy of different product prototypes and better understand potential differences in mussel susceptibility throughout the year due to changes in physiology and temperature. In order to conduct a full scale demonstration trial, Reclamation designed and constructed gate to close off one of the fresh water intake lines that is currently highly infested with adult mussels so that it could be treated with Zequanox™. This intake line is also plumbed in-line with a biobox to monitor mussel mortality during treatment. In March 2010, Reclamation and MBI plan to initiate a settlement prevention trial for the cooling water system of one turbine in Davis Dam. Also in early 2010, settlement prevention trials will be conducted using low doses multiple times a week and monitored to observe new settling.

This presentation will focus on the results from the biobox and demonstration trials being conducted at Davis Dam and the potential of this product compared to the other treatment technologies currently being evaluated at other Reclamation facilities.

NOTES

Evaluation of Auto-Backwash Filters in an Irrigation System to Control Dreissenid Mussels

Garry Smythe

Shaw Environmental and Infrastructure Inc.

Gary Osminski

Huron County Highway Engineer – Deputy Drain Commissioner

A long-term study of an automatic-backwash filter system was conducted to evaluate the technology as a control for zebra and/or quagga mussels. The objectives were to demonstrate that auto-backwash filters were effective in controlling mussels in an irrigation system, had potential to protect similar systems (e.g., industrial fire-protection, sprinklers), and/or could prevent the spread of mussels between adjacent water bodies if fields were irrigated. The effect of suspended solids on filter function was also considered. The research was conducted sequentially in two states. It was supported by federal agencies, an irrigation district, and/or a power company. In study phase-I a pilot scale test stand was constructed at a power plant in Greenville, MS, where the plant's auxiliary pump provided a flow of mussel infested, Mississippi River water. The flow was split into a control leg and a treatment leg (the latter fitted with a full scale filter with 40m absolute mesh). Sample pairs were examined on-site via microscopes and cross-polarized light techniques and indicated the filter retained mussels. Phase-II then began. A permanent, four-filter system (40m and 20m meshes) was designed and constructed on agricultural land in Huron County, MI. Water was pumped from Mud Creek, a tributary of Saginaw Bay. As a condition of permit the state mandated a pre-startup study to confirm mussel eggs/larvae were retained. Surrogate mussels (micro glass-beads) were initially injected into the filter system. In following tests eggs/larvae (obtained by inducing spawning using serotonin) were injected. It was demonstrated on-site that the system effectively retained beads and larvae. The system was then permitted to operate but was monitored long-term. Negotiations among agencies related to use of the system later occurred. Details of test procedures, results and current status of the irrigation system will be presented.

NOTES

Evaluation of New Coating Products for Mitigation of Zebra/Quagga Mussel Colonization

Allen Skaja and David Tordonato
Bureau of Reclamation

Coatings research is part of an ongoing interdisciplinary program being conducted by the Bureau of Reclamation to reduce invasive mussel impacts to hydraulic structures. In May 2008, a project was initiated to evaluate the efficacy of commercially available technologies in preventing mussel attachment to underwater infrastructure. Selected products were tested *in situ* at Parker Dam on the lower Colorado River where quagga mussel colonization has become extensive. Products were selected based on previous research by others, such as the US Army Corps of Engineers, and manufacture recommendations.

The testing is ongoing and currently includes antifouling and foul-release coatings, conventional polymer coatings and metalized coatings. Newer commercially available products are the main focus of the research. Over the course of the 17 months, several coatings and metal alloys have been installed and evaluated including four copper metal alloys, three zinc plated steels, two epoxy coatings, three zinc rich primers, six antifouling coatings, seven foul release coatings, one asphaltic coatings, one aluminum ion additive product, one polyurea coating, one fusion bonded nylon, one vinyl ester, and five fluorinated powder coatings. Panels and grates were coated and deployed in both static and dynamic conditions.

From the initial set of 18 products, only three products were found to exhibit satisfactory performance after 18 months of freshwater exposure. The remaining samples were heavily fouled with mussels. Foul release coatings were effective in resisting mussel attachment, especially under dynamic conditions. The primary advantage of foul-release products is that they are nontoxic. However, durability has been found in all cases to be a significant limitation. As such, the focus on foul release coatings is to find products with greater durability. Additional coatings which are expected to exhibit greater durability were added to the testing program in 2009. The results for tests of these coatings are currently pending.

NOTES

Mussel Eradication: A Portable Option

Dan Butts
ASI Group

Zebra and quagga mussels (*Dreissena polymorpha* and *D. bugensis*) (mussels) have been present in North American waters for over 20 years. Since the mussels' introduction in the late eighties, ASI Group Ltd. (ASI) has refined chlorination/dechlorination treatment protocols designed specifically for mussel control, resulting in a portable, turnkey treatment alternative. ASI has eradicated mussels from industrial facilities throughout North America by performing on-site control programs for more than fifty facilities annually, with raw water systems ranging in size from 600 USGPM to 250,000 USGPM.

ASI's treatment protocol is reactive in nature, and is intended to eradicate settled adult mussels from a raw water system within approximately two weeks. The goal of the strategy is to achieve lethal concentrations of residual chlorine (TRC) in the raw water system, through the controlled addition of 12% sodium hypochlorite and to maintain that level until complete mortality is observed in adult mussels seeded in flow-through monitors. Complete mortality is generally achieved within 14 days at water temperatures greater than 15°C (59 F).

Dechlorination is the key component of this treatment methodology. Liquid sodium bisulphite (38%) is injected into the effluent stream prior to discharge to the receiving water body to ensure the TRC is neutralized. Thus it ensures that the chlorinated water, which is toxic to mussels within the raw water system, is detoxified prior to discharge protecting the natural environment from negative impacts.

This paper will discuss ASI's treatment methodology, applications and will compare the pros and cons of a reactive treatment vs. a proactive treatment.

NOTES

Two New Coatings for Preventing Biofouling of Zebra Mussels and Algae

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*Craig Bartling
Battelle Memorial Institute, Applied Biology and Aerosol Technology*

Recently, two of the areas of technical development that have received great interest for their potential to reduce biofouling are (1) superhydrophobic coatings to prevent formation of the initial conditioning layer that promotes fouling and (2) the development of zwitterionic coatings to disrupt the initial biological moieties that attach themselves to the surface. However, each of these technical approaches has difficulty with implementation in real fouling environments. Particle based hydrophobic coatings often do not exhibit the robust behavior that is required for materials in long-use real-world environments and can be prone to damage. Zwitterionic molecules are highly water soluble and the methods that have been used to immobilize these coatings on surfaces in aqueous environments may prove to be impractical for the larger area surfaces that need to be protected against biofouling. We have recently developed coatings in both of these technical paths that have the potential to significant improvements for the long-term real-use antifouling performance of materials. First, we have developed methods for embedding hydrophobic particles in coatings that demonstrate improved hardness to some state of the art coatings and have demonstrated a resistance to zebra mussel fouling in western water systems. Second we have developed novel methods for incorporating zwitterionic molecules into coatings that can be cured to render them insoluble in aqueous environments. This second class of zwitterionic coatings has demonstrated resistance to algae fouling after one month in estuarial waters in Florida. Both coatings have been designed keeping with ultimate large-scale industrial processing in mind as a goal. Additional information in this talk will present data on a mussel protein fouling assay developed to rapidly assess the relative anti-fouling performance of coatings in the lab.

NOTES

U.S. Coast Guard Experience with Implementation of a Prototype Ballast Water Management Equipment Evaluation Program

*LCDR Brian Moore and Richard Everett
U.S. Coast Guard; Environmental Standards Division*

In December of 2004 the Coast Guard announced that it was establishing a prototype evaluation program to encourage owners of ships to install promising but as yet unproven technologies for combating invasive species in ballast water. Specifically, the shipboard Technology Evaluation Program (STEP) offers an equivalence determination to qualified ships that have installed ballast water management systems which had under gone a technical review and land based testing to validate treatment efficacy potential. This equivalence provides an enrolled ship with an alternative means of meeting U.S. ballast water management regulations for the life of the system, or the ship- whichever is shorter. This "incentive" to ship owners has been sufficient to generate six applications for enrollment. The presentation will focus on the evolution of both the shipboard program as well as the methodology for conducting shipboard efficacy testing. Additional information on the preliminary efficacy research will also be presented as data come available from the shipboard trials and evaluations.

NOTES

Assessment of Plankton Density in Ballast Water Samples Using a High Resolution Laser Optical Plankton Counter and FlowCAM®

*Jocelyn Gerlofsma and Sarah Bailey
Fisheries and Oceans Canada*

To protect Canadian waters from introduction of aquatic non-indigenous species, Transport Canada (TC) introduced Ballast Water Control and Management Regulations in June 2006, which are consistent with the Ballast Water Management Convention adopted by the International Maritime Organization. The regulations require vessels entering Canadian waters to exchange and/or flush foreign ballast water to achieve a minimum final salinity of 30‰, or to use an approved ballast water treatment system to achieve a final plankton density below a prescribed density standard. For plankton ≥ 50 μm (minimum dimension) ballast water must contain less than 10 viable organisms per cubic meter.

While evaluating compliance with ballast water exchange regulations is quickly accomplished through measurement of ballast water salinity, evaluating compliance with discharge standards in a rapid, but reliable, manner is an extremely difficult task. Traditional taxonomic enumeration methods can take days to process a sample and typically do not incorporate a reliable measure of viability.

Fisheries and Oceans Canada, in partnership with TC, has purchased a high resolution Laser Optical Plankton Counter (HR-LOPC) and a FlowCAM® with the aim to develop reliable and accurate protocols for ballast water inspection. The HR-LOPC has the capability of acquiring rapid counts of the number of particles in a large volume sample.

The FlowCAM®, an imaging flow cytometer, can generate quality images of particles in a small volume sample, allowing the user to assess the composition of particles in a sample. It is envisioned that these two tools could be used in combination to rapidly enumerate the density of particles in a ballast water sample. Here, we will present data from laboratory tests evaluating the accuracy, precision and reliability of these tools for enumeration of plankton greater than 50 μm (minimum dimension) in ballast water and natural water samples. We will discuss the strengths and weaknesses of the tools for use in ballast water compliance testing based on data collected thus far.

NOTES

Verification Trial of IMO Type Approved Ballast Water Management Systems

Peter Neimanis

Australian Quarantine and Inspection Service

The Australian Quarantine and Inspection Service (AQIS) is the lead agency in the regulation of internationally sourced ballast water intended for discharge into Australian ports and waters. The Australian Ballast Water Management Requirements came into effect on 1 July 2001.

The International Maritime Organization's (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments stipulates a gradual introduction of Ballast Water Management Systems (BWMS) as the recognised and approved method of ballast water management with the phase out of current deep ocean exchange.

AQIS is aware that ships are installing BWMS and intend to utilise them to meet Australia's ballast water management requirements. As the Convention is not yet in force, documentation and certification of BWMS may differ between ships.

AQIS commenced a trial of verification procedures, to check the effective operation of BWMS, in March 2010. The trial aims to establish verification procedures and BWMS expertise within the AQIS Seaports inspectorate and to give effect to the Convention under the existing Australian Ballast Water Management Requirements.

AQIS is currently seeking applications from vessels to use a BWMS to manage their ballast water prior to the Convention coming into effect. Vessels are required to manage their ballast water via existing methods (e.g. deep ocean exchange) until the approval to use a BWMS has been issued from AQIS.

AQIS will only consider applications to use an IMO Type approved BWMS on a case by case basis. That is, only BWMS that have received Type-approval in accordance with the IMO's BWM Convention and supporting Guidelines 8 and 9.

Ship Agents and Operators are requested to notify AQIS of any arriving vessels fitted with a BWMS. The following information should be provided to AQIS:

- Vessel details (name, IMO, vessel type)
- Details of the BWMS (name, make, approving Administration)
- Planned arrival
- Discharge intentions (full ballast capacity and forecast discharge volume)
- Copy of Type Approval Certificate and Ballast Water Certificate
- Ballast pump capacity
- Further voyage intentions (i.e. Victorian arrival, departing Australia etc)

This information is requested to be provided as soon as possible but at least 12-96 hours prior to arrival to allow AQIS to prepare to assess the status of the BWMS. Co-operation will be sought from vessels in the form of providing access for AQIS and DAFF officers to assist in the verification.

The vessel will be provided with an approval to use the system on future visits to Australia should it meet AQIS's verification requirements. Vessels will continue to be inspected on arrival and ballast water management verified as a part of the pratique inspection.

This presentation will provide an overview of the approach, feedback on experiences of the trial and options for addressing the issue at an international level for progressing through the IMO.

NOTES

Prevention and Detection of Quagga Mussels (*Dreissena Bugensis*), Zebra Mussels (*Dreissena Polymorpha*), and Other Aquatic Invasive Species at Aquaculture Facilities

Martha C. Volkoff

California Department of Fish and Game, Habitat Conservation Planning Branch

Aquatic invasive species, notably quagga and zebra mussels (*Dreissena bugensis* and *D. polymorpha*), have the potential to infest aquaculture facilities and clog intake structures, aeration devices, pipes, and screens, resulting in increased operation costs. In addition, aquaculture facilities have the potential to spread invasive species when discharging water, stocking fish, or transferring product. Spread of invasive species into the environment threatens the welfare of native species through competition for resources, predation, parasitism, transmission of diseases, or by causing physical or chemical changes in the environment. Increasingly, California is employing regulatory tools to address invasive species issues.

Prevention is the most cost-effective strategy for invasive species management. Prevention includes preventing an introduction, as well as containing an infestation to a facility if preventatives fail. HACCP Plans are a valuable tool for identifying pathways for the introduction of invasive species, and developing measures to prevent their introduction and spread. Plans are tailored to individual aquaculture facilities, and should be developed and implemented at every aquaculture facility for their protection, as well as to protect the environment.

In addition to prevention, aquaculturists should routinely monitor their facilities for invasive species. Like HACCP Plans, early-detection monitoring programs should be specific to individual facilities, and capable of detecting the gamut of aquatic invasive species. Early detection of an invasive species not only allows intervention to prevent spreading it, but control actions are more likely to be successful.

NOTES

Workshop: Using the Bureau of Reclamation Equipment Inspection and Cleaning Manual

Joseph DiVittorio
Bureau of Reclamation

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation) has developed an Equipment Inspection and Cleaning Manual in cooperation with the U.S. Army Corps of Engineers. This manual provides recommendations for inspection and cleaning of vehicles and equipment as a useful prevention tool to limit the spread of invasive species. The presentation will detail use of the manual and provide an introduction to its concepts, protocols and methods. The manual is available to the public on-line and employs hyperlinks, highlighted text, discussion points, photography, keyed line drawings, symbols and a summary table to guide the user through equipment inspection and cleaning tasks.

The information presented in the manual will provide outreach to and assist the target audience of field personnel who regularly operate various types of equipment and who are generally engaged in construction, operation and maintenance actions. Equipment operators would gain a better understanding of how invasive plants and animals in both aquatic and terrestrial environments can adversely impact Reclamation mission and the environment; and how invasive species are spread via the contaminated equipment pathway into new work locations. The manual has broad application for many organizations and agencies.

The manual is organized to present equipment inspection techniques first, because inspection will determine the need for later cleaning, if indicated. Equipment cleaning methods are explained next. Finally, the manual offers information on the identification, biology and habitats of some common invasive species that are of potentially high consequence to Reclamation, and which may be transported by equipment use.

The types of equipment described in this manual are rubber-tired land vehicles, tracked land vehicles, personal use equipment, construction and facility equipment, and watercraft. It is not possible to discuss all of the many and varied types of equipment used throughout Reclamation in detail. Therefore, the manual also presents processes developed from situational examples to help guide field personal through general inspection and cleaning decisions for equipment. Such decisions will likely be encountered in actual field practice, and can be applied to pre-inspect, clean, and re-inspect many equipment types

NOTES

California's Marine Invasive Species Program: Merging Stakeholder Involvement, Politics and Good Science

Maurya B. Falkner
California State Lands Commission

Since the passage of the Ballast Water Management and Control of Nonindigenous Species Act in 1999 and continuing with the passage of the Marine Invasive Species Act in 2003, the Marine Invasive Species Program (MISP) at the California State Lands Commission has aggressively pursued the prevention of non-indigenous aquatic species (NAS) release from commercial vessels into California.

The MISP advances this goal with a comprehensive and multi-pronged approach that includes: 1) *Sound policy development* in consultation with a wide array of scientists, state and federal regulators, non-government organizations and the maritime shipping industry. Expert panels are convened routinely to evaluate the current state of knowledge, available strategies, and develop specific recommendations to guide policy development and enforcement. This approach provides the best available science, engaging some of the foremost ecologists, oceanographers and relevant researchers in the world; 2) *Outreach* designed to bridge the knowledge gaps between scientists, legislators, the regulated industry, non-government organizations and regulating agencies. This component is also crucial for encouraging knowledgeable cross-disciplinary input as policies are crafted; 3) *Funding and coordination of targeted, applied research* that advances the development of strategies for NAS prevention from the commercial ballast water and hull fouling vectors. Examples include: a) research to develop tools to verify ballast water exchange and compliance with ballast water performance standards, needed for stronger enforcement; b) demonstration, testing, and development of shipboard ballast water treatment technologies to reduce invasion risk; and c) the investigation of fouling NAS on commercial vessel hulls arriving to the west coast; and 4) *Ballast water and hull management tracking, compliance, and enforcement* of more than 750 vessel arrivals every month. This activity includes a standardized, step-wise progression of tracking all vessel arrivals, reviewing ballast water and hull management reports, identifying and clarifying inconsistencies, physical vessel inspections, violation citations, and delinquency notices. Clearly for balanced and effective management, no single programmatic element should operate in isolation. This comprehensive approach has enabled the MISP to push both the management and research agendas, resulting in numerous accomplishments.

The MISP and Commission's goal focuses on protection, prevention, outreach and education, and solution-based actions. This is achieved by concentrating available resources on working proactively with the regulated industry to achieve a high rate of compliance with required management practices which minimizes the discharges of un-managed water and reduces the risks of biological invasions.

NOTES

The National Invasive Species Council – an All Taxa Approach

Chris P. Dionigi
National Invasive Species Council

Invasive mussels in western waters is just one facet of the larger invasive species problem. Although there are specific efforts to address individual species and locations, the 2008-2010 National Invasive Species Management Plan remains the only comprehensive attempt to address cross-cutting issues such as: adequate cleaning standards, appropriate roles of federal managers, and prioritization.

NOTES

Integrating Landscape-Level Strategies and Tools to Manage Invasive *Egeria densa* in the Sacramento-San Joaquin Delta, California, USA

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The Sacramento-San Joaquin Delta in Central California provides critically important habitat for fish and wildlife as well as an essential water supply for irrigated agriculture and domestic water supply for over 20 million Californians. The invasive, non-native aquatic macrophyte *Egeria densa* has successfully occupied very large areas (ca. 4,000- 8,000 acres) in the Sacramento-San Joaquin Delta for the past 25-30 years. The tidal flows and attendant changes in water elevation, seasonal snowmelt- driven river flows, coupled with the need to protect habitats for endangered fish species make this an extremely difficult ecosystem in which to control invasive plants. A range of tools were used for landscape scale assessments and planning for herbicide application, including remote sensing (hyperspectral analysis), hydro-acoustic analysis for plant biovolume and abundance, and applications of Rhodamine WT dye as surrogate for herbicide movement and dissipation. The information resulting from these approaches has led to successful reduction in *E. densa* abundance and biovolume over the past 3 years through the use of fluridone, a systemic herbicide. A major central Delta infestation (ca. 2,800 acres) in Franks Tract was reduced by 80 to 90% and lesser infestations in smaller sloughs have been reduced by 50 to 90%. Importantly, at no time during the herbicide applications nor during subsequent post-treatment assessments, were any fish-kills, bird-kills or other adverse environmental effects observed, nor were any adverse effects observed on irrigated crops dependent upon water from the Delta. The uses of several technologies at the landscape level have provided an effective combination of strategies, tactics and tools all focused on reducing infestations of *E. densa* in this important resource. This type of information is vital to ensure that landscape level programs are adaptive and can respond to shifts in relative plant abundance. For example, we have already observed expansions of currently non-targeted plants such as curlyleaf pondweed (*Potamogeton crispus*), and pennywort (*Hydrocotyle ranunculoides*) as populations of *E. densa* and water hyacinth (*Eichhornia crassipes*) have been reduced.

NOTES

New Data on the Reproductive Phenology of the Introduced Kelp *Undaria pinnatifida* (Phaeophyceae, Laminariales) in Port Phillip Bay (Victoria, Australia)

Carmen Primo, Marnie L. Campbell and Chad L. Hewitt

National Centre for Marine Conservation and Resource Sustainability, Australian Maritime College - University of Tasmania

A thorough understanding of the reproductive phenology of introduced species critically informs cost-effective management and control. *Undaria pinnatifida* is an invasive macroalga from the Northwest Pacific which has been introduced in several places around the world including the Mediterranean and Atlantic European coasts, New Zealand, Australia (Port Phillip Bay in Victoria and SE Tasmania), Argentina and, more recently, California and Mexico. Reproductive phenological studies in Port Phillip Bay [PPB] were undertaken and compared with other introduced populations in the Southern Hemisphere, especially with those from Tasmania which were suspected to be very different. The growth season began later in Tasmania than in PPB, New Zealand and Argentinean populations; sporophytes never completely disappear in this last region. Growth rates were lower in PPB than in Tasmania (the rest of the countries are not comparable), but this might be due to the different morphology of both populations. The maximum spore release of *U. pinnatifida* in PPB was 12.1×10^5 spores $\text{cm}^{-2} \text{h}^{-1}$, which is 20 times the maximum obtained in Tasmania (0.6×10^5 spores $\text{cm}^{-2} \text{h}^{-1}$); for most of the growth season, spore release rates in PPB were 3–5 times higher than in Tasmania. To our knowledge, no other study of progression in spore release has been published for Southern Hemisphere populations. The influence of different sea surface temperatures on *Undaria* population characteristics was also studied.

All introduced populations of *U. pinnatifida* have continued regional spread through time. New Zealand populations have extended their distribution about 1300 km from the initial location of introduction in 21 years; Tasmanian populations have spread about 250 km in 20 years; Argentinean populations appeared c. 500 km south of the initial introduction after 16 years of its first detection; in the present study, we found a spread of about 200 km around PPB in 12 years. Although ship traffic intensity is likely to influence the human-mediated aspects of spread, these introduced populations have diverse origins (recognised by unique genetic makeup) resulting in differing morphologies and population characteristics which may directly influence human-mediated or natural dispersal capabilities.

Undaria pinnatifida has yet to establish outside PPB in continental Australia despite the numerous marinas and fishing harbours that have direct vessel traffic with PPB and SE Tasmania. However, the early detection and successful removal of *U. pinnatifida* from Western Port (40 km east of PPB) and Apollo Bay (100 km west of PPB) suggest that propagules are capable of arriving in areas outside PPB; therefore, a precautionary approach should be undertaken in order to avoid further spread. Monitoring for early detection and removal of immature sporophytes prior to spore release seem to be the best options. This monitoring should be continuous since new recruits may appear throughout the growth season (April to February) and it should be combined with informative programmes to reduce the chances of spread.

NOTES

Understanding the Lifecycle and Morphology of the Invasive *Lagarosiphon major* in Lough Corrib, Ireland, in Order to Develop Effective Control Practices

Michael Millane, Stephanie Evers, Joseph Caffrey, H. Moran and S. Sayed
Central Fisheries Board

Although, originally introduced *via* the horticultural industry as an oxygenating plant for artificial watercourses, the first record of the highly invasive aquatic weed *Lagarosiphon major* (Ridley) becoming successfully established under natural habitat conditions in Ireland was in the north-west of Lough Corrib in 2005. This 178 km² lake is of major international conservation importance and includes 12 habitats listed in Annex 1 of the EU Habitats Directive. Since establishment, the weed has increasingly expanded its range throughout the northern and into the middle portion of the lake typically colonising shallow sheltered bays and littoral areas (< 6m water depth). In turn, this has resulted in the displacement of the native keystone charophyte dominated plant communities, with additional implications for the resident macroinvertebrate and fish populations.

The aim of this study was to examine the lifecycle and morphology of *L. major* in order to better inform current and future control measures, as well as to investigate whether vulnerabilities exist that can be used to optimise these practices. Sites infested by *L. major* were examined on a monthly basis over a continuous long-term period to determine the particular morphological, growth and reproductive strategies used by the weed. Further research was conducted on sites subjected to mechanical control in order to assess the efficacy of this practice and determine the level of post-cutting re-growth. The Lough Corrib weed population appears to have a specific temporal growth pattern, unlike in its native range, as the plant forms an erect canopy stage and subsequently returns to a collapsed state. As only female plants are present in the lake, the weed reproduces asexually through vegetative reproduction and fragmentation, having the peculiar capacity to produce aerial roots before fragmenting from the parent plant. Understanding the functional ecology of *L. major* in European waters is key to the development of effective control strategies.

NOTES

Control of *Lagarosiphon major* and Restoration of Indigenous Communities Using a Biodegradable Geotextile to Exclude Light

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Central Fisheries Board

M. Butler
Western Regional Fisheries Board

Lough Corrib is the second largest lake in Ireland, measuring 178 square kilometers. It is of major conservation importance and supports 14 habitats and six species that are listed on Annex I and Annex II, respectively, of the Habitats Directive. The lake is a nationally important wild brown trout and Atlantic salmon angling resource and a major tourist angling destination. In 2005 the presence of an aggressive invasive submerged plant species, *Lagarosiphon major*, was confirmed. This southern African plant had become established in a number of key angling bays on the western side of the upper lake and was expanding its range within the upper and middle lakes. In 2005 it was estimated that *circa* 1,670 tonnes wet weight of *Lagarosiphon major* was present in one single bay. This biomass had increased to 2,700 tonnes at this site in 2007. The rate of spread of the invasive weed within the upper and middle lakes was also dramatic and increased from 9 sites in 2005 to 113 sites in 2008. To date, no *Lagarosiphon* has been recorded in the lower lake and every effort is being made to halt the southerly spread of the plant into this large and shallow watercourse.

A variety of weed control methods have been tested in Lough Corrib in an effort to control the growth and spread of this highly invasive weed. One method that is currently proving to be both highly effective and environmentally safe is light exclusion through the use of a geotextile material. In 2008 initial trials using a biodegradable jute or hessian geotextile were undertaken in the middle lake. A methodology to effectively cover both large (> 500 sq metres) and relatively small (< 100 sq metres) areas of weed-infested lake bed was developed. Results from trials that were established at a range of *Lagarosiphon*-infested sites demonstrate that the target weed dies rapidly beneath the geotextile cover. An unexpected result to emerge was the fact that native macrophyte species, and particularly members of the charophyte community, became established at these trial sites following the demise of the invasive *Lagarosiphon*. This paper will describe the rate at which the *Lagarosiphon* dies and decays, the longevity of the biodegradable geotextile and the rate and course of recovery of the indigenous macrophytes community.

NOTES

Genetic Population Structure of an Invasive Aquatic Weed, *Elodea canadensis*, in Finland – One or Multiple Invasions?

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Kirsi Kostamo
Finnish Environment Institute

Canadian water weed (*Elodea canadensis*) is a submerged aquatic angiosperm native to North America. This invasive species was introduced to Europe in 1836 and to Finland, to the Botanical Garden of the University of Helsinki, in 1884. At present, it is common in the whole Southern and Central Finland. Its aggressive growth and mass occurrences may change the balance of lake and river ecosystems and make the recreational use of lakes more difficult. Only female plants have been reported from Europe since 1903, thus reproduction is thought to be only vegetative.

Our aims are to analyze the genetic characteristics of Finnish *E. canadensis* populations within neutral genomic areas, and to clarify the dispersal history of *E. canadensis*, specifically whether there have been one or multiple invasions to Finland. As the species has spread to Finland recently and may originate from only few clonally reproducing individuals, we expected to find a small amount of genetic variation. To determine the genetic characteristics of Finnish populations, we developed and used ten polymorphic microsatellite markers. In all, 20-30 samples from seven Finnish populations were collected and genotyped.

The ten microsatellite markers amplified from two to five alleles per locus and the mean number of alleles per population varied between 1.6 and 2.4. The H_E ranged from 0.19 to 0.37. The majority of genetic variation (75.9 %) was found within Finnish populations. Genetic analyses indicate that *E. canadensis* has been introduced to Finland more than once. Multiple introductions are supported by the higher level of genetic diversity detected within and among Finnish populations, than would be expected from a single introduction followed by vegetative spread. In addition, in two rounds of Bayesian analysis using the software STRUCTURE, Finnish samples from seven populations were divided into three clusters. This geographical structure was further supported by pairwise F_{ST} values among populations. No evidence of a recent bottleneck was found in Finnish population of *E. canadensis*, indicating multiple introductions as random mating is not expected.

NOTES

Habitat Use and Dispersal Capacity of the Non-indigenous Isopod *Cirolana harfordi*

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The University of New South Wales, School of Biological, Earth and Environmental Sciences

On a global scale, biological introductions of species to regions outside their known natural environment are one of the major threats to native biodiversity. In aquatic environments, biogenic habitats formed by bivalve molluscs modify the original habitat, usually increasing complexity and/or heterogeneity. Such changes may increase the abundance and/or diversity of associated species compared to substrata without these habitats. The presence of biogenic habitats and their provision of otherwise limiting resources (e.g. food and refuge from predation) may however, also facilitate colonisation, increase in abundance and aid further spread of exotic organisms. Successful colonisation by exotic organisms and their subsequent survival and abundance may then be dependent on the facilitative effects of different habitat-forming species.

Our sampling indicated more exotic species were found living in the habitat created by the exotic mussel *Mytilus* spp. than in the habitat created by the native mussel (*Trichomya hirsuta*). There was, however, no difference in the numbers of exotic species within these habitats on artificial structures when compared to similar habitats on natural rocky shores. *Mytilus* spp. is more abundant on artificial structures in Sydney Harbour, the presence of this habitat-forming organism may explain why there are more exotic species found on these structures.

The North American isopod *C. harfordi*, which has been introduced to many regions including Japan, Russia and Australia, is found amongst the *Mytilus* spp. assemblage and is being used as a model organism to test hypotheses about distribution and habitat use in the harbour and whether an exotic habitat-forming organism can facilitate establishment of other exotic organisms. *C. harfordi* is a direct developer (no larval phase) and it would be expected that dispersal capacity would be limited. The species is more abundant in the inner harbour but is present in the outer harbour and this distribution might be related to available habitat restricting successful establishment of populations and/or range expansion via recreational boating activity. Population genetics on *C. harfordi* populations within Sydney Harbour and other harbours/bays along the Australian coast are compared to native populations to test hypotheses of single source populations, extent of connectivity, and multiple points of introduction.

Determining the effects of habitat-forming species on exotic species assemblages, will increase our knowledge of the processes and mechanisms behind the spread of non-indigenous species. Understanding some of these mechanisms will lead to more accurate predictions of changes in ecosystem biodiversity and may be useful in invasive species management.

NOTES

Distribution and Habitat Preferences of the Invasive Crustacean *Hemimysis anomala* in the Great Lakes

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T. Johnson
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The bloody red shrimp (*Hemimysis anomala*) was first identified in the Great Lakes in 2006. As of late 2009, this Ponto-Caspian mysid has been found in lakes Michigan, Huron, Erie and Ontario, as well as the St. Lawrence River and Oneida Lake in NY.

Our pier-based sampling program in Lake Ontario has found that numbers are generally low in the spring and increase through the summer and late fall when large swarms may occur. Densities of over 3000 individuals.m⁻² were commonly found at Bronte Harbour, Oakville, Ontario, during December 2008 and the fall of 2009. *Hemimysis* dry biomass in western Lake Ontario ranged from 0 to 52 mg.m⁻² from June to September 2008, and 93 to 2371 mg.m⁻² from November 2008 to January 2009. Nighttime surveys using vertical net hauls at several nearshore sites in Lake Ontario indicate that *Hemimysis* are usually tightly associated with breakwalls and piers, and may be virtually absent beyond these structures. These structures likely provide daytime refuge from predators and opportunities for grazing on attached algae and detritus. We also found low densities of this invader in rocky nearshore areas 3-9 m deep. *Hemimysis* were also found among submerged macrophytes in eastern Lake Ontario. Nighttime surveys using vertical net hauls in deeper water (10-30 m) have not yielded any *Hemimysis*, although other agencies have reported them on reefs as deep as 20 m. Dense swarms have been observed by SCUBA divers in the fall adjacent to piers or closely associated with boulders.

It has been difficult to develop an appropriate sampling method for *Hemimysis* due to its cryptic daytime nature. Vertical net hauls yield areal density estimates, but must be carried out at night and only capture pelagic animals. Although traps set overnight eliminate the need for nighttime sampling, it is more difficult to estimate areal abundance with this gear. However, they can yield relative measures of abundance from one site to another. To date, we have found the best trap design to be a weighted five gallon pail with a large funnel inserted in the mouth. In rocky nearshore areas, these traps yielded higher numbers than other traps or vertical net hauls. It is hoped that multiagency use of a consistent gear type such as the bucket trap will provide data on distribution, abundance and habitat preferences of this invader. This, combined with information on its role in the nearshore food web, will aid in our understanding of the ecological consequences of *Hemimysis* invasion in the Great Lakes.

NOTES

A Quick Test to Establish the Predation Capacity in Exotic and Native Gammaridean Species

*Gerard van der Velde, Bart Stoffels, Jeroen Tummers and Rob Leuven
Radboud University Nijmegen*

*Dirk Platvoet
University of Amsterdam*

Predicting the impact of biological invasions is one of the main topics in invasion biology. Gammaridean species belong to the most successful invaders and are able to dominate in numbers in macroinvertebrate assemblages. Although gammaridean species are omnivores a series of invasions by various gammaridean species showed impact caused by predaceous behaviour. Even replacement of native gammaridean species by exotic ones seemed to be the result of intraguild predation.

Observations and experiments demonstrated that the various gammaridean species have different abilities to prey on relatives and other prey. Because of the high impact of predaceous behaviour in gammaridean species by which the macroinvertebrate assemblages are controlled a quick screening of this behaviour in as much species as possible could be of predictive value at invasions.

We developed a quick, standardized one-hour test in which we studied the ability of various species to catch and consume prey. These tests can easily be repeated and carried out at different temperatures give information about the predaceous capacity at different temperature regimes.

NOTES

Genetic Admixture Dynamics Reveal Dispersal Patterns in a Coastal Marine Invasion

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A number of recent studies have recognized the important roles that multiple introductions and intra-specific genetic admixture may play in determining the success of biological invasions. What is less widely recognized is that study of these phenomena can prove extremely useful for understanding the dispersal processes driving population expansion.

Here we describe detailed genetic study of a paradigmatic case of multiple introduction, the invasion of European green crabs (*Carcinus maenas*) to the northwestern Atlantic. Using both mitochondrial and nuclear genetic datasets collected over multiple years, we demonstrate that populations in the region of overlap between two distinct invasion fronts exhibit unique genetic signatures reflecting intra-specific admixture. By exploring genetic relatedness between sampled populations and conducting assignment tests to determine patterns of recent migration within the region, we further determine that these admixed populations have served as source populations for subsequent secondary spread via anthropogenic dispersal. In addition, assessment of gene flow inferred from temporal dynamics within the admixture zone clarifies the roles of advective larval dispersal and other demographic parameters in determining complex patterns of introgression of both nuclear and mitochondrial genomes.

NOTES

Potential Impact of Chinese Mitten Crab (*Eriocheir sinensis*) on Turbidity and Submerged Vegetation in Lake Zuidlaardermeer, Northern Netherlands

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The Chinese mitten crab (*Eriocheir sinensis*) is an invasive species in Europe and North America. In 1927 the first crabs were found in the Netherlands. According to local fishermen, the population in the shallow Lake Zuidlaardermeer, in the northern Netherlands, has increased dramatically during the last decade. It has been suggested that the crab could be responsible for the observed decreases in the commercial fish catches. Such a negative effect of the crab could have materialized in various ways, like 1) predation of fish eggs, 2) competition for space between crab and fish, 3) removal by the crab of plant structures on which some fish species depend for deposition of their eggs, or 4) increased water turbidity through digging activities of the crab.

The two latter aspects were investigated experimentally in 2004, by comparing mesocosms with or without a crab. In a pair-wise comparison, there was a significant reduction of submersed vegetation (Nuttall's waterweed *Elodea nuttallii*) and a significant increase in turbidity in the mesocosms with a crab, but the experimental set-up did not allow us to distinguish between direct (plant consumption) and indirect (plant mortality through increased turbidity) effects on the submerged vegetation. However, comparable experiments done in 2005 showed that a crab could consume 0.06 g day⁻¹ of Nuttall's waterweed and 0.4 g day⁻¹ of Pondweed (*Potamogeton* sp.).

Can the strong impact of crabs on submerged vegetation and turbidity in the mesocosms be extrapolated to Lake Zuidlaardermeer? The lake used to have extended areas of submerged vegetation. Their disappearance has been attributed to a rise in turbidity, followed and enhanced by a growing number of bentivorous fish, *i.e.* Common bream (*Abramis brama*). Suspended solids have increasingly contributed to turbidity. Although the production of this seston has been stimulated by eutrophication, there is no clear relationship between turbidity and chlorophyll-*a* content, due to the resuspension of bottom material by wind and possibly bream. Based on the mesocosm experiments, we suggest that Chinese mitten crab could theoretically have a greater impact than bream, because in addition to increasing turbidity the crab can directly remove vegetation. The disappearance of the submerged vegetation from the lake cannot likely be attributed to the crab, as it occurred before the assumed population increase of the latter. Depending on the abundance of the crab in the lake, the species may be seriously obstructing the recovery of submerged vegetation, however, by contributing to the high turbidity of the water.

During 2006 a first attempt has been made to estimate crab abundance in the lake from the density of marked animals in eel-fyke catches, using a modified Petersen index. This preliminary estimate amounts to about 200 crabs ha⁻¹, distributed in the inshore waters. Though this is only 20% of the estimated bream abundance, the contribution of the crab to the high turbidity may be substantial. It has yet to be investigated whether the presumed fish egg predation by the crabs could have a significant negative effect on the bream population, thus reducing another important source of turbidity.

Patterns of Compliance, Geography and Management of Ballast Water in California

*Lynn Takata, Chris Scianni, Nicole Dobroski, and Maurya Falkner
California State Lands Commission*

Since 2000, the California Marine Invasive Species Program has overseen the state's program to prevent non-indigenous species introductions to California waters through the commercial ballast water vector. One of the most important components of the program has been the requirement that vessels submit ballast water reporting forms upon departure from each port or place of call in California. These forms detail ballast management activities for over 10,000 vessel arrivals each year, forming a data-rich time series through which compliance and management patterns can be examined. The data also allows for the geographic and temporal examination of source and exchange patterns of ballast water that is eventually discharged within the state.

Compliance with the requirement to submit the ballast water reporting forms consistently exceeds 90%, due to an active inspection and outreach program. The vast majority of vessels (over 80%) comply with California's regulations by retaining ballast water, a proportion that has steadily increased throughout the years. Of ballast water discharged into the state, over 80% is appropriately managed through ballast water exchange. Most of the ballast water discharged in the state is attributable to tank and bulk vessels, although these ships do not compromise the majority of California arrivals by vessel type.

This talk will present details of these patterns of vessel compliance with California's ballast water regulations during recent years, as well as summaries on the quantities and geographies of managed ballast water, where such ballast water has been exchanged, and where it has been discharged. Such analyses may provide valuable information that can inform the development of more effective ballast water management regulations, as well as inform both retrospective and predictive studies of NIS invasion patterns

NOTES

An Analysis of the Fouling-Related Practices of Commercial Vessels in California

*Christopher Scianni, Nicole Dobroski, Lynn Takata and Maurya Falkner
California State Lands Commission*

Fouling of aquatic organisms to the submerged surfaces of vessels can be a major vector for the transfer of non-indigenous species (NIS) both locally and globally. Introduction of NIS through vessel fouling can occur as organisms spawn, fall off, or are physically removed from the hull and other underwater surfaces of a vessel. Many studies worldwide have suggested that the number of NIS introductions through commercial vessel fouling may be equal to, or greater than, introductions via ballast water. However, it is difficult to assess the risk of NIS introduction through this vector because very few substantive studies have been conducted to evaluate how vessel practices and behaviors influence the extent of fouling accumulation on the underwater surfaces of vessels.

In an attempt to fill this information gap, the California State Lands Commission (Commission) has developed a Hull Husbandry Reporting Form that all commercial vessels operating in California must submit on an annual basis, as of January 1, 2008. This reporting form is a ten-question survey aimed at gathering information related to factors that are likely to influence fouling extent on the submerged surfaces of vessels. These include hull husbandry practices, such as type and age of antifouling coating and length of time since the most recent out-of-water drydocking or in-water cleaning, as well as certain voyage characteristics, such as traveling speed and port residency times. A complete look at these fouling-related practices for all vessels operating in California during 2008 and 2009 will be presented and discussed, as well as potential implications for vessel fouling extent and NIS introduction risk. A preliminary view of the data thus far indicates that 99% of all vessels operating in California during 2008 have been removed from the water for hull cleaning and treatment with an antifouling coating within the past 5 years, and 87% were treated with antifouling coatings containing copper-based biocides. The information gathered from this Hull Husbandry Reporting Form will provide detailed insight into characteristics thought to influence vessel fouling and will be used in conjunction with fouling-related research the Commission is currently funding to guide the development of regulations governing the management of fouling on vessels operating in California. The implementation of these science-based management policies will greatly enhance the ability of the Commission to prevent the spread of NIS into the waters of California.

NOTES

Minimizing the Spread of Marine Non-indigenous Invasive Species through Application of Boat Hull Antifouling Strategies: To Clean or Not to Clean?

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Henry Page and Jenifer Dugan
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Antifouling strategies have been developed to control recruitment of all types of organisms on the hulls of boats, including marine non-indigenous invasive species (NIS) that can have detrimental impacts on ecosystems and coastal communities. In-water hull cleaning is one antifouling strategy that is used in combination with antifoulants and other hull coatings. The California hull cleaning industry has developed and trains members on hull fouling best management practices (BMPs). Concerns have been raised, however, about whether this companion hull cleaning practice may stimulate fouling through increased disturbance of the fouling community and alteration of the coated surface. To evaluate this concern, we conducted a field experiment that assessed recruitment of NIS and other fouling species following the application of hull cleaning BMPs to tiles with various hull coatings. The experiment was conducted in two marine biogeographic subregions of California, at Santa Barbara Harbor and at Shelter Island Yacht Basin, San Diego Bay. Experimental fiberglass tiles were coated with copper-based antifouling paint, nontoxic epoxy or nontoxic siliconized epoxy. Hull cleaning practices were applied to a group of each type of tile for 3 months during the peak season of recruitment of fouling organisms. After this time, all tiles were cleaned and redeployed for one month, with an additional group of new tiles deployed. Biomass of accumulated fouling organisms was measured at the end of the experiment. We also assessed type and level of fouling when BMPs were applied (every 2-3 weeks) and at the experiment's end.

California hull cleaning BMPs did not stimulate fouling in our experiment. The amount of fouling did not differ significantly among the cleaning treatments tested: tiles that had been cleaned once, continually cleaned or never cleaned. Cleaning treatment did, however, affect the tool and effort required to remove fouling growth. More abrasive tools and additional effort were needed to remove growth from previously cleaned tiles than from tiles that had never been cleaned. Hull coating type also influenced fouling and cleaning practices. Tiles with copper-based antifouling paint had significantly less fouling – lacking calcareous organisms and algae altogether – and required less abrasive tools and effort when cleaned. While location had no influence on type of fouling or tools and effort required to remove fouling growth, there was dramatically lower accumulation of fouling on experimental tiles at the northern location (Santa Barbara).

Our results have implications for policies regarding antifouling strategies that control NIS and other fouling organisms while protecting water quality. Although copper-based antifouling paints were highly effective at reducing fouling, negative impacts on water quality and movement of copper-tolerant NIS make them a far less ecologically-sound strategy. Copper antifoulants are under increased regulatory scrutiny in California and have been restricted in some areas. Instead, our findings indicate: 1) California's hull-cleaning BMPs provide an effective means for controlling fouling of NIS and other fouling organisms on boat hulls and 2) California BMPs should be adapted to address differences in fouling rates among locations within the State and elsewhere.

NOTES

Elements of Marine Biofouling Risk

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Ashley Coutts and Derek Shields
Aquenal

Joe Valentine
Hobart

Non-indigenous marine species are transported by a number of different human mediated vectors, which operate across a range of distinct pathways. International, regional and national efforts have largely focussed on ballast water as a primary vector of modern invasions, however marine biofouling, specifically of vessel hulls, has now become the focus for international efforts. Here we consider the elements appropriate to the development of a biofouling risk framework with application to the Australian context.

Risk assessment is increasingly becoming a tool for environmental management comprising both the likelihood and consequences of an event such as the invasion of a species or the arrival of a vessel with high risk species. We have taken the approach of analysing three interacting risk sets: species, vector and pathway. The identification of high risk vectors and/or pathways will therefore be reliant on determining the species level hazards to a receiving region.

Key hazards for Australia were deemed to be those species with a recognised invasion history and not present in Australia. More than 1780 species have been identified as being introduced to some region of the world. These species were evaluated for the species' association with biofouling coupled with the transport pressure. Species association with biofouling was assessed based on life history characteristics. Transport pressure was calculated as a function of the intersection between a species' global distribution and the opportunities for transport calculated as a combination of the number of vessels arriving in Australia from regions where a species is present.

Consequence (or impact) was assessed across four core values of environment, economic, social and human health for each species based on information derived from the literature. The vast majority of species did not have either demonstrable or inferred impacts stated in the published literature creating a significant limitation to the application of risk assessment. For those species with consequence information, risk was calculated as the product of likelihood and consequence resulting in a restricted suite of species that have the potential to cause moderate to extreme impacts across one or more of the four core values if introduced to Australian waters.

Vessel assessments identified the per vessel likelihood of *at least one species of concern* arriving in Australia, based on Last Port of Call, 1 year and 5 year voyage durations given that biofouling represents an accumulation of species starting shortly after dry-docking. We evaluated vessel behaviours over a six year period (2002-2007) to determine individual vessel and vessel class risks. Duration in port and bioregion fidelity were analysed for potential risk factors.

NOTES

National Risk Assessment of Ship-mediated ANS Introductions to Canada's Four Coasts

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Fisheries and Oceans Canada

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The introduction and establishment of aquatic non-indigenous species (ANS) follows a sequence of steps or stages that must be transitioned for successful invasion: uptake of AIS from a donor region by a transportation vector; transportation between donor and recipient habitats; release into the recipient habitat; survival; and reproduction, which may lead to secondary introductions wherein the invasion process begins anew. In order to predict new ANS, and to efficiently manage vectors of introduction, rigorous risk assessments must be conducted to quantify propagule pressure and evaluate probabilities of survival at each stage of the invasion process for all potential recipient habitats.

Shipping, and introduction of ANS, has historically been identified as an activity that may negatively impact aquatic ecosystems in Canada, and much effort has been expended to manage this vector. We will present the results of a national risk assessment of ship-mediated ANS introductions to the four coasts of Canada (including the Great Lakes/St. Lawrence River, Arctic, West Coast, Gulf of St. Lawrence/East Coast). The risk assessment is based on analyses of vector activity, environmental matching between donor and recipient ports, and probability of negative impact. The risk assessment will include analysis of all ship-mediated invasion pathways (e.g., ballast water, sediments, hull fouling). The results of this national project will elucidate whether current regulations for ballast water management have sufficiently reduced the risk of introduction of ANS for all regions of Canada.

NOTES

Alien Attack – Invasion of *Alternanthera philoxeroides* (Mart.) Griseb (Alligator Weed) in Wular Lake of Kashmir, India

Ather Masoodi and Fareed A. Khan

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Jonathan Newman

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Invasive non-native species are one of the top five threats to global biodiversity according to the United Nations Convention on Biodiversity. The valley of Kashmir has experienced a continuous addition of non-native species to its flora in the last few years. Some of these are known to be highly invasive species with the potential to significantly alter ecosystem structure and function.

Alternanthera philoxeroides (Mart.) Griseb (Alligator weed) (Amaranthaceae), native to South America, was collected in 2008 during a vegetation survey of Wular Lake, located at an altitude of 1,530 m amsl between 34°20' N latitude and 70°24' E longitude. This study is the first report of this species from this region. *A. philoxeroides* is a noxious invasive weed widespread in the world. It can be assumed that all lakes and wetlands in the Kashmir valley are susceptible to this weed and may support destructive levels of Alligator weed growth. In view of the importance of studies on alien invasive plants, particularly in areas of high anthropogenic interference, the present study puts on record the distribution and biology of *A. philoxeroides* in Wular Lake. The locations of all major populations of alligator weed were recorded using a GPS and then downloaded to ArcGIS 9.2. The plant areas were converted into georeferenced polygons and added to the map. These maps will be useful in determining how native plant communities change in response to invasions and to track the spread of invasive aquatic plants in Wular lake. Data collected during this study will be used to influence the development of an aquatic plant management plan for Wular Lake.

NOTES

***Caulerpa taxifolia* in South Australia and Queensland: Parallel Histories**

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Caulerpa taxifolia is one of the best known marine invasive species: its reputation is based largely on its rapid expansion across the Mediterranean, where it was reported to out compete native seagrasses. In Australia, *C. taxifolia* has expanded its range over the last decade in Moreton Bay, Queensland, where it is native, and the Port River, South Australia, where it is exotic. In both localities, *C. taxifolia* occurs primarily in areas of low water quality. Monitoring data suggest that there is a trend of seagrass loss followed by *C. taxifolia* colonisation. *In situ* and large-tank experiments show that *C. taxifolia* responds rapidly to the addition of nutrients but that light and temperature are also important influences on growth.

Environmental conditions, primarily light, temperature and nutrients appear to regulate the occurrence/survival/growth/balance of seagrass and *C. taxifolia*. Environmental quality is likely to be a determinant of the success of invasions. Coastal ecosystems that are healthy and therefore more resilient include less suitable habitat for *C. taxifolia*. Sound coastal management will probably prevent further invasions better than biosecurity measures aimed at preventing introduction.

NOTES

Research and Testing of a System for Precision Littoral Zone Application of Aquatic Herbicides

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Clean Lakes, Inc.*

*Bruce Sabol
U.S. Army Engineer Research and Development Center, Waterways Experiment Center*

The US Army Engineer Research and Development Center, Environmental Laboratory (ERDC-EL), and Clean Lakes, Inc. entered into a Cooperative Research and Development Agreement for the “Research and Testing of a System for Precision Littoral Zone Application of Aquatic Herbicides”. The Scope of the Cooperative Research and Development Program is to provide for the joint conduct of research and development investigations related to coupling the LittLine® System (Littoral Zone Treatment Technology) with ERDC-EL Hydroacoustic Submersed Plant Mapping capabilities (SAVEWS™ and related developments). The technologies will be used together to achieve precision application of herbicide to submerged, nuisance aquatic vegetation. The Project Objective is to design a LittLine® System that utilizes SAVEWS™ or variations of that technology in an optimized system for automated aquatic herbicide applications. Field testing and modifications will yield a new real-time application system capable of delivering excellent plant control with a reduction in the amount of herbicide required by conventional delivery methods. The research team began the initial CRADA investigations in Florida during the period of January 5 through January 12, 2010 within Hydrilla control zones within **Lake Tohopekaliga**, or **Lake Toho**. **Lake Toho** is an 18800 acre lake in Osceola County known as one of the best lakes in Florida for bass fishing, and is located within the Kissimmee Chain of Lakes. For the initial investigations, aquatic herbicide treatments were mock treatments using water rather than aquatic herbicides. Through the initial research investigations, the abilities of combining the two systems was demonstrated, and an update on the efforts will be presented.

NOTES

Introduction of the European Common Barnacle *Balanus perforatus* Brugière (Crustacea, Cirripedia) into Korean Waters

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The common barnacle *Balanus perforatus* Brugière, 1789; (Crustacea, Cirripedia) from the European waters is recently discovered to be established very quickly in the eastern coasts of Korea. It has jumped a historic oceanographical barrier from the European waters to the Northwest Pacific waters. It is a warm water species between 36° N and 52° N, occurring commonly in the Mediterranean and along the eastern Atlantic coast from north Wales to West Africa. Usually, it occurs in the lower half of the littoral zone and may extend into the sublittoral on rocks and artificial structures and is sometimes common in wave exposed situations but also present on ships' hulls. On British coasts, this barnacle *Balanus perforatus* had a limited south-western distribution (Southward, 2008) and recently its distribution may be expected to extend further north and east with a warming climate (Hiscock et al., 2004). Subsequently the range has extended eastwards to Hastings on the English side of the Channel and to Le Treport on the French side and it has extended its range eastward by upwards of 100 km in the past 25 yr (Herbert et al., 2003). This species now lives in places in the eastern English Channel that were formerly considered to be too cold for it in winter.

The success of the establishment of invasive species is dependent primarily on the temperature of the recipient waters. Moreover, the distributions of many species broadly follow summer or winter isotherms. Mean surface temperatures in summer around the English Channel where a large number of the common barnacle were recently found are between 15°C-18°C and those in winter between 6°C-9°C respectively (Hiscock, 1998; Hiscock et al., 2004). In the Western Mediterranean where this species is very abundant in the intertidal rocky shore, the annual average SST between 1982-1990 was about 19°C with 25°C in summer and 15°C in winter. On the other hand, the mean August SST between 1970 - 2000 around Ulsan and Pohang Ports in Korea where the population of *Balanus perforatus* was well established reaches 25°C, while the mean February SST reaches 11°C (Japanese Meteorological Agency). Therefore, the temperature condition in the recipient waters in Korea is by far within its distributional range and this may imply the rapid colonization of this invasive species in Korean coasts after settlement.

Balanus perforatus was found for the first time in Guryongpo (35°59'10"N, 129°33'20"E), Yangpo (35°52'40"N, 129°31'30"E), and Gampo (35°43'18"N, 129°30'27"E) Ports on June 24, 2006. Two years later in 2008, 31 sites were visited in all around the South Korean coasts. This survey showed that 13 sites were invaded by this species and they were concentrated rather in the east coasts where some of the important international shipping traffic ports are located such as Busan and Ulsan. Therefore, it is possible to assume that the observed invasion pattern may suggest ships' hull fouling and/or their ballast water as pathways and dispersal after establishment according to the circulation pattern of Tsushima Warm Current in this region. Based on the northern limit of its distribution in Sacheon Port (37°50'00"N, 128°52'36"E) in 2008, this would be approximately equivalent to movement of water with passive larvae of about 300 km to the north for two years. As a conclusion, the rapid colonization of this introduced species extending its distribution north by 150 km a year should be monitored together with the impact of this invasion on the other species or communities in Korean coasts.

NOTES

Canada's Ballast Water Program – Science, and Risk Supporting Internationally Based Regulatory Regime

*Paul Topping and David Yard
Transport Canada*

Canada has had a ballast water program since 1989. The discovery of the Ruffe in the Great Lakes caused the International Joint Commission and the Great Lakes Fisheries Commission to ask the government of the United States and Canada to “do something”. That something, starting in 1989 with the *“Voluntary Guidelines for the Control of Ballast Water discharges from Ships Proceeding to the Great Lakes and St Lawrence River”* has morphed (with a lot of work from many countries) into the basis for an International Ballast Water Convention. In the context of the Great Lakes, this mean possibly the most stringent, and effective, ballast water enforcement in the world

Canada will ratify the Ballast Water Convention in the near future. Doing so should be straightforward as the current Ballast Water (BW) Control and Management Regulations promulgated in 2006 by Transport Canada, essentially put in place the requirements of the B.W. Convention in Canadian law. There is an outstanding need to incorporate the treatment requirements and schedule as per the convention. This will be incorporated in the next iteration of the regulations prior to ratification.

Backstopping this regulatory process is a vibrant scientific research program that is active on all coasts. Fisheries and Oceans scientists have provided advice on the placement and positioning of alternate exchange zones on all three coastlines, including the sensitive waters of the Arctic. They have looked at the appropriateness of the International Maritime Organization ballast water discharge standards for Canada, the role of the domestic fleet in the spread of aquatic invasive species, both by hull fouling and ballast water discharge, examined the efficacy of the first generation of Ballast Water Treatment systems currently on ships, and have undertaken full scale studies on alternative emergency treatments for vessels that were unable to comply with the regulatory requirements. A database that will support regulatory and science goals continues to evolve.

Recent research has indicated that the current enforcement program for the Great Lakes is highly effective at reducing risk of ballast water discharge of aquatic invasive species that are likely to survive.

Future support for the ballast program will be in providing tools and sampling analysis to support port state control initiatives.

On overall risk assessment process is currently underway to place ships and shipping in the context of all vectors of introduction to Canadian waters.

NOTES

Fresh Water; Neglected in Shipboard Ballast Water Treatment Testing and Approval – A Potential Solution

Christopher J. Wiley

Fisheries and Ocean Canada, Central & Arctic Region and Transport Canada, Ontario Region

With the recent adoption of the International Convention for the Control and Management of Ships' Ballast Water and Sediment, vendors, ship owners, flag states and the IMO have significantly ramped up the approval process for ballast water treatments

However relatively few of these approved and subsequently type tested treatment systems have been tested for approval in fresh water. The IMO Guidelines specifically require testing in two, of three, possible salinities, fresh water, brackish water and marine water. As the majority of ports worldwide are brackish or marine, most treatment system proponents have opted to test in those conditions.

Unfortunately, there are a considerable number of fresh water ports and ecosystems that ships do call at. Full scale testing of type tested shipboard installations entering the fresh waters of the Great Lakes, has shown that, at least for some ballast water treatment systems, successful tests in saline or brackish conditions do not guarantee success in fresh water conditions. Indeed for the ballast water treatment systems tested, the systems simply did not work.

Ships entering the Great Lakes are currently required to exchange or flush their ballast under Canadian regulations, such that a salinity of not less than 30 parts per thousand is achieved in each ballast tank. Scientific oversight of the enforcement program has indicated that for high risk organisms, on average, the exchange / flushing requirement under the regulations meets the D2 treatment standards and significantly reduces the risk of potential invasions to the Great Lakes.

If a ship has a treatment system aboard that has not been specifically type approved for fresh water, it is proposed that, the ship will exchange / flush consistent with the current regulatory requirement, then utilize the treatment system,, on the exchanged (now saline) water,

Preliminary evidence suggests that such action would not only allow treatment systems to operate in fresh water but also significantly increase the effectiveness of the system.

NOTES

Establishing a Scientific Foundation for Numeric Concentration of Living Organisms in Ballast Water Discharge Limits under U.S. EPA's Vessel General Permit (VGP)

Ryan Albert

U.S. Environmental Protection Agency, Office of Water

Henry Lee II

U.S. Environmental Protection Agency, Office of Research and Development, Western Ecology Division

On March 30, 2005, the U.S. District Court for the Northern District of California (in *Northwest Environmental Advocates et al. v. EPA*) ruled that the United States Environmental Protection Agency (EPA) regulation excluding discharges incidental to the normal operation of a vessel (including ballast water) from National Pollution Discharge Elimination System (NPDES) permitting exceeded the Agency's authority under the Clean Water Act. As a result of this ruling, EPA issued the first Vessel General Permit (VGP) on December 18, 2008 which is valid for a 5-year period. Since this ruling subjects these discharges to Clean Water Act regulation without altering other federal regulatory programs, EPA's VGP ballast water requirements, though generally complementary, are additional to US Coast Guard requirements under its statutory authorities including NANPCA/NISA. EPA has partnered with the US Coast Guard on numerous projects so that both Agencies can most effectively implement their ballast water programs, and where possible, requirements under both regulatory programs can be generally consistent.

The 2008 VGP includes general effluent limits applicable to 26 specific discharge streams including ballast water. EPA has already begun contemplating what requirements are appropriate for the next (2013) VGP. The most significant deliberation is what, if any, numeric ballast water discharge standards to apply in this nationally applicable permit.

EPA is actively engaged in building a strong scientific basis for inclusion of those limits. The Clean Water Act requires that NPDES permits contain both technology-based (TBEL) and water-quality (WQBEL) based limits, with the more stringent of those two limits governing. EPA, in partnership with the US Coast Guard, has approached its Science Advisory Board (SAB) to seek advice on the efficacy and availability of existing technologies: that report is due out in early 2011. This report will inform EPA's decision for its ballast water TBELs in the next VGP. EPA, also in partnership with the Coast Guard, has asked the National Academy of Sciences to evaluate approaches used to determine what would constitute ecologically protective ballast water discharge limits of concentrations of living organisms. This report, due in the Summer of 2011, will help inform EPA's decision for the VGP's ballast water WQBELs. As background for this evaluation, EPA, USGS, and Smithsonian scientists prepared a white paper* evaluating the strengths and weaknesses of six previous approaches to setting numerical standards as well as proposing a new method ("per capita invasion probability") based on historical invasion rates and propagule pressure.

This presentation will summarize EPA's strategy for establishing a firm scientific basis for establishing numeric limits in the next VGP. It will also discuss other major EPA efforts to realize effective and ecologically protective ballast water treatment, including committing over 10 million dollars to ballast water research projects in 2010, with similar funding commitments expected for 2011. At the conclusion of this presentation, viewers should understand EPA's approach for developing VGP ballast water permit limits and how this approach might integrate with the proposed Coast Guard ballast water rulemaking.

*Lee II, H., Reusser, D.A., Frazier, M., and Ruiz, G. 2010. *Density Matters: Review of Approaches to Setting Organism-Based Ballast Water Discharge Standards*. U.S. EPA, Office of Research and Development, National Health and Environmental Effects Research Laboratory, Western Ecology Division. EPA/600/R-10/031.

NOTES

Can We Sample Ships to Assess Compliance with Ballast Water Management Standards?

Stephan Gollasch
GoConsult

Matej David
University of Ljubljana, Faculty of Maritime Studies and Transport

Ballast water sampling of vessels is very difficult compared to water samplings in the environment. This is because of several reasons, including port logistics, onboard sampling access points, availability of ship crews in ports and the lack of appropriate sampling gear. However, sampling ships to assess compliance with ballast water management standards becomes a pressing regulatory issue. Sampling methods and approaches need to result in representative results of biota in ballast water and at the same need to meet the minimum sample volume and/or number of samples needed from a statistical perspective. The authors were involved in two sampling voyages comparing various approaches, sample volumes and frequencies. These studies were undertaken to gather representative ballast water sampling recommendations. The data will also show the differences and similarities when using different in-line and in-tank sampling points onboard ships. Results from these studies and possible sampling strategies will be presented also discussing statistical recommendations.

NOTES

Marine Invasive Species in the Greater Gulf of Maine/Gulf of St. Lawrence Ecoregion – an Information Perspective

David G. Oliver
Skylark Information Systems Ltd.

A project was undertaken on behalf of the Commission for Environmental Cooperation (CEC) to review and assess existing data/information on current invasions – and potential future ones, where possible – in the Greater Gulf of Maine/Gulf of St. Lawrence Ecoregion. The project aimed to determine whether the right information, at the right level of resolution, is available to support desired conservation and management outcomes.

Specialists in marine invasive species in the study area were contacted in order to create a matrix summarizing key information about those invaders (taxonomy, origin, invasion pathway, physiology and life cycle, geographic extent, biodiversity and ecological impacts, economic impacts, control and management measures taken, and the actors involved). Internet resources (e.g. ITIS) were used to supplement the information supplied by the specialists.

The matrix documented 133 species considered invasive in the Greater Gulf of Maine/Gulf of St. Lawrence Ecoregion. A summarized version of the matrix was reviewed by the marine invasive species specialists for their judgment on the “worst offender” species, from ecological and/or fisheries and/or economic points of view. Further key information on the 11 worst offenders was researched and presented as part of the project’s final report.

Despite some excellent examples of high-quality information (e.g. comprehensive biological synopsis reports, an Internet-based database of observations from rapid assessment surveys, a web-based repository of basic biological information and invasion histories, a work-in-progress spreadsheet, and various published scientific papers), integrated marine invasive species information for making conservation and management decisions was not available to this project. A conceptual data model of basic marine invasive species information was developed, and its implications described. Key aspects of the information management required to support the identification and management of marine invasive species include cooperation among stakeholders, shared long-term geospatial information, and the deliberate design of information resources. Internet-based technologies enable, but do not guarantee the accessibility of well-designed, integrated marine invasive species information to ecological and economic stakeholders. Effective management of marine invasive species requires the coordinated knowledge and actions of many affected stakeholders. There is a pressing need to make the best knowledge available on a shared platform that enables effective actions, and the review of the outcomes of those actions.

NOTES

***Celtodoryx ciocalyptoides*: The First Record of a Sponge Species Transferred from One World Ocean into Another by Human Activity**

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In 1996 a sponge was found in a well-studied area in the Ria of Etel, Brittany, France that had never been recorded there before. Later this sponge was described as a new species and genus, *Celtodoryx girardae*, by Perez *et al.* (2006). Within several years *C. girardae* was found to occur successively in the Gulf of Morbihan, France, and Oosterschelde estuary, Netherlands. The sponge is characterized by an extensive spatial spreading, covering an area up to 25 m² with a thickness of up to 50 cm. As a result, it is today part of the dominant benthic megafauna in the shallow waters of the Gulf of Morbihan and Dutch inshore waters. Furthermore it seems to be a successful competitor, overgrowing several other invertebrates, such as other Porifera and Octocorallia (Perez *et al.* 2006), due to its high abundance and biomass.

In the course of my study on the sponge fauna of the Chinese Yellow Sea, the same species was found. After a detailed morphological and taxonomical investigation *Celtodoryx girardae* Perez *et al.*, 2006 is now considered to be a junior synonym of *Celtodoryx ciocalyptoides* (Burton, 1935), a species that was up to that time exclusively known from the shallow waters of the Posiet Bay, Sea of Japan and South Korea. According to my results the transfer of the Pacific oyster *Crassostrea gigas* Thunberg, 1793 to aquaculture farms in lagoons along the French and the Dutch coast is the probable vector for the invasion of this sponge into the NE Atlantic Ocean. The variability in the morphology and population structure of sponges from both oceans is discussed with respect to differences in ecology and seasonal variations. Furthermore, *C. ciocalyptoides* is presented as the first “non-cosmopolitan” sponge species that was verifiably transferred from one world ocean into another by human activity.

My results confirm the need of taxonomical and ecological surveys, especially in poorly investigated regions, in order to detect potential sources for invasive species.

NOTES

Investigating the Microbiology of a Successful Invasive Marine Oyster: Gulf of Eilat vs. the Eastern Mediterranean Sea

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Invading species in marine habitats represent a recognized worldwide threat to the integrity of native communities, to the economy and to human health. Recently, microbial pathogens and symbionts have been attracting increased attention as important factors that may promote or prevent a successful invasion. In marine bivalves, bacteria are known to accumulate in a viable state in the digestive tract and gills, providing the host with food and protection against disease. The eastern Mediterranean Sea is susceptible to biological invasions due to its location between the Atlantic, Pontic and Erythrean regions. The greatest influx of invaders into the Mediterranean Sea resulted from the opening of the Suez Canal in 1869, which allowed the entry of tropical biota, such as the oyster *Chama pacifica*, first recorded from the Mediterranean coast of Israel in 1993. This oyster which is regarded as a successful invader, has established a substantial population, both in terms of density and size of individuals compared to its Indo-Pacific counterpart. However, the oyster's microbiota and its possible effects on the ecosystem it has invaded have not been explored. In the present study we compared the microbial communities of individual *C. pacifica* oysters from Sdot-Yam (Mediterranean Sea, invasion site) to *C. savignyi*, a con-generic oyster from Eilat (Red Sea, source of invasion) and, using 16s ribosomal DNA clone libraries and the Automated Ribosomal Intergenic Spacer Analysis (ARISA). The ARISA results revealed significant differences in community structure and seasonal dynamics between the microbial communities harbored by the oysters in both regions. However, the clone libraries revealed possible symbiotic bacteria that appeared in all oysters examined, regardless their origin. Further microbiological and molecular studies are being undertaken in order to understand the possible role of the symbiotic bacteria in *C. pacifica* which successfully invaded the eastern the Mediterranean Sea.

NOTES

How to Kill Over 100,000 Wild Pacific Oysters in One Day: Research and Experiences from a Successful Control Exercise over 25km of Infested Intertidal Reef in South Australia

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The Pacific oyster is a native species of Japan which is cultured in around 70 countries. Prompted by low catch rates of the native mud, or flat oyster *Ostrea angasi* in South Australia and after several failed attempts at its cultivation, it was decided that a hardier species such as the Pacific oyster *Crassostrea gigas* should be trialed. By 1969 the first shipment of oyster spat from Tasmania arrived in South Australia and today, the oyster farming industry is a significant economic contributor of seafood for South Australia.

In some areas of Australia, invasive colonisation by Pacific oysters escaping leases then forming self propagating populations has caused serious damage to the aesthetics, biodiversity and public amenity of intertidal reefs. Initial trials in South Australia led the wider community to believe that Pacific oysters would not self propagate outside of lease areas due to incidental high salinities. Despite 30+ years of cultivation, surveys of several South Australian Pacific oyster cultivation areas have previously exhibited low spat fall and the incidence of self sustaining populations had not been established. More recently however, surveys have detected increased numbers of escaped oysters in some but not others of the major oyster growing regions. This prompted several research projects with the aim to determine appropriate management actions to prevent reef systems being overcome by the invasive nature of the oyster. The outcomes of the research projects and a successful control operation which resulted in the clearance of over 25km of wild Pacific oyster infested reef in one day will be discussed.

NOTES

Understanding and Describing Impacts of Aquatic Non-indigenous Species

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Understanding and describing impacts of aquatic nonindigenous species (ANS) is a difficult task. Significant challenges include: the paucity of impact data regarding many ANS; the uncertainty often surrounding the existing data; the variety and relevance of different data types, many of which are observational or anecdotal in nature; and the lack of common descriptors for impact magnitude and type. Resolving these issues in order to accurately assess ANS impacts is critical given the increasing frequency of invasions and the associated legislative and regulatory decisions that require reliable descriptions of species impacts.

This interactive workshop will present resource managers and others with responsibility in the marine environment with a suite of non-indigenous species, with directed discussion and the opportunity for the participants to provide their assessment of the impacts. The outcomes of this workshop will assist efforts to develop a comprehensive framework to describe the types and magnitudes of impacts to environmental, economic, social, cultural, and human health values, and how to proceed in situations with scarce, uncertain, or non-experimental data.

NOTES

Ballast Water Management Study for Halifax Class Frigates

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Naval ships worldwide have operational and engineering constraints that are different from those of commercial ships. Ballast is rarely used, capacities are small and there are significant space limitations for equipment. While legally exempt from the provisions of the BW Convention, from a policy point of view, the Canadian Navy has made every effort to comply with discharge requirements for all ships source discharges.

The Ballast Water convention, under Regulation B-3-7 allows the use of "Other Methods" of Ballast Water Management provided, that such methods ensure at least the same level of protection to the environment, human health etc as ballast water treatment systems. The issue is still under consideration at the International Maritime Organization, and to date no approved procedure has evolved.

In this context, technical and operational issues were examined for Ballast Water Management aboard Canada's Halifax Class frigates and innovative solutions proposed.

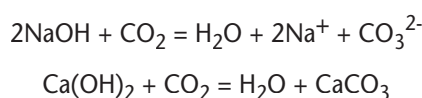
NOTES

Refinement of a Hydroxide Stabilization Process for Treatment of Ballast: Effect of Relative Headspace Volume, Ventilation Rate and Liquid Phase Mixing on pH Depression

Barnaby Watten and Philip Sibrell
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There is a pressing need for new economical and environmentally safe control strategies for both water and residual solids present under ballast and “no-ballast-on-board” (NOBOB) conditions. Residuals can contain high numbers of virus like particles, bacteria, algae and invertebrates which combined represent a significant threat to receiving waters if discharged without treatment during standard tank fill/drain operations. Stabilization of biologically active water and sludge has been achieved in wastewater applications through use of excess lime treatment. Here hydroxide alkalinity is elevated through reagent addition (NaOH or hydrated lime) so as to establish a killing effect that is easily controlled by regulation of the target pH (11-12.5). Exposure requirements are short and pH can be readily returned to neutral levels through use of dilution during a subsequent reballasting step or dilution combined with recarbonation. Recarbonation, the transfer of CO₂ into the liquid phase from ambient air or through application of commercial CO₂, results in desirable alkalinity products as described by the following reaction stoichiometries:



Hydroxide stabilization appears attractive given (1), the long history of successful use in agricultural and wastewater solids applications as a means of controlling pathogens and other hard-to-kill life forms (2), the ease of applying the relatively inexpensive base through existing ballasting/deballasting plumbing and (3), the avoidance of ship corrosion concerns, associated with pH depression, that are linked to certain alternative acid/oxidant addition treatments. Preliminary reagent cost estimates established for the proposed stabilization processes are attractive but research is required to verify treatment/recarbonation effects on pH dynamics. In this presentation we present a multi-component gas transfer model, based on chemical reactor theory, which predicts CO₂ reaction rates/pH depression as a function of time and important operating conditions. These conditions include the initial tank head space gas composition, tank ventilation rate, tank residual volumes (solids/liquids), temperatures, local pressures and the initial hydroxide dose. Model inputs also include a user set value for K_La, the overall mass transfer coefficient that reflects ship ballast movement (turbulence) during transport as well as available gas-liquid interfacial areas. Model calibration and validation trials will be described along with examples of model use in identifying least- cost treatment approaches for application of the hydroxide stabilization process.

NOTES

Tales from the Crypt: Instrument Records from Inside Operating Ballast Tanks

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Multiparameter instrument sondes were deployed in ballast tanks of commercial cargo ships for voyages in the Great Lakes lasting less than a week and transoceanic voyages lasting several months. Conductivity, temperature, dissolved-oxygen, sonde depth relative to the surface of the ballast water, chlorophyll, and turbidity were recorded in different combinations on different voyages. Instrument records were compared to ballast management events listed in the ships' logs, especially ballast water exchange and ballast tank flushing. Instrument data from long-term transoceanic voyages were useful for verifying ship ballast operations as well as providing information on conditions in the ballast tanks before, during, and after ballast operations. The short-term instrument records were associated with NaCl brine treatment experiments conducted in the Great Lakes. The spatial deployment of multiple instruments during these experiments provided insight into mixing within the ballast tanks. In all cases thorough mixing was not achieved until after the ship was underway in the open lake. In all cases complete mixing, as demonstrated by a convergence of the calculated NaCl concentration measured at all instrument locations, was eventually achieved. These results suggest that embedding one or more sensors in ballast tanks could be useful for verification by regulators of ship ballast logs and for ship operators to monitor conditions inside ballast tanks, if satisfactory procedures can be developed to maintain such sensors.

NOTES

On-board Ship Tests in the Great Lakes Measured the Efficiency of Basic Dosing Methods for Treating Ballast Tanks

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Over 30,000 commercial ships transit between the world's ports and move with them ballast water which may contain aquatic nuisance species and harmful pathogens. Effective treatment of this ballast water is vital to stopping the spread of non-native species from one ecosystem to another. Effective treatment of ballast tanks requires the biocide to be evenly distributed. This paper presents quantitative comparisons of the efficiency of five basic methods for mixing biocides into ballast tanks.

To quantify the effectiveness of these dosing methods, full scale tests were conducted in April of 2009 on board the marine vessel *Indiana Harbor*, a 1,000 foot Great Lakes bulk carrier operated by American Steamship Company. The five dosing methods tested were: 1) bulk dosing of an empty tank where dye (Rhodamine WT) was pumped into the tank before ballast water was admitted; 2) in-line dosing where dye was pumped into the piping used to fill the ballast tank during ballast water uptake; 3) internal water transfer where ballast water was circulated from the bottom aft of the filled tank to the top forward corner using a portable pump and injecting the dye into the circulation loop; 4) perforated hose dosing where dye was injected throughout the water column in a filled tank using a perforated hose and portable pump deployed through the tank vent; and 5) vent dosing where dye was pumped into the vent of a filled ballast tank and allowed to mix using natural ship motion. A YSI Environmental 600 OMS Sonde, Rhodamine Sensor, and meter was used to monitor dye concentrations over time at 152 locations in 6 ballast tanks. Samples were taken by lowering the probe into the tanks through the tank vent access points and by taking samples throughout the inside of the tanks using pre-mounted tubes. The movement of the ship was expected to influence the dispersion of the dye in the tank. Ship movement was quantified by measuring acceleration forces, vibration, the pitch, yaw, and roll of the ship, and pressure variations in the tanks as an indicator of wave action.

Of the methods tested, the time-series analysis showed that the inline dosing of a tank during ballast water uptake and the bulk dosing of an empty tank prior to ballast water uptake were most effective at distributing the dye throughout the tank. While these results were not surprising, we are unaware of any other study that quantitatively compares the efficiency of these methods. None of the methods that would be used to administer biocides to a full ballast tank were very effective at distributing the dye throughout the tank. It took over 48 hours for the dye to come close to being fully mixed in the tanks using these methods. Ongoing activities by our research team, including computational fluid dynamics model tests, experimentation using physical scale models of ballast tanks, and further on-board tests, are focused on developing specialized tools and techniques designed to promote greater mixing efficiency and reduced application time in full ballast tanks.

NOTES

Computational Analysis of Reagent Mixing in Ballast Tanks

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Invasive species continue to be a significant threat to local ecosystems in the Great Lakes regions and other places around the world. One of the major contributors to the spread of non-indigenous aquatic species is the introduction of organisms in discharged ballast water. This and other related efforts are aimed at trying to gain a better understanding of the flow behaviors in ballast tanks and the impact of tank structure and improved mixing techniques on the effectiveness of treatment methods to reduce or eliminate aquatic organisms resident in ballast water. Researchers at the Naval Surface Warfare Center – Carderock Division have been actively investigating certain aspects of invasive species in ballast water over the past several years. In particular, efforts have focused on computational fluid dynamics (CFD) predictions of ballast water exchange procedures in bulk carriers[i],[ii]. One of the outcomes of this investigation was in determining the appropriate level of detail about the internal tank structure necessary to provide accurate computational results. The intent of current efforts, in collaboration with researchers at USGS Leetown Science Center, is to try to gain some understanding of how a treatment reagent might mix in a similar type of ballast tank, and the potential use of an air lift mixer to enhance the mixing process. Here, the tank would be closed (no inflow/exit of resident ballast water). A specified flow rate would then be applied to one of the connection pipes that connect the upper wing tanks with the hopper side tanks. This would create a circulating flow through the remaining tank bays that would potentially promote the mixing of the reagent. In order to assess the effectiveness of this type of mixing, a matrix of computational simulations have been performed that involve changes in volumetric flow rate, different injection methods, and potential uses of the air-lift mixing technique. The results of the computations performed as part of this effort provide a great deal of insight into the characteristic flow patterns in a representative large ship ballast tank. It is the hope that these types of investigations will impact the ability to reduce the spread of invasive aquatic species in ballast water. [i] Wilson W., Chang P., Verosto S., Atsavapranee P., Reid D.F., Jenkins P.T.(2006), “Computational and experimental analysis of ballast water exchange,” NAVAL ENGINEERS JOURNAL 118 (3): pp. 25-36. [ii] Reid, D., Verosto, S., Chang, P., Wilson, W., Atsavapranee, P. and Jenkins, P. (2005) “Modeling of Ballast Water Mixing and Flow Dynamics to Understand Ballast Water Exchange,” ENSUS 2005, Marine Science and Technology for Environmental Sustainability, Newcastle, UK.

NOTES

Developmental Plasticity and Successful Fish Invasions

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Successful invaders are generally believed to have several attributes, such as generalist life-history, tolerance to a wide range of environmental conditions, high fecundity, high phenotypic plasticity, physiological tolerance, etc. These attributes are supposed to provide them with advantages in colonizing new habitats and ecosystems. However, not so often attention is paid to the question, where do such attributes come from. Examples with successful invasions that started with small and genetically uniform founder populations indicate that the success does not need to be associated with high genetic diversity. Moreover, experience with fishes invading waters across Europe suggests that, in contrast to general believe, many of these successful invaders are specialists rather than generalists, in terms of their life-histories. Therefore, the present contribution focuses on the capacity of fishes to generate diverse life-histories that result from alternative ontogenetic trajectories.

The ontogeny of a multicellular organism appears to be an extremely complex process, which supplies the organisms with an enormous potential to generate a variety of phenotypes, an emergent property that is essential for species to survive in various environments and consequently very useful for a species to establish self-sustaining populations in novel environments. Phenotypic plasticity of organisms appears to be a function of epigenesis, the process that shapes the developing individuals and has the potential to generate alternative ontogenetic trajectories. This is usually expressed through the formation of both generalized (altricial) and specialized (precocial) forms within and/or among populations. These forms can be best evaluated by a thorough examination of their ontogenies, especially early development, associated with studies of life history traits such as fecundity, number of spawning acts per season, parental care, egg size, age at maturation, as well as both among- and within-population ontogenetic variability in external morphology.

It has been found that ontogenies of such successful invaders as round and bighead gobies, topmouth gudgeon and black bullhead produce precocial forms in their native areas (i.e. under stable organism-to-environment interactions that have resulted from evolution), however, in unknown environment of the areas they have invaded, they shift toward more altricial forms and life-histories. Nevertheless, a life-history that is advantageous at the beginning of the invasion, i.e. during the establishment of a new population, may turn into disadvantage once the population has established and achieved high density. Indeed, a shift back to precocial life-history, typical for native populations, has been observed in those invasive populations that managed to establish safely. This capacity to generate a wide range of alternative ontogenetic trajectories and life-histories is here discussed from a wider perspective of developmental plasticity – a phenomenon that helps organisms, especially the invaders, to survive under various environmental conditions.

This study is supported by VEGA, project 1/0226/08.

NOTES

Do Long-time and Recently-established Populations of Topmouth Gudgeon (*Pseudorasbora parva*) Follow Different Ontogenetic Trajectories and Life-histories?

Eva Záhorská and Vladimír Kováč
Comenius University

Topmouth gudgeon (*Pseudorasbora parva*, Temminck & Schlegel, 1842) is one of the most invasive species in Europe. It appears to be a good example of successful invaders due to some typical attributes, such as protracted spawning season and overall environmental plasticity. The main aim of the present study was to examine the hypothesis that recently-established populations of topmouth gudgeon employ a less specialized (altricial) rather than the specialized (precocial) ontogenetic trajectory and life-history typical of native and/or long-time established populations. Therefore, we studied fecundity and other life-history traits in two populations. The first population comes from an old abandoned gravel-pit with a relatively stable environment with no external disturbances. This population has a relatively long history (more than 10 years) of continuous undisturbed existence, which is, for the purposes of this study, considered to imitate native populations. The second population comes from a channel that serves as an outflow for two large ponds. Regular manipulation with water level in these ponds causes heavy disturbances to the local habitat of topmouth gudgeon. Thus, this population has to cope with permanent stress and has never been established safely. The number of oocytes in the well-established population ranged from 220 to 1 060 during the post-spawning season and only 18% of these females had ovaries with ripened eggs. In contrast, as many as 522-7 508 oocytes were found in females from the stressed population, and 71% of them had ovaries with ripened eggs. Such a significant difference between the two populations suggests that the above hypothesis is plausible. Further life-history traits, such as absolute and relative fecundity, size of oocytes, number of spawning batches, age and size at maturation, annual gonadosomatic index variation and Fulton's condition index, were examined to test the hypothesis.

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NOTES

Morphological Variability of Non-native Black Bullhead *Ameiurus melas* Populations in Four European Countries

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The North American ictalurid fish, black bullhead *Ameiurus melas*, was introduced to Europe in the late 19th and early 20th centuries, and it is now established in at least 13 countries. However, the species has received little study, in particular regarding its external morphology which in successful invading species is an attribute that often displays great plasticity, effectively allowing body shape adaptation to fit better the environmental conditions of the invaded ecosystems. In the present study, the external morphology of four black bullhead populations from the species' introduced range (Slovakia, $n = 231$ specimens; England, $n = 163$; France, $n = 93$; Italy, $n = 342$) was evaluated within an ontogenetic context to assess its phenotypic plasticity. The minimum and maximum standard lengths (SL) of the Slovak, English, French and Italian bullheads (in mm) were: 17.6–184.9, 60.2–193.7, 49.1–200.7, and 29.4–229.3, respectively. A total of 32 morphometric characters, including SL and total length, were treated using the triple-regression analysis to examine the patterns of relative growth of these body proportions in respect of the size of fish. Subsequently, 18 landmarks were set for the geometrical analysis, which examined ontogenetic patterns and changes in external morphology. Relatively high variability between the four populations was found, though, the differences were significant only in a few morphometric characters. The Italian population demonstrated the most distinct phenotype, with a proportionately longer and narrower head, smaller eye diameter, smaller caudal peduncle and smaller caudal fin relative to all the other three populations. The differences increased with increasing fish SL. No notable morphological changes were observed in juveniles, which means that black bullhead reaches its definite phenotype already at a small body size. In conclusion, black bullhead appears to be a species capable of considerable morphological variability, expressed in the formation of different adult phenotypes and in the manner the phenotypes are achieved. These results are consistent with the great flexibility observed in black bullhead life-history traits, suggesting that the species has a great potential to be invasive.

Study was supported by VEGA 1/0226/08 and UK/24/2010.

NOTES

Fathead Minnow *Pimephales promelas* in Europe: Preliminary Results on the Environmental Biology of a Feral Population of 'Rosy Reds' in Northern England

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The North American cyprinid, fathead minnow *Pimephales promelas*, has for some decades been used in Europe for toxicity testing and the 'rosy red' variety in the ornamental pet fish trade. Although established feral populations has been reported in four European countries (Belgium, France, Germany, United Kingdom), there are no published data on the environmental biology of the species in its introduced European range. To address this gap, life-history and back-calculated growth were investigated in two feral populations of the rosy red variety discovered in open ponds on a farm near York (England). Believed to have been introduced over 10 years ago as a contaminant of 'pinhead' larvae of golden orfe, the ornamental variety of ide *Leuciscus idus*, the fathead populations consisted of ornamental (rosy red) and naturally pigmented fish, as well as mixtures thereof. The fish were collected in early May 2009, prior to the onset of spawning, and processed in the laboratory for studies of body morphology, back-calculated growth, diet, and length and age at maturity. The results are discussed in light of previous risk pre-screening analysis of the species and the potential risk posed by the species to inland waters of the UK.

NOTES

A New Mention for an Aquatic Invasive Species at the Northern Limit of its Range: Dynamic of an Asiatic Clam Population in Association with a Power Plant

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Exotic species recognized to invade freshwater ecosystems tend to be overrepresented by highly fertile and tolerant species, such as filter feeder molluscs (bivalves). Accordingly, the Asiatic clam (*Corbicula fluminea*), a hermaphrodite bivalve, is recognized as one of the most economically and environmentally damaging aquatic invasive species in United States and Europe. Until now, water temperature in winter still limited the northern distribution range of this species in America, its survival being compromised under 2°C. Recently, the presence of the Asiatic clam was nevertheless detected in several northern regions, including the Great Lake watersheds, the Connecticut river, and the Lake Champlain canal. In fall 2009, we discovered the presence of *C. fluminea* in the St. Lawrence River, i.e, in the discharge plume of the nuclear power plant Gentilly-2 (Bécancour, Québec, Canada). In order to document the most northern mention of the species, we set up 25 sampling stations upstream and downstream the nuclear station and collected bottom sediments. We found 303 ± 132 ind./m² alive specimens per stations (between 32-1184 ind./m²), varying in size from few millimetres and up to 25 mm, which confirmed the establishment of an Asiatic clam population in the St. Lawrence River. So far, we have not found any specimens upstream the nuclear station, but individuals were still present at least 2 km downstream the station. This study permitted us to better understand the distribution of the species in studied sites, and help to determine the risk of Asiatic clams establishment elsewhere in the St. Lawrence River. The presence of the Asiatic clam in Québec is even more worrying as climate change could favour the success of this species in northern watersheds. It is essential to rapidly document the new establishment of species known to be invasive, before they dramatically modify aquatic ecosystems, as observed for other invasive mussels, such as the zebra (*Dreissena polymorpha*) and the quagga mussels (*Dreissena rostriformis bugensis*).

NOTES

Integrating an Emerging Tool into Native Freshwater Mussel Protection and Recovery Efforts

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Dreissena spp. (zebra and quagga mussels) impact almost every aspect of the ecology of the waterbodies they invade. The restoration of these aquatic ecosystems has been impossible due to the lack of environmentally safe options for controlling dreissenid mussels. There is an immediate need for effective and safe tools to prevent the spread of planktonic larval dreissenids and to rehabilitate and protect native mussel (unionid) habitats from dreissenid fouling. More than half of the 78 native unionid species in Minnesota, Wisconsin, Iowa, Missouri, Illinois, Indiana, and Ohio are listed as endangered, threatened, or of special concern, and zebra mussels are often their most immediate threat. Unionid recovery plans are in place for many species, and partnerships are in place between federal and state agencies to protect the future of this threatened group of freshwater bivalves. Scientists at the New York State Museum, with collaborators from the US Geological Survey and US Fish and Wildlife Service in the Midwest, have recently launched a research program to integrate a promising, soon-to-be-commercialized control method, the bacterial biopesticide *Pseudomonas fluorescens*, as a control tool for inclusion in integrated pest management programs to limit dreissenid mussel populations, slow their spread, and reduce impacts on native unionid mussels. Procedures are being developed to use this breakthrough biopesticide to prevent the spread of planktonic dreissenid larvae and to reduce unionid fouling by dreissenids in targeted restoration areas.

NOTES

Assessment of the Invasion of *Limnoperna fortunei* in the Lower Paranaíba River and its Tributaries of the Right Bank – the Stretch Between São Simão (GO) and Paranaíba (MS)

Mônica de Cássia Souza Campos, **Fabiano Alcísio e Silva** and Pedro Henrique Rolin Benini
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The Parnaíba River is about 1.070km long up to the junction of the Rio Grande, where both start to form the Paraná river. The section under study is one of the routes of invasion of *Limnponerma fortunei* species in Brazil, with 18 sampling points, starting from the previously colonized areas by the species to places even where there is no record of the invasion. The section corresponds to the Paranaíba River and its tributaries from the right bank, on the border between Goiás and Mato Grosso do Sul states and the Rivers Claro, Verde, Corrente, Aporé and Barreiro, amount respectively, near the Power Plant of São Simão (area unaffected), to downstream, near the town of Paranaíba MS (area already colonized by the species). This region, which belongs to the Brazilian Cerrado, is very rich in water and it is quite useful for the production of electrical energy through a chain of hydroelectric. The attempt was to diagnose the occurrence and distribution of this species on the route of invasion. The larval densities by means of horizontal and vertical hauls and the presence of adults for manual removal on rigid substrates and “dipping” in sandy and clay sediments were assessed. In the tributaries, there was the occurrence of the species only in its larval stage in the Aporé river and in the Barreiro stream, and in both, vertical and horizontal hauls, the population was higher in the Aporé river, although this river is more upstream on the route of invasion of the species, probably correlated to the population boom characteristic of invasive species at the time of colonization of new environments. The horizontal hauls in the Parnaíba river allowed the observation of larvae from the point collected to more downstream in the river, which is from the ES13 station in Porto Alencastro, up to the ES09 station, which is located downstream of the Corrente river. It was noticed that the density of organisms falls downstream to upstream. The vertical drag done in the Parnaíba River showed larvae only up to the ES11 point, therefore the stretch downstream where bodies were registered in the horizontal drag. In the vertical drag the volume of filtered water is far below the horizontal one. So, this result confirms the fact that the bodies are well established in the ES11 station area and in recent process of invasion in the upstream. Except for the Barreiro stream, there was no record of *Limnoperna* adults on small consolidated sediments such as clays and sands on the Paranaíba River and its tributaries. In the Barreiro stream, the densities in this type of substrate were of 50 ind/m². In the upstream ES11 station, a well stablished population of adults was not found. However, from this station (the densities are extremely high (17650 ind/m²), reaching a maximum of 68,245.12 ind/m² in the ES13 station in Porto Alencastro.

Support: UHEs Foz do Rio Claro, Salto do Rio Verdinho, Salto, Caçu and Barra dos Coqueiros, Mais Verde Enviromental Consulting.

NOTES

Environmental Aspects of the Invasion of *L. fortunei* in the Upper Parana River (Minas Gerais, Goiás, Brazil)

Mônica de Cássia Souza Campos

Fundação Centro Tecnológico de Minas Gerais – CETEC

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Limnoperna fortunei (Dunker, 1857), the golden mussel is an invasive species that arrived in the South American continent in the basin of the Prata River, in 1991, (34° 55'S, 57° 49'W) by accidental or deliberate introduction of specimens brought in ballast water. This mussel has widely spread out in only 10 years (Pastorino et al. 1993, Cataldo and Boltovskoy 2000). In Brazil, the first record of its presence was in 1998 in Delta do Jacuí, Porto Alegre (RS) (Mansur 1999).

This work was developed in the upper reaches of the Paraná River, Brazil, formed by the confluence of the Grande and the Paranaíba Rivers between the states of Minas Gerais, Goiás, São Paulo and Mato Grosso do Sul. In 2004, Campos *et al.*, (data is still unpublished) it was reported the presence of adults of the species in the lower Paranaíba River, (MG / MS) (19° 39' 66 " S 01° 55' 08 W). However, since its first record in 2004, the forward speed of the species in this journey of just over 100 km along the Paranaíba river, which runs from Porto Alencastro to immediately downstream of the dam of São Simão, hasn't been longer than 240 km a year according to the indication of the literature.

To characterize the environmental area of occurrence and the dispersion of the mussels in the lower Paranaíba River, including the hydroelectric reservoir of São Simão, twelve sampling campaigns were made from March 2006 to November 2007. Although adult mussels are constantly seen on the hulls of vessels that travel on this stretch of the Paraná-Tietê waterway and which are docked in the harbors of the grain exporters located in São Simão (GO), during this period, there were no larvae or adults on the facilities of the São Simão Hydroelectric Power Station plant.

The concentrations of dissolved oxygen, pH and calcium values between lotic habitats and reservoir are similar: the water is well oxygenated in all environments with values close to 7 mg.L⁻¹ and the pH average is near neutrality. The average values of total Ca are about 4 and 6 mg. L⁻¹. Chlorophyll values are generally low in all environments.

The peaks in larval densities occur between the months of September and January, the warmest period during spring and summer, followed by a decline between May and August. The maximum larval densities are between 1000 and 1500 ind.m⁻³. By analyzing the physical chemical aspects of water as limiting factors to the establishment of the species, there were no expressive fluctuations of the average of the pH values, calcium, dissolved oxygen and water temperature, which could represent a restriction to the species. So, it is believed that the hydrological mechanism, according to the operational system of the São Simão reservoir, could act as a hydraulic control mechanism contributing to the flow of the planktonic larval forms acting as a negative vector for the juveniles settlement and decreasing the recruitment.

NOTES

Ballast Water Treatment Systems; Current Status and Future Perspective

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As of the end of 2009 eight BWT systems have been given IMO Final Approval, six of those also received Type Approval. Remarkably enough there is still some hesitation in installing these Type Approved BWT systems on board of ships despite the fact that they meet the IMO requirements. To some extent this can be due to upcoming national legislation proposing a more strict standard for the maximum allowed organisms in the near future.

In recent years a total of five full-scale BWT systems were tested at NIOZ for land-based approval according to the IMO guidelines, while using the turbid Wadden Sea as the challenging water. These BWT systems included a variety of commonly accepted technologies like chlorine-based, UV and organic acid. During a three months period these systems were extensively tested and, where possible, information was gained from the individual components (plus or minus filtration step). Environmental conditions and test procedures, covering virus till whale, were nearly identical. This allows us to determine the technological possibilities/limitations of current BWT-systems with respect to their efficacy in the elimination of viable organisms but also potential intra-specific differences between the various technologies applied. An overview will be given of the 'benchmark' of these systems (organisms > 50 micron) but also of the smaller planktonic organisms including micro- and nanoplankton and bacteria. Results clearly demonstrated a high degree of similarity between the different technologies, but there were also differences in terms of the duration of the deactivation or decomposition process of the organisms present.

NOTES

Influences on Aquatic Micro-organisms when Qualifying Ballast Water Treatment Systems

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Aquatic organisms in the size class of 10 to 50 micron are an important parameter when qualifying ballast water treatment (BWT) systems. This group, consisting of phytoplankton as well as micro-zooplankton is, together with other organisms, pumped in ballast water tanks of ships. To assure that non-native organisms are discharged into a foreign environment by emptying ballast water tanks, water is filtered (50µm filter) and treated with either UV-radiation or active substances. While the effect of these treatments on the presence and viability for phytoplankton is well addressed the fate of the micro-zooplankton component is far less studied. Experimental tests were performed using different full-scale BWT systems in the NIOZ harbor (NIOZ, Texel, The Netherlands) during spring in order to test the abundance, viability and fate of this plankton group. Sampling was done before pumping, after filtering and after a second treatment in the ballast water tank (using UV radiation or active substances). In addition survival was monitored during the (long)-term storage in holding tanks prior to discharge. Quantitative analysis was done by using microscopy, Flow Cam and flow cytometry. Analysis of the quantitative data showed an effect of the pumping and filtering system. Furthermore time of season and nutritional compounds in the water had an effect. These factors are discussed in further detail and different methods of quantitative measurement of micro-zooplankton are evaluated.

NOTES

Influence of Species Composition and Organism Density of Zooplankton on Land-based Testing of Ballast Water Treatment Systems

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Data from full scale land-based testing were analyzed regarding the influence of species composition and number of organisms present on the performance of 6 different ballast water treatment units. Furthermore data from stand alone tests of filters intended for use with ballast water treatment units were also included in the analysis and compared with the complete systems. Data collected are semi-quantitative in regard to abundances of groups/species. Counts were done down to the lowest taxonomic level practical with the less dense samples. In more dense samples the relative dominances of groups/species in the sample was determined. Results show that species composition does play an crucial role in evaluating a systems performance. Organism density of mesozooplankton is of less importance, when speaking of total numbers. System performance is not significantly influenced by numbers ranging from 10^4 to 4×10^5 per cubic meter. Nevertheless the number of certain indicator organisms becomes very important when testing, e.g. systems without filtration step. Results show that numbers of hard-shelled organisms capable of surviving adverse conditions, like balanid cypris and (older) bivalve larvae should be present at intake in numbers exceeding 10^4 per cubic meter for at least part of the tests.

NOTES

The Role of Microbial Regrowth in the Mineralization of PERACLEAN® Ocean

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PERACLEAN® Ocean is the chemical constituent of the SEDNA® Ballast Water Treatment System (BWTS). The two active substances in PERACLEAN® Ocean, hydrogen peroxide and peroxyacetic acid, create free radicals which pose a severe oxidative and mortal stress on the organisms in the ballast water. Elaborate land-based and shipboard testing have resulted in the approval of PERACLEAN® Ocean for use in BWTS according to the IMO standards and regulations.

However, the effects of PERACLEAN® Ocean on the microbial community in seawater at different temperature conditions has not been adequately investigated. The degradation product of PERACLEAN® Ocean is acetic acid which serves as a carbon source for any microbes that might survive the treatment. Therefore natural seawater was pre-filtered over a 50 µm filter, treated with PERACLEAN® Ocean (150 ppm) and incubated at five different temperatures (25, 15, 10, 4 and -1°C) for several weeks. The phytoplankton and bacterial abundance, Dissolved Organic Carbon (DOC), oxygen and inorganic nutrient concentrations were monitored on a frequent basis.

Phytoplankton cells were effectively eradicated due to the addition of PERACLEAN® Ocean. After a lag phase, which lasted between 8 and 48 days varying with temperature, regrowth of heterotrophic bacteria was observed in all but the -1°C incubation. The bacteria were responsible for the mineralization of acetic acid. The highest growth and mineralization rates were observed at the higher temperatures (10, 15 and 25°C) and mineralization rates showed an inverse relationship with the concentrations of inorganic nutrients and oxygen. Bacterial growth was halted due to the depletion of inorganic nutrient and oxygen sources. During the oxygenated phase the acetic acid (measured as DOC) was partly decomposed. The DOC decrease continued into the subsequent anoxic phase.

Therefore, PERACLEAN® Ocean is a highly effective active substance for eradicating virtually all living organisms but fails to prevent bacterial regrowth on the long-term. The heterotrophic bacteria depleted inorganic nutrient and oxygen sources. Also, the heterotrophic bacteria were an effective way of decomposing a substantial fraction of the acetic acid.

NOTES

Potential Freshwater Fish Invaders to the North American Arctic

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The Arctic freshwater fish fauna of North America is depauperate with ecosystems having relatively few species often with multiple forms filling different niches. Many freshwater species stand poised on the edge of Arctic systems and are likely to invade given relatively small shifts in environment conditions or other changes brought about by human industrialization of the north. We analyze the potential invaders and couple this with laboratory tests of suitability of different taxa to invade. Generalist temperate and sub-Arctic species such as Pearl Dace, (*Margariscus margarita* Cope, 1868), are most likely to be successful while more specialized taxa will likely not invade. The effects on the Arctic fauna may be the loss of ecotypes as they are replaced by superior competitors.

NOTES

Food Web Changes Following Introduction of Nile perch (*Lates niloticus*) into Lake Victoria

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The species-rich fish community of East African Lake Victoria was characterized by a high number of specialist feeders. During the 1980s, the upsurge of introduced Nile perch (*Lates niloticus*) and concomitant environmental perturbations had dramatic consequences. An estimated number of about 200 (out of 500+) species of haplochromine cichlids disappeared from the lake, while many others declined strongly. In accordance with theory, which predicts that generalists survive perturbations better than specialists, wide food spectra are common among the surviving cichlid and non-cichlid species. However, most of the survivors investigated to date used to be specialists, expanding their diet, particularly by including macrobenthos, after the ecological changes. This may be attributed to the observed increase in the abundance of macrobenthos and/or to the decreased total fish biomass, resulting in reduced competition.

In the sublittoral waters of the Mwanza Gulf (Tanzania) more than 110 species of haplochromine cichlids belonging to 12 trophic groups coexisted with various other taxa. They formed a food web that was complex by the large number of trophic links. Shortly after the Nile perch boom, the key taxa in this area were reduced to Nile perch, the cyprinid dagaa (*Rastrineobola argentea*), the cichlid Nile tilapia (*Oreochromis niloticus*) and the characid *Brycinus sadleri*. During the 1990s, over-exploitation of Nile perch resulted in the recovery of about 25 haplochromine cichlid species, mainly zooplanktivores and some detritivores. The zooplanktivores *Haplochromis pyrrhocephalus*, *H. laparogramma* and *H. tanaos* now occur in even higher densities than before the ecological changes. The new food web initially seemed rather simplified, comprising phytoplanktivorous Nile tilapia, herbivorous (with some insect prey) *B. sadleri*, zooplanktivorous dagaa and haplochromines, and piscivorous Nile perch. Only the variable diet of juvenile Nile perch seemed to increase food-web complexity again. However, the other species have all expanded their diet, now including insect larvae and shrimps (*Caridina nilotica*), and some even molluscs and fish. Consequently, the new food web has retained complexity through a high frequency of intraguild predation, making it difficult to predict further developments.

Nile perch introduction has caused a shift from a competition-structured to a predation-structured cichlid fish community. Under the formerly high levels of interspecific competition a clear pattern of size structured predator-prey relationships existed between the main trophic groups in the study area: detritivores, phytoplanktivores, zooplanktivores, insectivores, molluscivores and piscivores. After the ecological changes, the relatively small-sized survivors (mainly the former zooplanktivores) started to include much larger prey into their diet. They now exploit the whole range of prey types formerly taken by the aforementioned different trophic groups. At the interspecific level, size structured predator-prey interactions have virtually disappeared.

NOTES

Status of Two North American *Ameiurus* species (Ictaluridae) in Flanders (Belgium) with Preliminary Genetic Screening of Specimens from Belgium, France and the Netherlands

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Several North-American Ictalurid fish species were introduced in Europe around 1900 for aquaculture purposes but also for stocking in impoverished European rivers. Nowadays, species like *Ameiurus melas* (black bullhead) and *A. nebulosus* (brown bullhead) are still quite common in several European countries. While recent risk assessments (e.g., FISK) classify both bullheads as high risk species of becoming invasive, the scarcity of good quality status reports on the distribution and density of these fishes in European waters is conspicuous. Most literature reports remain vague about their distribution and fail to reproduce a European distribution map. The identification of *Ameiurus* species is difficult and identification criteria often used (colour of the body and serration on the pectoral spine) are unreliable. This has led to considerable confusion about the presence and actual distribution of both *Ameiurus* species in Europe.

According to historical literature both black and brown bullhead were introduced in Belgium (and in Flanders, the northern region of Belgium, more specifically) between 1880 and 1900. However, recent records during fish stock assessments of the Flemish Freshwater Fish Monitoring Network seem to provide only evidence for the occurrence of brown bullhead in Flemish rivers, canals and lakes with the highest densities occurring in the north-eastern part. Contrary to Flanders, recent literature mentions only the presence of *A. melas* in Wallonia (southern region of Belgium) and that while both regions have many river and canal systems in common.

To clear the uncertainty about the identification of *A. melas* and *A. nebulosus* in Flanders we sampled *Ameiurus* fin clips from eight sites in Flanders, and for comparison three in The Netherlands and one in France for genetic study. A 650 basepair fragment of the 5' end of the mitochondrial Cytochrome Oxidase I (COI) gene (bar-coding region) was analysed using universal COI primer cocktails with M13 tails. For species identification, the obtained sequences were compared to published sequences in Genbank.

The results from the genetic analysis confirmed the superficial identification in the field and diagnosed all specimens from Flanders and the Netherlands as brown bullhead while the French fish were clearly black bullheads.

This study wants to contribute to a better understanding of the status of the highly invasive *Ameiurus* species in Europe and elucidate the confusion about the presence of both bullheads in Flanders (Belgium).

NOTES

Invasive Fishes in the Aral Sea Basin, Central Asia

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The ichthyofauna of the Aral Sea basin has changed as a result of human activities. One of the main causes of these changes is the introduction of alien species. The introduction of fishes in Central Asia has been conducted since 1920s when *Acipenser stellatus* was unsuccessfully introduced into the Aral Sea. That attempt led to a population decline of the endemic sturgeon *A. nudipectus* due to the invasion of the gill trematode, *Nitzschia sturionis*. Another vain attempt to introduce in Aral Sea *Mugil auratus* and *M. saliens* has "enriched" ichthyofauna with eight pest species. However, introduction of Chinese carps proved the most harmful to the fish fauna. The introduction was initiated in 1958 when the grass carp *Ctenopharyngodon idella* and the silver carp *Hypophthalmichthys molitrix* were introduced in fish farm in Turkmenistan and then into the Karakum Canal. Nineteen fish species from the Yangtze River were accidentally introduced along with this fish seed and spread throughout the Amu-Darya River basin. In 1960s, work on introduction of Chinese carps was launched in Uzbekistan. About 20 species (most of them pests) were released into fish farms together with these two intentional species from the rivers Yangtze and Amur. Later, they escaped into the wild and spread in the Syr-Darya River basin. The dense network of irrigation canals and a fish seed handling between fish farms helped them to penetrate into other basins. At present, Chinese invasive fishes spread in all water bodies of the Aral Sea basin. Most of alien species are pests but only three of them (black carp, bighead and snakehead) are used by capture fishery. Actually only the snakehead has established a commercial stock which gives 5-10% of the total capture fishery production in Uzbekistan. The other small invasive fishes cause damage to fish farming and displace native species. More than fifteen small local fish species (some of them are endemic) have disappeared from the plains and significantly reduced their number in foothills. In addition, one shrimp species, eight mollusk species, fish parasites and pathogens were introduced as well. Unfortunately, ichthyologists and fishery managers in the Aral Sea basin have not learned a lesson. Even now they work on the introduction of alien species in the region.

NOTES

Population Genetic History of the Dreissenid Mussel Invasion: Expansion Patterns Across North America

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Population genetic patterns are tested across the Eurasian dreissenid mussel invasion of North America – encompassing the zebra mussel *Dreissena polymorpha* (1986 detection) and the quagga mussel *D. rostriformis bugensis* (detected in 1990, which now has largely displaced the former in the Great Lakes). We evaluate their source-spread relationships and invasion genetics using 8-9 nuclear microsatellite loci for 583 zebra (21 sites) and 269 quagga mussels (12 sites) from Eurasian and North American range locations, with the latter including the Great Lakes, Mississippi River basin, Atlantic coastal waterways, Colorado River system, and California reservoirs. Our results indicate that North American zebra mussels originated from multiple non-native northern European populations, whereas North American quagga mussels trace to native estuaries in the Southern Bug and Dnieper Rivers. Invasive populations of both species show considerable genetic diversity and structure. Most newer zebra mussel populations have appreciable genetic diversity, whereas quagga mussel populations from the Colorado River and California show some founder effects. The population genetic composition of both species changed over time at given sites; with some adding alleles from adjacent populations, some losing them, and all retaining closest similarity to their original composition. Zebra mussels from Kansas and California appear genetically similar and assign to a possible origin from the St. Lawrence River, whereas quagga mussels from Nevada and California assign to a possible origin from Lake Ontario. These assignments suggest that overland colonization pathways via recreational boats do not necessarily reflect the most proximate connections. In conclusion, our microsatellite results comprise a valuable baseline for resolving present and future dreissenid mussel invasion pathways.

NOTES

Invasion Paradox: Why *Dreissena rostriformis bugensis*, Being Less Invasive, Outcompete *D. polymorpha*?

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Although *Dreissena polymorpha* and *D. r. bugensis* are closely related, share common morphology and life history, have similar dispersal potential, share a native habitat, and have become important invaders of freshwaters throughout the northern hemisphere, *D. polymorpha* has been a better invader than *D. r. bugensis* both in Europe and North America. However during recent decades, quagga mussels are expanding and often displacing zebra mussels where the two co-occur. To determine which dreissenid species is a better invader, we compared the rates of spread of *D. polymorpha* and *D. r. bugensis* at different spatial scales including regional, local, and waterbody scales. We found that the zebra mussel is a better invader than the quagga mussel at most spatial scales throughout their invasion history. We also found that the time lag between when a species was first detected in a waterbody and reached its maximum population density was much shorter for the zebra mussel (2-4 years) than for the quagga mussel (6-19 years). Although in many waterbodies *D. r. bugensis* has been reported to outcompete *D. polymorpha*, local competition may be much more dependent upon local environmental conditions and will determine which dreissenid species is to become dominant in a given waterbody. Quagga mussels may have an advantage in waterbodies with a large profundal zone, prone to mid-summer hypoxia, or where the bottom is covered with soft substrates. In shallow lakes and rivers, however, zebra mussels are likely to retain an advantage. However, even lakes where quagga mussel dominate among dreissenids (e. g. lakes Erie and Ontario), could act as sources for the zebra mussels invasion. While zebra mussels win the race for invading new waters, quagga mussels, despite their slower rate of spread at decadal time scales, will likely become more important and conspicuous in North America and elsewhere, especially in water bodies with a large profundal zone.

NOTES

Using GARP to Investigate the Present and Future Distribution of Zebra Mussel in Europe

Belinda Gallardo

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Biological invasions coupled with climate change are currently the greatest threat to biodiversity worldwide and to the ecological and economic well-being of society. However, in Europe, for 90% of invasive species almost nothing is known about their distribution and impacts; and there are relatively few studies on freshwater invasive species compared with the extensive documentation of terrestrial species. Among freshwater invasive species, the zebra mussel (*Dreissena polymorpha*) has been identified as one of the world's most economically and ecologically important pests.

In the present study, large-scale data from public databases is used to model the actual distribution of the zebra mussel in Europe, as well as to forecast its spread in a scenario of increased globalization and climate change. To that end, the Genetic Algorithm for Rule-set Prediction (GARP) is used in combination GIS tools to develop distribution models.

The models predict an increase in zebra mussel spread all over Europe as a consequence of climate change, though these initial models may overestimate the spread of the mollusc. Pitfalls for the development of accurate Europe-scale predictions include i) the lack of updated integrated databases on both the presence of invasive species and habitat characteristics and ii) uncertainties related to climate change scenarios and the limited number of variables (mostly climatic) that can be use for modelling.

Despite caveats are in order, GARP has proved to be a useful tool to improve our knowledge on the areas and ecosystems which are at the highest risk of being invaded, which would greatly improve their management.

NOTES

Re-growth of Algae and Bacteria After Treatment with UV- or Chemical-based Ballast Water Treatment Systems

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Invasive species are a large threat to aquatic ecosystems and the introduction of organisms through ballast water is one of the main causes for invasive species introductions. To prevent this, the International Maritime Organisation (IMO) made regulations putting limits on the number of organisms allowed to be present in ballast water. A number of companies designed ballast water treatment systems (BWTS) to treat the ballast water so that it meets the standards set by the IMO. These BWTS use a variety of techniques; UV-radiation, various classes of active substances, ultra-sound, heat and others. As part of the our study to determine the effectiveness of various classes of BWT technologies treated water was incubated for a period of up to 25 days under optimal growth conditions. These incubations were then monitored for re-growth of both phytoplankton and bacteria.

So far three active substance-based and two UV-based BWTS have been tested with this method. All treatments reduced the number of phytoplankton to below detectable levels but re-growth was usually observed. In general, re-growth of both phytoplankton and bacteria occurred faster in UV-treated incubations. However, UV-systems usually treat water at both uptake and discharge. Incubations of uptake water (single UV-treatment) had faster re-growth than incubations of discharge water (two UV-treatments). The discharge treatment removes any re-growth that might have occurred in the ballast water tanks.

The incubations from samples of chemical-based BWTS showed a much longer lag period, and occasionally showed no phytoplankton re-growth at all. If no phytoplankton re-growth occurred we mixed some of the incubation water with natural seawater to see if growth was inhibited due to residual toxic effects. For both types of systems the theoretical minimum of organisms was calculated by determining the intersection between the slope of decline after treatment and the slope of re-growth. This theoretical minimum is an accurate measure of BWTS efficacy, especially if the number of organisms drops below the detection limits of conventional methods.

NOTES

Identification of Potential Invasive Phytoplankton Species in Re-growth Experiments after UV-based Ballast Water Treatment

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Non-indigenous species can get transported by ballast water of ships. Once released at the port of destination, they may become established in the native ecosystem and start to spread. By that, they pose a risk to biodiversity and in some cases also to human health. Different technologies exist to treat the ballast water in accordance with the Ballast Water Convention. To reduce numbers of organisms present in the ballast water, one option is using Ultra-Violet radiation. However, incubation experiments of UV-treated samples show re-growth of selective phytoplankton species. Our hypothesis is that phytoplankton species, which are more resistant to UV-radiation and recover faster, are re-growing and are more likely to become invasive in their new environment. Finding out the difference in functional aspects between the identified species (mainly diatoms), which show re-growth and those which do not, is a valuable approach to identify traits of invasive phytoplankton species. As the control of harmful invasive species is difficult, it is even more crucial to prevent further invasions. For this purpose, the identification of potential invaders and their functional aspects is essential.

NOTES

Quantifying the Likelihood of Invasion by Global Shipping

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The successful prevention of bioinvasion requires detailed knowledge how the global spread of species proceeds. Global shipping represents one of the most important vectors for the spread of invasive species but empirical data of ship movements has rarely been used to predict invasion dynamics.

Combining global ship movement data with biogeography and environmental conditions, we quantify the likelihood of invasion through the exchange of ballast water of large cargo ships. The backbone of the study represents a database of global shipping containing nearly 500.000 ship movements of 16.000 large cargo vessels traveling between 1.000 ports. For each time a ship called a port, a likelihood of invasion is calculated depending on 1) environmental similarity of ports, 2) biogeographical similarity of ports and 3) travel time of ships. Linking these invasion quantities with the network of global shipping, the model identifies high risk invasion routes, hot spots of invasion and major source regions from which invasive species are likely to occur. Model predictions agreed comparably well with observations from various locations in the world. The model allows us to investigate strategies to reduce the likelihood of invasion through global shipping.

NOTES

P r e s e n t e r B i o s k e t c h e s

Ryan Albert

Ryan Albert is an environmental scientist in the Office of Wastewater Management in EPA's Office of Water. He is the technical lead for EPA's NPDES vessels program, which includes EPA's Vessel General Permit or VGP. He is also the lead scientist for EPA's recently conducted study evaluating discharges from smaller vessels and commercial fishing vessels which is scheduled to be finalized in a Report to Congress in summer, 2010. Ryan received his bachelors degree from Emory University in Atlanta, Georgia, and his doctorate from George Mason University in Fairfax, Virginia.

Lars Anderson

Dr. Anderson has 36 years' experience in research on the biology and management of invasive aquatic weeds, including two years with the US Environmental Protection Agency and 34 years with the US Dept. of Agriculture. He is Lead Scientist for the USDA-ARS Exotic and Invasive Weed Research Laboratory in Davis, CA. His research projects include: (1) responses of plant canopy structure to neighboring plants; (2) tidal waters of the Sacramento-San Joaquin Delta, lakes, ponds, (3) development of strategies for management of aquatic weeds in the San Joaquin River; (4) Rapid response/ early detection methods for aquatic invasive species, including marine macroalgae; (5) Explorations in S. America for biological control agents for *Egeria densa* (2005-2008), (6) Lake Tahoe aquatic Invasive weed management strategies. Dr. Anderson received a BA from the University of California, Irvine, Biology in 1967; an MA from San Diego State University, Biology in 1970; and a Ph.D. from the University of California, Santa Barbara, Biology in 1974.

Thomas Armon

Mr. Armon has over 30 years of experience in the water treatment industry. Mr. Armon has spent most of his career with H-O-H Water Technology a, manufacturer, applicator, and vendor of water treatment/management technologies. Mr. Armon has specific application expertise in controlling micro & macro fouling species in open evaporative and once through cooling water systems. In June of 2000, Mr. Armon was tasked with market application of Mexel a unique filming amine developed in France as a corrosion inhibitor and preventive macro-fouling biocide. Mr. Armon travelled to France to understand the products genesis, its niche application, and review successful case histories at a number of facilities including EDF, the French power company.

In 2006 Mr. Armon and his team of H-O-H engineers worked closely with DC Cook Nuclear Plant's Environmental Department to design, install and operate a pilot plant modeling DC Cooks intake water system. This study was operated contiguously for 1 full year to robustly evaluate Mexel's efficacy under natural conditions and lake biota. The results of this study have been used to obtain additional funding for full-scale plant application and environmental permitting.

Mr. Armon has completed undergraduate course work in physical & biological sciences at the University of Illinois Chicago and is an alumnus of Northwestern University's Kellogg School of Management (KMI 2000).

Emily Austin

Since 2009, Emily Austin has served as the Quagga Mussel Coordinator for the National Park Service at Lake Mead National Recreation Area. She earned undergraduate degrees in Biology and Animal Behavior at Towson University, Maryland, and a Master's degree in Conservation Ecology at the University of Pretoria, South Africa. From research and monitoring to public education and decontamination, Emily works with a wide variety of groups affected by invasive mussels. Integrating researchers, law enforcement, educators, boaters, and marina operations, Emily strives to unify these diverse groups to prevent the spread of mussels.

Mindong Bai

Mindong Bai received the B.S., M.S., and Ph.D. degree in Environmental Engineering from Dalian University of Technology, Dalian, Liaoning, P. R. China, in 1988, 1995, and 1998, respectively.

Following graduation, she joined at the Environmental Engineering Institute in Dalian Maritime University as an associate professor, full professor in 1998, 2002, respectively. Currently, she is a Chair Professor of "Cheung Kong Scholar" of Ministry of Education in China, Head of professor, Dalian Maritime University, Director of Key Laboratory of Strong Electric-Field Ionization Discharge of Liaoning Province. Her research interests include the production of scale and high-efficiency hydroxyl radicals using micro-gap discharge and its applications, such

as treatment of ship's ballast water and red tide in ocean, removal of SO₂ and NO_x, and AOT, also the plasma chemistry synthesis as well as ozone generator, ozone mass transfer and so on.

She has been in charged of 10 Key Project of National Basic Research from Ministry of Science and Technology of China and Projects of National Natural Science Foundation of China (NSFC). Until now, she has published more than 100 scientific papers in the world.

Sarah Bailey

Sarah Bailey is a Research Scientist with Fisheries and Oceans Canada, Adjunct Professor at the Great Lakes Institute for Environmental Research, and member of the NSERC Canadian Aquatic Invasive Species Network. She has worked on ship-mediated invasions since 2000, and leads a federal ballast water research and monitoring program in the Central & Arctic region of Canada. Her research interests include quantification of propagule pressure associated with different invasion vectors, development and evaluation of management strategies, and methodologies for ballast water sampling and analysis.

Blaise Barrette

Blaise Barrette is a WEB programmer, advanced diver, cinematographer, naturalist, aquatic ecosystems consultant, reptiles and amphibians specialist. He is a member of the Greenland Shark and Elasmobranch Education and Research Group science committee (GEERG). He has co-founded and developed the "Réseau des observateurs sous-marins" (ROSM), a dynamic web application network of observers posting underwater sightings online. His company - Les Productions un Monde à Part Inc. – is specialized in underwater imagery, scientific consulting, video, DVD and web production. He has recently created the online version of the Diving Almanac & Book of Records.

Chad Boeckman

Chad Boeckman is currently a Ph.D. candidate in the department of Zoology at Oklahoma State University. He began working with zebra mussels as a masters student under the direction of Dr. Joe Bidwell in 2003. To date, most of their zebra mussel research has involved characterizing seasonal population dynamics, growth rates, body condition indices, and glycogen levels in several Oklahoma reservoirs. Jason Goeckler, with the Kansas Department of Wildlife and Parks, and Everett Laney with the U.S. Army Corps of Engineers, are frequent collaborators on these research objectives.

Pieter Boets

After obtaining a degree in Biology, Pieter completed his Master in Environmental Sciences. His interest in exotic species started during his Master thesis. In this thesis the predatory behavior of dominant aquatic invasive species on the macroinvertebrate community of rivers was investigated by means of laboratory experiments. Pieter began working on his PhD in 2008 at Ghent University in the Department of Applied Ecology and Environmental Biology. His PhD deals with the impact of exotic macro-Crustacea on local species assemblages and the spread of these exotic species in inland waters in Flanders (Belgium).

Bill Bolen

Bill Bolen is currently a Senior Advisor with the U.S. Environmental Protection Agency (EPA). Mr. Bolen joined the EPA in 1987 after working in the private sector where he was engaged in petroleum exploration and environmental consulting. Mr. Bolen also provides leadership, advice and consultation on Federal policy and program efforts at all levels of government involving invasive species, in particular issues relating to the spread of invasive species to and from the Great Lakes basin and the Mississippi River basin. He has held a variety of senior management positions within the Agency including Emergency Response Program Manager, Superfund Enforcement Coordinator, and RCRA Corrective Action Program Manager. Currently, he is coordinating; the multi-agency Asian Carp Response Strategy. This \$78.5 million dollar effort is intended to prevent the Asian Carp from establishing a self-sustaining population in Lake Michigan. Mr. Bolen is responsible for the budgeting, planning, tracking, and operational implementation of all aspects of this effort including coordination with the Executive Offices of the Administration, various Federal, State, Tribal, Local, and private sector stakeholders, and Non-Governmental Organizations. He is also considered one of the nation's leading experts on applying Emergency Response protocols and procedures in combating the introduction and spread of invasive species.

Steve Bollens

Steve Bollens currently serves as Professor and Director of the Washington State University (WSU) system-wide School of Earth and Environmental Sciences (SEES), as well as Director of Sciences at WSU's Vancouver campus. He has previously held permanent or visiting faculty positions at the Woods Hole Oceanographic Institution, San Francisco State University, and the University of Washington. His research is broadly concerned with aquatic ecology, including animal behavior, population dynamics, community ecology and ecosystem dynamics. Dr. Bollens' research often has an applied aspect to it, touching upon such areas as invasive species, conservation biology, restoration ecology, fisheries oceanography, and global change.

Nathan Bott

Dr Nathan Bott currently holds the position of MISA Research Scientist, Molecular Diagnostics at SARDI Aquatic Sciences. Since 2000 he has conducted research and consultancy services on a wide range of parasitic and free-living taxa and specialises in the development of molecular diagnostic assays for the surveillance of aquatic pathogens and pests, and livestock parasites. Nathan has published his work in peer-reviewed scientific literature on taxonomy, phylogenetics, life-cycles, molecular biology and diagnostics. Nathan's current research is focussed upon the development of effective molecular diagnostic methods for the detection and surveillance of marine invasive species and aquaculture pathogens.

Kelly Bowen

Kelly Bowen has worked as a biologist at the Great Lakes Laboratory for Fisheries and Aquatic Sciences, Fisheries and Oceans Canada, Burlington, Ontario, for the last nine years. She studies Great Lakes zooplankton and mysid ecology and food web interactions. Her lab monitors invaders such as *Bythotrephes*, *Cercopagis* and *Hemimysis*. Their *Hemimysis* research began in 2007, with work focusing on distribution, habitat associations and the species' role in the nearshore food web. Kelly has a B.Sc. in Biology and a M.Sc. in Environmental Biology, both from the University of Guelph in Ontario, Canada.

Doug Bronicki

Doug Bronicki has been working at the D.C. Cook Nuclear Plant in Bridgman, Michigan for over 27 years. 26.5 of these years were spent within the Radiation Protection Department. He recently accepted a position within the Environmental section where he is becoming familiarized with the zebra mussel monitoring and control program (among other things).

Denise Bunting

Denise gained her B.Sc. (Hons.) in Marine Biology from University of Wales, Bangor in 2007. For her B.Sc. she studied factors affecting the feeding behaviour and foraging strategy of the subtidal burrowing starfish, *Astropecten irregularis*. She is now enrolled in a full time Ph.D. funded by the Northcote Graduate Scholarship which is awarded through The Menzies Centre for Australian Studies, King's College London. The main focus of her research is to determine the effects of different bivalve biogenic habitats on associated exotic species assemblages.

Lyubov Burlakova

Dr. Lyubov Burlakova is a Research Scientist in the Great Lakes Center at Buffalo State College (NY). She received her undergraduate degree in Biophysics and Ph.D. in Hydrobiology from Belarusian State University. Her research interests and areas of expertise include ecology, biology, patterns of spread of aquatic invasive species and their role in freshwater ecosystems, and ecology, diversity and conservation of benthic communities. Her research has been funded by federal and state agencies including US Fish and Wildlife Service, USDA, and EPA. She has published 49 peer-reviewed papers, and made over 50 presentations at scientific meetings.

Mark Burrows

Mark J. Burrows is a Physical Scientist at the International Joint Commission's Great Lakes Regional Office in Windsor, Ontario. He represents the IJC on the Great Lakes ANS panel, the Fish Dispersal Barrier Panel and is Project Coordinator for the IJC's binational AIS rapid response work group. His perspective on rapid response

comes from more than twenty years of U.S. Coast Guard experience with marine safety, environmental protection and spill response. He holds an MSE in Naval Architecture and Marine Engineering from the University of Michigan and a BS in Marine Science from the United States Coast Guard Academy.

Dan Butts

Mr. Butts is currently Manager of Biofouling Services at ASI Group Ltd. (ASI), which specializes in engineering, ecological and marine services for industries and municipalities worldwide. His experience in the ecological industry spans over 18 years and includes development of zebra mussel control protocols and installations, biofouling turnkey treatment systems, fire protection system control, client relations, and contract administration.

Joe Caffrey

Dr. Caffrey is a Senior Research Officer with the Central Fisheries Board. He has conducted applied research with the Board for more than 30 years and specialises in the areas of Aquatic Plant and Invasive Species Management, and Recreational Fisheries Development.

Aquatic invasive non-native species are currently threatening important habitats in Ireland. Dr Caffrey is heading up research in this area on behalf of the Irish Fisheries Boards. Dr Caffrey was recently awarded a European Life+ grant worth €1.5 million to conduct research into the 'Control of Aquatic Invasive Species and Habitat Restoration in Lough Corrib and in the Grand and Barrow Canals'. This project will run from 2009 to 2013.

Dr. Caffrey has considerable experience in the area of aquatic ecology and has written numerous scientific and peer reviewed papers on this and related themes He is the primary editor of, and a contributor to, three books dealing with Aquatic Plant Biology, Ecology and Management, published in 1966, 1999 and 2006.

Marnie Campbell

Associate Professor Marnie Campbell is the Head of the Department of Conservation and Ecology at the National Centre for Marine Conservation and Resource Sustainability at the Australian Maritime College, an institute of the University of Tasmania. Her research interests focus on elucidating human mediated impacts on biodiversity in the marine environment and developing remediation and management options. Her career has maintained a balance between active science research and the interface with management/policy. She has 15 years experience in introduced marine species, having worked in more than 14 countries as a biosecurity (introduced marine species) researcher with agencies such as CSIRO-CRIMP, the United Nations IMO GloBallast Programme, Biosecurity New Zealand, and the University of Tasmania.

Mônica de Cássia Souza Campos

Mônica de Cássia Souza Campos holds a M.Sc. in Sanitary Engineering, and graduate in Biological Sciences from the Federal University of Minas Gerais (UFMG). Currently she is completing her PhD at Universidade Federal de Ouro Preto. She has worked at the Fundação Centro Tecnológico de Minas Gerais (CETEC) since 1985 and is responsible for the Macroinvertebrates laboratory. She is also consultant in Limnology with emphasis on macroinvertebrates ecology. Her research lines include ecology and control of *Limnoperna fortunei* and bioindication of water quality.

W. Lindsay Chadderton

Lindsay has worked as the Aquatic Invasive Species Director for The Nature Conservancy's Great Lakes Project since January 2007. He joined the conservancy from New Zealand where he worked for 16 years for the Department of Conservation a federal government agency (USFWS, USFS, National Park Service equivalent), the last seven years spent leading their freshwater science program. He has experience in the management of invasive species in terrestrial, marine and freshwater ecosystems having managed or advised on rat eradication programs in New Zealand, Falkland Islands and Fiji, established an incursion response and eradication program for an introduced marine algae (*Undaria pinnatifida*), and was a technical advisor on national and regional rapid response programs for common carp, mosquito fish, rudd and European gudgeon, and an introduced diatom (*Didymosphenia geminata*). Lindsay is based at the University of Notre Dame and was part of the four person team that developed the environmental DNA surveillance methods being used to track the invasion Asian carp in Chicago waterways.

Samuel Chan

Sam Chan is an Assistant Professor in the Fisheries and Wildlife Dept at Oregon State University. He is the statewide watershed health and invasive species specialist with the OSU Sea Grant Extension Program and the Assistant Program Leader for Sea Grant Extension. Sam is the Chair of the legislatively established Oregon Invasive Species Council which is leading an evaluation based statewide invasive species campaign. Sam's research and education programs have recently focused on the connections between schools, science curricula and biological science suppliers as potential pathways for aquatic invasive species. In addition Sam is collaborating with social scientists to understand barriers that prevent stakeholders from taking action to prevent the spread of invasive species and ways to overcome these barriers. Sam's international activities include projects on *Spartina* invasion in the estuaries of Fujian Province, China. Prior to joining the University, Sam served as a research plant physiologist with the USDA Forest Service where he studied the structure, function, microclimate and management of riparian areas, tested methods to restore degraded riparian areas and conducted physiological studies on the impacts of elevated CO₂ and drought on riparian forests in the Pacific NW.

Duane Chapman

Duane Chapman is a research fisheries biologist with the U.S. Geological Survey, Columbia Environmental Research Center. His first contact with Asian carps was in aquaculture while an undergraduate summer helper for the Iowa Conservation Commission in 1978. His first scientific journal publication was on grass carp in 1987 while working on his M.S. at the University of Wyoming. Duane then took a 14-year detour into limnology and aquatic and marine toxicology. He has been working almost exclusively with invasive species, especially Asian carps, since 2002.

Michelle Chapman

Michelle Chapman is a research physical scientist with the Bureau of Reclamation, Technical Service Center, Water Treatment Engineering Research Team. She has a BS in Physical Geography from University of Oregon and MS in Technology and Human Affairs from Washington University. Since joining the Bureau of Reclamation she has specialized in development and evaluation of advanced water treatment processes.

Eglantine Chappuis

Eglantine (Tina) Chappuis is an aquatic plant ecologist interested in the use of aquatic macrophytes and their communities as bioindicators, conservation problems and the introduction of invasive species. Since 2005 Ms. Chappuis has researched submersed aquatic vegetation in a variety of ecosystems including high mountain lakes, coastal lagoons, temporary ponds, karstic lakes, reservoirs and wetlands. She is currently a PhD student at the University of Barcelona and at The Spanish National Research Council (CSIC). She is working on the interactions between plants and the environment (water column, sediment and watershed), species changes through time, richness patterns and conservation threats.

Patrice Charlebois

Patrice Charlebois has been an Aquatic Invasive Species Specialist with Illinois-Indiana Sea Grant and the Illinois Natural History Survey since 1996. In that capacity, she has developed a comprehensive outreach program focused on the pathways/vectors through which aquatic species invade including recreational water users, water gardeners, and classroom use of live specimens. Pat earned her undergraduate and graduate degrees from the University of Notre Dame and is currently housed at the Chicago Botanic Garden.

Renata Claudi

Renata Claudi is a biologist with over 30 years of diverse business and technical experience. At this time she is the Chief Scientists of RNT Consulting Inc. This Environmental Consulting firm focuses on the various aspects of alien species invasions, including their economic impact, risk of introductions, selection of appropriate control options and their installation.

Ms. Claudi received her BSc and MSc degrees in Marine Biology from McGill University, Montreal, Quebec. From 1989 – 2000 she worked for a major Canadian Electrical Utility. There she was responsible for the assessment of the impact of zebra mussels on operating stations, development of mitigation plans, interaction with other utilities

and industries, organization of major scientific meetings. She was also one of the chief organizer of numerous International Conferences on Aquatic Nuisance Species.

Ms. Claudi co-authored and edited a number of different publications. The latest, *Monitoring and Control of Macrofouling Mollusks in Fresh Water Systems* was published by CRC Press in 2009.

Gordon Copp

Prof. Gordon Copp is a Canadian currently based in England. Following a BSc in Biology/Environmental Studies (Trent University, Peterborough, Ontario), Gordon undertook post-graduate training in environmental sciences (IHE, Delft, Netherlands), a PhD in fish biology (Université de Lyon, France), post-doctoral research (Fishmongers' Company fellowship) for the Freshwater Biological Association (FBA, Cumbria, UK) and subsequently was awarded a 'Habilitation à diriger la recherche' (HdR) in ichthyology (Université de Toulouse, France). Gordon's past research experience includes doctoral studies of larval and juvenile fish biology in large river flood plains (Lyon, France), post-doctoral studies of 0+ fish recruitment in the River Great Ouse (FBA, England), nine years on the faculty of the University of Hertfordshire (England) where he was a Reader in Ichthyology. Gordon is currently a Principal Scientist in Fish Biology at Cefas (Lowestoft, UK) and Visiting Professor at Bournemouth University (Bournemouth, UK), carrying out research for, and providing advice to, the UK Department of Environment, Food & Rural Affairs. Gordon's current research focuses on the risks and impacts of non-native freshwater fishes, including the development of risk analysis protocols, within a climate change context. His research in conservation biology encompasses threatened native freshwater fishes, river rehabilitation, and interactions between fish and Eurasian otters.

David Copplestone

David has worked with the Ontario Federation of Anglers and Hunters' Invading Species Awareness Program for the past three years as the aquatic invasive species outreach liaison. Previously he worked for the O.F.A.H. on the Community Stream Steward Program, and the Atlantic Salmon Restoration Program. Prior to working for the O.F.A.H. David worked for the Ontario Ministry of Natural Resources, and private consulting companies.

Timothy Counihan

Tim has been a Research Biologist with the USFWS and USGS at the Western Fisheries Research Center, Columbia River Research Laboratory since 1993. He now coordinates invasive species studies for the Columbia River Research Laboratory.

Helen Cribb

Helen is an aquatic scientist and joined Northern Territory Fisheries (Australia) in 2002. As manager of the Aquatic Biosecurity section, Helen is responsible for key environmental surveillance, vector management and emergency response programmes, and applying these to meet the unique challenges experienced in the Territory. Helen also represents the Northern Territory on committees developing consistent national approaches to marine and freshwater pest management.

Jeffrey Cross

Jeffrey Cross is Chief of the Ocean and Coastal Resources Branch in the Natural Resource Program Center of the National Park Service. The Branch provides technical assistance and leadership in natural resource programs to 80 ocean and coastal parks across 26 states and territories. Cross has served in various resource management positions in NPS for 10 years. Prior to that, he was the director of NOAA Fisheries' James J. Howard Marine Sciences Laboratory in New Jersey and director of Southern California Coastal Water Research Project. He has a Ph.D. in marine fisheries from the University of Washington.

Becky Cudmore

Becky Cudmore is the senior science advisor for aquatic invasive species for Fisheries and Oceans Canada. She has been worked on binational issues regarding aquatic invasive species for the Canadian federal government since 2004. She is also the manager of the department's Centre of Expertise for Aquatic Risk Assessment, which assesses ecological risk of potential aquatic invasive species to Canadian and international waters. She has degrees in

Environmental Science/Biology (Trent University, Peterborough) and a masters in Zoology (University of Toronto). She has written more than 50 publications and reports on a variety of issues involving the biodiversity of freshwater fishes, and is an active member in the aquatic invasive species community in both the United States and Canada.

Carolynn Culver

Dr. Carolynn Culver is a marine scientist whose work focuses on aquatic invasive species (AIS), marine fisheries and mariculture. Currently a California Sea Grant Marine Advisor, her projects include research, education and outreach that assist with the management of AIS. Recently, she helped develop a training program for early detection of quagga and zebra mussels. She is also working on practical means for reducing the spread of invasive species via boat hulls. Carrie played a major role in successful eradication of a marine pest, and remains engaged in work that helps minimize the impacts of AIS.

Ronan Cusack

Ronan Cusack joined the Western Regional Fisheries Board in August 2006 having had a long association with game angling in the west of Ireland. He was based initially on Lough Corrib, Co. Galway, Ireland, for a six month period and now works on Lough Mask, Co. Mayo, Ireland. The fisheries board is divided into two sections; protection (law enforcement) and development (water quality and habitat) of the waterways of Ireland, Ronan works in the development area. He has recently completed a Diploma Course in Fisheries Management at the Institute of Technology, Sligo, Ireland under the tutorage of Dr. Frances Lucy, and in part fulfilment of the course undertook a study into the effects of an invasive species, Roach, on the flesh colour of the indigenous trout population on Lough Mask.

Alisha Dahlstrom

Alisha Dahlstrom is a PhD student at the University of Tasmania's National Centre for Marine Conservation and Resource Sustainability (NCMCRS). She joined the NCMCRS after two years of working on the UC-Sea Grant Extension West Coast Ballast Outreach Project. She is currently focusing on risk and impact assessment for aquatic nonindigenous species, to inform aquatic biosecurity decisions. Particularly, in the face of uncertainty, how to make management decisions that sufficiently protect the variety of values at risk from introductions but also meet requirements under the World Trade Organizations Sanitary and Phytosanitary Agreement (e.g., a science-based risk assessment).

John Darling

John Darling is a Research Biologist in the Molecular Ecology Research Branch of the US Environmental Protection Agency. He is interested primarily in the utilization of genetic data to inform ecological risk assessments, with particular emphasis on aquatic biological invasions.

His research has adopted methods in population genetics and phylogeography to reconstruct invasion histories and to infer demographic patterns associated with introduction and expansion of non-native populations.

Ricardo De Leon

Dr. De Leon is the Laboratory Manager for the Microbiology Unit of the Water Quality Laboratory of Metropolitan Water District of Southern California (Metropolitan) and the Quagga Mussel Control Program Manager. As part of his duties as program manager, he developed Metropolitan's Rapid Response Plan for addressing the discovery of quagga mussels in the Lower Colorado River. The intake to Metropolitan's Colorado River Aqueduct (CRA) is located at Lake Havasu and Metropolitan's Quagga Mussel Control Program (QMCP) which is based on Integrated Pest Management (IPM). Dr. De Leon also prepared Metropolitan's Plan for AB 1683 compliance as incorporated into Fish and Game Code 2301. This was the first plan approved by the Department of Fish and Game to address the spread of Dreissenid mussels. He is a member of the California Invasive Species Advisory Committee (CISAC).

Marty Deveney

Marty is Subprogram Leader, Marine Biosecurity at the South Australian Research and Development Institute (SARDI). His current research focuses on the environmental effects of invasive species including the alga *Caulerpa taxifolia*, treatment technologies for marine pests and ballast and developing technologies for pest detection.

Marty provides advice on adapting research outcomes to policy, including in the development and testing of the Australian Marine Pest Monitoring Manual, AQUAPLAN, its aquatic animal health policy, and AQUAVETPLAN, its response plan for aquatic animal health emergencies.

Chris Dionigi

Chris Dionigi has served as the Assistant Director for Domestic Policy for National Invasive Species Council (NISC) since 2000. His work covers the full range of topics addressed by NISC with a particular emphasis on the early detection rapid response and the control of widespread invasive species. Prior to joining NISC, he was a USDA legislative fellow on the U.S. Senate Committee for Agriculture where he worked on Clean Water Act and invasive species issues. Before joining NISC, Chris was a Research Plant Physiologist for the U.S. Department of Agriculture's Agricultural Research Service (ARS) where he led an aquaculture/aquatics research program and authored over 20 peer-reviewed scientific manuscripts. He holds a Ph.D. in Crop Science (emphasis in Weed Science), and Masters and Bachelor of Arts degrees in Biology. Chris is a third generation native of Colorado.

Joseph DiVittorio

Joe is the Bureau of Reclamation Invasive Species Program Coordinator. He holds a Master of Science degree in Plant and Soil Science, and is a Certified Professional Agronomist. Joe is a member on several national teams: Western Regional Panel on Aquatic Nuisance Species; Quagga-Zebra Mussel Action Plan steering committee; Technical Advisory Group for the Biological Control of Weeds; and the Federal Interagency Committee for the Management of Noxious and Exotic Weeds. Coauthored with the Army Corps of Engineers, Joe recently completed an Equipment Inspection and Cleaning Manual. Joe is a graduate of the U.S. Navy's Leadership Development Initiative and is a co-recipient of the Albert Gore Vice President's Hammer Award.

Marcia Divina de Oliveira

Since 1995, Dr. Divina de Oliveira has worked at the Brazilian Center of Agricultural Research, located in the Pantanal wetland (South America). Her interest is in wetland aquatic ecology. Over the last 8 years she has dedicated some time to understanding the development of the exotic species golden mussel at extreme environmental conditions in the Pantanal, and forecasted its expansion in the Paraguay basin and Brazilian waters. Her presentation at the Conference will be related to oxygen depletion events controlling golden mussel.

Nicole Dobroski

Nicole Dobroski has been a Staff Environmental Scientist with the California State Lands Commission's Marine Invasive Species Program since 2006. Previously, Nicole worked for the California Sea Grant Extension Program's West Coast Ballast Outreach Project. She has over 10 years of experience working on the science and management of nonindigenous species. Her graduate research focused on the distribution, physiology and behavior of invasive crab species along the New England coast. Nicole received a B.A. in Biology from Pomona College and a M.S. in Biological Sciences from the University of Rhode Island.

Lisa Drake

Lisa Drake is a marine scientist who has conducted research on organisms in ships' ballast water, sediments, and biofilms for more than ten years. Her current position is located at the U.S. Naval Research Laboratory in Key West, Florida as a Senior Scientist with the company SAIC. She is the lead biologist in a group of scientists, engineers, and a statistician developing procedures and methods used in testing ballast water management systems. Specifically, the biology group is developing robust, automated methods to determine protist and zooplankton viability.

Erik Edwards

Dr. Erik Edwards joined Battelle in September 2007 and has extensive experience in the development and implementation of novel polymeric materials for a broad range device oriented applications. As a doctoral student at the University of Wisconsin-Madison he developed processes and materials for implementing self-assembling nanoscale materials as novel materials for use in lithographic device fabrication processes. After his doctoral work he spent 18 months at the Max Planck Institute for Colloids and Interfaces designing and synthesizing polymeric coatings for metallic nanoparticles and quantum dots. These biofunctionalized nanoparticles and quantum dots

were designed to be used as imaging agents for in-vivo biological applications. Since coming to Battelle he has been involved in multiple projects that focus on the implementation and design of nanoscale materials in government and consumer applications including as refractive index modifiers for optical applications, fillers for conductive composites, as electrodes in photovoltaic devices, as printed electronics. His recent research projects have focused on designing more robust polymeric materials for in-vivo biological analyte detection, and the develop new coatings to mitigate biofouling in a broad range of environments.

Susan Ellis

Susan Ellis is an Environmental Program Manager for the Invasive Species and Rare Plant Protection Programs at the California Department of Fish & Game. She has worked for more than 25 years for the Department of Fish and Game on program and policy issues, including, most recently, nine years on invasive species. She served as Incident Commander for the Quagga Mussel Incident and chairs the quagga mussel interagency team. Her program is responsible for providing staff support to the California Invasive Species Council and Advisory Committee and is the primary implementing agency for the California Aquatic Invasive Species Plan.

Richard Everett

Rich Everett coordinates the USCG's research activities on the prevention of biological invasions via the operations of ships, provides technical assistance in developing regulations, and is technical advisor on the U.S. delegation to the International Maritime Organization. He holds a BA in Biology from the University of California, Santa Cruz, and a Ph. D. in Zoology from the University of California, Berkeley. Prior to his current position, he was a Senior Staff Biologist with the U. S. Fish and Wildlife Service and held post-doctoral positions at the Smithsonian Environmental Research Center and the Oregon Institute of Marine Biology.

Maurya B Falkner

Maurya Falkner has managed California's Marine Invasive Species Program since its inception in 1999. She and her staff have developed and implemented laws and regulations regarding the prevention of biological invasions via the operation of commercial vessels in California waters. She coordinates research funding and activities addressing ballast water treatment compliance verification methods, ballast water exchange verification, hull fouling, and shipboard treatment technologies. She provides technical and policy development assistance to other state, regional, national and international organizations developing ballast water and hull management control programs. She is a member of the Pacific Ballast Water Group, Oregon's Ballast Water Task Force, and the North Sea Ballast Water Opportunity Project. She holds a BS in Zoology and a MS in Ecology from Colorado State University. Prior to her current position, she was Program Manager for the Central Grasslands Global Change Project, Ecosystems Studies Group, with Colorado State University's Natural Resource Ecology Laboratory.

Linda Fernandez

Linda Fernandez is Associate Professor of environmental and resource economics at University of California, Riverside. Her research explores public and private economics incentives for pollution control and natural resource protection on local and international scales. Environmental protection along international borders is one focus of her research addressing transboundary water and air resources pollution prevention. The economics of invasive species control in the marine environment as well as in agriculturally traded commodities worldwide is another focus. Additionally, Fernandez has conducted economic analyses of energy resources, such as offshore oil platform decommissioning, and various gasoline blends that have both led to the state of California and EPA making decisions about banning gasoline additives.

Frank Fuhr

Frank Fuhr received his masters degree in biology at the University of Kiel in 2000. He works as a freelance, biological consultant since 2001 and has been conducting numerous tests on ballast water treatment systems since 2003. He is currently affiliated to the Royal Netherlands Institute for Sea Research (NIOZ) as a PhD-student. He is part of the research team conducting full scale type approval tests at the NIOZ since 2007. The focus of his work on ballast water is on meso-zooplankton.

Michael Gabaldon

Mr. Gabaldon is the Director of Technical Resources for the Bureau of Reclamation. The position, located in Denver, Colorado, oversees Reclamation's Technical Service Center; the Research and Development Office; the Power Resources Office; and the Design, Estimating, and Construction Office. He began his career with Reclamation in 1982 as a Construction Engineer at the Montrose Projects Office in Colorado. He has served in several key positions including Liaison Officer, in Washington, D.C., Area Manager in Albuquerque, New Mexico, and Director of Policy and Management in Washington, D.C.

Mr. Gabaldon's years of experience on key Reclamation projects and his in-depth knowledge of Reclamation's programs and policies have allowed him to serve as a highly visible member of Reclamation's leadership. He is well-versed in construction, technical, administrative, operational, Congressional, and policy issues. A native of New Mexico, Mr. Gabaldon earned a Bachelor of Science degree in Civil Engineering from the University of New Mexico. He also holds a degree in Water Technology/Utilities from New Mexico State University. Mr. Gabaldon is a registered Professional Engineer.

Belinda Gallardo

Dr. Belinda Gallardo was previously a pre-doctoral researcher in aquatic ecology and ecosystem restoration at Pyrenean Institute of Ecology (Spain). Currently she is a postdoctoral researcher in invasive species at Cambridge University (UK) granted with a Marie Curie fellowship for the project "Freshwater Invasive species: control, prevention and eradication". This project integrates statistical modelling, ecological niche modelling, distribution maps and bioassays in order to: (i) identify multiple factors that affect the occurrence of freshwater invasive species, (ii) understand the current distribution of invasive species and forecast shifts in geographical range due to global changes, and (iii) evaluate environmental friendly methods to mitigate biofouling.

James Garvey

Jim Garvey is an aquatic ecologist interested in studying interactions between fishes and their environment in lakes and rivers. He received his PhD in Zoology at The Ohio State University in 1997, served as an Assistant Professor at Kansas State University during 1998-2000, joined the faculty of SIUC in 2000, and has served as Director of the Fisheries and Illinois Aquaculture Center since 2009. Garvey teaches undergraduate courses regularly in the Department of Zoology and has advised 20 Zoology MS- and PhD-level graduate students. Garvey also advises many undergraduate students and is passionate about giving these students diverse research experiences. Garvey garners funding from many federal and state agencies, has published > 60 peer-reviewed publications and book chapters, and serves on many national panels and committees, including those associated with the National Science Foundation, professional organizations such as the American Fisheries Society (membership of 9,000), and government agencies. Garvey is also involved in many local, state, and regional issues of science and policy. He recently served as president of the Illinois state chapter of the American Fisheries Society. Garvey has been conducting research on Asian carp population dynamics in the Mississippi River for the past 10 years; he and his students have published several peer-reviewed articles on the subject.

Holly Gellerman

Holly Gellerman is a Staff Environmental Scientist with California Department of Fish and Game's (CDFG) Invasive Species Program. Holly currently works to prevent and reduce invasive species throughout California with a focus on the San Francisco Bay-Delta ecosystem. Prior to CDFG, Holly worked on several seabird and island conservation projects including eradication of an invasive grass from Laysan Island, Hawaii, and eradication of black rats from Anacapa Island of the California Channel Islands. Holly received her B.A. in Natural History from Prescott College, Arizona and her M.S. in Biological Sciences from Cal Poly at San Luis Obispo, California.

Jocelyn Gerlofsma

Jocelyn Gerlofsma has been with Fisheries and Oceans Canada as a biologist and technician since 1999 after receiving her MSc from the University of Windsor. Currently her work has been supporting Fisheries and Oceans Canada's ballast water monitoring program under the supervision of Dr. Sarah Bailey. Over the last two years Jocelyn has participated in conducting biological sampling of ballast tanks and researching new technologies, like the FlowCAM® and high resolution Laser Optical Plankton Counter for ballast water monitoring.

Sara Ghabooli

Sara Ghabooli received her B.Sc. in Marine Biology from the University of Shahid Beheshti, Tehran, Iran. She finished her M.Sc. in Marine Biology at the University of Tarbiat Modarres, Tehran, Iran. She is currently working towards her PhD in Environmental Science at the Great Lakes Institute for Environmental Research, part of the University of Windsor under the supervision of Dr. Hugh MacIsaac. Her research focuses on revealing genetic pathway of aquatic invasions.

Adriaan Gittenberger

As a multidisciplinary sea researcher, Adriaan Gittenberger has worked for the National Museum of Natural History Naturalis (The Netherlands), the Muséum National d'Histoire Naturelle (France), the Smithsonian (USA), National Geographic (USA), and several Dutch Ministries. Since 1998 he has been the coordinator of a marine monitoring project with a few hundred volunteer scuba-divers. In 2006, he started an ongoing marine monitoring project focusing on fouling species involving volunteers and professionals in Europe, the USA and New Zealand. At present he is a guest researcher at the Natural History Naturalis, the Institute of Biology and the Institute of Environmental Sciences of Leiden University, The Netherlands. He is director of the company GiMaRIS (founded in 2006) focusing on marine research, inventory and strategy solutions. Species inventories and risk analyses of marine invasive species in temperate northern Atlantic waters have been his main line of business.

Michael Goehle

Mike Goehle has worked for the U.S. Fish & Wildlife Service since 2002. He serves as the Northeast Regional AIS Coordinator, stationed at the Lower Great Lakes Fish and Wildlife Conservation Office. For the past seven years, Mike has led several AIS projects, including the New York State Canal Prevention program. Working with partners like New York Sea Grant, the New York State Canal Corps, and the New York State Department of Environmental Conservation, Mike has led and coordinated early detection surveys, prevention and control activities, and education and outreach events related to the New York State Canal.

Sharyn Goldstien

Sharyn uses a multi-disciplinary approach to marine ecology and evolution including: bioinvasions, dispersal and population connectivity, evolutionary determinants of ecological interactions, ecosystem processes and conservation. Most recently, Sharyn has been studying the pre- and post-border spread of marine invasive species in New Zealand and assessing their ability to adapt to novel environments.

Stephan Gollasch

Dr. Gollasch was involved in the first European sampling programme on ballast water, tank sediments and ship hull fouling (1992-1996). His PhD is worldwide the first thesis based on ballast water sampling. He sampled ballast water of more than 200 vessels. As an independent consultant he is today involved in biological invasions research and was also contributing to the development of ballast water management scenarios for European seas. Since 1994 he is with the German Delegation at IMO/MEPC. Ongoing contracts also include onboard efficacy tests of ballast water treatment systems according to IMO guidelines.

Sonia Gorgula

Sonia Gorgula has been employed in the Invasive Marine Species Program of the Department of Agriculture Fisheries & Forestry since 2006. The main focus of her work in the Invasive Marine Species Program has been on the development and implementation of policies to manage marine pest risks as biofouling on both internationally arriving vessels and on vessels travelling domestically within Australian waters. During that time she has worked closely with a range of maritime industries, scientific consultants and other government agencies in developing policies and providing technical advice on a range of biofouling issues. She has tertiary training in marine biology and ecology, and her honours year specifically focussed on quantifying anthropogenic impacts on reef systems in southern Australia. Sonia is currently a senior policy officer within the Invasive Marine Species Program at DAFF.

Jonathan Grant

Jonathan F. Grant is responsible for development of test methods and protocols for the testing of ballast water management systems (BWMS) at the US Naval Research Laboratory. He has been involved with NRL's Ballast Water Treatment Test Facility (BWTF) facility since its inception in 2003, where he was responsible for design and implementation of the instrumentation, system control and data acquisition facilities, and served as Test Director during the first full scale Pilot Test to the ETV draft protocol. Mr. Grant is a member of the team responsible for revising the ETV Draft Protocol, and is supporting development and validation of new methods and equipment for full scale BWMS testing. Mr. Grant is Vice President of Battenkill Technologies, Inc., a small business that provides scientific, engineering and software R&D services and products to the US Government and their contractors.

Albert L. Graves, P.E.

Mr. Graves has worked in the water resources field for 36 years. He has enjoyed a wide variety of engineering experiences on five continents, working on water resources management, water systems operation and maintenance, dam safety, and infrastructure inspection. As the Senior Maintenance Engineer for the Central Arizona Project, Mr. Graves was tasked to lead the Project's efforts related to Quagga Mussels.

Phyllis Green

Phyllis Green has a leadership role for the National Park Service in finding tools to stop the spread of Aquatic Invasive Species. She successfully implemented interim treatment of ballast on a NPS ballasted ship in under two weeks and has since worked with researchers to design emergency delivery systems for treatment on any ship. Green is a line manager with over 19 years experience with for federal natural resource agencies and has extensive background in emergency response. She is working to develop a strategy for protecting the Great Lakes and nationally by building emergency response capacity and creating tools for treatment.

Sherril Green

Sherril L. Green, DVM, PhD, is a professor in the Department of Comparative Medicine at Stanford University School of Medicine. She obtained her doctorate degree in neurobiology at the University of California-Davis and has a long established interest in the biology and diseases of *Xenopus laevis*, the African Clawed Frog. Dr. Green has authored numerous papers on *Xenopus*, a much studied laboratory animal model. Her current research focuses on investigating naturally occurring diseases in feral populations of *Xenopus* and establishing normal hematological reference ranges in wild and captive populations. Dr. Green can be reached at Sherril@Stanford.edu or via <http://www.laboratoryxenopus.com/>.

Ned Gruenhagen

Ned Gruenhagen is a wildlife biologist with the Bureau of Reclamation, South-Central California Area Office, in Fresno, California. He received BS and MS degrees in Wildlife from the University of California-Davis, and University of Missouri, respectively, and earned a Ph.D. in Entomology from the University of California-Riverside. His major responsibility at the Bureau of Reclamation is to ensure that projects are in compliance with environmental regulations. He has worked on a variety of pest related problems affecting facility operations and maintenance, and is a representative on the Mid-Pacific Region Mussel Task Force.

Julio Harvey

J. B. J. Harvey (www.mbari.org/staff/jharvey) is a molecular ecologist and evolutionary biologist currently designing molecular probes capable of detecting a variety of marine invertebrate larvae, copepods and other zooplankton from environmental seawater samples in addition to conducting his ongoing research exploring the evolution and population genetics of various deep-sea invertebrates with R. C. Vrijenhoek (www.mbari.org/staff/vrijen) at the Monterey Bay Aquarium Research Institute (MBARI). Design of molecular target detection technologies is linked to the development of robotic in situ sampling platforms including the Environmental Sample Processor (www.mbari.org/esp) developed by C. A. Scholin et al. (www.mbari.org/staff/scholin) and the Autonomous Underwater Vehicle (www.mbari.org/auv).

Mark Heilman

Dr. Mark Heilman is Aquatic Technology Leader for SePRO Corporation and has a leadership role in SePRO's effort to develop and market new technologies for the management of aquatic nuisance species with a focus on control of invasive aquatic vegetation. He has his Ph.D. in Aquatic Ecology from the University of Notre Dame and 20 years of experience in the assessment of invasive species infestations and the experimental study and operational use of chemical and biological control technology for aquatic resource management.

Paul Heimowitz

Paul Heimowitz is the aquatic invasive species coordinator for the U.S. Fish and Wildlife Service's Pacific Region, which includes Oregon, Washington, Idaho, and Hawaii. In that role, he helps develop regional and national policies and programs to enhance prevention, early detection, and control of biological invasions in freshwater and marine habitats.

Daniela Henkel

Daniela Henkel completed her diploma thesis in Biology at the University of Rostock, Germany dealing with the effects of bivalves on nearby biogeochemistry. Currently she is in the final stages of her PhD candidature at the Research Institute Senckenberg, Germany under the supervision of PD Dr. D. Janussen. Her research focuses on the diversity, distribution and chemical ecology of the sponge fauna in the shallow waters of the NE Yellow Sea, China. Her principal research interests deal with general aspects of biodiversity and ecosystem functioning. Furthermore, she is interested in taxonomy, systematics, biogeography and ecology of bryozoans and corals.

Penny Herring

Penny Herring has worked on ballast water issues since 2000 and has headed the Aquatic Nuisance Species program at the U.S. Coast Guard Research and Development Center since 2002. Other Coast Guard research efforts include determining leeway drift, fielding Self-Locating Datum Marker (SLDMB) buoys, and working on technologies to sense and recover heavy oil. She spent 14 years conducting numerous mapping surveys worldwide at the U.S. Navy's Naval Oceanographic Office. Her background is in math, physics, and marine ecology.

Chad Hewitt

Professor Chad Hewitt is a global expert in the ecology and management of introduced marine species with more than 25 years experience. Chad has been the lead Research Scientist in Invasion Processes at the Centre for Research on Introduced Marine Pests with CSIRO in Australia, leading the understanding of invasion drivers and the development of risk based management tools. He then became Chief Technical Officer – Marine Biosecurity for the New Zealand Government, a statutory role with regulatory and funding responsibilities leading the development of the marine system. In 2003, Chad moved back to academia to develop the National Centre for Marine Conservation and Resource Sustainability. There he has worked on the scale and scope of marine invasions including the development of risk tools for the USA, Australia, and a number of developing economies such as the Galapagos and Micronesia.

Jae-Sang Hong

Jae-Sang Hong is a Professor of Marine Ecology in the Department of Ocean Sciences at Inha University, Incheon, South Korea. His research specialty is in the field of benthos community ecology, especially that of tidal flats which are well developed in the Yellow Sea, West coast of Korea. However, recently he became interested in the marine biodiversity in Korean waters and biological invasions as well.

Terrance Hubert

Dr. Terrance (Terry) Hubert is a 1980 graduate of Ripon College and received a doctorate in organic chemistry from the University of Iowa in 1985. He worked as a research scientist and team leader in the Agrochemicals Division of Hazleton Laboratories America, Inc. (now Covance Inc.) from 1986 to 1992. At Hazleton his primary responsibility was to conduct plant metabolism studies to support the registration of agricultural pesticides with the U.S. Environmental Protection Agency (EPA). He joined the U.S. Geological Survey, Upper Midwest Environmental Sciences Center in La Crosse, Wisconsin in late 1992. His initial focus was to lead the effort to reregister the

lampricides TFM and niclosamide with EPA. Dr. Hubert is currently team leader for the Center's Aquatic Invasive Species Team. His responsibilities include technical support of the Great Lakes Fishery Commission Sea Lamprey Management Program and directing research on the control and management of aquatic invasive species. He is co-lead of the Center's research program to investigate methods of control of Asian carps and zebra mussels, funded through the EPA Great Lakes Restoration Initiative.

Tea Huotari

Tea Huotari is a PhD student at the University of Helsinki in the Department of Agricultural Sciences. She began her PhD in 2007 and she is working in a research group studying plant population biology and population genetics. Tea is studying population genetics of an invasive water weed *Elodea canadensis* and she is especially interested in the evolutionary consequences of invasion to population structure of aquatic plants.

Jeff Janik

Jeff is a Limnologist with California Department of Water Resources and received his Ph.D. degree from the University of California, Davis and B.S. from the University of Connecticut. He currently directs DWR's Aquatic Nuisance Species Program, working on a wide and diverse range of subjects including nuisance algae, aquatic weeds, water quality, and most recently, quagga and zebra mussel management and control in the State Water Project.

Douglas Jensen

Doug Jensen joined the University of Minnesota Sea Grant Program in 1993. As AIS program coordinator, he specializes in strategic outreach and evaluation aimed at preventing the spread of AIS through behavior intervention. Jensen co-leads *Habitattitude*TM, a national campaign aimed to prevent the release of aquarium fish and plants. In collaboration with partners, he is also leads implementation of *Stop Aquatic Hitchhikers!*TM, another campaign aimed at preventing AIS spread. He is current chair of the I&E Committee of the Great Lakes Panel on ANS. He earned an MS in Education and a BS in Biology from the University of Minnesota-Duluth.

Leigh Johnson

Leigh Johnson is an Advisor with University of California Cooperative Extension in San Diego. She conducts applied research and education on environmental issues affecting marinas and recreational boating. She has conducted programs on boat pollution prevention and alternatives to copper antifouling paints. Recent research with economists and invasive species experts addressed cost- and environmentally effective means for boaters to protect water quality while preventing invasive species transport on boat hulls. Her website at <http://ucanr.org/coast> has publications and a video-documentary on pollution prevention, alternative anti-fouling strategies and preventing invasive species transport on boats. Some publications are available in English and Spanish.

Lisa Jones

Lisa Jones is a PhD student in the Department of Biology at McGill University (Montreal, Canada) under the supervision of Dr. Anthony Ricciardi. Her doctoral research explores the value of a trait-based approach in explaining and predicting the outcome of exotic species interactions and their impact, with a particular focus on invasive species in aquatic systems such as the St. Lawrence River and the Great Lakes. Her research involves both field experiments and using meta-analytical techniques to examine patterns in species replacement and impact.

Alexander Karatayev

Dr. Alexander Karatayev is a Director of the Great Lake Center and Professor of Biology at Buffalo State College (NY). He received his undergraduate degree, Ph.D., and Doctor of Science degrees in Hydrobiology from Belarusian State University. His research interests include ecology, biology, patterns of spread of exotic species and their role in aquatic ecosystems, and biodiversity, conservation and management of freshwater ecosystems. He has published 110 papers, and made 97 presentations at scientific meetings. His research has been funded by numerous federal and state agencies including US Fish and Wildlife Service, USDA, and US National Geographic Society.

Ernest Khurshut

Ernest Khurshut is a Senior Research Scientist (ichthyologist) at the Laboratory of Ichthyology and Hydrobiology, Institute of Zoology, Uzbek Academy of Sciences. He completed his PhD thesis in 2006, which focused on the study of ecological traits and morphological variability of *Hemiculter leucisculus*, an alien invasive fish species unintentionally introduced in the Aral Sea 1960s. His MSc thesis was completed in 1992 on using computers in ichthyology, specifically growth and reproduction of *Rutilus rutilus*, *Abramis brama* and *Schizothorax intermedius* were studied. A computer program for statistical analysis was developed. His research interests include: ecology and morphology of Cyprinids; invasive Species; population dynamics and fish stock assessment and population genetics. Personal website: <http://uznix.narod.ru> (Fishes of Uzbekistan).

Vladimír Kováč

Vladimír Kováč is a Professor at Comenius University (Department of Ecology), Bratislava, Slovakia. His research activities are related to ecomorphology, ontogeny, ecology and evolution of freshwater fishes; and have focused on biological invasions over the last ten years. His current studies are devoted to alternative ontogenies and phenotype plasticity in invasive fishes. Vladimír is a team leader in several national and/or international research projects and he has written more than 50 scientific papers related to the above topics published in European and/or North American peer-reviewed journals. He is a member of the Fishery Society of British Isles (currently a council member), and member of the Slovak Ichthyological Society.

Everett Laney

Everett, M.S., is a Biologist with the U.S. Army Corps of Engineers at the Tulsa District, Environmental Analysis & Compliance Branch. He has been with the Corps of Engineers 31 years; 12 as a Park Ranger, 12 as the Operations District Wildlife Biologist, and 7 as an Environmental Biologist. He has dealt with Zebra Mussels since they were discovered in Oklahoma in 1993, serving as the Tulsa District Invasive Species Subject Matter Expert and the Southwest Division Invasive Species Subject Matter Expert. Everett is a member of the Corps National Invasive Species Leadership Team that provides oversight of the Corps Invasive Species Program.

Elizabeth LaPlante

Elizabeth LaPlante is the Lake Superior Regional Team Manager with the United States Environmental Protection Agency, Great Lakes National Program Office. Elizabeth is the U.S. coordinator for the Lake Superior Lakewide Management Plan, or LaMP, and is also the US Co-Chair of the Binational Lake Superior Work Group. She is responsible for implementing and supporting binational actions to protect and restore Lake Superior, including actions to control the introduction of aquatic invasive species. Elizabeth holds a BA from U of Illinois, Champaign, and a Masters from Harvard University.

Edward Lemieux

Ted Lemieux is currently the Director of the Center for Corrosion Science & Engineering of the US Navy's Naval Research Laboratory in Washington, DC. Mr. Lemieux currently leads a diverse research portfolio annually in marine corrosion and coatings, cathodic protection, environmental effects on materials, fouling control, condition based maintenance and material science in general. Mr. Lemieux is the principal investigator for two current ONR Future Naval Capabilities efforts including EPE-08-09 Maintenance Reduction Technologies and EPE-10-03 Corrosion and Corrosion Related Signature Technologies. Mr. Lemieux is also an Engineering Agent and Manager for Corrosion Control and Cathodic Protection for the Naval Sea Systems Command, respectively. He currently supports NAVSEA OSP2 as the technical lead for corrosion control R&D for the OHIO REPLACEMENT Program. With respect to ballast water S&T, Ted is the principal investigator for an ongoing S&T sponsored by the USCG to develop test facilities and methods for standardized testing of ballast water treatment systems. Ted currently supports the US delegation to the IMO's Marine Environmental Protection Committee and is a former member of the GESAMP Ballast Water Working Group for the review of Active Substances.

Rob Leuven

Dr. Rob S.E.W. Leuven (1957) studied aquatic ecology. His PhD-thesis concerned the impacts of acidification on aquatic ecosystems. He is appointed as associate professor at the Department of Environmental Science, Institute for Water and Wetland Research, Radboud University Nijmegen (The Netherlands). By a Royal decree, he is also assigned as member of the Dutch Commission for Environmental Impact Assessment. His recent research focuses on effects of aquatic invasions on biodiversity and functioning of riverine ecosystems. Special attention is paid to ecological risk assessment of exotic species, physiological tolerances and biological traits of invasive species and effects of climate change on species redistribution. Rob Leuven was project leader of several large research projects commissioned by the World Bank, European Commission, the Netherlands Organization for Scientific Research and several Dutch governmental and non-governmental organizations.

Viola Liebich

Viola Liebich received her Diploma in biology from the University of Berlin. She did part of her studies at the Alfred Wegener Institute under the supervision of Karsten Reise working on invasive tunicates. Today, she holds a scholarship at the International Max Planck Research School for Maritime Affairs and is working at the NIOZ on her PhD project focusing on invasive plankton species. Her presentation will give an overview about the identified phytoplankton species, which survived ballast water treatment and showed re-growth in incubation experiments.

Carolyn Link

After receiving a bachelor's of science degree in environmental chemistry from Northern Arizona University with research in benthic ecology along the Colorado River, Carolyn worked in Las Vegas in aquatic animal husbandry and life support for 5 years. She recently completed a Masters Degree in Water Resources Management from the University of Nevada, Las Vegas with a thesis focusing on quagga mussel ecology. Currently Carolyn is a Field Research Scientist for Marrone Bio Innovations, where she works on development of Zequanox, an invasive mussel biopesticide.

Edward Little

Edward Little received his BA from Hiram College and his Ph.D. from Stony Brook University where he studied pheromone communication in crayfish. He continued his interest the chemical senses of fish during a post doc at Florida State University. He is presently serves as Chief of the Ecology Branch at the USGS Columbia Environmental Research Center in Columbia, Missouri where he has conducted 31 years of research on the environmental impact of chemical, physical, and biotic perturbations on aquatic organisms. An emphasis of the research has been on species at risk (amphibians, sturgeon) as well as invasive species, and has included examination of multiple stressors on chemical contaminant impacts. He has studied potential pheromone repellants and lures for the control of Asian carp.

Frances E. Lucy

Dr. Frances E. Lucy is a lecturer at the Institute of Technology, Sligo in Ireland, where she teaches ecology, fisheries management, conservation and water pollution. Actively involved in zebra mussel research, she is fortunate to work with a range of international scientists, many of whom she met at this ICAIS conference series.

Francine MacDonald

Francine MacDonald has coordinated the Invading Species Awareness Program for Ontario for eight years; a successful partnership initiative of the Ontario Federation of Anglers and Hunters and the Ontario Ministry of Natural Resources, along with numerous other federal and regional governments, industry and non-governmental organizations. Through this successful program, Francine has led or contributed to the development of a variety of initiatives directed at the major pathways for invasive species introduction. She is a member at large of the U.S Great Lakes Panel on Aquatic Nuisance Species and a founding member of the Ontario Invasive Plant Council's Advisory Board.

She is a graduate of Trent University's Biology program and Niagara College's Environmental Management Program. Prior to working with the OFAH, Francine worked with Ducks Unlimited and with several conservation authorities in Ontario.

Hugh MacIsaac

Hugh MacIsaac is a professor and Fisheries and Oceans' Aquatic Invasive Species Research Chair at the Great Lakes Institute for Environmental Research. He is also Director of the Canadian Aquatic Invasive Species, a consortium of >30 professors from across Canada. His interests are vector and pathways for invasions by non-indigenous species into freshwater and estuarine ecosystems. He has been working on invasive species in the Great Lakes since shortly after zebra mussels were first reported in North America. Hugh completed his undergraduate work at University of Windsor, his MSc at University of Toronto, and his Ph.D. at Dartmouth College. He will speak on the importance of a collaborative, preventative approach involving university, government and industry sectors to effectively address species invasions of aquatic ecosystems.

Susan Mangin

Susan Mangin is a fish and wildlife biologist who has worked for the U.S. Fish and Wildlife Service (Service) for almost 20 years. Her first job with the Service was as the National Fish Health Coordinator, which gave her an opportunity to work closely with the Service's fish health center and hatchery staffs. Additionally, she has worked on injurious wildlife, Sikes Act, RAMSAR, recreational fishing, fisheries management, and native mussel issues. She also served as the Coastal Program Coordinator. One of her most rewarding positions was working in the Service's aquatic nuisance species program where she helped develop the 100th Meridian Initiative. She is serving currently as the Executive Secretary of the Aquatic Nuisance Species Task Force, which is composed of 13 Federal and 12 non-Federal members. She received a BS in biology from George Mason University and an MPA of public administration from American University.

Ather Masoodi

Ather is currently working on his PhD thesis, carrying out ecological studies on some alien invasive weeds in Wular Lake of Kashmir. Alien Invasive weeds are a great threat to the ecological security and the livelihood of thousands of people inhabiting the lake. Unfortunately, Wular Lake has been altogether neglected and no monitoring of the flora has been undertaken so far. In the last 6 years, *Alternanthera philoxeroides* is the second notorious invasive species to invade the Wular Lake after *Azolla*. Ather is currently undergoing training to start the biological control programme for these species with the collaboration of CABI and CEH Wallingford.

Denise Mayer

Denise Mayer studied microbiology and aquatic ecology at the universities of Wisconsin-Superior and Minnesota-Duluth and is the senior research scientist at the New York State Museum's Field Research Laboratory in Cambridge, NY. Since the discovery of *Pseudomonas fluorescens* 15 years ago, she and Daniel Molloy have worked to develop it into a safe and effective dreissenid control agent. Having earned ABD status at the University at Albany (State University of New York), Denise plans to complete her doctoral dissertation on the effectiveness, ecotoxicology and potential applications of *P. fluorescens* for dreissenid control later this year.

Tom McMahon

Tom McMahon is currently the Invasive Species Program Coordinator in the Habitat Branch of the Arizona Game and Fish Department. Over the course of the past 23 years, Tom has worn many hats within Arizona Game and Fish. He has been a fisheries assistant, habitat specialist, fisheries specialist, Sport Fish and Wildlife Restoration Program public information officer, and Range Manager for the Ben Avery Clay Target Center. Tom has also thrived within the Department as a Team leader/facilitator, 4-wheel drive instructor, event coordinator, and is currently the Department's facilitator and liaison to the Governor's Arizona Invasive Species Advisory Council.

Tom has also had the great fortune of representing the Department within the leadership of the American Fisheries Society (AFS). He was the Arizona/New Mexico Chapter President in 1997, General Chair for both the AFS 2001 Annual Meeting in Phoenix and the AFS Western Division's 2003 Annual Meeting in San Diego, and the AFS Western Division's President in 2003/2004. He also served on the AFS Governing Board from 1999 thru 2005.

Thomas McNabb

Thomas J. McNabb, President, Aquatic Pest Control Advisor, Clean Lakes, Inc.: McNabb has been involved in the development and implementation of aquatic vegetation management programs in thirteen countries (13) since 1974. Mr. McNabb served as Program Director under a Cooperative Agreement with the United States Agency for International Development's (USAID) Regional Lake Victoria Water Hyacinth Control Program, East Africa (1996-2002) that encompassed various objectives that included the development of a Cooperative Research and Development Agreement (CRADA) with the United States Department of Interior, USGS for the Monitoring of East African Aquatic Ecosystems. McNabb holds a California Pest Control Advisors License.

Roberto Mendoza

Roberto Mendoza is a marine biologist with over 25 years experience in the field of aquaculture, physiology of aquatic organisms and aquatic invasive species. Within his activity as a researcher at the Universidad Autónoma de Nuevo León he has been enthusiastically collaborating with the Mexican Commission for the Knowledge and Use of Biodiversity (CONABIO) and the Ministry of Environment (SEMARNAT) in the field of exotic invasive species in Mexico. For several years he has been the Mexican representative in the Gulf of Mexico and South Atlantic Panel of the US ANSTF. In a joint effort with members of the GMSARP and the WRP he organized the first bi-national (USA-Mexico) meeting on Raising awareness on the aquatic invasive species in Mexico. Together with members of the US Fish & Wildlife Service he organized the first workshop on the use of the HACCP planning tool to prevent unintended spread of invasive species. He has been working within the invasive species group of the North American Commission for Environmental Cooperation (CEC) in the development of risk analysis for potentially invasive aquatic species. With the participation of several organizations (CONABIO, CEC, NOAA, OSPESCA, INAPESCA) he has been training ornamental fish producers, importers, academics and government officers from Mexico and Central America on the use of HACCP and Risk Analysis tools for avoiding the introduction and spread of invasive species. He is a member of the advisory committee for the Mexican National Strategy to prevent, control and eradicate invasive species in Mexico.

Michael Millane

Michael Millane is a Research Officer with the Irish Central Fisheries Board (CFB) working on the CAISIE (Control of Aquatic Invasive Species in Ireland) project. He holds a M.Appl.Sc. in Environmental Science and a Ph.D in Zoology from University College Dublin. He has previously worked as a Fishery Assistant with the CFB and as a Fishery Officer at the Eastern Regional Fisheries Board as well as in private ecological consultancy. The CAISIE project is funded by the European Union Life+ Biodiversity project, with co-financing from the National Parks and Wildlife Service.

David Miller

Dr. Miller is a Research Scientist with the U.S. Environmental Protection Agency, Mid-Continent Ecology Division. His areas of expertise include application of mathematics and computer simulation to model dynamic systems in the biological sciences including the projection of population trends, modeling of habitat suitability, and investigation of complex systems of interactions between groups of species. He received his Ph.D. from The School of Natural Resources and Environment at the University of Michigan in 2002.

Meg Modley

Meg has worked for the Lake Champlain Basin Program for 7 years. As Aquatic Invasive Species Management Coordinator, she has been involved in facilitating AIS management in NY, VT and QC with local, state, and federal partners. Meg is the current freshwater co-chair of the Northeast Aquatic Nuisance Species Panel and sits on the National ANS Task Force. She has been involved in developing the Lake Champlain Basin AIS Rapid Response Action Plan, transport laws for NY and VT, and partnerships to address AIS in the Champlain Canal and Chambly Canals. During the summer field season she may occasionally be found underwater assisting research and management programs in hand harvesting aquatic invasive plants.

Brian Moore

Lieutenant Commander Brian Moore is the program manager for the US Coast Guard Shipboard Technology Evaluation Program (STEP). His previous duty assignments have been as a CG Marine Inspector and Casualty Investigator working in the Gulf of Mexico region. Prior to joining the US Coast Guard he was a US Army National Guard helicopter mechanic/co-pilot, chemistry teacher as well as an environmental response/hazardous materials handling technician. He has masters degrees in Environmental Science from the Johns Hopkins University and in Quality Systems from the National Graduate School.

Douglas Mountfort

Doug Mountfort currently leads the Cawthron component of the New Zealand Government's long term Output Based Investment (OBI) programme "Effective Management of marine Biodiversity and Biosecurity" seeking to develop molecular tools for the detection of marine pests in surveillance and compliance monitoring. Doug also manages a number of projects aimed at developing biosensors for the detection of marine biotoxins with the goal of ensuring safety of aquacultural produce. Recently he has been involved in some new projects using high tech solutions to prevent fouling of aquaculture structures.

Philip B. Moy

Dr. Phil Moy has been the Fisheries and Nonindigenous Species Specialist for the University of Wisconsin Sea Grant Institute Since 1999. Based in the Manitowoc field office, he works with Great Lakes commercial, sport and charter anglers as well as inland lake groups to address fisheries and aquatic invasive species concerns and to provide research information to Great lakes user groups. Phil holds a doctorate in zoology from Southern Illinois University at Carbondale. He is currently vice-chair of the Great Lakes Aquatic Nuisance Species Panel and in addition to several Great Lakes Sea Grant Network awards he received the Great Lakes Fishery Commission Jack Christie/Ken Loftus Award for Distinguished Contributions to Healthy Great Lakes Ecosystems. Before coming to Wisconsin, Phil was the Fisheries Biologist for the Chicago District Army Corps of Engineers and remains involved with the Chicago dispersal barrier project as Co-Chair of the Dispersal Barrier Advisory Panel.

Nicole Murphy

Nicole Murphy is a project manager at the civil engineering firm, Kennedy/Jenks Consultants. She is a registered professional engineer in California and Arizona, and graduated from University of California at Davis with a Bachelor of Science and Master of Science in Civil Engineering.

During her fourteen years in consulting, Nicole has been primarily focused on project management, design and construction support services of water and wastewater treatment plant and pipeline projects. The project areas include pipe, pumps, wells, basins & ponds, clarifiers, chlorination/dechlorination facilities and odor control systems. Nicole also prepares risk management plans that address emergency response and offsite consequence analysis for federal and state regulated substances, i.e., gaseous chlorine and 19% aqueous ammonia.

Nicole recently served as design engineer on the Rancho California Water District (RCWD) Vail Lake Transmission Main & Pump Station project, which will pump 80 cfs surplus Metropolitan Water District of Southern California (MWD) raw water via a 48-inch CML&C steel pipeline to nearby Vail Lake. She is currently managing the RCWD Vail Lake Quagga Mussel Screen Filtration Pilot Study to determine the effectiveness of screen filters to provide 100% prevention of quagga mussel organisms, since quagga mussels are present in MWD raw water and Vail Lake is currently uninfested.

Peter Neimanis

Peter has worked for the Australian Quarantine and Inspection Service (AQIS) for 13 years with the last ten in the Seaports Program. The Seaports Program conducts quarantine clearances and surveillance of international vessels, associated crew, passengers and baggage at Australian ports to monitor, assess and manage biosecurity risks associated with vessels, passengers and crew to reduce the risk to Australia's animal, plant, marine and human health status.

Peter is directly involved in the day to day support and continual improvement of the Australian Ballast Water Management Requirements and the underpinning operational procedures - providing training, decision support and operational advice to inspecting AQIS Officers in the role of National Ballast Water Advisor. Peter previously fulfilled

the role of Ballast Water Decision Support System (BWDSS) Administrator for five years. The BWDSS was a risk assessment tool that formed part of the current Australian mandatory ballast water management requirements.

Peter has also contributed to the development of the Australian Biofouling Management Requirements since July 2005. In particular, Peter has contributed to operational elements of the requirements, training for AQIS officers, legislative amendments, consultation with affected industry parties and wider communication strategy issues.

Bruce Nelson

Mr. Nelson specializes in developing systems that incorporate advanced algorithms that perform functions that are normally executed by human operators. He is supporting the Naval Research Laboratory on the development of systems for the automated inspection of ballast tanks and topside coatings and for the real-time monitoring of surface profiles. He has worked on the development of automated methods for the enumeration and classification of zooplankton and phytoplankton in complex ballast water samples. Mr. Nelson is the President of Battenkill Technologies Inc. Prior to founding Battenkill, Mr. Nelson was a Principal Scientist and Manager at GEO-CENTERS, INC. for 21 years.

Andrea Novomeská

Andrea is a PhD student at Comenius University in Bratislava, Slovakia. Her PhD program is devoted to the study of morphological variability and life-history traits in various non-native European populations of black bullhead (*Ameiurus melas*). Based on the results, the invasive potential of this species is being evaluated. She has presented her results at various international conferences (Croatia, Portugal, Czech Republic, Slovakia), and published a paper in the Journal of Applied Ichthyology. Further papers are in the process of preparation. Currently she is at a 5-months scholarship stay at the University of Perugia, Italy. She is a member of the Slovak Ichthyological Society.

David G. Oliver

David G. Oliver has over 27 years' experience applying information technology to solve problems for scientists in conservation biology, invasive species, fish genetics, fisheries management, and environmental protection. He has international experience in Romania, México, and the USA.

After 13 years focused on fisheries with the Ontario Ministry of Natural Resources (Ontario, Canada), David left the public sector to join Geomatics International Inc., a firm that specialized in geographic information systems (GIS) in Burlington, Ontario, where he stayed until the company went bankrupt 3 years later – not! his! fault!

Following the crash of 'Geomatics', David founded Skylark Information Systems Ltd., to make his GIS, database, and information management experience available to scientific clients. At age 11, 'Skylark' has now out-endured 'Geomatics'...

David has volunteered for 12 years as an advocate for bicycling and pedestrian safety with the Burlington Road Safety Committee, a local NGO in Burlington, Ontario, Canada.

He holds 2 university degrees in biological science: a Bachelor of Science from McGill University (Montréal, Québec, Canada), and a Master's of Science from the University of Toronto (Toronto, Ontario, Canada). To relax, he walks dogs, rides bicycles, and plays the violin – though not all at the same time...

Yves Paradis

Yves Paradis is a biologist for the Québec Department of natural resources (Canada). He is in charge of the ichthyological survey network an extensive sampling program that covers freshwater habitats of the St-Lawrence River. He is interested on the impact of exotic species on native fish, fisheries management, food web structure and fluvial ecology.

Kent Peterson

Kent Peterson serves as CEO of Fluid Imaging Technologies, Inc, an emerging growth technology firm providing image-based analysis of cells and particles in a fluid medium for numerous applications and geographic markets.

Mr. Peterson has been named MaineBiz leader of the year in the small business category, and Fluid Imaging won the U.S. S.B.A. New England Exporter of the year award, as well as, the Maine International Trade Center's Exporter of the Year. Prior to FIT, he served in a number of high-growth, high technology firms, as well as multinational organizations. He serves on a number of Boards and is active in community affairs. He is credited with a number of technical publications and speaking engagements. Mr. Peterson is an honors graduate from Boston University's Graduate School of Management, and a member of American Mensa Society.

Stephen Phillips

Stephen Phillips is a senior program manager at the Pacific States Marine Fisheries Commission (located in Portland Oregon) where he has worked for over 18 years. For the last 10 years his main responsibility has been management of PSMFC's Aquatic Nuisance Species Project. Prior to the ANS project, Mr. Phillips worked as a habitat biologist for the PSMFC. Mr. Phillips received his Bachelor's in Biology from Baldwin Wallace College (Berea, Ohio) in 1979 and a Master's of Fisheries Science from Oregon State University in 1987.

Cristina Preda

Cristina is a research assistant and second year PhD student in Biology at the Faculty of Natural and Agricultural Sciences, Ovidius University in Constanța, Romania. Her research is focused on the inventory of alien invertebrate species and monitoring of high risk areas for alien species introduction from south-eastern Romania. She is part of the research teams of two projects focused on invasive species: MODSIS (Monitoring and Detection System for Invasive Species) and DNA – BRIS (DNA bar coding technique applied in the study of alien and/or invasive species in Romania). She has already published 2 papers and has 2 papers submitted.

Carmen Primo

Carmen Primo is a postdoctoral fellow at the National Centre for Marine Conservation and Resource Sustainability (Australian Maritime College, University of Tasmania). For the last two years she has been studying the reproductive phenology of the invasive kelp *Undaria pinnatifida* in Port Phillip Bay, demonstrating the potential of this kelp to spread in Australian continental coasts. Her research also includes a study on transfer of spores via wetsuit material and how to mitigate this transfer. Previous research involved identification of introduced ascidian species, and biogeography and taxonomy of ascidians in the cold regions of the Southern Hemisphere.

Robert J. Quint

Robert Quint is Director, Operations for the Bureau of Reclamation. Reclamation is the largest wholesale water supplier in the United States, and the nation's second largest producer of hydroelectric power. Its facilities also provide substantial flood control, recreation, and fish and wildlife benefits. In his position, Mr. Quint is responsible for providing direction, management and coordination among regional and area offices and addressing the resolution of major operational issues.

Mr. Quint began his career with Reclamation as a civil engineer in 1978 where he worked in Denver, Colo., and Boulder City, Nev., Mr. Quint came to Washington, D.C. in 1996, where he has served as a Regional Liaison Officer and Reclamation's Chief of Staff. Mr. Quint also spent a year in Iraq in 2005 as Senior Consultant to the Iraqi Ministry of Water Resources and the Ministry of Municipalities and Public Works. Mr. Quint is a 1978 graduate of Iowa State University with a Bachelor of Science in Civil Engineering. He is a registered Professional Engineer in Colorado.

Sanjeevi Rajagopal

Sanjeevi Rajagopal was an undergraduate in Zoology at the American College (Madurai, India). He did his Masters in Zoology at The Pachaiyappas College (Chennai, India) and M.Phil. in Zoology at Madras Christian College (Chennai, India). He earned a PhD degree from University of Madras in 1991. For his PhD degree, he worked on biofouling problems in cooling conduits of the Madras Atomic Power Station at Kalpakkam. Subsequently, he obtained a D.Sc. degree from University of Nijmegen, Netherlands in February 1997. In April 1991, he became Assistant Professor at the Department of Zoology, Thiagarajar College (Madurai Kamaraj University, India). He joined the Department of Animal Ecology and Ecophysiology, Radboud University Nijmegen, Netherlands in June 1994.

He is presently analyzing genetic diversity of European (Baltic, Atlantic and Mediterranean coasts) populations of *Mytilus* spp. and invasive routes including dispersal pathways of *Dreissena polymorpha* as determined by PCR-based AFLP fingerprinting. He is also studying the population structure of commercially important fish fauna in mangrove ecosystems, especially with reference to their recruitment patterns and trophic relationships in the Caribbean Sea and the Godavari estuary on the east coast of India. He is also involved in the development of novel (carbon dioxide based), environmentally sound (heat treatment), chemical (chlorination) and non-chemical (biological control) technologies for the control of macrofouling in raw water systems.

He is an Advisory Member of Grupo Ecologista, University of Misiones, Argentina and a Member of numerous societies, including the Marine Biological Association of the United Kingdom and The British Ecological Society, England. He has published more than 100 scientific papers in International journals and has edited two books.

David Reid

David Reid received a Ph.D. in oceanography from Texas A&M University and was a research scientist at NOAA's Great Lakes Environmental Research Laboratory until retiring in March 2010. He worked on characterization and prevention of the invasive species vector risk from residual ballast water in collaboration with scientists at University of Michigan, University of Windsor, and the Smithsonian Environmental Research Center. Most recently he's been investigating the efficacy of salt brine as a biocide in ballast tanks. He served on the ICAIS Technical Program Committee from 2002 through 2010 and was co-chair of the 16th ICAIS in 2009.

Kevin J. Reynolds

Kevin Reynolds is a Senior Associate at The Glosten Associates, Inc., with a B.S. in Marine Engineering Systems and 17 years of marine engineering and design experience. A graduate of the U.S. Merchant Marine Academy, he holds an Unlimited Chief Engineer merchant mariner license for operating ships, has hands-on shipyard experience as a new construction project engineer, and is professionally licensed as a naval architect/marine engineer in the State of Washington.

Reynolds leads Glosten's marine environmental engineering efforts with a focus on a holistic approach that considers water effluent, air emissions, and energy efficiency. These efforts have led to the development of a hydrocarbon vapor recovery system, application of advanced wastewater treatment systems, and the integration of control technology for reduction of the overall energy use and air emissions of marine vessel propulsion and auxiliary plants.

Since 2001, Reynolds has performed significant work in the pursuit of solutions for off-loading ballast water in accordance with sound environmental practice. This work has resulted in a broad range of experience that ranges from advising science teams and regulatory agencies to performing design and engineering for treatment system suppliers and ship owners. He has performed due-diligence reviews of treatment systems during acquisition processes, led the design of a treatment system prototype installation, and led the design of the Maritime Environmental Resource Center and *T.S. Golden Bear* ballast test facilities. He led the development of an automated compliance, monitoring, and advisory ballast management program for shipboard use under U.S. Coast Guard and NOAA guidance.

Reynolds serves the broader maritime community by participating in various work groups, projects, and panels studying ballast water issues. These groups include: *Washington State* Governor's Ballast Water Work Group; *California State Lands Commission* Ballast Technology Assessment Panel; *International Maritime Organization* – International Workshop on Compliance Monitoring and Enforcement for Ballast Water Management; *Naval Research Laboratory* – Testing and Evaluating Ballast Water Treatment Technologies; *National Science Foundation* – Engineering Controls for Ballast Water Discharge, and the U.S. EPA Science Advisory Board.

Anthony Ricciardi

Dr. Anthony Ricciardi is an associate professor of biology at McGill University (Montreal, Canada), where he holds a Québec Strategic Professorship and teaches courses in freshwater ecology, animal diversity and biological invasions. His research examines the ecological impacts of nonindigenous aquatic invertebrates and fishes. He is an associate editor for the journal *Biological Invasions* and the journal *Diversity and Distributions*. He serves on the scientific committee of the Canadian Aquatic Invasive Species Network – a national research group that assesses the risks and mechanisms of invasion in Canada's lakes, rivers and coastal waters.

Larry Robinson

Dr. Larry Robinson is Assistant Secretary of Commerce for Oceans and Atmosphere. He is the former Vice President for Research and professor in the Environmental Sciences Institute at Florida A&M University (FAMU). Since 2001 he has served as Director of the National Oceanic and Atmospheric Administration's Environmental Cooperative Science Center housed at FAMU. He earned a Ph.D. degree in nuclear chemistry from Washington University in St. Louis in 1984. Robinson served as a graduate research fellow at Los Alamos National Laboratory in 1983. From 1997 to 2003 Robinson was the director of FAMU's Environmental Sciences Institute where he led efforts to establish B.S. and Ph.D. degree programs in 1998 and 1999, respectively. He was selected to serve as FAMU's Provost and Vice President for Academic Affairs in 2003 before returning to the faculty ranks in 2005. In 2007 Robinson was called upon by the Florida A&M University Board of Trustees to serve as interim Chief Executive Officer for the University in 2007. Also in 2007 he became the first African American to serve as Science Advisor to the United States Department of Agriculture's Cooperative State Research, Education, and Extension Service (CSREES). In 2008 he was selected to serve on the Oceans Research and Resources Advisory Panel (ORRAP) and as a founding member of the National Science Foundation's National Ecological Observatory Network (NEON) Science Technology Education Advisory Committee. Previously, Robinson served as a research scientist and group leader at Oak Ridge National Laboratory (ORNL) during the period 1984 – 1997. His work at ORNL included detection and assessment of special nuclear materials and application of nuclear methods in non-proliferation, environmental science, forensic science and assessment of high purity materials. His research interests include environmental chemistry, the application of nuclear methods to detect trace elements in environmental matrices, and environmental policy and management.

Peggy Roefer

Peggy Roefer is the Regional Water Quality Program Manager for the Southern Nevada Water Authority. She has worked for SNWA for 24 years and her jobs have included Microbiology Supervisor and Regional Water Quality Supervisor. She has a degree in Microbiology from the University of Texas at Austin and has spent the last 15 years dealing with emerging issues in southern Nevada such as *Cryptosporidium*, perchlorate, selenium, golden algae, and quagga mussels.

Greg G. Sass

Dr. Sass received a B.S. with honors in biology from University of South Florida in 1999, a M.S. in zoology from the University of Wisconsin-Madison in 2001, and a Ph.D. in zoology from the University of Wisconsin-Madison in 2004. Since 2006, he has been in the position of Director, Illinois River Biological Station, Illinois Natural History Survey, Institute of Natural Resource Sustainability, University of Illinois at Urbana-Champaign.

Christopher Scianni

Christopher Scianni has been with the Marine Invasive Species Program at the California State Lands Commission since 2007. During this time, he has overseen the development and analysis of California's database on the fouling-related practices of commercial vessels operating in the state. He has also participated in numerous dry dock and in-water surveys of fouling organisms on commercial and recreational vessels. He received his undergraduate degree in marine biology from California State University, Long Beach and a Master of Science degree in Marine Science from Moss Landing Marine Laboratories through California State University, Stanislaus.

Hanno Seebens

Research assistant Hanno Seebens has been a member of the joint project entitled "Epidemic spread and bioinvasion in complex transportation networks" in the working group Mathematical Modeling at the Institute for Chemistry and Biology of the Marine Environment, Oldenburg, Germany. In his research, Hanno Seebens is combining the network of global cargo ship movement with global data bases of environmental conditions, to predict the invasion of species through ballast water exchange of large cargo ships. Using mathematical models, he is also investigating spreading patterns on arbitrary, small networks and on the global ship network.

Linda Shaw

Linda Shaw has been a biologist with the National Marine Fisheries Service (NMFS) in Juneau, Alaska, USA, since 1991. She began working on invasive species issues while on a detail assignment to NMFS headquarters in 2004, where she co-authored a paper on invasive species threats to marine managed areas. Linda represents NMFS on the multi-partnered Alaska Invasive Species Working Group and is facilitator of the Marine Invasive Species Subcommittee of that group. She also coordinates citizen monitoring programs for marine invasive species in Southeast Alaska. Her poster shows how a coastal habitat mapping project can be leveraged to create tools for invasive species management.

Michael T. Sierp

Dr Michael Sierp is the Manager, Marine Biosecurity for South Australia at the Department of Primary Industries and Resources SA (PIRSA). Michael has BSc., Honors and PhD degrees from Flinders University and an MBA from the Australian Institute of Business Administration (AIBA). Michael manages research and development projects as South Australia's representative on the National Introduced Marine Pests Coordination Group (NIMPCG) and Consultative Committee on Marine Pest Emergencies (CCIMPE). Key projects include the National System for the Prevention and Management of Marine Pest Incursions, wild Pacific oyster eradication exercises and the establishment of the Australian Testing Centre for Marine Pests (ATCMP).

Fabiano Alcísio e Silva

Fabiano received his Bachelor's degree in Environmental Management from the Catholic University of Minas Gerais. He is a Masters student at Federal University of Ouro Preto in the Department of Geology studying Bioindication Water Quality by Benthic Macroinvertebrates. In conjunction with Biologist Foundation Technology Center in Minas Gerais – CETEC/MG, he is working on "Águas de Minas" project which addresses water quality monitoring of all the basins of Minas Gerais/Brazil and Program Monitoring and Control of *L. fortunei*.

Anouk Simard

Anouk Simard completed undergraduate studies from 1998-2001 at the Macdonald campus of McGill University at Montréal. Before beginning her graduate studies, she worked for different research projects in Canada and US measuring human impacts on biodiversity. She began her Masters in 2002, which she followed with a PhD project starting in 2004 at Laval University in Québec. She studied population dynamics of an introduced white-tailed deer population on Anticosti Island (Québec, Canada). Since the fall of 2009, Anouk has worked for the Ministry of Natural Resources in Québec where she is interested in the conservation of biodiversity and issues related to introduced invasive species.

Annie Simpson

Annie Simpson is the invasive species information manager at the National Biological Information Infrastructure (NBII), based at the US Geological Survey, but formerly worked for 20 years in Costa Rica. Her research interests include invasive species information sharing and species online identification tool development.

Ms. Simpson manages the Invasive Species Information Node of the NBII <http://invasivespecies.nbii.gov>, chairs of the Global Invasive Species Information Network <http://www.gisnetwork.org>, and co-manages the Invasives Information Network of the Inter-American Biodiversity Information Network (I3N) <http://i3n.iabin.net>. The NBII has an ongoing seven year partnership with the Invasive Species Specialist Group, and hosts a mirror of their Global Invasive Species Database at <http://www.invasivespecies.net/database>.

Allen Skaja

Allen Skaja earned his BS in Chemistry in 2000 and Ph.D. in Coatings and Polymeric Materials in 2005 from North Dakota State University. He joined the Bureau of Reclamation in June 2005 as a Coatings Specialist. Immediately he began evaluating coatings for corrosion protection. In Jan. 2008, he began testing coatings to deter the attachment of zebra/quagga mussels.

Garry Smythe

Garry received a Bachelors degree in Biology, and Master of Science in Natural Science and Math from the State Univ. of New York at Buffalo. He is a Senior Scientist at Shaw Environmental Inc.

His primary work is on environmental assessments related to government regulations. He's also worked for years with native and non-indigenous aquatic species including mollusks, fish, and plants. Over the past 20-years he conducted many research & development studies to evaluate chemicals or physical technologies relative to control of AIS, and studies to monitor the spread of AIS.

Clifford Starliper

Clifford E. Starliper, PhD is a microbiologist with the U.S. Geological Survey, Leetown Science Center (LSC), Leetown, WV. He is a bacteriologist with the National Fish Health Research Laboratory and conducts research on pathogens and diseases of freshwater fishes and mussels, with emphasis on bacteriological media development, pathogen transmission, and disease control and prevention. Dr. Starliper is collaborating with Dr. Barnaby Watten, LSC Restoration Technologies Branch, on methods development for ship ballast water decontamination using controlled laboratory studies on the bactericidal effects of treatments to pathogenic and environmental bacteria.

Peter Paul Stehouwer

Peter Paul Stehouwer is a PhD student at the Royal Netherlands Institute for Sea Research. He received his MSc degree in Marine Biology at the University of Groningen. He has been a part of the ballast water project since 2007. His focus within the project is on re-growth of phytoplankton and bacteria in water which has been treated with a ballast water treatment system.

Mia Steinberg

Mia Steinberg is a postdoctoral fellow with the U.S. Navy's Naval Research Laboratory where she is part of a multi-disciplinary team developing protocols used for testing ballast water treatment systems. She graduated from the University of Delaware in 2008, and her dissertation research investigated the chemical and physical cues for the settlement and metamorphosis of larval Asian shore crabs (*Hemigrapsus sanguineus*) as well as the population genetics of the shore crab in the United States.

Carol Stepien

Dr. Carol Stepien is the Director of the Lake Erie Research Center and Professor of Environmental Sciences at the University of Toledo. She is an associate editor for the journals *Biological Invasions* and the *Journal of Great Lakes Research* and on the Editorial Board of *Molecular Phylogenetics and Evolution*. Dr. Stepien's research work centers on the population genetics and evolutionary patterns of invasive species, including dreissenid mussels and fishes in the Great Lakes and beyond. Dr. Stepien has published several studies on the genetic relationships of dreissenid mussels, including this new study with her now-graduated Ph.D. student, Dr. Joshua Brown, who is currently working at NOAA in Washington, D.C. Their paper is in press in *Biological Invasions*.

Rochelle Sturtevant

Dr. Rochelle Sturtevant has served as coordinator for the Great Lakes Sea Grant Network and Sea Grant's liaison to NOAA's Great Lakes Environmental Research Laboratory since 2001. She currently is the project manager for NOAA's GLANSIS (Great Lakes Aquatic Nonindigenous Species Information System). In addition, she serves as Sea Grant Extension's representative to the Great Lakes Panel on Aquatic Nuisance Species and has served two terms as the chair of the Panel's Information and Education Committee.

Yajun Sun

Yajun Sun is a PhD student in the Department of Geography, University of Toronto. He earned his M.Sc. in Ecology, Evolution and Conservation, Imperial College, London. His current focus is on the influences of water dispersion pattern on aquatic alien species invasion in the Great Lakes. Yajun's main research includes field work on physical dispersion patterns in water body, modelling on aquatic alien species invasion, and the risk analyses based on the combination of both physical and ecological factors.

Lesly Swanson

Lesly holds a Biological Sciences degree from California Polytechnic State University. At present, she is working on her MBA from Arizona State University. Lesly is a Senior Environmental Scientist for Salt River Project (SRP), the third largest public power utility in the U.S. and one of Arizona's largest water providers. Lesly has worked on a variety of projects supporting both the water and power sides of SRP since 2004. In 2008 she began coordinating the company's invasive mussel effort, in collaboration with other agencies, to focus on keeping mussels out of SRP facilities and infrastructure.

Mark Sytsma

Mark Sytsma is a Professor and Chair of the Environmental Science and Management, director of the Center for Lakes and Reservoirs, and co-director of the Aquatic Bioinvasion Research and Policy Institute at Portland State University. He is a founding member of the Oregon Invasive Species Council and the Western Regional Panel on Aquatic Nuisance Species and co-chair of the Spartina Action Team of the West Coast Governor's Agreement. He authored and coordinates the Oregon AIS Management Plan and works closely with the Oregon Department of Agriculture on aquatic weed management in Oregon.

Lynn Takata

Lynn Takata joined the California State Lands Commission's (CSLC) Marine Invasive Species Program as a Staff Environmental Scientist in 2004, and currently works with the program team on policy development and administration. She has spent nearly 10 years working on marine invasive species science and policy, beginning as an undergraduate volunteer at Scripps Institution of Oceanography and later working with the Smithsonian Environmental Research Center's Marine Invasions Laboratory before joining the CSLC. Lynn holds a B.S. in Biology from U.C. San Diego, and an M.S. in Marine, Estuarine and Environmental Science from the University of Maryland.

Ross Tallman

Dr. Tallman completed his B.Sc. and .M.Sc. at the University of Manitoba and his Ph.D. in stream fish ecology at the University of British Columbia, Institute of Animal Resource Ecology. Currently, Ross is a research scientist and Section Head Arctic Stock Assessment and Integrated Ecosystem Research at Fisheries and Oceans Canada, Central and Arctic Region. His section is responsible for fisheries assessment and invasive species in Canadian Arctic and sub-Arctic. Scientist responsible for Arctic invasive species in 2007 and 2009. Ross' research interests are in the process of colonization, adaptation and intra-specific life history variation in freshwater, anadromous and marine fishes.

Todd Tietjen

Dr. Tietjen joined the Southern Nevada Water Authority in 2008 to work on water quality issues in Lake Mead. Prior to this he was an Assistant Professor at Mississippi State University where he taught Limnology and Wetlands Ecology and conducted research on the Mississippi River Floodplain. He worked as a Postdoctoral Researcher with the USGS Grand Canyon Monitoring and Research Center examining nutrient and carbon dynamics in the Colorado River. Todd received his Ph.D. in Aquatic Ecology from the University of Alabama, M.S. in Aquatic Biology from Southwest Texas State University, and B.A. in Environmental Studies from Alfred University.

Paul Topping

Paul Topping is Manager, Environmental Protection, with Marine Safety at Transport Canada's Headquarters in Ottawa. He joined Transport Canada in November 2007 and manages a regulatory program dealing with environmental issues facing marine shipping, including preventing pollution, reducing greenhouse gases, managing ballast water, and recycling of old ships.

Mr. Topping holds a degree in honours biology from the University of Waterloo. He has held positions at Environment Canada for 18 years on waste management and marine environmental protection issues, often working with the marine industry, Transport Canada, other departments and international organizations.

David Tordonato

David Tordonato is a materials engineer with the US Bureau of Reclamation. He works in the Technical Service Center's Materials Engineering and Research Laboratory. He holds BS and MS Degrees in Mechanical Engineering from Virginia Tech as well as a Ph.D. in Materials and Metallurgical Engineering from the Colorado School of Mines. He is currently involved in research to identify and evaluate the coating products to prevent the attachment of fouling organisms such as zebra and quagga mussels on hydraulic infrastructure. His research consists of field and laboratory testing to determine coating effectiveness and expected service life. In addition, David is also a member of the Bureau's Rope Access Team which performs inspections and other work on the inaccessible features of Reclamation structures and equipment.

Cameron Turner

Cameron Turner's research uses genetic/genomic approaches to monitor populations, with a focus on threatened or invasive aquatic animals. He currently studies native and invasive fishes in the Great Lakes region, invasive fishes and invertebrates in California, and native amphibians in California. Cameron is an NSF IGERT fellow and Ph.D. student at the University of Notre Dame, working with Drs. David Lodge and Michael Pfrender. Prior to starting his Ph.D., he worked as a fisheries biologist in Northern California. He earned a M.S. in Ecology and Evolutionary Biology from Indiana University (2007) and a B.S. from Brigham Young University (2004).

Kent Turner

Kent Turner is the Chief, Resource Management, Lake Mead National Recreation Area, a position he has held since 1989. Mr. Turner led the Lake Mead NRA response in 2007 to the documentation of quagga mussels in Lake Mead, and coordinated an interagency team that developed a response plan within three months of discovery outlining measures for spread prevention, public information, and monitoring. He coordinated an interagency effort to develop an Ecosystem Health Monitoring and Research Plan for Lake Mead NRA that was completed in February 2010. Prior to his experience at Lake Mead NRA, Mr. Turner was the natural resource program manager for Cape Hatteras National Seashore from 1982 to 1989.

Tom van der Have

Tom van der Have is an ecologist at the Ministry of Agriculture, Nature and Food Quality, Invasive Alien Species Team involved in early warning, risk analysis and management of IAS. He was trained as an evolutionary ecologist at Free University Amsterdam (MSc 1984). Research fellow at Institute for Terrestrial Ecology, UK, Aarhus University, Denmark and Utrecht University, the Netherlands (1984 – 1992), working on sex ratio evolution in ants and phenotypic plasticity in ectotherms. PhD at Wageningen University (2008) on proximate models of thermal adaptation in ectotherms. Species and habitats officer at BirdLife Netherlands (1993-2003) working on conservation issues in coastal ecosystems and shellfish-fisheries. Science co-ordinator at the Faunafonds and project leader Wageningen University (2004-2009) on human – wildlife conflicts, wildlife management and sustainability. Organised and participated in wetlands and waterbird expeditions in Africa, Middle East and Europe and author of scientific papers, popular articles and books on ornithology.

Isabel van der Star

Isabel van der Star finished her Master's in Animal Sciences and Aquaculture (Wageningen University) in 2008. She worked at the pharmaceutical company Fort Dodge (Part of Pfizer) as a Quality Assurance officer and later as Project Manager (2007-2009). She started working at the NIOZ as Jr. Scientist in November 2009. Her focus is on microzooplankton in the North Sea Ballast Water Opportunity Project which is co-funded by the European Union.

Gerard van der Velde

Gerard van der Velde was born at 7th of September 1946 at Groningen, The Netherlands. After the high school at Delft and the military service, he studied biology and geology at Leiden University. Since 1974 he became a PhD student at the Laboratory for Aquatic Ecology of the University of Nijmegen. After PhD (promotor Prof. Dr. C. den Hartog) he became associate professor at the same laboratory, but is nowadays a member of the staff of the Department of Animal Ecology & Ecophysiology, Institute for Water and Wetland Research of the Radboud University Nijmegen. He was visiting professor at the Vrije Universiteit Brussel (Belgium) lecturing tropical coastal marine ecology, president of the Dutch Malacological Society, president of European Invertebrate Survey-

Nederland, vice president of the Netherlands-Flemish Society for Aquatic Ecology and member of the Scientific Council of the International Centre for Ecology of the Polish Academy of Sciences for years. He is a guest collaborator and member of the sea team of the Netherlands Centre for Biodiversity Naturalis, Leiden. He took part on several marine expeditions and was involved in research on marine coastal ecosystems in the Indo-Pacific and the Caribbean. Another main topic of his research is the Ecological Rehabilitation of Large Rivers and of Wetlands. He is (co)author of more than 310 international publications on aquatic ecology and (co)promotor of more than 25 PhD theses. He was in the editorial boards of Aquatic Botany, Aquatic Ecology, Biological Invasions, and Chemistry & Ecology, and still in the board of Crustaceana, Crustaceana Monographs and new in the board of Aquatic invasions and Bacteria. Main topics of his group are biological invasions and biofouling, riverine, estuarine and tropical coastal ecosystems, macroinvertebrates and fish.

Anthony Van Oostrom

Tony Van Oostrom graduated from University of Waterloo with a Bachelor of Environmental Studies Degree in 1985. He has been working with Ontario Power Generation for 25 years in a number of environment related capacities. Since 1998, Tony has been working in the Niagara Plant Group located in Niagara Falls, Ontario as a Senior Environmental Advisor. Niagara Plant Group has 5 hydroelectric generating stations that produce about 10 % of the power in the Province of Ontario. One of Tony's roles has involved overseeing management of the Zebra and Quagga Mussel Treatment to protect cooling water systems in the hydroelectric generating stations.

Since Tony's arrival, the Niagara Plant Group has re-built their Zebra and Quagga Mussel Treatment System using a state of the art design. With that new design, sodium hypochlorite usage was reduced by over 80 %. With limited opportunities to further reduce environmental impacts, and as part of the Ontario Ministry of Environment Environmental Leaders Program, the Niagara Plant Group entered a partnership with Marrone Bio Innovations of Davis, California, and ASI Group of St. Catharines, Ontario to carry out trials at the DeCew 2 Generating Station.

Cees van Slooten

Cees van Slooten studied Biology at the University of Groningen. He earned his Masters degree in Marine Biology with a focus on Marine Microbial Ecology. He began his employment at NIOZ in 2009, joining the North Sea Ballast Water Opportunity Project, which is co-funded by the European Union. His role in this project is assessing the long-term impacts that active substances might have in marine environments. Today he will address the results of an incubation experiment with the active substance PERACLEAN® Ocean and its effects on the microbial community.

Marcel JW Veldhuis

Dr. Marcel Veldhuis is a senior scientist, and head of the Department of Biological Oceanography, at the Royal Netherlands Institute for Sea Research (NIOZ). Since 2004 he is coordinating a scientific team studying coastal biodiversity and in particular invasive organisms transported by ships. From 2009 onwards he is the coordinator of the EU sponsored program North Sea Ballast Water Opportunity (www.northseaballastwater.eu). Within this program national administrations, industry, research and stakeholder join together in an integrated approach in the mitigation of invasive organisms using ballast water treatment systems of ships.

Tanya Veldhuizen

Tanya has studied nonnative species in the San Francisco Estuary and the Central Valley watershed of California for over 15 years. Her thesis research focused on Chinese mitten crab habitat use in the Sacramento-San Joaquin Delta. Currently, she is a Staff Environmental Scientist with the California Department of Water Resources' Aquatic Nuisance Species Program, and manage the Zebra and Quagga Mussel Management Program for the State Water Project. In addition to mussels, DWR's ANS Program encompasses aquatic weeds, nuisance algae, and any new introductions that may impact water operations or water quality.

Laura Verbrugge

Laura Verbrugge studied Environmental Sciences at Utrecht University and Radboud University Nijmegen. She performed research on the effects of climate change (e.g. changing water temperature and salinity) on native and non-native mollusc species in riverine ecosystems and recently completed a comparative study on risk assessment

protocols for invasive alien species. At present she is working as a researcher/PhD-student on risk assessment, risk perception and risk management of invasive alien species at the Department of Environmental Science of the Radboud University.

Guy Verreault

Guy Verreault is a fisheries scientist with the Québec Ministry of Natural Resources and Wildlife (Canada). He graduated with a M.Sc. from the University of Québec in Rimouski and he is involved in fisheries management and research since early nineties. He has developed several monitoring programs dealing with exploited and endangered fish species in the St. Lawrence River and estuary. Since several years, he has developed and implemented an early detection network for aquatic alien invasive species in collaboration with commercial fishermen.

Hugo Verreycken

Hugo is a senior scientist at the Biodiversity and Natural Environment Department of the Flemish Research Institute for Nature and Forest (INBO). His research is focused on the study of non-native freshwater fish in Flanders, the northern part of Belgium. The occurrence and distribution of non-native fish and the evolution of these populations over time are closely monitored. Beside this, Hugo is responsible for the online freshwater fish database of INBO: the 'Fish Information System (VIS)'.

Martha Volkoff

Martha Volkoff, Senior Environmental Scientist with the California Department of Fish and Game's Invasive Species Program, leads and coordinates the Department's Quagga/Zebra Mussel Project. Project efforts focus on prevention, containment, early-detection monitoring, outreach and education, and coordination within California, as well as with national efforts. Martha has earned a B.S. and M.S. in Conservation Biology and for much of her career has worked as a fisheries biologist, with an emphasis on the application of fish age and growth information to the management of fisheries.

Jan H. Wanink

Jan Wanink is a Dutch ecologist, currently senior consultant at Koeman en Bijkerk bv, and guest researcher at Leiden University. After receiving his MSc at Groningen University, he conducted a long-term study on shorebirds and their macrozoobenthic prey in the intertidal areas of the Dutch Wadden Sea. As a PhD student and as postdoc he spent 5.5 years at Lake Victoria (Tanzania), investigating the impact of introduced Nile perch at various levels of the food web. One of his hydrobiological projects with Koeman en Bijkerk involves an attempt to estimate the impact of Chinese mitten crab on a small lake.

Barnaby Watten

Dr. Watten is Chief of the Restoration Technologies Branch of the USGS Leetown Science Center, Kearneysville, West Virginia. He has worked for the Center 22 years conducting research in gas transfer, hydraulics, dissolved gas instrumentation, mitigation of acid mine drainage, hydropower technologies and control of invasive species primarily in support of the U.S. Fish and Wildlife Service and National Park Service. He holds a Bachelors degree in Aquatic Biology, a Masters of Agriculture degree in Agricultural Engineering and a PhD in Fisheries and Allied Aquacultures. He is a past President of the American Fisheries Society's Bioengineering Section and is a past President of the Aquacultural Engineering Society. Dr. Watten is currently involved in the development of advanced mixing techniques for ballast tanks as well as hydroxide stabilization/recarbonation as an alternative biocide treatment.

Timothy Wier

Tim is a Mechanical engineer employed by Excet Incorporated to work for the Naval Research Laboratory Aquatic Nuisance Species team. Throughout the last four years, he has participated on several large scale land-based ballast water treatment system experiments as well as conducted research related to sampling of ballast water.

Chris Wiley

Chris straddles two Canadian Federal Government departments. He is the Aquatic Invasive Species Coordinator for the Department of Fisheries and Oceans, Central and Arctic Region as well as the Environmental Issues Manager for Transport Canada Ontario Region.

Chris spent fifteen years as Chief Engineer on ships worldwide; serving on Icebreakers, Tankers, Cruise and Passenger Ships, Supply Vessels and Mega Yachts.

He joined the Canadian Federal government in 1993 and has had responsibility for a variety of diverse files ranging from Senior Marine Surveyor (Machinery), Executive Advisor to the Regional Director General of Fisheries and Oceans, Regional Director of Technical Services for the Canadian Coast Guard. and Manager Arctic Ship Based Science Programs, He was co chair of the Machinery portion of the IACS Unified Requirements for Polar Ships

He has been involved in the Ballast Water file since 1994 His is Chair of the Ballast Water Working Group at the International Maritime Organization.

He has a BSc in Chemistry from the University of Toronto, a MSc in Maritime Management from Maine Maritime Academy and holds a First Class Combined Certificate of Competency as a Marine Engineer.

Leonard Willett

Leonard Willett has a degree in Business Management and specializes in Water & Wastewater Treatment Process and serves as the Quagga Mussel Coordinator for the US Department of Interior Bureau of Reclamation (BOR) at Hoover Dam. His experience includes operating and managing large municipal water/wastewater treatment facilities for 27 years and working with US Foreign Aid in Pavalador, Kazakhstan on water quality concerns. Since 2003 he has worked for the BOR with most of his efforts focused on environmental compliance, conducting facility reviews, coordinating research efforts, and installing control barriers to combat the western invasion of the dreissenid. He is an active member of the Water Environment Federation, American Water Works Association and Committee member for 218 filter materials, and a Certified Water & Wastewater Treatment Operator in several states.

Wesley Wilson

Wesley Wilson is an engineer in the Computational Hydromechanics Division at the Naval Surface Warfare Center - Carderock Division in West Bethesda, MD. He received an MS in mechanical engineering from West Virginia University in 1999, where his research area included liquid-liquid mixing mechanics and droplet formation and entrainment. For the past 13 years Mr. Wilson has been involved in using computational fluid dynamics (CFD) to solve a variety of problems relevant to the US Navy in the areas of surface ship and submarine hydrodynamics, shape optimization, ballast water exchange, and compensated ballast mixing.

Wei Ying Wong

Wei Ying Wong is a cultural ecologist whose work grapples with how the complexities of human-environment relationships impact conservation efforts. In particular, she is engaged with examining the importance of socio-cultural and historical contexts in formulating responses and management of invasive species. Much of her work focuses on how the science and management of invasive species can better incorporate social and environmental justice principles through improving understanding and communication amongst stakeholders. Wong is currently a Mellon postdoctoral fellow at Connecticut College.

David Wong

David Wong is a faculty in Department of Environmental and Occupational Health, University of Nevada Las Vegas. He has studied ecology and physiology of bivalve mollusks for 18 years. He is especially interested in invasive mussels such as the green mussel *Perna viridis*, the quagga mussel *Dreissena rostriformis bugensis*, and the zebra mussel *Dreissena polymorpha*. His current focus is on monitoring, prevention, control, and management of invasive quagga mussels in the Lower Colorado River Basin. He has 25 peer-reviewed publications. He is an invited editor and reviewer for more than 10 scientific journals and federal agency proposals.

Eva Záhorská

In 2005, Eva became a PhD student at Comenius University in the Department of Ecology, and since then she has been working on phenotype plasticity and life-history traits of topmouth gudgeon (*Pseudorasbora parva*) – an invasive fish species in Europe. She published four papers in international peer-reviewed journals and participated at several international conferences, including ICAIS, Montreal (2009). She completed her PhD degree in Ecology in July 2009. Currently Eva is in a post-doc position at Comenius University, where she continues her previous research on topmouth gudgeon. She is a member of the Slovak Ichthyological Society.

Dror Zurel

Dror Zurel is a PhD candidate at the Porter School for environmental studies, Tel Aviv University, Israel. He earned a BSc. degree in Life Sciences from the Hebrew university, Jerusalem. His MSc. degree was earned from Tel Aviv University, the Zoology Department. His research focused on the symbiosis between soft corals and their endo-symbiotic zooxanthellae and his results were published in Symbiosis journal. Dror's current research focuses on the symbiosis between an Indo-Pacific marine oyster, which has successfully invaded the Mediterranean coast, and its residing bacterial flora.

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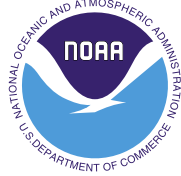
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